POWER MODULES

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DATABOOK

1st EDITION

SGS-THOMSON
ELECTRONICS

POWER MODULES

DATABOOK

1st EDITION

SEPTEMBER 1990

TABLE OF CONTENTS

INTRODUCTION

For many years SGS-THOMSON has been amongst the formost innovators in power transistor technology for switching applications. This is well evidenced by the high current and voltage range, the range of isolated packages and by data sheets that fit designers' needs.

The databook presents the bipolar transistors, both standard and easy-to-drive (ETD), Power MOSFETs, IGBTs and fast recovery power diodes that are avaiable in ISOTOP and TRANSPACK(TO-240) power modules.

The databook features:

TRANSISTORS - with and without free-wheeling diode,
DARLINGTONS - with and without free-wheeling diode,
HALF-BRIDGE configurations with free-wheeling diode
POWER MOSFETs
IGBTs with free-wheeling diode
and an associated range of very fast recovery power
RECTIFIER DIODES in the ISOTOP package.

From the wide choice of current, voltage and power dissipation presented in this databook, it is possible to select the optimum device for all power control designs for industrial, computer and telecom applications.

The large investment that has been made in manufacturing these devices ensures the best service together with an excellent quality level, making them indispensible for all power control applications.

ALPHANUMERICAL INDEX

PRODUCT GUIDE

ALPHABETICAL LIST OF SYMBOLS

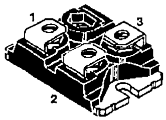
C_{DB}	Parasitic capacitance between drain and body
C_{CBO}	Collector-base capacitance (emitter open to a.c. and d.c.)
C_{DS}	Parasitic capacitance between drain and source
C_{GD}	Parasitic capacitance between gate and drain
C_{GS}	Parasitic capacitance between gate and source
C_{iss}	Input capacitance
C_{oss}	Output capacitance
C_{rss}	Reverse transfer capacitance
D.U.T.	Device under test
$E_{s/b}$	Second breakdown energy (with base-emitter junction reverse biased)
f	Frequency
f_T	Transition frequency
g_{fe}	Forward transconductance for IGBT
g_{fs}	Forward transconductance for POWER MOS
h_{FE}	Common emitter static current gain
I_B	Base current
I_{B1}	Turn-on current base current
I_{B2}	Turn-off current base current
I_{BM}	Base peak current
I_C	Collector current
I_{CBO}	Collector cut-off current with emitter open
I_{CEO}	Collector cut-off current with base open
I_{CER}	Collector cut-off current with specified resistance between emitter and base
I_{CES}	Collector cut-off current with emitter short-circuited to base
I_{CEV}	Collector cut-off current with specified reverse voltage between emitter and base
I_{CEX}	Collector cut-off current with specified circuit between emitter and base
I_{CM}	Collector peak current
I_{CRMS}	RMS collector current
I_D	Drain current
I_{DLM}	Drain peak current, inductive load
I_{DM}	Drain peak current
I_{DSS}	Zero gate voltage drain current
I_E	Emitter current
I_{EBO}	Emitter cut-off current with collector open
I_F	Rectifier continuous DC forward current
I_{FM}	Diode peak forward current
I_G	Gate current
I_{GES} (I_{GDS})	Gate-body leakage current with coll-emitt short circuited for IGBT
I_{GSS}	Gate-body leakage current with drain short circuited to source
I_N	Nominal current
I_R	Continuous DC reverse current for a diode
I_{RM}	Peak reverse current for a diode
$I_{s/b}$	Second breakdown collector current (with base-emitter junction forward biased)
I_{SD}	Source-drain diode current
I_{SDM}	Source-drain diode peak current
L	Load inductance of a specified circuit
P_{tot}	Total power dissipation
P_W	Pulse width
Q_{rr}	Reverse recovery charge
R_{BB}	Base dropping resistance
R_{BE}	Resistance between base and emitter
R_{CC}	Collector dropping resistance
$R_{DS(on)}$	Static drain-source on resistance

R_{EE}	Emitter dropping resistance
R_G	Gate series resistance
R_{GE}	Gate-emitter resistance
R_{GS}	Gate-source resistance
R_i	Generator internal resistance
R_L	Load resistance
r_s	Series resistance
R_{th}	Thermal resistance
$R_{th\ j\text{-}case}$	Thermal resistance junction-case
$R_{th\text{-}jamb}$	Thermal resistance junction-to-ambient
t	Time
t_c	Crossover time
t_d	Delay time
$t_{d(off)}$	Turn-off delay time
$t_{d(on)}$	Turn-on delay time
t_f	Fall time
t_{off}	Turn-off time
t_{on}	Turn-on time
t_p	Pulse width - pulse duration
t_r	Rise time
$t_{r(off)}$	Rise time of collector voltage for switching off.
t_{rr}	Reverse recovery time of a diode
t_s	Storage time
t_{IRM}	Recovery time for maximum value of recovery current (IRM)
T_{amb}	Ambient temperature
T_{case}	Case temperature
T_j	Junction temperature
T_{stg}	Storage temperature
T_l	Maximum lead temperature for soldering purpose
V_{BE}	Base-emitter saturation voltage
$V_{BE\ (sat)}$	Base-emitter voltage
$V_{(BR)\ CBO}$	Collector-base breakdown voltage with emitter open
$V_{(BR)\ CEO}$	Collector-emitter breakdown voltage with base open
$V_{(BR)\ CER}$	Collector-emitter breakdown voltage with specified resistance R_{BE}
$V_{(BR)\ CES}$	Collector-emitter breakdown voltage with emitter short-circuited to base
$V_{(BR)\ CEV}$	Collector-emitter breakdown voltage with specified reverse voltage between emitter and base, rs=0
$V_{(BR)\ CEX}$	Collector-emitter breakdown voltage with specified circuit between emitter and base
$V_{(BR)\ EBO}$	Emitter-base breakdown voltage with collector open
$V_{(BR)DSS}$	Drain-source breakdown voltage with gate short circuited to source
V_{CB}	Collector-base voltage
V_{CBO}	Collector-base voltage with emitter open
V_{CC}	Collector DC voltage supply
V_{CE}	Collector-emitter voltage
$V_{CE(sat)}$	Collector-emitter saturation voltage
V_{CEK}	Knee voltage at specified condition
V_{CEO}	Collector-emitter voltage with base open
$V_{CEO(sus)}$	Collector-emitter sustaining voltage with base open
V_{CER}	Collector-emitter voltage with specified resistance between emitter and base
$V_{CER(sus)}$	Collector-emitter sustaining voltage with specified resistance between emitter and base
V_{CES}	Collector-emitter voltage with emitter short-circuited to base
V_{CEV}	Collector-emitter voltage with specified reverse voltage between emitter and base
$V_{CEV(sus)}$	Collector-emitter sustaining voltage with specified reverse voltage between emitter and base

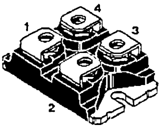
ALPHABETICAL LIST OF SYMBOLS

V_{CEW}	Maximum collector-emitter voltage at turn-off with a specified current and base drive
$V_{CEX(sus)}$	Collector-emitter sustaining voltage with specified circuit between emitter and base
V_{clamp}	Drain clamping voltage
V_{DG}	Drain-gate voltage
V_{DGR}	Drain-gate voltage with specified resistance between gate and source
V_{DS}	Drain-source voltage
$V_{DS(on)}$	Drain-source on state voltage
V_{EB}	Emitter-base voltage
V_{EBO}	Emitter-base voltage with collector open
V_F	Continuous DC forward voltage for a diode
V_{FM}	Peak forward voltage for a diode
V_{GE}	Gate-emitter voltage
$V_{GE\ (th)}$	Gate threshold voltage for IGBT
V_{GS}	Gate-source-voltage
$V_{GS(th)}$	Gate threshold voltage
V_I	Input voltage of a specified circuit
V_R	Continuous DC reverse voltage for a diode
V_{RM}	Peak reverse voltage for a diode
V_{RRM}	Repetitive peak reverse voltage
V_{SD}	Source-drain diode forward on voltage
δ	Duty cycle
ΔT	Temperature variation

SCREW VERSION

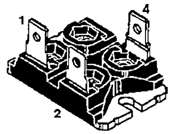


For configuration 1

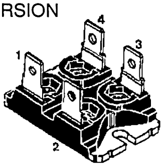


For other configurations

FAST-ON VERSION

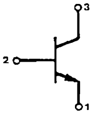


For configuration 1

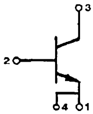


For other configurations

Internal schematic diagrams



Configuration 1



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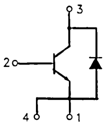

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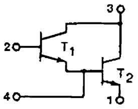

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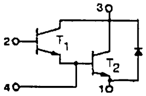
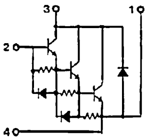


Configuration 5



Configuration 6

BIPOLAR IN ISOTOP

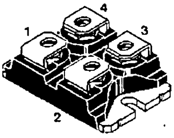
Type	V_{CEO} (.)	V_{CEV}	I_C	$V_{CE(sat)}$ @ I_C / I_B (..)			t_s (▲)	t_f (▲)	P_{tot}	Configuration
	(V)	(V)	(A)	(V)	(A)	(A)	(µs)	(µs)	(W)	
ESM2012DF/V	125	150	120	2	100	1	2	0.3	175	5
BUT30F/V	125	200	100	1.5	100	10	2	0.2	250	1
BUT230F/V	125	200	200	1.2*	200	20	2	0.3	300	2
ESM2030DF/V	300	400	67	2.2	56	1.6	3	0.6	150	5
BUT32F/V	300	400	80	1.9	40	4	3	0.4	250	1
ESM3030DF/V	300	400	100	2.2	85	2.4	3.5	0.6	225	5
BUT232F/V	300	400	140	1.9	70	7	5	0.4	300	2
ESM3045DF/V	450	600	24	2	20	1.2	4	0.4	125	5
ESM4045DF/V	450	600	42	2	35	2	4.5	0.5	150	5
STF4045DF/V	450	600	42	2	35	2	4.5	0.3	150	5
ESM5045DF/V	450	600	60	2	50	2.8	5	0.5	175	5
ESM7545DF/V	450	600	75	2.7	50	1	8	1.5	250	5
BUF460DF/V	450	600	80	2	60	12	5	0.2	270	3
ESM6045DF/V	450	600	84	2	70	4	5.5	0.5	250	5
STF6045DF/V	450	600	84	2	70	4	5	0.4	250	5
STF8045DF/V	450	600	100	2	85	4.9	5.5	0.5	270	5
BUV98F/V	450	850	30	5**	20	4	5	0.4	150	1
BUF298F/V	450	850	50	2	32	5.4	4.5	0.4	250	1
BUV298F/V	450	850	60	2	32	8	4.5	0.4	250	1
BUF460F/V	450	850	80	2	60	12	5	0.2	270	2
ESM3045AF/V	450	1000	22	2	18	0.72	4.5	0.5	125	4
BUV98AF/V	450	1000	30	1.5**	16	3.2	5	0.4	150	1
ESM4045AF/V	450	1000	36	2	30	1.2	5	0.6	150	4
STF4045AF/V	450	1000	36	2	30	1.2	5	0.3	150	4
BUF298AF/V	450	1000	50	2	32	6.4	4.5	0.2	250	1
BUV298AF/V	450	1000	50	2	32	6.4	4.5	0.4	250	1
ESM6045AF/V	450	1000	72	2	60	2.4	6	0.6	250	4
STF6045AF/V	450	1000	72	2	60	2.4	6	0.4	250	5
BUF460AF/V	450	1000	80	2	60	12	5	0.2	270	2
STF8045AF/V	450	1000	100	2	72	2.9	6	0.6	270	4
ESMT5070DF/V	700	1000	50	3.5	30	0.3	14*	1.5*	300	6
BUF824F/V	800	1200	36	2	24	6	6.5*	0.1*	270	2
BUF832F/V	800	1200	48	2.2	32	8	8*	0.1*	300	2

(.) V_{CEO} Sustaining. (..) Max Value at T_j = 100°C. (▲) Max Value, inductive Load and T_j=100°C. * Typical value ** T_c = 25°C

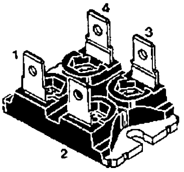
Note: Final Digit F = Fast-on; V = Screw.

SELECTION GUIDE

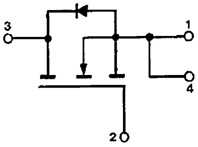
SCREW VERSION



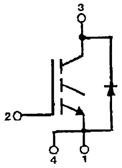
FAST-ON VERSION



Internal schematic diagrams



Configuration 13



Configuration 14

POWER MOS IN ISOTOP

Type	V_{DS}	I_D Tc=25°C	I_D Tc=100°C	$R_{DS(on)}$ @ I_D/V_{gs}			P_{tot}	Configuration
	(V)		(A)	(Ohm)	(A)	(V)	(W)	
TSD250N05F/V	50	250	155	0.004	–	–	500	13
TSD200N05F/V	50	200	126	0.006	–	–	400	13
TSD4M151F/V	80	135	85	0.014	70	10	500	13
TSD180N10F/V	100	180	112	0.007	–	–	500	13
TSD4M150F/V	100	135	85	0.014	70	10	500	13
TSD4M251F/V	150	110	69	0.021	60	10	500	13
TSD4M250F/V	200	110	69	0.021	60	10	500	13
TSD4M351F/V	350	50	31	0.075	30	10	500	13
TSD4M350F/V	400	50	31	0.075	30	10	500	13
TSD2M350F/V	400	30	19	0.15	18	10	300	13
TSD4M451F/V	450	45	28	0.1	28	10	500	13
TSD4M450F/V	500	45	28	0.1	28	10	500	13
TSD40N50DF/V	500	40	24	0.12	–	–	500	13
TSD2M450F/V	500	26	16	0.2	13	10	300	13
TSD22N80F/V	800	22	13.7	0.4	12	10	400	13
TSD20N100F/V	1000	20	12.5	0.5	–	–	500	13
TSD5MG40F/V	1000	17	10.7	0.7	9	10	500	13

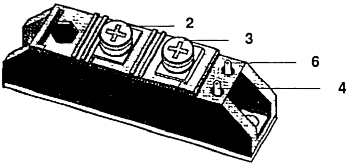
Note: Final Digit F = Fast-on V = Screw.

IGBT IN ISOTOP

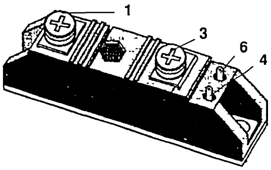
Type	V_{CES}	I_C	I_C Tc=90°C	$V_{CE(sat)}$ @ I_C / V_{ge}			t_f •	P_{tot}	Configuration
	(V)	(A)	(A)	(V)	(A)	(V)	(µs)	(W)	
TSG50N50DF/DV	500	100	50	3.3	50	15	*0.4	300	14
TSG25N100DF/DV	1000	50	25	3.5	25	15	*0.8	300	14

* Typical value • Inductive Load.

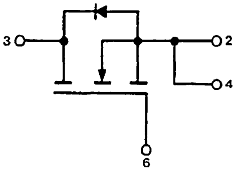
TO-240



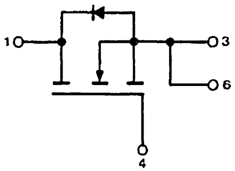
TO–240A



Internal schematic diagrams



Configuration 10



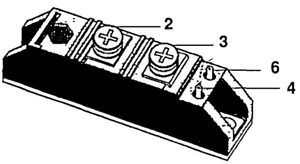
Configuration 12

POWER MOS IN TO–240

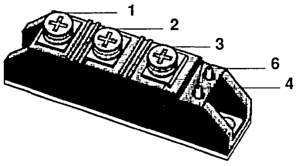
Type	$V_{(BR)DSS}$ (V)	I_D (A)	I_D T_C=100°C (A)	$R_{DS(on)}$ @ I_D/V_{GS} (Ω)	(A)	(V)	P_{tot} (W)	Configuration
SGS150MA010D1	100	150	95	0.009	75	10	400	10
IRFK6H150	100	150	120	0.010	100	10	625	12
IRFK4H150	100	145	90	0.014	80	10	500	12
SGS100MA010D1	100	120	75	0.014	50	10	400	10
IRFK6H250	200	140	90	0.015	90	10	625	12
IRFK4H250	200	108	68	0.021	64	10	500	12
IRFK6H350	400	75	48	0.050	48	10	625	12
IRFK6H450	500	66	42	0.067	42	10	625	12
IRFK4H450	500	44	28	0.100	28	10	500	12
SGS35MA050D1	500	35	22	0.160	17.5	10	400	10
SGS30MA050D1	500	30	19	0.200	15	10	400	10

SELECTION GUIDE

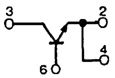
TO–240
Single switch



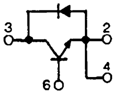
TO–240
Half bridge



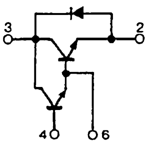
Internal schematic diagrams



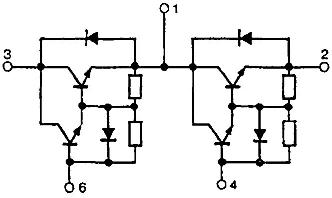
Configuration 6



Configuration 7



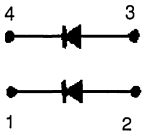
Configuration 8



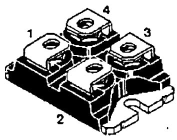
Configuration 9

BIPOLAR IN TO-240

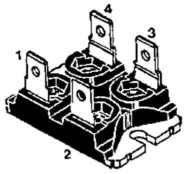
Type	V_{CEO}	V_{CEV}	I_C	$V_{CE(sat)}$ @ I_C / I_B			t_s T_j = 125°C	t_f	P_{tot}	Configuration
	(V)	(V)	(A)	(V)	(A)	(A)	(µs)	(µs)	(W)	
SGS250DA013D	130	200	250	2.5	250	3.3	6	1	400	8
SGS80DA020D	200	300	80	2	80	1	4	0.6	375	8
SGS100DA020D	200	300	100	2	100	1	4	0.6	375	8
SGS150DA020D	200	300	150	2	150	2	5	0.8	400	8
SGS30DB040D	400	500	30	3	30	2	3	0.7	375	9
SGS50DB040D	400	500	50	3	50	5	3	0.7	375	9
SGS30DB045D	450	600	30	3	30	2	3	0.7	375	9
SGS50DB045D	450	600	50	3	50	5	3	0.7	375	9
SGS40TA045D	450	850	40	2	40	8	5	0.55	375	7
SGS40TA045	450	850	40	2	40	8	5	0.55	375	6
SGS50DA045D	450	850	50	2.5	50	2	5	0.6	375	8
SGS30DA060D	600	1000	30	2.5	30	1.5	6	0.8	375	8
SGS25DB070D	700	1000	25	3	25	2.5	5	1.5	375	9
SGS35DB070D	700	1000	35	3	35	3.5	5	1.5	400	9
SGS30DA070D	700	1200	30	2.5	30	1.5	6	0.8	375	8
SGS60DA070D	700	1200	60	3	60	2	6	0.8	400	8
SGS35DB080D	800	1200	35	3	35	3.5	5	1.5	400	9
SGS25DA080D	800	1200	25	3	25	2.5	6	0.8	375	8
SGS25DB080D	800	1200	25	3	25	2.5	5	1.5	375	9
SGS50DA080D	800	1200	50	3	50	2.5	6	0.8	400	8



SCREW VERSION



FAST-ON VERSION

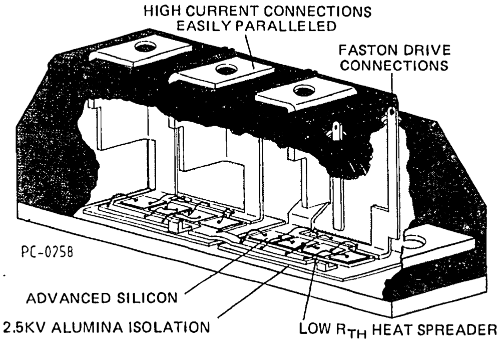


FAST RECOVERY DIODES

Type	I_{OA}/T_{case}	V_{RV}	I_{FSMA}	V_{FV}/I_{FA} Tr=100°C	t_{rr} ns	Suffix
BYV54- 50	2 x 50 90°C	50	1000	0.85 V 50 A	60	F V
BYV54-100		100				
BYV54-150		150				
BYV54-200		200				
BYV255-50	2 x 100 110°C	50	1600	0.85 V 100 A	80	F V
BYV255-100		100				
BYV255-150		150				
BYV255-200		200				
BYT230PI-200	2 x 30 60°C	200	350	1.4 V 30 A	50	F V
BYT230PI-300		300				
BYT230PI-400		400				
BYT230PI-600	2 x 30 50°C	600	200	1.8 V	55	
BYT230PI-800		800				
BYT230PI-1000		1000			70	
BYT230PI-1200		1200				
BYT261PI-200	2 x 60 80°C	200	600	1.4 V 60 A	50	F V
BYT261PI-300		300				
BYT261PI-400		400				
BYT261PI-600	2 x 60 60°C	600	400	1.8 V 60 A	65	
BYT261PI-800		800				
BYT261PI-1000		1000			70	

PACKAGE INTERNAL DESCRIPTION

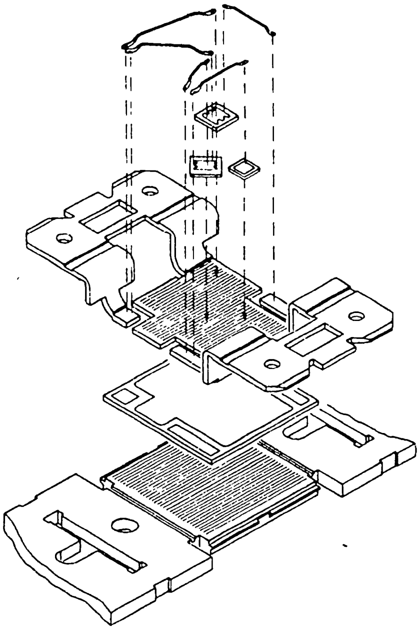
TO–240

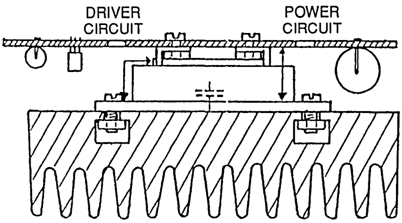


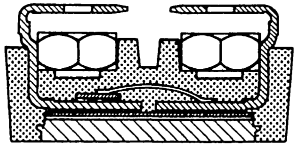
The TO-240 is a well established "Package" in the industrial electronics field.
SGS-THOMSON TRANSPACK power modules conform to this standard outline whilst offering improved performance. The TRANSPACK range provides choice and flexibility. SGS-THOMSON offer a wide choice of transistors and POWER MOS chips to cope with varying application requirements.
Quality and Reliability is ensured by the proven high volume technology of SGS-THOMSON POWER DISCRETES.

TRANSPACK internal design provides optimised electrical and thermal balancing plus minimum thermal resistance which ensures improved performance and a lower operating temperature. The internal layer of ceramic material means that external mica or ceramic washers are unneccessary and removes the problems associated with device failure caused by insulating washer breakdown.

ISOTOP





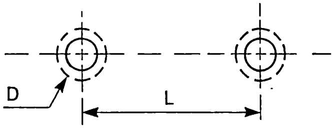


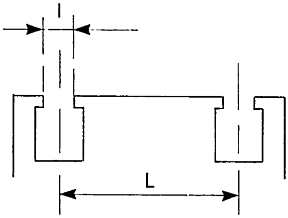
ISOTOP is a power device package offering the maximum power switching capability (3,9 KVA/cm^3) and very low RTH with the smallest on the market volume. Its versatility, its very easy mounting in compact circuits make the ISOTOP case particulary suitable for high performance, low volume, power switching circuits designs.

MOUNTING INFORMATION

Power module packages are designed for high mechanical robustness and optimum heat removal. The basic mounting procedures are as follows.

I - MOUNTING ON HEATSINK





I1 - HEATSINK SPECIFICATION:

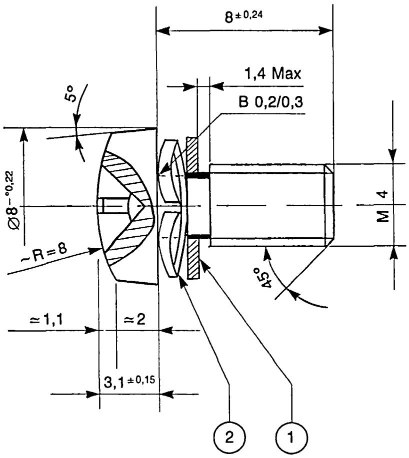
	ISOTOP	TO240
Flatness (max concavity or convexity between fixing holes)	<= 20 microns (0.78 mils)	<= 40 microns (1.18 mils)
Surface Finish	± 1.2 microns (± 0.05 mils)	
Fixing Holes	D = M4 L = 30 +3 mm (1.181 + 0.012 Inches)	D = M6 L = 80 ± 0.1 mm (3.15 ± 0.004 Inches)
Extruded Heatsink		L = 80 ± 0.3 mm l = 6.5 + 0.2 mm (3.15 = ± 0.012 Inches) (0.256 + 0.008 Inches)

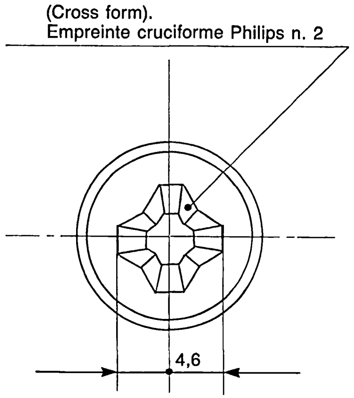
I2 - MOUNTING SPECIFICATION:

	ISOTOP	TO240
Fixing Screw	M4 + lock washer	M6 x 15 allen + lock washer
Torque	1.3 ± 0.2 N • m (7.6 ± 1.2 LBS • Inches)	3.5 ± 0.5 N • m (20.5 ± 3 LBS • Inches)
R_{th} Case/Heatsink (with thermal compound)	≤ 0.05 °C/W	≤ 0.05 °C/W

II – CONNECTIONS

	ISOTOP	TO240
Screws	See Drawing page 18	M5 x 10 + Lock Washer + Washer
Torque	1.3 ± 0.2 N • m (7.6 ± 1.2 LBS • Inches)	2.2 ± 0.5 N • m (13 ± 2.3 LBS • Inches)
Pull Test (fast on pins)	<= 80 N.	<= 55 N.
Twist Test	Not applicable	Not applicable
Contact Area (screw version)	45 mm^2	70 mm^2
Lead Inductance	<= 5 nH	





III - INSULATION

	ISOTOP	TO240
Insulation Material dice to base	Ceramic	Ceramic
Insulation Voltage pins to base	2500 V.RMS 1 minute	2500 V. RMS 1 minute
Stray capacitance	40 to 70 pF.	
Creepage and Clearance Distance pins to base-heatsink	>= 9.5 mm (0.374 Inches)	>= 29 mm (1.14 Inches)
Creepage and clearance distance pin to pin	>= 4.5 mm (0.177 Inches)	>= 8 mm (0.315 Inches)
Resin: Flammability UL 94 V-O	UL Recognized	UL Recognized
UL Qualification	File E817344	Conforms to UL Requirements

RELIABILITY

PACKAGE ORIENTED TESTS:

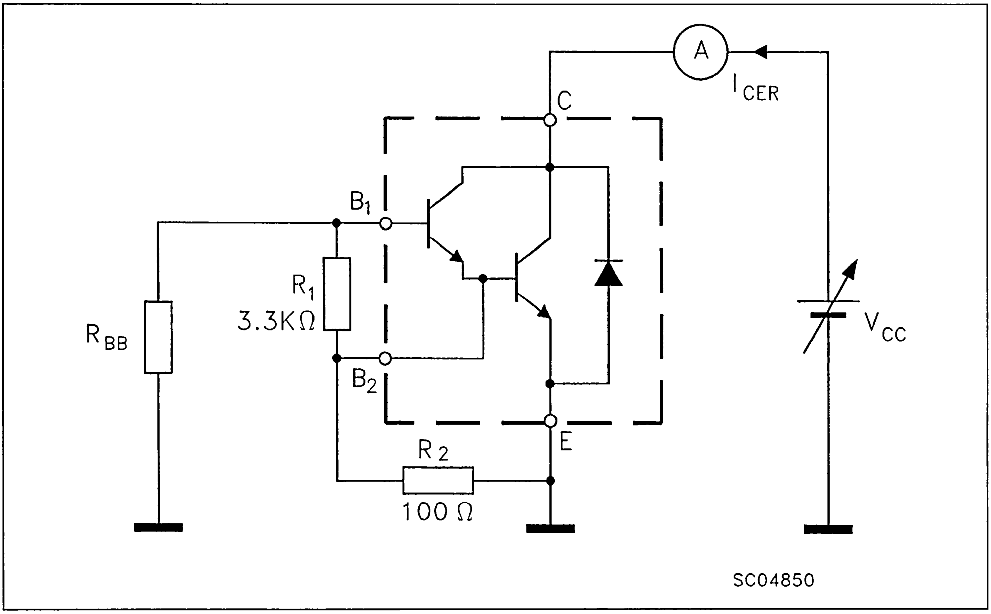
Periodic reliability tests are performed in order to prevent any drift in the in-built reliability level of power module cases.

	CUMMULATIVE RESULTS	
TEST AND CONDITIONS	ISOTOP	TO240
Thermal fatigue $\Delta T_C = 70°C$, P_D = low, 5 K cycles	$1.9x10^6$ device cycles 1 failure	$1.1x10^6$ device cycles 1 failure
Thermal fatigue –40°C/125°C, 100 cycles MIL-STD 202F/107G	$41x10^3$ device cycles 1 failure	$25x10^3$ device cycles 1 failure
Vibrations 6 hours MIL-STD 202F/204D	0% (0/310)	0% (0/220)
Moisture T_A = 85°. RH = 85% 100 H.	0% (0/290)	0% (0/220)

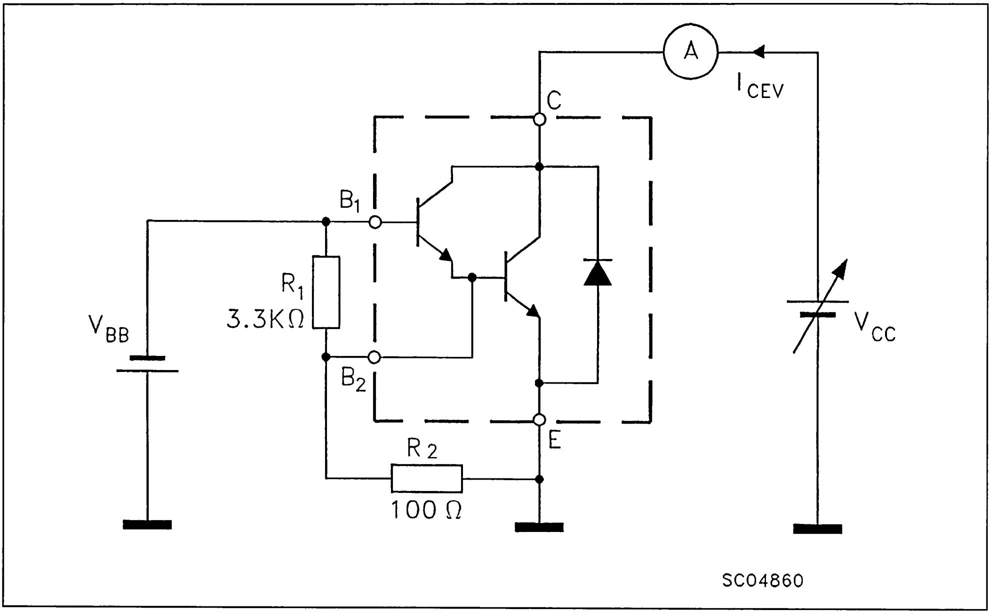
PACKAGING FOR SHIPMENT

PACKAGE	ISOTOP SUFFIX F	 SUFFIX V	TO240
Tube	10 PCS	10 PCS + contact set (screws + washers)	5 pieces + contact set (screws + washers)
Elementary box (bulk quantity)	100 pieces (10 tubes)		25 pieces (5 tubes)
Ordered quantity	Multiples of 10 PCS		Multiples of 5 pieces

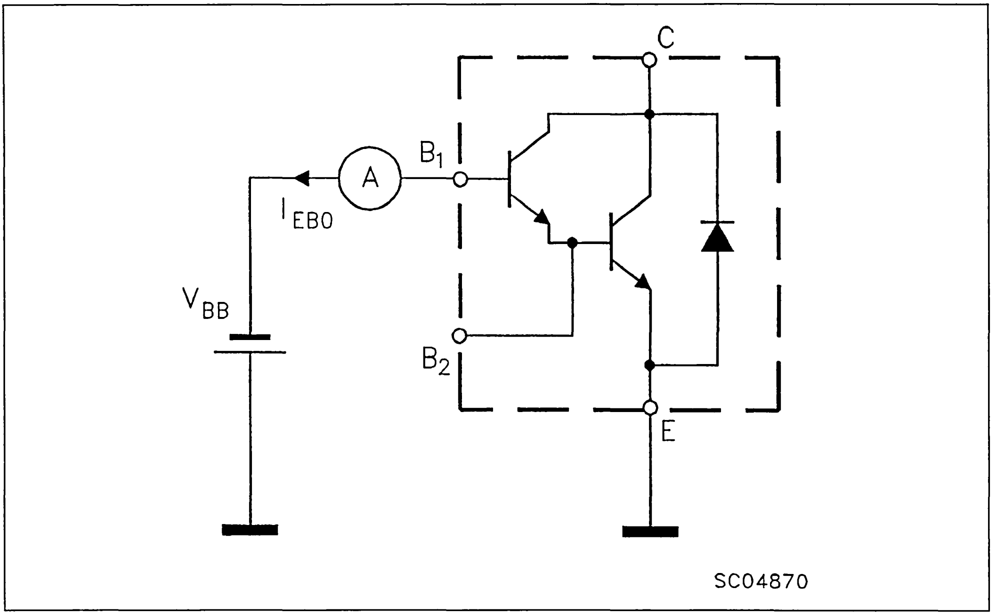
I_{CER}


A
I_{CER}
C
B_1
R_1
3.3KΩ
R_{BB}
B_2
E
R_2
100 Ω
V_{CC}
SC04850

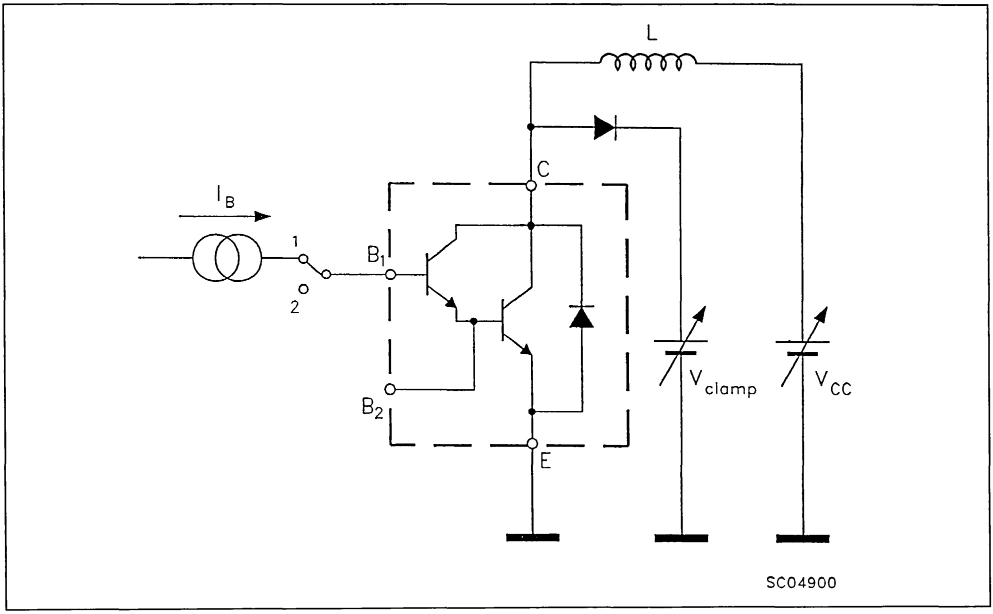
I_{CEV}


A
I_{CEV}
C
B_1
R_1
3.3KΩ
V_{BB}
B_2
E
R_2
100 Ω
V_{CC}
SC04860

I_{EBO}



V_{CEO} (sus)



INDEX APPLICATION NOTE

APPLICATION NOTES

NOVEL PROTECTION AND GATE DRIVES FOR MOSFETs USED IN BRIDGE-LEG CONFIGURATIONS

BY C. PATNI

INTRODUCTION

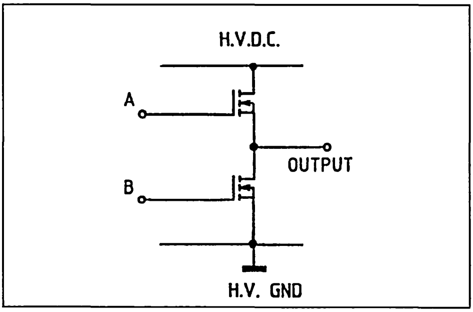
The bridge-leg is an important building block for many applications such as drives and switch-mode power supplies. Simple gate drives with protection for POWER MOSFETs need to be designed for the "low-side" and the "high-side" switches in the bridge-leg. The POWER MOSFET can conduct a peak drain current, I_D, which is more than three times its continuous current rating. The POWER MOSFET peak current capability and its linear operating mode are used to good effect in designing device protection circuitry.

Bridge-leg configurations have a direct bearing on the degree of protection that can be incorporated. Consequently, bridge-leg configurations, protection concepts and gate drives are created simultaneously to design optimised and reliable power electronic circuits.

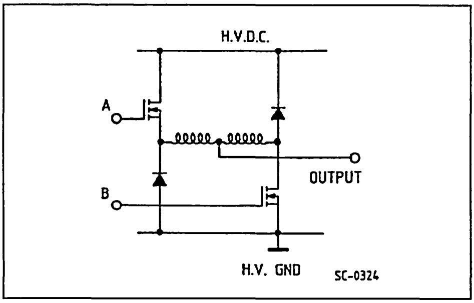
H-BRIDGE USING POWER MOSFETs

Three POWER MOSFET based bridge configurations are illustrated in figure 1. Figure 1a illustrates a bridge-leg which uses the internal parasitic diode as a free-wheeling diode thus reducing cost. However, since the reverse recovery of this parasitic diode is in the order of a microsecond, the turn-on switching times of the POWER MOSFET have to be increased in order to reduce the reverse recovery current. The turn-on time of the POWER MOSFET is controlled such that the pulse current rating of the internal diode is not exceeded. Hence a compromise is made between maintaining the safe operating area of the MOSFET and reducing turn-on switching losses. For example, an SGSP477 MOSFET has a diode pulse current rating in excess of 80A and a typical diode reverse recovery time of 300ns. A rate of change of current at turn-on, limited to 50A/s, is a realistic compromise between reverse recovery current magnitude and turn-on losses. Consequently switching speed is sacrificed for cost. For switching frequencies up to 10kHz, when operating on a 400V DC high voltage rail, this configuration can be chosen as switching losses are limited, thus enabling a realistic thermal design.

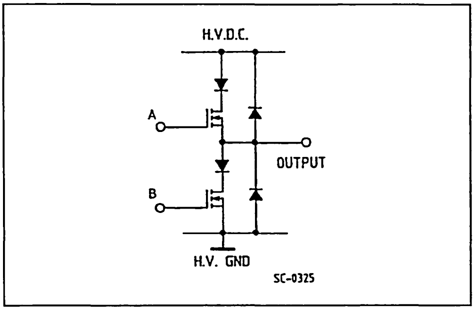
Figure 1 : Bridge Configurations.



a) Bridge-leg using Internal Parasitic Diode.



b) Asymmetrical Bridge-leg providing di/dt Protection.



c) Bridge-leg with blocking Diodes.

The turn-off speed of the POWER MOSFET in this configuration has no restrictions. Thus a fast turn-off is desirable to reduce turn-off losses. As the rate of change of current is limited, radio frequency interference (RFI) and electromagnetic interference (EMI) are reduced.

An asymmetrical bridge-leg, illustrated in figure 1b ; can be used to limit di/dt during a short-circuit condition thus providing sufficient time to switch-off the appropriate power devices. The inductors limit the rate of rise of output current. They also limit the free-wheeling current through the internal parasitic diodes of the MOSFETs. Adding external free-wheel diodes and inductors increases reliability at the cost of increased complexity. The inductors reduce RFI and EMI as the rate of change of current is limited.

The configuration illustrated in figure 1c has Schottky "blocking" diodes to prevent current going through the MOSFET internal parasitic diodes. Schottky diodes are often used since conduction losses are kept to a minimum.

Bridge configurations shown in figure 1b and 1c are considered for high frequency switching applications. The advantage of the asymmetrical bridge-leg configuration over the bridge configurations in figures 1a and 1c is that the bridge-leg is capable of withstanding simultaneous conduction of the two devices in the bridge-leg since there are series inductors which reduce the dI/dt under this condition. Hence the short-circuit detection loop time is not so critical and the devices are not stressed with high dI/dt and high pulse currents.

The choice of the bridge configuration depends on the technical specification of the application. For example, if the technical specification for a specific application can be met by using the configuration shown in figure 1a, then this configuration should be used as costs are lower than with the other two configurations shown in figures 1b and 1c.

GATE DRIVE CIRCUITS

The POWER MOSFET is a voltage controlled device, unlike the bipolar transistor which requires a continuous base drive. An application of a positive voltage between the gate and the source results in the device conducting a drain current. The gate to source voltage sets up an electric field which modulates the drain to source resistance. The following precautions should be considered when designing the gate drive ;

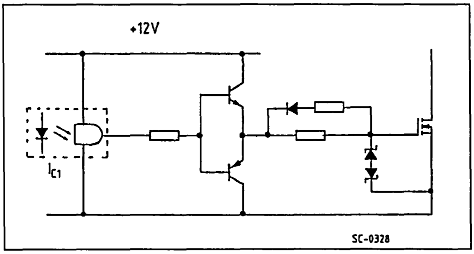
1 - Limit V_{GS} to 20V maximum. Use of a gate to source voltage in excess of 16V has a marked effect on the lifetime of the device.

2 - Gate drive parasitic inductance can cause oscillations with the MOSFET input capacitance. This problem becomes more pronounced when connecting devices in parallel.

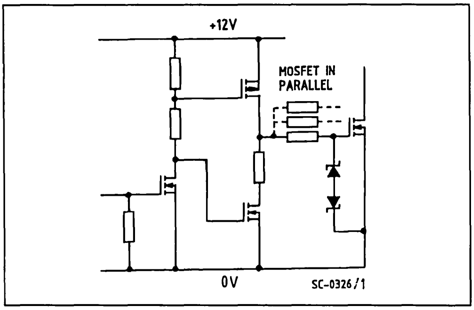
3 - There should be sufficient gate to source voltage for the transistor to be fully conducting.

Figure 2 : Gate Drive Circuits.

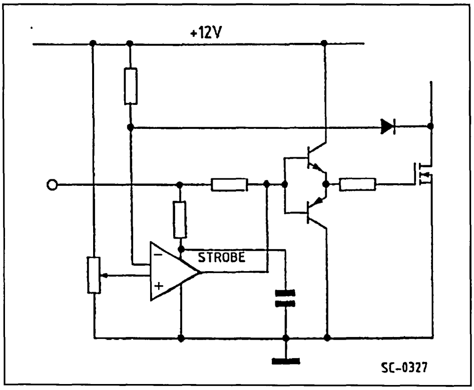
a) Isolated gate drive with controllable switching times.



b) Simple gate drive for N-Channel MOSFETs in parallel.



c) Gate drive with $V_{DS\ (on)}$ control for short-circuit protection.



Bipolar, MOSFET, CMOS or open-collector TTL logic can be used in the design of simple high performance gate drives. Totem-pole buffers, (figure 2a), are often effectively used to control the turn-on and turn-off individually. Figure 2b illustrates a total MOSFET based gate drive with which the switching speeds at turn-off can be individually controlled. CMOS or open-collector TTL logic can be used to drive MOSFETs directly, provided an ultrafast switching speed (50ns) is not necessary. In motor drive applications switching speeds of 100 to 200 nanoseconds are sufficient as switching frequency is seldom in excess of 50kHz. Discrete buffers are used to provide high current source and sinking capability when improved switching speeds are required or when MOSFETs are connected in parallel.

Short-circuit protection techniques similar to those for bipolar transistors may be considered for MOSFETs. $V_{DS(on)}$ monitoring permits the detection of short-circuit conditions which lead to device failure. The device can be switched off before the drain current reaches a value in excess of the peak pulse current capability of the MOSFET. This form of protection is very effective with MOSFETs as they can sustain a pulse current in excess of three times the nominal continuous current. Figure 2c illustrates a gate drive which incorporates $V_{DS(on)}$ monitoring and linear operating mode detection for the MOSFET in the case of short-circuit conditions. When the MOSFET is turned on the on-state voltage of the device ($V_{DS(on)}$) is compared with a fixed reference voltage. At turn-on, $V_{DS(on)}$ monitoring is inhibited for a period of approximately 400ns in order to allow the MOSFET to turn-on fully. After this period, if $V_{DS(on)}$ becomes greater than the reference value, the device is latched-off until the control signal is turned-off and turned-on again.

"HIGH-SIDE" SWITCH GATE DRIVES

The top transistor in a bridge-leg requires a "high-side" gate drive circuit with respect to the bridge ground. Three possible gate drive concepts are shown in figure 3 :

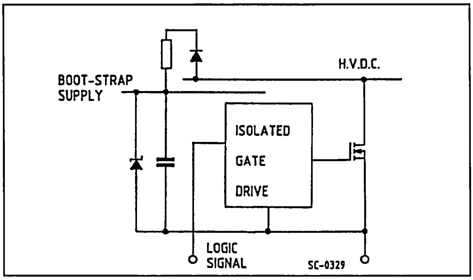
a) The "bootstrap" drive, requiring logic signal isolation, but no auxiliary floating supply.

b) The level shifting drive.

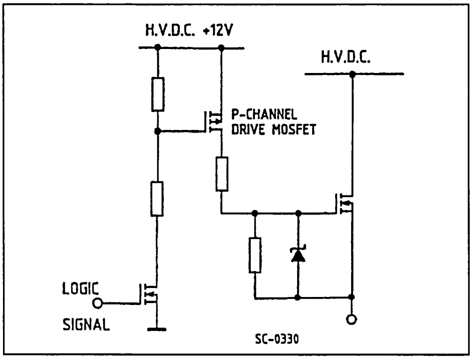
c) The floating gate drive with optically coupled isolators, pulse transformers or DC to DC chopper circuit with transformer isolation.

Figure 3 : Gate Drives for Top Transistor of Inverter Leg.

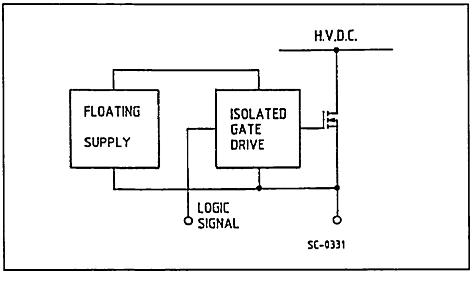
a) "Bootstrap" supply floating gate drive.



b) Level shifting gate drive.



c) Floating supply isolated gate drive.



Bootstrap supplies are particularly well suited to POWER MOSFET gate drives which require low power consumption. Figure 4 illustrates two bootstrap supply techniques. Bootstrap supplies limit transistor duty cycle since they require a minimum transistor off time during which they are refreshed.

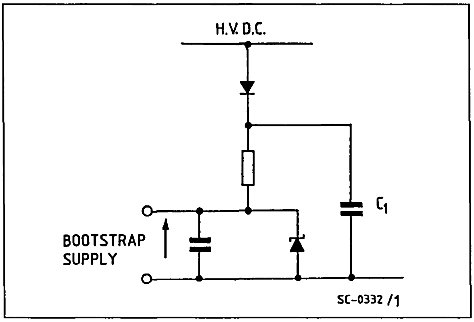
Supply efficiency and maximum duty-cycle are parameters which govern the design of the bootstrap. Figure 4a illustrates a conventional bootstrap with an additional capacitor, C1, which improves the maximum duty cycle as the supply is refreshed even during transistor on time by this capacitor. Figure 4b illustrates a high efficiency bootstrap supply which uses a small MOSFET, Q1, for regulation. In this design a low power bootstrap drives the gate of Q1.

The level shifting gate drive, (figure 3b), requires a high voltage p-channel MOSFET which drives the n-channel power device. The p-channel MOSFET is switched using a resistor divider network. No floating supplies are required. A power supply of 12V, referenced to the high voltage d.c., is used to provide positive gate source voltage for the n-channel POWER MOSFET. This circuit eliminates the need for logic signal isolation and a floating supply. The disadvantage of this circuit is the high cost of the p-channel drive MOSFET.

Figure 3c illustrates a floating gate drive with a floating supply. This drive is the most expensive out of the three shown in figure 3. However, the floating supply need only have a low output power, since MOSFETs are voltage controlled devices. The advantages of this drive are its high efficiency and unrestricted transistor duty-cycle.

Figure 4 : Bootstrap Supply Techniques.

a) Conventional bootstrap with additional capacitor C1.



b) High efficiency bootstrap.

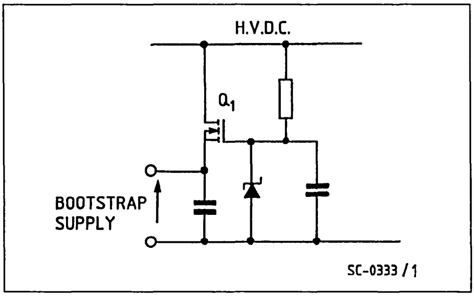
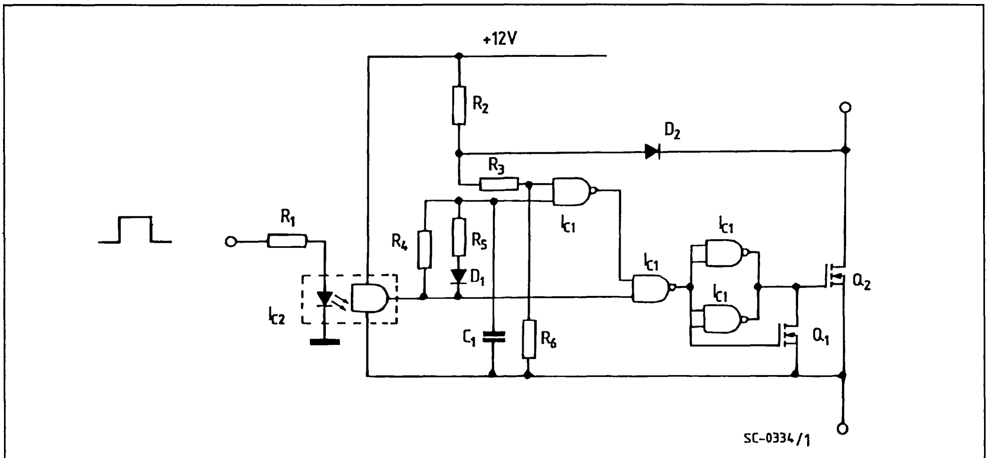


Figure 5 : Isolated CMOS Drive with V_{DS} Control for Short-circuit Protection.

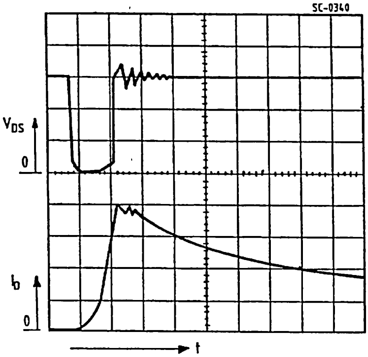


R1	= Dependent on application	R4	= 1kΩ	I_{C2}	= HCPL2200	Q1	= BSS100
R2	= 10kΩ	R5	= 120kΩ	C1	= 560pF	Q2	= SGSP477
R3	= 22kΩ	R6	= 56kΩ	D1	= 1N41448		
		I_{C1}	= HCF4093	D2	= BYT11/600		

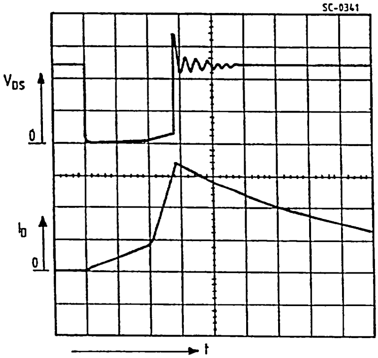
Figure 6 : Short-circuit Conditions for an SGSP477 V_{DS} & I_D.

V_{DS} : 50V/DIV
I_D : 10A/DIV
t : 2µs/DIV

a) Output to high voltage short-circuit.



b) Output to Output Short-circuit.



PROTECTION

Power electronic circuits such as bridge-legs are often required to have protection against output to output short-circuit, over-temperature, simultaneous conduction of devices in series in a bridge-leg and output to high voltage supply or ground rail short-circuit. These power stages are generally part of an expensive system such as a machine-tool or a robot motor drive. Thus the additional cost of protection circuitry is commercially acceptable. A compromise is generally reached between equipment costs and the degree of protection required.

Short-circuit protection of a power MOSFET can be achieved by either $V_{DS(on)}$ monitoring or a current sense. In the previous section gate drives using the $V_{DS(on)}$ monitoring technique were presented. Figure 6 illustrates the MOSFET drain to source voltage, V_{DS}, and the drain current, I_D, when short-circuits are experienced by the POWER MOSFET, SGSP477, driven by the gate drive illustrated in figure 5.

The MOSFET is turned-off when the drain current increases sufficiently and $V_{DS(on)}$ monitoring is inhibited for a period of 400ns to allow the device to turn-on fully.

An inductor is used in series with the device, as illustrated in figure 1b. This inductor saturates when a large short-circuit current flows. The rate of change of the short-circuit current due to the saturation of this inductor is illustrated in figure 6a and 6b. Figure 6a illustrates the POWER MOSFET drain to source voltage, V_{DS}, and the drain current, I_D, when a bridge-leg output to high voltage supply rail short-circuit occurs. Figure 6b illustrates an output to output short-circuit of two bridge-legs.

Another protection technique uses the "current mirror concept", (1). An image of drain current is obtained by having a small MOSFET, (integral or discrete), in parallel with the main power MOSFET as illustrated in figure 7.

Figure 7 : The Current Mirror.

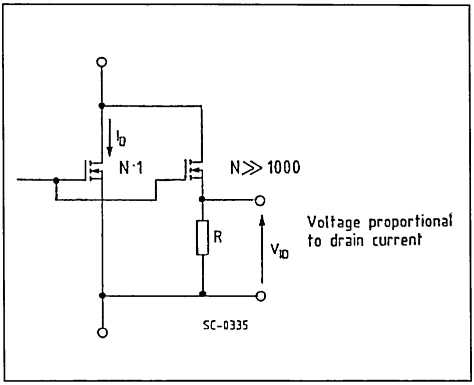
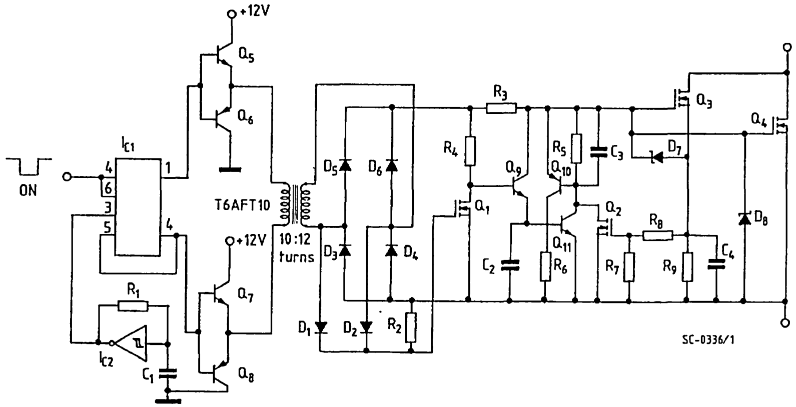


Figure 8 illustrates a floating gate drive which utilizes a pulse transformer for transmitting simultaneously the MOSFET on-signal together and the gate to source capacitance charging current. The current mirror technique is used to provide short-circuit and over-load current protection. The pulse transformer operates at an oscillating frequency of 1MHz when a turn-on control signal is present.

The secondary is rectified to provide the gate source capacitance charging voltage. The current mirror provides a voltage "image" of the main MOSFET drain current. This voltage is compared with a fixed reference voltage in order that the gate drive be latched-off when the drain current becomes in excess of a specificed value. Figure 9 illustrates how the MOSFET, SGSP477, is latched-off when the drain current exceeds 10A with this gate drive circuit.

Figure 8 : Pulse Transformer Gate Drive with Current Mirror Protection for an SGSP477.



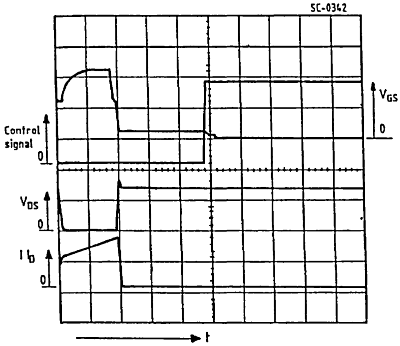
R1 = 470Ω
R2 = 1kΩ
R3 = 33Ω
R4 = 2kΩ
R5 = 100Ω
R6 = 100Ω
R7 = 100Ω
R8 =100Ω

R9 = 100Ω
C1 = 330pF
C2 = 10nF
C3 = 10nF
C4 = 220pF
D1 = 1N4148
D2 = 1N4148
D3 = 1N4148

D4 = 1N4148
D5 = 1N4148
D6 = 1N4148
D7 = BZX85C15
D8 = BZX85C15V
Q1 = ⎧ small
Q2 = ⎨ signal
Q3 = ⎩ n-channel MOSFETs

Q4 = SGS477
Q5 = BC337
Q6 = BC327
Q7 = BC337
Q8 = BC327
Q9 = BC337
Q10 = BC327
Q11 = BC337

Figure 9 : Overload Current Protection using Current Mirror Concept with the Gate Drive of Figure 8 for an SGSP477.



Time scale : 5µs/DIV – I_D : 5A/DIV – V_{DS} : 100V/DIV
Control signal : 5V/DIV – V_{GS} : 5V/DIV.

CONCLUSION

MOSFET based bridge-leg configurations requiring protection and floating gate drives have been presented. Novel self-protecting gate drives for the "high-side" and "low-side" switching have been discussed. These drives provide protection against output to high voltage d.c., output to ground and output short-circuit. For the high-side switch "bootstrap" supply gate drive, level shifting gate drive and floating supply isolated gate drives have been compared. Protection against short-circuit condition has been demonstrated using $V_{DS(on)}$ monitoring and the current mirror concept. Both techniques are well suited for protection against short-circuit conditions. However, the current mirror concept also provides a sufficiently linear image of the current for regulation.

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Current-mirror FETs cut costs and sensing losses EDN September 4 th, 1986.

USE OF INTERNAL MOSFET DIODE IN BRIDGE-LEGS FOR HIGH FREQUENCY APPLICATIONS

By C.K. PATNI - D. STEED - J.M. CHARRETON

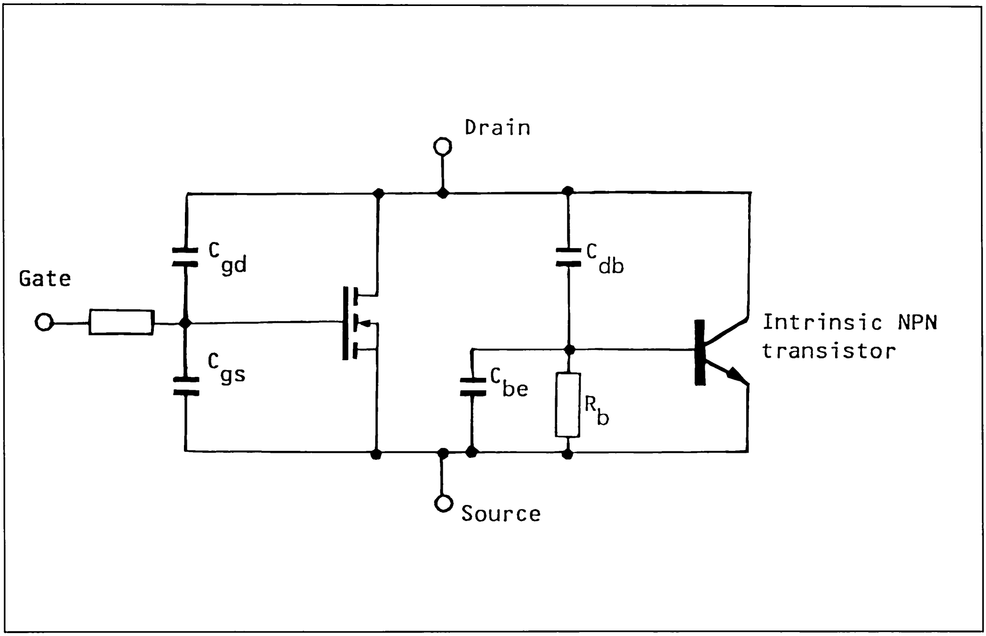
ABSTRACT

Reverse recovery of the intrinsic MOSFET diodes is investigated for the classical MOSFET and the MOSFET with minority carrier lifetime control. Turn-on losses in bridge-legs using intrinsic MOSFET diodes limit the switching frequency particularly in the case of the classical MOSFET. Adapted bridge-leg configurations are presented which enable the use of the intrinsic MOSFET diodes for the free wheeling function in inductive load switching without any appreciable reverse recovery current and MOSFET turn-on switching losses !

INTRODUCTION

The MOS field effect transistor (MOSFET) contains an intrinsic PN diode within the structure which can conduct a current from source to drain. The PN junction diode is in fact part of a parasitic NPN bipolar transistor as shown in figure 1. Free-wheeling diodes in bridge-legs are necessary when switching inductive loads. The intrinsic diode can be used to fulfil this free-wheeling function. However, the intrinsic diode of the classical MOSFET has a long reverse recovery time and "snap-off" characteristic which can cause large dV/dt. The snap-off can result in the device failing in one of two ways. Firstly, due to internal capacitances, C_{db} and C_{be}, a base current may be established which turns-on the intrinsic bipolar transistor (see figure 1)[1]. Secondly, the dV/dt may be such that the drain to source voltage of the MOSFET exceeds the blocking voltage thus causing avalanche breakdown. This paper investigates various means of limiting the maximum reverse recovery current of the intrinsic diode to ensure reliable operation. A comparison is made between the novel solutions presented permitting the use of the internal diode, and conventional solutions for using MOSFETs in bridge-legs, such as lifetime controlled MOSFETs and series blocking diodes.

Figure 1 : Equivalent Circuit for a MOS Field Effect Transistor (MOSFET).



METHODS OF LIMITING REVERSE RECOVERY CURRENT

Limiting the reverse recovery current of the intrinsic diode can be achieved by stopping current from passing through the blocked MOSFET by means of a series blocking diode or limiting the rate of change of current in the intrinsic diode. The snap-off characteristics of the internal diode can be limited by having small RC snubbers across the drain to source of MOSFETS in bridge-leg configuration. Solutions which limit the rate of change of current in the intrinsic diode are discussed below.

BRIDGE-LEG DESIGNS UTILIZING MOSFET INTRINSIC DIODES

a) SOLUTION WITH UNCOUPLED UNSATURABLE INDUCTORS

In the circuit shown in figure 2, if T1 is blocked and T2 is conducting, the load current flows through T2. As T2 turns-off the current transfers to the freewheeling diode D2, as the rate of change of current into the intrinsic MOSFET diode of T1 is limited by inductors L1 and L2. The zener voltage across Z2 causes the current to transfer from the external freewheeling diode D2 to the intrinsic MOSFET diode in T1 until D2 no longer conducts (as shown in figure 3). When T2 is turned-on subsequently the current transfers from the intrinsic diode of T1 to T2. The reverse recovery of the intrinsic diode is, however, limited by inductances L1 and L2. This can be seen clearly in figure 4. The bridge-leg can be designed (by dimensioning L1, L2 and V_Z) such that the external freewheeling and zener or transil diodes only conduct for a small fraction of the freewheeling period. Consequently, they do not have to be mounted on a heatsink. The disadvantage of using the zener is that the MOSFETs must now be rated for at least the high voltage DC rail, HVDC, plus the zener voltage.

Figure 2 : Bridge-leg with Uncoupled Unsaturable Inductors.

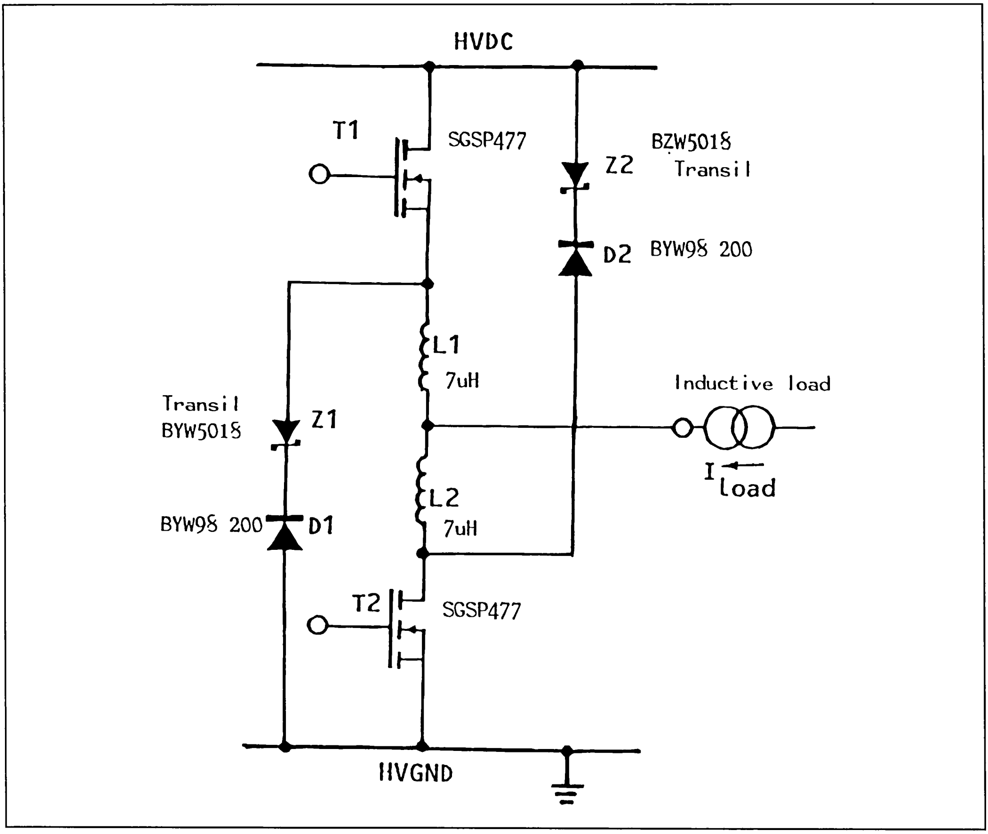
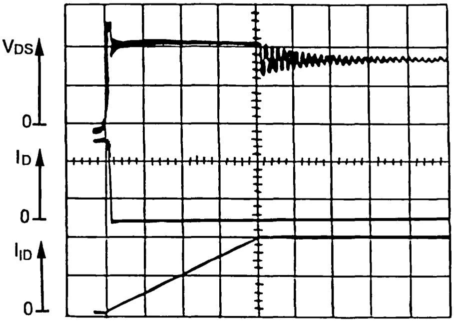


Figure 3 : Transfer of Current to Intrinsic Diode.

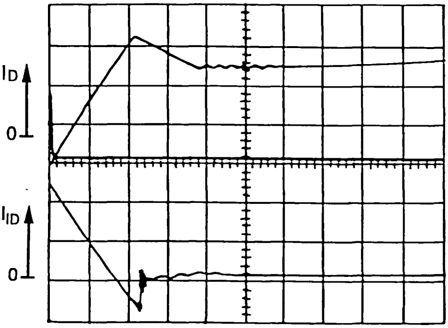


Time scale : 2µs/DIV
V_{DS} : 50V/DIV
I_D : 10A/DIV

Intrinsic
Diode : 10A/DIV
Current (I_{ID})

MOSFET : SGSP477

Figure 4 : Turn-off of the Intrinsic Diode.



Time scale : 1µs/DIV
V_{DS} : 50V/DIV
I_D : 10A/DIV

Intrinsic
Diode : 10A/DIV
Current (I_{ID})

MOSFET : SGSP477

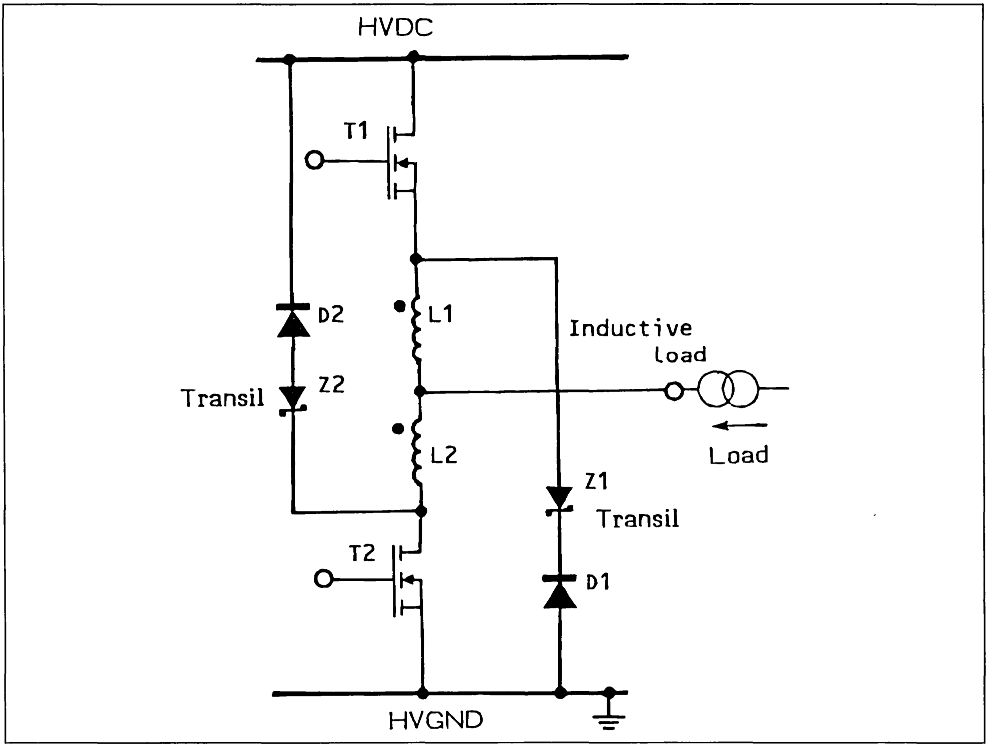
Another advantage of inductances L1 and L2 in the circuit is that they limit the build up of current during fault conditions such as simultaneous conduction of the two devices.

L1 and L2 must be chosen such that their inductances are big enough to prevent intrinsic diode reverse recovery problems hence reduce losses. They must be small enough to allow current to transfer from the freewheeling diodes D2 and D1 to the intrinsic MOSFET diodes in T1 and T2 such that the average current passing through the external diode and zener or transil is low.

b) SOLUTION WITH MUTUALLY COUPLED INDUCTORS

Inductors L1 and L2 can be mutually coupled as shown in figure 5. Coupling L1 and L2 doubles the inductance between transistors T1 and T2 (SGSP477), thus reducing the reverse recovery problem of the intrinsic diode as the rate of change of current is reduced. Coupling, therefore, saves the cost of one core and less windings are necessary to provide the same degree of protection as in the case of uncoupled inductors. The voltage and current waveforms of the MOSFETs and their intrinsic diodes for this solution are similar to that obtained with solution (a).

Figure 5 : Bridge-leg with Mutual Inductors.



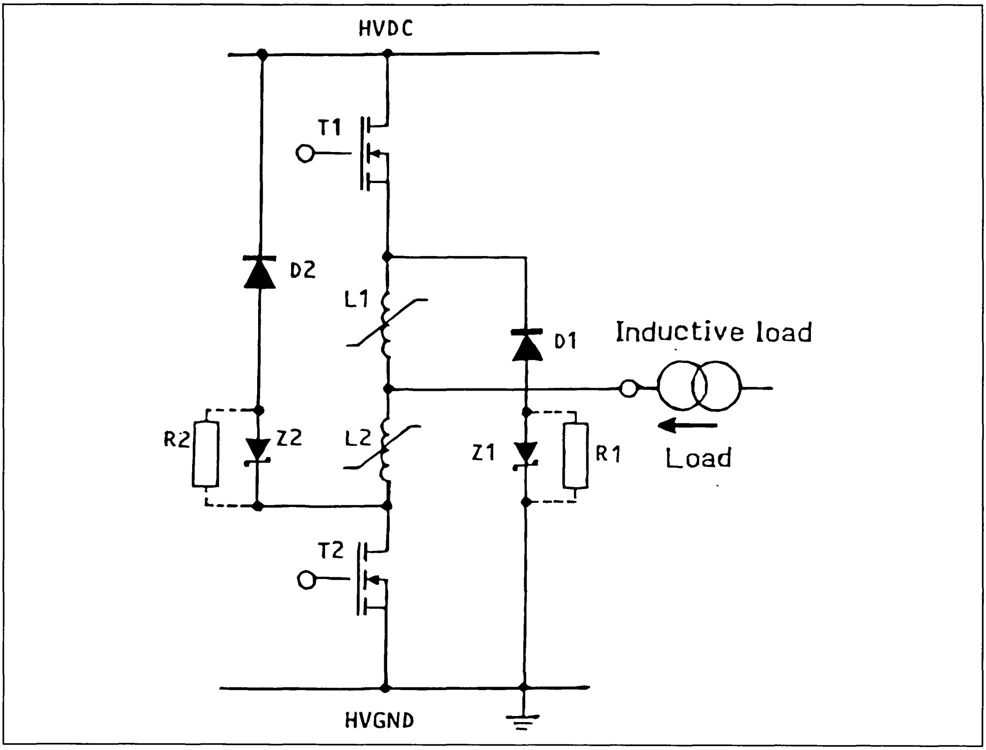
C) SOLUTION WITH SATURABLE INDUCTORS

Saturable inductors such as toroids with a few turns can be used in the bridge configuration shown in figure 6. Saturable inductors are better suited than non-saturable inductors in so much as they can be used to limit the reverse recovery of the intrinsic diode to an almost negligible level. The saturable inductor is designed to saturate after the intrinsic diode has reverse recovered. Before saturation the inductor presents a high impedance and only a low magnetising current flows.

In figure 6, it is assumed that T1 and T2 are blocked and the intrinsic diode of T1 is conducting. If T2 is now turned-on, the current in the intrinsic diode decreases rapidly since inductor L1 is saturated until this current reverses resulting in negative volts-seconds across the inductor which thus desaturates. The inductor thus presents a high impedance while the current through it is equal to or less than the magnetising current. The intrinsic MOSFET diode begins to reverse recover as the current through it becomes negative. The inductor is designed not to saturate for a period of at least 1µs, thus enabling the reverse recovery of the intrinsic diode without excessive reverse recovery current. There is a certain degree of minority carrier recombination while the inductor is unsaturated which also reduces the maximum reverse recovery current, I_{RM}. The reverse recovery of the intrinsic diode can be seen in figure 7.

While T2 is conducting the load current inductor L2 is saturated. When T2 turns-off the MOSFET current transfers to diode D2. The free-wheeling current path through the intrinsic diode of T1 has a high impedance due to L1 being unsaturated. Consequently the build-up of current through the intrinsic diode of T1 is slow until this current reaches a value equal to the magnetising current, I_{mag}, of inductor L1 which then saturates. This effect can be clearly seen in figure 8.

Figure 6 : Bridge-leg with Saturable Inductors.



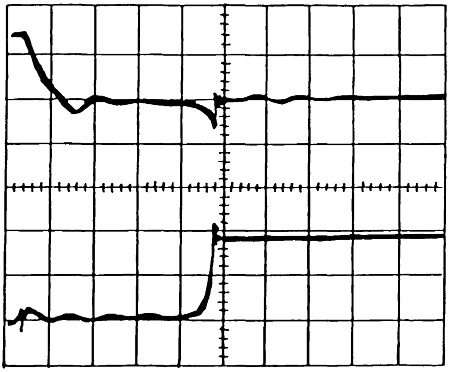
The turn-on of the MOSFET in the solution with saturable inductors (shown in figure 6) is illustrated in figure 9. It can be seen that the MOSFET losses are negligible, since the saturable inductor in series with the MOSFET that turns-on, limits the rate of rise of current while it is unsaturated. Figure 9 also illustrates that the reverse recovery of the intrinsic diode of the free wheeling MOSFET is also limited..

In the bridge-leg with saturable inductors (figure 6), if transils (Z1 and Z2) and resistors (R1 and R2) are removed, the external free-wheeling diodes have to be of high current rating as they conduct all the load current until the saturation of L1 and L2. Subsequently the external diode shares part of the free-wheeling current with the intrinsic diode. It is advantageous to reduce the current through the external free-wheel diodes D1 and D2 as rapidly as possible for the following reasons :

1. If D1 and D2 conduct for a small fraction of the maximum free-wheeling duty cycle, then their power rating is substantially reduced.
2. If the free wheeling current through the external diode D1 or D2 is reduced rapidly, the inductor in series (L1 or L2) is no longer saturated. At the consecutive turn-on of T1, L1 presents a high impedance thus performing a turn-on snubber function. Transistor turn-on losses are thus minimised particularly for inductive loads.
3. Output short-circuit protection is also enhanced if the inductors are unsaturated prior to transistor turn-on.

The current through the external free-wheeling diodes can be reduced rapidly by increasing the rate of release of inductor stored energy by transils (Z1 and Z2) and/or resistors (R1 and R2) as shown in figure 6.

Figure 7 : Reverse Recovery of Intrinsic Diode using Saturable Inductors in the Configuration of Figure 6.



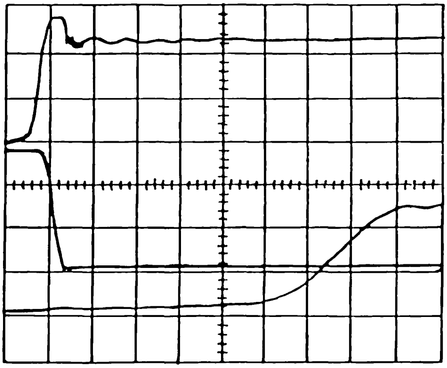
Time scale : 500ns/DIV

Intrinsic
Diode Current
I_{ID} : 10A/DIV

Voltage across
MOSFET intrinsic
diode
V_{ID} : 50V/DIV

Time scale : 500ns/DIV

Figure 8 : Transfer of Current to Intrinsic Diode using Saturable Inductors in the Configuration of Figure 6.

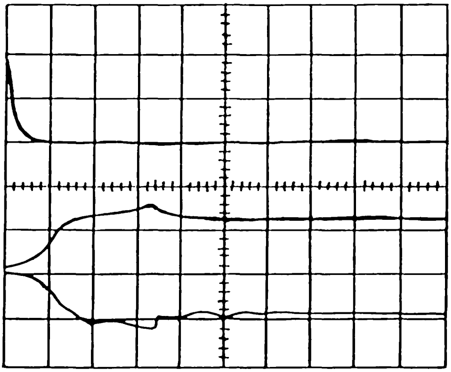


V_{DS} : 50V/DIV
I_D : 5A/DIV

Intrinsic
Diode : 5A/DIV
Current (I_{ID})

MOSFET : SGSP477

Figure 9 : Turn-on of the MOSFET in the Configuration with Saturable Inductors.
(The turn-on snubber and the intrinsic diode reverse recovery actions are illustrated).



Time scale : 500ns/DIV
V_{DS} : 50V/DIV
I_D : 10A/DIV

Intrinsic
Diode : 10A/DIV
Current (I_{ID})
MOSFET : SGSP477

Table 1 : Advantages and Disadvantages of Solutions for limiting Reverse Recovery Current in the Intrinsic MOSFET Diode.

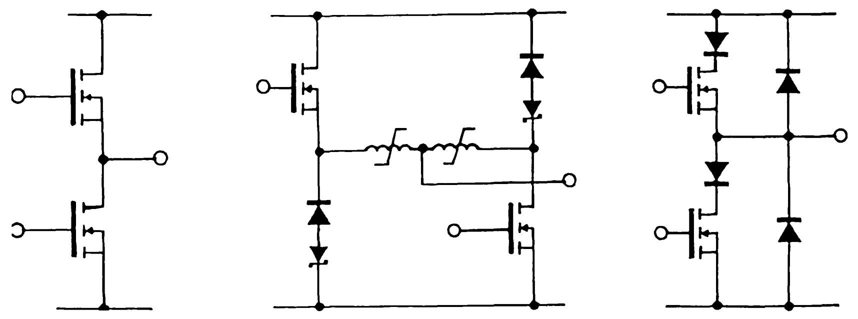
Sol.	Type of Protection Used	Advantages	Disadvantages
a)	Unsaturable Inductors	– Reduction of turn-on losses. – Controlled dI/dt at turn-on. – Controlled reverse recovery of intrinsic diode.	– In order to use low current rated freewheeling diodes, transil diodes have to be used increasing the voltage rating of the MOSFETs in the circuit.
b)	Unsaturable Mutual Inductances	– Smaller and less expensive than two inductors since only one coupled inductor. – As above.	– As above.
c)	Saturable Inductors	– Negligible turn-on losses. – Negligible intrinsic MOSFET diode reverse recovery losses. – Controlled dI/dt turn-on.	– As above.

COMPARISON OF USE OF INTRINSIC MOSFET DIODE WITH ALTERNATIVE SOLUTION

Figure 10 illustrates three bridge-leg configurations that can be used with MOSFETs when switching inductive loads. Figure 10a) illustrates a bridge-leg which uses the intrinsic diode of a classical MOSFET having a reverse recovery in the order of a microsecond. The same configuration can be used with a lifetime controlled MOSFET which has an intrinsic diode having a reverse recovery time around 250ns. An asymmetrical bridge-leg illustrated in figure 10b), is similar to the above mentioned solutions permitting the use of the intrinsic diode. The configuration illustrated in figure 10c) has series "blocking" diodes which prevent conduction of the intrinsic MOSFET diodes and thus avoid reverse recovery problems associated with the slow intrinsic diodes. In this configuration fast recovery epitaxial diodes are used as external free wheeling diodes.

Tests were performed using 500V, 0.6 ohm at 25°C classical MOSFETs (BUZ353) and lifetime controlled MOSFETs in the bridge-leg illustrated in figure 10a). Experimentally obtained losses within the diode and the MOSFET at turn-on are presented in figure 11. The solution enabling the use of the intrinsic diode without reverse recovery problems (figure 10b) has practically no losses due to reverse recovery of the intrinsic diode.

Figure 10 : Bridge-leg Configurations.



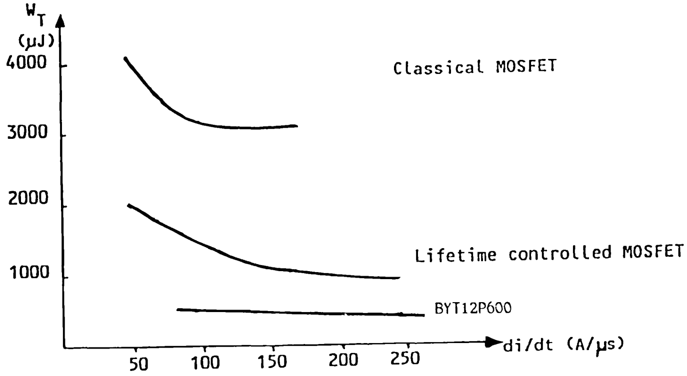
a) Bridge-leg using intrinsic MOSFET diode

b) Asymmetrical bridge-leg providing di/dt protection, turn-on snubber and limited reverse recovery problems

c) Bridge-leg with series blocking diodes and fast freewheeling diodes

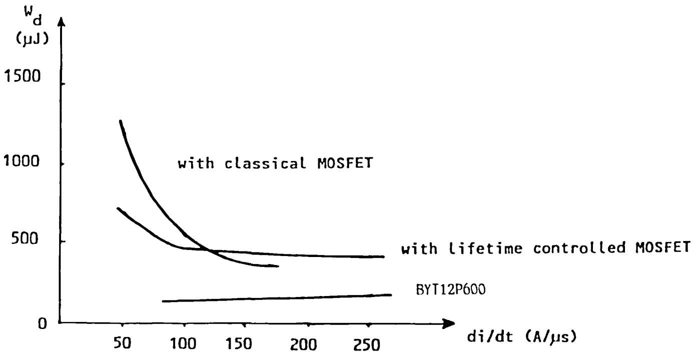
Figure 11 : Turn-on Losses in a Bridge-leg.

Turn-on Losses in the MOSFET



a) Turn-on losses in the MOSFET when switching 10A inductive load current on 400V_{DC} rail as a function of the rate of change of MOSFET drain current (dI_D/dt)

Reverse Recovery Losses in the Diode

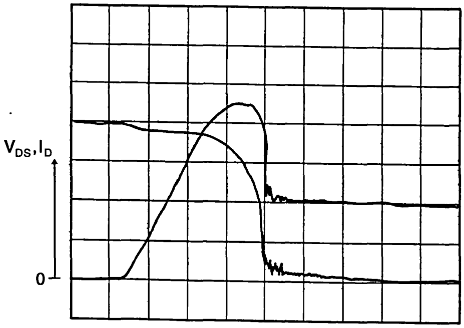


b) Reverse recovery losses in the freewheeling diode when switching 10A inductive load current on 400V_{DC} rail as a function of the rate of change of freewheeling diode current (dI_{FD}/dt) during diode turn-off.

Figure 12 : Turn-on Ilustrations of the MOSFET Drain to Source Voltage (V_{DS}) and Current (I_D) at Turn-on of the Transistor Limited to 100A/µs.

a) Classical MOSFET
(500V, 0.6 ohm)
BUZ353
Diode losses = 540µJ
MOSFET losses = 3200µJ

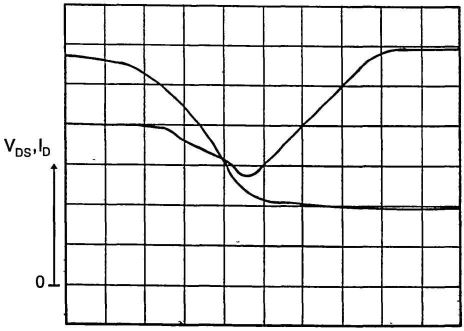
V_{DS} MOSFET drain to source voltage
100V/DIV
I_D Drain current
5A/DIV
Time 200ns/DIV



b) Lifetime controlled MOSFET
(500V, 0.6 ohm)

Diode losses = 460µJ
MOSFET losses = 1600µJ

V_{DS} 100V/DIV
I_D 5A/DIV
Time 100ns/DIV



c) External fast diode
BYT12P-600

Diode losses = 130µJ
MOSFET losses = 560µJ

V_{DS} 100V/DIV
I_D 5A/DIV
Time 50ns/DIV

It can be seen that due to the slow intrinsic diode of the classical MOSFET, turn-on losses are twice that with a lifetime controlled MOSFET. With external fast freewheeling diodes losses are only 20% of the losses in the classical MOSFET.

CONCLUSION

Reverse recovery of the intrinsic MOSFET diode has been investigated. Losses caused by slow intrinsic diode recovery for the classical MOSFET have been compared with losses using lifetime controlled MOSFETs in a bridge-leg and losses using fast external freewheeling diodes. It has been shown that turn-on losses in a bridge-leg using classical MOSFETs are five times greater than losses in bridge-legs with fast external freewheeling diodes and two times greater than losses in bridge-legs using lifetime controlled MOSFETs.

By using different types of inductors (such as saturable inductors) in bridge-legs it has been shown that negligible turn-on losses can be achieved as reverse recovery of the intrinsic MOS FET diode can be limited. Practical results confirm that by using saturable inductors astutely in bridge-legs, it is possible to use the intrinsic diode of the classical MOSFET in high frequency inductive load switching applications with negligible turn-on losses.

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"Optimisation of VDMOS power transistors for minimum on-state resistance", IEE Proceeding, vol. 134, PT.1, No. 3, June 1987.

SGS-THOMSON
MICROELECTRONICS

APPLICATION NOTE

ENVIRONMENT DESIGN RULES OF MOSFETs IN MEDIUM POWER APPLICATIONS

BY B. MAURICE

ABSTRACT

The use of POWER MOSFETs, allows high switching speed in power applications above 10kW. Nevertheless the main limitations come from the characteristics of the circuit design. From a practical example, this paper analyses and proposes solutions to adapt the POWER MOSFET and the layout in order to minimize parasistic inductances. Special emphasis is given to the driver circuit, package, wiring rules and voltage spike protection at turn-off.

I - INTRODUCTION

POWER MOSFETs are now considered standard tools by circuit designers working at tens of Amps and hundreds of Volts. Their traditional advantages (easy drive and over current capability) remain true when switching over 10KWatts. Nevertheless, the main limitations encountered are not from the MOSFET itself as it can switch high current at high speed (over 1000Amps/sec), but from characteristics of the circuit design. After presentation of a specific example of Power MOSFETs drive, the optimisation of the power devices and the layout will be analysed in the practical example of a chopper operating with an ISOFET (1000V - 0.7Ω or 100V - 0.014Ω). Finally, an over-voltage protection circuit is presented.

II - HIGH POWER MOS DRIVE

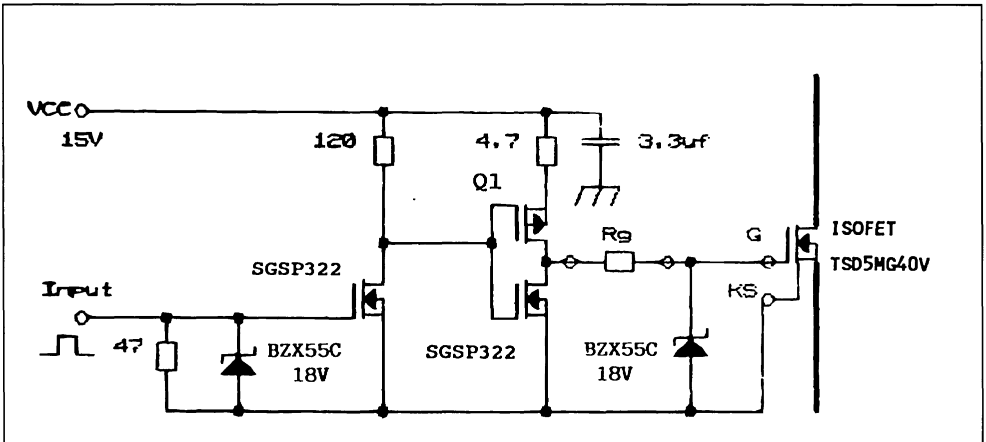
Even with high power switching (over 10KW), the driver circuit can be very simple (fig. 1), comparable to the ones used for low power circuits.

The major characteristic of a POWER MOSFET is its high input capacitance (ie : $C_{iss} \approx 12$nF for 100V - 14mΩ MOSFET) which must be rapidly charged and discharged when switching without creating oscillations.

The following rules have been used for the design of the driver :

- A low dynamic internal impedance which permits a peak current greater than 1Amp for 300nanosec to charge and discharge the ISOFET input capacitance.
- A low impedance circuit reduces the sensitivity to dV_{DS}/dt at turn-off of the ISOFET.
- The total resistance of the gate circuit must be greater than 5Ω in order to sufficiently damp the circuit preventing oscillations and possible parasitic turn-on of the ISOFET.

Figure 1 : Driving Circuit for ISOFET Over 10kW Switching.



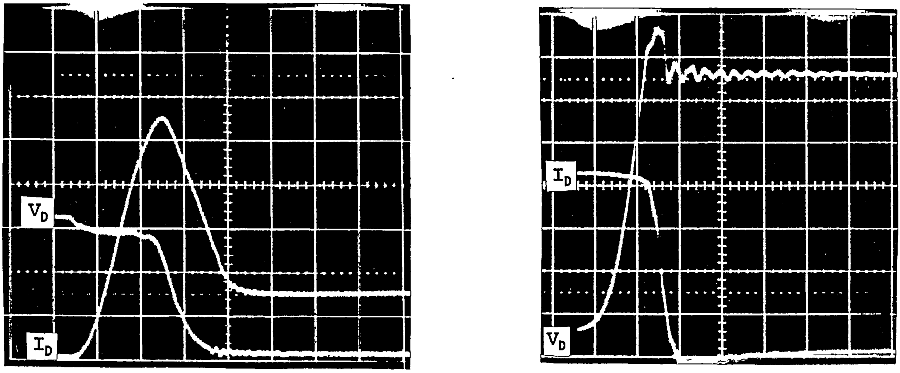
Q_i = 100V 0.4Ω P-channel MOSFET

- The links between drive and gate, short and non-inductive, are made between the gate pin and the "Kelvin Source" pin. The use of the "Kelvin Source" pin is very important when driving Power MOSFETs. It avoids parasitic effects caused by dI/dt in the source lead.
- The gate protection Zener diode has to be mounted close to the ISOFET package.

Figure 2 : Over Current Capability and Switching Speed with ISOFET TSD5MG40 (1000V – 0.7Ω – I_D = 13A).

a. Turn-on ; the ISOFET controls 30A-650V and sustains 110A peak (8 x I_D). The over current is due to the recovery of the free-wheeling diode (BYT230PIV 1000).

b. Turn-off ; with dI/dt = 1600A/µsec ; and dV/dt = 15000V/µsec. The switched power = 25kW ; and the switching losses = 1.3mj



a. Turn-on

V_D = 200V/div

I_D = 20A/div

t = 50ns/div.

R_g = 5Ω

b. Turn-off

V_D = 100V/div

I_D = 10A/div

III - LAYOUT DESIGN FOR HIGH SPEED SWITCHING

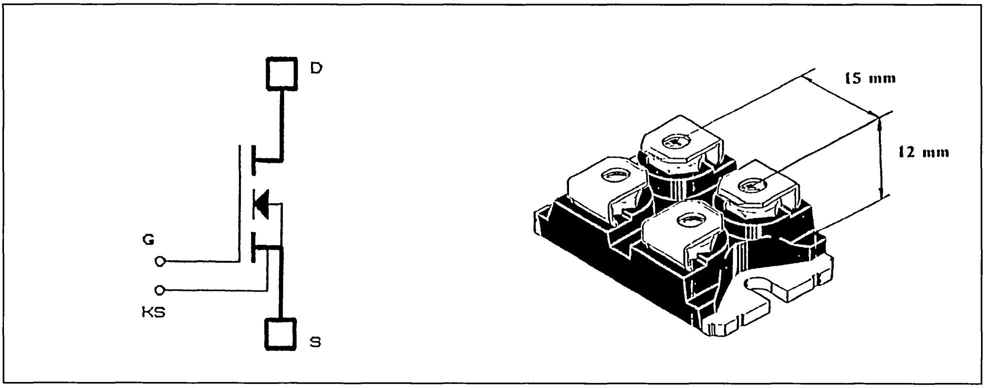
The reduction of the parasitic inductances is a major challenge for power switching especially with a power MOSFET switching over 1000Amps/usec (figure 2). With this switching leading edge, a 10cm diameter wiring loop causes a 100V voltage overshoot. To solve this potential problem two actions are necessary : choosing a well adapted device and optimising the layout design.

a. Adapting the device to the layout

ISOFET is a MOSFET housed in an ISOTOP package (figure 3) :

- The ISOTOP package can be directly screwed on to the printboard because all its terminals are at the same level. Therefore all inductances due to the length of external wiring connexions are eliminated.
- As a result of the low profile of the package (12mm), the internal parasitic inductance is less than 10nH. Moreover, its Kelvin source (KS) ensures a minimum of disturbance induced by the power circuit in the driver circuit.
- Even though it has a thermal resistance value of only 0.25°C/W, the case is fully internally insulated at 2.5kV_{RMS}. Therefore it can be mounted near to the diode package on a common heatsink in order to obtain a very compact circuit layout.

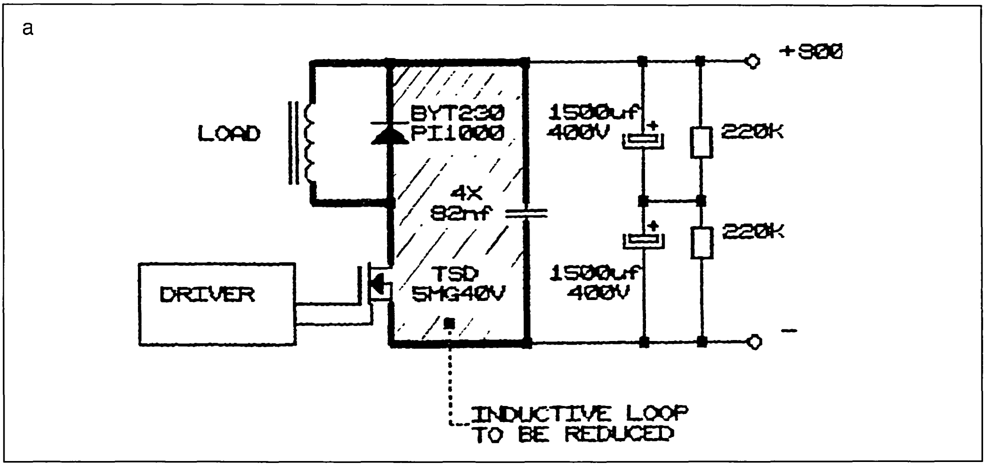
Figure 3 : An ISOFET is a MOSFET housed in an ISOTOP package, which has a low profile.
It is easily integrated in low inductive layouts.
The "Kelvin Source" lead (KS) separates the gate circuit from the internal inductance of the source connection.

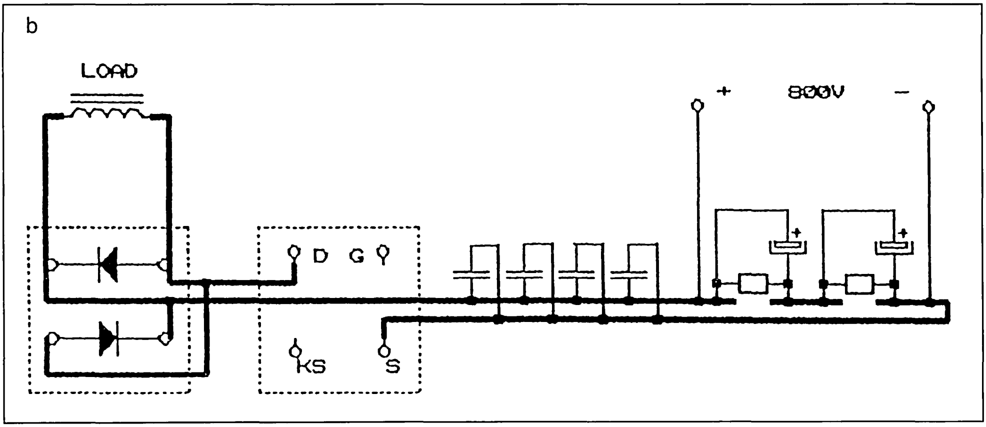


b. Design of the layout

The chopper shown in figure 4 contains two active components : the Power MOSFETs and the freewheeling diode ; both in ISOTOP package screwed side by side, on a common heatsink and directly connected on the printed circuit board (PCB).

Figure 4 : a. Chopper Schematic showing the Inductive Loop to be Reduced.
b. The Same Circuit with two ISOTOP Packages (diode and ISOFET). The packages and links adopt an "in line" configuration in order to reduce the inductive loop.





By observation of the facts presented in appendix 1, the design rules used for the layout are summarized :

- Use of double sided PCB where each high current path is immediately above its returns path on the other side of the board.
- The current densigy has been reduced by enlarging the copper tracks in order to decrease the local dI/dt and consequently the resulting induced voltage.
- Use of several links instead of one, between two large copper tracks, avoids high current concentrations and reduces the inductance (figure 5).
- Decoupling capacitors have been configured in the same direction as the direction of current flow. This prevents the formation of an inductive loop. (compare figure 6a and figure 6b hatched surfaces).
- The use of several smaller capacitors in parallel permits reduction of the equivalent internal parasitic inductance. (figure 6c).
- Choose components (e.g. capacitors) specified with a low internal inductance. (electrolytic capacitor 700µF/400V can have a parasitic inductance of several tens of nH). Prefer the capacitor packages which minimize the inductive connection length.

Figure 5 : Junction between two wide copper tracks is less inductive when several spaced links are used rather then a single link.

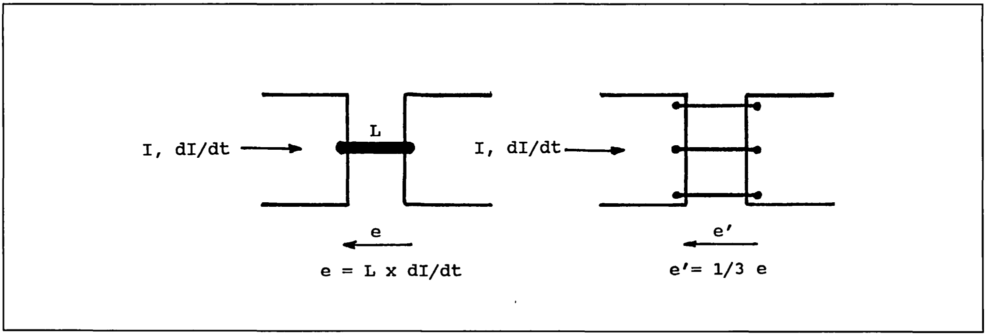
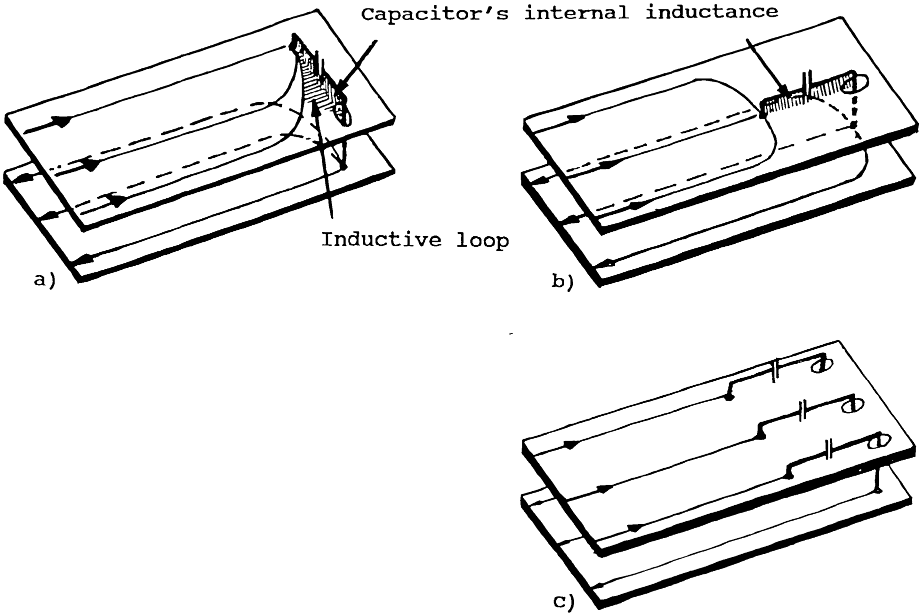


Figure 6 : Configuration of Decoupling Capacitors :

a. An inductive loop is formed, perpendicular to the current flow, because the current flow is not superimposed near the capacitor,

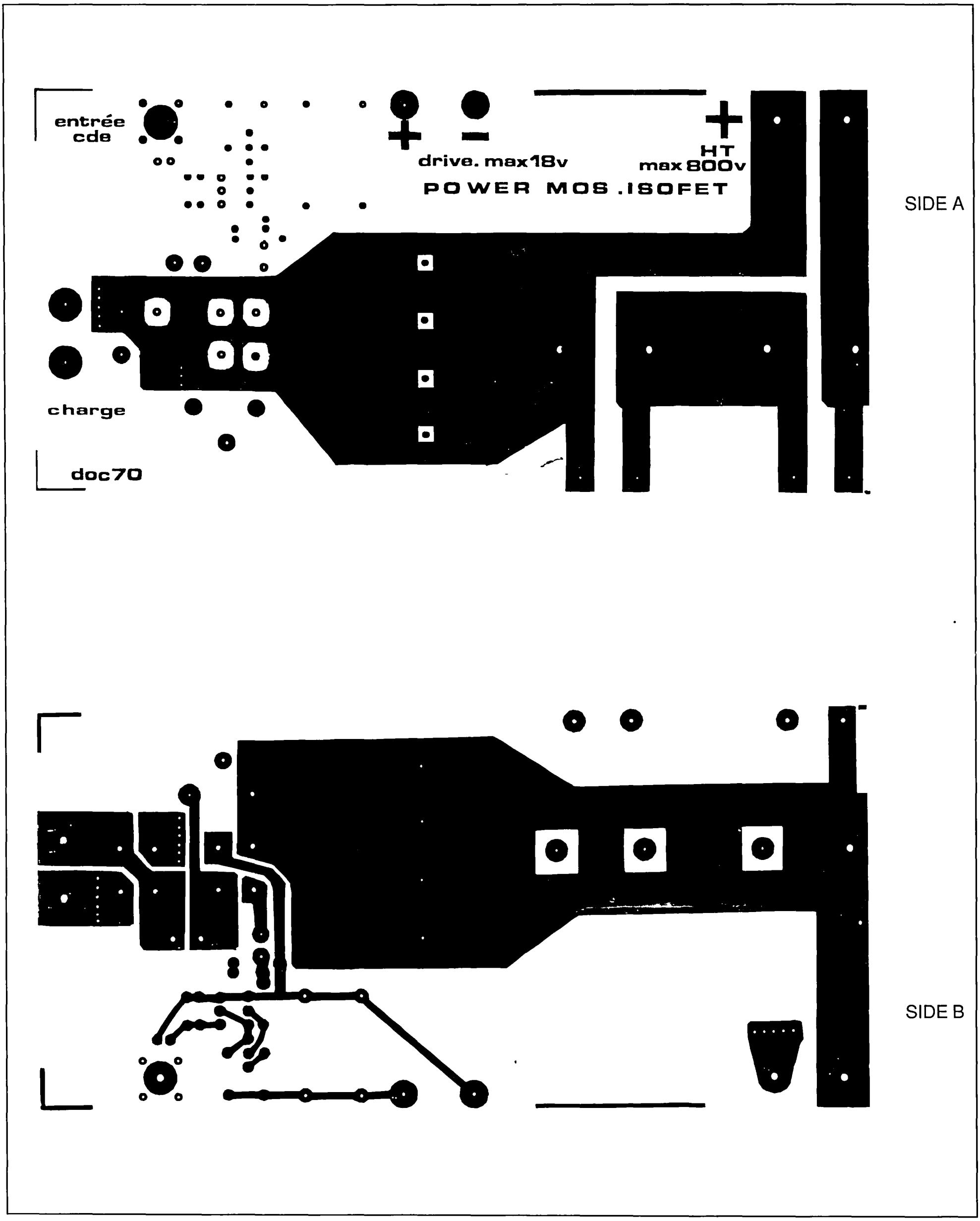
b. Capacitor lying in the same direction as the direction of current flow. inductive loop minimised.

c. Several smaller capacitors in parallel reduce their equivalent internal parasitic inductance for the optimum solution.



As a result the residual inductance of the finished layout (fig. 7) has been measured as 35nH, (fig. 8) plus 15nH when a current sensing loop (15mm^2) is added to the layout.

Figure 7 : A Double Side Very Low Inductive Print Circuit Board. (scale : 0.5)
Note the Multi Links (A) to connect One Side to the Other.



IV - OVERVOLTAGE DURING TURN OFF

We have previously seen that by following these sound rules a parasitic inductance value of 35nH can be achieved. It represents the sum of several small components : active components, passive components and PCB. It seems difficult to reduce it further in a circuit without paralleling several power switches.

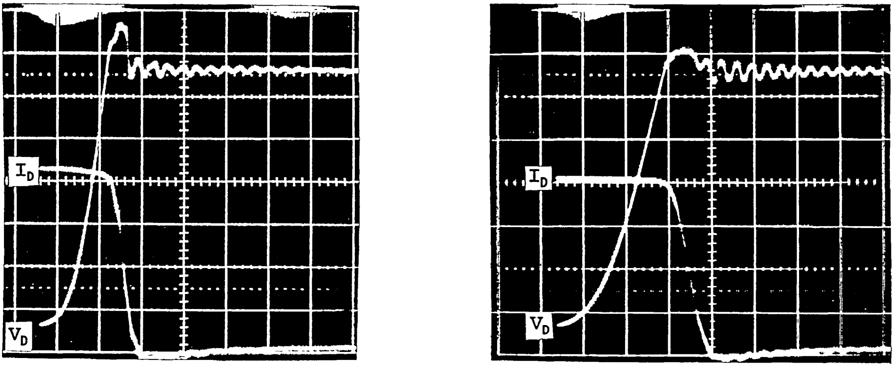
In view of the ISOFET fast switching speed at turn-off (1000Amp/usec), the inductive voltage spike with 35nH will be 35 Volts. This overvoltage is acceptable for devices rated over 500V. It is not negligeable in low voltage applications such as battery powered equipment.

Two solutions are possible :

a. Slowing down the ISOFET

The switching speed at turn-off can be slowed down by increasing the gate resistor value. This method increases the commutating time and consequently the switching losses. These losses are increased by 50% when R_g increases fro 5 to 10Ω. (figure 8).

Figure 8 : Increased Gate Resistor reduces dI/dt and Overvoltage at Turn-off. (driver circuit fig. 1). The total parasitic inductive loop (50nH) includes the inductance of the sense current loop.
I_D = 10A/div V_D = 100V/div t = 50ns/div (ISOFET TSD5MG40V 1000V – 0.7Ω)
Switched power = 25kW ; Switching losses = 1.3mJ in (a) and 2.0mJ in (b).



b. Protection against over-voltage at turn-off

Use of a MOSFET with a low margin for the rating voltage ($V_{BR(DSS)}$) can be achieved by using active protection (i.e. Transil) in order to clamp the voltage spikes.

One solution is to connect a Transil across the drain-source leads. In this case, the energy is dissipated in the Transil which has to be cooled in order to dissipate the average power.
(1/2 LI^2f = 20W with 40nH, 100A, 100kHz)

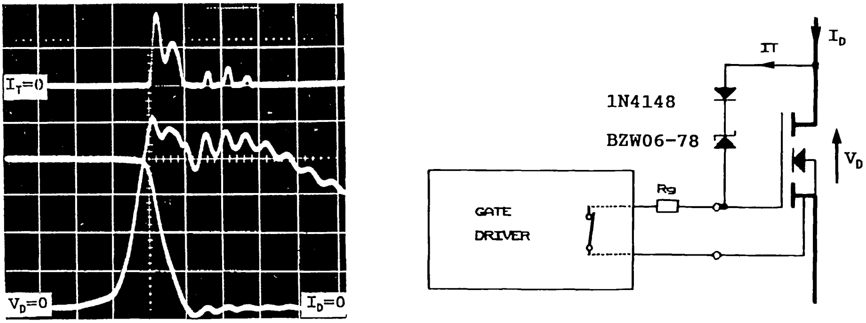
We have chosen another solution by connecting the Transil across the drain-gate leads (figure 9). When the over voltage transient reaches the clamping voltage, the clamping current goes through the gate resistance and biases gate above 5V. (ex : 1A into 5Ω).

This way, the clamping power is dissipated in the MOSFET and a smaller Transil is required ($P \approx 1W$ at 100kHz in our case).

As the Transil does not heat up, the clamping voltage does not vary with temperature. The equivalent dynamic resistance is very low because the serial resistance of the Transil is divided by R_g and by the MOSFET transconductance.

The current though the Transil being low, the voltage to be considered for its choice is the breakdown voltage at test level (V_{BR} at I_R) instead of the surge clamping voltage (V_{CL}). The Transil breakdown voltage should be chosen to be lower than the maximum desired clamping voltage less 5 Volts to take into account the MOSFET gate threshold voltage.

Figure 9 : Over Voltage clamping by a Transil across the Drain-gate Leads durring turn-off. (ISOFET TSD4M150V 100V – 14mΩ). Upper Trace shows the Current in the Transil (IT).
I_D = 20A/div, V_D = 20V/div, I_T = 1A/div, t = 100ns/div.



V - CONCLUSION

MOSFETs switching power over 10kW have the same basic advantages as lower power Mosfet. The driving circuit remains very simple and the over current capability is huge. A specific emphasis has been placed on the minimization of circuit layout inductance. Because of the very fast switching (easily over 1000A/s) it is advantageous to use :

packages like ISOFET which minimise their internal inductance and allow easy connection to printed circuit board and to heatsink. Also Kelvin Source contact to minimise drive circuit interference.

- double side printed circuit board with symmetrical copper tracks, reduced current concentration, and components positioned in order to minimise parasitic inductance.
- overvoltage protection which avoids oversizing the voltage rating of MOSFETs in low voltage applications.

BIBLIOGRAPHY

[1] An Innovative High Frequency High Current Transistor Chopper. L. PERIER ; E.P.E. Bruxelles 1985.

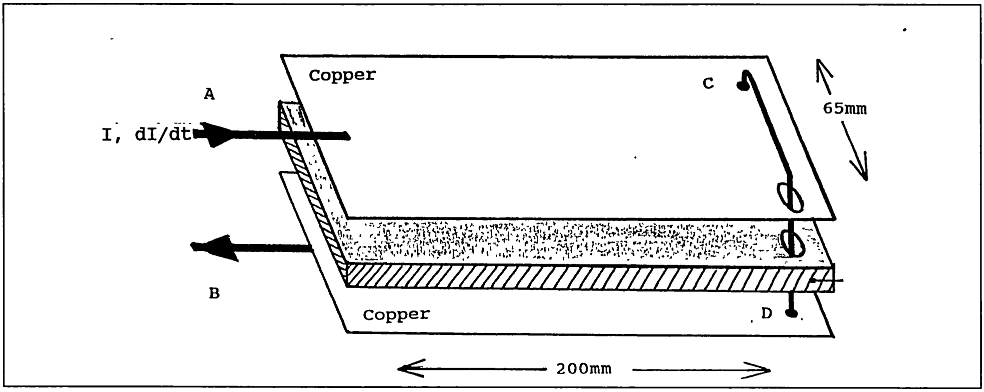
[2] POWER MOS DEVICES Data Book 1st edition June 1988 SGS-THOMSON Microelectronics.

APPENDIX 1

MEASUREMENT OF PARASITIC INDUCTANCES ON A DOUBLE SIDED PCB

- In the figure below, the link between points C and D simulates the connection of a capacitor with no internal inductance, connected on double sided Printed Circuit Board.

Figure 10.

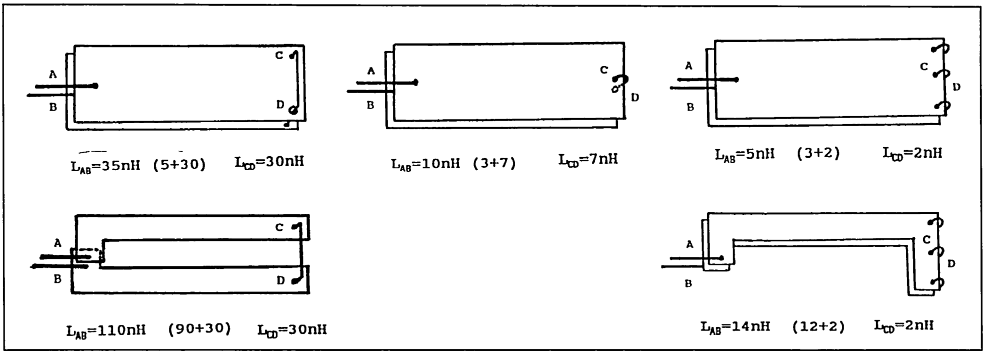


- The measurements are made with a dI/dt generator :
- I = 0 to 40Amps with a dI/dt = 1000A/s

The measurement of the induction voltage VL between A to B, and C to D, permits calculation of $L = V_L / (dI/dt)$

MEASUREMENT RESULTS

Figure 11.



MEASUREMENT CONCLUSIONS

- Capacitors should be positioned in the same direction as direction of current flow.
  Compare : a. to b.
- Several links between two large copper tracks are less inductive than a single link.
  Compare : b. to c.
- Every current path should be exactly above its return path on the other side of the board.
  Compare : d. to e.
- Decrease local dI/dt density by enlarging copper tracks.
  Compare : c. to e.

SGS-THOMSON
MICROELECTRONICS

APPLICATION NOTE

COMPACT HIGH PERFORMANCE BRUSH D.C. MOTOR SERVO DRIVES USING MOSFETS

By C.K. PATNI

ABSTRACT

For medium power (200VA to 6kVA) brush D.C. motor servo drives, MOS field effect transistors (MOSFET) are ideally suited. A compact high performance (20 to 50kHz) 1.2kVA brush D.C. motor velocity servo drive, which has been developed and tested, is presented. SGSP477 and BYW8PI200 high efficiency fast recovery epitaxial diode (FRED) are used in the 1.2kVA power stage. A 6kVA motor drive design using ISOFETs is also presented.

TSD4M250 (ISOFET) and BYV54V200 FRED diodes are utilized in the 6kVA design in which FREDs are used as the MOSFET series blocking diode and the freewheel diode. Different power H-bridge configurations are chosen and justified for the 1.2 and 6kVA drives. Particular emphasis is placed on short-circuit protection techniques and simple gate drives.

INTRODUCTION

Brush D.C. permanent magnet motors are extensively used as velocity servo drives for high performance applications such as robotics and machine-tools. The high voltage D.C. (HVDC) supply of the power stage for such motors rated up to 6kVA is generally limited to 200V D.C. because of sparking of the commutator and brush assembly.

The commutator has a maximum volts per segment rating at rated power above which there is excessive brush wear. MOSFETs are well adapted for medium power applications at voltages up to 500V. Consequently the ease of paralleling, high peak current capability and the ease with which MOSFETs can be controlled and protected make them ideal power semiconductor switching devices for such motor drives. Medium power brush D.C. motor voltage limitation of 200V D. C. enables fast recovery epitaxial diodes (FRED) to be used which have high efficiency due to very low conduction losses and negligible switching losses :

BYW81PI-200 : FRED :
$V_f < 0.85V$ ($I_F = 12A$; $T_j = 100°C$)
$t_{rr} < 35ns$

Block diagram schemes for brush D.C. permanent magnet velocity servo drives are discussed. Servo drive specifications shown in table 1 are considered and solutions for the 1.2kVA and 6kVA motor drives are presented. The 1.2kVA motor drive is developed and tested. Protection, efficiency and switching frequency requirements have strongly influenced the designs.

Other than the power ratings, the parameters listed in the specification are common for many high performance servo drives. The main component in the design of the hardware is the power H-bridge switching ideally above the audio-frequency range. High frequency switching permits a compact power output filter to be used to filter the switching frequency if so desired.

SWITCH-MODE MOTOR DRIVE CONCEPTS

Figure 1 illustrates a conventional pulse width modulated (PWM) D.C. motor servo drive. The velocity demand and the tachogenerator feedback signals are compared and the resultant velocity error is amplified. This error is fed to the current servo amplifier where it is compared with the actual current flowing in the motor armature. The amplified current error is fed into a linear PWM generator. The control of the mark to space ratio of the PWM generator is achieved by comparing the input error signal with a constant frequency triangular waveform. This results in a fixed frequency PWM signal which is fed to the power stage.

A switch-mode drive designed to the specification in table 1 comprises of :

1/ Drive and protection for power devices
2/ Power supplies
3/ Regenerative energy clamp (4 quadrant control)
4/ Current loop
5/ Control and logic for PWM and velocity servo.

The block diagram of the drive which has been developed is outlined in figure 2. (The complete circuit diagram is provided in figure 14). The differences between the two schemes outlined in figures 1 and 2 are that the current control loop and the PWM integrated circuit are eliminated in the second scheme. In the second scheme the velocity error is fed directly into a velocity compensation and modulation circuit. The elimination of the current feedback loop limits this scheme in so much as it can not be used in torque control applications.

Table 1 : Typical Brush D.C. Servo Drive Specification.

Specification	1.2kVA	6.0kVA
Modulation Frequency	> 20kHz < 50kHz	
Continuous Power	1300VA	6000VA
Maximum Continuous Current	10A	50A
Bus Voltage Input	$120V_{DC}$	
Efficiency	> 90%	
Short to Ground	Shut down	
Short to Bus Voltage	Shut down	
Armature Short	Shut down	
Operating Temperature	0 to 50°C	
Velocity Demand	10V	
Regenerative Energy Dissipation	10% of Continuous Rating	

Figure 1 : PWM D.C. Servo Drive.

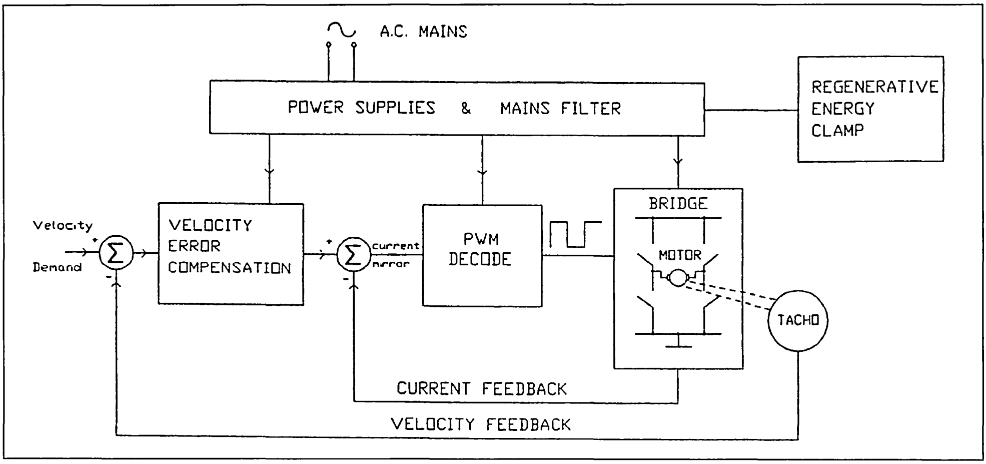
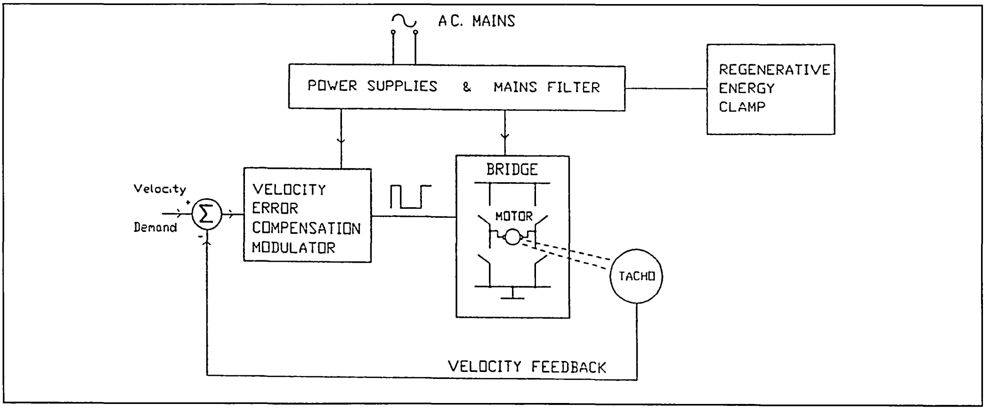


Figure 2 : Schematic Diagram of Brush D.C.P.M. Motor Drive.



BRIDGE CONFIGURATIONS & MODULATION TECHNIQUES

The bridge design must be capable of supplying bidirectional current to the motor for optimal four quadrant control. This can be achieved by using a "T-bridge" or an "H-bridge", as shown in figure 3. The H-bridge is generally chosen since it requires a single power supply. The voltage rating of the power semiconductor devices matches the motor voltage rating for the H-bridge alternative.

The H-bridge has eight operating modes when connected to a D.C. motor load. These modes can be seen in figure 4. Two of the modes increase current supplied to the motor winding in either direction. The other six operating modes reduce current in the motor winding and are commonly known as freewheeling modes. Numerous switching modes are possible for PWM and current control. For example, it is possible to PWM both the top and bottom devices in the bridge or simply either the top or bottom device. It is possible to use the PWM mark to space ratio such that the mark provides a positive rate of change of current in the motor winding and the space provides a negative rate of change of current. The control of the pulse width thus establishes an adjustable average voltage across the motor load.

A modulation technique used in the developed servo drive is illustrated in figure 5. This modulator is based on "delta modulation" (reference 1). The mark to space ratio of the modulator output (0(t)), determines the conduction period of the MOSFETs in the H-bridge. The modulator comprises of the standard delta modulator (part A), the proportional term (part B) and the integral term (part C) of the PID controller.

Figure 3 : Bridge Configurations.

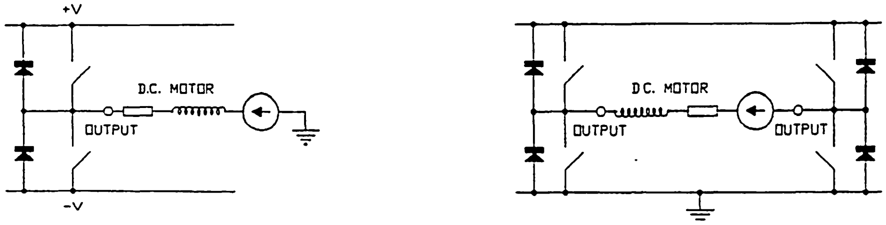


Figure 4 : Operating Modes of the H-bridge Showing Current Flow Paths.

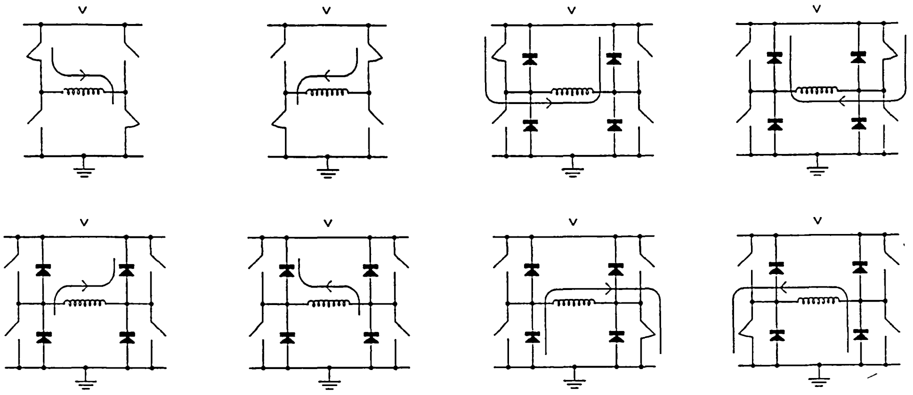
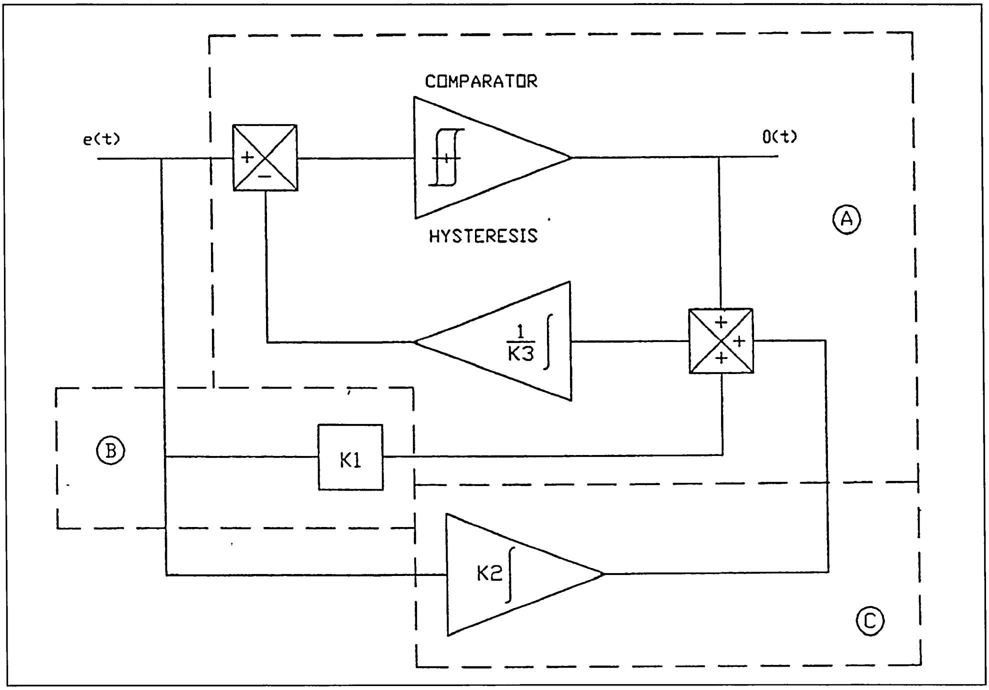


Figure 5 : A PID Controller with Binary Output.



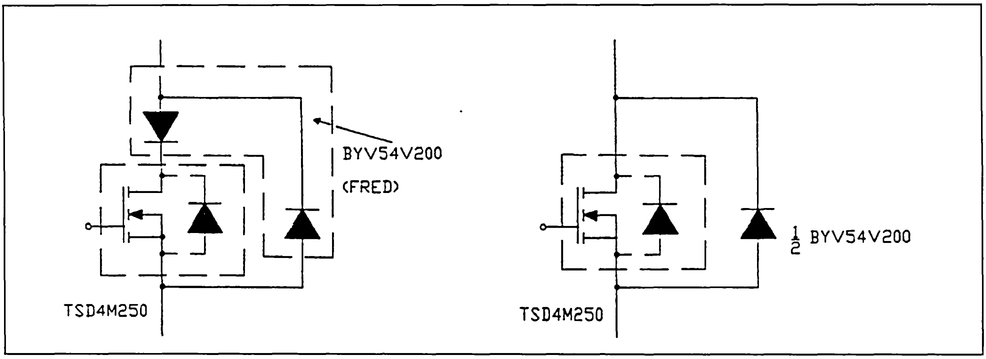
SWITCHING DEVICES FOR A RANGE OF D.C. MOTOR SERVO DRIVES

At medium power levels the MOSFET is ideally suited offering high switching speed, ease of paralleling and simple gate drive and protection. SGS-Thomson has introduced a range of MOSFET devices in plastic isolated packages. The 200V devices, summarised in table 2, can be used to design a servo drive range from 600VA to 6kVA without the need to parallel MOSFETs in separate plastic packages.

The MOSFET internal parasitic diode is too slow for applications requiring ultrasonic switching frequencies. Excessive switching losses in the MOSFET can result from the reverse recovery time of the internal parasitic diode (greater than 600ns). Noise is also induced on the supply rails when the conducting diodes reverse recover. Table 2 specifies high efficiency ultra fast recovery epitaxial diodes for freewheeling. These diodes, having a conduction voltage of less than 0.85V at rated nominal current, are ideally suited as MOSFET series blocking diodes used to prevent the conduction of the internal parasitic diode.

Figure 6 illustrates possible techniques for utilizing fast external diodes for the 6kVA brush D.C. motor design.

Figure 6 : 6kVA MOSFET Switch Configurations Using ISOFETs and FREDs.



Manufacture : SGS - THOMSON							Basic Brush D. C. Motor Drive Spec. Switching Freq. > 20kHz		
Part N° MOSFET	$R_{DS(ON)}$ $T_j = 25°C$ (Ω)	I_D $T_c = 100°C$ (A)	R_{TH} (°C/W)	Part N° Diode FRED	V_F at $T_j = 100°C$ (V)	I_F (A)	POWER (VA)	V_{nom} (V)	I_{nom} (A)
SGSP367[1]	0.45	10	1	BYW80PI200	0.85	7	600	120	5
SGSP477[1]	0.17	20	0.83	BYW81PI200	0.85	12	1200	120	10
TSD4M250[2]	0.021	68	0.25	BYV54V200	0.85	50	6000	120	50

Table 2 A range of brush D. C. motor velocity servo drives.

[1] - without insulation.

[2] - ISOFET : MOSFET chips in parallel in ISOTOP package.

1.2.KVA BRUSH D.C. SERVO DRIVE

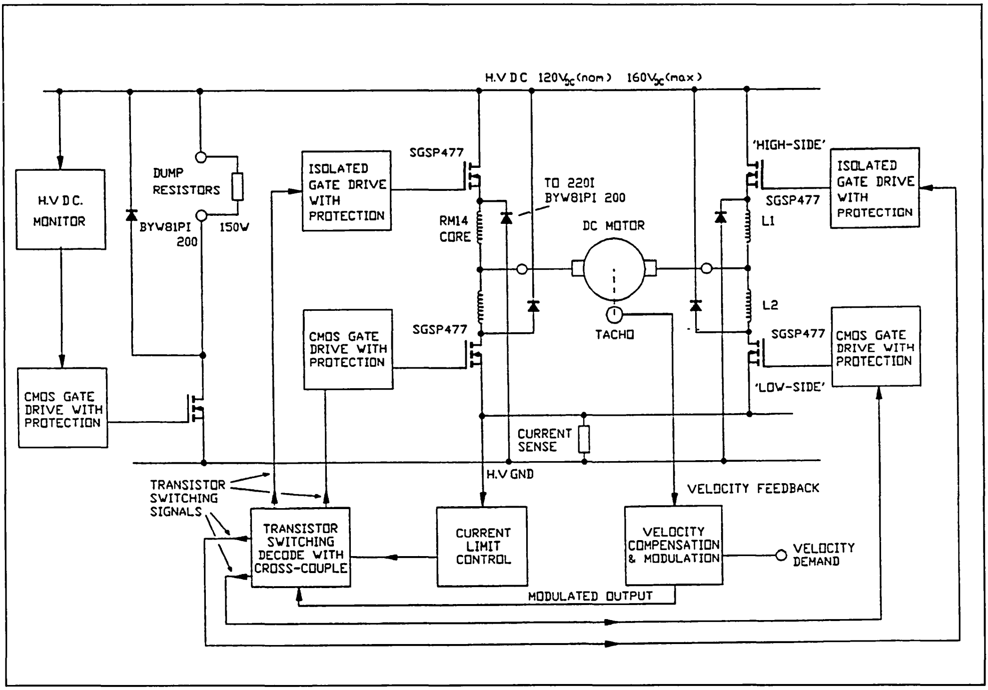
Figure 7 illustrates the block diagram of the developed 1.2kVA brush D.C. servo drive. The H-bridge operates at a nominal voltage of 120V_{DC}. The D.C. motor in certain applications is driven by its load and hence is a generator of energy. This regenerative energy causes the HVDC rail voltage to increase as energy is stored in the smoothing capacitors.

At a maximum voltage of 160V_{DC}, a resistive dump is turned-on to dissipate the regenerative energy and thus limit the HVDC to 160V_{DC}. The drive utilizes the velocity PID controller illustrated previously in figure 5. A current sense resistor is incorporated in the H-bridge to provide load current feedback necessary to limit this load current to the maximum continuous current rating of the drive.

MOSFET based bridge-leg configurations have previously been discussed (reference 2). The bridge-leg utilized comprises of "low-side" and "high-side" switches connected in series across the HVDC. In this asymetrical bridge-leg, (illustrated in figure 7), the rate of change of short-circuit current is limited by inductors (L1 and L2 : RM14 cores) which also limit freewheeling current from going through the parasitic diodes of the MOSFETs. At the 10A maximum continuous current rating of the drive, these inductors are still a manageable size. This bridge-leg configuration is capable of withstanding simultaneous conduction of the two devices in the bridge-leg since there are series inductors which reduce the rate of change of drain current. This provides sufficient time for the short-circuit detection loop to operate. The power devices are thus turned-off without being stressed with high rates of change of pulse currents.

At a maximum continuous current rating of 10A, SGSP477 MOSFETs and BY81PI200 fast free-wheel diodes plastic packages are optimally rated for the 1.2kVA power stage.

Figure 7 : 1.2 Brush D.C. Motor Velocity Servo Drive (120V_{DC} ; 10A : nom.).

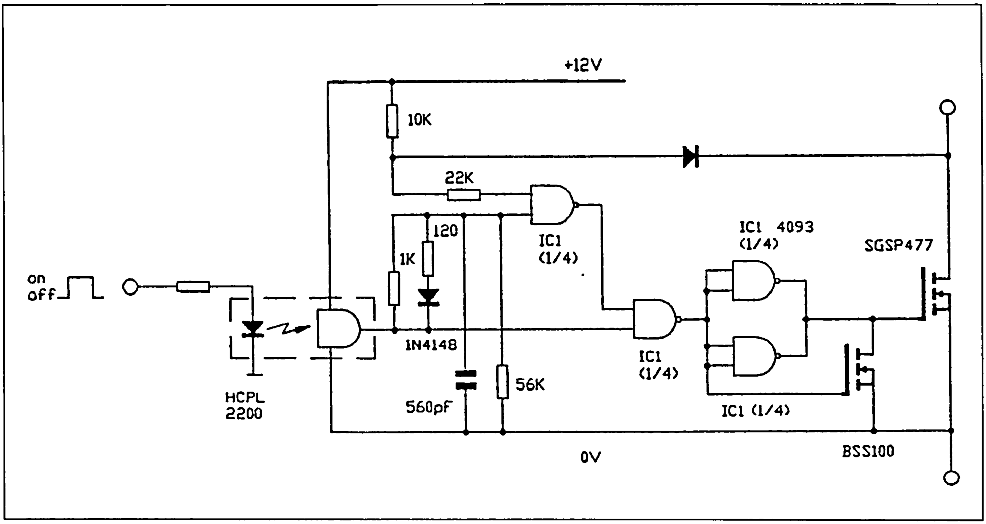


GATE DRIVES AND PROTECTION

Similar gate drives and protection circuits, (illustrated in figure 8), have been used for the "high-side" and "low-side" switches. This CMOS gate drive is well suited as switching speeds of 100 to 250 nanoseconds are sufficient in motor drive applications requiring a switching frequency of around 20 to 30kHz. Monitoring of the drain to source voltage while the device is conducting permits the detection of short-circuit conditions which lead to device failure. The device is turned-off before the drain current reaches a value in excess of the peak pulse current capability of the MOSFET. When the MOSFET is turned-on the on-state voltage of the device ($V_{DS(on)}$) is compared with a fixed reference voltage of approximately 8V. At the turn-on instant, $V_{DS(on)}$ monitoring is inhibited for a period of approximately 400 nanoseconds in order to allow the MOSFET to turn-on fully. After this period, if $V_{DS(on)}$ is detected to be greater than the fixed reference voltage, the device is latched-off until the control signal is turned-off and turned-on again.

The "high-side" gate drives have isolated low voltage supplies and isolated command signals using high speed opto-couplers.

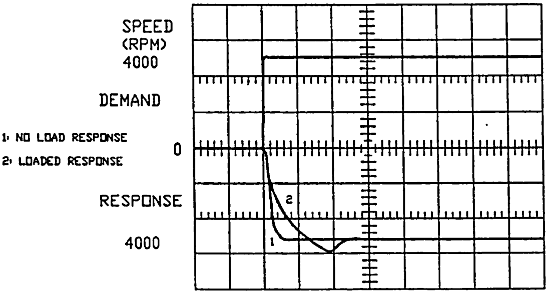
Figure 8 : An Isolated CMOS Gate Drive with Protection.



MOTOR DRIVE PERFORMANCE

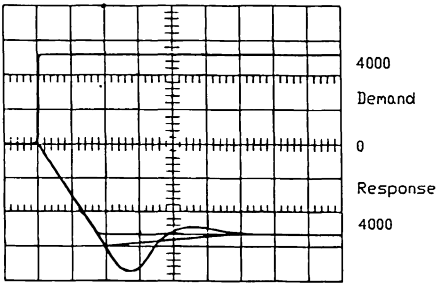
Figure 9 illustrates the dynamic response of the motor drive to a step demand of 4000rpm. The response has been optimised for the no-load case (trace 1). Under heavy load inertia there is an overshoot in the velocity response (trace 2). The effects of changing the proportional gain and the integrator time constant of the PID controller can be seen in figures 10 and 11.

Figure 9 : Velocity Response of Motor Drive.



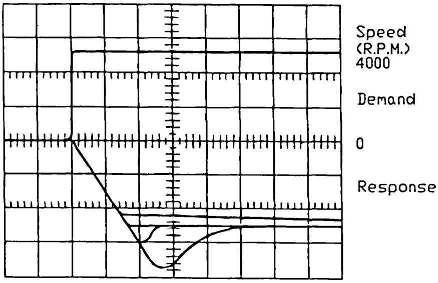
Time scale : 0.5s/div

Figure 10 : The Effect Upon the Dynamic Response of the Analogue Velocity Servo System, when the Gain of the Proportional Term in the PID Controller is Varied.



Time scale · 0.05s/div

Figure 11 : The Effect Upon the Dynamic Response of the Analogue Velocity Servo System, when the Time Constant of the Integrator in the PID Controller is Varied.



Time scale : 0 05s/div

6KVA BRUSH D.C. MOTOR SERVO DRIVE

Figure 12 illustrates the block diagram of the proposed 6kVA (120V_{DC} ; 50A) motor drive using ISOTOP packages for the MOSFETs in parallel (ISOFET) and the FRED diodes.

Blocking diodes in series with the MOSFETs are proposed to prevent the MOSFET internal parasitic diodes from conducting. The asymetrical bridge-leg configuration is not a cost-effective solution since inductors rated for 50A continuous operation are large and expensive. The series blocking diode has to be an ultra fast high voltage type. If the transistor F2 (shown in figure 12) is conducting, the drain to source capacitance of the transistor F1 is charged to the HVDC voltage. If F2 is turned-off, the load current transfers from F2 to the free-wheel diode, D1. Consequently the series blocking diode, D2, supports the drain to source capacitance voltage of F1 (equal to HVDC) provided this capacitance is not discharged by turning-on F1.

An isolated D.C. current measurement device, (such as an Hall-effect current sensor, LT80-P, manufactured by LEM), is recommended for the measurement of load current necessary for current limit control.

Pulse transformer based floating gate drives illustrated in figure 13 can be used for the TSD4M250 ISOFETs. The pulse transformer is used to transmit simultaneously the ISOFET logic command signal together with the gate to source capacitance charging current. The current mirror technique (reference 2) is used to provide short-circuit and over-load current protection. The pulse transformer operates at an oscillating frequency of 1MHz when a turn-on control signal is present. The secondary is rectified to provide gate source capacitance voltage. The current mirror provides a voltage "image" of the main drain current. This voltage is compared with a fixed reference voltage in order that the gate drive be latched-off whenever the drain current exceeds the specified overload current level.

Figure 12 : 6kVA Brush D.C. Motor Velocity Servo Drive (120V$_{DC}$; 50A : nom.).

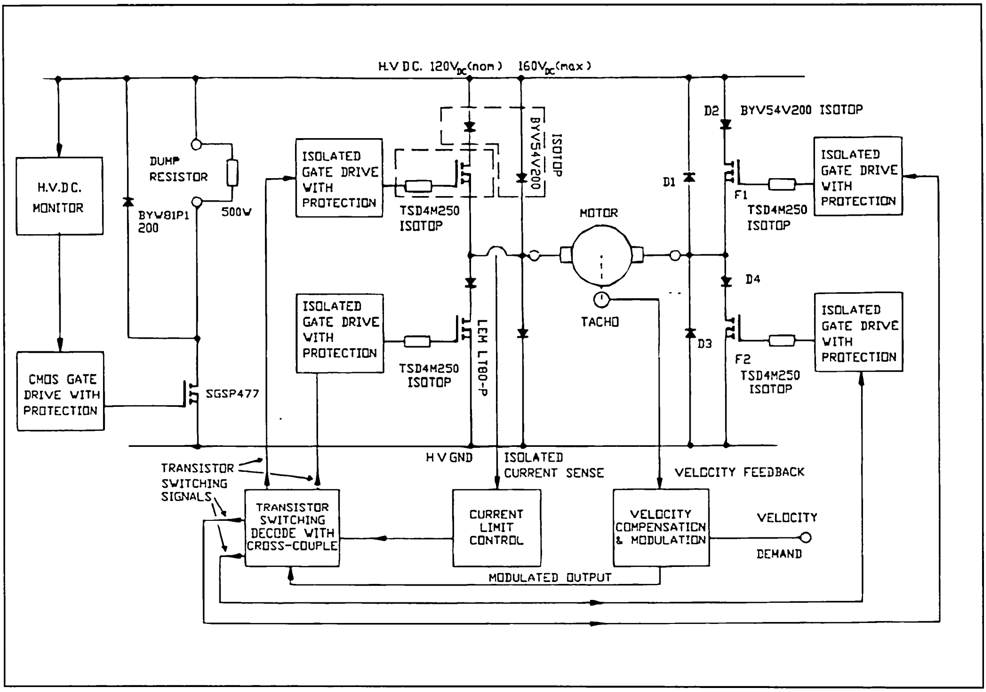
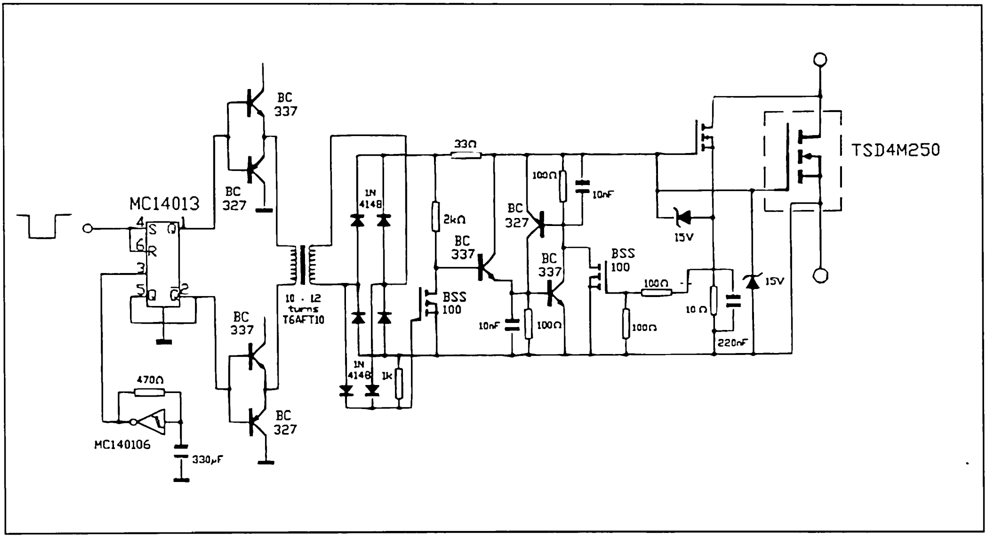


Figure 13 : Pulse Transformer Gate Drive with Current Mirror Protection for a TSD4M250.

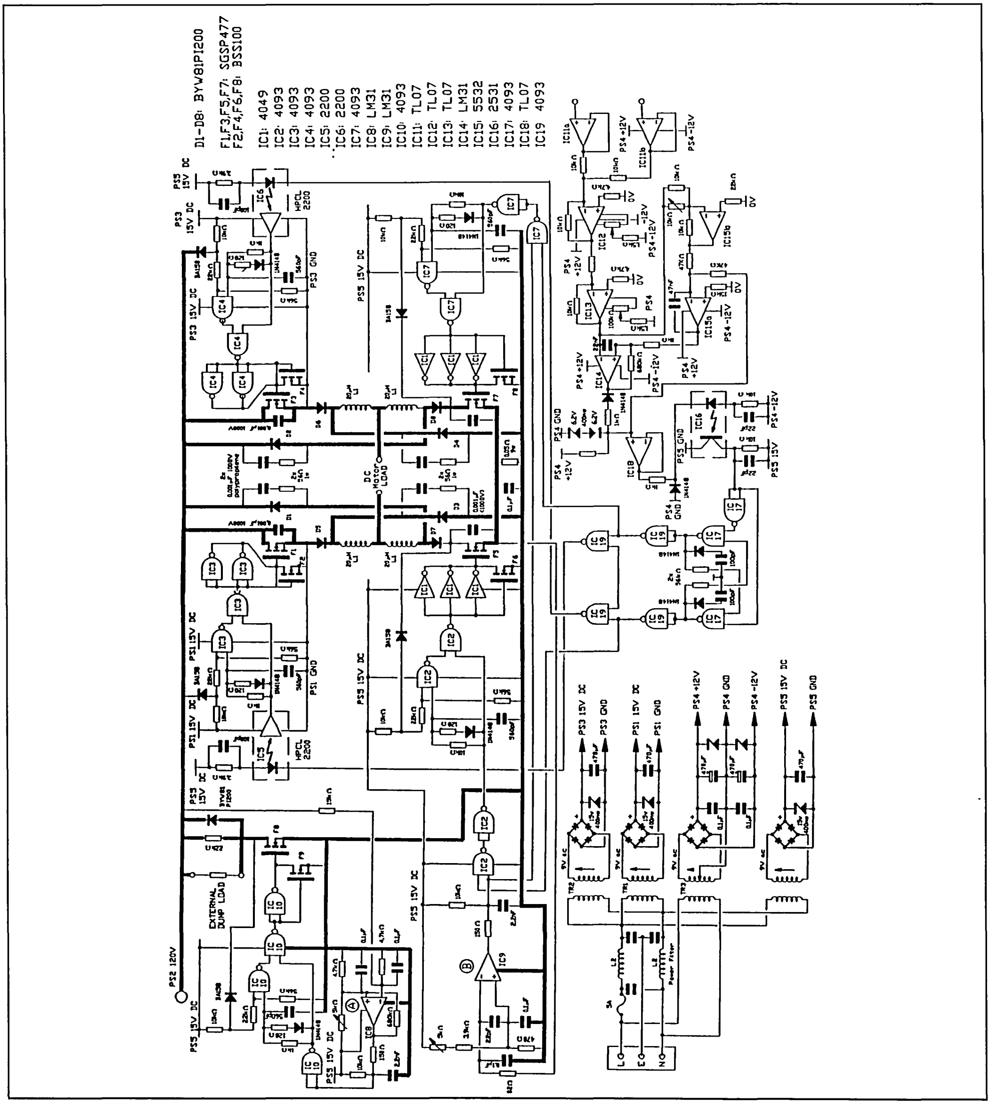


CONCLUSION

MOSFET based brush D.C. motor velocity servo drives have been described, with particular emphasis placed on the bridge-leg configuration, the PID compensation and modulation, the gate drive and protection techniques. The PID compensation and modulation circuits require few components to achieve good velocity servo performance.

The development has led to a compact high performance 1.2kVA drive which is fully protected against output short-circuit conditions. A 6kVA motor drive is proposed using ISOFETs. MOSFET switching devices and their associated free-wheel and blocking diodes have been specified for a range of brush D.C. motor drives rated between 600VA to 6kVA without the need to parallel MOSFETs in separate plastic packages.

Figure 14 : 1.2kVA Switched-mode Motor Drive.



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APPLICATION NOTE

A TRANSISTOR FOR 100 kHz CONVERTERS : ETD

BY Luc WUIDART

INTRODUCTION

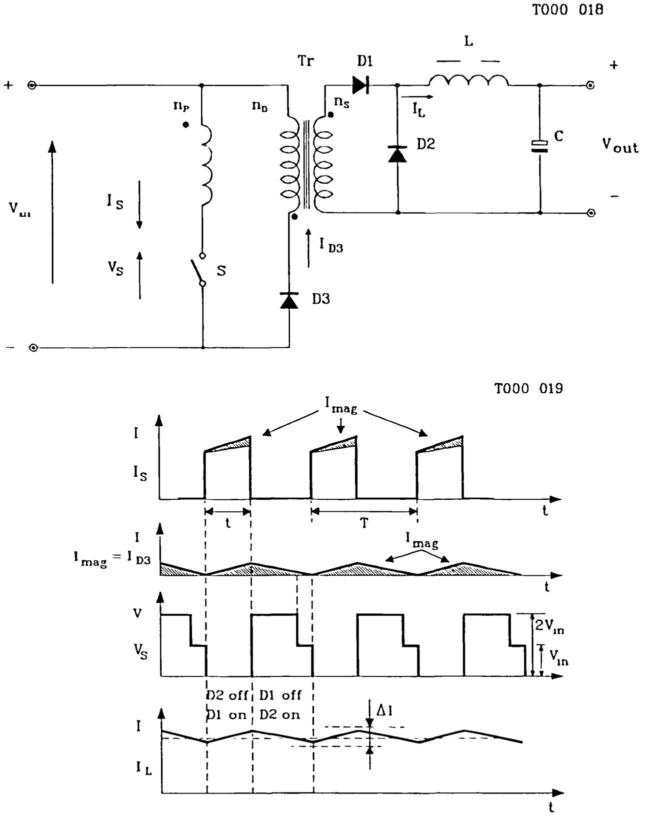
Power converter designers aim to reduce the size and the weight of their equipment. Hence, there is a trend towards higher operating frequencies. Consequently for the semiconductor manufacturers, there is a growing demand for fast switches. The POWER MOSFET transistor is now well known as a fast device.

However, the development of ultra fast "ETD" bipolar transistors is now challenging this way of thinking in certain applications. As an illustration, we have selected an example of a "300W - 100kHz forward" switch mode power supply (SMPS).

VOLTAGE CONSTRAINTS

This "forward" converter contains a single power switch and operates directly from the 220V AC mains. The principle wave-forms are illustrated in figure 1.

Figure 1 : Basic Theoretical Wave-forms of the Forward SMPS.



The switch must be capable of withstanding a static collector-emitter voltage which, to a first approximation, is given by :

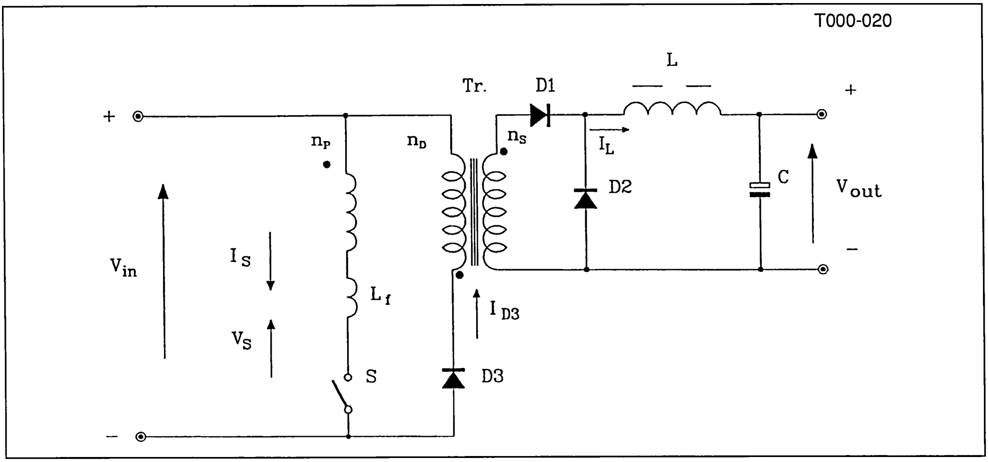
$(1 + n_p/n_D) \times V_{in}$, where,

- n_p = number of turns in the primary winding
- n_D = number of turns in the demagnetization winding
- V_{in} = rectified mains voltage

When operating on the 220V AC mains and when n_P equals n_D, the voltage across the switch terminals should only reach 750V in the worst case (corresponding to a maximum rectified mains value of 375V AC).

In reality, the voltage across the switch terminals reaches a peak value (V_{peak}) which is much higher. The peak value depends upon the switching time, the circuit capacitance and the leakage inductance L_f between primary winding n_p and the demagnetization winding n_D (see figure 2).

Figure 2 : Leakage Inductance L_f between Primary Winding n_P and Demagnetization Winding n_D.



DESIGN OF SNUBBER CIRCUIT

At turn-off, energy stored in the transformer leakage inductance generates a voltage spike (figure 3). In order to limit this voltage spike, the energy must be transferred to the capacitor C_{min} in the snubber circuit. The energy depends on the switching current. In a 300W SMPS, the peak value of the current I_{max} is 5A. It is this value of current which is used to calculate the value of the capacitance C_{min} required.

With a maximum voltage V_{peak}, the value of C_{min} can be calculated using the following formula :

$$C_{min} = \frac{L_f \times I_{max}^2}{V_{peak}^2 - V_{in\ max}^2 \, (1 + N_p/N_D)^2}$$

Figure 3a : Wave Forms of Switching Current and Voltage Across the Switch Terminals at Turn-off.

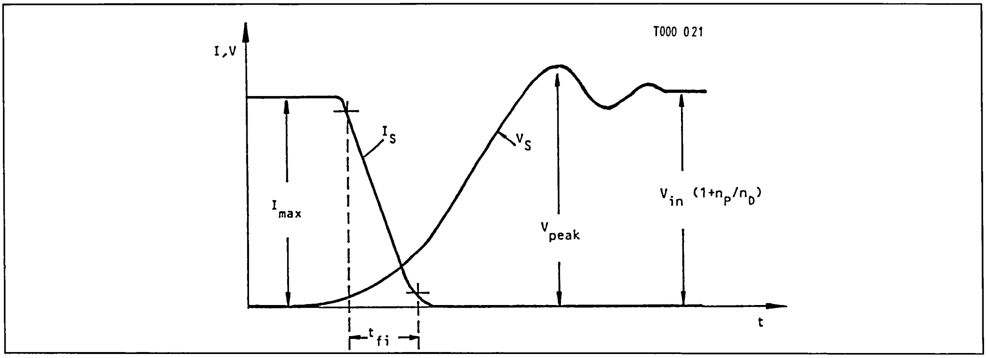
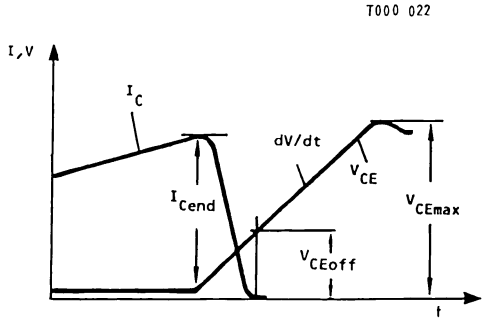


Figure 3b : Definition of the Voltage V_{CEoff}. V_{CEoff} is measured when the Collector Current Reaches 2 % of the Collector I_{Cend}.



We call V_{CEoff} the voltage which appears during the turn-off at the moment when the collector current I_C reaches 2% of its value I_{Cend} If the value V_{CEoff} measured in the circuit is low compared to the rating V_{CEW} of the transistor, the safety margin between the SOAR and the stress on the transistor is large.

In practice, V_{peak} can be set between 800 and 900V. To provide a safety margin, a switch with a blocking voltage capability of 1000V must be used. This voltage corresponds to parameter V_{CEV} for bipolar transistors and to V_{DSS} for POWER MOSFET components.

For bipolar transistors, an additional parameter must be considered : the Reverse Biased Safe Operating Area : (RBSOA). The turn-off cycle must remain within the RBSOA, otherwise, the value of capacitance must be increased from C_{min} to a higher value C_r.

Thermal dissipation in the snubber resistor, R_S (figure 6), will be increased in the same ratio :

$$C_r = \frac{t_{fi} \times I_{max}}{2 \times V_{CEoff}}$$

For the selected transistor, V_{CEoff} must be less than the specified V_{CEW} (see figures 3a and 3b).

SWITCH TYPE

In this application, three different types of switch using different technologies are considered. These are :

- conventional bipolar transistor,
- POWER MOSFET,
- ultrafast bipolar "ETD" transistor (see appendix).

Table 1 summarizes the performances of these types of switches under operating conditions, i.e., for a junction temperature of 100°C and with an optimized gate/base drive (optimized totem-pole drive for POWER MOSFETs and negative bias drive for bipolar transistors).

Table 1 : Transistor Characteristics.
Characteristics at Tj = 100°C "Totem-pole" gate drive. Base drive with negative bias. Same silicon area for each switch.

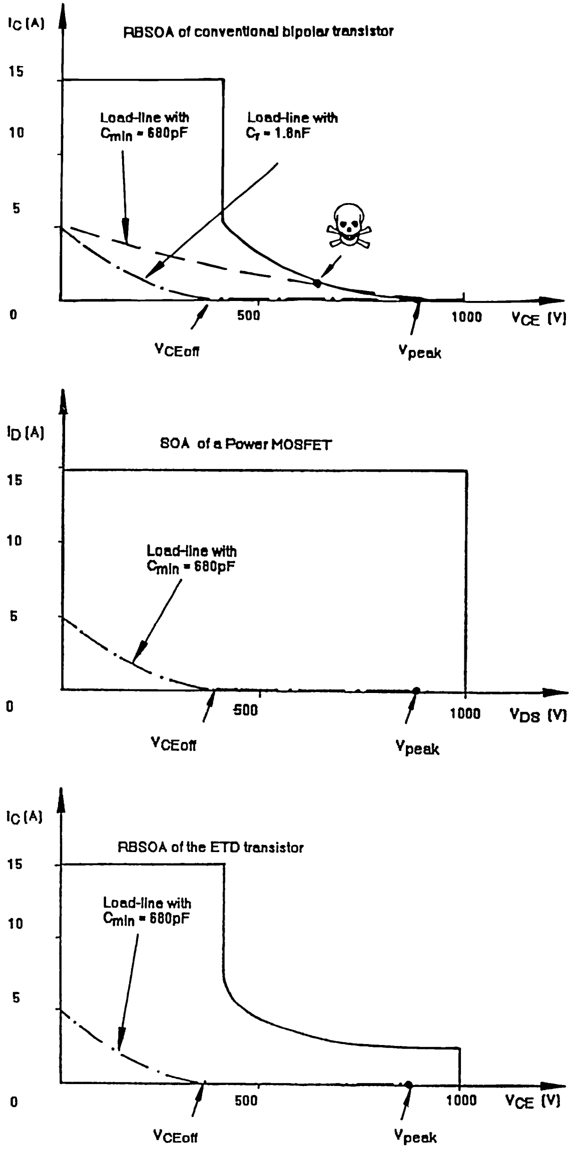
	Blocking Voltage Capability	**Switching Time** (Tj = 100°C)		**Conduction** (T_j = 100°C)
		t_r	t_{fi}	R_{DSon}, V_{CEsat}
STHV 102 VDMOS	1000V	100ns	100ns	5.4Ω
BUV 48 Conventional Transistor	1000V	85ns (60A/µs)	250ns	2.8V (5A)
BUF 410A ETD Transistor	1000V	50ns (100A/µs)	100ns	2.8V (5A)

The first point to notice is that at turn-off, an ETD transistor is as fast as a POWER MOSFET.

More surprisingly, the ETD transistor is twice as fast as a POWER MOSFET at turn-on.

Let us now consider the effects of the characteristics upon the size of the snubber. With a leakage inductance of 6.5µH and a current of 5A, a capacitor C_{min} of value 680pF is sufficient to limit the voltage V_{peak} to 900V (fig. 4) :

Figure 4 : Comparison of Turn-off Cycle Within the Safe Operating Areas for the Three Different Switches.



- However, a capacitor C_r of 1.8nF is required to limit the V_{CEoff} voltage to a value that is within the RBSOA of the bipolar conventional transistor.
- In comparison, the POWER MOSFET and ETD transistors can be kept within their safe operating areas with a capacitor of only 680pF.

LOSS EVALUATION

For the 300W forward SMPS operating at 100kHz, the following assumptions have been made.

The losses have been evaluated assuming a current I_{nom} of 4A, corresponding to the nominal output power. A current of 2.8A rms is obtained with a duty cycle of 48.5%. For a realistic comparison, conduction losses were reduced by paralleling two POWER MOSFETs (the conduction losses of a single POWER MOSFETs would be approximately 43W). The results of this evaluation are as shown in Table 2.

Table 2 : Results of Loss Evaluation for the Conventional Bipolar Transistor, the two paralleled Power MOSFET and the ETD BUF 410A Transistor.

	BUV48A	2 x STHV102	BUF410A
Silicon Area	30mm^2	40mm^2	30mm^2
Snubber (RCD) C_r	1.8nF	680pF	680pF
P_R*	51W	19W	19W
Losses in the Switch	30W	34W	17.5W
Conduction	5.4W	21.3W	5.4W
Switching	20.7W	12.3W	9.2W
Drive	3.9W	0.4W	2.9W
TOTAL LOSSES (RCD + COM)	81W	53W	36.5W

* P_R is the power dissipated in the resistor of the snubber circuit.

- for this application, the ETD transistor requires no more silicon area than a conventional bipolar transistor.
- the ETD transistor uses the same value of snubber capacitance as a POWER MOSFET.
- conduction losses in the ETD and the conventional bipolar transistor are the same.
- the ETD transistor has the lowest switching losses of the three devices considered.

In our example, at 100kHz, the superior performance of an ETD transistor results in about a 50% reduction in losses as compared to the BUV48A and 30% compared with POWER MOSFETs.

CONCLUSION

The example described in this paper (300W - 100kHz SMPS), figure 6 shows that of the three devices considered, the ETD transistor is the optimum cost/performance solution.

In addition, as a result of its fast switching capability (t_r < 50ns ; t_{fi} < 100ns) and its extended RBSOA, the ETD transistor can be successfully used in other applications such as resonant converters, motor drives or uninterruptible power supplies.

ETD transistors with blocking voltage capability higher than 1000V are under development. These transistors will enable higher switching frequencies to be used in equipment supplied directly from the 380/440V mains supply.

APPENDIX I

WHAT MAKES ETD TRANSISTORS SO ATTRACTIVE ?

The new generation of ETD transistors adapted for high voltage applications is designed with an inovative technology utilizing a high degree of interdigitation.

The most innovative feature of this technology consists of the replacement of the traditional bipolar structure with emitter fingers (size : 250µm) by a cellular structure with much smaller dimensions (80µm cells). This cell design considerably eases the extraction of charge stored in the transistor during each switching cycle, since access to the intrinsic base is easier. This makes it possible to reduce switching times to values as low as 100ns.

The "Planar" technology has been selected for two reasons :

It permits extension of safe operating area at turn-off. Moreover, it requires a reduced number of masking levels with respect to conventional high voltage "mesa" power technologies.

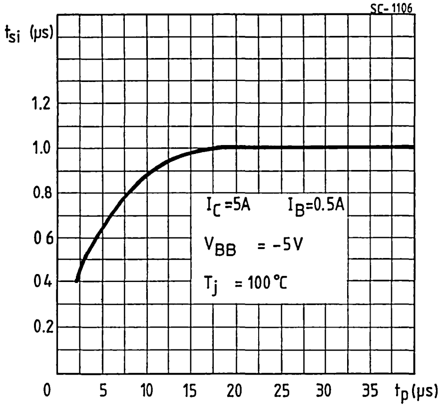


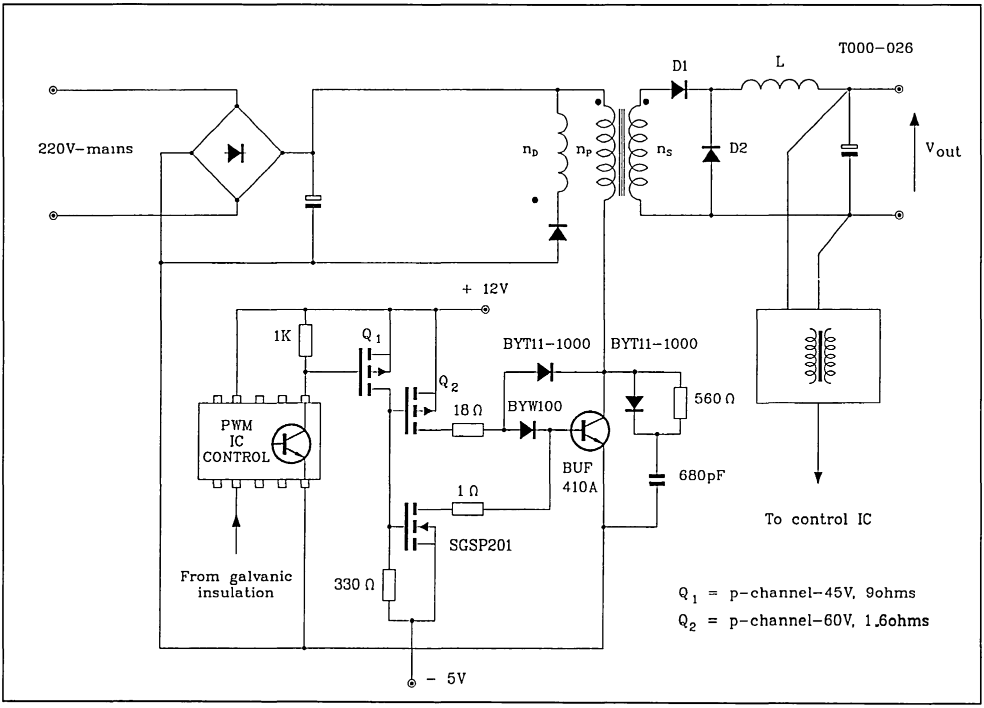
Figure 5 : Curve Illustrating the Variation of Storage Time t_{si} versus Conduction Time t_p. (ETD transistor BUF410A).

REGULATION DYNAMICS

In SMPS or motor drive applications, the minimum conduction time is a fundamental parameter when considering the dynamic regulation. The delay time at turn-off of the POWER MOSFETs specified in the data sheet is sufficiently low.

In the case of bipolar transistors, storage time depends on conduction time. In our application at 100kHz, conduction time must vary from less than one microsecond to five microseconds. In the BUF410A data sheet, the curve showing the variation of storage time, t_s, versus conduction time, t_p, shows that storage time varies from zero to 750ns maximum (see Figure 5). Consequently, the regulation dynamics are not limited.

Figure 6 : Schematic Diagram of an ETD BUF410A Transistor Implemented in a 300W – 100kHz Forward SMPS Application.



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APPLICATION NOTE

AN INNOVATIVE HIGH FREQUENCY HIGH CURRENT TRANSISTOR CHOPPER

By L. PERIER & J. BARRET

INTRODUCTION

Recent developments in power semiconductors and associated technologies have made possible the realization of medium power converters (5-50kVA) operating at switching frequencies higher than 20kHz.

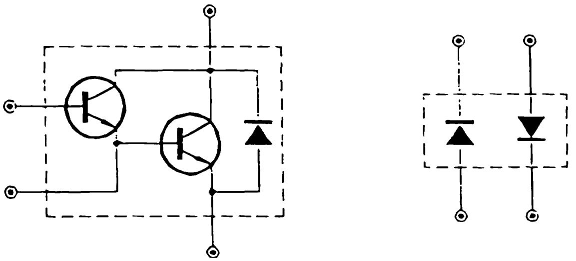
This paper presents the design of a high current (500A), high frequency (20kHz) chopper using fast Darlington switches operating from a low voltage supply (60V). New optimised design techniques for paralleling power semiconductor devices are described. The association of these methods allows the switching of 500A in less than 200ns.

These new techniques are also suitable for high voltage medium power converters operating at high switching frequency, such as UPS, welding converters, motor drives and battery chargers.

A 500A - 20kHz CHOPPER WITH DARLINGTON IN PARALLEL

High frequency bandwidth and regulation is achieved for the 500A output current by switching at an ultrasonic frequency of 20kHz with a turn-off time of less than 200ns. Consequently, high rates of change of current (in excess of 2000A/µs) are experienced. Six Darlington transistors (ESM2012 D) in parallel and four ultra fast rectifiers (BYV54-200) in parallel are used to achieve the current rating.

Figure 1 : Switches used in the Chopper.



ESM 2012 D

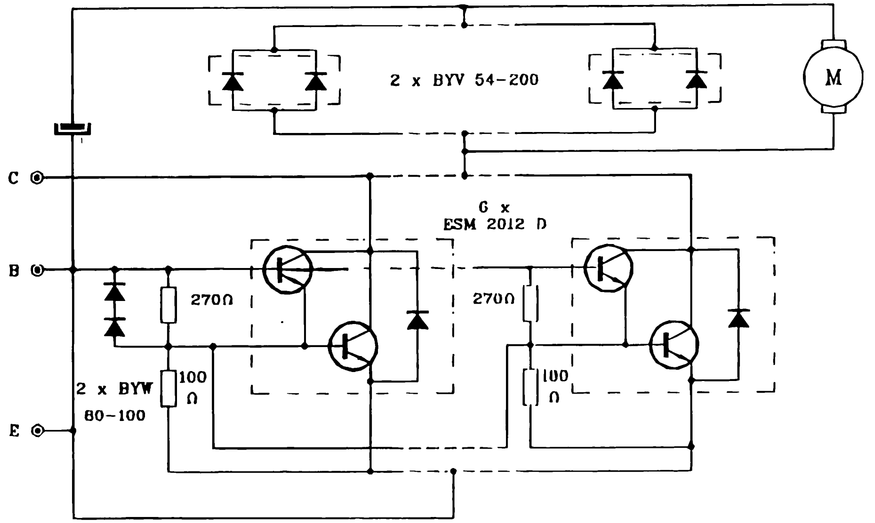
V_{CEW} = 125V
V_{CEV} = 150V
V_{CEsat} (100°C) < 1,5V
for I_C = 70A
I_B = 0,25A
t_{fi}(100°C) < 0,4ms
R_{th} = 0,7K/W

BYV 54-200

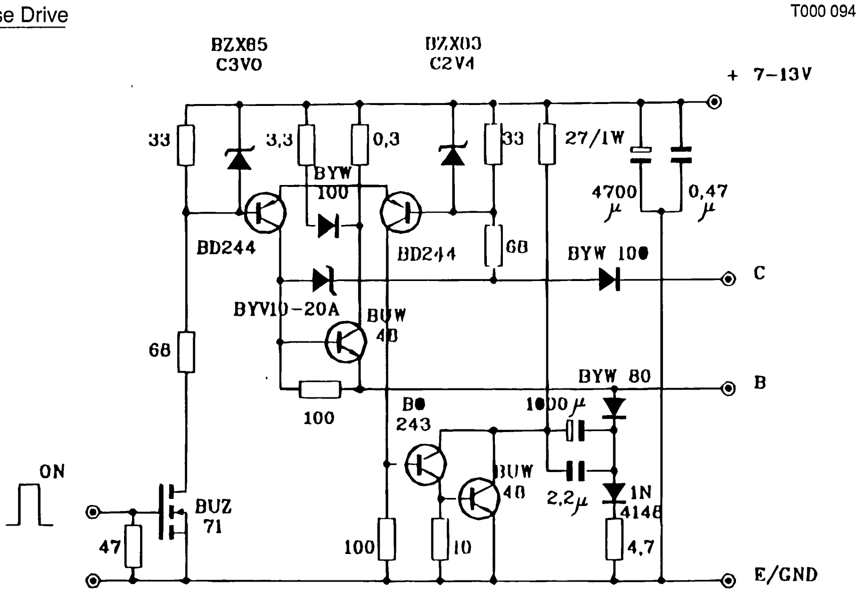
V_{RRM} = 200V
V_F(100°C) < 0,85V for I_F = 50A
R_{th} = 1,2K/W

Figure 2 : New Base Drive Concept which Automatically Generates the Negative Bias. (The negative bias generated is independent of the duty cycle).

1/ Power stage



2/ Base Drive



The 500A/60V/20kHz chopper

A power Darlington and diodes are shown in figure 1 together with their important characteristics. Figure 2 shows the power stage and the base drive circuit.

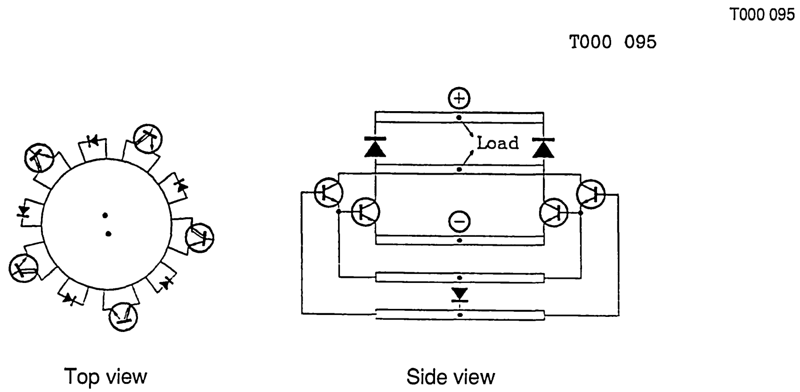
A base current of 5A is sufficient to control a collector current of 500A. The static and dynamic sharing of the collector and base current between the paralleled devices is better than 90% provided :

a) The devices are mounted in a circular layout on a common heatsink as shown in figure 3. Good utilization of the heatsink is achieved using this physical layout.

b) The bases of the output stages of the Darlingtons must be linked together. The access to the bases of the output stage of the ESM2012 D Darlingtons enables this.

Due to excellent current sharing, the Darlingtons can be used close to their nominal collector current rating.

Figure 3 : Circular Geometry for the Physical Layout of Power Devices.



The BYV54-200 ultra fast rectifiers in parallel are not derated as these fast recovery epitaxial diodes have negligible voltage drop (V_F) spread.

Figure 4 : Power Stage.

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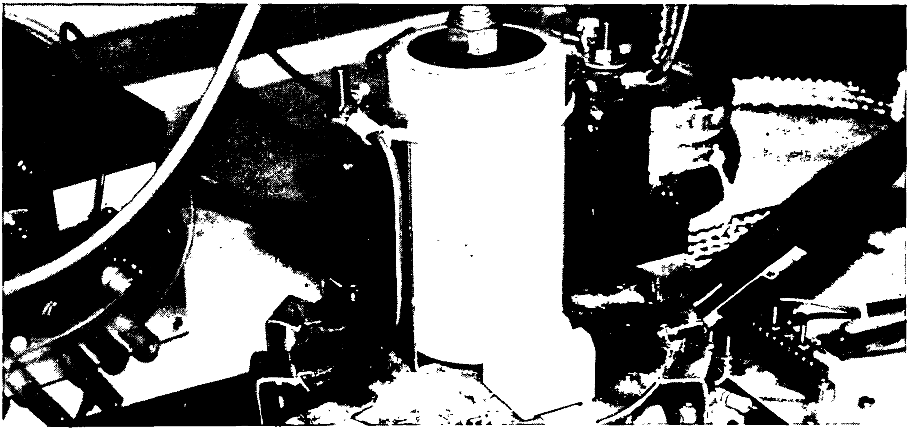
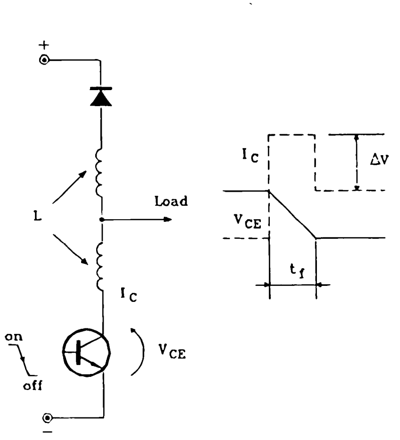


Low wiring inductances are required for high performance switching as parasitic inductances cause overvoltage spikes at turn-off.

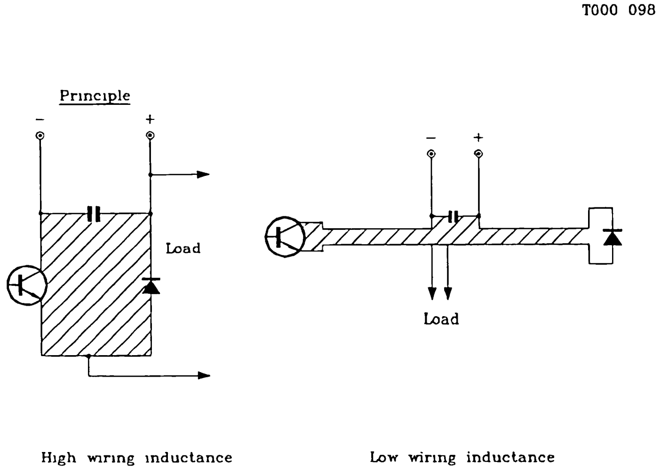
Figure 5 : A Low Wiring Inductance is Necessary in Order to Avoid High Over Voltages at Switch off.



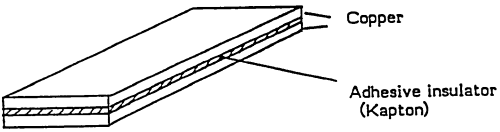
L	100nH	
t_f	200ns	
I_C	10A	500A
Δ_V	5V	250V

The 500A chopper has been designed with a low inductance plate wiring method. The plate wiring consists of 2 parallel copper plates separated by a thin adhesive insulator (see figure 6).

Figure 6 : Low Inductance Wiring.



Technology

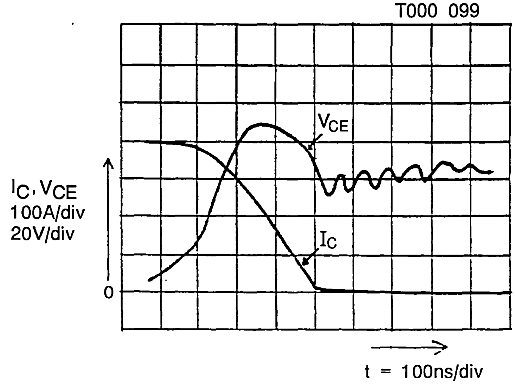


Wiring inductances as low as 5nH/m can be achieved in a 500A$_{RMS}$ circuit using plate wiring.

The parasitic inductance of the power stage of the 500A chopper (capacitor + Darlington + free-wheeling diode) has been estimated at 20nH. Such a reduction of wiring inductance in the power stage and the base drive allows :

- * Very high switching speed of the Darlingtons at turn-on and turn-off : 2000A/µs.
- * At turn-off an overvoltage of only 50V is experienced by the Darlingtons for a dI/dt of 2000A/µs.

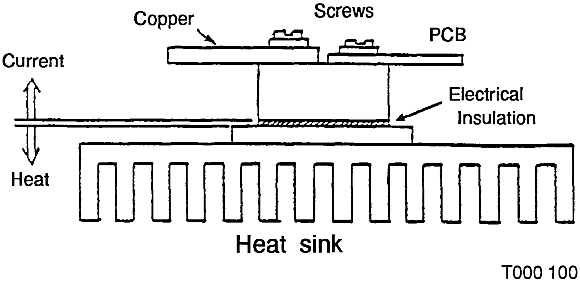
Figure 7 : Turn-off Switching of the Fast Darlington Switch.



The ISOTOP package is used for all the power semiconductor components in order to optimize cooling and wiring.

The package has screw terminals on the top of the case suitable for plate wiring, low parasitic inductance due to its low profile and internal insulation with low thermal resistance.

Figure 8 : A High Current Package : ISOTOP.



CONCLUSION

The design of a 500A - 20kHz chopper using fast switching Darlingtons and diodes has been presented.

The power semiconductor components have been packaged in the ISOTOP package, allowing screw connections and plate wiring techniques to be used. The techniques developed also can be applied in the design of medium and high voltage converters.

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APPENDIX I

LOW INDUCTANCE WIRING

1. Modelling an inductance

The inductance of wiring made with circular cross section wire, can be modelled as the sum of two terms :

a) Self inductance of one wire :

$$L_1 = \frac{\mu O}{8\pi} \text{ (H/m)} \qquad \text{Eqn.1}$$

b) Mutual inductance of the loop :

$$L_2 = \frac{\mu O}{\pi} \; L_n \frac{b-a}{a} \text{ (H/m)} \qquad \text{Eqn.2}$$

The total inductance of the wiring os thus :

$$L_T = \frac{\mu O}{\pi} \left(\frac{1}{4} + \ln \frac{b-a}{a} \right) \text{ (H/m)} \qquad \text{Eqn.3}$$

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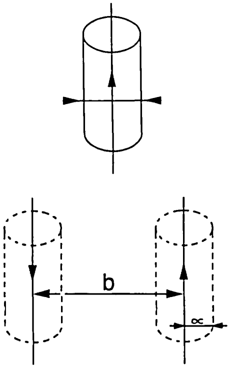

LT depends strongly on the geometry of the circuit. The best way to decrease LT is to decrease the area of the loop :

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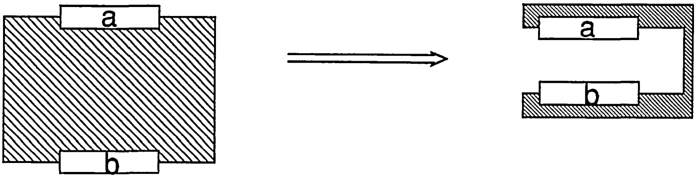

2. TECHNOLOGY FOR LOW INDUCTANCE WIRING

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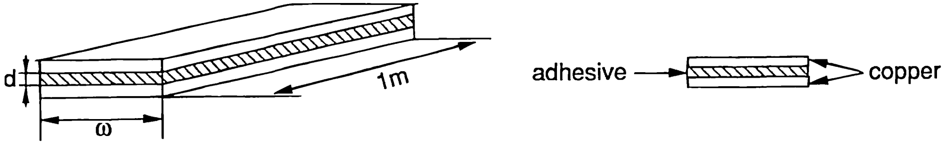


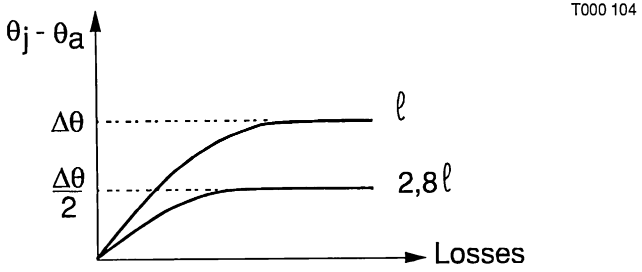
$$L = \mu O. \frac{d}{W} \qquad \text{Eqn.4}$$

$$I = 500\text{A}, \ \delta = 20\text{A/mm}^2, \ W = 50\text{mm}, \ d = 1\text{mm}$$

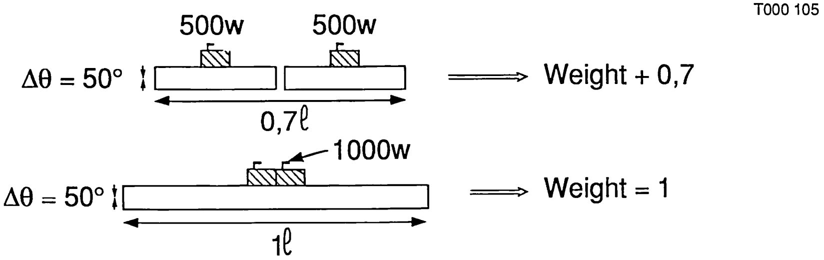
$$\Rightarrow L = 20\text{nH/m}$$

APPENDIX II

The cooling ability of a heatsink is not linearily dependent on its length



Separation of heat sources is thus necessary to optimize the cooling



Length, volume and weight can be reduced in some case by a factor of $\sqrt{2}$ if heating sources are spread over the heatsink

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APPLICATION NOTE

A POWER STAGE FOR A 20kHz 10kW SWITCHED MODE POWER SUPPLY FOR THE INDUSTRIAL 380/440V MAINS

By Jean BARRET

INTRODUCTION

The theory of transistor converters operating from the single phase 220V mains is not the same as that for switched mode power supplies operating directly from the 380V and 440V mains and delivering an output power of more than 10kW. For the latter the increased technological constraints must be taken into account when designing such a converter. This paper explains the design of a 10kW - SMPS operating on the three-phase 380V - 440V mains and the solutions which have been found to resolve the technological problems.

CHOICE OF THE CONVERTER STRUCTURE

The converter has been designed for a supply from the 380V and 440V mains. It must provide an output voltage of 80V and an output power of 10kW. The operating frequency has been chosen to be 20kHz. There are several possible solutions for the topology of the converter. The choice of topology has been strongly influenced by technological considerations.

CONVERTER TOPOLOGIES FOR THE 10kW - POWER RANGE

Considering the high supply voltage and the switching frequency of 20kHz, converter topologies applying a voltage in excess of the supply voltage to the transistors, or necessitating a power transformer with a low leakage inductance have been eliminated. Transformers with a low leakage inductance that respect the insulation standards are difficult to manufacture. The one transistor "forward" converter and "push pull" converter are thus eliminated.

The choice of the converter topology is reduced to two converter types :

- The full-bridge (figure 1) which is a symmetrical structure with alternating magnetic polarisation.
- The asymmetrical half-bridge (figure 2) in which the magnetic polarisation is uni-directional.

Figure 1 : Full Bridge Converter.

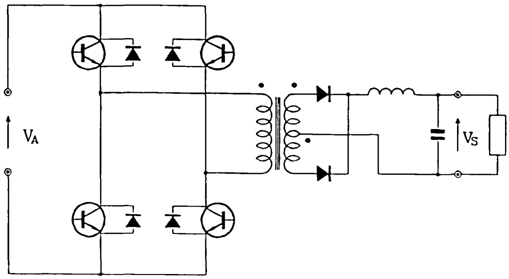
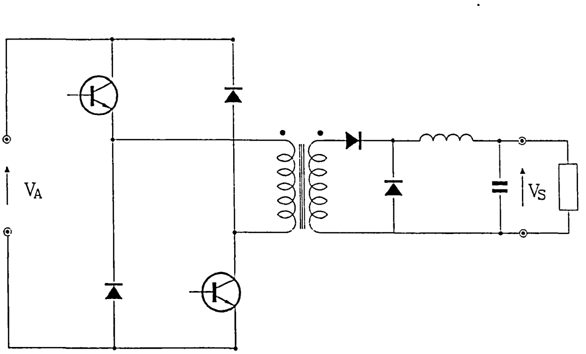


Figure 2 : Asymmetrical Half Bridge FORWARD Converter.



CHOICE CRITERIA

Theoretically the complete bridge is the solution for high output power : at equal output power the transformer is half as big as that of an asymmetrical half bridge.

In practice, there exist a certain number of secondary parasitic phenomena which reduce the advantages of a symmetric structure in comparison to the half bridge. One of these phenomena is that a full bridge is never perfectly balanced. A circuit to correct the symmetry must therefore be designed in and the transformer must be slightly larger to avoid saturation due to dissymmetry.

The full bridge necessitates the use of 4 bidirectional switches and therefore of 4 galvanically isolated drive circuits, whilst the half bridge only requires 2. Simple switching aid networks cannot be directly applied to a full bridge, due to the direct coupling between the upper and lower switches. Supplementary chokes therefore have to be added which would complicate the circuit considerably.

The asymmetrical half bridge does not have these problems. The input current of the asymmetrical half bridge has a bad form factor. Consequently and contrary to a full-bridge, the input filter capacitors of a half-bridge are subject to a high RMS-current. These different considerations led us to choose an asymmetrical half bridge. The experiment has shown that our choice was reasonable and we think today that for an output power in the 10kW area, the asymmetrical half bridge presents the best technical and economical compromise.

For a substantially higher output power the full bridge seems to be preferable. Alternatively, 2 asymmetric half-bridge circuits can be used, operating in antiphase.

THE ASYMMETRICAL HALF BRIDGE

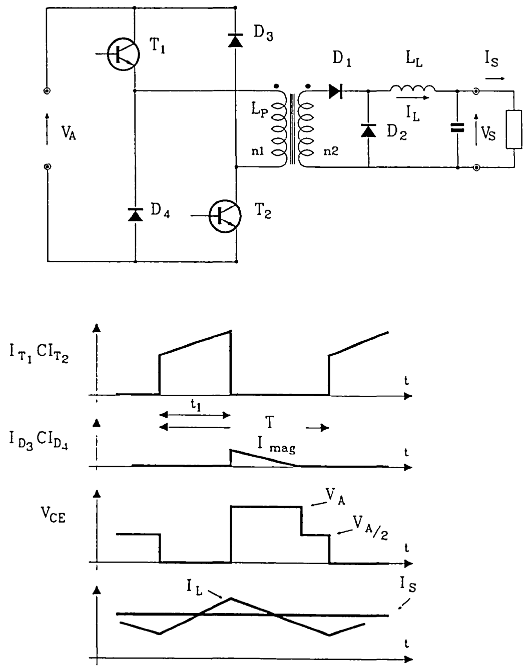
GENERAL CIRCUIT DIAGRAM

The figure 3 shows the basic circuit and the principal voltage and current waveforms of an asymmetrical half bridge.

In this converter, the transistors T1 and T2 are driven simultaneously. They conduct for a time τ and are off for the rest of the period, $T - \tau$.

The diode D1 on the secondary conducts while the transistors are conducting (time τ). The secondary current (during time τ) goes through the inductance L. The diode D2 operates as a free-wheel diode (time $T - \tau$).

Figure 3 : Forward Asymmetrical Half Bridge Converter.



THE MAIN FEATURES OF AN ASYMMETRICAL HALF BRIDGE

The main features of an asymmetrical half bridge are :

- The power transformer and ferrite core. Litz wire is used for the primary because of its reduced skin effect. The low leakage inductance is obtained by winding a half-primary and a half-secondary onto each leg of the transformer. A reduction of the duty cycle with increasing input voltage limits the magnetisation of the core. This reduces the transformer's volume to a minimum.
- The Power Switches. The simultaneously driven power switches must be fast. Their drive must not be disturbed by parasitic signals. To obtain a good voltage safety margin, turn-off snubbing networks are necessary.
- Rectifiers and filter components. The choke inductance is the principal component of the output circuit. As far as possible, the inductance must be high, so that the maximum current in the power switches and the recifier diodes is as low as possible. Fast recovery diodes are used to reduce the switching oscillations. The use of an RC network in parallel to each diode reduces the voltage ripple on the output.
- Safety. In power equipment, safety is a fundamental element which must be considered from the very first stages of design. The principal active safety elements we introduced are :
  a. current limitation for the power switches,
  b. a soft start,
  c. protection against overload on the output,
  d. control of auxiliary voltages,
  e. control of the transformer core magnetisation,
  f. minimum conduction time for complete discharging of the snubbers.
- Control. The control circuit was developed with an integrated circuit, the UAA4006. Amongst other things, this circuit contains several protection functions. The output voltage is detected by means of an extra winding on the filter choke. The free wheel diode is conducting during the demagnetisation phase of the filter choke. During that time interval the voltage across the filter choke is equal to the output voltage. This voltage is fed to the control IC. The control IC also provides the features a-f listed above for safe operation.

THE POWER SWITCHES

For the 10kW switched mode power supply operating from the 380V - 440V mains two fast power switches able to switch 100A with a maximum supply voltage of 700V are required.

There are two possible solutions when choosing the power transistors.

1. To choose transistors with V_{CEW} higher than the maximum voltage the switch has to sustain. Theoretically, this would allow a design without turn-off switching aid networks.
2. To choose transistors with V_{CEW} higher than half the maximum supply voltage and with a V_{CEV} rating higher than the maximum voltage the switch has to support.

The second solution has the advantage of better switching performance than the first one.

The switching times must be as short as possible since the minimum conduction time is of the order of 7µs and during a short circuit at the output about 2 to 3µs.

Our choice is a Darlington combination using ESM6045A (fig. 4).

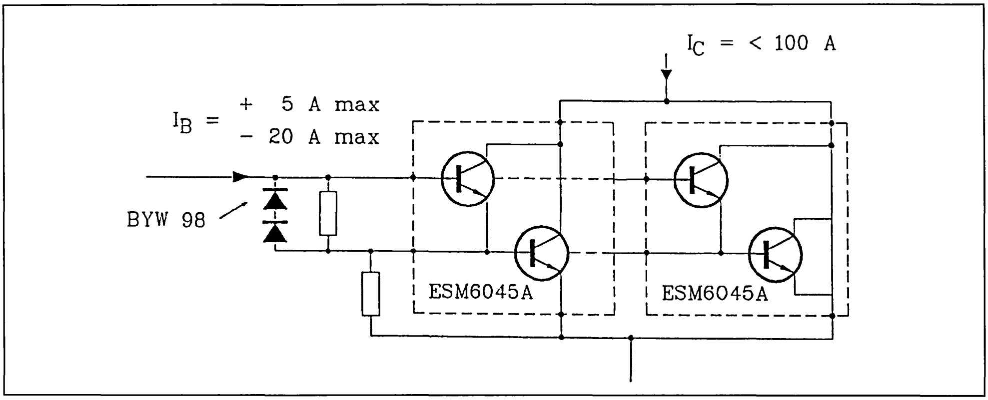
PRINCIPAL CHARACTERISTICS OF THE TRANSISTORS USED

ESM6045A

- $V_{CEW} > 450V$
- $V_{CEV} > 1000V$ ($V_{BE} = -5V$)
- $V_{CEsat} > 2.0V$
- $t_{fi} < 0.6\mu s$
- $t_{si} < 6.0\mu s$
- $t_c < 2.0\mu s$

$\left.\right\}$ $I_C = 60A$ and $I_B = 2.4A$, $T_j = 100°C$

Figure 4 : Power Switch.



Note that this type of transistor is mounted in an ISOTOP package. The insulation voltage between the die and the bottom of the case is 2.5kV AC-RMS. This not only avoids external insulation but also considerably reduces the capacitance between the transistor and the heat sink, hence gives a reduction in RFI.

A certain number of precautions are required when using transistors with V_{CEW} lower than the maximum voltage, to which the switch is subjected :

- A base-emitter resistance must be connected to each transistor (value stated on the data sheet), which insures a static blocking voltage of 700V and therefore protects the switch against any problem arising from the negative bias. Nevertheless the auxiliary voltage should be monitored.
- A turn-off switching aid network must be connected to each switch to insure that the load line stays in the RBSOA at switch off. In our case, the network has to be calculated so that the collector-current reaches zero before the collector-emitter voltage reaches 450V.
- The driver circuit must be capable of providing sufficient base current with an optimized waveform.
- The conduction time of each transistor will always have to remain higher or equal to the time necessary to discharge the snubber capacitor even in the case of an overload.

If these precautions are respected, the voltage safety margin is the same as if very high voltage transistors were being used.

BASE DRIVE CIRCUIT

The base drive turns the transistor switches on and off as determined by the electronic control and safety circuit.

The positive base drive is regulated in order to maintain the power transistors in quasi-saturation. This reduces the effect of parameter spread of the power transistors and simplifies the paralleling. The storage and fall times are also reduced by this means.

The base drive must have a high immunity to electrical disturbances (dV/dt for example). The input interface uses a driver transformer with a bobbin with two segments. The base drive circuit for one switch is shown in figure 5.

Figure 5 : Base Drive Circuit.

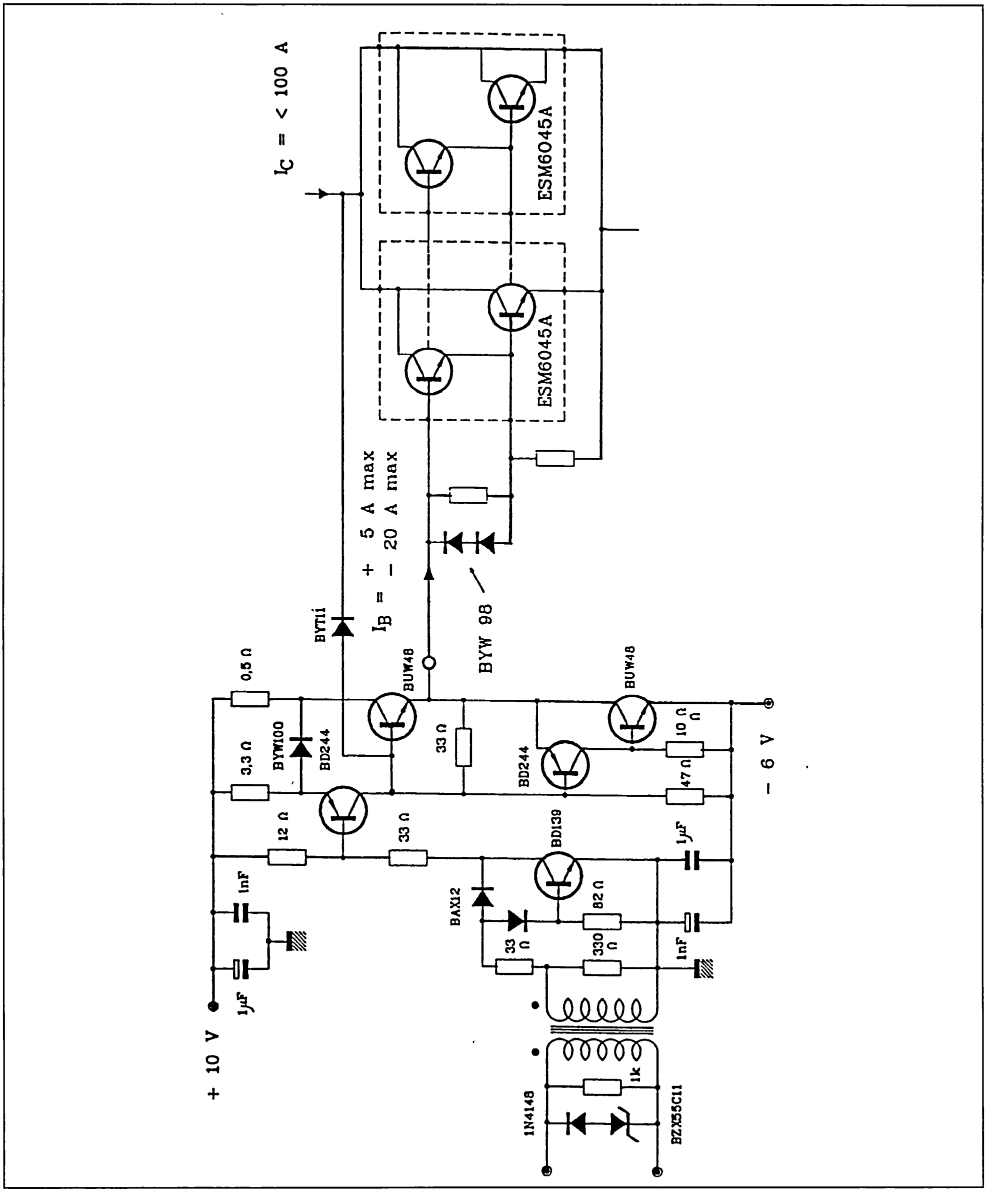
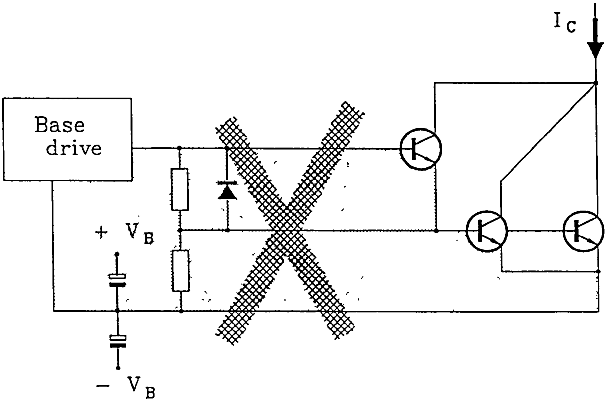
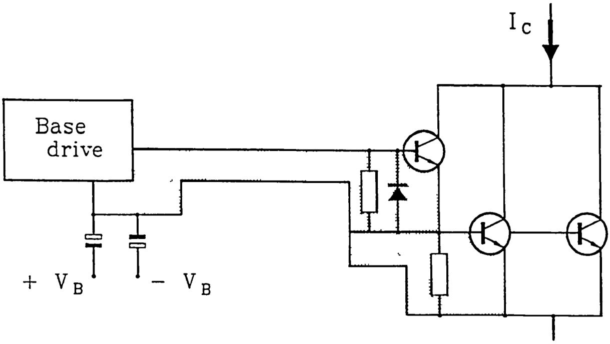


Figure 6 : Wiring for High Power Switching.

a) Base Drive with Poor Wiring.



b) Base Drive with Recommended Wiring.



WIRING PRECAUTIONS

Special care must be taken concerning the wiring of the fast high power switches. The switching speeds being in the order of 200A/µs (much more if they are not limited), current/voltage oscillations are induced in the leads.

It is therefore necessary to pay particular attention to the wiring to reduce the parasitic inductance :

- The connections between transistors, and to the drive must be as short as possible (figure 6) and form very small wiring loop areas.
- Try to obtain the highest symmetry possible between the paralleled transistors. The spread of the transistor -characteristics is only of second order, (for components of the same type and from the same manufacturer) the spread in switching times is essentially a result of the wiring dissymmetry.
- The reference point for the driver must be the emitter connection of the power transistor. Figure 6a shows an example where the zero point of the driver circuit is disturbed by voltages created by the fast rise and fall (dI/dt = 50A/µs) of the output current of the driver stage.
- The decoupling capacitors must be connected as close as possible to the switches.
- The decoupling capacitors must have low equivalent series inductances and resistances. To further reduce the impedance of the decoupling capacitor, multilayer film capacitors with low parasitic impedance have been connected in parallel to the electrolytic capacitors.

THE SNUBBERS

A turn-off switching aid network is needed due to the V_{CEW} rating of the switching transistors which is lower than the supply voltage. To obtain high efficiency from the power supply, switching aid networks with energy recovery have been choosen |2|.

Due to the reverse recovery behaviour of the diodes these snubbers do not operate in an ideal way. The reverse recovery current of the diode D_{AC3} (fig. 7) causes some problems.

The reverse recovery time, t_{rr}, is dependant on the diode technology and the switching conditions.

The reverse recovery current of this diode has several consequences.

- With a low load on the output of the power supply it produces a reverse collector-emitter current in the transistor. The transistor can be protected against this current by means of an antiparallel diode between collector and emitter.
- The reverse recovery current of D_{AC3} partially recharges the capacitor C1 (and discharges C2), figure 7.
- It also flows through the choke L. If the stored energy is not discharged it will generate overvoltages. The diode D_{AC4} clamps and limits this overvoltage to the supply-voltage. Unfortunately, the current through this "clamp" recharges C1 still more (fig. 8).

Diode D_{AC3} must be chosen with care. To reduce the parasitic phenomena it must have a very fast recovery characteristic. The type BYT30-1000 was used.

The resistor (R) parallel to the diode D_{AC1} allows the complete discharge of the capacitor C1 during the conduction time of the transistor (figure 8). This increases the snubber losses, but they are still significantly reduced (~ 30%) when compared to those of a conventional RCD-snubber.

These modifications to the snubber with energy recovery are justified with high switching frequencies (e.g. : 20kHz) and when the minimum conduction time is short. In this case the snubber must reset very rapidly and the parasitic phenomena of the components can no longer be neglected.

The other components of the snubber are chosen in the same way as those for the conventional RCD-snubber.

Figure 7 : Non Dissipative Snubber.

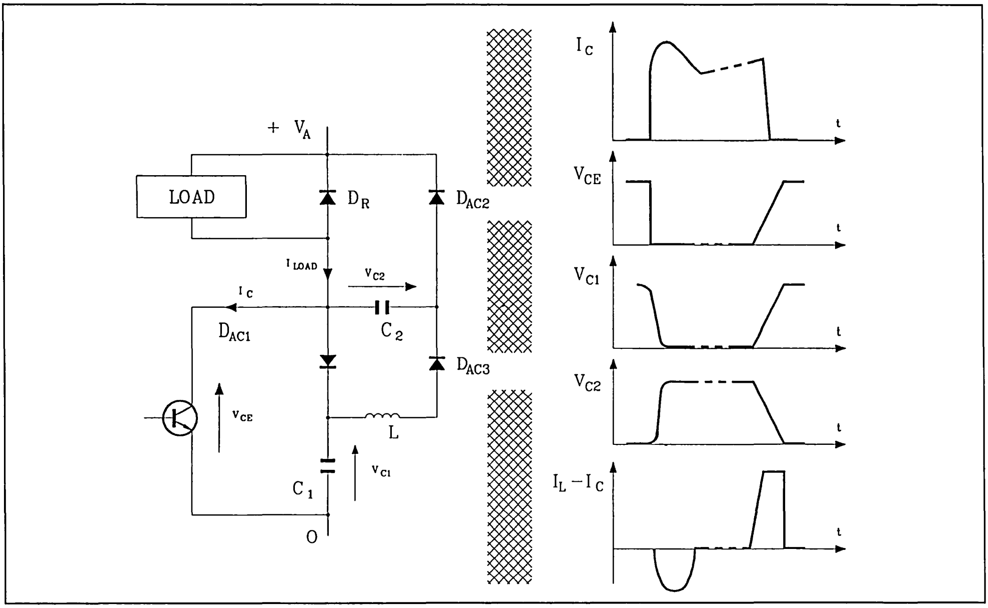
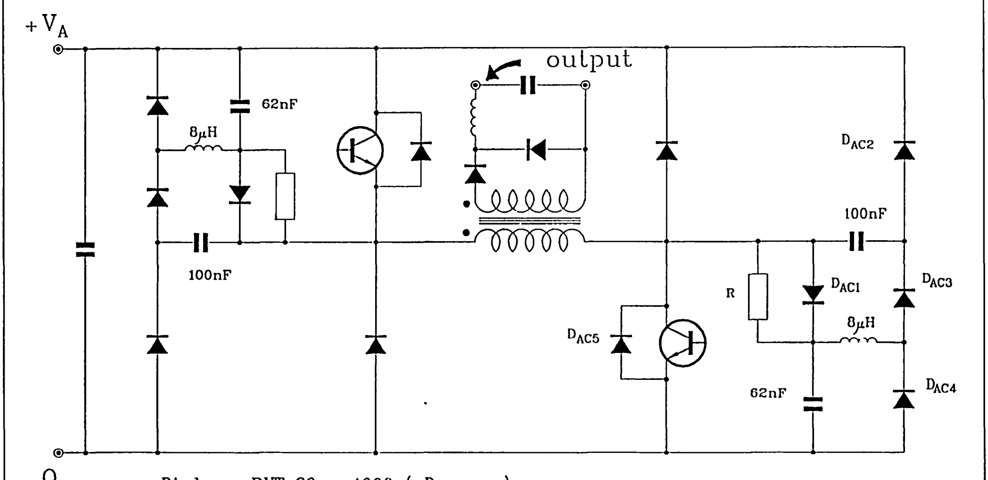


Figure 8 : Complete Diagram of a Power Converter Output Stage.



Diodes: BYT 30 − 1000 (D AC ....)
Transistors: 2 x ESM 6045A

CONCLUSION

The technological constraints are very important in the design of converters supplied from the 380V - 440V mains.

The use of high voltage transistors with a V_{CEW} rating lower than the supply voltage requires certain precautions, but enables a fast switching speed to be achieved.

The magnetic components (transformer, filter-choke), technological choices are also important since they affect the overall performance of the equipment as well as their influence on the size of the active components.

Adding the snubber with energy recovery increases the efficiency of the power supply and the overall reliability.

This circuit constitutes a basis for the development of switched mode power supplies in the power range of 1 to 10kW for power supply, welding induction heating, battery charger and other high power applications.

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APPLICATION NOTE

POWER SEMICONDUCTORS FOR HIGH FREQUENCY AC/DC CONVERTERS SUPPLIED ON THE 380/440V MAINS

By L. PERIER & J.M. CHARRETON

INTRODUCTION

This paper is the result of the development in our laboratory of different switches and converters able to operate at ultrasonic frequency, supplied directly from the rectified 380/440V mains.

This paper presents, in the first part, a typical specification for the converter and power switches.

The second part describes several switches and driving circuits optimized for those requirements.

1. SPECIFICATION :

Our objective was to develop switches and drivers optimized for AC/DC converters supplied on the industrial 380/440V mains, switching at ultrasonic frequency as used in Switch Mode Power Supply, battery charger or welding converter applications.

We based our development on the design of a 5KW asymetrical half bridge (2 transistor forward) converter. An equipment of 10kW could be design with the same switches mounted in full bridge or in the assembly of two asymetrical half bridge operating in antiphase.

Because of the high voltage supply, the blocking voltage capability of the switches is 1000V. In order to minimize the transformer and filters size and the acoustic noise a switching frequency over 20kHz is required.
In a 5kW asymetrical half bridge supplied by the 380V mains, the maximum duty cycle of conduction of the power switches is 50% of the total period. The current in the switch is 15A. Consequently the RMS current in the switch is 11A.

In order to use a very small heatsink the conduction losses in each switch are minimized (30W).

Auxiliary supplies for the power switches are also excluded in order to minimize the volume and the cost of the auxiliary circuitry.

2. A 1000V MOSFET SWITCH :

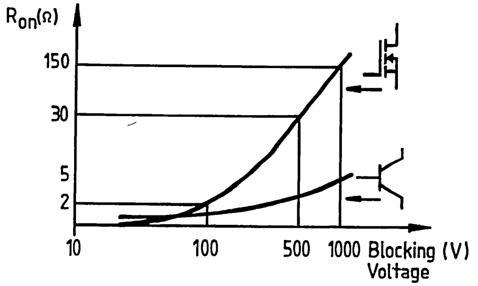
Power MOSFET technology is well adapted for the design of switches able to operate at high frequency. 1000V MOSFETs exist and they present the classical advantages of the MOSFET technology : low drive consumption, good turn-off safe operating area, high over current capability, ...

But the resistance of the epitaxial layer required to withstand the blocking voltage V_{DS} (if 250V) is approximately proportionnal to $V_{DS}^{2,5.}$ Consequently, the on resistance of the Power MOSFET increases rapidly with the blocking voltage capability V_{DSS}.

The only way to reduce the conduction losses with a 1000V MOSFET is to operate at very low current density and to use very large die areas.

In our design, one switch requires a Ron of 0.15 ohm (Tj = 25°C). That means the paralleling of 25xSTHV102 (3.5 ohms in SOT93 package) or more reasonably 5xST5MG40 (0.7 ohm in ISOTOP package).

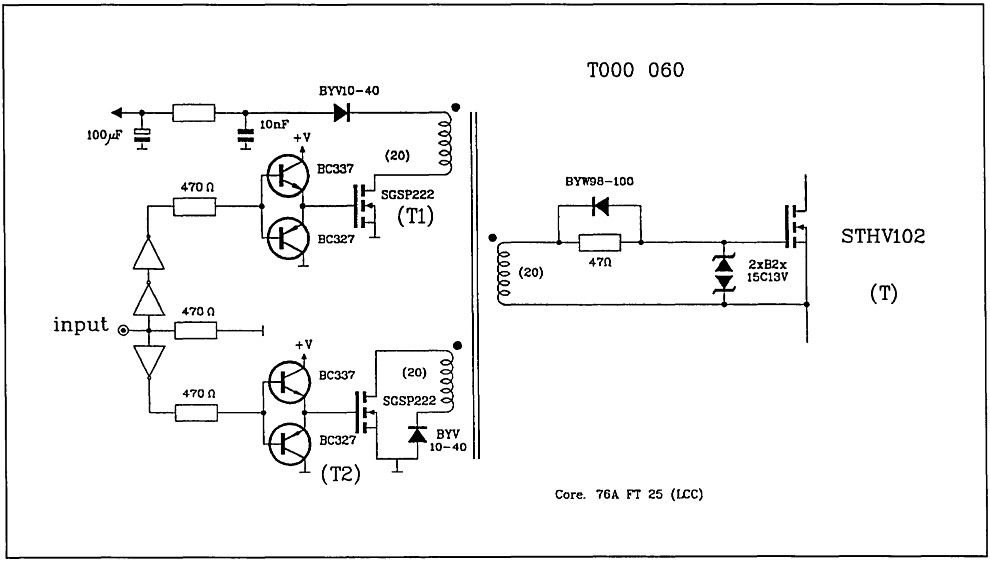
Figure 1 : ON Resistance $R_{(on)}$ versus Blocking Voltage $V_{off.}$
(die area = 1mm2 - junction temperature = 100°C).



The gate drive presented in figure 2 provides the galvanic isolation of the drive signal and avoids auxiliary supplies.

When the signal MOSFET T1 is on, the power MOSFET T is on. When the signal MOSFET T2 is on, the driving transformer is short circuited and discharges the gate source capacitance of T, turning Power MOSFET T 'off'.

Figure 2 : Schematic of the Power Switch and Driver.



3. A CASCODE/EMITTER SWITCHING SWITCH :

50V high density Power MOSFET can operate at a current density 100 times the current density of 1000V MOSFET for the same conduction losses (typically 2A/mm2 instead of 0,02A/mm2).

The current density of a 1000V bipolar transistor is in the region of 0.4A/mm^2. For applications requiring the same current capability and the same dissipation, the 1000V MOSFET requires about 30 times more silicon than the equivalent bipolar solution resulting in a substantially higher power switch cost.

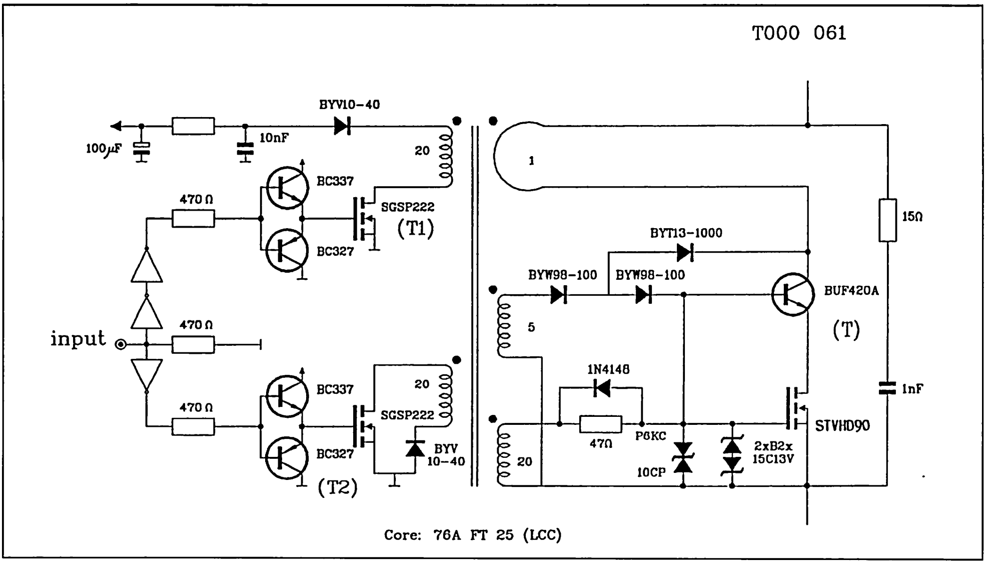
Bipolar transistors developed with highly interdigitated technologies such as the Easy-To-Drive technology (ETD) have a very fast fall time compatible with operation at high frequency.

Consequently a solution using a high density 50V Power MOSFET (STVHD90) and a 1000V bipolar in ETD technology (BUF420A) in cascode configuration has been developed.

The driving circuit presented in figure 3 requires only one transformer to provide the voltage control of the MOSFET and the base current of the bipolar.

When the signal MOSFET T1 is on, the power switch T is on. The turn-on of the signal MOSFET T2 turns-off T.

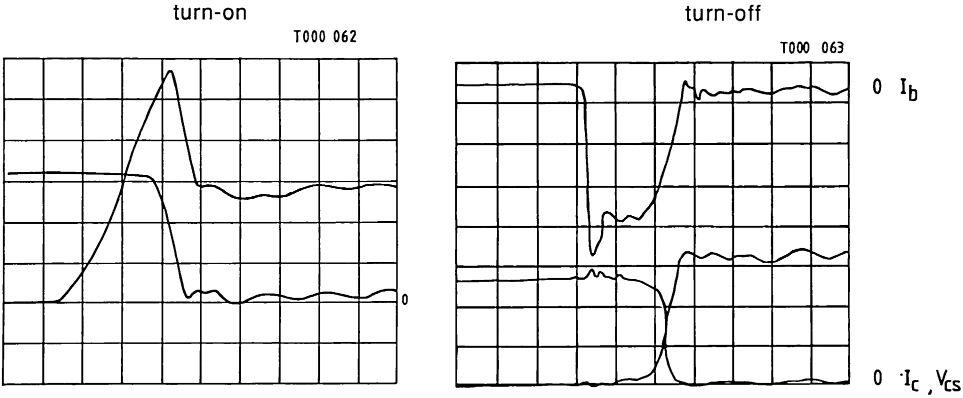
Figure 3 : Schematic of the Cascode Switch and Driver.



As presented in figure 4, the cascode switch is very fast at turn-off. A Storage time less than 500ns and fall time less than 20ns have been obtained. The rate of fall of the collector current is very high (2000A/µs). The use of low inductance wiring methods and packages is a condition for the design of this circuit. A turn-off snubber (R, C) limits oscillations and maintains the bipolar switch inside its specified Reverse Bias Safe Operating Area.

The rate of rise of the collector current (dI/dt)on at turn-on is limited in the converter by the leakage inductance of the power transformer. Therefore turn-on speed of the switch is not very critical. A (dI/dt)on of 50A/s has been obtained.

Figure 4 : Cascode Switching Waveforms.



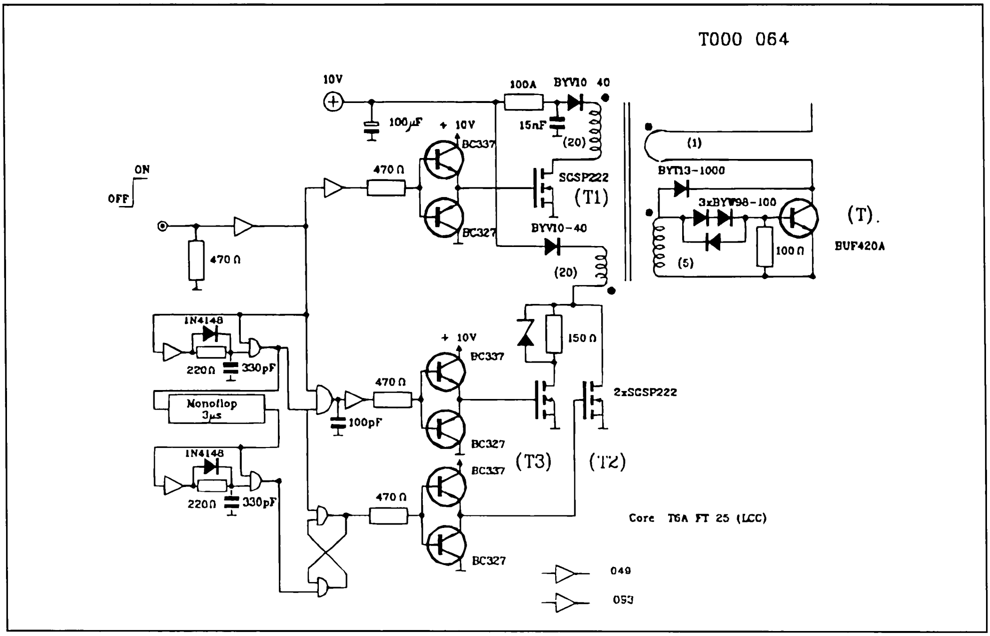
Ic, Ib : 5A/div. Vcs : 200V/div. t : 0,2µs/div.

4. BIPOLAR SWITCH :

The elimination of the 50V high density MOSFET is the last step to reduce the conduction losses and the number of power packages. But the remaining bipolar transistor must be driven with a negative bias on the base/emitter junction in order to obtain fast turn-off and a blocking voltage capability extended up to V_{CEV}.

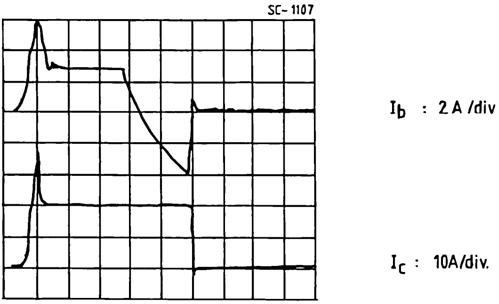
In the circuit presented in figure 5, when T1 is on the power switch T is on. T is turned-off when T2 and T3 are on. T2 drives the negative base current of T and is turned-off after 3µs. T3 resets the magnetic flux in the driver transformer before the next turn-on of T.

Figure 5 : Bipolar Switch and Driver.



With this circuit, a BUF420A switches 20A with a storage time of 2µs and a fall time of 50ns at Tj = 100°C, see figure 6.

Figure 6 : The Bipolar Switching Waveforms.



5. CONCLUSION :

This paper proposes different switches and drivers able to operate in AC/DC converters switching at ultrasonic frequency and directly supplied from the rectified 380/440V mains.

The availability of 1000V MOSFET makes possible the design of switches with high frequency capability, large turn-off safe operating area, large overcurrent capability and easily controlled gate drive. A limitation of this solution is in the trade-off between the conduction losses and the current density. A medium current 1000V MOSFET switch needs several packages in parallel or a big heatsink.

A switch developed with 1000V bipolar transistor has low conduction losses and few parallel packages. Thanks to the use of highly interdigitated very fast technology (ETD) the switching speed is comparable to the MOSFET solution. But the turn-off delay time is longer and the driving circuitry is more complex than a MOSFET circuit.

A Cascode circuit has the advantages of both bipolar and MOSFET technologies. It allows low dissipation with short turn-off delay time and simple driving circuitry. High density low voltage MOSFETs minimises the increase of the forward drop. Because of the very fast turn-off speed, special care must be taken with the wiring.

Driving circuits using only one transformer to provide the galvanic isolation power/logic and the energy to drive the power switches are also presented and adapted to each configuration of power switch.

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APPLICATION NOTE

OPTIMISED POWER STAGES FOR HIGH FREQUENCY 380/440VAC MEDIUM POWER SWITCH MODE SUPPLIES

By C.K. PATNI & L. PERIER

ABSTRACT

This paper presents the elements necessary to make the optimum choice of power semiconductors (for the transistors and secondary diodes) and the power stage configurations for medium power SMPS (from 1kVA to 15kVA).

The power stage practically realized comprises of an asymmetrical bridge forward converter. An optimised power switch combining bipolar and MOSFET technologies is developed. It is capable of switching in excess of 50A at 25kHz on the 380/440VAC rectified three phase mains.

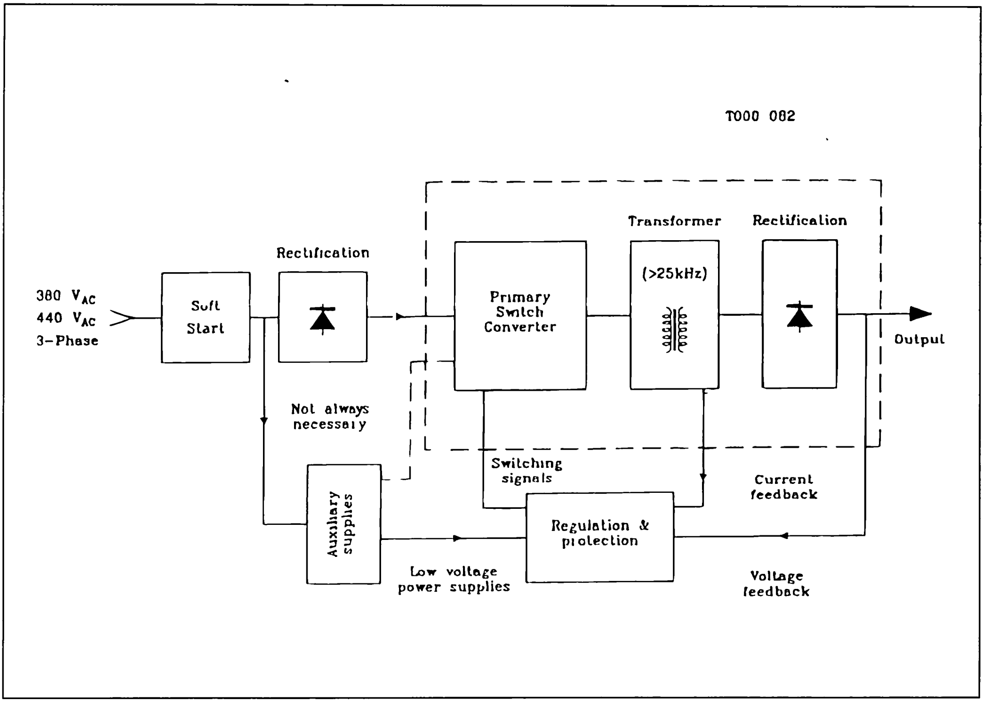
Secondary diode choice depends largely on the transformer ratio and the desired output D.C. voltage. Conduction losses at 25kHz govern the choice of secondary diodes.

INTRODUCTION

System designers of switch-mode solutions for electric welders, battery chargers and computer power supplies need to choose the power-stage configuration, power semiconductors and regulation best suited for their application. This paper provides data necessary to make this choice.

Figure 1 illustrates a system block diagram of a typical medium power SMPS with the primary operating directly on the 380/440VAC rectified mains. The paper limits the discussion to the power-stage of the SMPS. Power stage configurations such as asymmetrical bridge, full-bridge and half-bridge converters are compared. Bipolar and MOSFET technologies are compared. Schottky and fast recovery epitaxial diodes are considered for the secondary rectification.

Figure 1 : Block Diagram of a Medium Power SMPS.

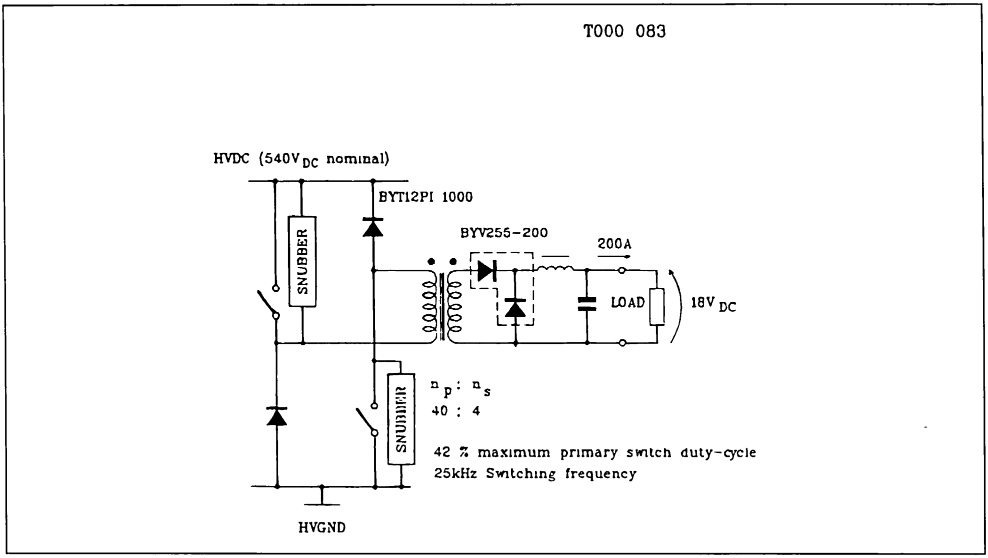


POWER STAGE CONFIGURATIONS

For medium power applications (1kVA to 15kVA), the choice of the converter on the 3-phase industrial mains is between the asymmetrical bridge, capacitor-split half-bridge and full-bridge converters [1]. The half-bridge and full-bridge converters are symmetrical converters and thus require smaller input filtering than asymmetrical bridge converters. However, it is possible to combine two asymmetrical bridge converters operating in antiphase in order to obtain a power stage, which viewed from its input and output current waveforms, appears to be a symmetrical full-bridge converter.

The asymmetrical bridge converter (figure 2) comprises of two power switches in series with the load connected between the two switches. Simultaneous conduction of these power switches when a fault condition exists on the secondary of the transformer is not catastrophic as there is at least the leakage inductance of the transformer limiting the rate of rise of primary switch currents. The controlled rate of rise of primary current enables low-cost feedback protection circuits to react to the fault condition and turn-off the primary switches.

Figure 2 : Asymmetrical Bridge Converter - The Developed Power Stage.



The use of turn-off switching-aid-networks (snubbers) does not pose a problem in asymmetrical bridges. In half-bridge and full-bridge converters, the use of turn-off snubbers generally necessitates the use of turn-on snubbers required to limit the rate of rise of primary switch currents [2].

The power stage developed utilizes the asymmetrical bridge converter because of these reasons.

For very high output power capability (in excess of 10kVA), the full-bridge converter can be the optimum choice provided the circuitry necessary to maintain volts-seconds symmetry can be easily implemented. The full-bridge operates the transformer in two magnetic quadrants. Consequently the size of the transformer can be reduced. Figure 3 illustrates a full-bridge converter which incorporates the advantages of the asymmetrical bridge structure (no catastrophic simultaneous conduction of transistors and easy snubber networks) with the advantages of the symmetrical converter of reduced transformer size.

TECHNOLOGY CHOICE

Bipolar and MOSFET technologies are best adapted for high frequency (greater than 20kHz) medium power SMPS. Figure 4 illustrates the on-state resistance for 1mm2 of silicon surface versus blocking voltage for high voltage power MOSFETs. The resistance of the epitaxial layer required to withstand blocking voltage VDS (in excess of 250V) is approximately proportional to VDS2.5. Consequently, even if this theoretical limit is approached, the on-state resistance increases rapidly as blocking voltage VDS increases for high voltage power MOSFETs.

Figure 3 : A Quasi-asymmetrical Full-bridge Converter.
– Transformer provides inductance between two switches in series.

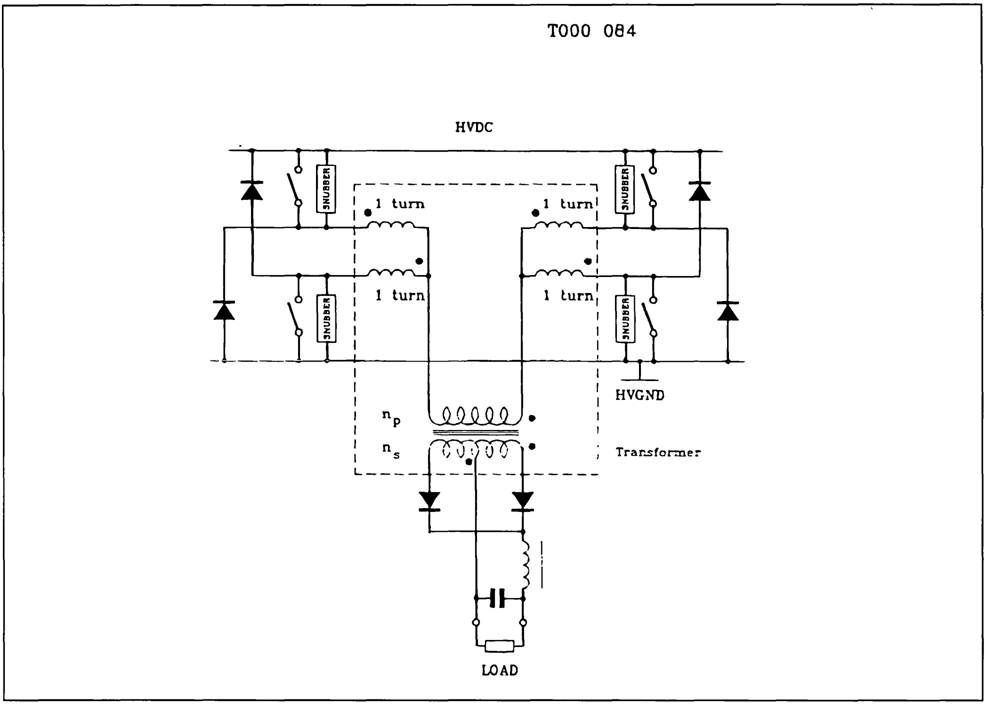
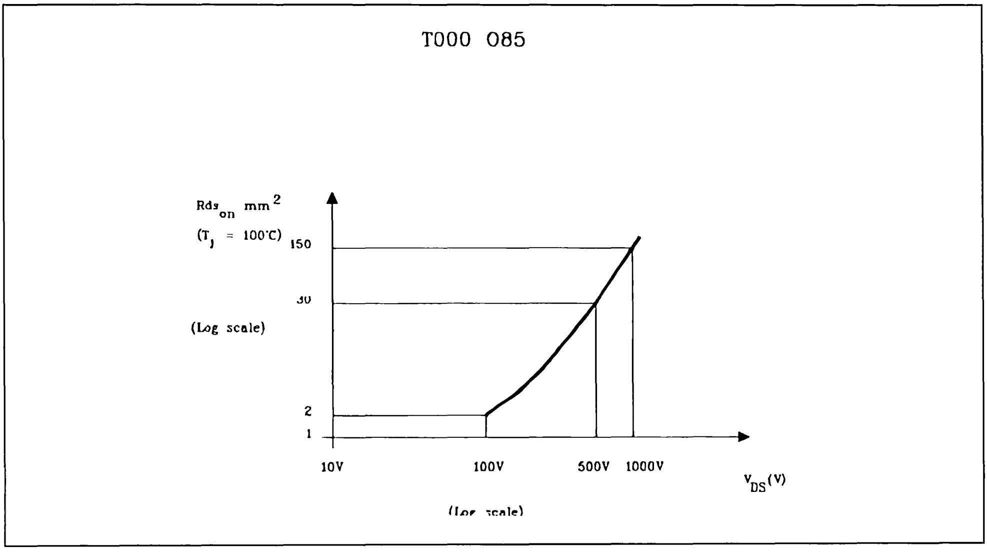


Figure 4 : MOSFET Blocking Voltage versus on-state Resistance/mm^2.



The current density for a 1000V bipolar transistor, such as a BUF410A is in the region of 0.4A/mm^2 when conducting a nominal current of 10A with an on-state collector-emitter voltage of 2V maximum at 100°C junction temperature. The equivalent on-state resistance for a 1000V bipolar is thus approximately 5 Ohm/mm^2 whereas for a 1000V Power MOSFET is 100 Ohm/mm^2. For an application specifying only nominal switching current capability, the Power MOSFET solution requires 30 times more silicon than the equivalent bipolar solution (not considering the drive requirements) resulting in substantially higher power transistor cost.

Even though higher current density is achieved with bipolar transistors, the Power MOSFET has the clear advantage of a larger safe operating area at turn-off, larger peak current capability and easy voltage controlled gate drive. The 1000V bipolar transistor has the disadvantage of longer turn-off delay time (due to its storage time) and high drive current requirements. A cost comparison of a Power MOSFET based solution with a bipolar based solution should thus be based on cost of the switch together with its drive, protection and auxiliary power supply circuits.

Quantitative comparison is complicated by the very different operational characteristics of Power MOSFETs and bipolar transistors. However, qualitative comparison leads the authors to conclude the following :

1) In medium power SMPS, where bipolar and Power MOSFET technologies can be used, the technology comparison must be based on cost evaluation of solutions meeting the specification both for PEAK transistor switching current as well as AVERAGE/RMS transistor switching current.
2) Generally the Power MOSFET is sized for the RMS transistor switching current, whilst verifying that the peak current capability of the device meets the specification.
3) The bipolar solution is sized on the peak transistor switching current specified in the application.

THE DEVELOPED POWER STAGE

The developed power-stage has the characteristics listed in table 1. The asymmetrical bridge forward converter was used with the maximum duty cycle limited to approximately 40%. The continuous rated primary current was 20A (for 40% duty cycle). The peak primary switch current capability was 50A. The transformer design (provided in appendix I) had a primary to secondary turns ratio of 10 to 1. Consequently the continuous rated secondary output current was 200A at a secondary output voltage of approximately 18V. The secondary output peak current was 500A when the primary switch current was 50A.

Table 1 : Developed Power Stage Characteristic.

Comments	Value
Input Supply Voltage	380/415/440V$_{AC}$
Continuous Primary Current	20A
Peak Primary Current	50A
Maximum Duty Cycle	40%
Switching Frequency	25kHz
Continuous Secondary Current	200A
Peak Secondary Current	500A
Secondary Voltage (nominal)	18V

THE ASYMMETRICAL BRIDGE CONVERTER

A solution for the converter, based on bipolar and Power MOSFET technologies, encompassing the advantages of high switching current density and voltage controlled drive, was developed : this converter for the power stage was based on the CASCODE switch [3]. Due to the relatively large nominal primary switch current (20A), a bipolar based solution was necessary. The CASCODE switch required a simple voltage controlled drive signal. No floating auxiliary supplies were required as the base current for the bipolar transistor was provided by a proportional current transformer. Figure 5 illustrates the primary CASCODE switch (based on bipolar and MOSFET technologies) which is used in the asymmetrical bridge converter.

The switch comprises of a BUV298A bipolar transistor (B1) in ISOTOP package and a high density 50V (23 mOhm at 25°C) Power MOSFET STHVD90 (F1) connected in CASCODE. A 1000V Power MOSFET STHV102 (F2) provides the initial base current. A 50V Power MOSFET BUZ11 (F3) turns-on when the STHVD90 CASCODE MOSFET (F1) is turned-off. Consequently the collector current is extracted via the base through Power MOSFET F3. A turn-off snubber (comprising of R1, D1 and C1) maintains the turn-off within the reverse bias safe operating area (RBSOA) of the bipolar BUV298A.

The primary switch conduction losses (at nominal 20A current for 40% duty cycle) are approximately 30W at a 100°C junction temperature for the CASCODE switch. The primary switch could be based purely on 1000 volts Power MOSFETs (STHV102, 3.5 ohm at 25°C) in parallel. However, for 10 of these Power MOSFETs in parallel, under the same operating condition, the conduction losses would be approximately 90W.

Figure 6 illustrates a pulse transformer gate drive used with the primary switches. This gate drive provides positive and negative bias of the Power MOSFETs in the CASCODE switch. The pulse transformer also provides the isolation between the primary switches and the control logic. With this gate drive, the asymmetrical bridge converter requires no auxiliary power supplies.

Figure 5 : The Developed CASCODE Asymmetrical Bridge Converter.

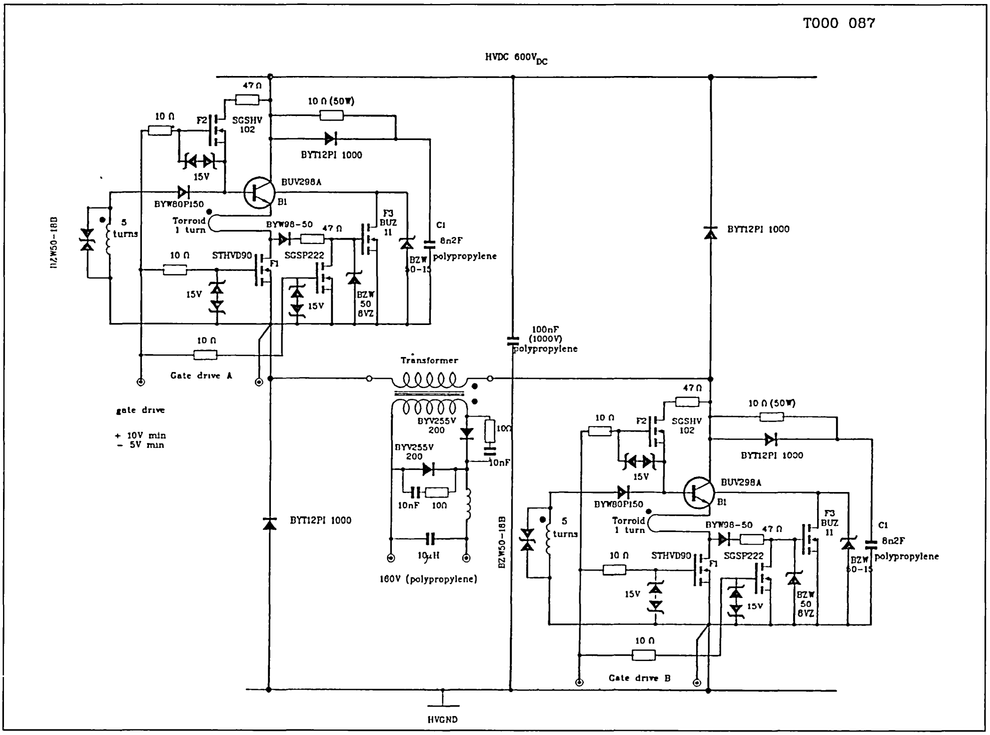
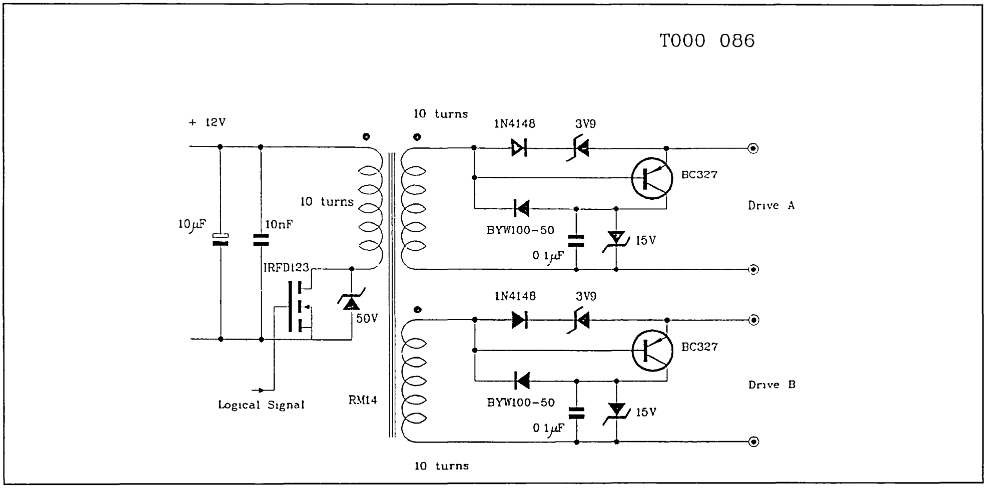


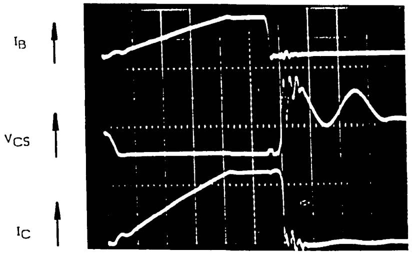
Figure 6 : Isolated Pulse Transformer based Gate Drives for Power Stage.



ASYMMETRICAL BRIDGE OPERATION

Figure 7 illustrates the extremely fast switching and short (less than 500ns) storage time at turn-off obtained using this CASCODE switch. The primary switch was tested with a bridge high voltage DC rail of 600V_{DC}, primary current of 50A at 25kHz switching frequency.

Figure 7 : CASCODE Primary Switch Commutation – (I_{PEAK} = 50A).



t = 1µs/div
I_B = 10A/div
V_{CS} = 200V/div
I_C = 20A/div

SECONDARY RECTIFYING DIODES

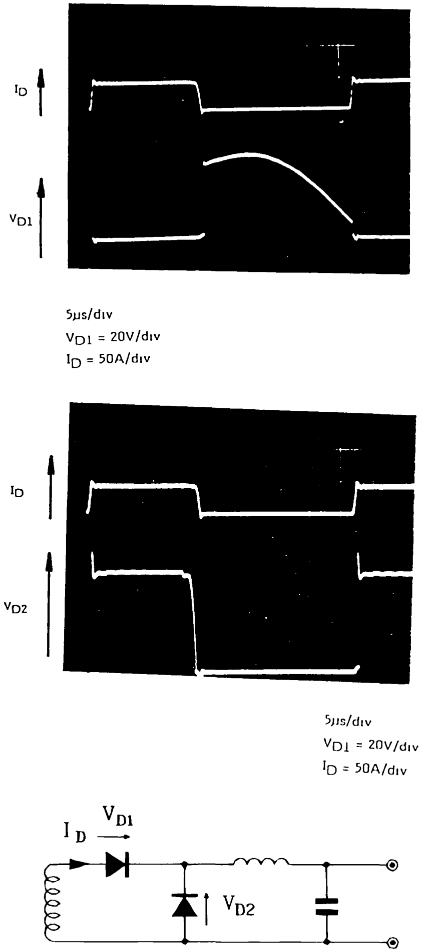
The transformer had a primary to secondary turns ratio of 10 to 1. Consequently the voltage experienced by the secondary diodes at 600V_{DC} HVDC was 60V in addition to any overvoltage due to parasitic inductances.

Schottky diodes which have extremely low conduction voltage (approximately 0.4V) can not be used for this application as they are limited in blocking voltage to approximately 50V. If the secondary output voltage was 5V (for example, computer applications), the transformer ratio would have been higher thus permitting the use of Schottky diodes.

The diodes best suited for the specified secondary output are fast recovery epitaxial diodes ('FRED'). FRED diodes BYV255V200 were used in the circuit having conduction voltages of approximately 0.85V at rated current and at 125°C junction temperature. Figure 8 illustrates the blocking voltage experienced by the secondary diodes with resistor/capacitor snubber networks.

At continuous rated output power, each secondary diode conducts for approximately 50% of the time an average current of 100A. Assuming a junction temperature of 125°C, the instantaneous forward voltage drop is 0.85V at approximately 100A. Hence diode conduction losses are approximately 85W ; (0.85Vx100A = 85W).

Figure 8 : Secondary Diode Switching Waveforms.



5µs/div
V_{D1} = 20V/div
I_D = 50A/div

5µs/div
V_{D1} = 20V/div
I_D = 50A/div

The leakage inductance between primary and secondary of the transformer is generally large such that the rate of decay of current in these diodes is controlled. Hence the reverse recovery is not critical. Thus at 25kHz switching frequency conduction losses are the prime criteria for the choice of the secondary diodes.

CONCLUSION

Bridge converters for medium power SMPS (1kVA to 15kVA) have been discussed. Turn-off snubbers and low-cost protection circuitry can be used with asymmetrical converters. A quasi-asymmetrical full-bridge converter has been proposed for high power SMPS which operate the transformer in two magnetic quadrants.

The 1000V Power MOSFET is a well adapted choice for low continuous power SMPS especially when high pulse current capability is specified for the primary switch. Bipolar transistors have high current density and are better adapted for medium power SMPS.

The choice of secondary diodes at 25kHz switching frequency is based primarily on conduction losses.

The developed power stage utilized the CASCODE configuration for the primary switch. This solution had the advantages of both the bipolar and Power MOSFET technologies. Fast epitaxial rectifying diodes (FRED) have been used in this power stage.

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1. SGS-THOMSON Microelectronics, 1984, "Transistor and Diodes in Power Processing", 187-198.
2. SGS-THOMSON Microelectronics, 1978, "The Power Transistor in its Environment", Chapter 8, 181-206.
3. Robinson F. and Williams B.W., 1987, "Emitter Switching High-Power Transistors", EPE Conference, 55-59.

ANNEX I

TRANSFORMER DESIGN

The transformer design parameters for the developed asymmetrical bridge forward converter are :

$V_{MIN} = 500V_{DC}$	$V_{MAX} = 600V_{DC}$
$V_{OUTPUT} = 18V$	$I_{OUTPUT} = 200A$
Duty cycle = 0.4 (MAX)	Freq. (f) = 25kHz

For forward converter operation equation [1] provides an approximate practical method of calculating the ferrite cross-sectional area.

$$S = K\sqrt{V_{OUTPUT}.I_{OUTPUT}} = 900mm^2 \quad [1]$$

S = cross-sectional area in mm^2

V_{OUTPUT} = Output secondary voltage

I_{OUTPUT} = Output secondary current

$K = 15$ (for B50 ferrite material).

Two GER65/33/27 (LCC) E shape B50 ferrites were sandwiched together to form a ferrite core cross-sectional area (S) of $1064mm^2$.

Minimum number of primary turns (N_p) can be calculated using equation [2].

$$Np > \frac{V_{MAX}\ \text{Duty cycle}}{B_{MAX.}\ S.f} > 36 \quad [2]$$

N_P was made equal to 40.

The number of secondary turns can be calculated using equation [3].

$$Np > \frac{V_{OUTPUT.}\ Np}{V_{MIN.}\ \text{Duty cycle}} > 3.6 \quad [3]$$

N_S was made equal to 4. Hence the primary to secondary turns ratio was 10 to 1. Consequently peak primary current (20A) was one tenth of 200A secondary current.

The primary RMS current can be calculated using equation [4].

$$I_{RMS} = I_{PEAK}.\sqrt{\text{Duty cycle}} = 20\ \sqrt{0.4} = 12.5A \quad [4]$$

Using a current density of $5A/mm^2$, the primary was wound using two wires in parallel of 1.25mm diameter.

The secondary wire cross-sectional area was $20mm^2$ calculated in a similar manner as for the primary wire.

MEASURED PARAMETERS

Leakage inductance = 90µH

(secondary short-circuited)

Primary inductance = 17.5mH

Insulation material used between primary and secondary was capable of supporting $1500V_{AC}$ at 50Hz. Three pieces of 0.65mm plastic film were used for this isolation.

SGS-THOMSON
MICROELECTRONICS

APPLICATION NOTE

ANALYSIS AND OPTIMISATION OF HIGH FREQUENCY POWER RECTIFICATION

By J.M. PETER

How can the performance of power electronics be improved ? Today, in many cases, it is the job of the designer. The fast rectifier switching behaviour depends on the operating conditions. The analysis and the optimisation of these conditions can be an important source of improvement in performance.

1. SWITCH-OFF OF FAST RECOVERY RECTIFIERS

It is possible to define theoretically two types of switch-off[1].

1.1. FREE-WHEEL MODE (figures 1 & 2)

When the rectifier switches-off it is always in parallel with a voltage source. In this case the assumption is that the parasitic inductances are negligible. This type of behaviour can be met in the majority or rectifier applications such as free-wheel rectifiers in step-down and step-up converters, full wave rectifiers, etc... (figure 2). Generally, a rectifier in free-wheel mode is always in parallel with a voltage source when it turns-off.

1.2. RECTIFIER MODE (figures 1 & 3)

An inductance defines the dI_F/dt (decreasing slope of the rectifier current) and when the rectifier switches-off it is always in series with this inductance. This type of behaviour can be met in some applications such as rectifiers in flyback converters and many functions in thyristor circuits, (figure 3). Generally speaking a rectifier in the rectifier mode is always in series with an inductance L and this inductance L defines the dI_F/dt. The fundamental difference between these two modes is that in the rectifier mode there is a stored energy $1/2LI_{RM}^2$ due to the series inductance. After the turn-off this energy is dissipated in the rectifier and/or in the associated circuits.

1.3. TURN-OFF LOSSES

Free-wheel mode

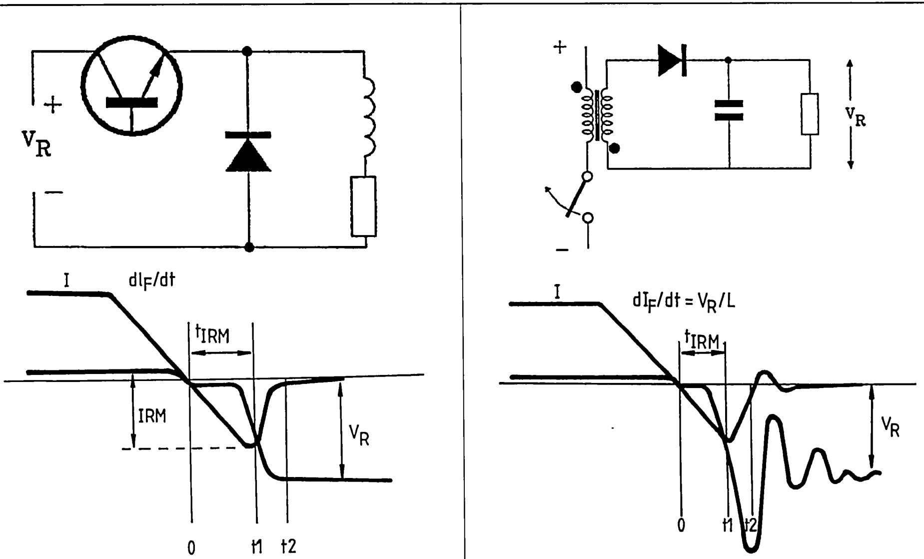
W_{OFF} is the energy dissipated in the rectifier during turn-off.

$$WFR = \int_{t_1}^{t_2} VI dt \text{ (refer to figure 1)}$$

Low voltage (< 200V) fast rectifiers have a high internal capacity and the minority carriers have a very short life time. High voltage fast rectifier have a thicker N silicon layer and the minority carriers have longer life time and consequently different behaviour during the turn-off condition blocking state. (Higher I_{RM} and t_{IRM} - more damping).

Figure 1 : Fast Rectifier : the two turn-off modes.

a) Free-wheel Mode. b) Rectifier Mode.



a) d_{IF}/dt FIXED BY THE TRANSISTOR (or by the external circuit)

LOW LOSSES IN THE RECTIFIER

$W_{OFF} = K \cdot V_R \cdot I_{RM} \cdot T_{IRM}$

$(0.15 < K < 0.35)$

NO OSCILLATIONS AND OVERVOLTAGE

b) d_{IF}/dt FIXED BY THE INDUCTANCE

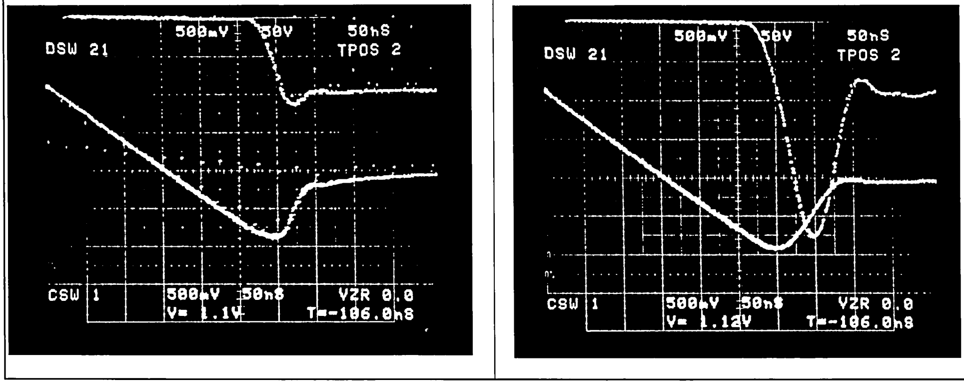
$dI_F/dt = V_R/L$

HIGH LOSSES IN THE RECTIFIER

$W_{OFF} = K \cdot V_R \cdot I_{RM} \cdot T_{IRM} + 1/2\, L J^2_{RM}$

When a snubber is used some of the energy is dissipated in the snubber.

ALWAYS OVERVOLTAGE AND OSCILLATIONS IN SOME CONDITIONS



5A/div. 50V/div. 0.05µs/div.

BYT30 – 1000 – $I_F = 3A$ – $dI_F/dt = -75A/\mu s$ – $V_R = 100V$ – $T_{CASE} = 25°C$

According to the experimental results the turn-off energy loss $(W)_{FR}$ in the free-wheel mode can be written :

$$(W)_{FR} = K \times V_R \times I_{RM} \times t_{IRM} \ (1)$$

K(1) is a constant that depends on the thickness of the N type silicon layer.

Max Voltage Rating (V)	200	400	800	1000	1200
K	0.12	0.14	0.22	0.28	0.35

Rectifier mode

Losses in this mode, $(W)_{REC}$, are the sum of the stored energy $1/2\ L\ I_{RM}^2$ and the recovery energy $(W)_{FR}$:

$$(W)_{REC} = (W)_{FR} + 1/2\ L\ I_{RM}^2 \ (2)$$

In some cases, oscillations can occur. This depends on the damping due to the current tail effect after switch-off. When oscillations occur energy is dissipated during the oscillations partly in the rectifier and partly in the circuit. When snubbers are used a significant part of the energy is dissipated in the snubber.

2. PRACTICAL SWITCH-OFF BEHAVIOUR

The two cases, free-wheel mode and rectifier mode are simplified cases that are easy to simulate in a laboratory characterisation. In practical equipment there is always a possible overlap between the two theoretical modes, because :

1. No circuit is without parasitic inductances.
2. The rise time (or the fall time) of the switch is not infinitely fast when compared with the rate of change of current, dI_F/dt.

Experimental results show that in all cases the following formula can be used :

$$(W)_{OFF} = (W)_{FR} + 1/2\ L_S\ I_{RM}^2 \ (3)$$

Where L_S = series inductance

This important relationship is a useful tool for the designer, giving him the main parameters that influence the turn-off energy.

N.B. : The following relationship (4) is only true for the pure rectifier mode.

$$(W)_{OFF} = Q_R \times V_R \ (4)$$

Where Q_R = recovered charge

(1) K is experimental - Defined for SGS-THOMSON Microelectronics fast rectifiers.

Figure 2 : Rectifiers in Free Wheel Mode.

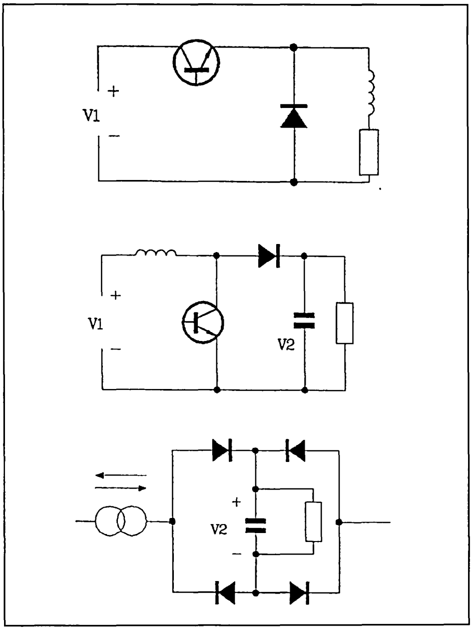


Figure 3 : Rectifiers in Rectifier Mode.

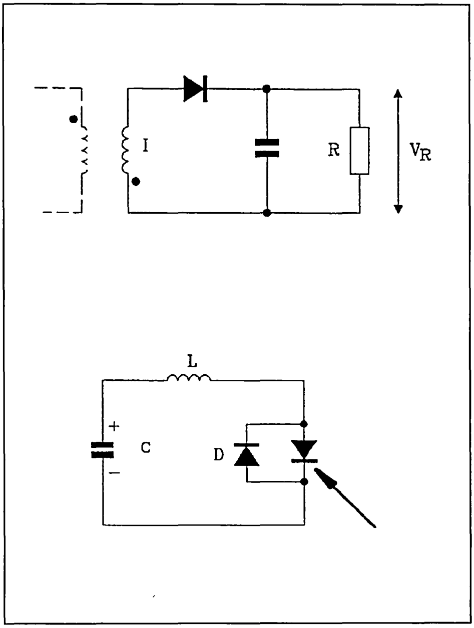
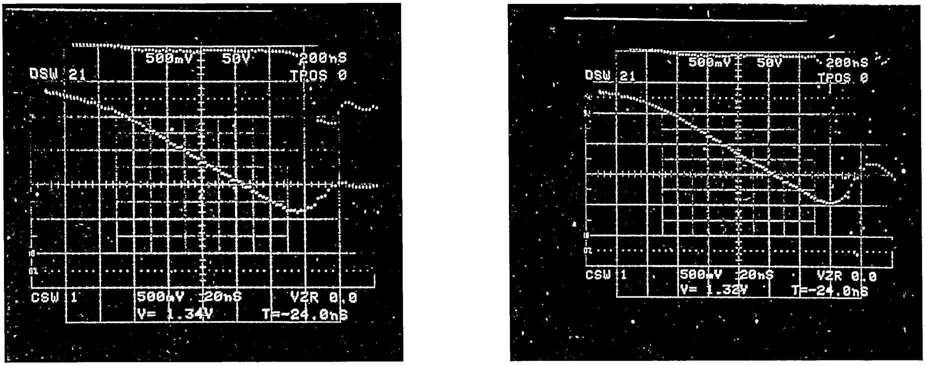


Figure 4 : Switch-off Behaviour of the Ultrafast BYT12-400V Rectifier (current rating 12A - voltage rating 400V).
Conditions : I_F = 13A dI_F/dt = – 150A/µs V_R = 100V T_{case} = 25°C.
In the case of rectifier mode : L = 0,6µH.
The turn-off lost energy calculated by the current and voltage is :
$(W)_{FR}$ = 3µJ free-wheel mode.
$(W)_{REC}$ = 10µJ rectifier mode.
The storage energy in the inductance is : 1/2 L I_{RM}^2 = 7.5µJ.



a) Free wheel mode.

b) Rectifier mode.

The use of this equation for a lot of practical circuits can be considered as a first approximation. It leads to over estimated losses, if the rectifier does not operate in pure "rectifier mode".

3. CHARACTERISTICS OF FAST RECTIFIERS

The characteristics of fast rectifiers are the result of a trade off between :

- Speed (I_{RM})
- Max voltage rating (V_{RRM})
- Forward voltage drop (V_F).

Example : 12A fast rectifiers.

Operating conditions

V_{RRM}		200	400	800	1000
Type		BYW81	BYT12-400	BYT12-800	BYT12-1000
T_j = 100°C	I_{RM}(A)	1.8	3.7	6	7.8
dI_F/dt = – 50A/µs					
	t_{IRM}(µs)	0.05	0.075	0.160	0.200
V_F	(V)	0.66 + 0.0071	11 + 0.021	1.3 + 0.031	1.3 + 0.031

I_{RM} increases with dI_F/dt (figure 5).

I_{RM} increases with T_j (figure 6).

The important points that emerge are :

1. High voltage fast rectifiers are not so fast as low voltage fast rectifiers, (comparing devices of equal current rating).
2. T_j and dI_F/dt have a strong influence on the reverse recovery current.

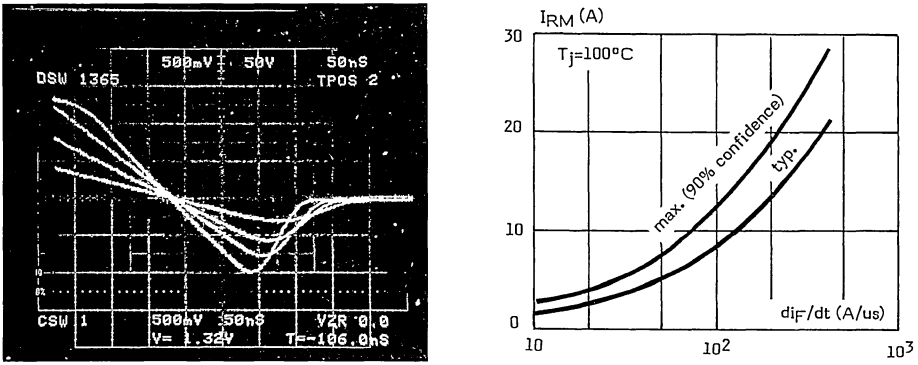
4. EXAMPLES

4.1. FLYBACK CONVERTER (figure 7)

The behaviour is as a pure rectifier ; the rectifier is driven by a current source, the inductor, L.

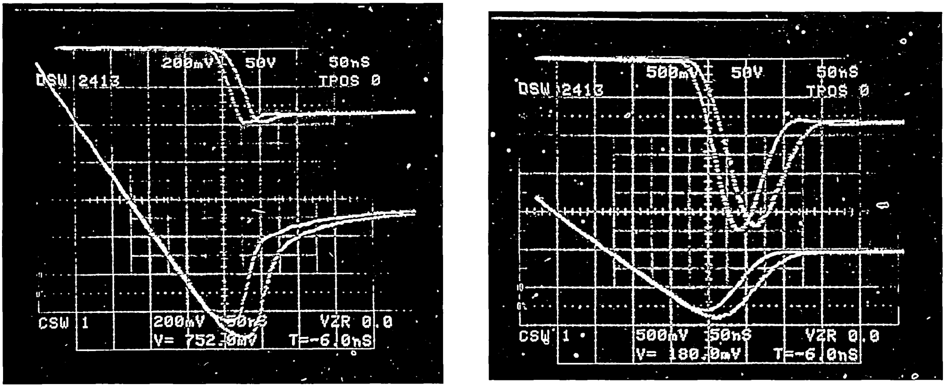
For a frequency less than 100kHz the switching losses are small in comparison to the conduction losses, because dI_F/dt defined by V_o/L is always small, (see table figure 7).

Figure 5 : Switch-off Behaviour of the Fast Rectifier BYT12P 1000 (current rating 12A voltage rating 1000V). Influence of the dI_F/dt.



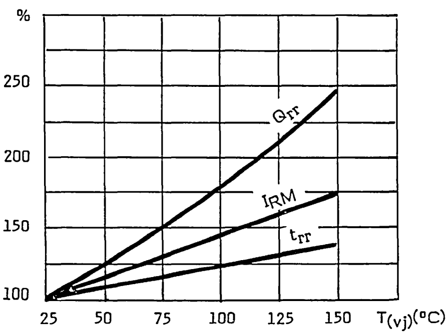
5A/div, 50ns/dıv, Tj = 25°C

Figure 6 : Switch-off Behaviour of the Fast Rectifier BYT12 1000 Influence of T_J.
One Curve T_J = 25°, one curve T_J = 60°.



100V/C, 2A/div, 50ns/div
Free-wheel mode

100V/C, 2A/div, 50ns/div
Rectifier mode



How can the designer reduce the losses ?

1. The ratio I peak/I_{AVG}, is very unfavourable in this type of circuit. It is essential when the peak voltage is less than 200V that the "high efficiency ultra fast" family which have very low conduction losses are used. When the peak voltage is greater than 200V one solution is to use a rectifier with higher current rating.

Example :

In the same circuit at 12A with :

- BYT12-800 : conduction losses = 7.6W, a 12A rectifier.
- BYT30-800 : conduction losses = 6W, a 30A rectifier

2. Reduce the junction temperature. If Tj is decreased from 100 to 75°C the switching losses are reduced by 20%.

4.2. SMALL CURRENT RECTIFIER (figure 8)

A transformer with a leakage inductance measured on the secondary side $L_S = 1\mu H$ supplies a fast diode D. The average output current is 0.8A and the output voltage is 48V.

The designer wants to use the popular diode BA157. This is not possible because the total power dissipation is 1.15W at 40kHz. At this frequency he can only use a popular 2A current rated diode (for 0.8A rectified current) and at 200kHz there is no solution with popular diodes (see table in figure 8).

How can the designer reduce the losses ?

1. Choose a diode in the "high efficiency family". For example he can use the BYW100 for 40kHz to 200kHz, (see table figure 8).
2. Reduce the leakage inductance : with a leakage inductance $L_S = 0.1\mu H$, BY218 at 200kHz (1.24W, $\Delta T_j = 93°C$).

4.3. FULL WAVE OUTPUT RECTIFIER

There are two different full wave rectifying circuits.

4.3.1. VOLTAGE SOURCE - CURRENT OUTPUT

Current and voltage behaviour are indicated in figure 9. The inductance L_S is the leakage inductance of the insulation transformer.

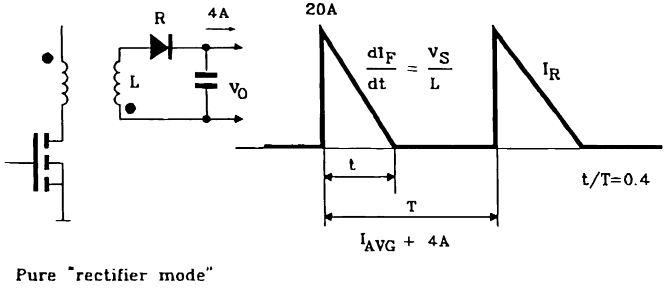
The 4 rectifiers operate in an intermediate mode between "free wheel" and "rectifier", because there are some 1/2 $L_S I_{RM}^2$ losses.

4.3.2. CURRENT SOURCE - VOLTAGE OUTPUT (figure 10).

In this circuit, each rectifier operates in "free wheel" mode. The series inductance does not introduce additional losses. (This assummes there is no parasitic inductance between the rectifiers and the capacitor C).

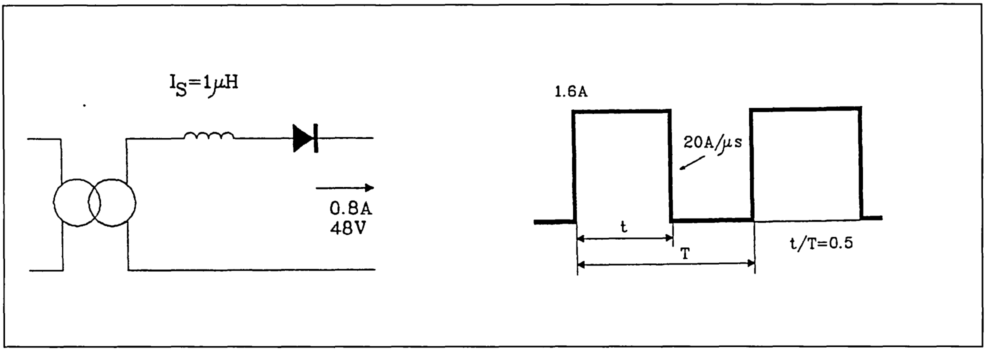
How can the designer reduce the losses ?

Figure 7 : Flyback Rectifier Output Average Current 4A.
Below 100kHz the switching losses are negligible, in comparison with the conduction losses.
The reason is limited dI_F/dt, consequently limited I_{RM}.



V_O (V)	12	48	100
Rectifier	BYW81-100 "High Efficiency"	BYT12-400	BYT12-800
Conduction Losses (W)	3.2	6	7.6
Switching Losses a 50kHz (W)	0.006	0.05	0.81
Switching Losses a 200kHz (W)	0.05	0.5	5.5

Figure 8 : The Popular Diodes BA157 – BY218 are not Fast Enough for High Frequency Rectifying. The BYW100 is well adapted.



DIODE	BA157 Popular	BY218 Popular	BYW100-200 High Efficiency
I_{RM} a 100°C dI/dt = – 20A/µs (A)	2.8	2.8	0.75
t_{IRM} a 100°C dI/dt = – 20A/µs (A)	0.14	0.14	0.05
$(W)_{FR}$ (µJ)	2.08	2.08	0.01
1/2 L_S I_{RM}^2 (µJ)	3.9	3.9	0.28
Conduction Losses (W)	0.944	0.744	0.592
Switching Losses a 40kHz (W)	0.2	0.2	0.012
Switching Losses a 200kHz (W)	1.3	1.3	0.06
Total Diode Losses a 40kHz (W)	1.15	0.44	0.6
Δ Tj a 40kHz (°C)	115°	71°	60°
Total Diode Losses a 200kHz (W)	1.97	1.77	0.65
Δ Tj a 200kHz (°C)	197°	132°	65°

a) Voltage source - current output

Reduce the transformer leakage inductance. Table of figure 11 shows that in the case of the 400V 10A 200kHz bridge circuit the suppression of the inductance L_S can save 4 x 16.5W = 66W. Replace in the same circuit the high voltage fast rectifier BYT12-600 by 3 "high efficiency" BYW81-200 in series (see figure 12 - table). The total losses decrease from 186W to 58W. This result is very important as it shows it is more efficient to use several "high efficiency" ultra fast rectifiers instead of a single high voltage one for high frequency operation.

b) Both

Use of sinusoidal current (resonant converter) instead of rectangular waveforms. Figure 11 shows that for the same conditions (400V - 10A - 200kHz) the switching losses with a sinusoidal current are only 4 x 7.5 = 30W (4 x 22 = 88W with rectangular wave forms).

4.4. STEP UP CONVERTER

The rectifier operates in free wheel mode. The main losses in this case occur in the transistor during the turn-on (similar to the step down converter). Figure 13 shows that with 600V output at 40kHz, if the rectifier switching losses are reasonable, the transistor turn-on losses are too high.

How can the designer reduce these turn-on losses ? (fig. 13).

a) Decrease the rectifier junction temperature by more efficient cooling.
   If the BYT12-800 junction temperature decreases from 100 to 70°C, the transistor turn-on losses decrease from 39.5W to 33W.
b) To replace one BYT12-800 by 4 high efficiency BYW81-200 in series. The total balance is a reduction in losses from 39.5 to 16.6W in the transistor with same losses in the rectifier.

IN SUMMARY

Two major actions reduce switching losses caused by fast recovery rectifiers :

1. APPROPRIATE CHOICE OF COMPONENT
   - The fastest rectifier compatible with the peak voltage in the application.

- If the peak voltage V_R exceeds 400V the designer must analyse carefully the switching losses:
  - These losses are proportional to $I^2_{RM} \times V_R$.
  - A 800V fast rectifier has an I_{RM} approximately two times higher than a 400V fast rectifier (same current rating).

Figure 9 : Voltage Source, Output Current Full Bridge Circuit.

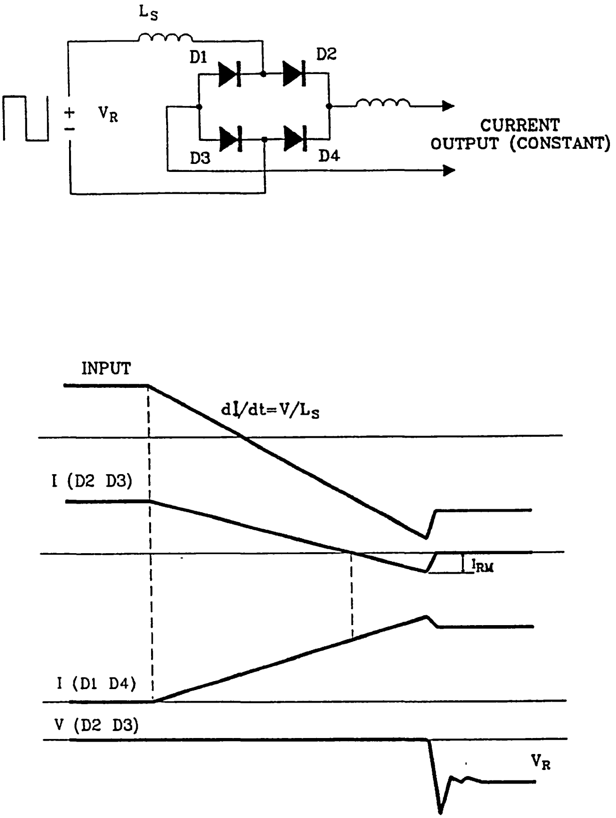


Figure 10 : Current Source, Output Voltage Full Bridge Circuit.

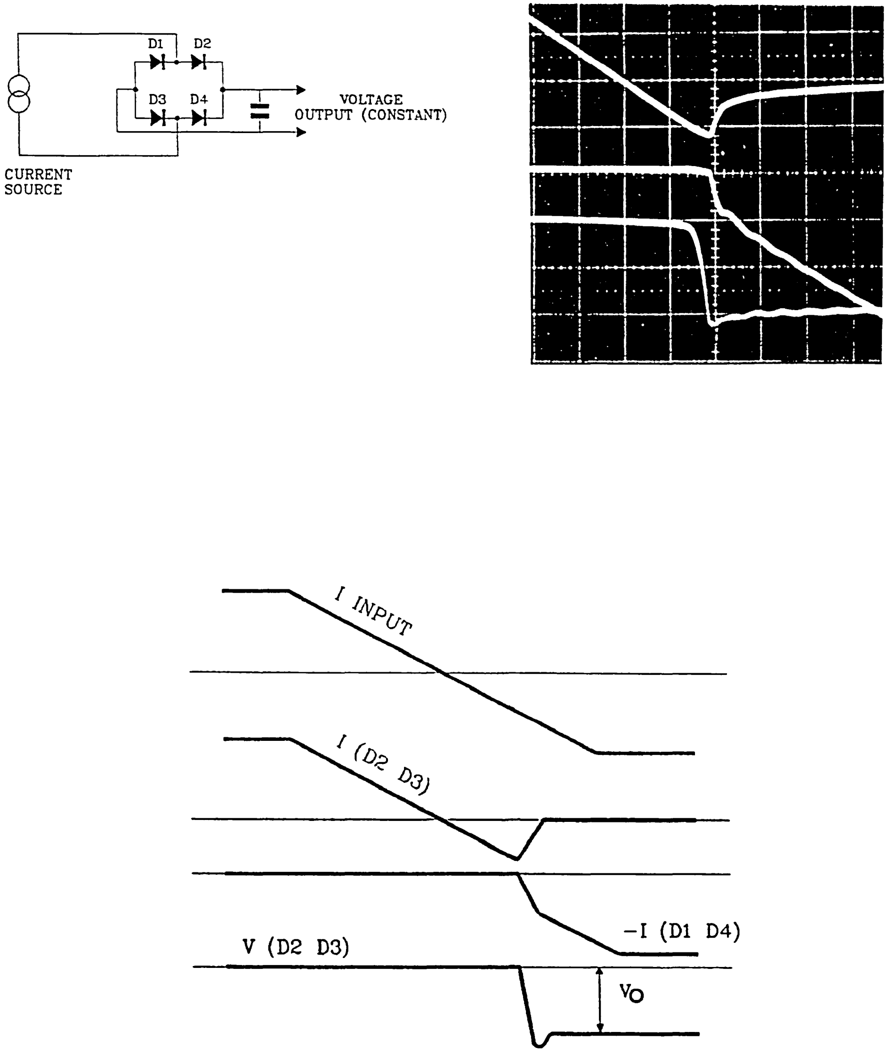
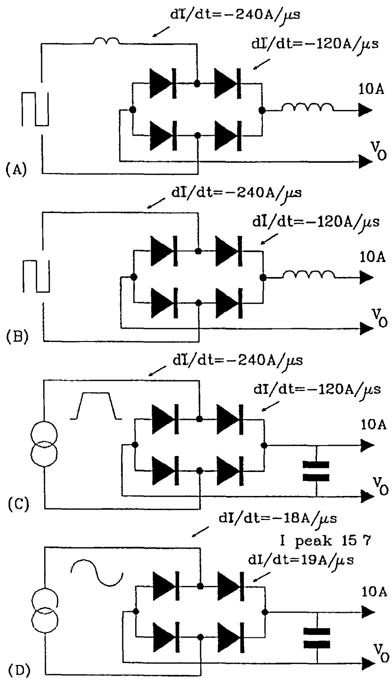


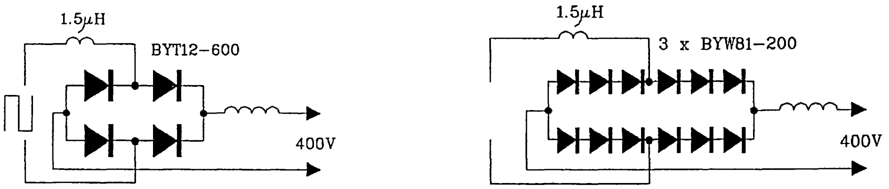
Figure 11 : Switching Losses (per leg) in a full Wave 200kHz Bridge Circuit. Output 10A.
In case of voltage source, current output, the (leakage) inductance L_S introduces $L_S I^2_{RM}$ losses.
In case D, the losses are smaller (6 x 4 = 24W instead of 22 x 4 = 88W) because dI/dt is smaller, consequently I_{RM} is smaller.

L_S = 0.5µH (48V)
1µH (200V)
1.5µH (400V)



V_0	48	200	400
Rectifier	BYW81-100	BYT12-300	BYT12-600
200kHz	0.76W	5.6W	38.5W
	0.16W	2W	22W
	0.16W	2W	22W
	0.04W	0.6W	6W

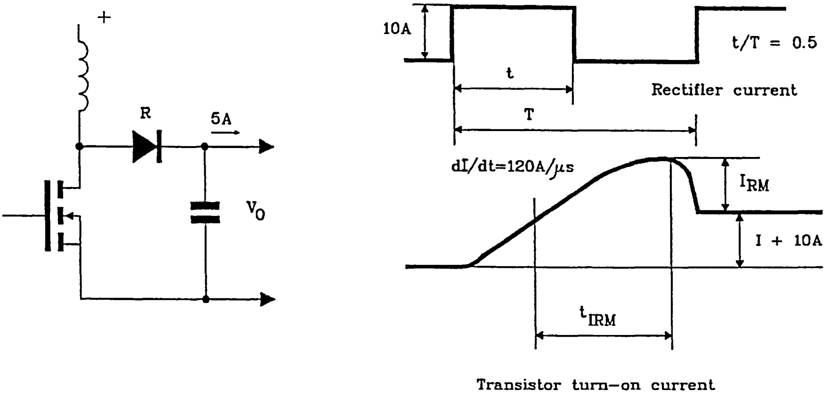
Figure 12 : Switching Losses (per leg) in the Full Wave 400V 200kHz Bridge Circuit with two Different "rectifiers".
Replacing the high voltage BYT12 – 600 rectifier by 3 "high efficiency" ultra fast BYW81 – 200 in series reduces the total losses dramatically. This is why the I_{RM} from BYW81 is very low and the voltage drop of this high efficiency rectifier is very low.



Rectifier	BYT12-600	3xBYW81-200
Conduction Losses (W)	8	11
Switching Losses (W)	38.5	3.5
Total Losses per Leg (W)	46.5	14.5

F = 200kHz
V_0 = 400V
I_{AVG} = 10A
dI_F/dt = – 120A/µs
t/T = 0.5

Figure 13 : In the Step-up (or step down) Converter the Majority of Losses Occur in the Transistor, Specially when a High Voltage Rectifier is used.
In some case replacing a high voltage rectifier by several faster rectifiers in series (and consequently with a lower voltage rating) can minimize the total losses despite the increase of the rectifier conduction losses.



$$(W)_{ON} = \frac{V_R}{2}\left[\frac{I}{dI/dt} + (I + I_{RM})\,t_{IRM}\right]$$

Figure 13 (continued).

V_0	**48**	**300**	**600**	**600**
Rectifier	BYW81-100	BYT12-400	BYT12-800	4 x BYT81-200
(d_I/dt = 120A/μs) I_{RM} (A) (T_j = 100°) t_{IRM} (μs)	3.8 0.04	6 0.06	10.5 0.12	3.8
Rectifier Conduction Losses (W)	3.65	6.5	8	14.6
Rectifier Switching Losses a 40kHz (W)	0.04	0.6	6.7	0.5
Total Rectifier Losses a 40kHz (W)	3.7	7.1	14.7	15.1
Transistor Turn-on Losses a 40kHz (W)	1.32	1	0.7	39.5

The rectifier voltage drop increases with the rating voltage.

Example : BYW81 "high efficiency" 200V rating V_F = 0.85V (max).

BYT12-600 600V rating V_F = 1.8 (max).

IMPORTANT CONSEQUENCES :

If the switching frequency is greater than 40kHz in many cases it will be more efficient to replace one high voltage (600 - 800 - 1000V) rectifier by a series of ultrafast rectifiers (200V or 400V). Despite the increase of conduction losses, a dramatic reduction of switching losses results in a decrease in the total losses.

2. OPTIMAL OPERATING CONDITIONS

2.1. In many cases parasitic inductance gives additional losses. A reduction of those parasitic inductances L_S decreases not only the voltage spikes but also the switching losses.

2.2. Junction temperature plays an important role. The switching losses are approximately proportional to Tj. Improving the rectifier cooling is very important for all high frequency rectifiers.

2.3. For full wave rectifying circuits, with an isolation transformer the switching losses are always lower in the case of :

Current source → rectifying → voltage source

than :

Voltage source → rectifying → current source

because the impedance due to the transformer leakage inductance is integrated in the current source, and does not play any part in the additional losses.

2.4. The use of the resonant circuit with sinusoidal current waveforms results in a significant reduction in the switching losses due to the limited dI_F/dt or to the smaller re-applied voltage V_R.

CONCLUSION

Reducing the switching losses in high frequency converters is team work.

The manufacturer has improved the fast recovery rectifier characteristics. The designer has now some tools to analyse, with a greater accuracy, the rectifier behaviour and choose the optimal solution in order to minimize the losses.

REFERENCE

|1| "Switching behaviour of fast diodes in the converter circuits" - p.63 to 78 in the hand book SGS-THOMSON Microelectronics "Transistors & Diodes in Power Processing".

APPLICATION NOTE

CONTROL OF A DC MOTOR USING TRANSPACK MICROPROCESSOR BASED FULLY INTEGRATED SOLUTION

INTRODUCTION

This article covers the design of a controller for a DC permanent magnet motor. The design is preceded by a mathematical simulation of the controller. The controller design is complete with working drawings and a programme for the microprocessor. A comprehensive collection of diagrams and photos shows the operational performance of the design under normal and adverse working conditions.

Simulation of Motor Behaviour

The motor chosen for the design is a constant current type with a permanent magnet with a stator flux nearly constant and a good power to weight ratio compared with classic DC motors.

Simulation forcast: - Maximum peak current, Ripple current at various chopper frequencies, Response speed of the system. Function in steady state.

The parameters are studied for extreme working conditions to optimise the choice of inverter components.

The Control Hardware

The hardware design is implemented with a microprocessors, D/A converter, switchmode driver and two power modules for the high current drive for a simple and integrated solution.

The bridge is construted with two TO-240 TRANPACK power modules of half bridge configuration, SGS30DB040D which permit fast acceleration of the motor and a compact structure.

The microprocessor allows simplicity and flexibility e.g. motor speed is controlled by a six bit word which accurately sets the speed between 0.5% and maximum.

Study of the System Behaviour

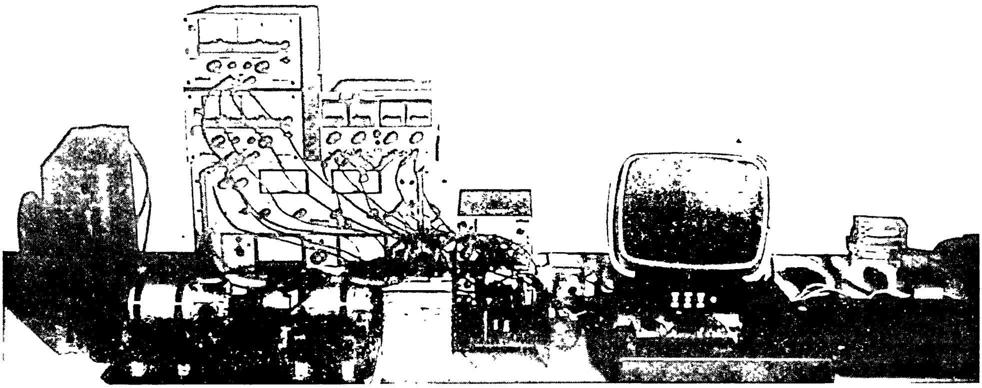
The system behaviour is studied to analyse the maximum stress conditions on the bridge corresponding to possible operating conditions, the algorithm of acceleration, braking, and inversion of the speed are demonstrated. The objective is to obtain the maximum performance possible with the transistors chosen for the bridge.

Balance of the Bridge

The evaluation of power abosrbed by the various parts of the system demonstrates the efficiency of the design.Detailed analysis of power absorbed in the motor and power dissipated in the bridge qualifies this design.

This study involves particularly heavy operating conditions for the power circuitry which verifies the excellent performance of the TRANSPACK (TO-240)devices above all in terms of switching speeds and low losses i.e. efficiency.

Laboratory implementation of the hardware



Motor Specification

Nominal Current	I_A =	1.8A
Nominal Supply Voltage	V_A =	200-220V
Peak Torque	T =	6Nm
Maximum Working Speed	Ω =	15000rpm
Absolute Maximum Speed	Ω' =	20000 rpm
Rotor Inertia	J =	$0.6\ 10^{-7}$ Kg.m^2
Torque Constant	K_T =	0.17Nm .A^{-1}
Resistance	R =	0.96Ω
Inductance	L =	6.6mH
Demagnetisation Current	I_{dm} =	105A
Nominal Power	P =	200W
Back EMF Constant	K_V =	0.17 V.s

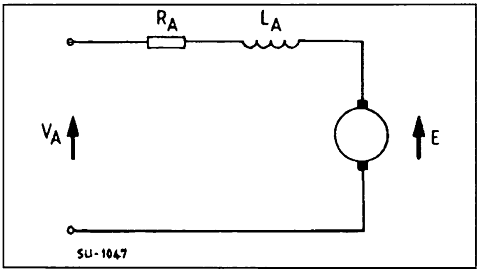
Drive Specification

Maximum Motor Current	30A
Maximum Supply Voltage	400V
Minimum Speed Variation for each direction	1/32 maximum speed
Chopper Frequency	21.7KHz
4 Quadrant Control	

Simulation of Motor Behaviour

The motor is a (DC) constant current type with a permanent magnet hence with a stator flux nearly constant and a good power to weight ratio compared with classic DC motors. The electrical circuit used for simulation is:

Figure 1



For the mathematical model it was decided to neglect the variation of stator flux due to the inductive reaction, hence considering the flux generated by the permanent magnets to be constant.This simplification has little effect on the representation of motor behaviour but it simplifies the calculations.

The equations which form the model are the following:

1) $V_A = R_A I_A + L_A\, dI_A/dt + E$
2) $C_M = J\, d\Omega/dt + D\Omega + Cr$
3) $E = K_V\, \phi\, \Omega$
4) $C_M = K_T\, \phi\, I_A$

Where:

V_A	= Armature Voltage	(Volts)
I_A	= Armature Current	(Ampere)
R_A	= Stator Resistance	(Ω)
L_A	= Stator Inductance	(H)
E	= Electro Motive Force	(Volts)
C_M	= Torque	(Nm)
Cr	= Friction	(Nm)
J	= Inertial Moment	(Kg. m^2)
Ω	= Angular Velocity	(rad/sec)
ϕ	= Stator Magnetic Flux	(Weber)
D	= Kinetic Friction	(Nm)
K_V	= Back EMF Constant	(V .s)
K_T	= Torque Constant	(Nm A^1)

From the balance of energy:

$C.\Omega = E.I_A$ where C equals the motor output (Watts)

$= \frac{E}{K_V\, \Phi} K_C\, \Phi\, I_A$ from which $K_C = K_V$

The differential equations were resolved by the Runga - Kutta method for solving non linear equations.

With the simulation it was proposed to forecast the following behaviour:

- Maximum Peak Current
- Ripple current at various chopper frequencies
- Response speed of the system
- Function in steady state

The phenomena were studied with the intention of seeing the maximum values of the observed parameters rather than instantaneous values in order to optimise the choice of inverter components. The simulation was made supposing a supply voltage of 200V.

N.B. - In Appendix A is the programme used for the simulation run on VAX.

Figures 2, 3 & 4 illustrate the simulated motor currents at chopper frequencies of 5, 10 & 20 kHz with the motor blocked and a 50% duty cycle (A = 5).

It can be seen that ripple current decreases in a practically linear relationship to the frequency, passing from 3A at 5kHz, to 0.9A at 20kHz.

The average of the current is zero as is the torque. The abosrbed power is however dissipated in the motor, becoming lower as the chopper frequency increases.

Figures 5 & 6 show the trend of velocity, at 10 & 20kHz, with a 70% duty cycle (A= 7) and load torque zero. Also the ripple on the speed is strongly influenced by the chopper frequency, going form 4.22% at 10kHz to 0.84% at 20kHz. Assuring a steady state speed of 237 rad/sec the ripple varies from 10 rad/sec at 10kHz to 2 rad/sec at 20kHz.

Under identical conditions (frequency and duty cycle) the motor current analysis shown in figures 7 & 8 was made.

Figure 2

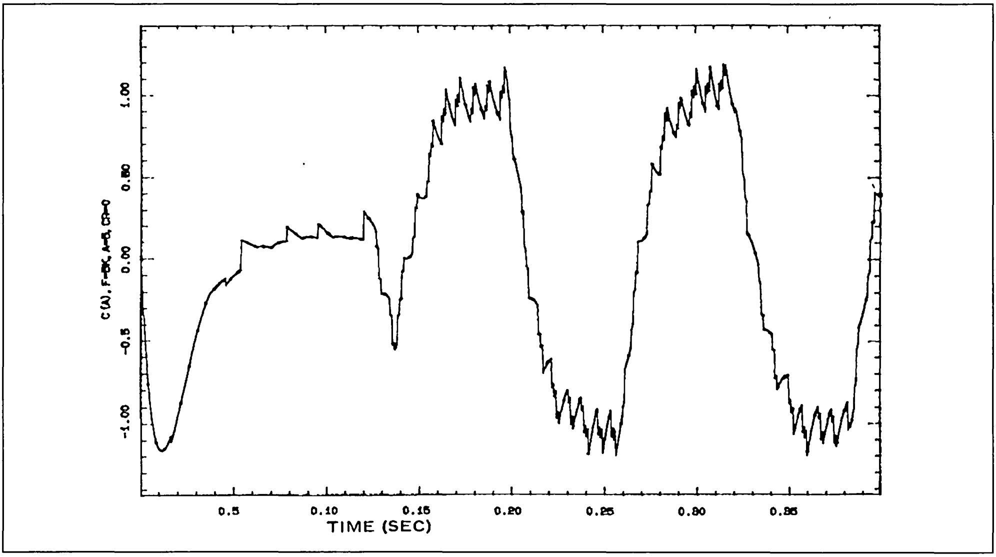


Figure 2a

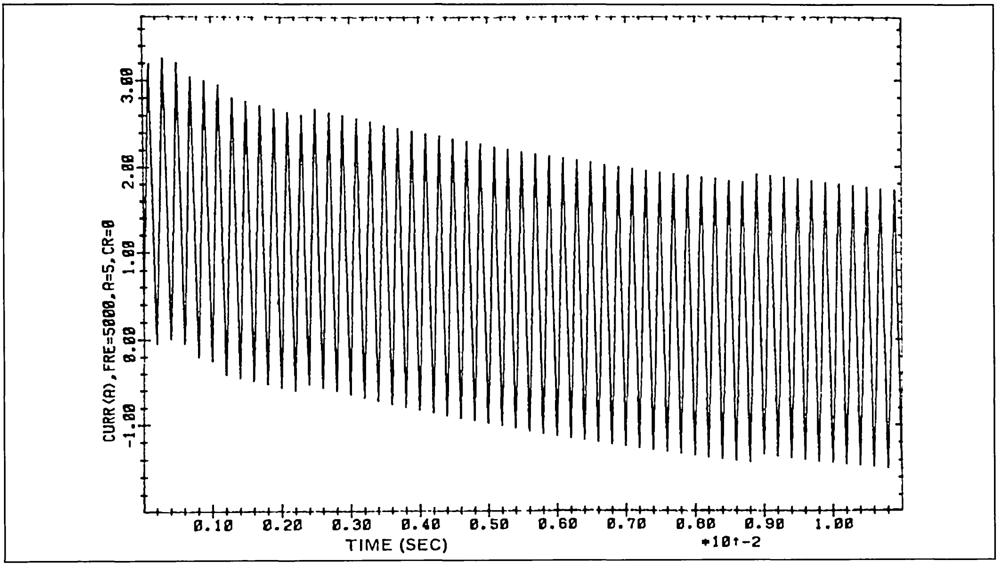


Figure 3

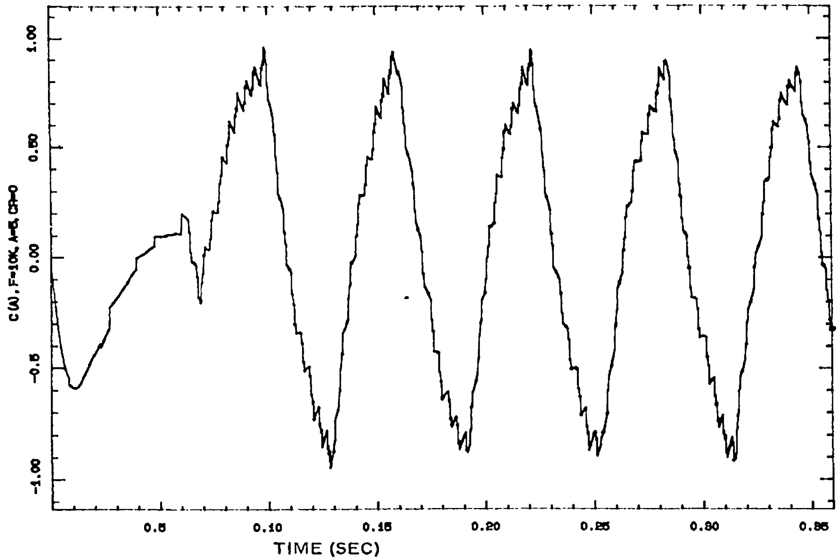


Figure 4

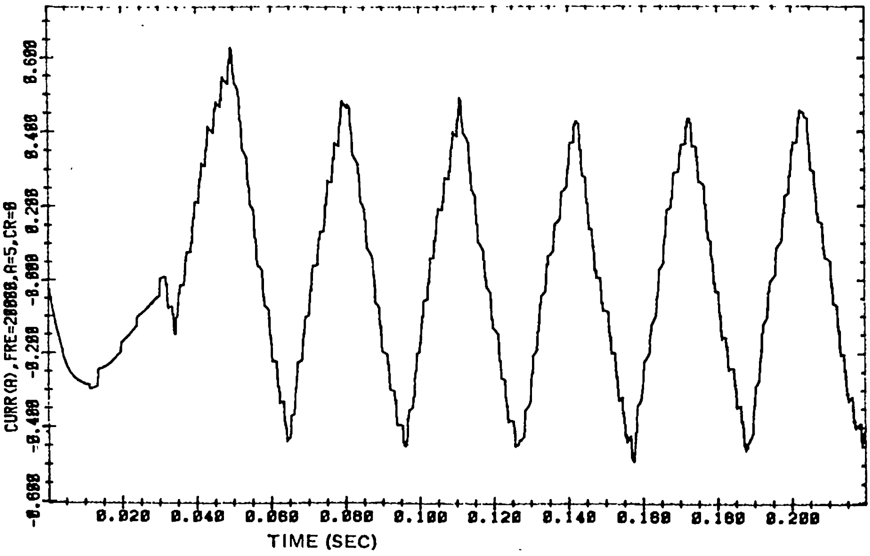


Figure 5

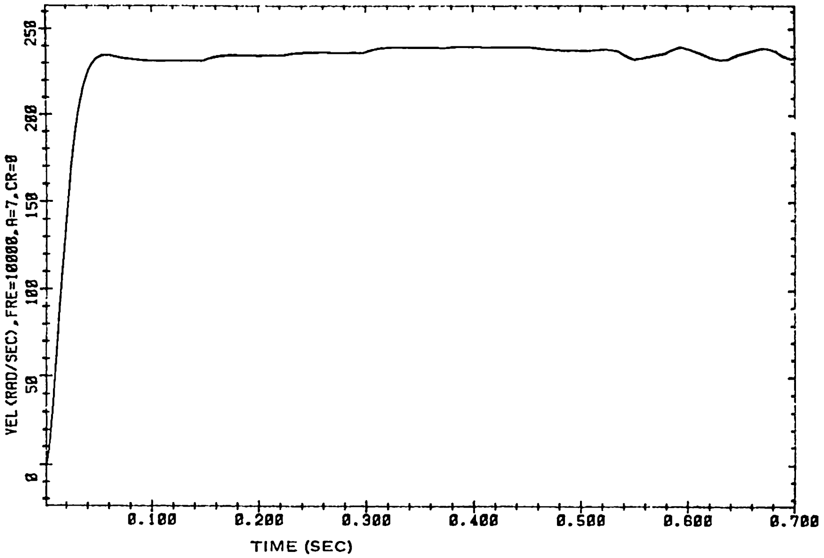


Figure 6

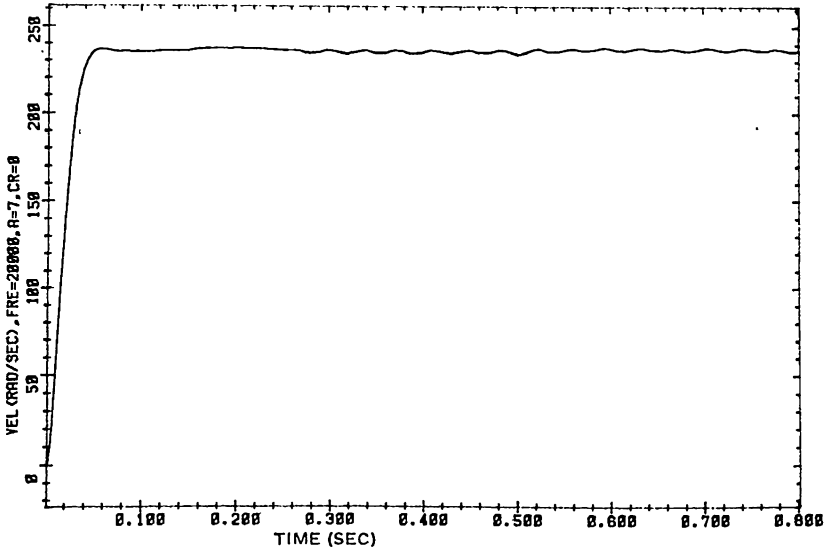


Figure 7

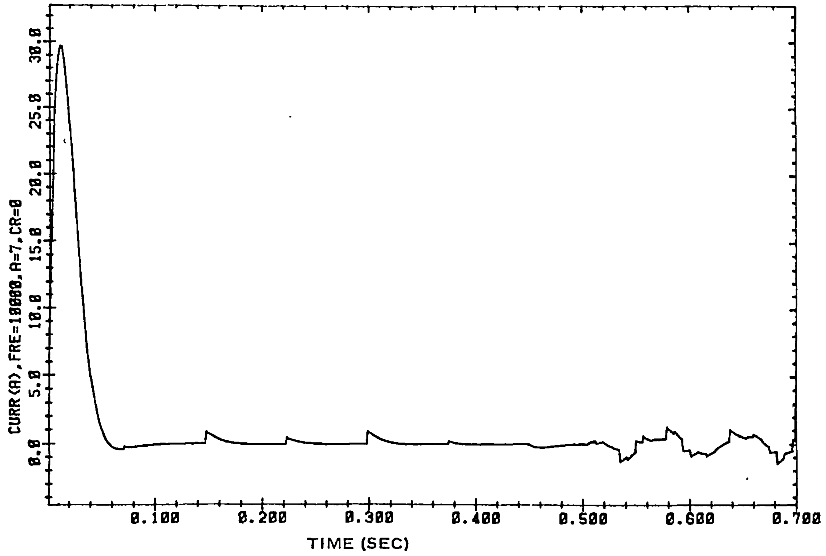


Figure 8

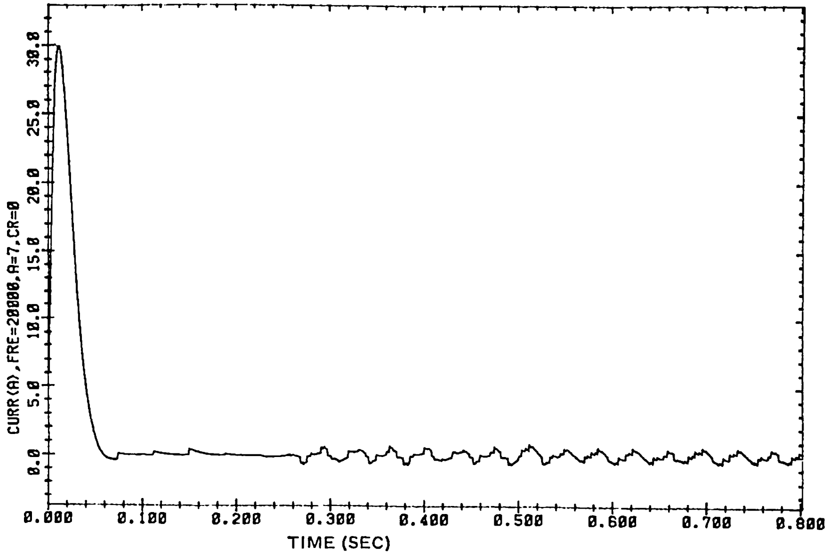
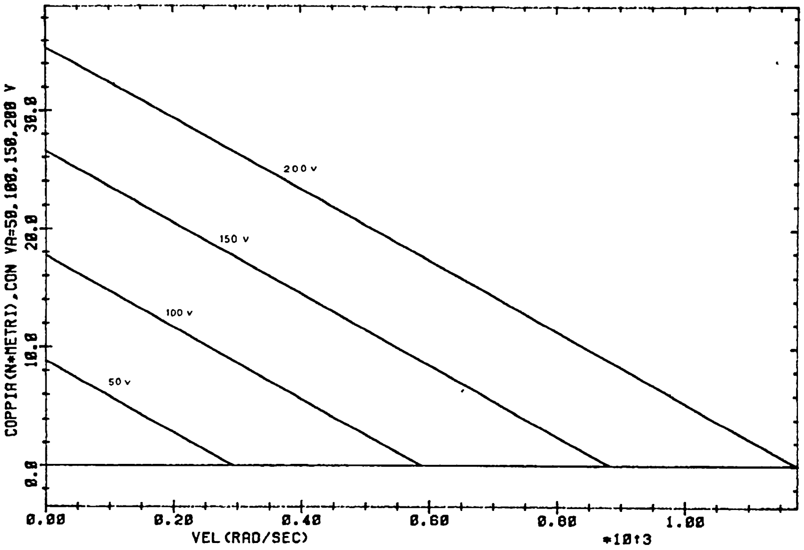


Figure 9



The ripple current and hence the torque merit observations similar to those made for the speed. From the simulations it was decided to operate with a frequency close to 20kHz both in terms of reduced losses in the motor as well as the ripple effects on speed and torque.
This choice is made possible by the availability of power transistors with very low switching losses.Also there is the advantage of much reduced interference on the supply.

From the performance reported in figures 5 & 6 the estimated acceleration time is around 80ms for a steady state speed of 237 rad/sec.

The data supplied from the simulation has also enabled an estimate that with a duty cycle of 70% the peak current amounts to around 30A.

This data has led to the choice of the SGS30DB040D for the power bridge.

The Controller Hardware

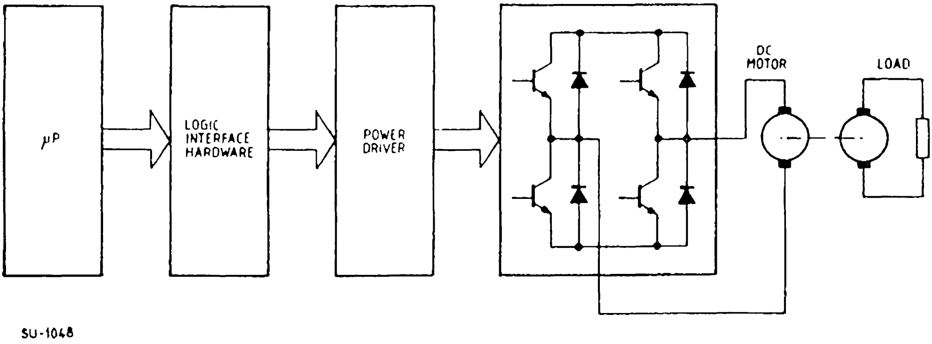
With the objective of analysing all the stresses on the components it was preferable to construct an open loop control which thanks to the lack of compensating feedback, permits an immediate study of the phenomena.

In order to operate with the maximum flexibility the system was designed to be microprocessor controlled using a Z80 SYSTEM.

The digital to analogue conversion and drive waveform generation was realised with the SGS L291 and L292 for a simple and efficient integrated solution.

The bridge was constructed with two TO-240 TRANSPACK power modules of half bridge configuration, SGS30DB040D, which permit fast acceleration of the motor and a compact structure.
The block diagram is shown in figure 10.

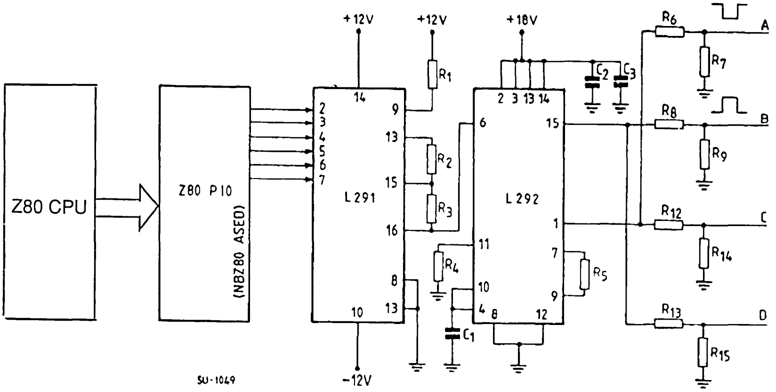
Figure 10



The Controller Schematic

The complete schematic of the controller is described as follows:
Fig 11 shows the control portion. A 6 bit word, generated by the microcomputer, representing the required speed of the motor, is converted into an analogue current. This D/A conversion is carried out by the L291. The analogue signal is then used to drive the L292 which generates pulses of variable duty cycle.
This device, normally used to drive low power motors, offers the advantage of outputs of two complementary signals of variable frequency between 1 and 30kHz.

Figure 11 - Control Section



Also it is possible to impose a delay between the end of one signal and the start of the complement, essential to avoid the short circuit condition on the bridge. The transfer of the signal from the controller to the high side of the bridge is via Q5 and Q6. These transistors are power devices working in the active zone with very low current and must sustain a voltage 5V greater than the voltage applied to the motor (fig. 11a).

This solution avoids the use of a transformer and is aimed towards the eventual integration of the power stage. The drive of the transistors in the bridge was realised with a simple integrated solution of the SGS L149, whose power for the high side is referred to the voltage at the motor terminals which follows the variations.

The power for the motor is provided by a full bridge circuit permitting operation in all 4 quadrants.

The two half bridge TRANSPACK, SGS30DB040D, are built using Darlingtons without integrated collector - emitter diodes which permits full use of the fast freewheel diodes incorporated in the power module and high frequency drive of the motor. The voltage waveforms on the motor are illustrated in photo 1.

Figure 11a

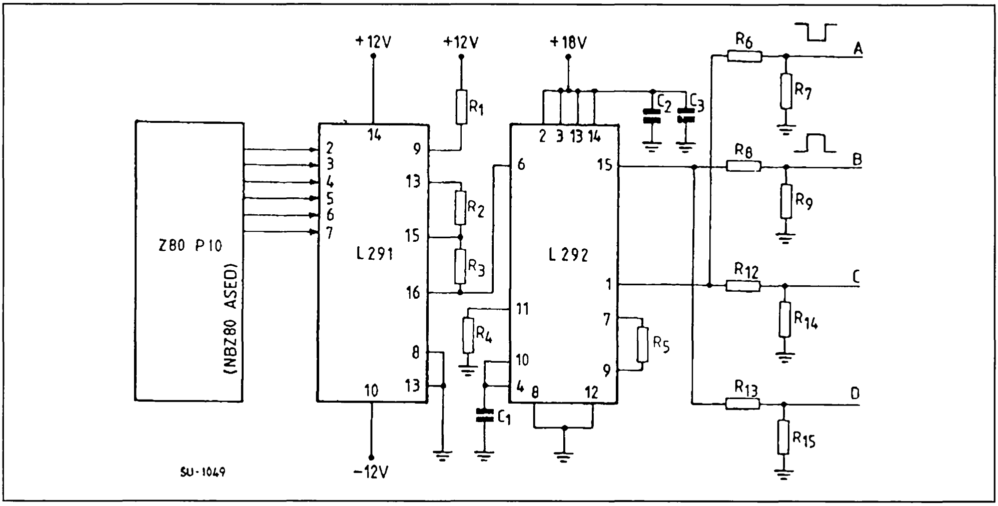
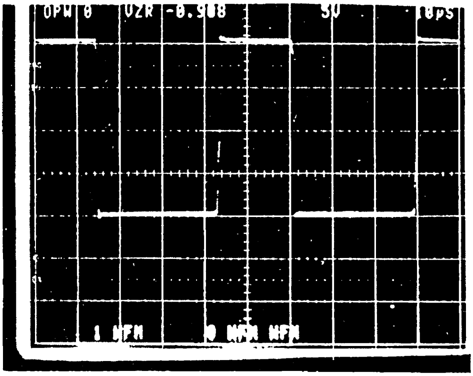
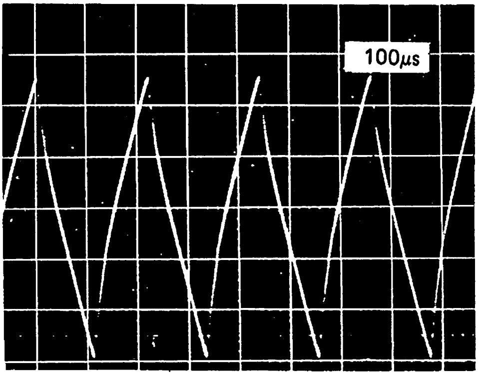


Photo 1 - Motor voltage



V = 50V/div
t = 100µs/div

Photo 2a - Ripple of 3A at 5KHz



I =0. 5A/div

The principle characteristics of the Darlington are as follows:

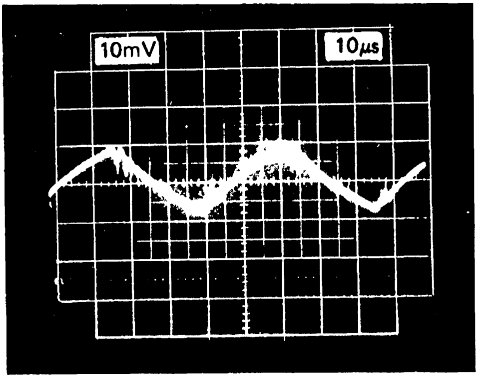
- V_{CEO} = 400V
- I_C = 30A
- H_{FE} = (I_C = 30A) 50
- $V_{CE(sat)}$ = (I_C = 30A, I_B = 2A) = 1.5V
- t_s (storage time = 1.2µs
- t_f (fall time) = 0.2µs

The main parameters of the diode are:

- V_F = 1.2V (I_F = 30A)
- t_{RR} < 0.2 µs (I_F = 30A, di/dt = 100A/µs)
- I_{RM} = 10A
- I_{FRM} = 250A

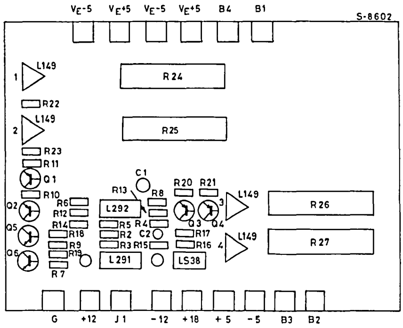
Photo 2a & b shows the behaviour of the motor, currents at chopper frequencies of 5kHz and 20kHz. It is possible to note in photo 2a (5kHz) a ripple of 3A in agreement with the simulated data, while in photo 2b one sees a ripple at 20kHz of around 0.9A.

Photo 2b - Ripple of 0.9A at 20KHz



I =0. 5A/div

Figure 12 - Assembly of the circuit board



COMPONENTS LIST

Components	Quantity	Value	Note	Components	Quantity	Value	Note
SGS30DB040D	2		TRANSPACK	R16, R17	2	100Ω	
L149	4		Driver	R18, R19	2	2.7KΩ,	
L291	1		d/a converter	R20, R21	2	670Ω	
L292	1		PWM generator	R22, R23	2	10KΩ	
R1	1	4.9KΩ		R24, R25	2	5Ω	
R2	1	3.9KΩ		R26, R27	2	5Ω	
R3	1	22KΩ		C1	1	100nF	
R4	1	8.4KΩ		C2	1	1000µF	
R5	1	5KΩ		C3	1	22nF	
R6, R7	2	15KΩ		Q1, Q2, Q3, Q4	4		2N4033
R8, R9	2	3.8KΩ		Q5, Q6	2		TIP50
R10, R11	2	1KΩ		B1, B2	2		
R12, R13	2	1.5KΩ		B3, B4	2		
R14, R15	2	470Ω		I1			

Study of the System Behaviour
To analyse the maximum stress condition on the bridge corresponding to possible operating conditions, the algorithm of acceleration, braking and inversion of the speed were performed. The objective was to obtain the maximum performance possible with the transistors chosen for the bridge. The strategy followed was to choose a speed of 3000rpm analysing the time needed to reach the speed.

Acceleration Tests
Firstly the motor was accelerated with a duty cycle corresponding to the chosen speed (steady acceleration with a drive signal duty cycle of 70%). The result of this test is shown in photo 3 & 4.

Photo 3 - Trend of the speed with only voltage changing (560 rpm/div)

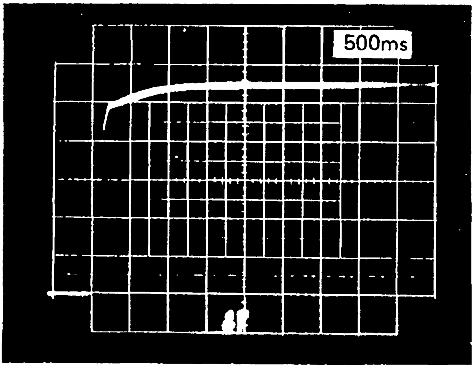
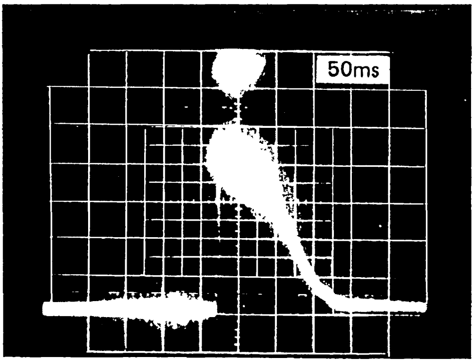


Photo 4 - Trend of the current under the same conditions as photo 3 (5A/div)



In photo 4 it is seen that the current reaches a peak of 23A in a limited number of pulses and then goes to full speed much more slowly, with a current of 0.6A. Regarding the speed, the period of the transition may be estimated as around 1.2s.

Photo 5 - The trend of the velocity with four progressive steps of voltage as intervals of 25ms (560 rpm/div)

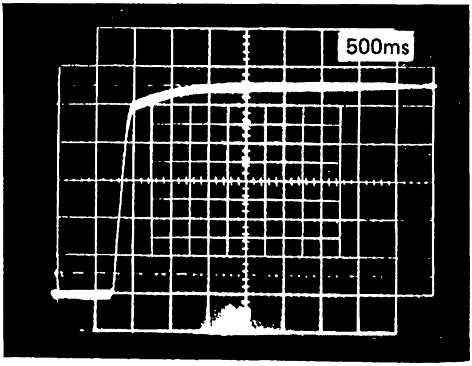
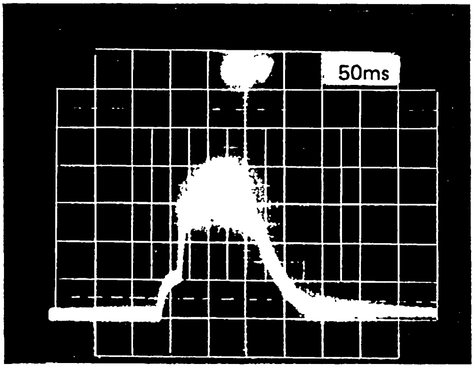


Photo 6 - The trend of the current under the conditions of photo 5 (5A/div)



Also a ramp of acceleration was tested imposing.4 increases in duty cycle of 5% with a 25ms delay between each (photo 5 & 6).

In this way the maximum current during acceleration is reduced to 20A without any significant variation of the time to reach full speed.

Photo 7- The trend of the speed with the drive of figure 13 (560 rpm/div)

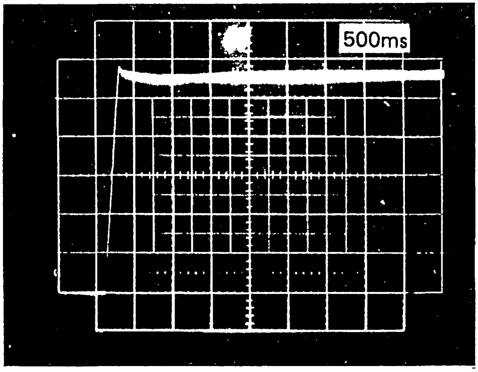
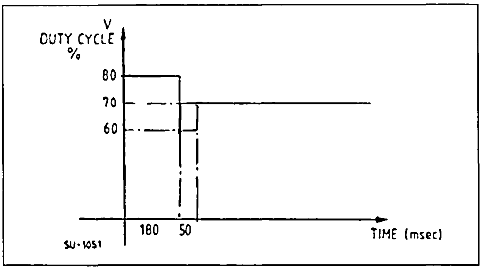


Figure 13



Other tests of acceleration are shown in photos 9, 10 & 11

Photo 8 - Trend of the current of the drive of figure13 (10A/div)

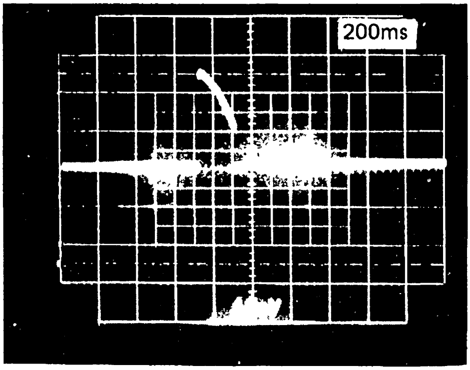


Photo 9 - Trend of velocity with a initial drive to produce 3750 rpm followed after 300ms by a drive to produce 3000 rpm (560 rpm/div)

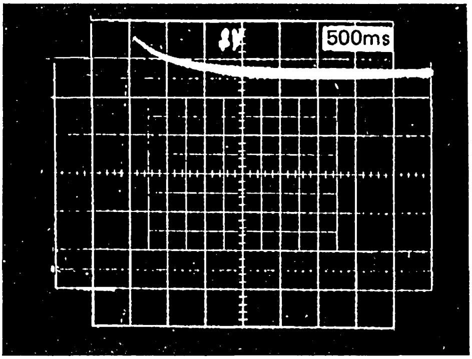


Figure 14

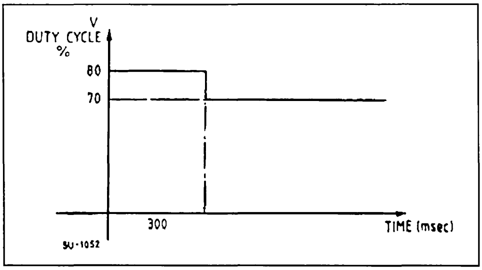
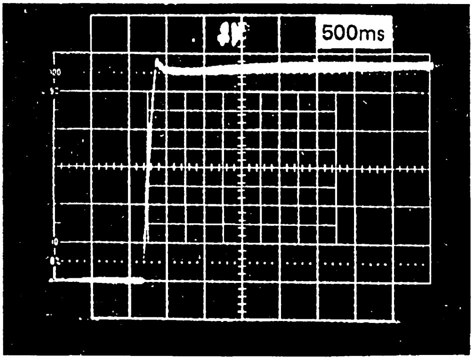


Photo 10 - Trend velocity with an initial drive to produce 3750 rpm followed after 180ms by a drive to produce 2250rpm and finally after 100ms by a drive to produce 3000rpm (560 rpm/div)



A series of tests were performed attempting to obtain a determined speed in the minimum possible time, working with duty cycles above and below that of steady state with the appropriate delays.

The best result was obtained driving with the sequence of duty cycles illustrated in fig. 13 as shown in photo 7.

Figure 15

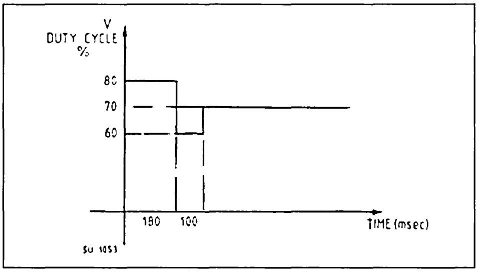


Photo 11 - Trend velocity with a initial drive to produce 3750 rpm followed after 160ms by a drive to produce 2250 rpm and finally after 50ms by a drive to produce 3000 rpm.

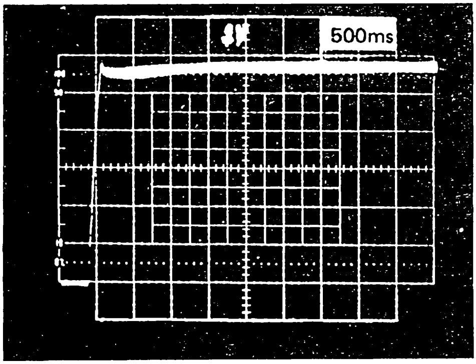
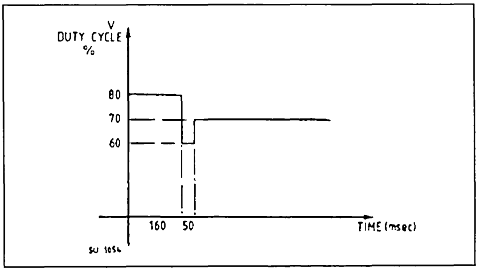


Figure 16



One notes that the duration of the transient may be estimated to be around 500ms, notably below the 1.2s in the case shown in photo 3, corresponding to an average acceleration of 628 rad/sec^2 and with an instantaneous acceleration of 7500 rad/sec^2, corresponding to a maximum current of 26A shown in photo 8.

Speed Reversal

Having reached the maximum, the objective was to achieve the maximum steady acceleration and to estimate the time needed to achieve an inversion of the speed passing from +3000rpm to -3000rpm having supposed that this is the most critical stress on the bridge.

There was first analysed the phenomena of braking and it was seen that braking too quickly may cause a change of function, making the motor a generator and creating excess emitter base voltage up to a situation intolerable for correct operation of the bridge components.

This phenomena was taken into account to achieve the most rapid braking possible without overstressing the bridge components.

We succeeded in this way to obtain a time, from +3k to + 3krpm, of about 500ms, as shown in photo no. 12 where the achievment of a steady state is not considered but only the transition from one speed to another.

The behaviour of the relevant currents are shown in photo 13 where points shown by the arrows are relative to the transformation of the motor into a generator

Photo 12 - Trend of velocity (1090 rads/sec/div)

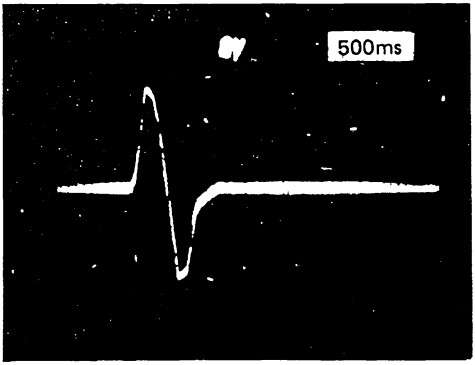


Figure 14

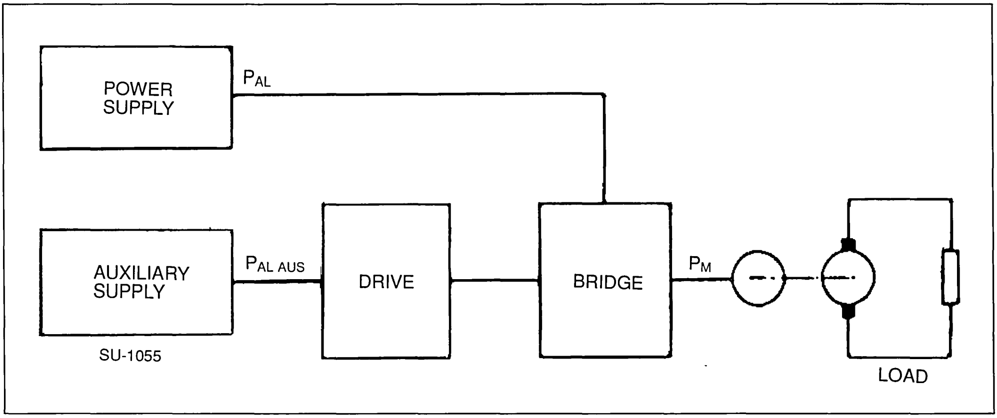
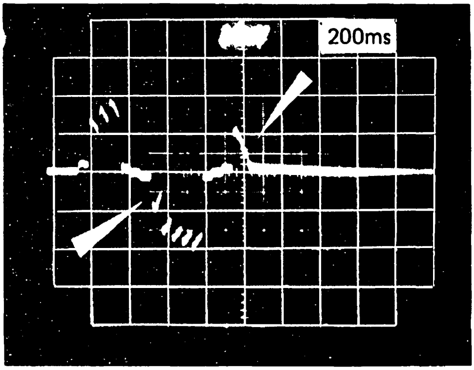


Photo 13 - Current absorbed by the motor with the described speed invertion (10A/div)



Both the tests of acceleration and speed reversal were made with repetitive cycles, with appropriate programmes, for periods of several hours without creating problems for the SGS30DB040D.

Balance of the Bridge

The evaluation of the power abosrbed by the various parts of the system is analysed in the following paragraph. The estimates obtained give an indication of the efficiency of the control system in that it gives a ratio of the power absorbed to that of the motor.

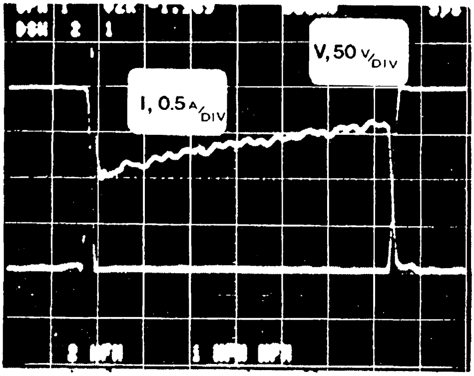
The power was measured using the following system (fig. 14).

The chosen conditions were:

- Duty cycle of 76%
- Average motor current 1.25A

The load was simulated by a generator connected to the motor and a rheostat of 200Ω.

Photo 14



In this situation the power taken from the supply was:

- $P_{AL} = 200V \times 0.83A = 166W$

The power absorbed by the drive circuit was:

- P_{AL} Auxiliary = 7.86W

The power absorbed by the motor was:

- $P_M = V_{av} \times I_A = 123.2V \times 1.25A = 154W$

Hence the power absorbed the bridge was:

- $P_{BRIDGE} = 12W$

Thus one has a dissipation of power in the bridge of 7.2%

Power Absorbed by the Motor
Photo 14 shows the waveforms of current and voltage on one arm of the bridge. The power in the motor was computed as the difference of the power absorbed during the conducting phases of the bridge less that returned during the conduction of the free wheel diodes.

Photo 15 represents the power absorbed. The energy corresponds to the area under the curve in a period. Given that:

E = 9.47mJ, F = 21700Hz

$P_{ABS} \bullet {}_{MOT} = E \times F\ 9.47\ 10^3 \bullet 21.7\ 10_3 = 205.6W$

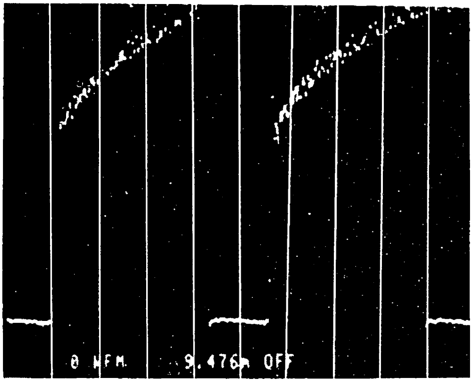
The power returned from the motor is shown in photo 16.

- E = 2.38mJ
- F = 21700Hz
- $P_{GEN.MOT.} = 51.6W$

Thus the total power absorbed by the motor is:

$P_{TOT.MOT} = P_{ABS.MOT} - P_{GEN.MOT} =$
$= 205.6 - 51.6 = 154W$

Photo 15



Power Dissipated in the Bridge
The power dissipated in the bridge was analysed in a more detailed manner by measuring the power dissipated in one transistor (high side) both in the turn-on and turn-off phases and estimating the dissipation during the on period.

Photo 16

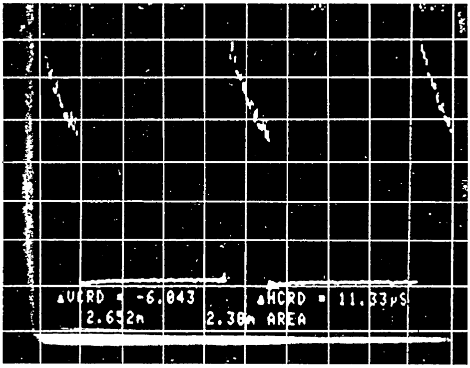


Photo 17

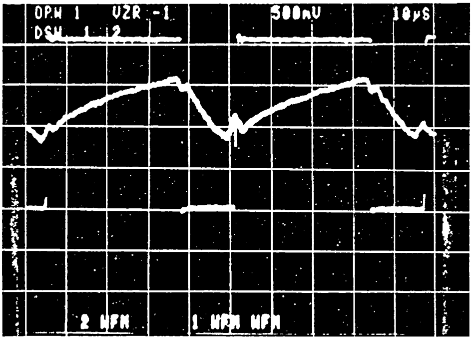
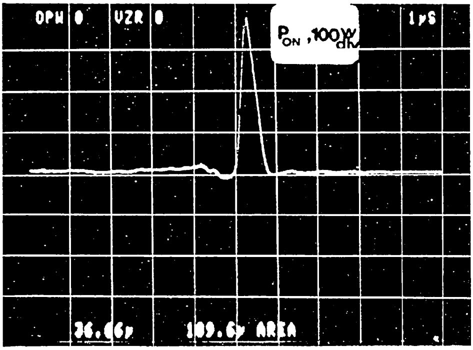


Photo 18



The waveforms of voltage and current during an entire period can be seen in photo 17.

The power dissipated during the turn-on phase and the respective voltage and current waveforms are shown in photos 18 & 19.

From the photo of the power it is possible also to measure the energy dissipated. This corresponds to an average power of:

P_{ON} = E x F = 189.6µJ x 21700Hz = 4.1W

The power dissipated during the turn-off phases and the respective waveforms are shown in photo 20 & 21.

The energy dissipated in this case is 188µJ thus:

P_{OFF} = E x F = 118.5 x 21700 = 2.47W

The dissipation of the conduction phase is not conveniently measured by the method used so it was preferred to make an estimate.

At the average current of 1.25A from the characteristic curves a $V_{CE(sat)}$ of 0.8V is found.

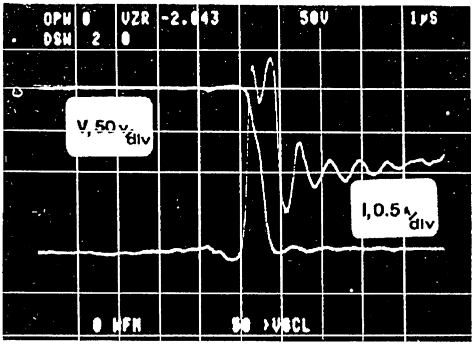
$P_{COND.}$ = 1.25A x 0.8V x 0.76 = 0.76W

Taking into consideration that the conduction phase is 76% of the full period:

The power dissipated in a transistor of the bridge is thus:

P_{TOT} = P_{ON} + P_{OFF} + P_{COND} = (4.1 + 2.57 + 0.76) W = 7.43W

Photo 19



CONCLUSION

During this work a study was made, both in theory and application, of the control of a DC motor. For this study, advantage was taken of the flexibility offered by using a microprocessor to make many tests. This allowed a comprehensive analysis of the behaviour of the SGS30DB040D TRANSPACK.

This involved the recreation of particularly heavy operating conditions for the power circuitry, which verified the excellent performance of the TRANSPACK devices, above all in terms of switching speed and low losses. Also studies were made of a number of drive circuits for the power transistors, useful for future projects.

Photo 20

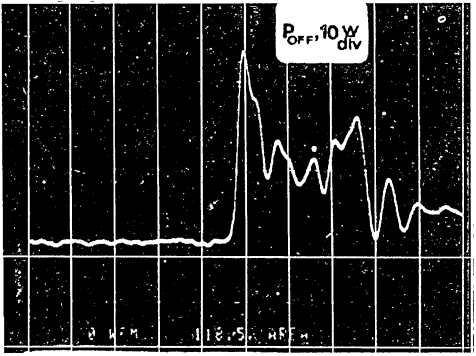
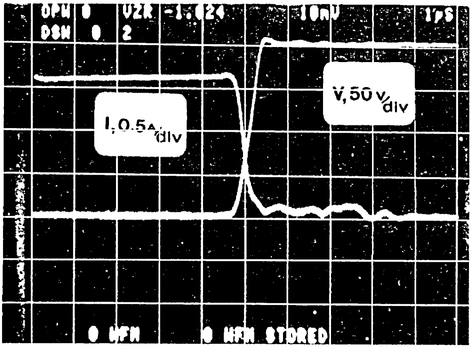


Photo 21



APPENDIX A

```
# TY Motor For
                    DIMENSION Y (20),YF (20)
                    EXTERNAL FUNC
                    REAL KC,KV
                    OPEN (UNIT=7,FILE ='MIKE,DAT',STATUS='NEW')
                    OPEN (UNIT=8,FILE ='MIKE1,DAT',STATUS='NEW')
                    OPEN (UNIT=9,FILE ='MIKE2, DAT',STATUS='NEW')
                    OPEN (UNIT=10,FILE ='MIKE3, DAT',STATUS='NEW')
                    OPEN (UNIT=11,FILE ='MIKE4,DAT',STATUS ='NEW')
                    WRITE (*,30)
30                  FORMAT (1X,'INTRODUCI H,NS,NT,CR,T,A')
                    READ (*,*) H, NS,NT,CR,T,A
                    TI=A*T/10
                    T2=T-T1
                    L=H*NS*NT/T
                    WRITE (*,*) 'VUOI I GRAFICI? (SI=1)'
                    REA (*,*) AAA
                    WRITE (*,*) 'LA MACCHINA E' QUELLA SOLITA? (SI=1)'
                    READ (*,*) Z
                    IF (Z,NE,1) GO TO 40
                    X=0.
                    N=2
                    Y (1)=0.
                    Y (2)=0.
                    RA=0.96
                    XLA=0.006
                    FL=1.
                    RJ=.00056
                    Kc=.17
                    Kv=.17
                    GO TO 50
40                   WRITE (*,17)
17                  FORMAT (1X, 'INTRODUCTI X,N,Y (I),RA,XLA,FL,RJ,Kc,Kv')
                    READ (*,*) X,N,(Y(I),I=1,N),RA,XLA,FL,RJ,Kc,Kv
50                  CONTINUE
                    DO 2 J=1,NT
                    DO 1 K=1,NS
                    CALL RKUTTA (N,X,Y,FUNC,H,XF,YF,CR,RA,XLA,FL,CM,E,RJ
               #    Kc,Kv,L,T,T1,T2)
                    X=XF
                    DO 1 I=1,N
                    Y(I)=YF(I)
1                   CONTINUE
                    CM=Kc*FL*Y (1)
                    E=KV*FL*Y (2)
                    IF (AAA.EQ.1) GO TO 333
                    WRITE (*,20)
20                  FORMAT (1X, 'TEMPO', 7X,'IA',10X,'VEL',9X,'CM',10X,'E')
                    WRITE (*,15) X,(Y(I),I=1,N),CM,E
15                  FORMAT (5 E12.5)
                    GO TO 2
333                 WRITE (7,*) X,Y (2)
                    WRITE (8,*) X,Y (1)
                    WRITE (9,*) X,CM
                    WRITE (10,*) X,E
                    WRITE (11,*) Y (2),CM
2                   CONTINUE
```

APPENDIX A (continued)

```
            CLOSE (UNIT=7)
            CLOSE (UNIT=8)
            CLOSE (UNIT=9)
            CLOSE (UNIT=10)
            CLOSE (UNIT=11)
            STOP
            END

            SUBROUTINE RKUTTA (N,X,Y,FUNCH,H,XF,YF,CR,RA,XLA,FL,CM,E,RJ,
            Kc,Kv,L,T,T1,T2)
            DIMENSION Y (20),YI(20),YF(20),D(20),A(5)
            REAL KC,KV
            A (1) = H/2
            A (2) = A (1)
            A (3) = H
            A (4) = H
            A (5) = A (2)
            XF=X
            DO 10 K=1,N
            YF (K) = Y (K)
10          YI (K) = Y (K)
            DO 20 J=1,4
            CALL FUNC (XF,YI,N,D,CR,RA,XLA,FL,CM,E,RJ,Kc,Kv,L,T,T1,T2)
            XF=X+A (J)
            DO 20 K=1,N
            YI(K)=Y(K)+A(J)*D(K)
20          YF(K)=YF(K)+A(J+1)*D(K)/3
            RETURN
            END

            SUBROUTINE FUNC (X,Y,N,D,CR,RA,XLA,FL,CM,E,RJ,Kc,Kv,L,T,T1,T2
            DIMENSION Y (20), D (20)
            REAL KC,KV
            DO 16 M=0,(L-1)
            IF (X-M*T).LE.T1) GO TO 11
            IF ((X-M*T).LE.(T1+T2)) GO TO 12
18          CONTINUE
11          VA=400.
            GO TO 21
12          VA = - 400.
            GO TO 21
21          CONTINUE
            D (1) = (VA-E-RA*Y(1))/XLA
            D (2) = (CM-CR)/RJ
            RETURN
            END
```

SGS-THOMSON
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APPLICATION NOTE

TRANSISTORIZED POWER SWITCHES WITH IMPROVED EFFICENCY

By M. Bildgen *, K. Rischmuller *

ABSTRACT.

An important objective for power electronic design is the reduction of power losses. This paper analyses the output characteristics of bipolar and MOS power stages and indicates limits for further on state loss reduction. A fast high voltage driver/switch combination with very low on state and switching losses is described. The switch is designed with cellular bipolar junction transistors driven by a smart power switch mode regulator. The driver handles duty cycles from 0...100 % and requires only one unregulated auxiliary supply. The static and dynamic behaviour of the switch and its new driver stage are shown and discussed. The switch exhibits low losses and is able to operate at inaudible switching frequencies on the rectified mains.

Keywords. Mains supplied operation, on state loss reduction, simplified base drive, smart power, high switching frequencies, Darlington, POWER MOSFET, cellular bipolar transistor.

INTRODUCTION

Loss reduction is a major objective in all power electronic equipment. The switching losses of all kinds of switching power semiconductors have been significantly reduced by means of structures with increased interdigitation, cellular structures and improved carrier lifetime control. Today performances are often close to those that physical laws allow. The switching losses have been reduced to such an extent, that lowering on state losses has become the key for further loss reduction. Further loss reduction can only be achieved through the reduction of on state losses which is the major topic discussed in this paper.

HOW TO REDUCE LOSSES?

Lowering on-state losses is of particular importance in inverter circuits operating with switching frequencies below 20kHz and in resonant converters where switching losses are already negligible.

For evaluation of on state losses, power semiconductor devices can be classified as:

a) devices with dominating resistive output behaviour

b) devices with dominating p-n junction behaviour of output characteristics (Fig.1).

The Power MOSFET (MOS), the Bipolar Modulated FET (BMFET)[5] and the Bipolar Junction Transistor (BJT) exhibit a resistive output behaviour (Fig.1a). Their on state voltage drop can be reduced through increasing die size, a question of technology and cost.

The Bipolar Darlington (DLT), the MOS Gated Bipolar Transistor (MOSBIP), the Insulated Gate Bipolar Transistor (IGBT) and Thyristors (GTO, FCTh...) exhibit a dominating p-n junction output behaviour (Fig 1b). The on state voltage drop of these devices is the sum of the threshold voltage of the p-n junction and the voltage drop across a resistance. The threshold voltage is determined by physical laws, only the resistive part of the on state voltage depends on the die size. The influence of die size on on-state losses is relatively limited and is not a feature that can be used to give significant loss reduction.

MOSFET AND BIPOLAR TRANSISTOR

The MOSFET, the BMFET and the BJT can have an on state voltage drop of less than 600mV and fast switching: A high power MOSFET e.g. a TSD4M450 ($R_{DS(on)} = 0.1\Omega$, $V_{DS} = 500V$, I_D MAX = 45A) handles a current of 5 Amps with an on state voltage drop of only 500mV. The die area of such a device is about 170 mm^2. The MOSFET requires only short gate current pulses for its drive.

A very fast cellular BJT e. g. a BUF410 (450V/1000V, 15A) switches 5 Amps with about 500mV on state voltage drop. The die area of this device is about 36mm^2 and has therefore a very low silicon cost. The BJT requires base current:

- — in excess of a fifth of the collector current
- — and negative bias for fast turn off switching, immunity against reverse current and dv/dt.

Nevertheless, the power gain is very high, e.g. when switching 400V x 5A = 2kW, a drive power

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Fig.1: Symbols, equivalent circuits and output characteristics of power semiconductor devices; a) devices with resistive output behavi0ur; b) devices with p-n junction behaviour

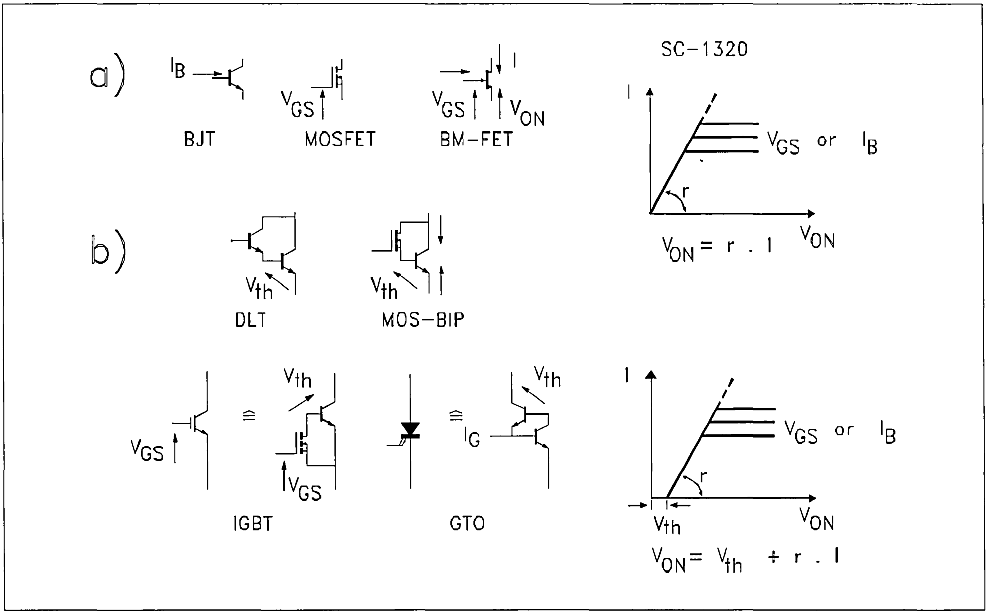


TABLE 1: On-state and driver losses of different device/driver configurations

Device + Driver	On-losses V_{CE} + I_C	Driver Consuptios V_S + I_B	Total Conductive Losses
BJT + (1)	0.5V x 20A = 10W	4A x 12V = 48W	58 W
DLT + (1)	1.5V x 20A = 30W	0.6A x 12V = 7W	37 W
BJT + (2)	0.5V x 20A = 10W	10W	20 W
DLT + (2)	1.4V x 20A = 28W	4W	32 W

of only 1A x 1V =1 W (base current multiplied by base emitter voltage) is needed.

The gap in die size between the POWER MOSFET and the cellular BJT, increasing with voltage and current, is so important, that it is worth thinking about low loss base drive for bipolar transistors.[1, 2, 3]

TRANSISTORS AND DARLINGTONS

The Darlington is the most popular switch in mains supplied, medium power applications. The major reason for this choice is its moderate base current consumption.

A typical fast switching 20A,450V Darlington requires a 0.6A base current. With a conventional driver circuit operating from an 8V to 12V auxilary supply, the worst case driver consumption would be 12V x 0.6A = 7W (Table 1).

The collector-emitter on state losses of the Darlington can be typically calculated to be about 30W. The total conduction losses amount to about 37W.

The bipolar junction transistor exhibits collector emitter on state losses of only 10W but requires a positive base current of 4A.

The total driver loss in the transistors is 4A x 1V = 4W (base current multiplied by base emitter voltage). With a conventional driver circuit operating

Fig. 2: Example of a switch-mode driver circuit for fast switching applications

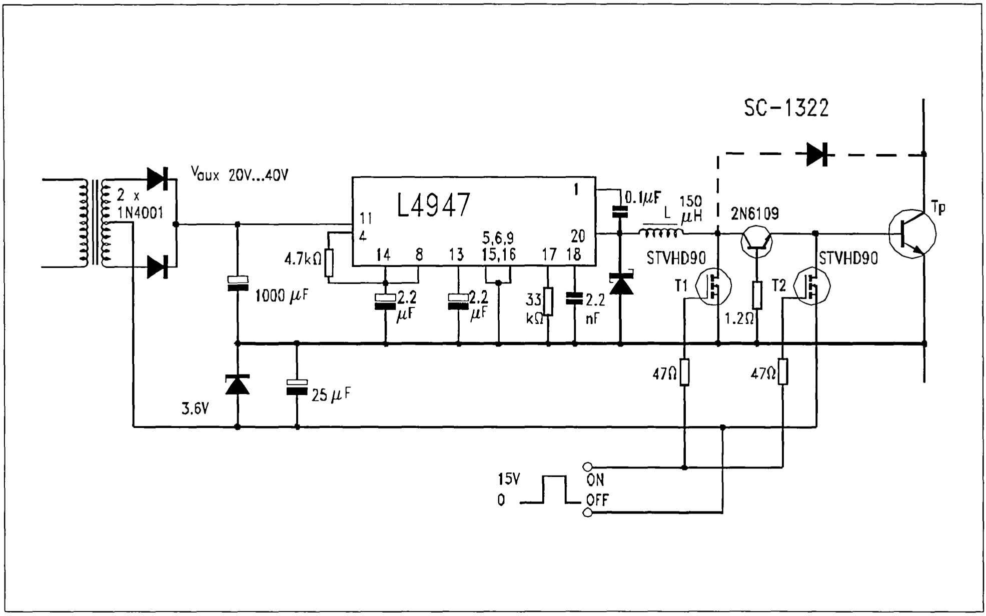
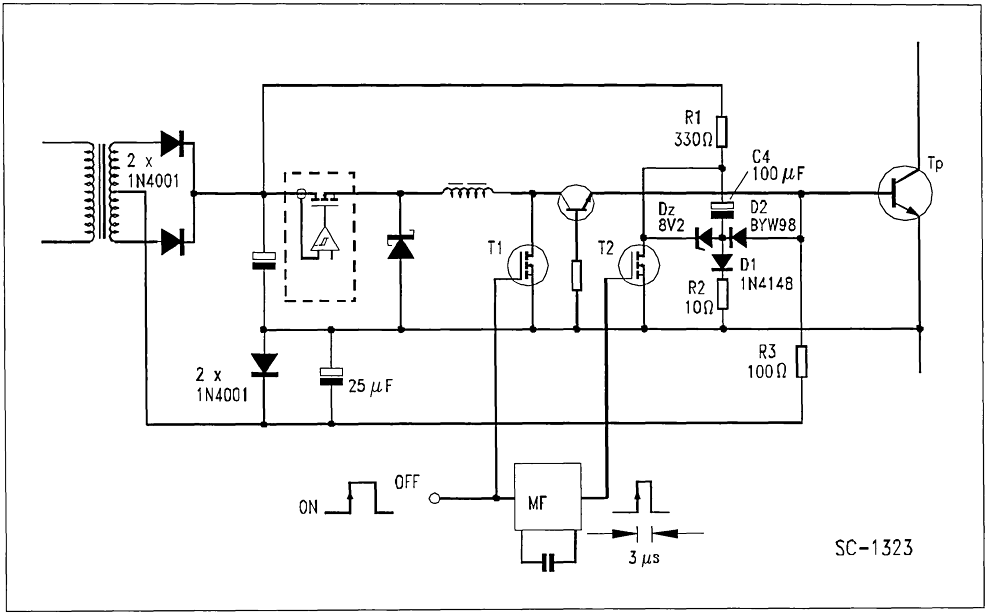


Fig.3: Self generation of negative bias from a positive supply voltage



from an 8V to 12V auxilary supply, the worst case driver consumption would be 48W - total conduction loss would be 58W. The poor efficiency of conventional driver stages is the reason that the transistor power switch exhibits higher conduction losses than the Darlington. Using driver stages with high efficiency allows BJT power stages to be used instead of Darlingtons which results in significant loss reduction.

DESCRIPTION OF THE SWITCH MODE BASE DRIVER

An L4974 smart power IC with a MOSFET output stage operates as a buck regulator in current mode. The IC is contained in a DIL package but is able to supply a 4 Amp base current. (Fig.2). The efficiency is so high that thermal conduction to the PCB provides sufficient cooling. During the off state of the power transistor, TP, a MOSFET T1 applies a short circuit to the output of the buck regulator. The IC operates with low duty cycle and maintains constant current in the choke L. For turn on of the power transistor TP, the MOSFET, T1, is turned off and the constant choke current flows into the power transistor's base. The rate of rise of base current is limited only by the MOSFET turn off speed. In order to obtain very fast switching, a high density MOSFET (STVHD90) which has a very reduced input and output capacitance, has been used.

If the power transistor base current is 4 Amps and the auxilary supply voltage 20V, the driver input current will be about 0.47 Amps. Increasing the auxilary supply voltage further reduces the input current.

NEGATIVE BIAS FOR FAST TURN OFF SWITCHING

The first version of the circuit generates negative bias with a Zener diode between auxilary supply and driver stage (Fig.2). The current return path to the auxiliary supply is through this diode. Losses in the Zener diode are small, due to the fact that input current of the driver circuit is small. For turn off, T1 and T2 are turned on, T2 applies the negative bias to the power transistor base, thus obtaining fast switching and immunity against reverse current and dv/dt.[4]

The second version of the circuit generates its negative bias directly from a positive auxilary supply:

> a capacitor C1 (Fig.3) is permanently charged via a resistor R1 and a diode D1. At turn off switching, T2 is turned on for a time t1, slightly longer than the power transistor's storage

Fig. 4: Test circuits for switching losses

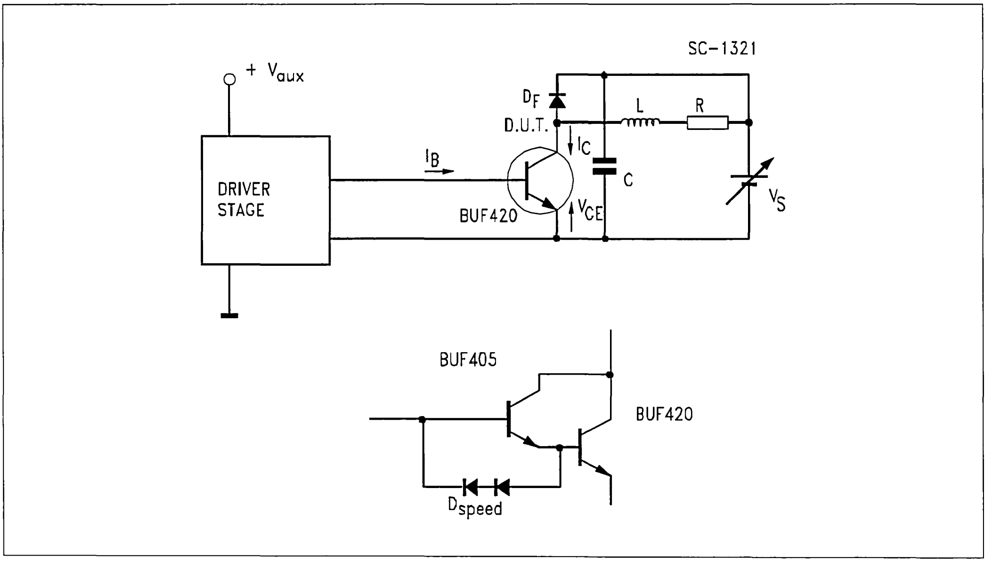
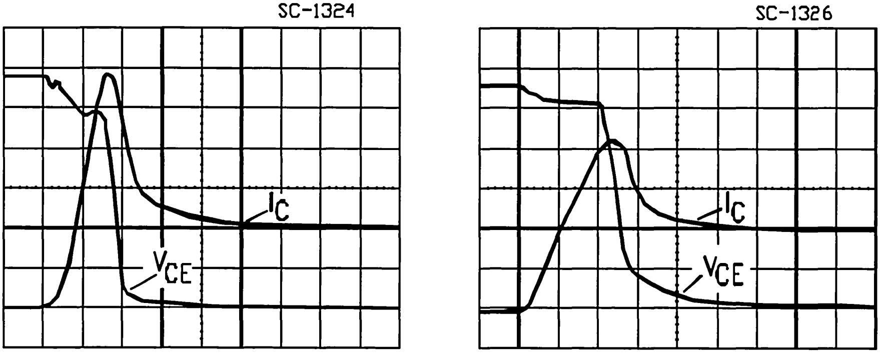
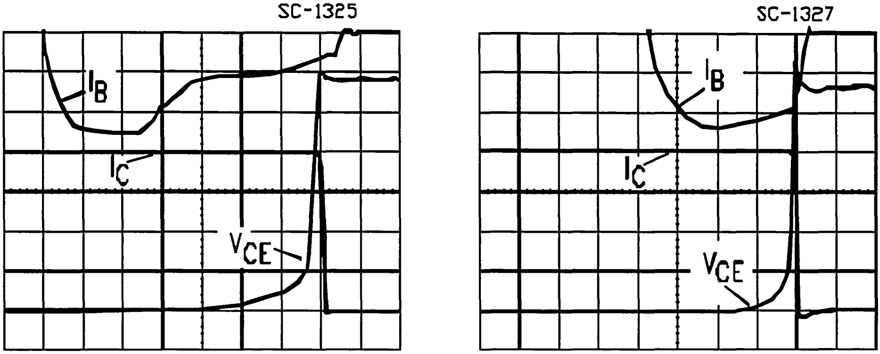


Fig. 5: Turn-on and off switching waveforms with transistors and Darlingtons



Darlington:
BUF405 + BUF420/BYT30-600
Turn-on: V_{CE} = 50V/div
I_C = 10A/div
t = 100ns/div
di_C/dt = 450A/µs

Bipolar Junction Transistor:
BUF420/BYT30-600
Turn-on: V_{CE} = 50V/div
I_C = 10A/div
t = 100ns/div
di_C/dt = 450A/µs



Darlington:
BUF405 + BUF420/BYT30-600
Turn-off: V_{CE} = 50V/div
I_C = 5A/div I_B = 2A/div
t = 500ns/div

Bipolar Junction Transistor:
BUF420/BYT30-600
Turn-off: V_{CE} = 50V/div
I_C = 5A/div I_B = 2A/div
t = 500ns/div

TABLE2: Switching energy losses of transistor and Darlington with BUF420 and BYT30-600

DEVICE UNDER TEST (DUT)	TURN-ON ENERGY	TURN-OFF ENERGY	TOTAL SWITCHING ENERGY
CELL. - BJT	1 mJ	0.5 mJ	1.5 mJ
CELL. - DLT	0.9 mJ	0.8 mJ	1.7 mJ

time, ts. T2 connects the positive electrode of C1 to ground, thus a negative voltage appears at the base of TP. T2 turns off after the turn off switching of TP and C1 continues charging. The state of charge of C1 is independant of duty cycle - sufficient negative bias is available with any duty cycle.

TEST RESULTS

Fast transistors and Darlingtons made using cellular technology (e.g.BUF420) have been tested in a buck converter with 280V supply voltage and 20A output current (Fig.4) Both types of switches have been driven from the same switch mode driver circuit. The turn on and turn off waveforms are shown in Fig. 5a and 5b. The devices were operated at Tj =85°C.

As expected, the turn on speed di_C/dt of the Darlington is twice as fast as that of the transistor switch. The reverse recovery current of the free wheel diode increases with di/dt. This makes the difference in turn-on loss between the fast switching transistor stage and the faster switching Darlington stage insignificant (Table 2). The storage time of a transistor stage is less than that of a Darlington stage. The test results confirm this well known fact.

With a given driver stage, the negative base current of a Darlington is reduced, due to the voltage drop of the speed up diodes. (Fig. 4) This explains the observed increased turn off losses with the Darlington.

CONDUCTION LOSSES

The conduction losses, including driver losses have been calculated and confirmed by measurement. With a duty cycle of 100% the total conduction losses of a 20A Darlington with conventional driver are O.6A x 12V + 1.5V x 20A = 37W. The same Darlington driven from the switch mode driver exhibits conduction losses of 32W. The conduction losses of the transistor with switch mode driver are 0.5A x 20V + 0,5V x 20A =20W.

This is about 60% of the switch mode driven Darlington.

CONCLUSION

Low loss driver circuits suffered from duty cycle limitations, or from excessive circuit complexity. New smart power devices reduce this complexity to an acceptable level, allowing the introduction of switch mode driver techniques in to transistorized power electronic equipment. The new configuration can be used to simplify and improve existing converter/inverter circuits (fewer auxiliary supplies, smaller heatsinks, higher efficiency).

The use of switch mode driver stages is not limited to BJTs, but offers improved efficiency in circuits with Darlingtons, BMFETs and GTOs.

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DATASHEETS

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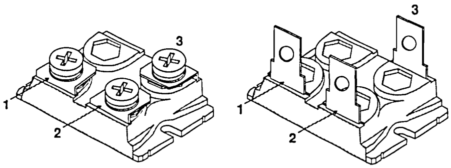
BUF298F
BUF298V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

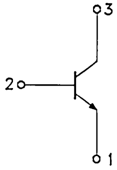
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUF298V **BUF298F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04830

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	850	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	90	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

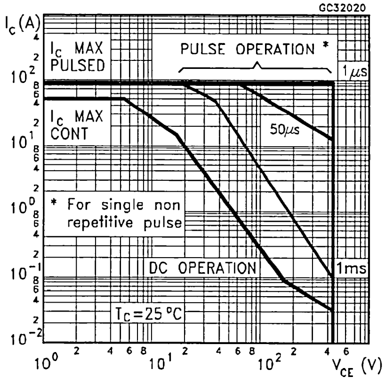
$R_{thj\text{-}case}$	Thermal Resistance Junction-case Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

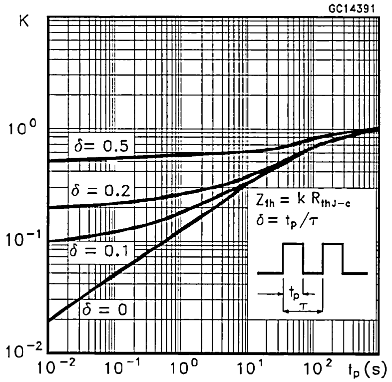
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 4	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 32 A V_{CE} = 5 V		17		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		0.35 0.4	1.2 2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		1 0.4	1.5 1.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 9.6 A T_j = 100 °C	160			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 3 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 3 A T_j = 100 °C		1.6	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 32 A V_{CC} = 300 V V_{BB} = -5 V R_{BB} = 0.39 Ω V_{clamp} = 450 V I_{B1} = 6.4 A L = 78 µH T_j = 100 °C		3.2 0.25 0.5	4.5 0.4 0.7	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 48 A I_{B1} = 6.4 A V_{BB} = -5 V V_{CC} = 50 V L = 52 µH R_{BB} = 0.39 Ω T_j = 125 °C	450			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

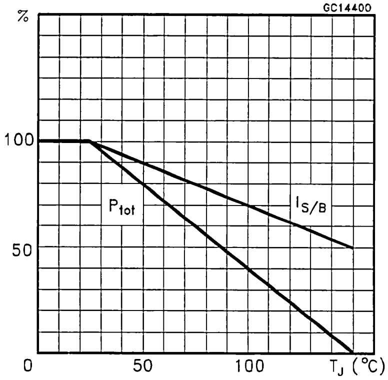
Safe Operating Areas



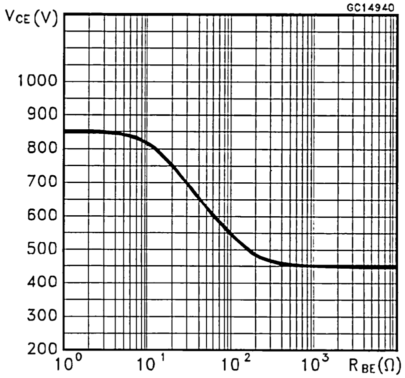
Thermal Impedance



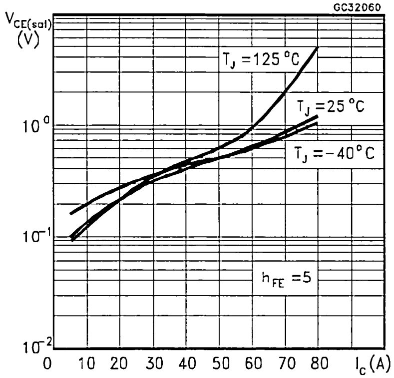
Derating Curve



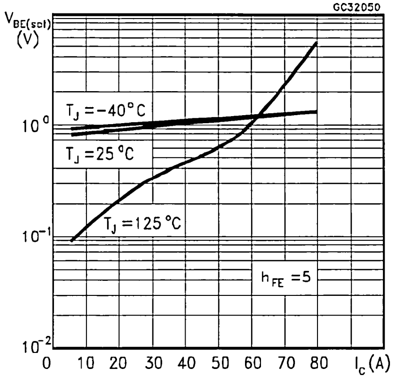
Collector-Emitter Voltage Versus Base-Emitter Resistance



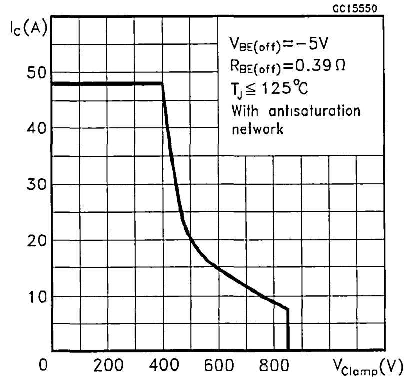
Collector-Emitter Saturation Voltage



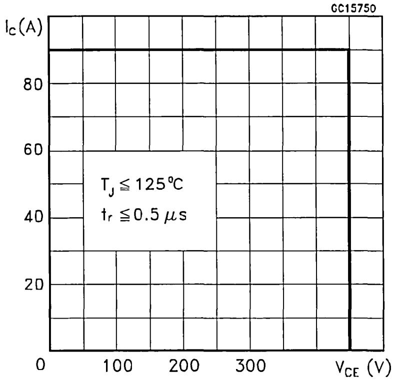
Base-Emitter Saturation Voltage



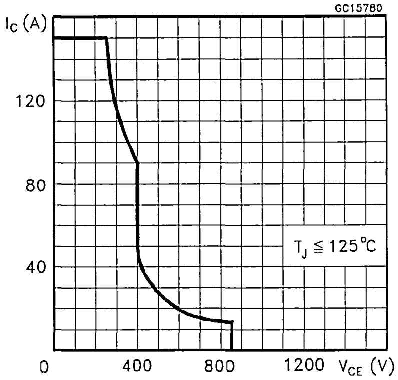
Reverse Biased SOA



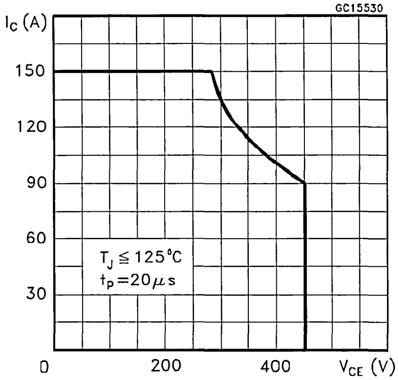
Forward Biased SOA



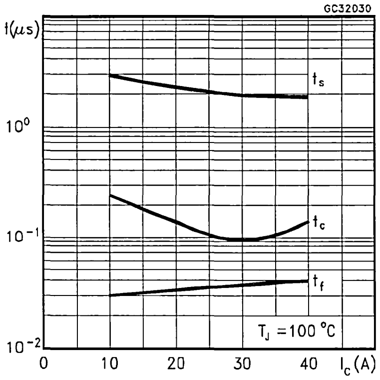
Reverse Biased AOA



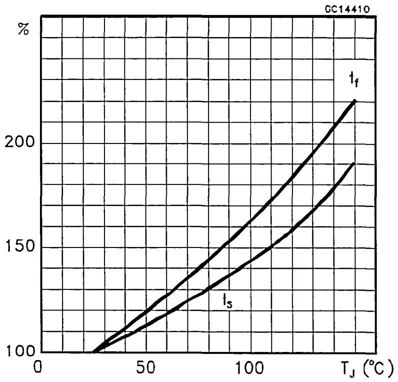
Forward Biased AOA



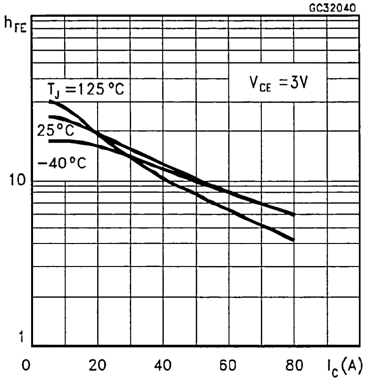
Switching Times Inductive Load



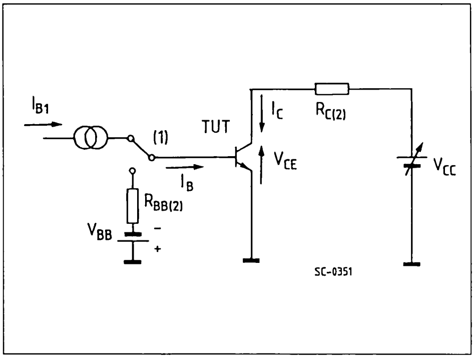
Switching Times Inductive Load Versus Temperature



DC Current Gain

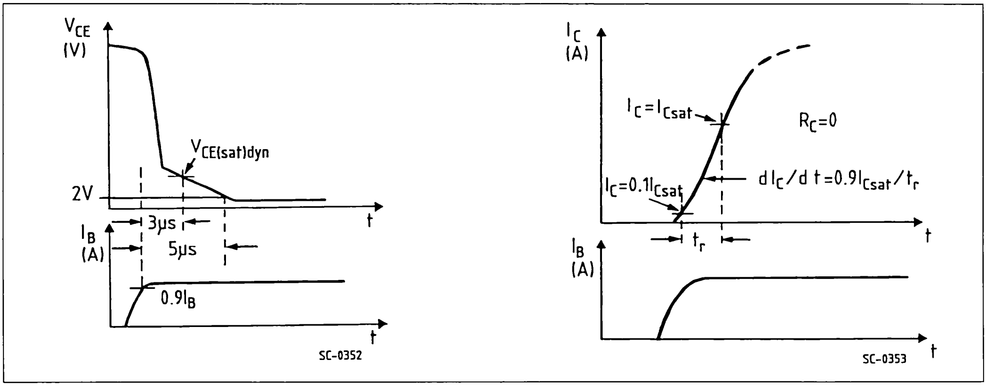


Turn-on Switching Test Circuit

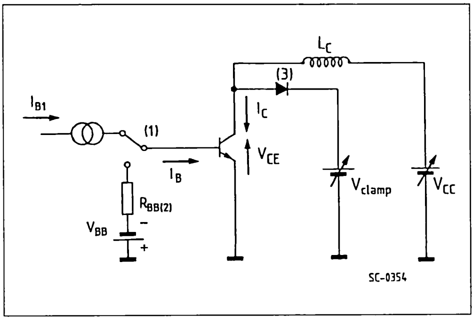


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

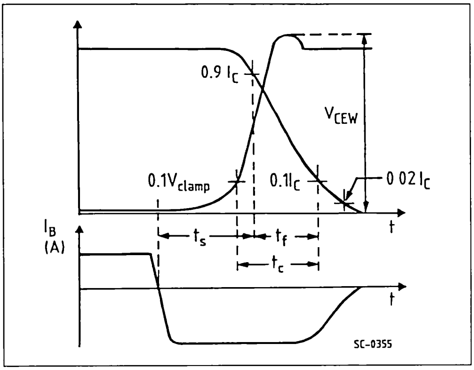


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms

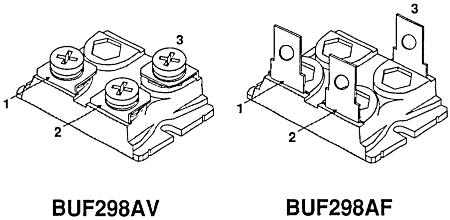


BUF298AF
BUF298AV

NPN TRANSISTOR POWER MODULE

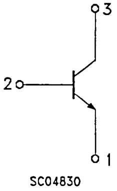
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	90	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

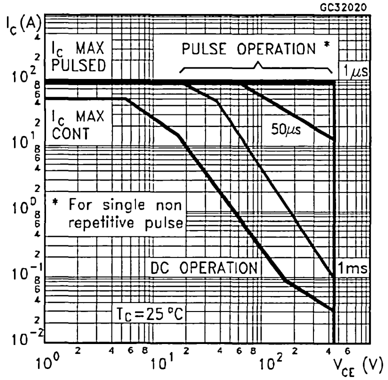
$R_{thj\text{-}case}$ $R_{thc\text{-}h}$	Thermal Resistance Junction-case Thermal Resistance Case-heatsink With Conductive Grease Applied	Max Max	0.5 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

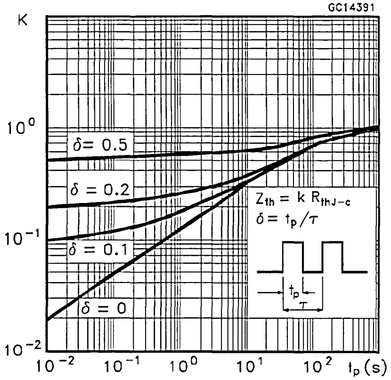
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 4	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 32 A V_{CE} = 5 V		17		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		0.35 0.4	1.2 2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		1 0.4	1.5 1.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 9.6 A T_j = 100 °C	160			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 3 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 3 A T_j = 100 °C		1.6	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 32 A V_{CC} = 300 V V_{BB} = -5 V R_{BB} = 0.39 Ω V_{clamp} = 450 V I_{B1} = 6.4 A L = 78 µH T_j = 100 °C		3.2 0.25 0.5	4.5 0.4 0.7	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 48 A I_{B1} = 6.4 A V_{BB} = -5 V V_{CC} = 50 V L = 52 µH R_{BB} = 0.39 Ω T_j = 125 °C	450			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

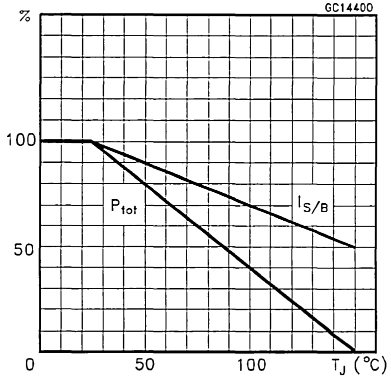
Safe Operating Areas



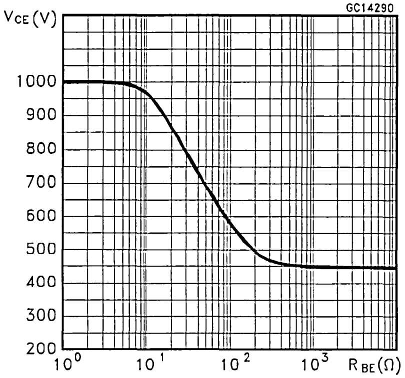
Thermal Impedance



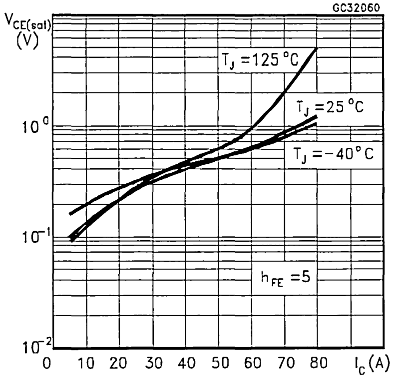
Derating Curve



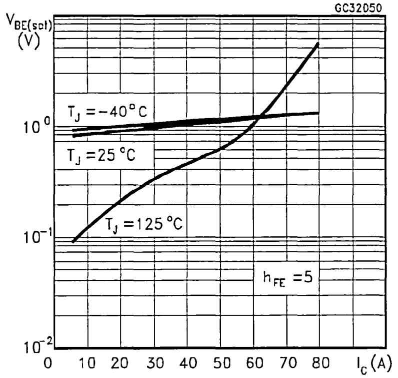
Collector-Emitter Voltage Versus Base-Emitter Resistance



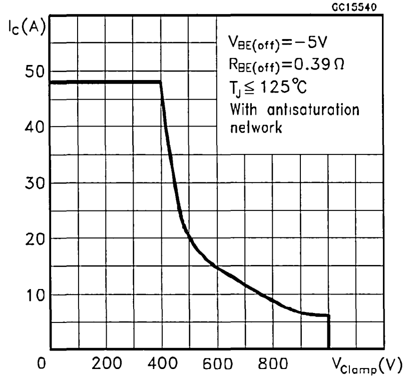
Collector-Emitter Saturation Voltage



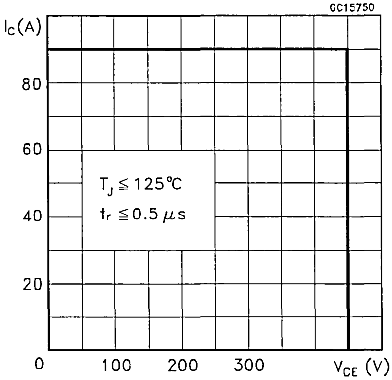
Base-Emitter Saturation Voltage



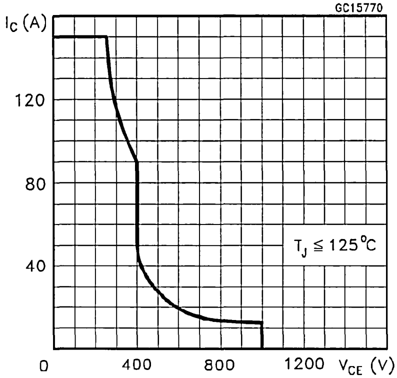
Reverse Biased SOA



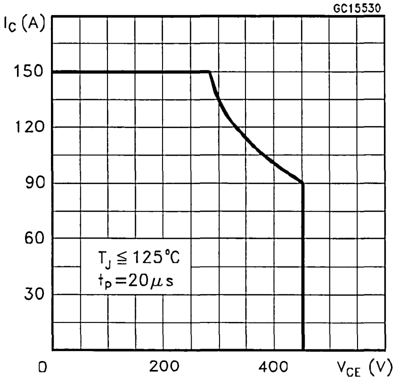
Forward Biased SOA



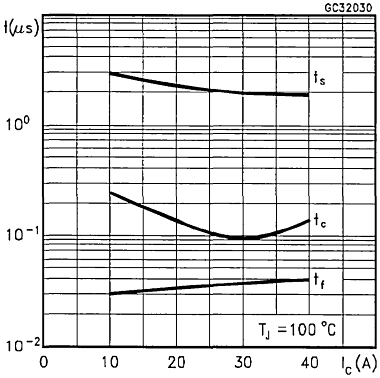
Reverse Biased AOA



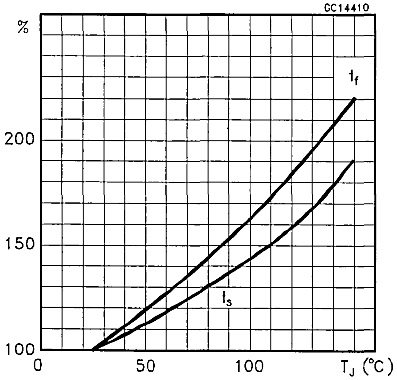
Forward Biased AOA



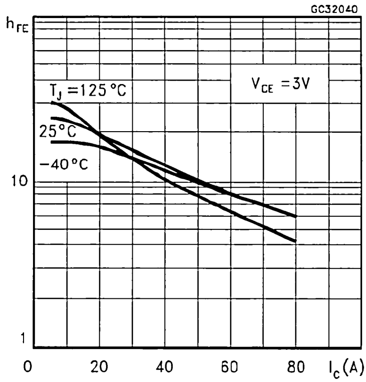
Switching Times Inductive Load



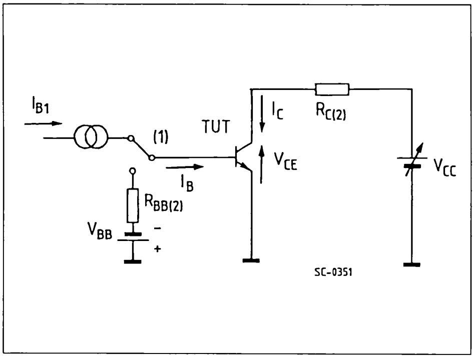
Switching Times Inductive Load Versus Temperature



DC Current Gain

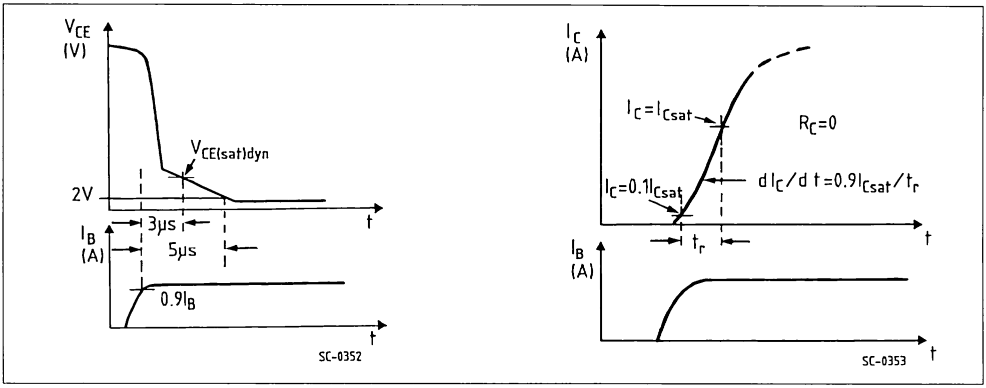


Turn-on Switching Test Circuit

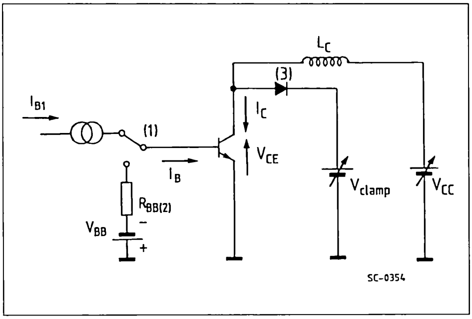


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

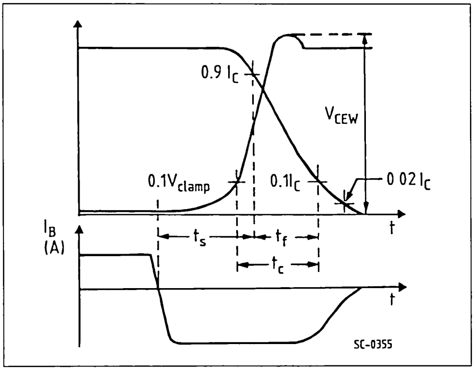


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



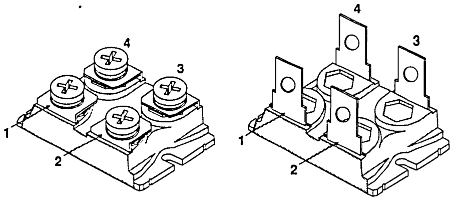
SGS-THOMSON
MICROELECTRONICS

BUF460F
BUF460V

NPN TRANSISTOR POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

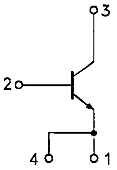
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUF460V **BUF460F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	850	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	80	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	160	A
I_B	Base Current	18	A
I_{BM}	Base Peak Current (t_p = 10 ms)	27	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

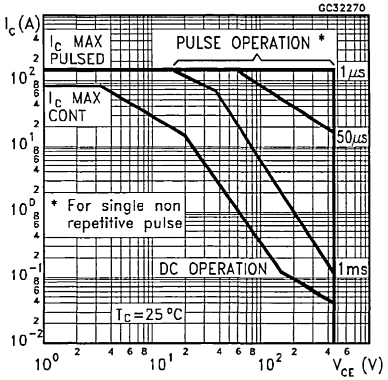
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.41	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

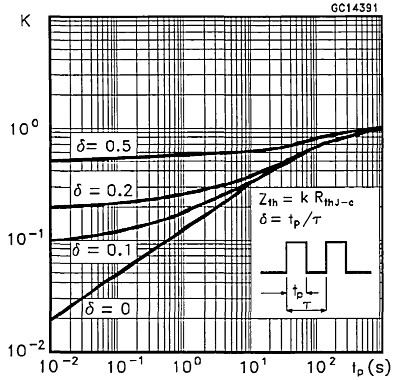
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$			0.2	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			2	mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5V)	$V_{CE} = V_{CEV}$			0.2	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 5 V		15		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 3 A		0.35		V
		I_C = 30 A I_B = 3 A T_j = 100 °C			2	V
		I_C = 60 A I_B = 12 A		0.5		V
		I_C = 60 A I_B = 12 A T_j = 100 °C			2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 12 A		1.1		V
		I_C = 60 A I_B = 12 A T_j = 100 °C			1.5	V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 18 A T_j = 100 °C	150			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		4	6	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.2 Ω V_{clamp} = 400 V I_{B1} = 3 A L = 25 µH T_j = 100 °C		4.5 0.1 0.3	5 0.2 5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 80 A I_{B1} = 16 A V_{BB} = -5 V V_{CC} = 50 V L = 80 µH R_{BB} = 0.2 Ω T_j = 125 °C	400			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

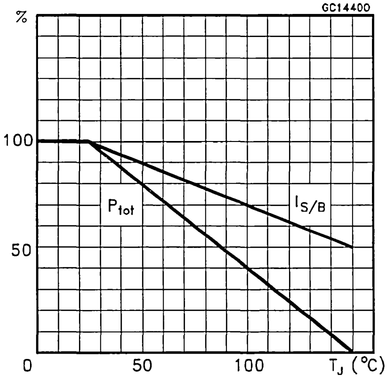
Safe Operating Areas



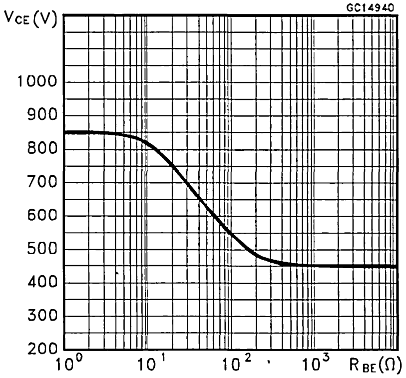
Thermal Impedance



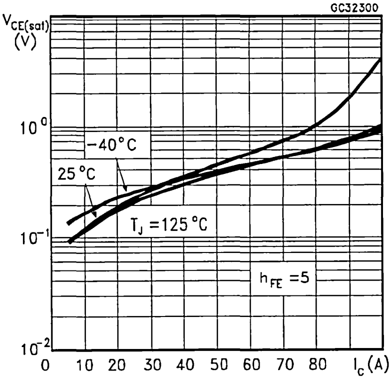
Derating Curve



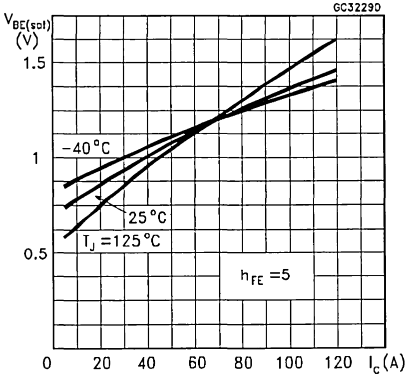
Collector-Emitter Voltage Versus Base-Emitter Resistance



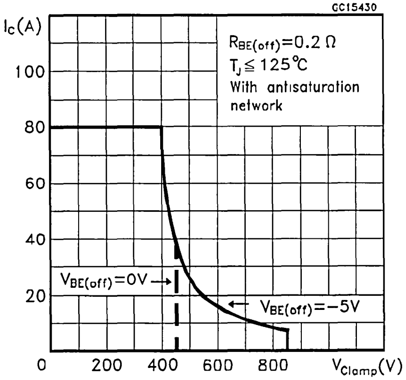
Collector-Emitter Saturation Voltage



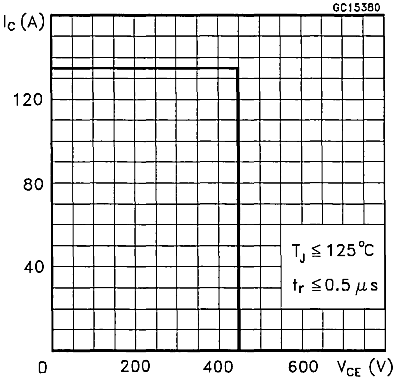
Base-Emitter Saturation Voltage



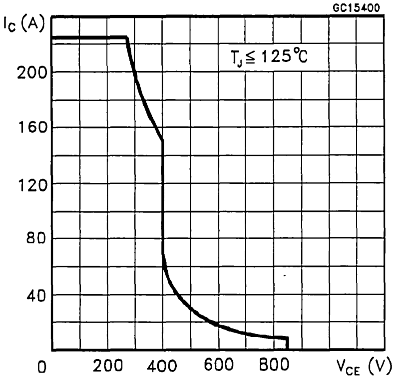
Reverse Biased SOA



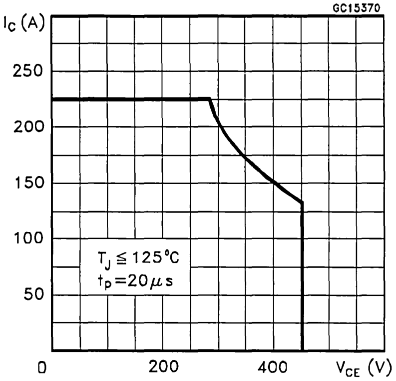
Forward Biased SOA



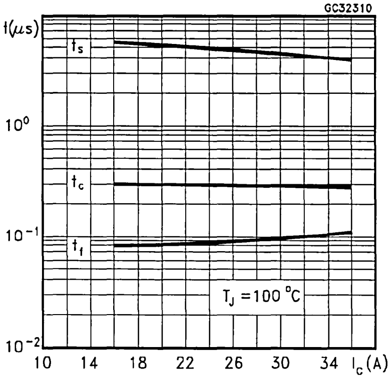
Reverse Biased AOA



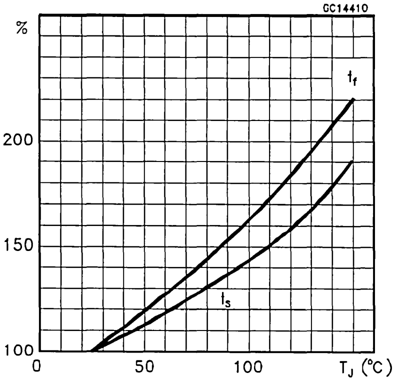
Forward Biased AOA



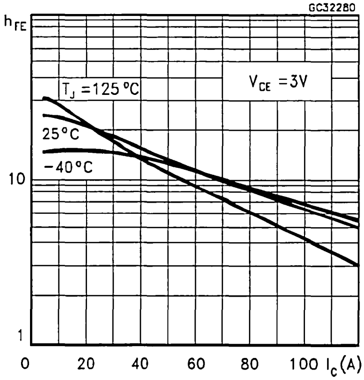
Switching Times Inductive Load



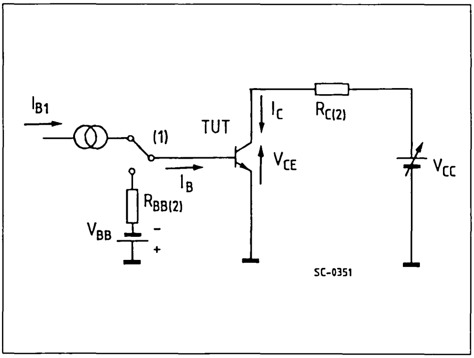
Switching Times Inductive Load Versus Temperature



DC Current Gain

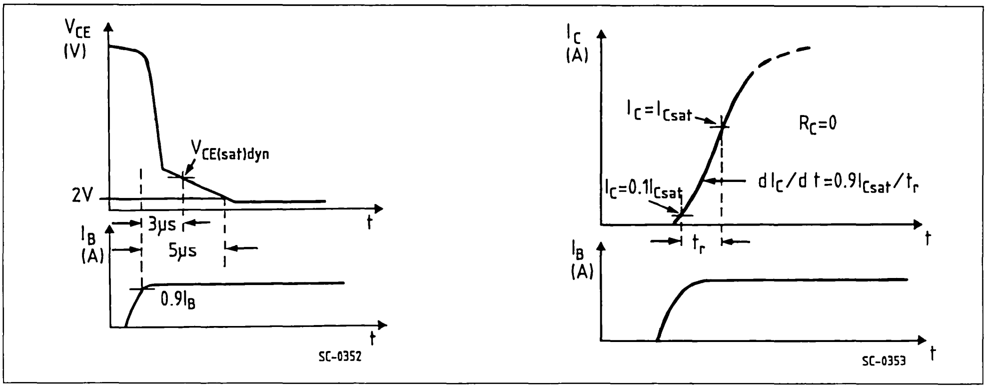


Turn-on Switching Test Circuit

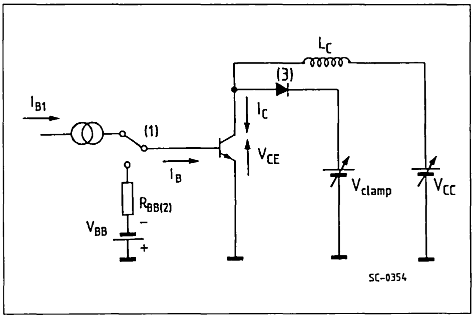


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

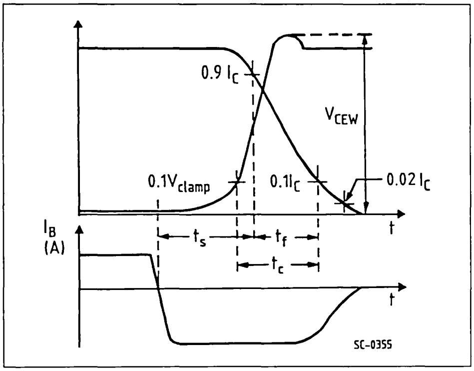


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

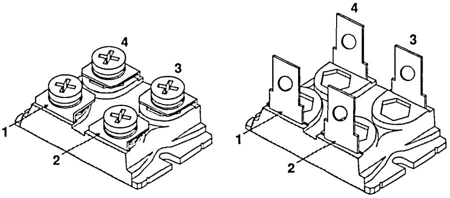
BUF460AF
BUF460AV

NPN TRANSISTOR POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

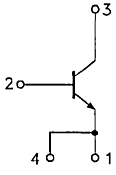
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUF460AV **BUF460AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04840

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	80	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	160	A
I_B	Base Current	18	A
I_{BM}	Base Peak Current (t_p = 10 ms)	27	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

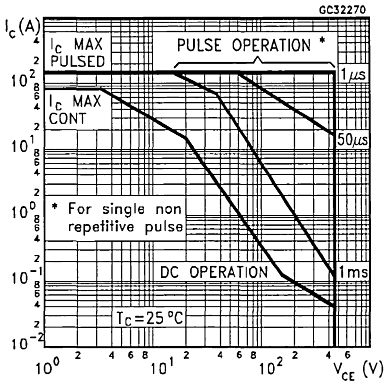
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.41	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

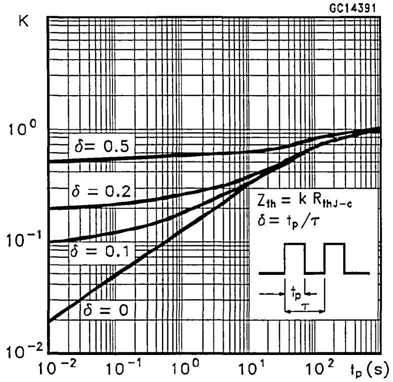
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$			0.2	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			2	mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5V)	$V_{CE} = V_{CEV}$			0.2	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}^*$	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 5 V		15		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 3 A		0.35		V
		I_C = 30 A I_B = 3 A T_j = 100 °C			2	V
		I_C = 60 A I_B = 12 A		0.5		V
		I_C = 60 A I_B = 12 A T_j = 100 °C			2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 12 A		1.1		V
		I_C = 60 A I_B = 12 A T_j = 100 °C			1.5	V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 18 A T_j = 100 °C	150			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		4	6	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.2 Ω V_{clamp} = 400 V I_{B1} = 3 A L = 25 µH T_j = 100 °C		4.5 0.1 0.3	5 0.2 5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 80 A I_{B1} = 16 A V_{BB} = -5 V V_{CC} = 50 V L = 80 µH R_{BB} = 0.2 Ω T_j = 125 °C	400			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

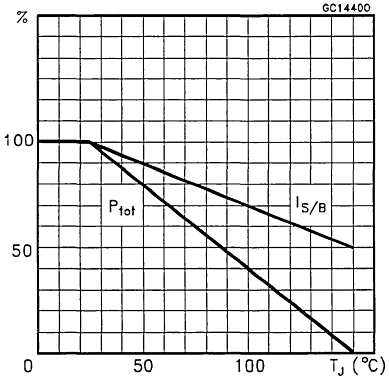
Safe Operating Areas



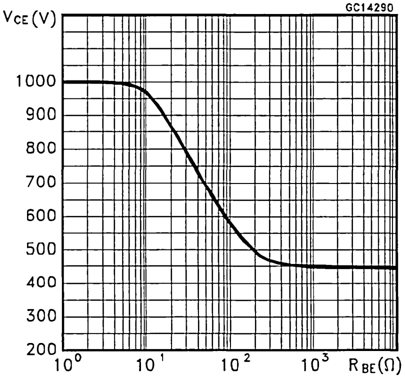
Thermal Impedance



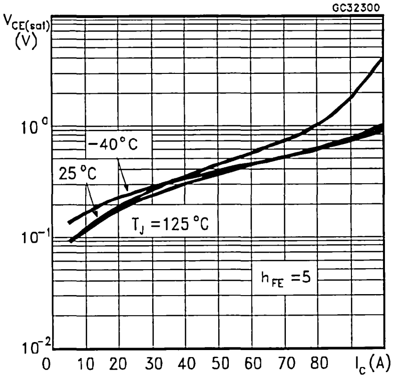
Derating Curve



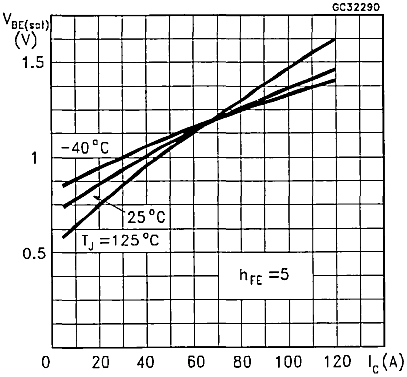
Collector-Emitter Voltage Versus Base-Emitter Resistance



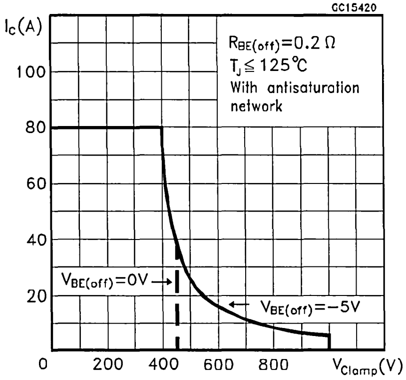
Collector-Emitter Saturation Voltage



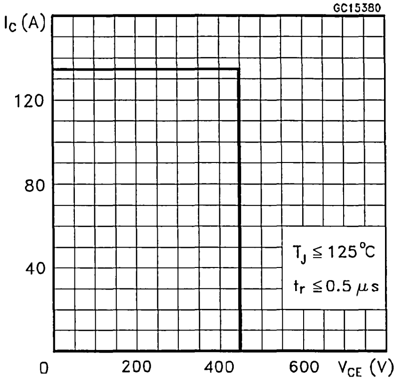
Base-Emitter Saturation Voltage



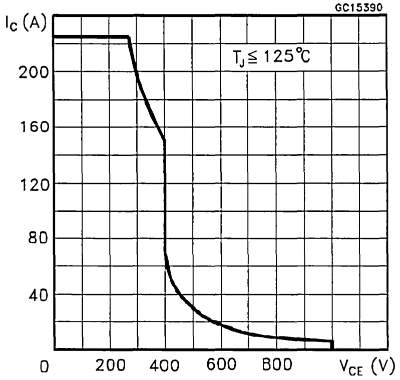
Reverse Biased SOA



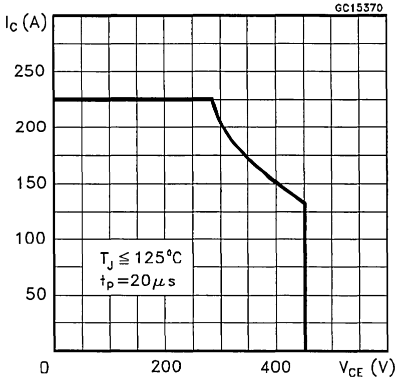
Forward Biased SOA



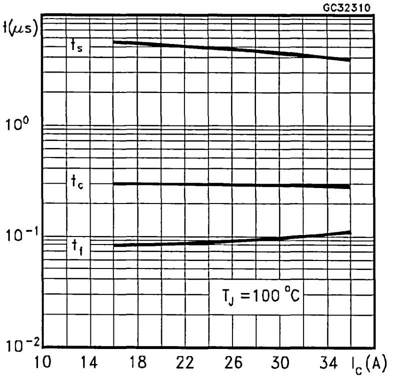
Reverse Biased AOA



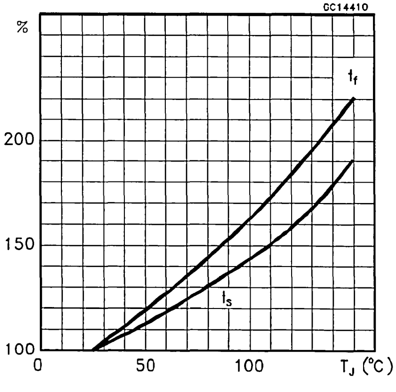
Forward Biased AOA



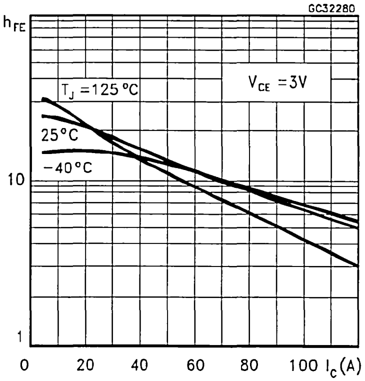
Switching Times Inductive Load



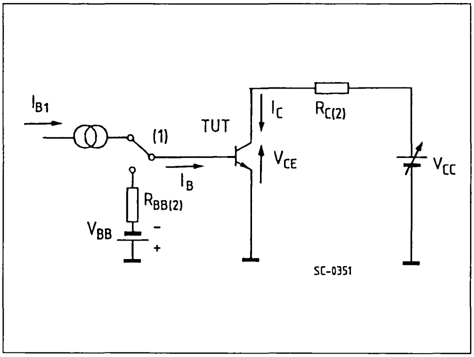
Switching Times Inductive Load Versus Temperature



DC Current Gain

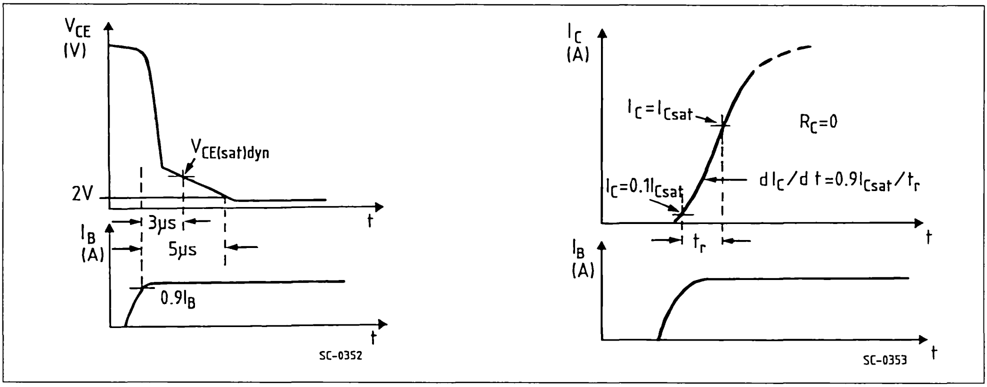


Turn-on Switching Test Circuit

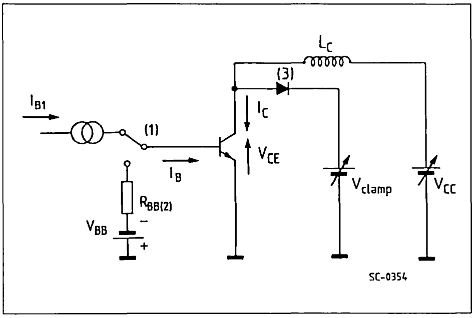


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

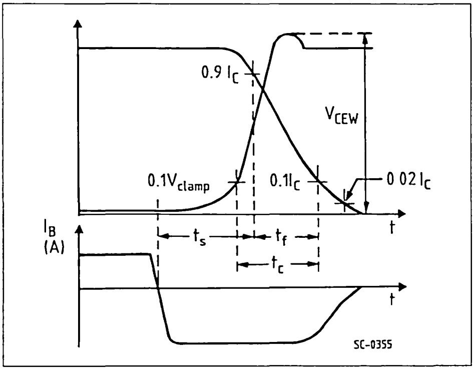


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

BUF460DF
BUF460DV

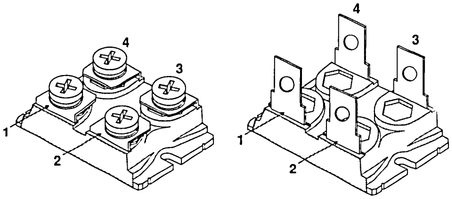
NPN DARLINGTON POWER MODULE

PRELIMINARY DATA

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

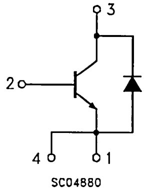
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUF460DV **BUF460DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	80	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	160	A
I_B	Base Current	18	A
I_{BM}	Base Peak Current (t_p = 10 ms)	27	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.41	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

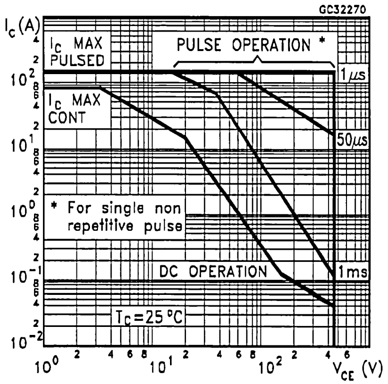
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.2 2	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.2 2	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 5 V		120		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 3 A I_C = 30 A I_B = 3 A T_j = 100 °C I_C = 60 A I_B = 12 A I_C = 60 A I_B = 12 A T_j = 100 °C		0.35 0.5 	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 12 A I_C = 60 A I_B = 12 A T_j = 100 °C		1.1 	 1.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 18 A T_j = 100 °C	150			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		4	6	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 30 Ω I_{B1} = 18 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.2 Ω V_{clamp} = 450 V I_{B1} = 3 A L = 0.25 mH T_j = 100 °C		4.5 0.1 0.3	5 0.2 5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 80 A I_{B1} = 16 A V_{BB} = -5 V V_{CC} = 50 V L = 80 µH R_{BB} = 0.2 Ω T_j = 125 °C	400			V
V_F*	Diode Forward Voltage	I_F = 70 A T_j = 100 °C		1.6	1.9	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 70 A di_F/dt = -375 A/µs L < 0.05 µH T_j = 100 °C		38	45	A

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

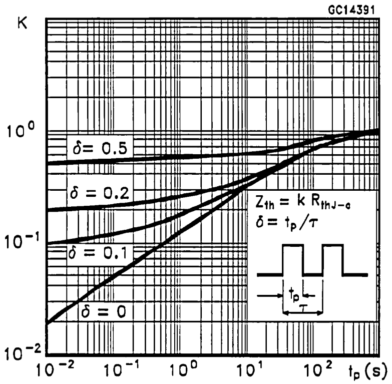
To evaluate the conduction losses of the diode use the following equations.

$V_F = 1.1 + 0.007\ I_F$ $P = 1.1\ I_{F(AV)} + 0.007\ I^2_{F(RMS)}$

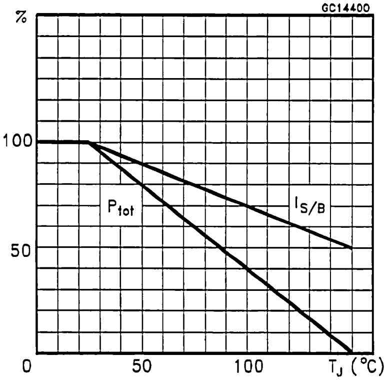
Safe Operating Areas



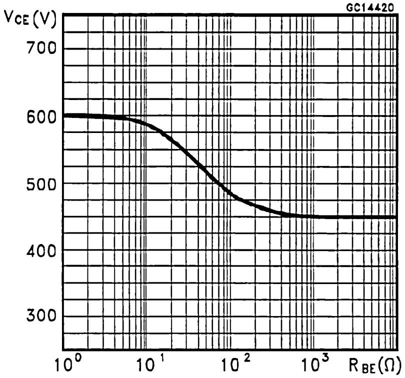
Thermal Impedance



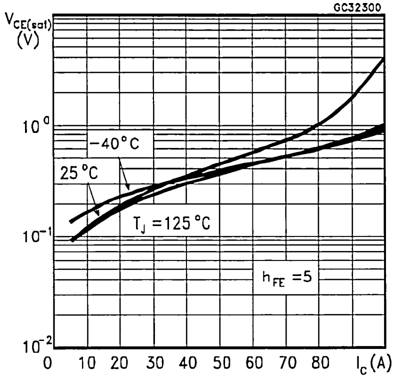
Derating Curve



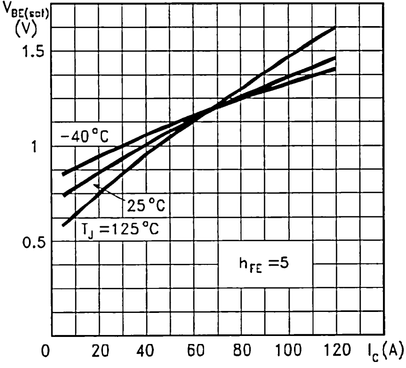
Collector-Emitter Voltage Versus Base-Emitter Resistance



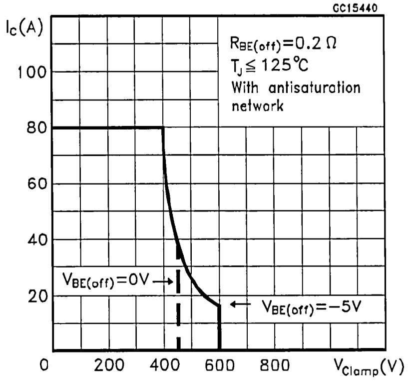
Collector-Emitter Saturation Voltage



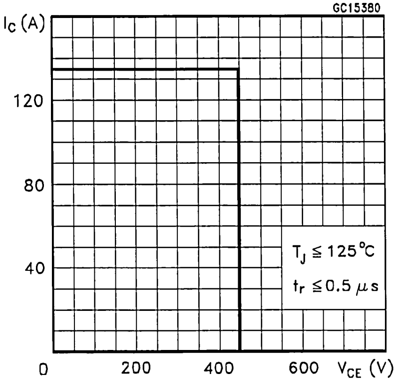
Base-Emitter Saturation Voltage



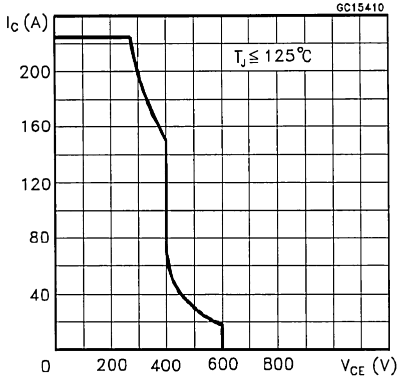
Reverse Biased SOA



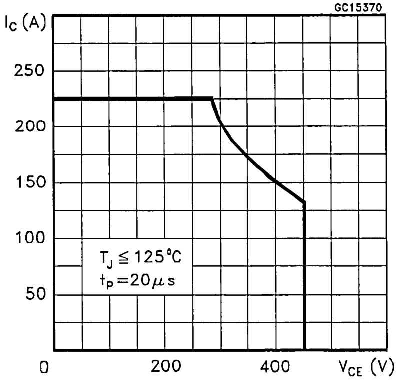
Forward Biased SOA



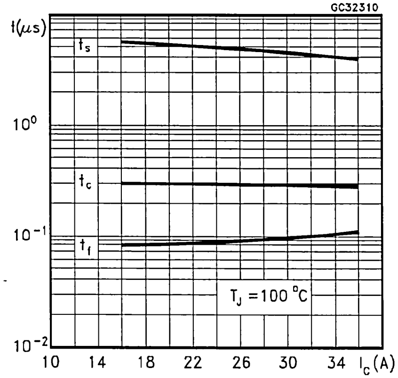
Reverse Biased AOA



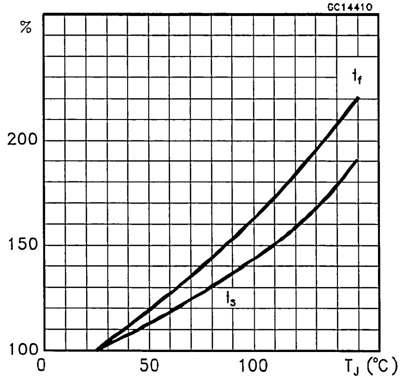
Forward Biased AOA



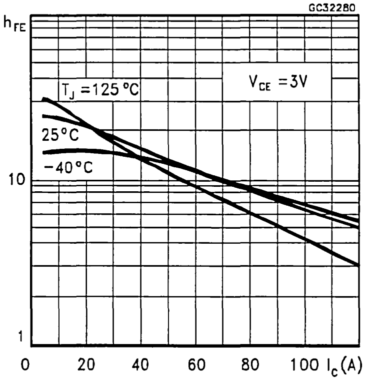
Switching Times Inductive Load



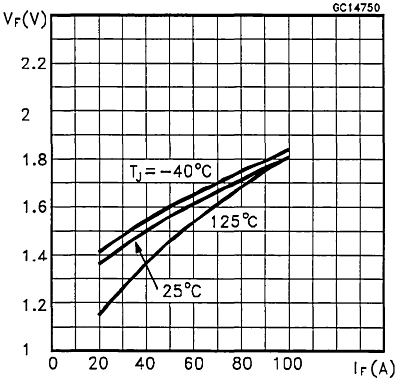
Switching Times Inductive Load Versus Temperature



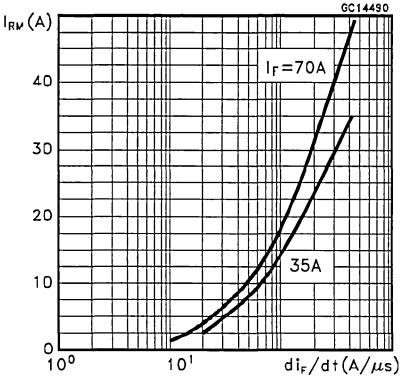
DC Current Gain



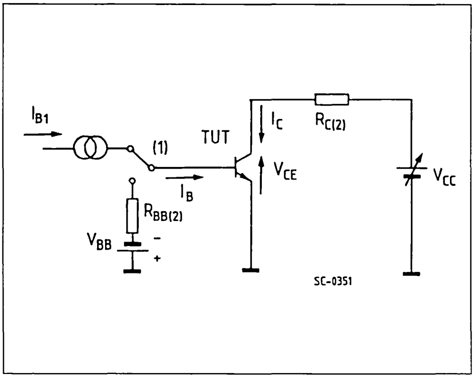
Typical V_F Versus I_F



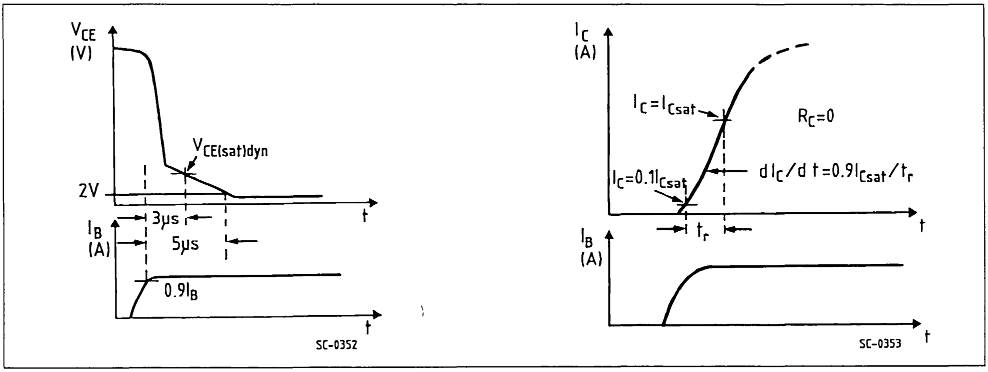
Peak Reverse Current Versus di_F/dt



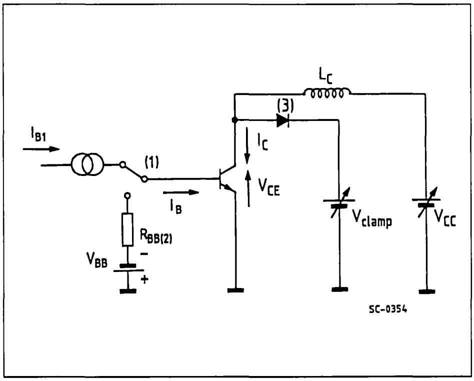
Turn-on Switching Test Circuit



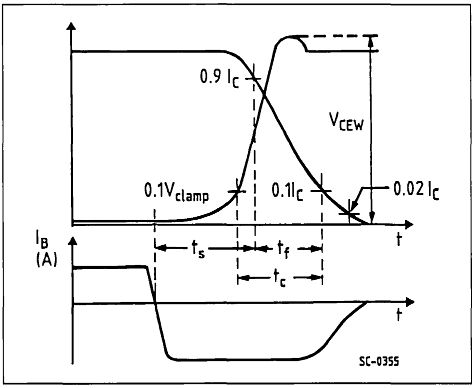
Turn-on Switching Waveforms



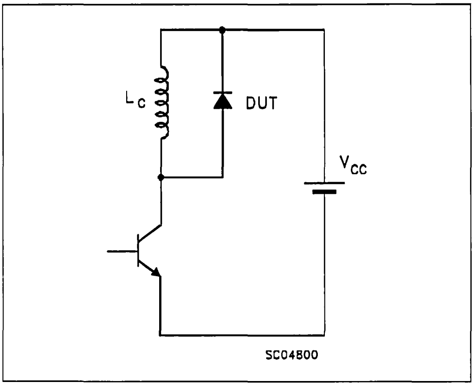
Turn-off Switching Test Circuit



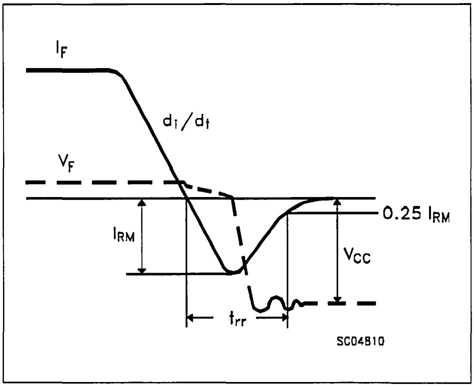
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

BUF824F
BUF824V

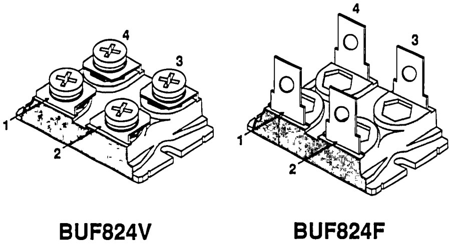
NPN TRANSISTOR POWER MODULE

ADVANCE DATA

- HIGH VOLTAGE, HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

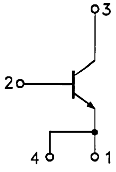
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04840

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1200	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	800	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	36	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	54	A
I_B	Base Current	9	A
I_{BM}	Base Peak Current (t_p = 10 ms)	18	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.45	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CE(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 800 V	800			V
h_{FE}*	DC Current Gain	I_C = 24 A V_{CE} = 5 V		8		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 24 A I_B = 6 A I_C = 24 A I_B = 6 A T_j = 100 °C			2 2.2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 24 A I_B = 6 A I_C = 24 A I_B = 6 A T_j = 100 °C			1 1	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 9 A T_j = 100 °C		200		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = Ω I_{B1} = A T_j = 100 °C				V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = Ω I_{B1} = A T_j = 100 °C				V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 24 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6Ω V_{clamp} = 800 V I_{B1} = 6 A L = 50 µH T_j = 100 °C		6.5 0.1 0.25		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 30 A I_{B1} = 8 A V_{BB} = -5 V V_{CC} = 50 V L = 50 µH R_{BB} = 0.6 Ω T_j = 125 °C	800			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

SGS-THOMSON
MICROELECTRONICS

BUF832F
BUF832V

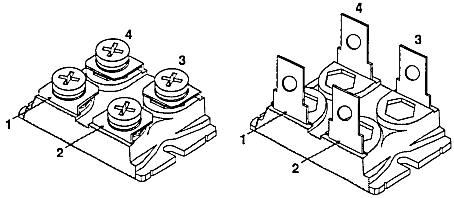
NPN TRANSISTOR POWER MODULE

ADVANCE DATA

- HIGH VOLTAGE, HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

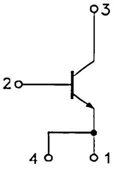
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUF832V **BUF832F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04840

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1200	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	800	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	48	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	72	A
I_B	Base Current	12	A
I_{BM}	Base Peak Current (t_p = 10 ms)	24	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.41	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CE(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 800 V	800			V
h_{FE}*	DC Current Gain	I_C = 32 A V_{CE} = 5 V		8		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 32 A I_B = 8 A I_C = 32 A I_B = 8 A T_j = 100 °C			2 2.2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 32 A I_B = 8 A I_C = 32 A I_B = 8 A T_j = 100 °C			1.2 1.2	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 12 A T_j = 100 °C		200		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = Ω I_{B1} = A T_j = 100 °C				V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = Ω I_{B1} = A T_j = 100 °C				V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 32 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 800 V I_{B1} = 8 A L = 50 µH T_j = 100 °C		8 0.1 0.25		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 45 A I_{B1} = 12 A V_{BB} = -5 V V_{CC} = 50 V L = 50 µH R_{BB} = 0.6 Ω T_j = 125 °C	800			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

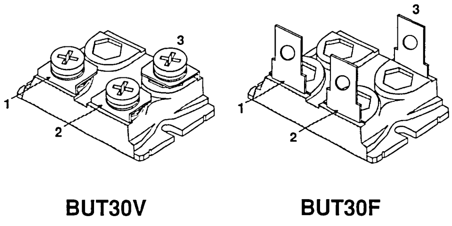
BUT30F
BUT30V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

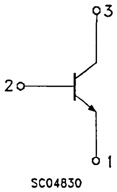
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS



ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	200	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	125	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	100	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	150	A
I_B	Base Current	20	A
I_{BM}	Base Peak Current (t_p = 10 ms)	30	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

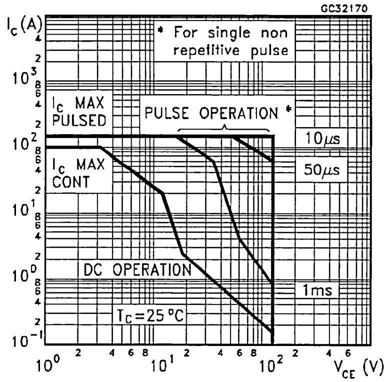
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

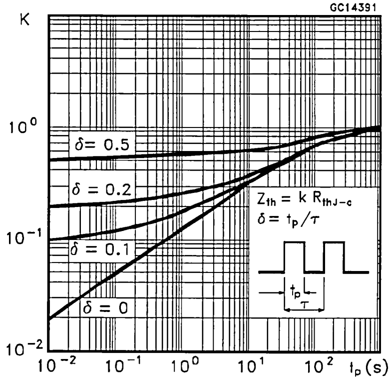
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 125 V	125			V
h_{FE}*	DC Current Gain	I_C = 100 A V_{CE} = 5 V		2.7		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 2.5 A I_C = 50 A I_B = 2.5 A T_j = 100 °C I_C = 100 A I_B = 10 A I_C = 100 A I_B = 10 A T_j = 100 °C		0.45 0.55 0.7 0.9	0.9 1.2 0.9 1.5	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 2.5 A I_C = 50 A I_B = 2.5 A T_j = 100 °C I_C = 100 A I_B = 10 A I_C = 100 A I_B = 10 A T_j = 100 $_o$C		1.15 1.1 1.45 1.55	1.4 1.4 1.8 1.9	V V V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 15 A T_j = 100 °C	270	350		A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 1 Ω I_{B1} = 15 A T_j = 100 °C		2.7	3.5	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 1 Ω I_{B1} = 15 A T_j = 100 °C		2	2.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 100 A V_{CC} = 90 V V_{BB} = -5 V R_{BB} = 0.47 Ω V_{clamp} = 125 V I_{B1} = 10 A L = 45 μH T_j = 100 °C		1 0.1 0.2	2 0.2 0.35	μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 150 A I_{B1} = 10 A V_{BB} = -5 V V_{CC} = 90 V L = 30 μH R_{BB} = 0.5Ω T_j = 125 °C	125			V

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

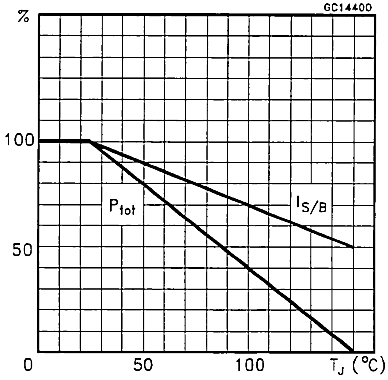
Safe Operating Areas



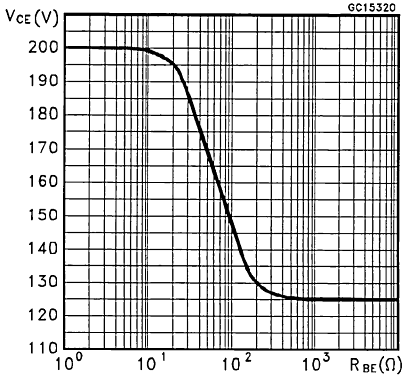
Thermal Impedance



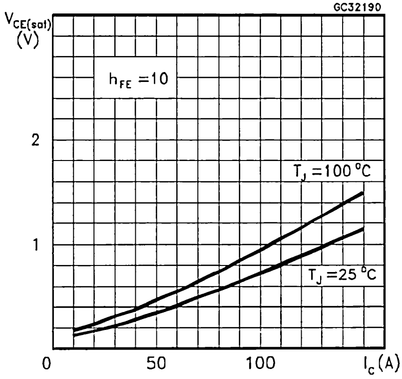
Derating Curve



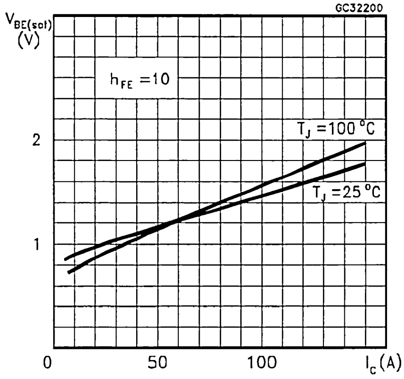
Collector-Emitter Voltage Versus Base-Emitter Resistance



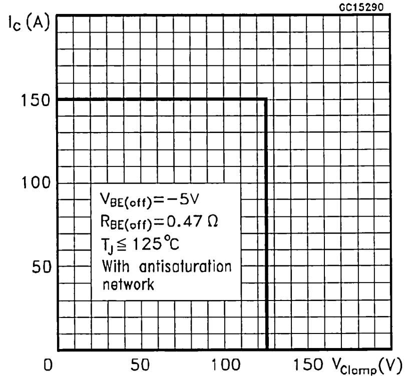
Collector-Emitter Saturation Voltage



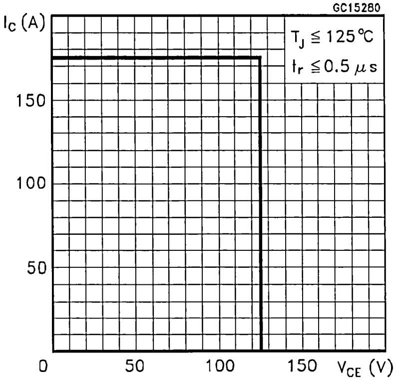
Base-Emitter Saturation Voltage



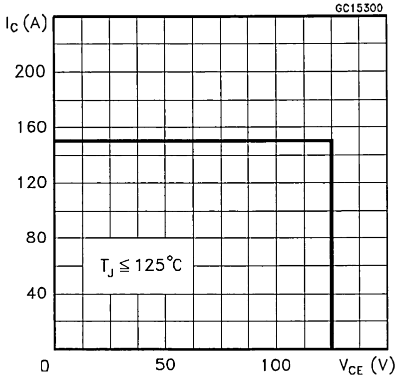
Reverse Biased SOA



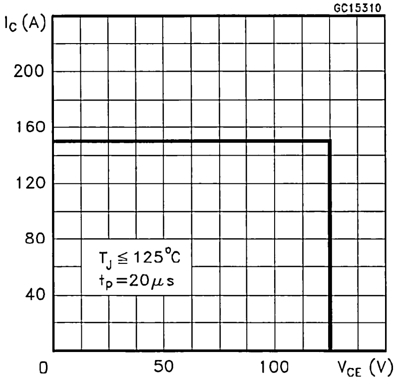
Forward Biased SOA



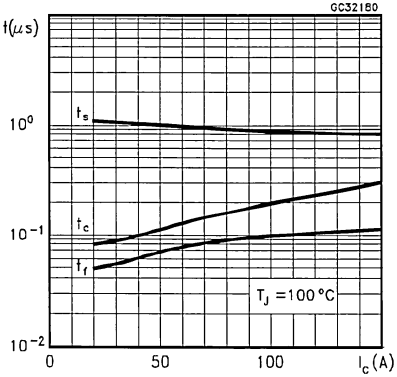
Reverse Biased AOA



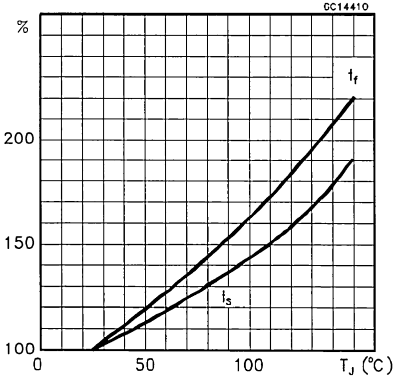
Forward Biased AOA



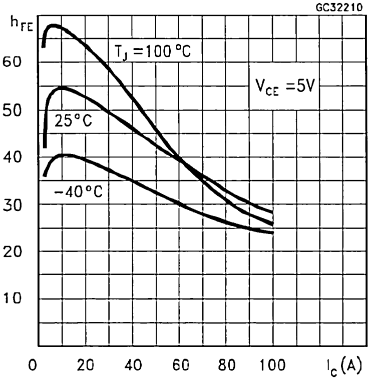
Switching Times Inductive Load



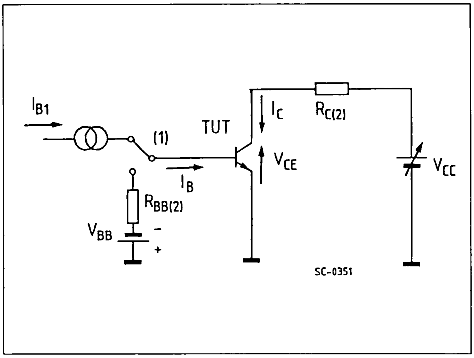
Switching Times Inductive Load Versus Temperature



DC Current Gain

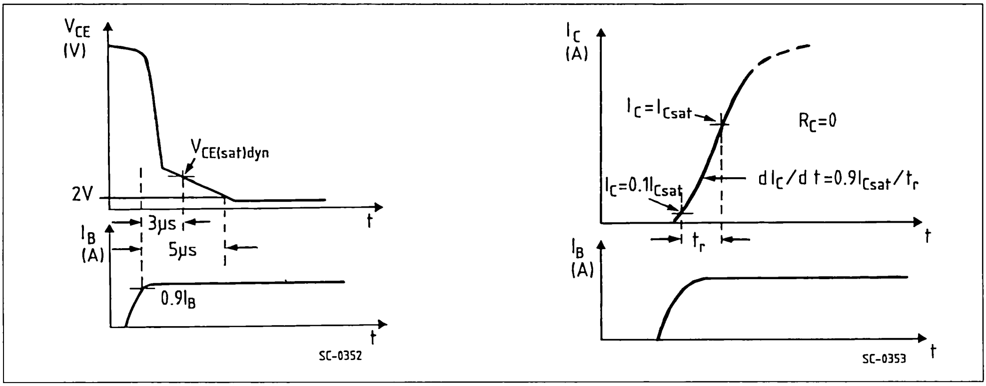


Turn-on Switching Test Circuit

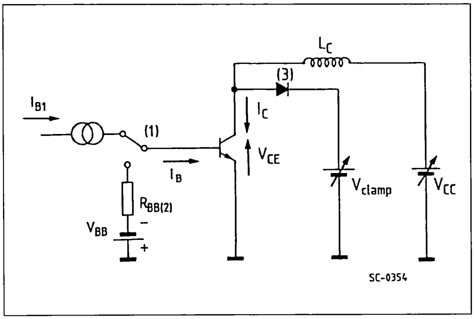


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

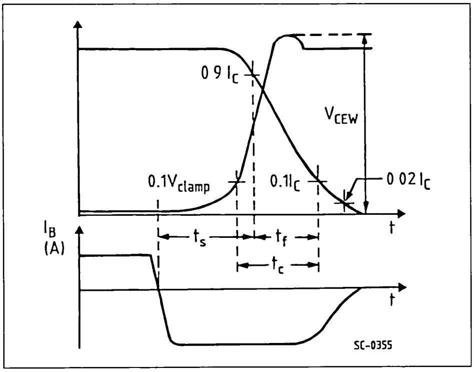


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



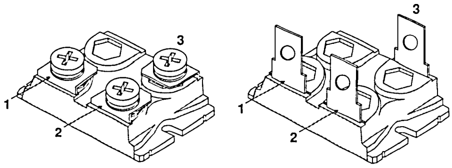
BUT32F
BUT32V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

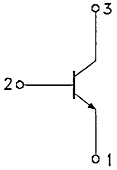
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS



BUT32V **BUT32F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04830

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	400	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	80	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	120	A
I_B	Base Current	16	A
I_{BM}	Base Peak Current (t_p = 10 ms)	24	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

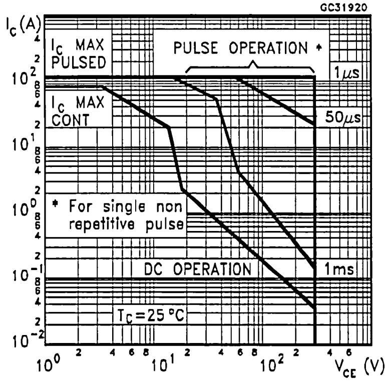
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

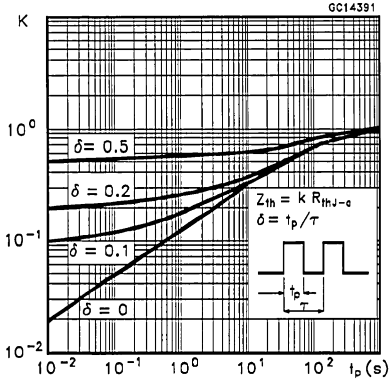
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 300 V	300			V
h_{FE}*	DC Current Gain	I_C = 40 A V_{CE} = 5 V		16		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 40 A I_B = 4 A I_C = 40 A I_B = 4 A T_j = 100 °C		0.6 1.2	0.9 1.9	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 40 A I_B = 4 A I_C = 40 A I_B = 4 A T_j = 100 °C		1.12 1.1	1.3 1.3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 6 A T_j = 100 °C	120	180		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6.2 Ω I_{B1} = 6 A T_j = 100 °C		3	6	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6.2 Ω I_{B1} = 6 A T_j = 100 °C		1.8	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 40 A V_{CC} = 250 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 300 V I_{B1} = 4 A L = 0.3 mH T_j = 100 °C		1.9 0.12 0.35	3 0.4 0.7	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 60 A I_{B1} = 4 A V_{BB} = -5 V V_{CC} = 50 V L = 42 µH R_{BB} = 0.6 Ω T_j = 125 °C	300			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

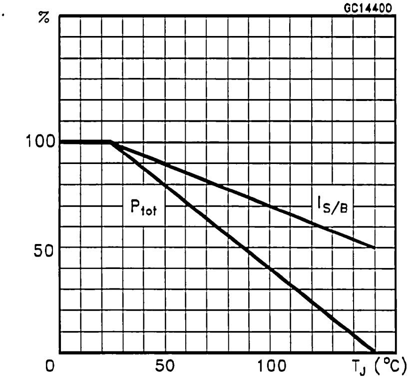
Safe Operating Areas



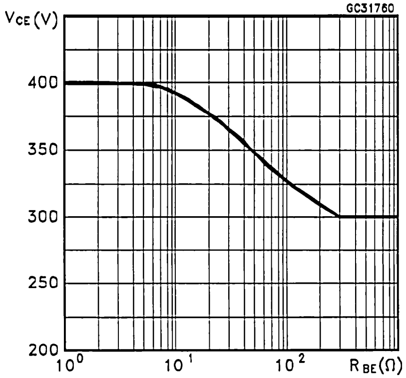
Thermal Impedance



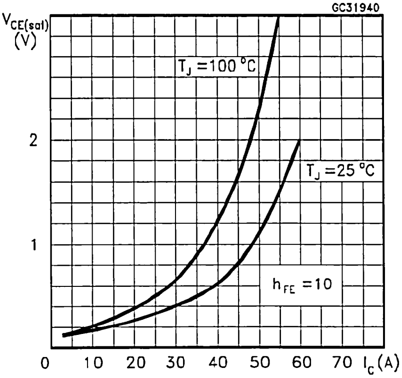
Derating Curve



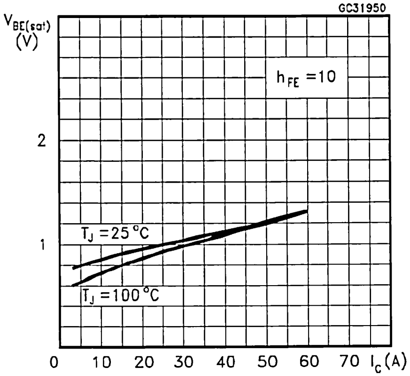
Collector-Emitter Voltage Versus Base-Emitter Resistance



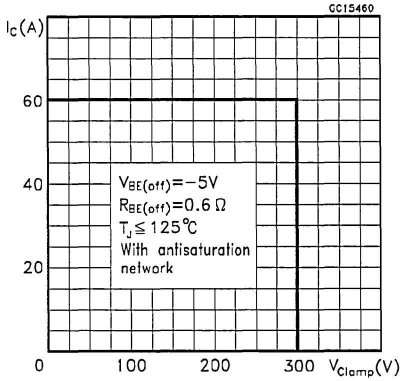
Collector-Emitter Saturation Voltage



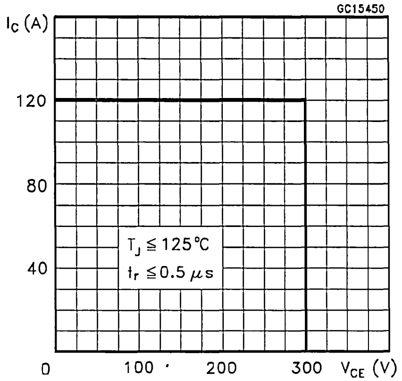
Base-Emitter Saturation Voltage



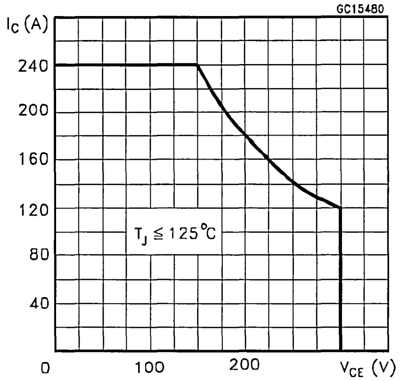
Reverse Biased SOA



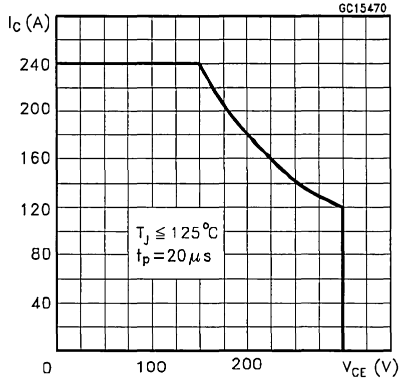
Forward Biased SOA



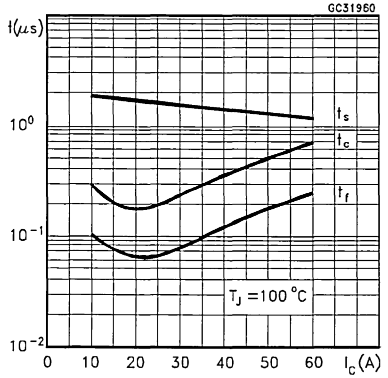
Reverse Biased AOA



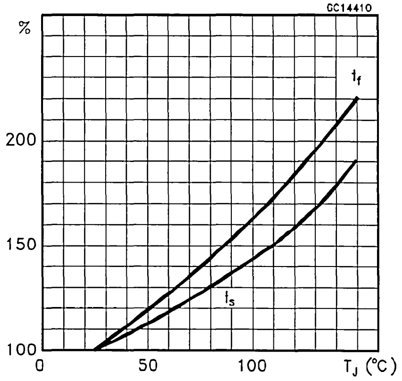
Forward Biased AOA



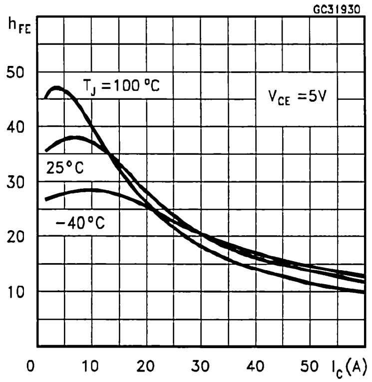
Switching Times Inductive Load



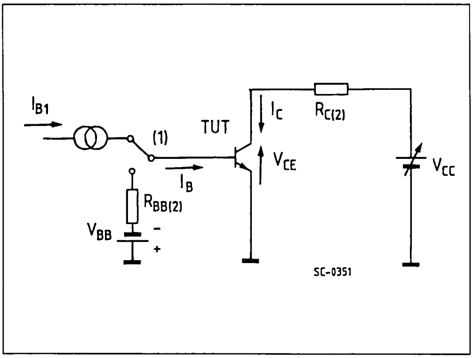
Switching Times Inductive Load Versus Temperature



DC Current Gain

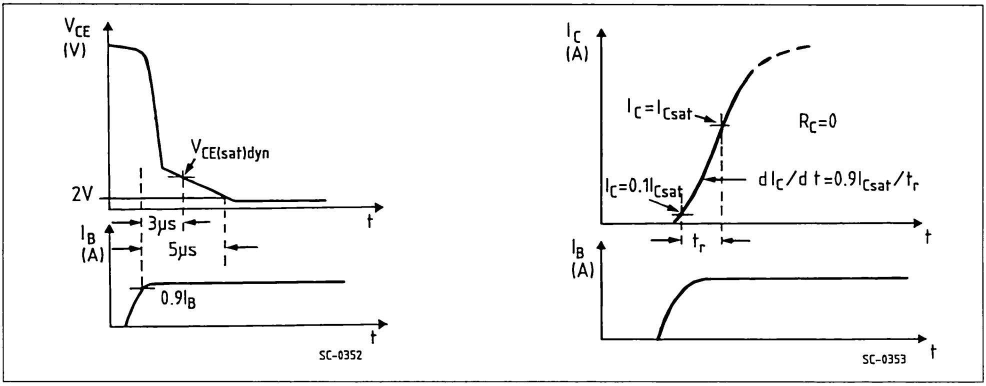


Turn-on Switching Test Circuit

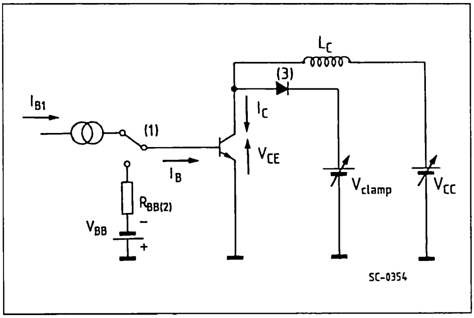


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

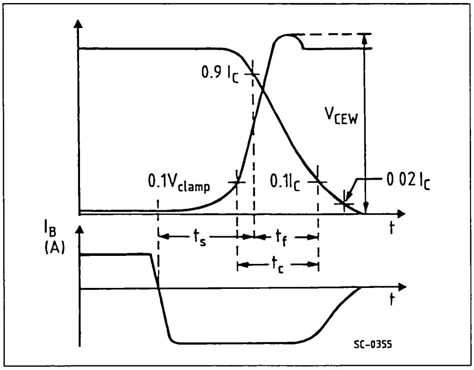


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

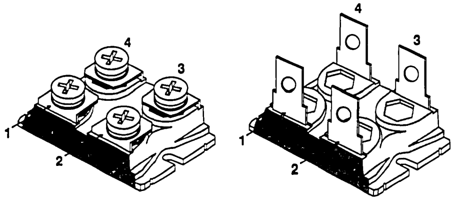
BUT230F
BUT230V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

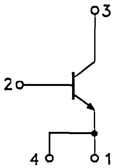
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS



BUT230V **BUT230F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	200	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	125	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	200	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	300	A
I_B	Base Current	40	A
I_{BM}	Base Peak Current (t_p = 10 ms)	60	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

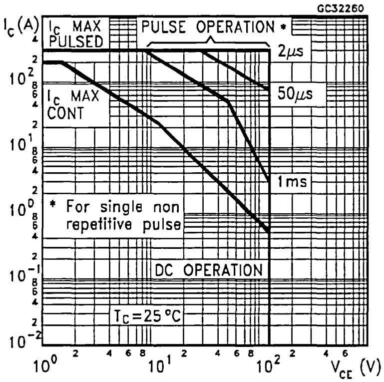
$R_{thj\text{-}case}$ $R_{thc\text{-}h}$	Thermal Resistance Junction-case Thermal Resistance Case-heatsink With Conductive Grease Applied	Max Max	0.41 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

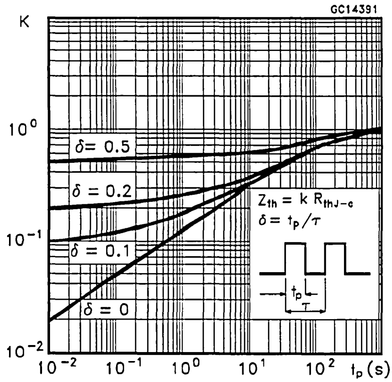
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 125 V	125			V
h_{FE}*	DC Current Gain	I_C = 200 A V_{CE} = 5 V		25		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 100 A I_B = 5 A I_C = 100 A I_B = 5 A T_j = 100 °C I_C = 200 A I_B = 20 A I_C = 200 A I_B = 20 A T_j = 100 °C		0.6 0.8 0.9 1.2	0.9 0.9 	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 100 A I_B = 5 A I_C = 100 A I_B = 5 A T_j = 100 °C I_C = 200 A I_B = 20 A I_C = 200 A I_B = 20 A T_j = 100 $_o$C		1.1 1.1 1.5 1.6	 1.4 2	V V V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 100 V R_C = 0 t_p = 3 μs I_{B1} = 30 A T_j = 100 °C	270	325		A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 100 V R_C = 0.5 Ω I_{B1} = 20 A T_j = 100 °C		2.8	3.8	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 100 V R_C = 0.5 Ω I_{B1} = 20 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 200 A V_{CC} = 90 V V_{BB} = -5 V R_{BB} = 0.25 Ω V_{clamp} = 125 V I_{B1} = 20 A L = 45 μH T_j = 100 °C		1 0.1 0.2	2 0.3 0.6	μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 300 A I_{B1} = 20 A V_{BB} = -5 V V_{CC} = 90 V L = 15 μH R_{BB} = 0.25 Ω T_j = 125 °C	125			V

∗ Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

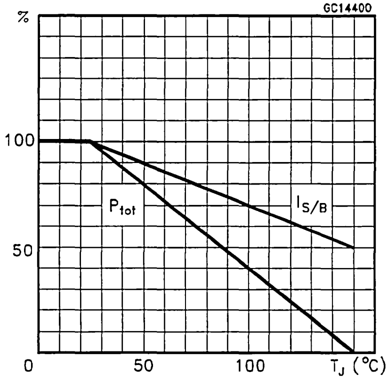
Safe Operating Areas



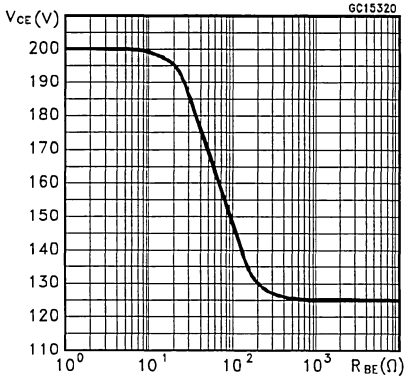
Thermal Impedance



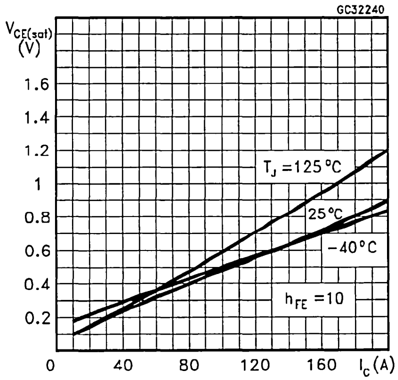
Derating Curve



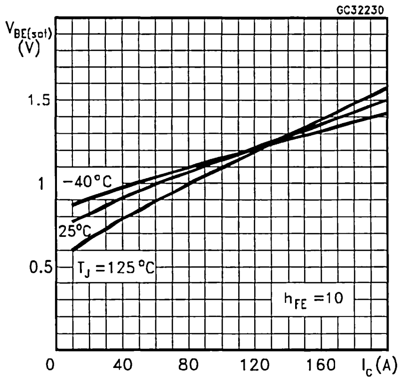
Collector-Emitter Voltage Versus Base-Emitter Resistance



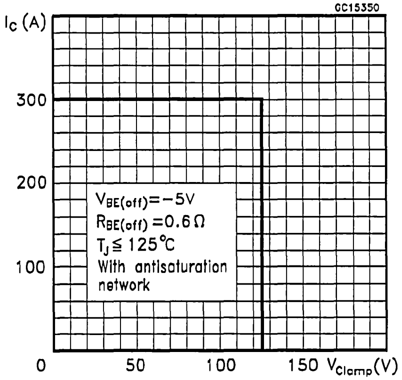
Collector-Emitter Saturation Voltage



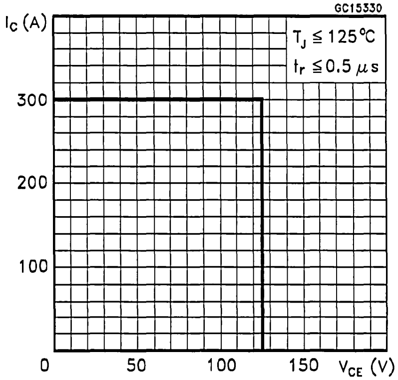
Base-Emitter Saturation Voltage



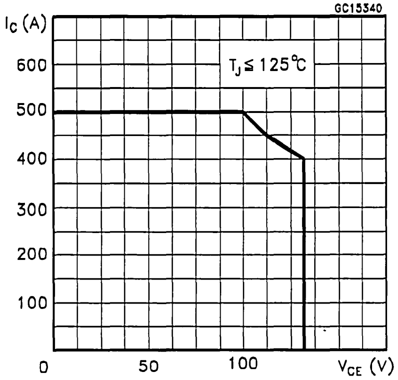
Reverse Biased SOA



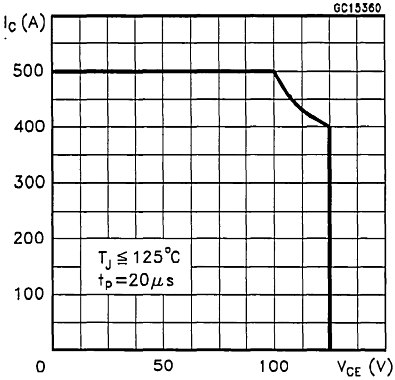
Forward Biased SOA



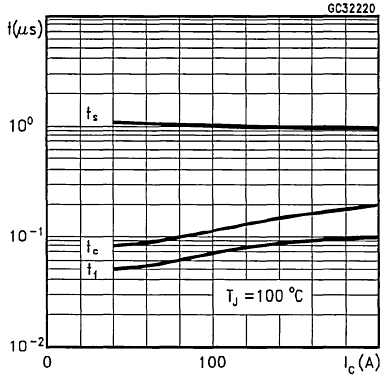
Reverse Biased AOA



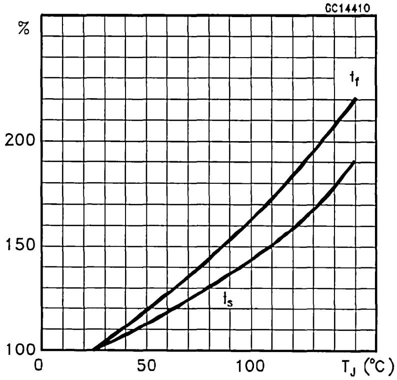
Forward Biased AOA



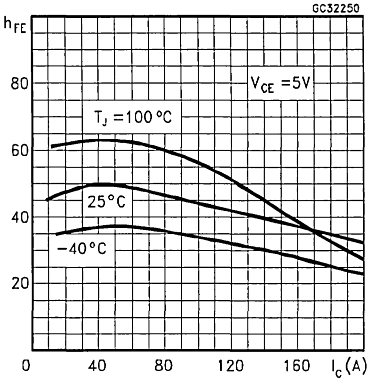
Switching Times Inductive Load



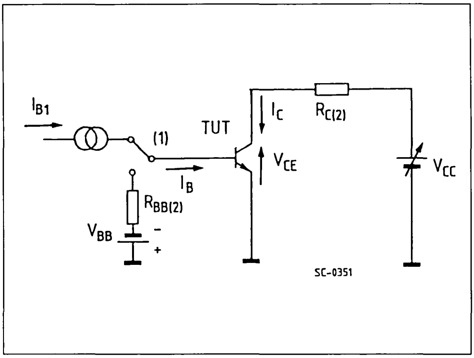
Switching Times Inductive Load Versus Temperature



DC Current Gain

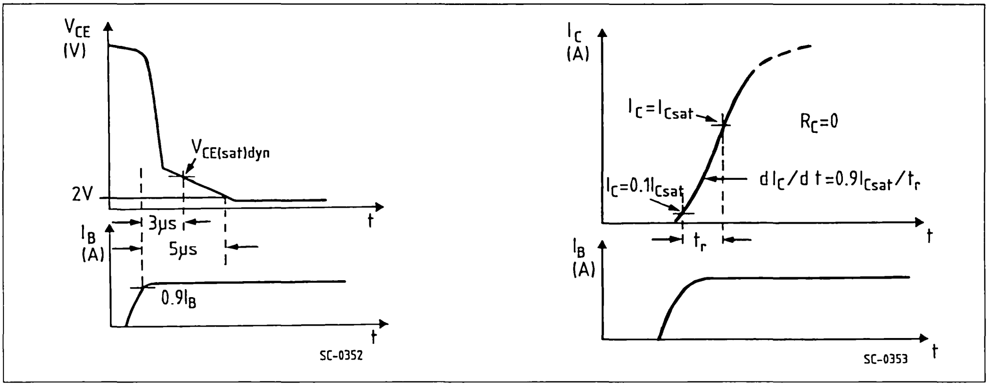


Turn-on Switching Test Circuit

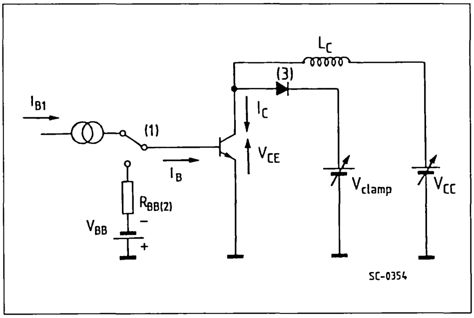


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

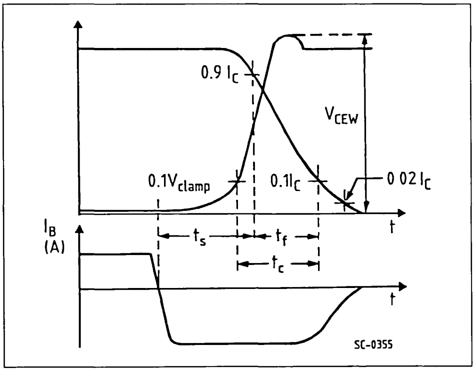


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

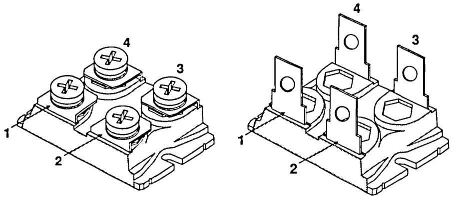
BUT232F
BUT232V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

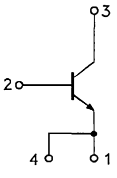
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS



BUT232V **BUT232F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	400	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	140	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	210	A
I_B	Base Current	28	A
I_{BM}	Base Peak Current (t_p = 10 ms)	42	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

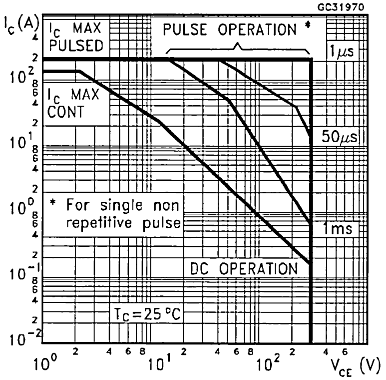
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.41	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

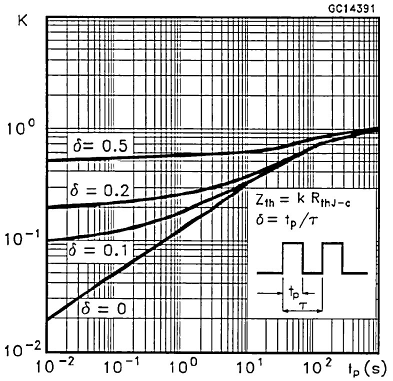
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -1.5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 300 V	125			V
h_{FE}*	DC Current Gain	I_C = 70 A V_{CE} = 5 V		17		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 35 A I_B = 1.75 A I_C = 35 A I_B = 1.75 A T_j = 100 °C I_C = 70 A I_B = 7 A I_C = 70 A I_B = 7 A T_j = 100 °C		0.5 0.7 0.5 0.9	 1.9 1.9	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 70 A I_B = 7 A I_C = 70 A I_B = 7 A T_j = 100 °C		1.1 1	 1.3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 10 A T_j = 100 °C	120	190		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 200 V R_C = 3.25 Ω I_{B1} = 6.4 A T_j = 100 °C		2.5	4	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 200 V R_C = 3.25 Ω I_{B1} = 6.4 A T_j = 100 °C		1.4	2.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 70 A V_{CC} = 250 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 300 V I_{B1} = 7 A L = 0.3 mH T_j = 100 °C		3 0.25 0.6	5 0.4 0.9	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 105 A I_{B1} = 7 A V_{BB} = -5 V V_{CC} = 50 V L = 42 µH R_{BB} = 0.6 Ω T_j = 125 °C	300			V

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

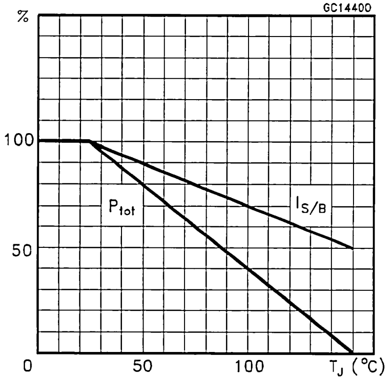
Safe Operating Areas



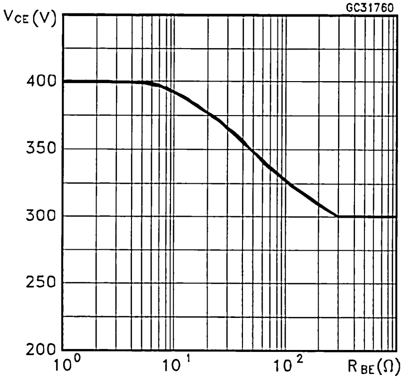
Thermal Impedance



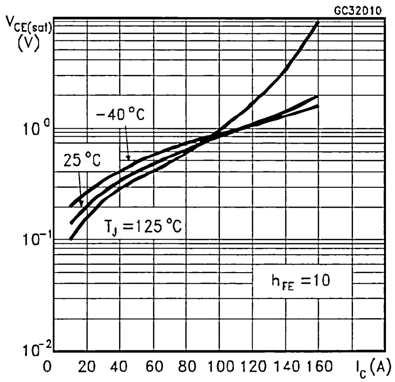
Derating Curve



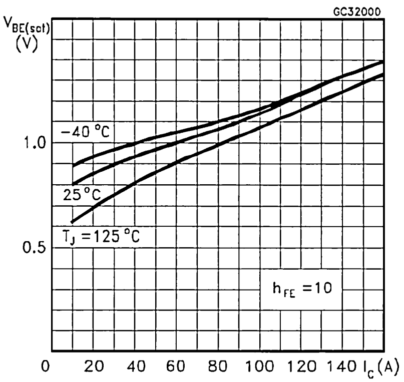
Collector-Emitter Voltage Versus Base-Emitter Resistance



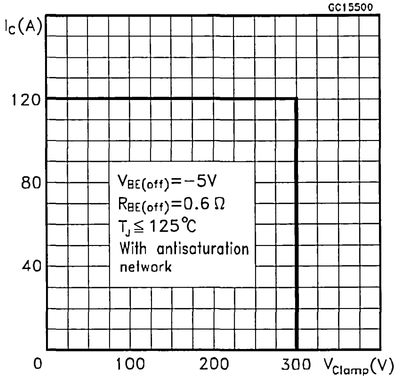
Collector-Emitter Saturation Voltage



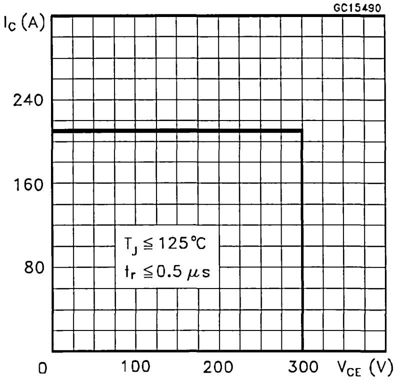
Base-Emitter Saturation Voltage



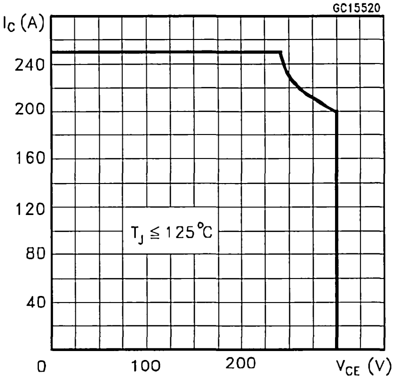
Reverse Biased SOA



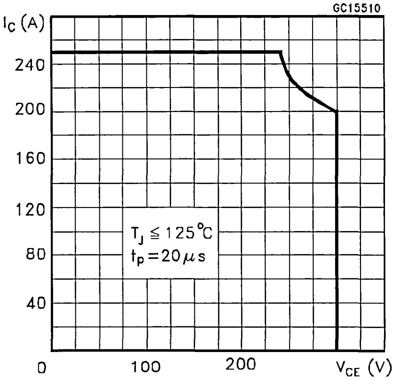
Forward Biased SOA



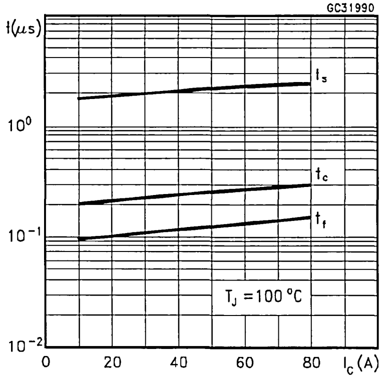
Reverse Biased AOA



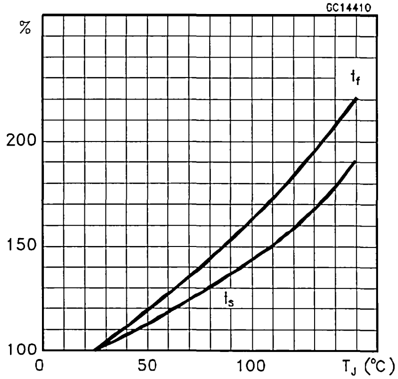
Forward Biased AOA



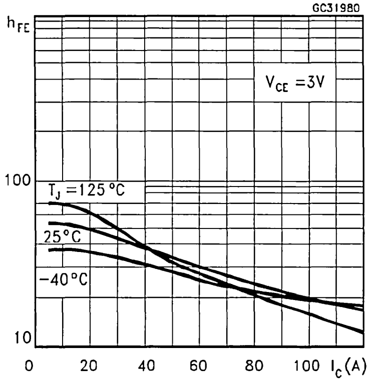
Switching Times Inductive Load



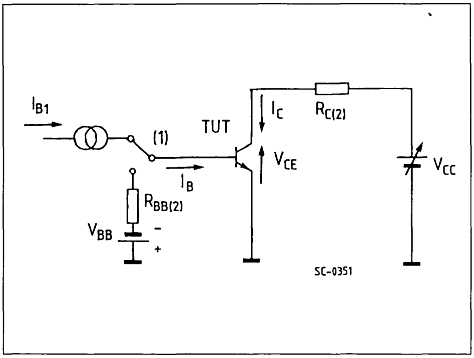
Switching Times Inductive Load Versus Temperature



DC Current Gain

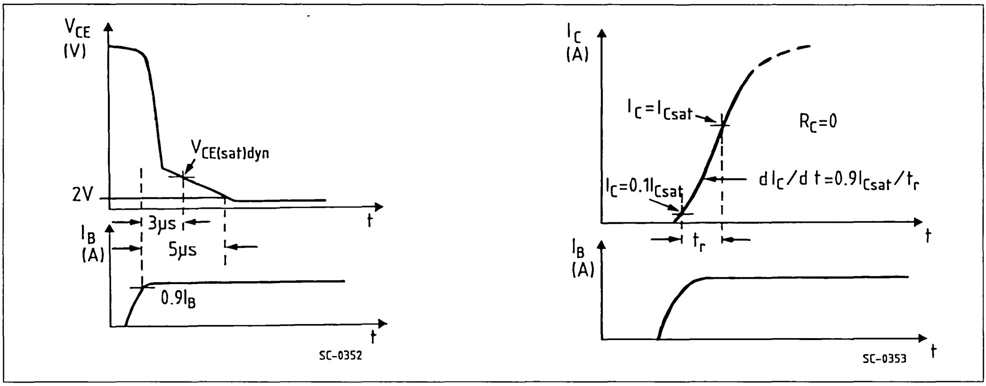


Turn-on Switching Test Circuit

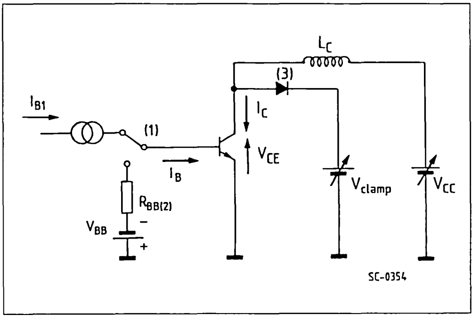


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

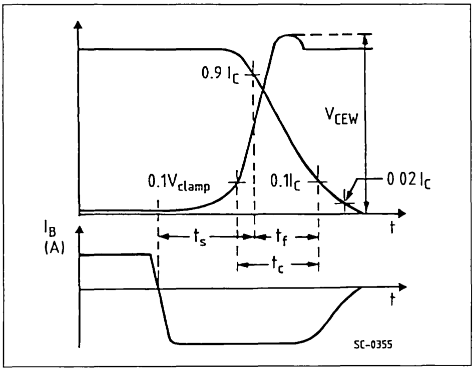


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

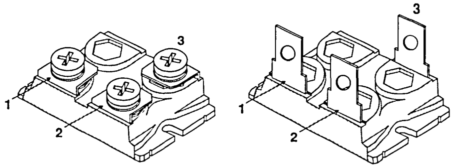
BUV98F
BUV98V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

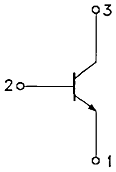
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUV98V **BUV98F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04830

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	850	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	30	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	60	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	30	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

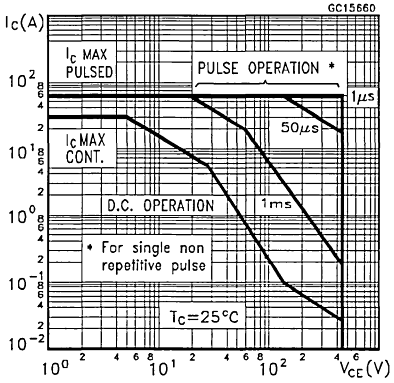
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.83	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

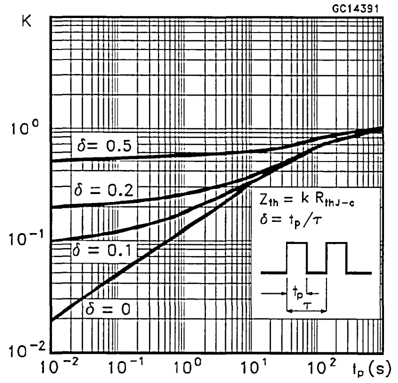
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ $T_j = 100$ °C			1 8	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ $T_j = 100$ °C			0.4 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 24 A V_{CE} = 5 V		9		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 20 A I_B = 4 A I_C = 30 A I_B = 8 A			1.5 3.5	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 20 A I_B = 4 A			1.6	V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 6 A T_j = 100 °C	100			A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 6 A T_j = 100 °C			8	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 6 A T_j = 100 °C			4	V
t_s t_f	Storage Time Fall Time	I_C = 20 A V_{CC} = 50 V V_{BB} = -5 V L_B = 1.5 μH V_{clamp} = 300 V I_{B1} = 4 A L = 750 μH T_j = 100 °C			5 0.4	μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 30 A I_{B1} = 6 A V_{BB} = -5 V V_{CC} = 50 V L = 750 μH L_B = 15 μH T_j = 125 °C	350			V

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

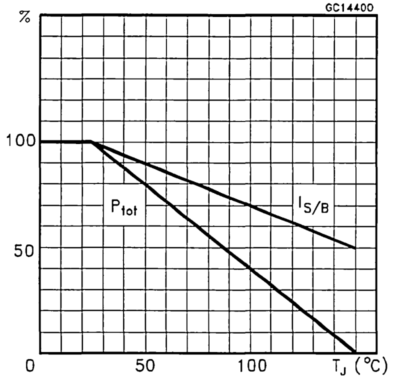
Safe Operating Areas



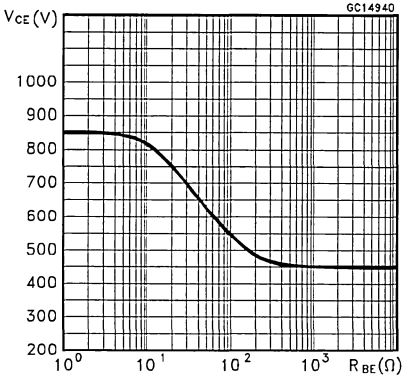
Thermal Impedance



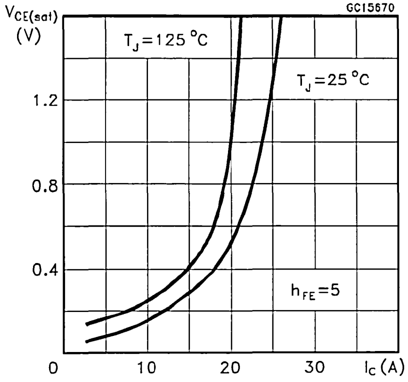
Derating Curve



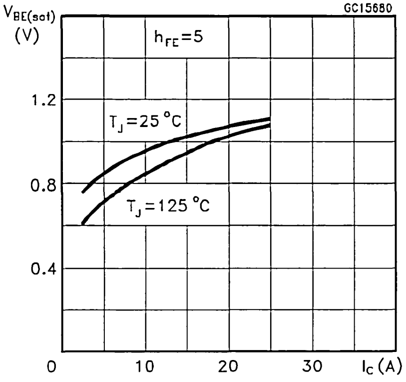
Collector-Emitter Voltage Versus Base-Emitter Resistance



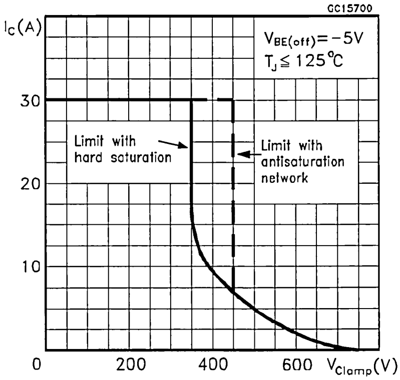
Collector-Emitter Saturation Voltage



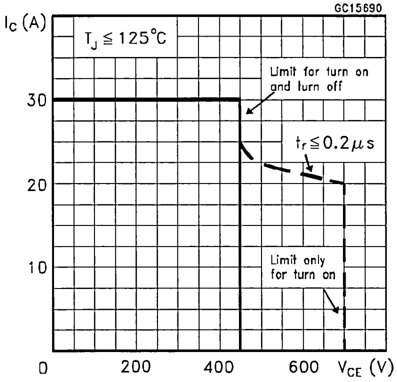
Base-Emitter Saturation Voltage



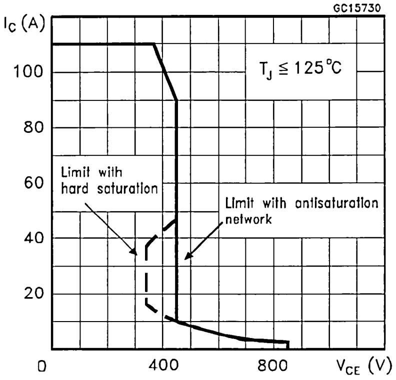
Reverse Biased SOA



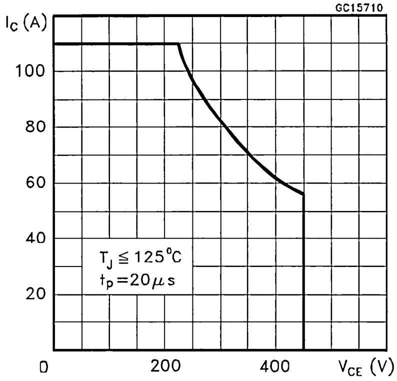
Forward Biased SOA



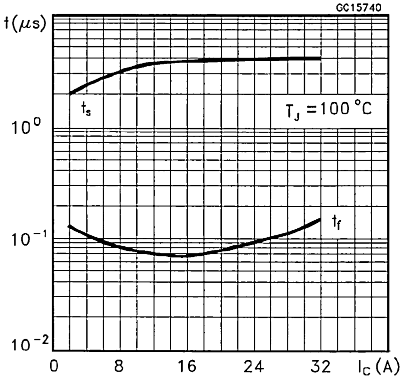
Reverse Biased AOA



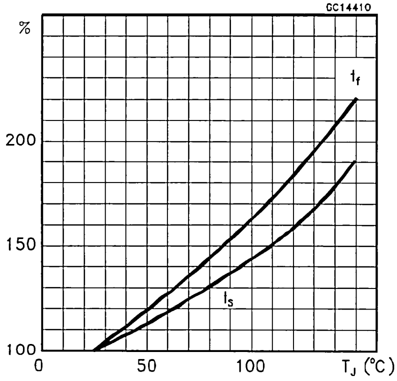
Forward Biased AOA



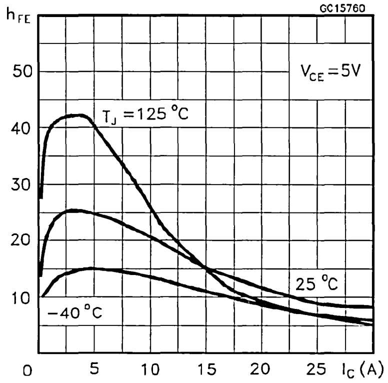
Switching Times Inductive Load



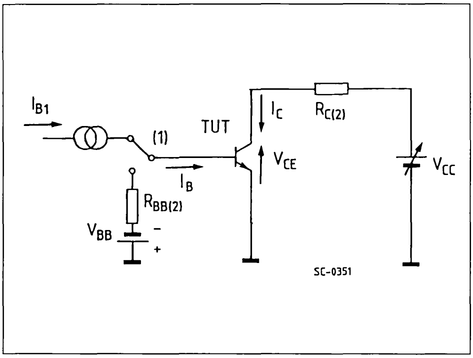
Switching Times Inductive Load Versus Temperature



DC Current Gain

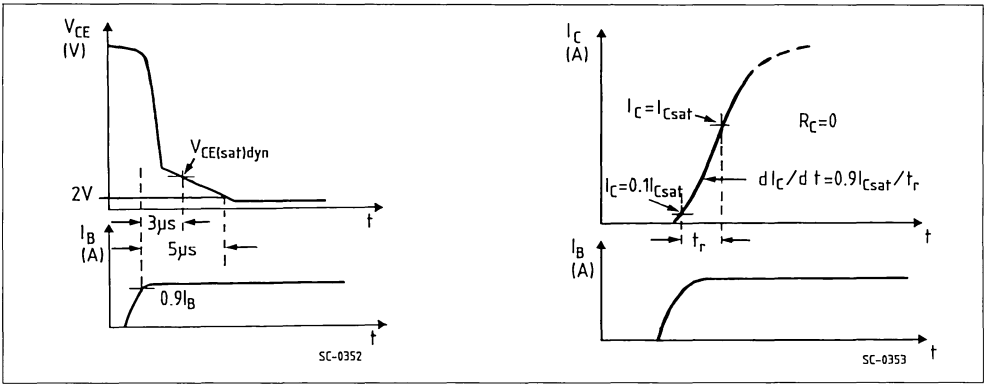


Turn-on Switching Test Circuit

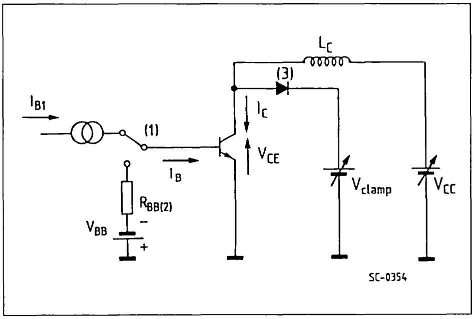


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

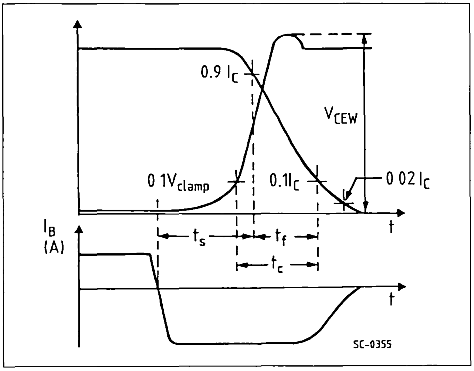


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms

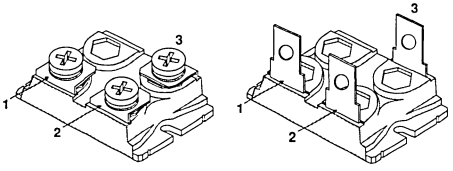


BUV98AF
BUV98AV

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

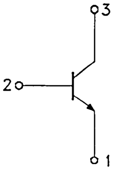
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUV98AV **BUV98AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04830

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	30	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	60	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	30	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

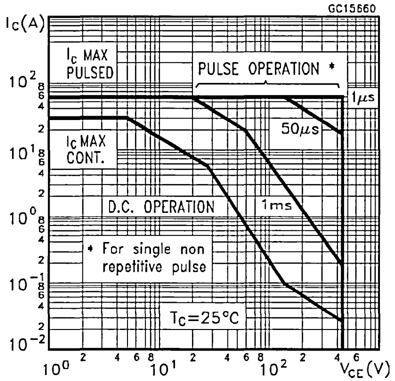
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.83	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

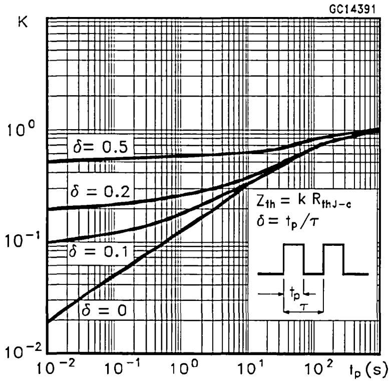
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 8	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 4	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 24 A V_{CE} = 5 V		9		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 16 A I_B = 3.2 A I_C = 24 A I_B = 5 A			1.5 5	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 16 A I_B = 3.2 A			1.6	V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 6 A T_j = 100 °C	100			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 6 A T_j = 100 °C			8	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 15 Ω I_{B1} = 6 A T_j = 100 °C			4	V
t_s t_f	Storage Time Fall Time	I_C = 16 A V_{CC} = 50 V V_{BB} = -5 V L_B = 1.5 µH V_{clamp} = 300 V I_{B1} = 3.2 A L = 750 µH T_j = 100 °C			5 0.4	µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 30 A I_{B1} = 6 A V_{BB} = -5 V V_{CC} = 50 V L = 750 µH L_B = 15 µH T_j = 125 °C	350			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

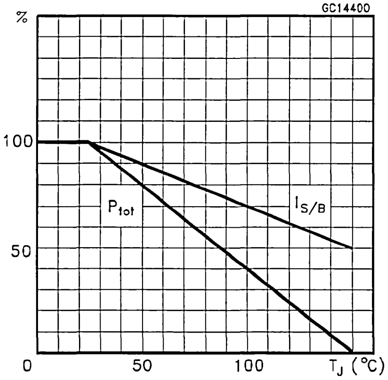
Safe Operating Areas



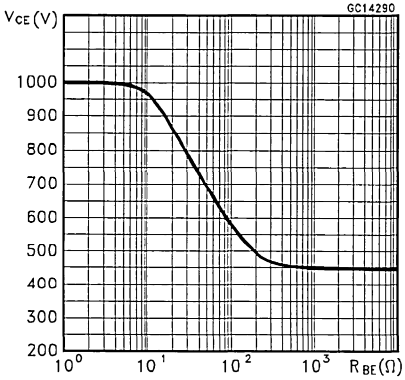
Thermal Impedance



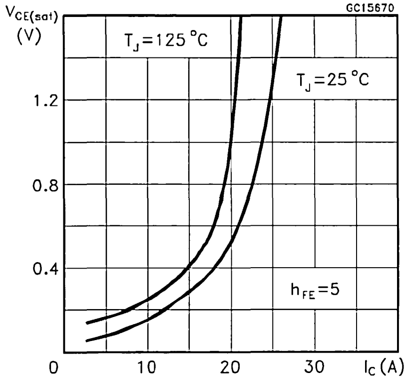
Derating Curve



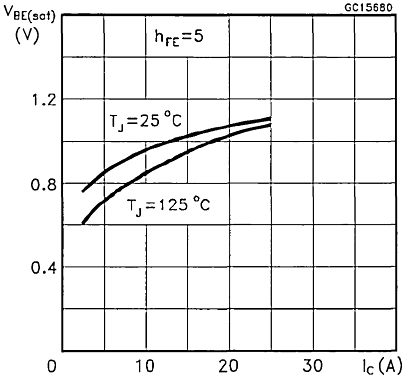
Collector-Emitter Voltage Versus Base-Emitter Resistance



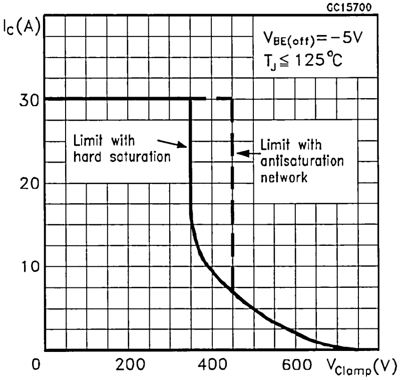
Collector-Emitter Saturation Voltage



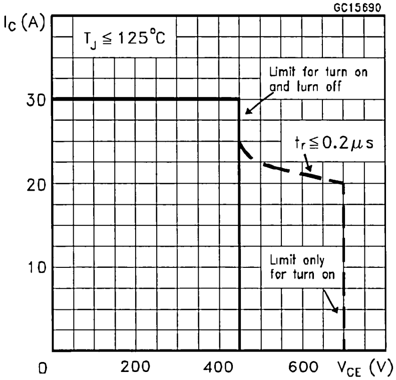
Base-Emitter Saturation Voltage



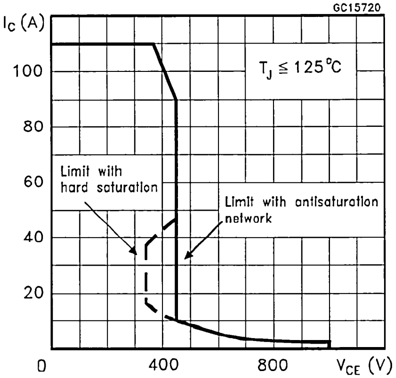
Reverse Biased SOA



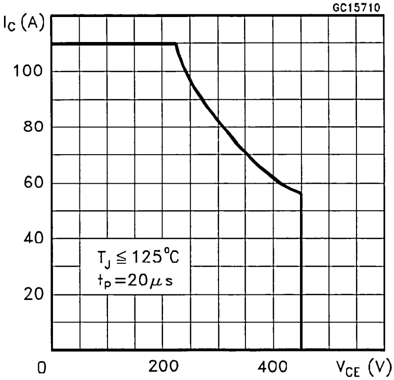
Forward Biased SOA



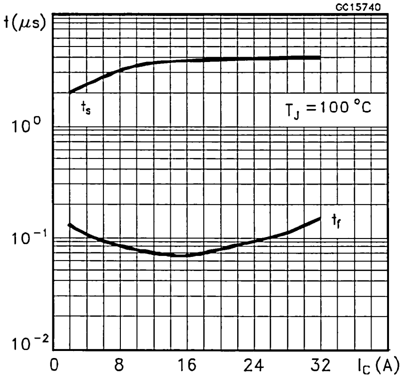
Reverse Biased AOA



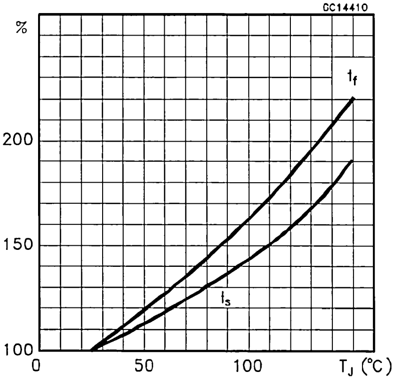
Forward Biased AOA



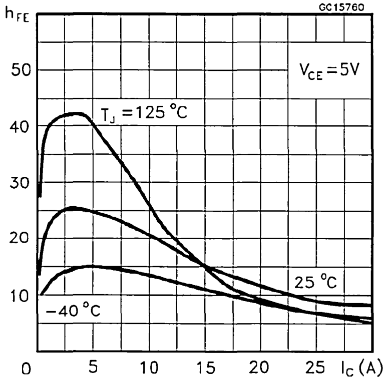
Switching Times Inductive Load



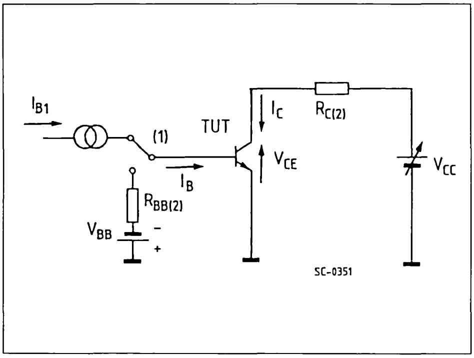
Switching Times Inductive Load Versus Temperature



DC Current Gain

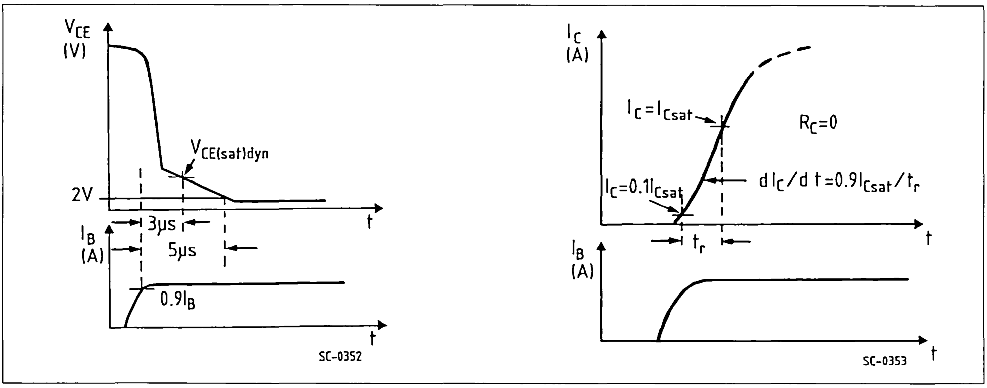


Turn-on Switching Test Circuit

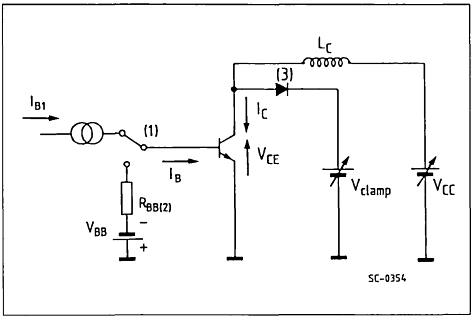


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

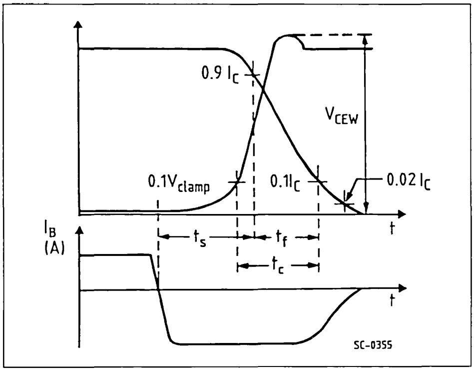


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

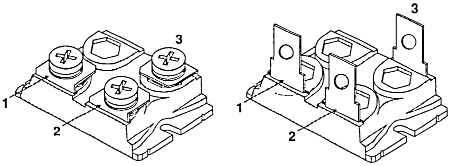
BUV298F
BUV298V

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

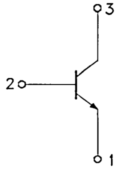
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUV298V **BUV298F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	850	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	75	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

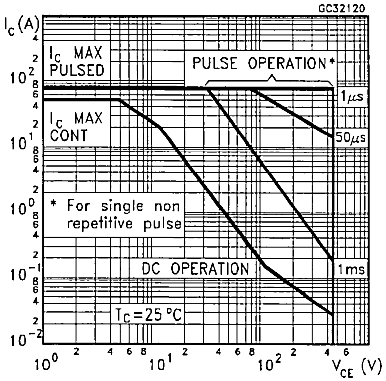
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

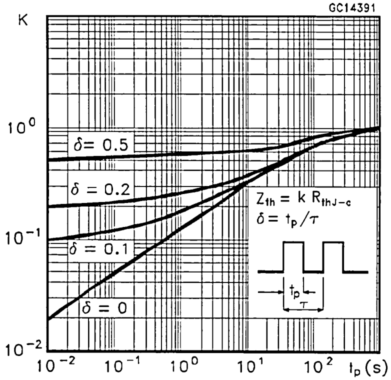
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 2	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 2	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 32 A V_{CE} = 5 V		12		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		0.35 0.6	1.2 2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		1 0.9	1.5 1.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 9.6 A T_j = 100 °C	160	210		A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 9.3 Ω I_{B1} = 9.6 A T_j = 100 °C		4.5	8	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 9.3 Ω I_{B1} = 9.6 A T_j = 100 °C		2.5	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 32 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.39 Ω V_{clamp} = 450 V I_{B1} = 6.4 A L = 78 μH T_j = 100 °C		3.2 0.25 0.5	4.5 0.4 0.7	μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 48 A I_{B1} = 6.4 A V_{BB} = -5 V V_{CC} = 50 V L = 52 μH R_{BB} = 0.39 Ω T_j = 125 °C	450			V

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

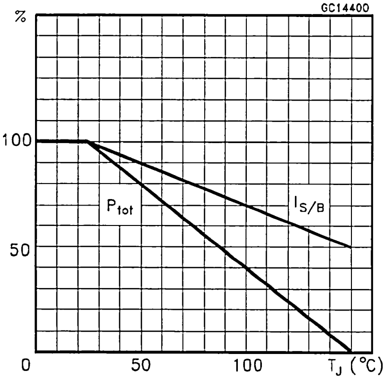
Safe Operating Areas



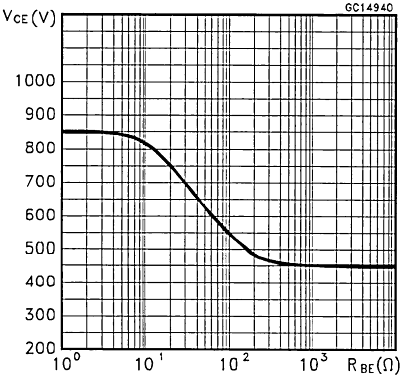
Thermal Impedance



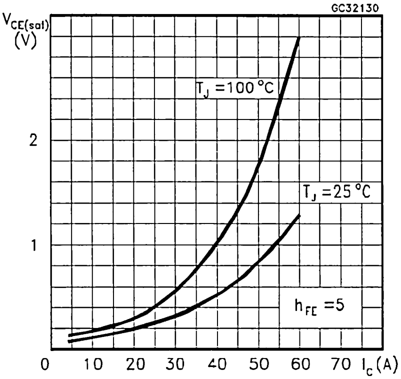
Derating Curve



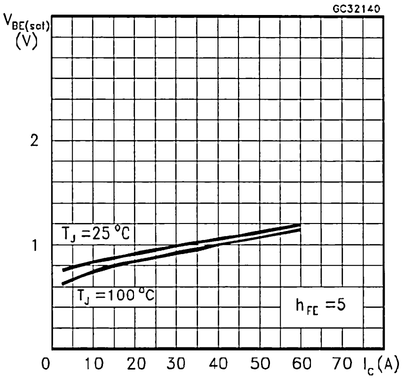
Collector-Emitter Voltage Versus Base-Emitter Resistance



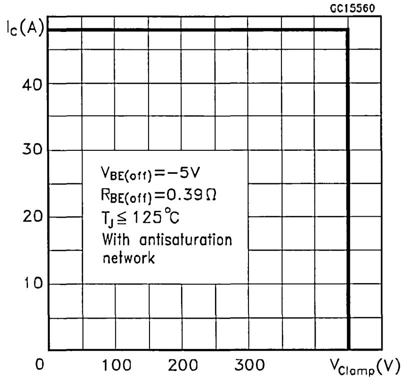
Collector-Emitter Saturation Voltage



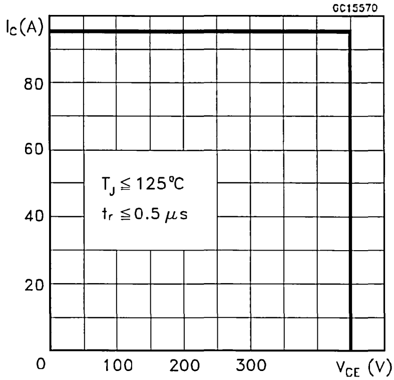
Base-Emitter Saturation Voltage



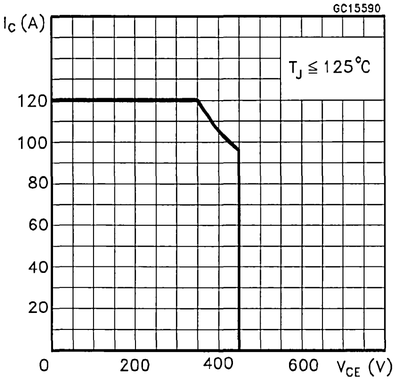
Reverse Biased SOA



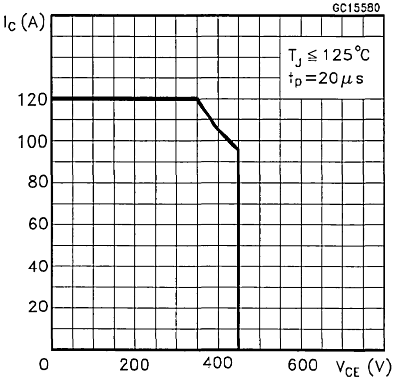
Forward Biased SOA



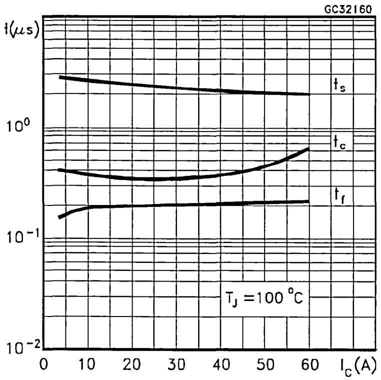
Reverse Biased AOA



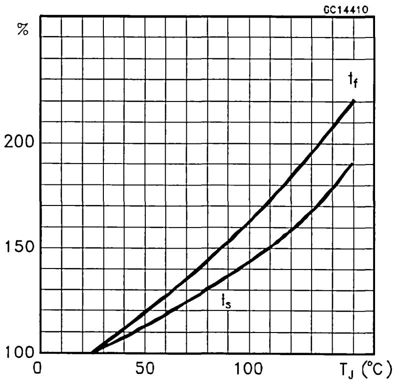
Forward Biased AOA



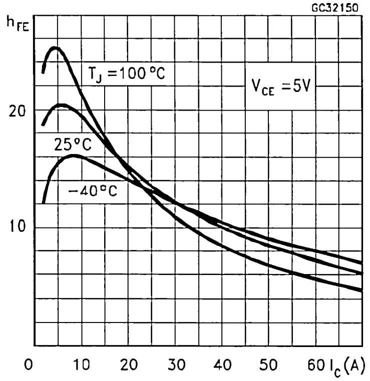
Switching Times Inductive Load



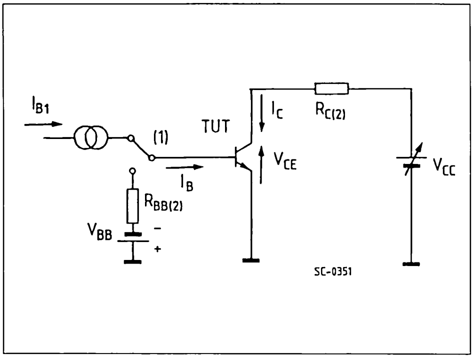
Switching Times Inductive Load Versus Temperature



DC Current Gain

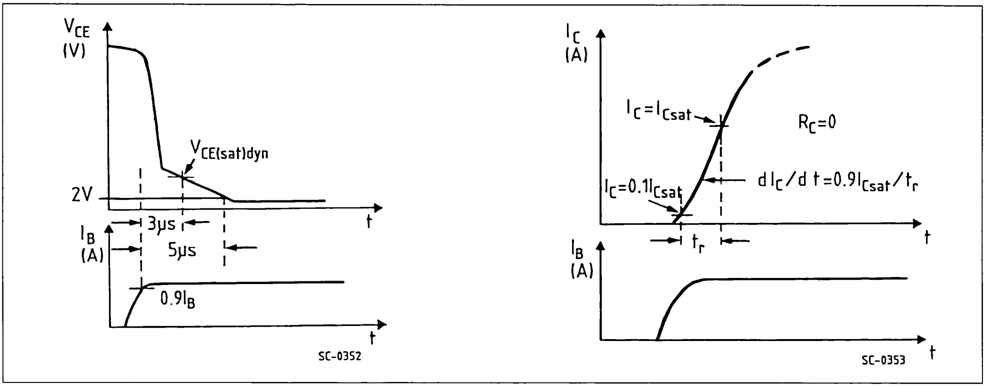


Turn-on Switching Test Circuit

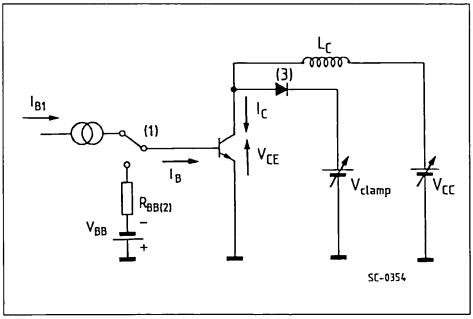


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

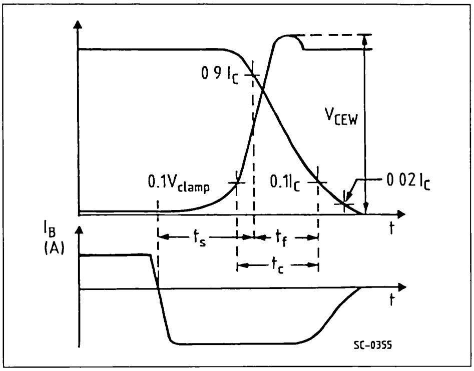


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

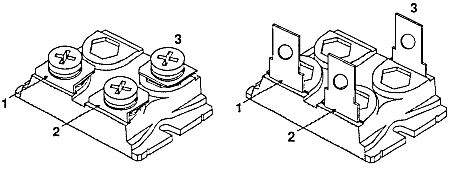
BUV298AF
BUV298AV

NPN TRANSISTOR POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

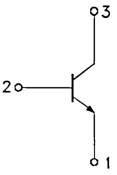
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



BUV298AV **BUV298AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



SC04830

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	75	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

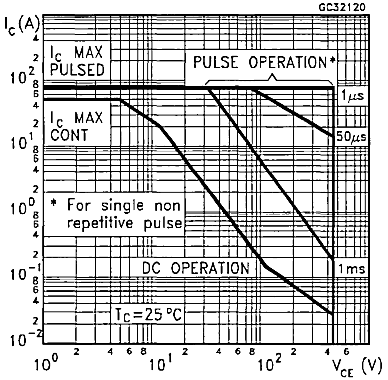
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

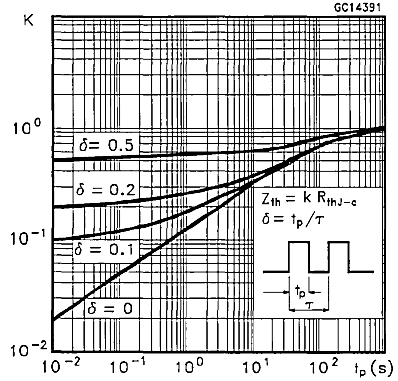
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 2	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			0.4 2	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 32 A V_{CE} = 5 V		12		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		0.35 0.6	1.2 2	V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 32 A I_B = 6.4 A I_C = 32 A I_B = 6.4 A T_j = 100 °C		1 0.9	1.5 1.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 9.6 A T_j = 100 °C	160	210		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 9.3 Ω I_{B1} = 9.6 A T_j = 100 °C		4.5	8	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 9.3 Ω I_{B1} = 9.6 A T_j = 100 °C		2.5	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 32 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.39 Ω V_{clamp} = 450 V I_{B1} = 6.4 A L = 78 µH T_j = 100 °C		3.2 0.25 0.5	4.5 0.4 0.7	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 48 A I_{B1} = 6.4 A V_{BB} = -5 V V_{CC} = 50 V L = 52 µH R_{BB} = 0.39 Ω T_j = 125 °C	450			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

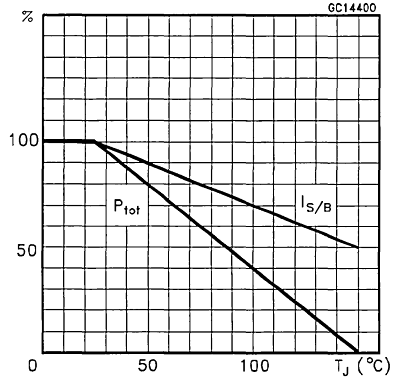
Safe Operating Areas



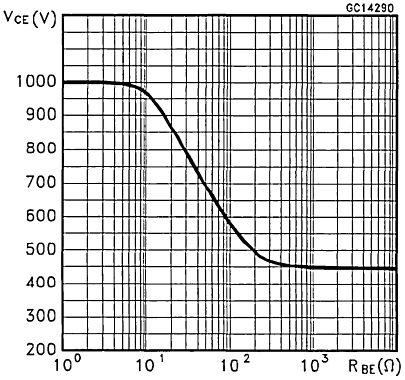
Thermal Impedance



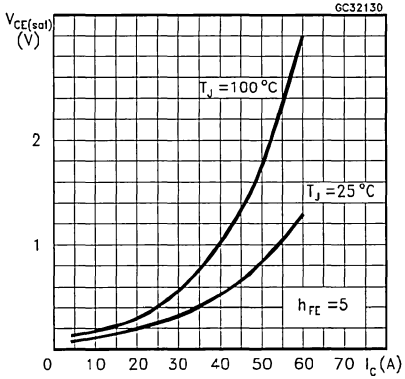
Derating Curve



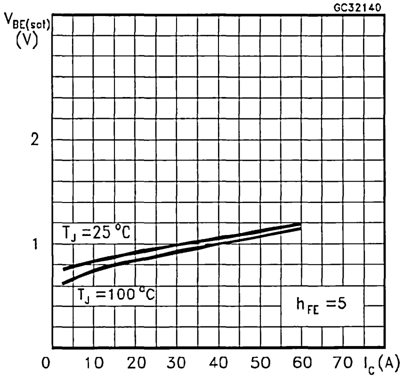
Collector-Emitter Voltage Versus Base-Emitter Resistance



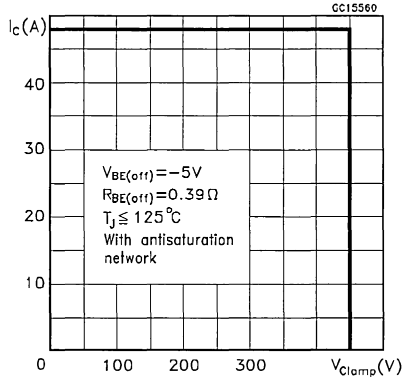
Collector-Emitter Saturation Voltage



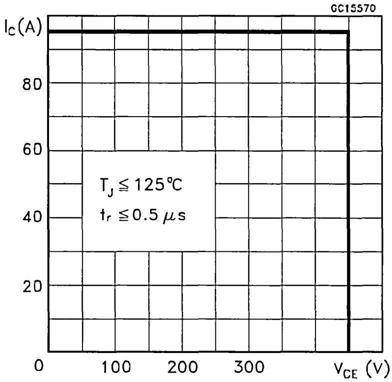
Base-Emitter Saturation Voltage



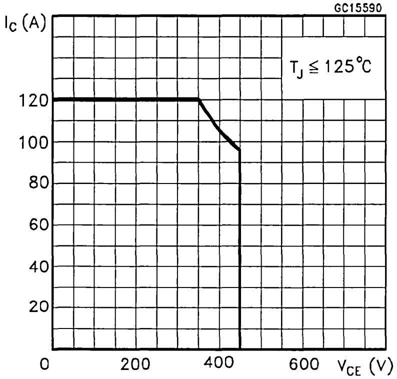
Reverse Biased SOA



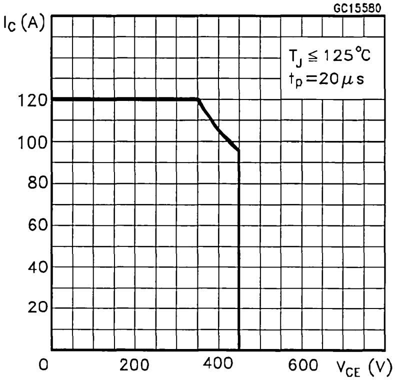
Forward Biased SOA



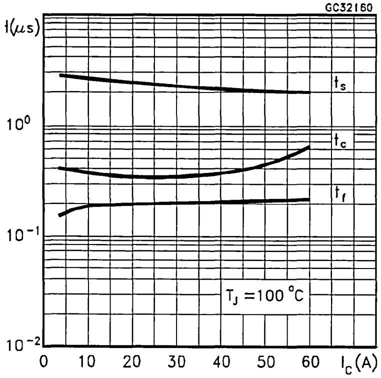
Reverse Biased AOA



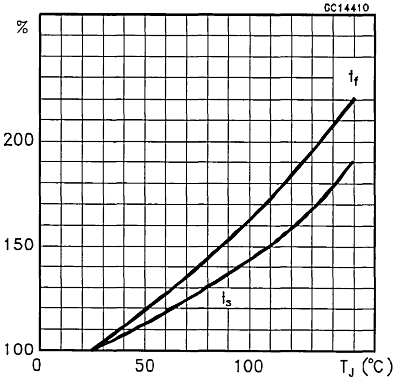
Forward Biased AOA



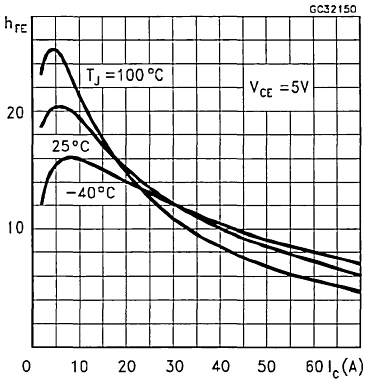
Switching Times Inductive Load



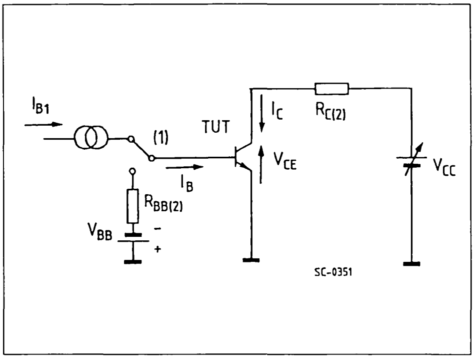
Switching Times Inductive Load Versus Temperature



DC Current Gain

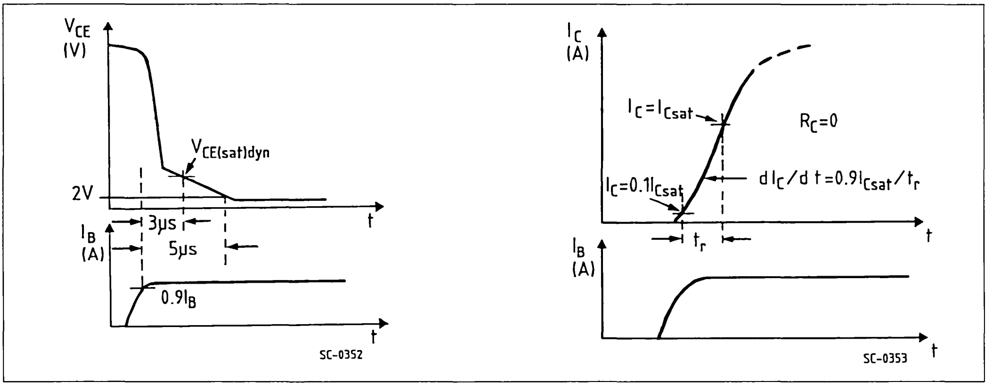


Turn-on Switching Test Circuit

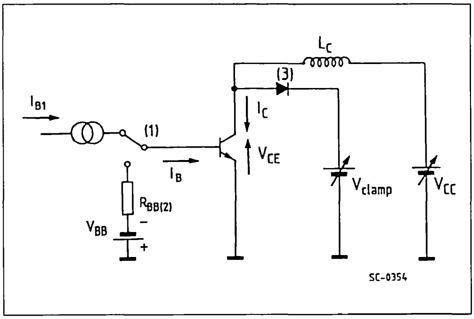


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

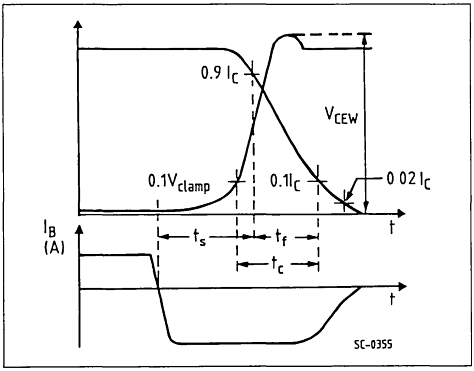


Turn-off Switching Test Circuit



(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

Turn-off Switching Waveforms



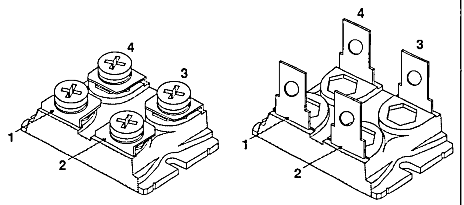
ESM2012DF
ESM2012DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

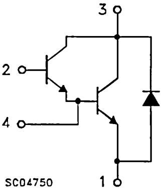
- MOTOR CONTROL
- UPS
- DC/DC & DC/AC CONVERTERS



ESM2012DV **ESM2012DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	150	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	125	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	120	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	180	A
I_B	Base Current	2	A
I_{BM}	Base Peak Current (t_p = 10 ms)	4	A
P_{tot}	Total Dissipation at T_c = 25 °C	175	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.7	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	0.9	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 7	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 5 A L = 15 mH V_{clamp} = 125 V	125			V
h_{FE}*	DC Current Gain	I_C = 100 A V_{CE} = 5 V		1200		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 70 A I_B = 0.25 A I_C = 70 A I_B = 0.25 A T_j = 100 °C I_C = 100 A I_B = 1 A I_C = 100 A I_B = 1 A T_j = 100 °C		1.25 1.35 1.5 1.65	 1.5 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 100 A I_B = 1 A I_C = 100 A I_B = 1 A T_j = 100 °C		2.3 2.35	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 90 V R_C = 0 t_p = 3 µs I_{B1} = 0.5 A T_j = 100 °C	200	230		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 90 V R_C = 1.3 Ω I_{B1} = 0.5 A T_j = 100 °C		2	3	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 90 V R_C = 1.3 Ω I_{B1} = 0.5 A T_j = 100 °C		1.8	2.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 70 A V_{CC} = 90 V V_{BB} = -5 V R_{BB} = Ω V_{clamp} = 125 V I_{B1} = A L = 60 µH T_j = 100 °C		0.9 0.15 0.3	2 0.3 0.6	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 120 A I_{B1} = 1A V_{BB} = -5 V V_{CC} = 90 V L = 60 µH R_{BB} = 1.25 Ω T_j = 125 °C	125			V
V_F*	Diode Forward Voltage	I_F = 100 A T_j = 100 °C		0.92	1	V
I_{RM}	Reverse Recovery Current	V_{CC} = 125 V I_F = 100 A di_F/dt = -200 A/µs L < 0.05 µH T_j = 100 °C		10	14	A

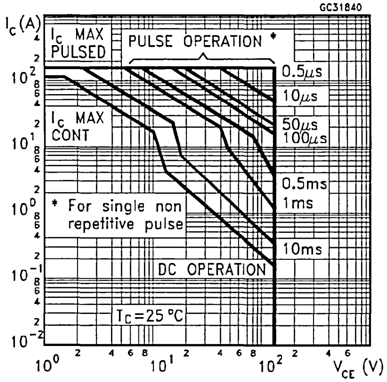
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

\# See test circuits in databook introduction

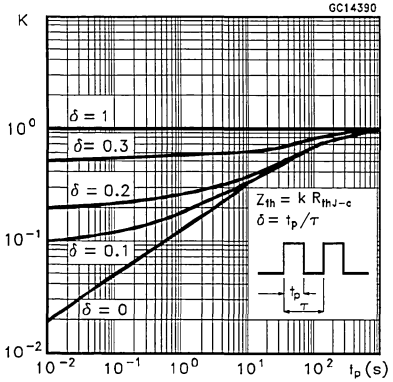
To evaluate the conduction losses of the diode use the following equations:

$V_F = 0.66 + 0.0034\ I_F$ $P = 0.66\ I_{F(AV)} + 0.0034\ I^2_{F(RMS)}$

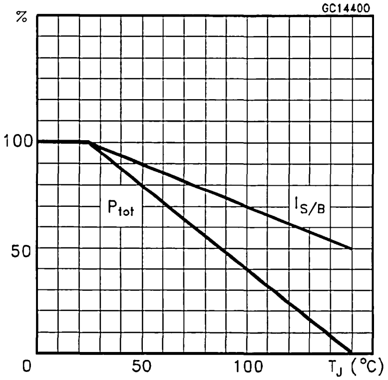
Safe Operating Areas



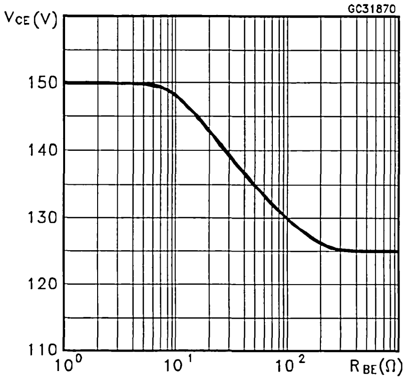
Thermal Impedance



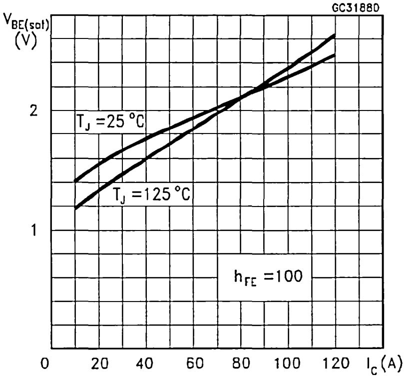
Derating Curve



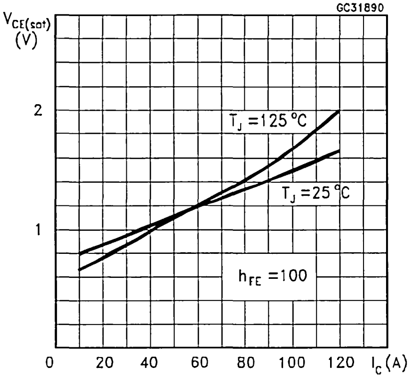
Collector-Emitter Voltage Versus Base-Emitter Resistance



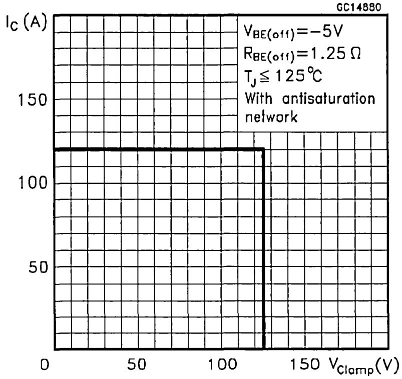
Collector-Emitter Saturation Voltage



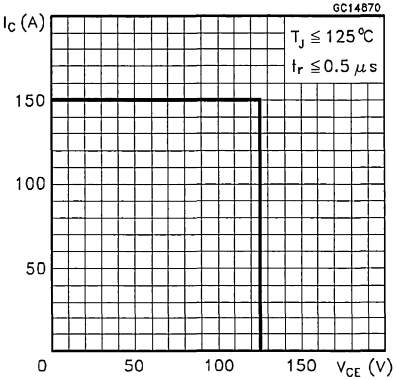
Base-Emitter Saturation Voltage



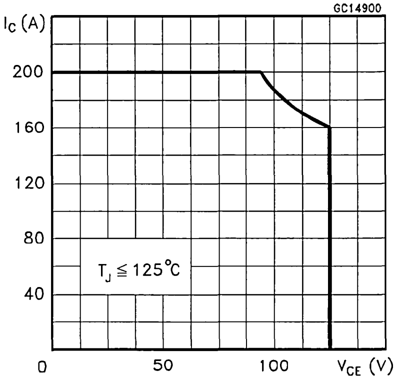
Reverse Biased SOA



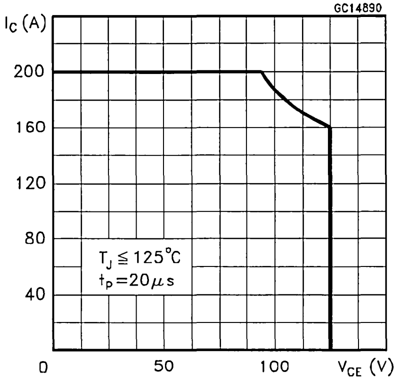
Forward Biased SOA



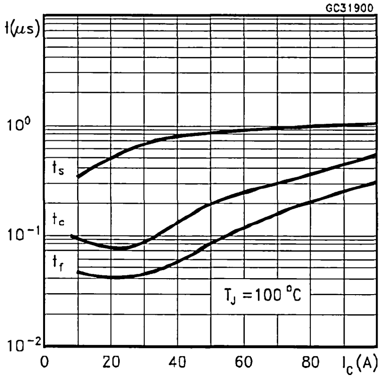
Reverse Biased AOA



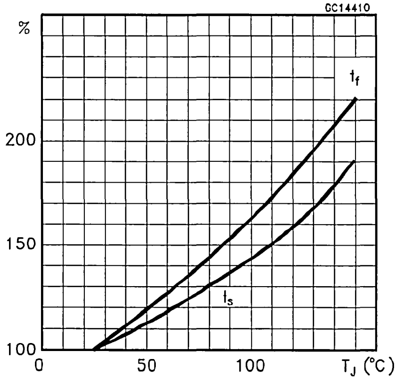
Forward Biased AOA



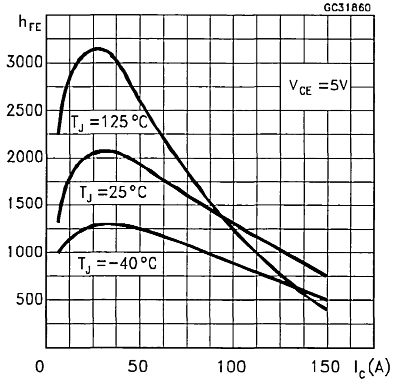
Switching Times Inductive Load



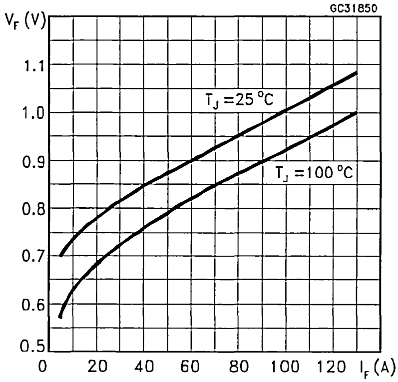
Switching Times Inductive Load Versus Temperature



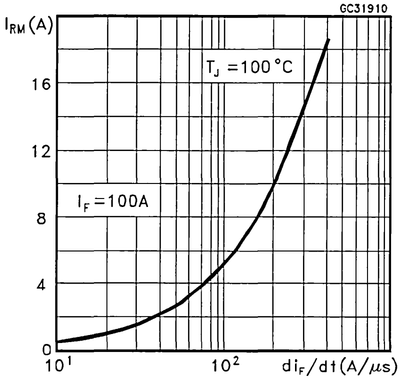
DC Current Gain



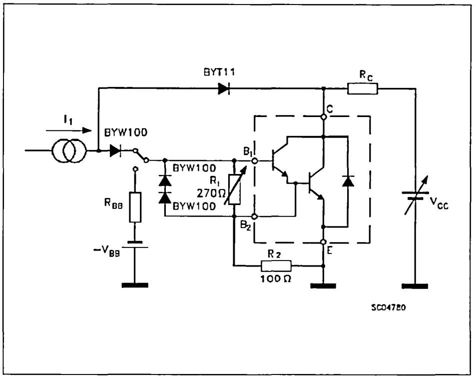
Typical V_F Versus I_F



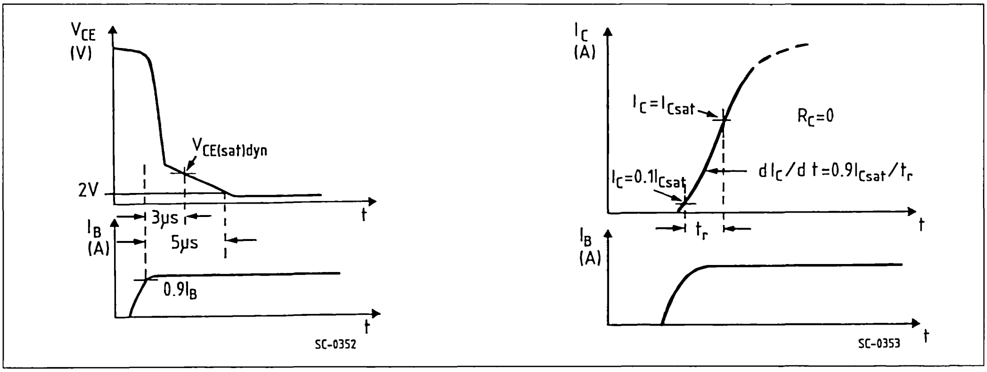
Peak Reverse Current Versus di_F/dt



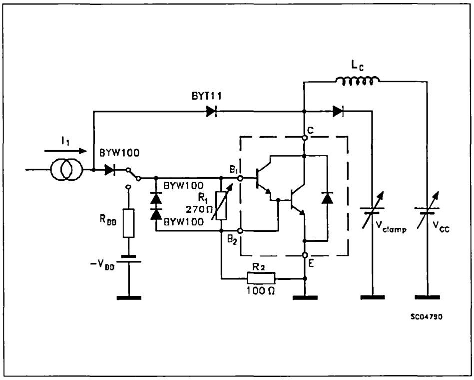
Turn-on Switching Test Circuit



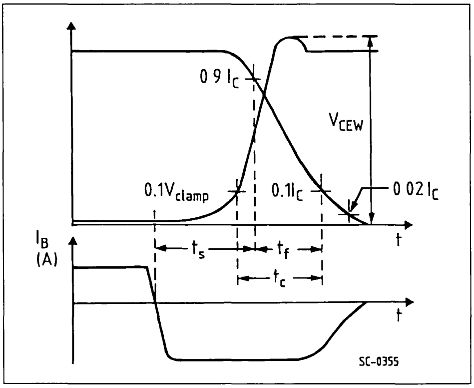
Turn-on Switching Waveforms



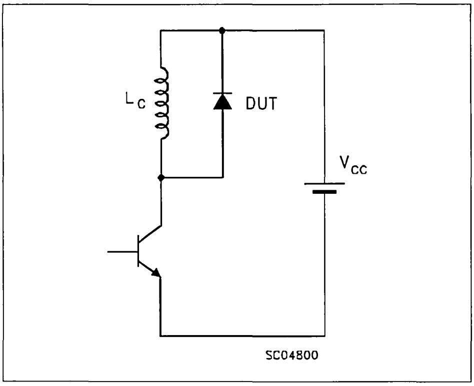
Turn-off Switching Test Circuit



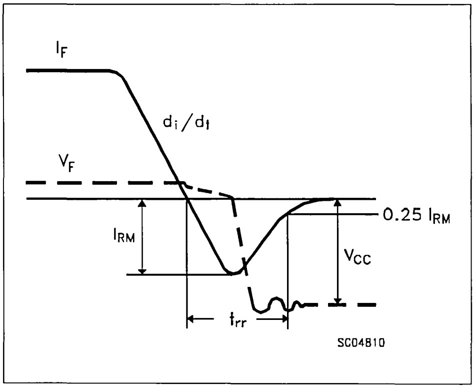
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

ESM2030DF
ESM2030DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
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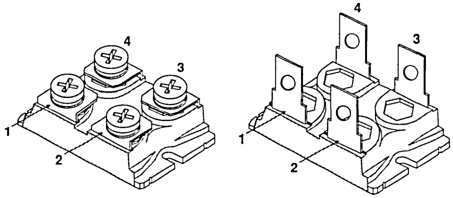
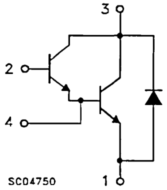


ESM2030DV **ESM2030DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	400	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	67	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	100	A
I_B	Base Current	3	A
I_{BM}	Base Peak Current (t_p = 10 ms)	6	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

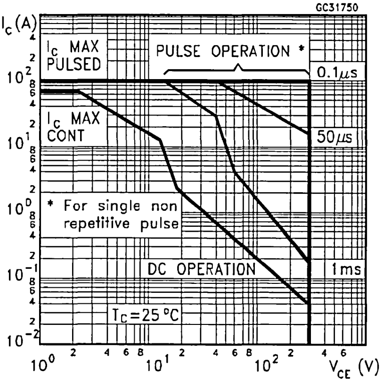
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor) Max	0.83	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

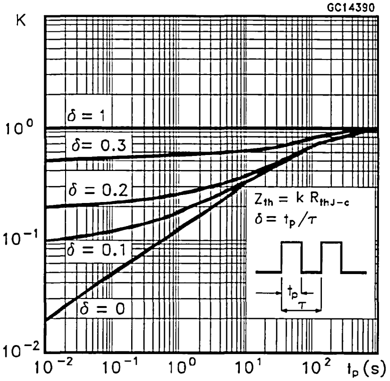
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 16	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5V)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 11	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 300 V	300			V
h_{FE}*	DC Current Gain	I_C = 56 A V_{CE} = 5 V		300		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 40 A I_B = 0.4 A I_C = 40 A I_B = 0.4 A T_j = 100 °C I_C = 56 A I_B = 1.6 A I_C = 56 A I_B = 1.6 A T_j = 100 °C		1.25 1.4 1.5 1.8	 1.8 2.2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 56 A I_B = 1.6 A I_C = 56 A I_B = 1.6 A T_j = 100 °C		2.4 2.5	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 0.6 A T_j = 100 °C	220	260		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 7.5 Ω I_{B1} = 0.6 A T_j = 100 °C		3	6	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 7.5 Ω I_{B1} = 0.6 A T_j = 100 °C		2.2	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 40 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 300 V I_{B1} = 0.4 A L = 0.06 mH T_j = 100 °C		2 0.35 0.8	3 0.6 1.2	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 67 A I_{B1} = 1.6 A V_{BB} = -5 V V_{CC} = 50 V L = 0.037 mH R_{BB} = 0.6 Ω T_j = 125 °C	300			V
V_F*	Diode Forward Voltage	I_F = 56 A T_j = 100 °C		1.15	1.4	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 56 A di_F/dt = -220 A/µs L < 0.05 µH T_j = 100 °C		12	17	A

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
See test circuit in databook introduction
To evaluate the conduction losses of the diode use the following equations:
$V_F = 1.1 + 0.0045\ I_F$ $P = 1\ 1\ I_{F(AV)} + 0.0045\ I^2_{F(RMS)}$

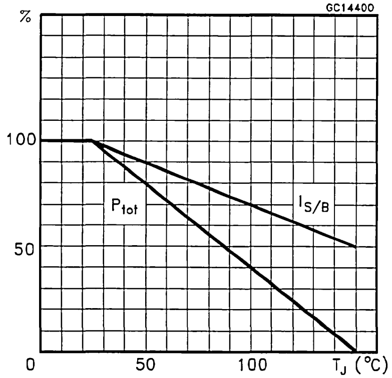
Safe Operating Areas



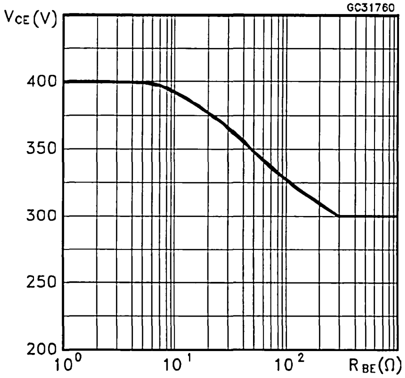
Thermal Impedance



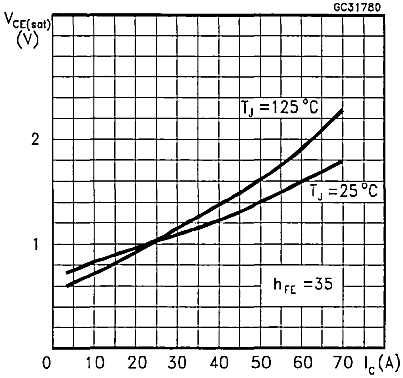
Derating Curve



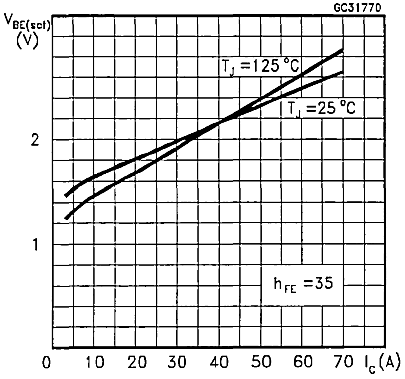
Collector-Emitter Voltage Versus Base-Emitter Resistance



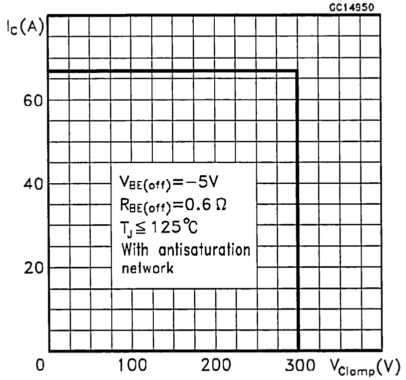
Collector-Emitter Saturation Voltage



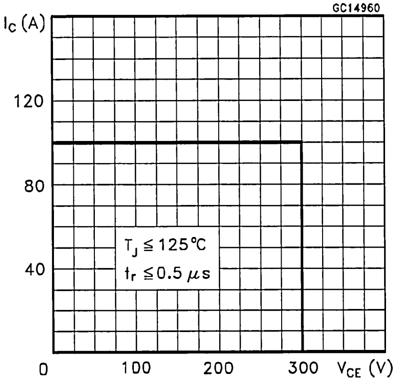
Base-Emitter Saturation Voltage



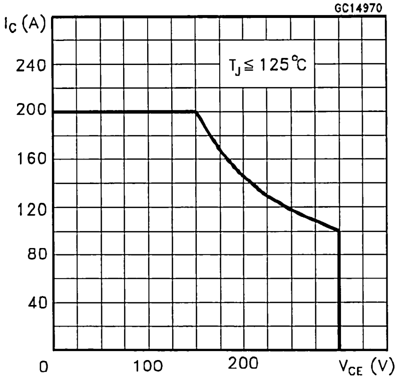
Reverse Biased SOA



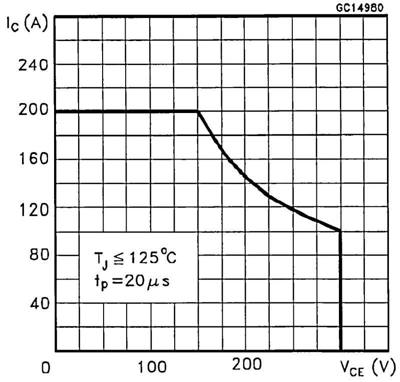
Forward Biased SOA



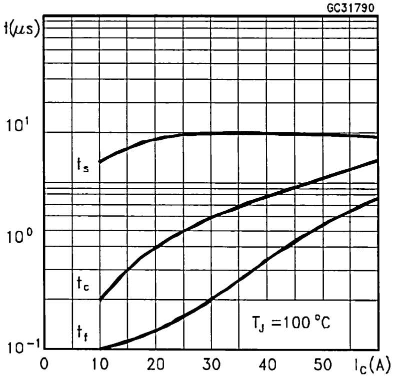
Reverse Biased AOA



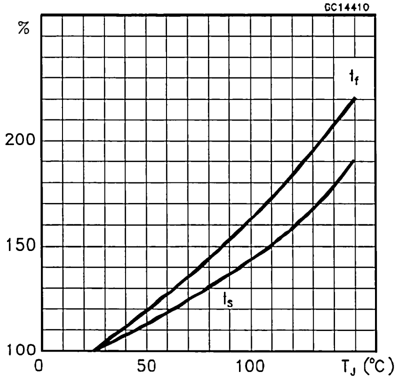
Forward Biased AOA



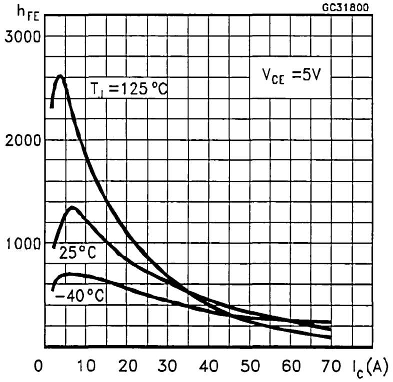
Switching Times Inductive Load



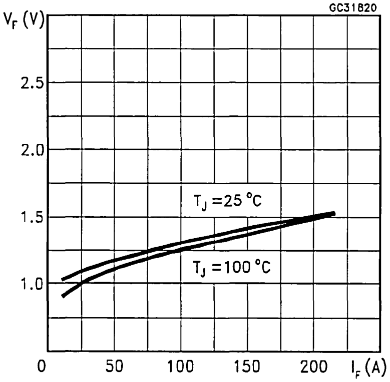
Switching Times Inductive Load Versus Temperature



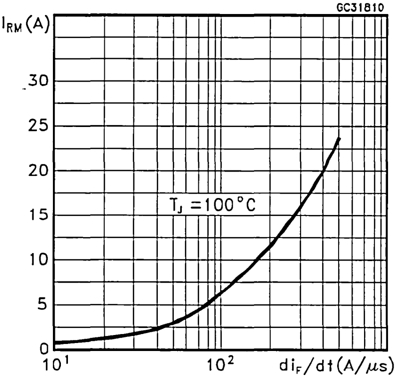
DC Current Gain



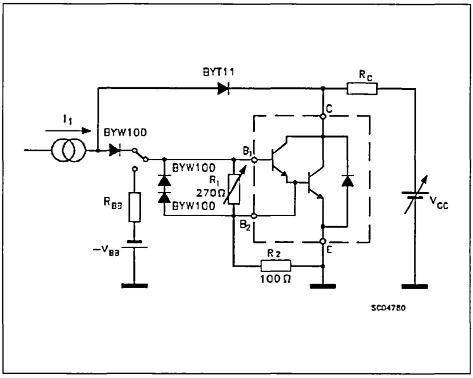
Typical V_F Versus I_F



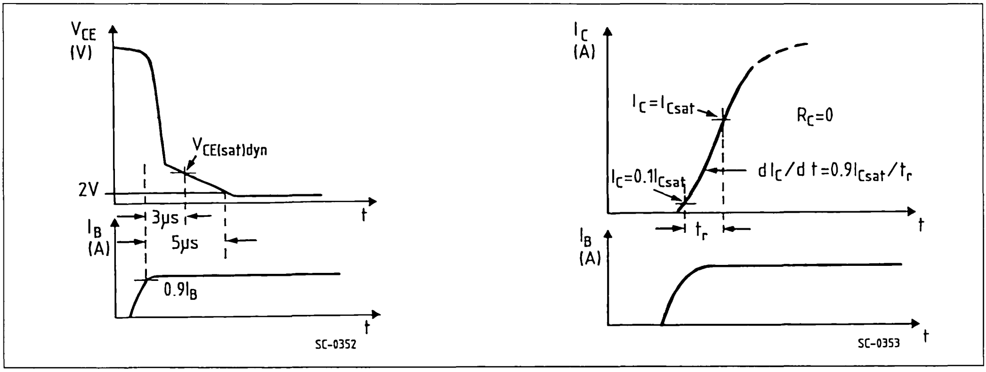
Peak Reverse Current Versus di_F/dt



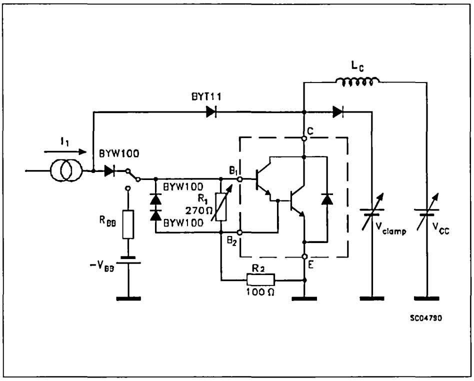
Turn-on Switching Test Circuit



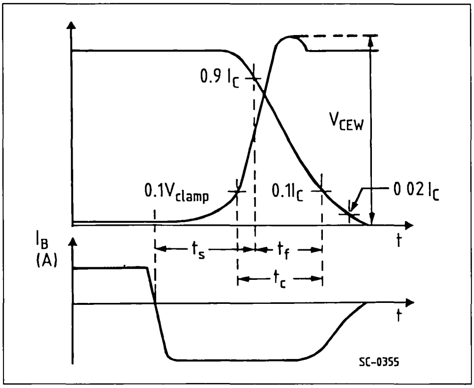
Turn-on Switching Waveforms



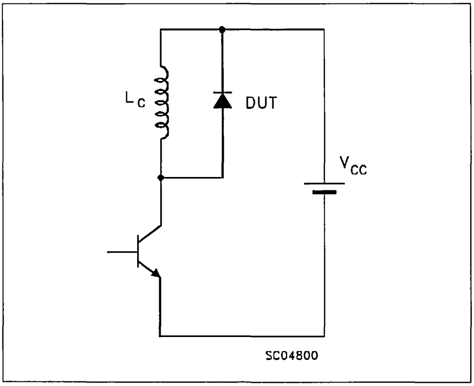
Turn-off Switching Test Circuit



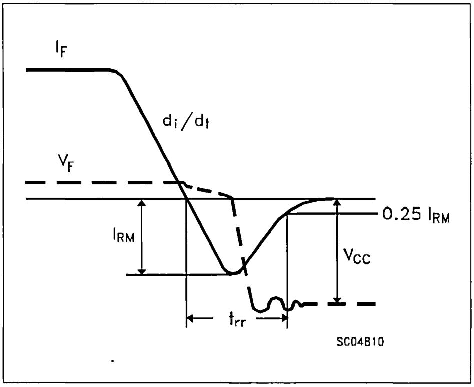
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

ESM3030DF
ESM3030DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
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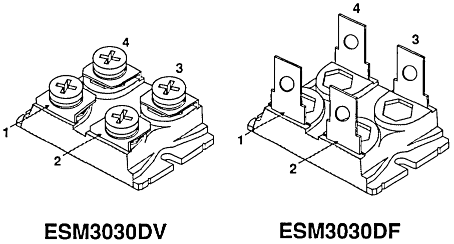
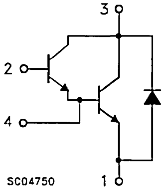
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS
- WELDING EQUIPMENT



ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	400	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	100	A
I_{CM}	Collector Peak Current (t_p = 10ms)	150	A
I_B	Base Current	5	A
I_{BM}	Base Peak Current (t_p = 10 ms)	10	A
P_{tot}	Total Dissipation at T_c = 25 °C	225	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

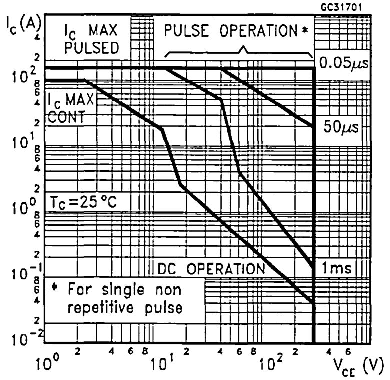
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.55	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

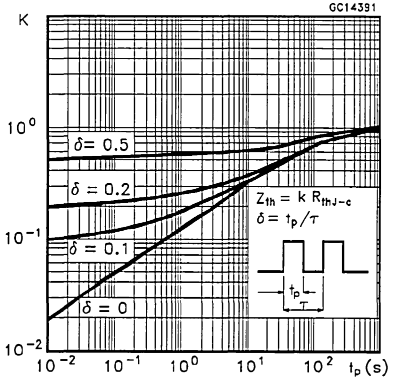
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 16	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 11	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 300 V	300			V
h_{FE}*	DC Current Gain	I_C = 85 A V_{CE} = 5 V		300		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 60 A I_B = 0.6 A I_C = 60 A I_B = 0.6 A T_j = 100 °C I_C = 85 A I_B = 2.4 A I_C = 85 A I_B = 2.4 A T_j = 100 °C		1.25 1.4 1.5 1.8	 1.8 2.2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 85 A I_B = 2.4 A I_C = 85 A I_B = 2.4 A T_j = 100 °C		2.4 2.5	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 0.9 A T_j = 100 °C	330	430		A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 0.9 A T_j = 100 °C		3	6	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 0.9 A T_j = 100 °C		2.2	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 300 V I_{B1} = 0.6 A L = 0.04 mH T_j = 100 °C		2.3 0.35 0.8	3.5 0.6 1.2	μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 100 A I_{B1} = 2.4 A V_{BB} = -5 V V_{CC} = 50 V L = 25 μH R_{BB} = 0.6 Ω T_j = 125 °C	300			V
V_F*	Diode Forward Voltage	I_F = 85 A T_j = 100 °C		1.2	1.55	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 85 A di_F/dt = -330 A/μs L < 50 nH T_j = 100 °C		18	25	A

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
# See test circuits in databook introduction
To evaluate the conduction losses of the diode use the following equations:
$V_F = 1.1 + 0.0045\, I_F$ $P = 1\ 1\, I_{F(AV)} + 0.0045\, I^2_{F(RMS)}$

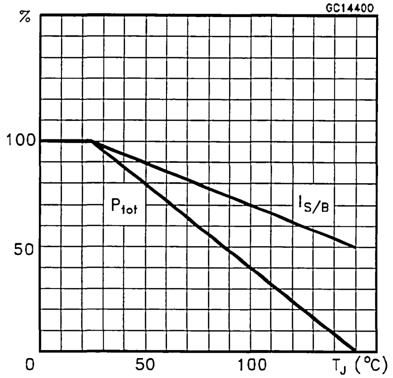
Safe Operating Areas



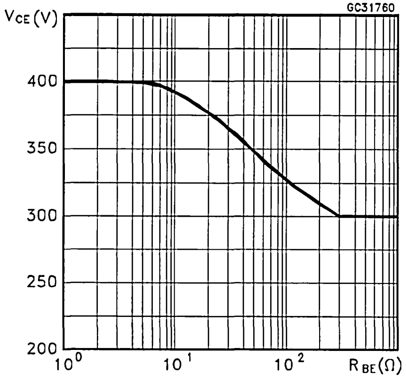
Thermal Impedance



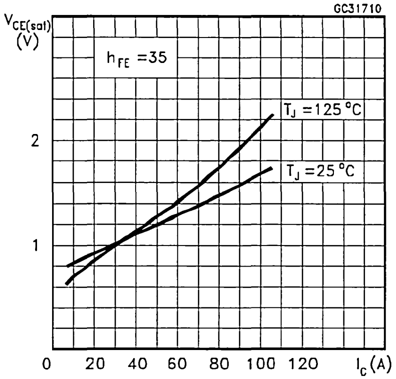
Derating Curve



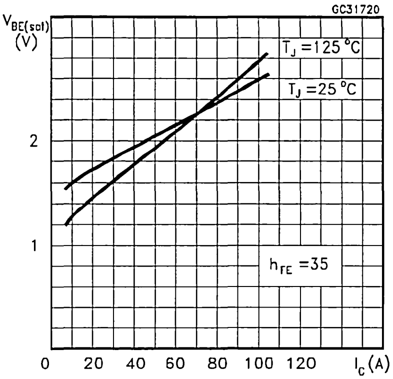
Collector-Emitter Voltage Versus Base-Emitter Resistance



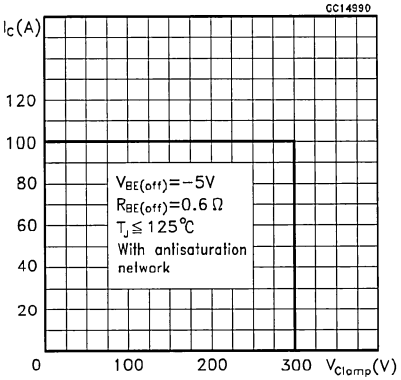
Collector-Emitter Saturation Voltage



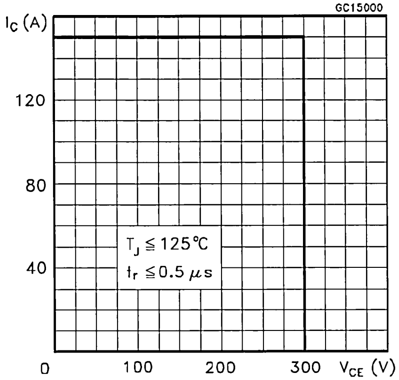
Base-Emitter Saturation Voltage



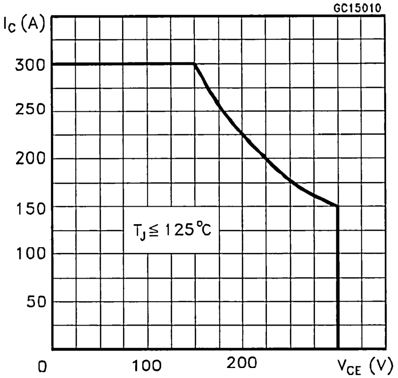
Reverse Biased SOA



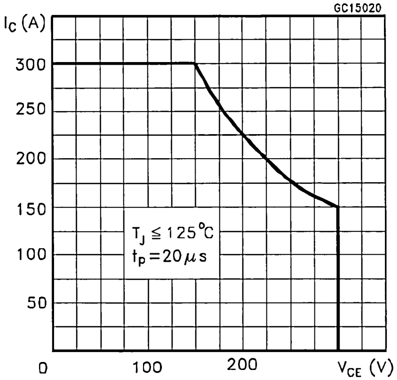
Forward Biased SOA



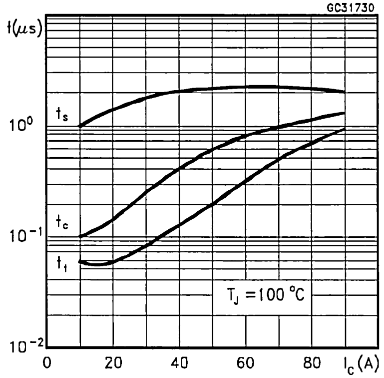
Reverse Biased AOA



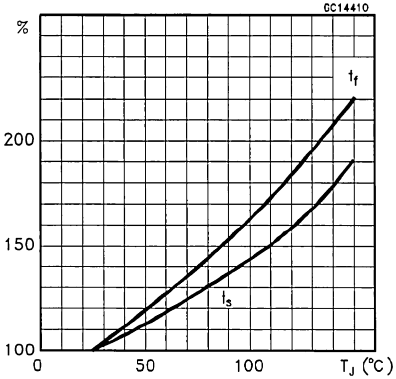
Forward Biased AOA



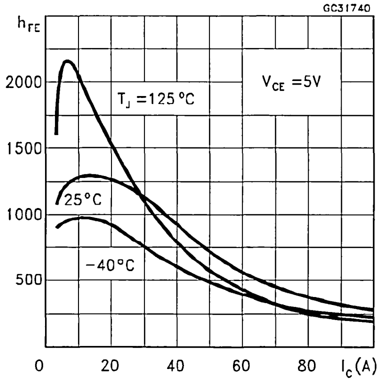
Switching Times Inductive Load



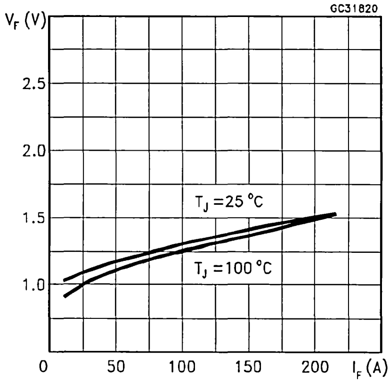
Switching Times Inductive Load Versus Temperature



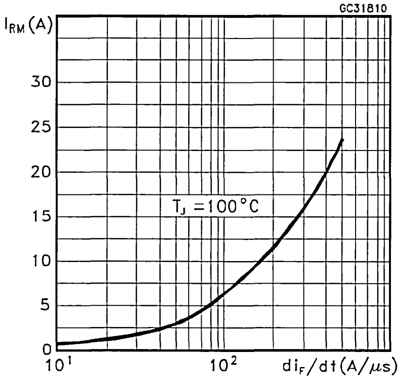
DC Current Gain



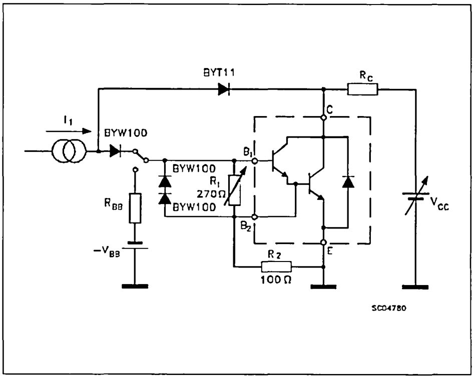
Typical V_F Versus I_F



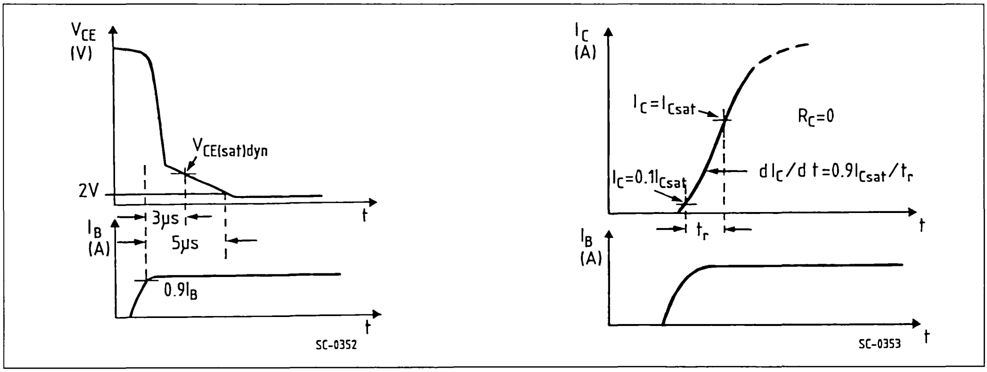
Peak Reverse Current Versus di_F/dt



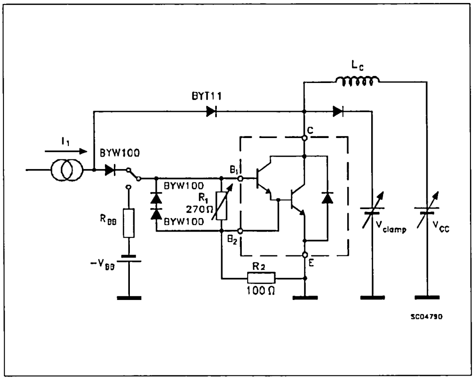
Turn-on Switching Test Circuit



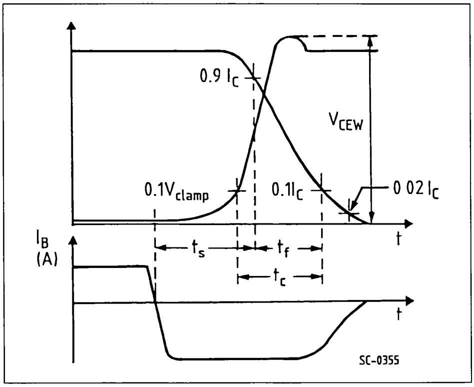
Turn-on Switching Waveforms



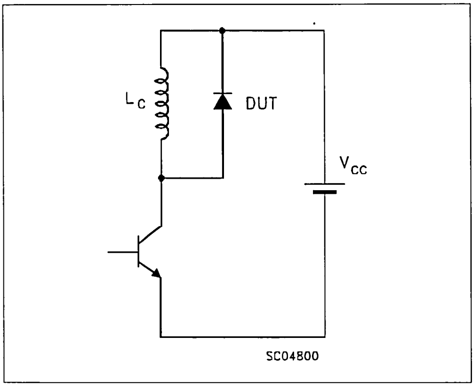
Turn-off Switching Test Circuit



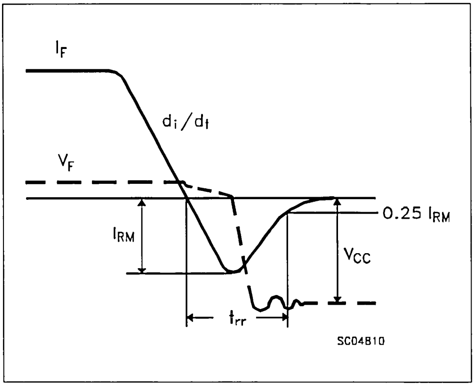
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



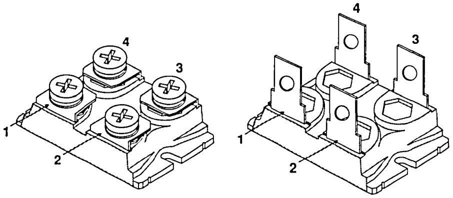
SGS-THOMSON
MICROELECTRONICS

ESM3045AF
ESM3045AV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

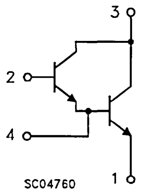
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ESM3045AV **ESM3045AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	22	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	33	A
I_B	Base Current	2.5	A
I_{BM}	Base Peak Current (t_p = 10 ms)	5	A
P_{tot}	Total Dissipation at T_c = 25 °C	125	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

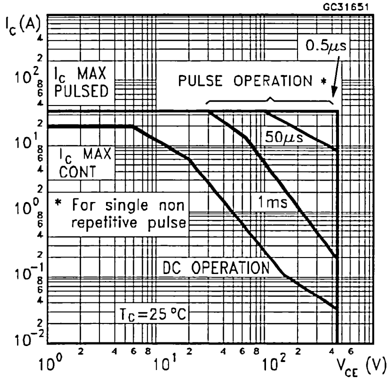
$R_{thj\text{-}case}$ $R_{thc\text{-}h}$	Thermal Resistance Junction-case Thermal Resistance Case-heatsink With Conductive Grease Applied	Max Max	1 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

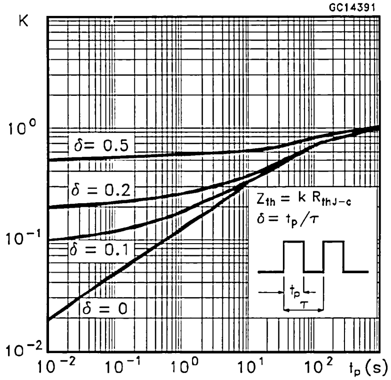
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 17	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 12	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 18 A V_{CE} = 5 V		120		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 15 A I_B = 0.3 A I_C = 15 A I_B = 0.3 A T_j = 100 °C I_C = 18 A I_B = 0.72 A I_C = 18 A I_B = 0.72 A T_j = 100 °C		1.2 1.3 1.3 1.45	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 18 A I_B = 0.72 A I_C = 18 A I_B = 0.72 A T_j = 100 °C		2 2	 2.5	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 1.08 A T_j = 100 °C	150	200		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 16.6 Ω I_{B1} = 1.08 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 16.6 Ω I_{B1} = 1.08 A T_j = 100 °C		2.5	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 18 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.72 A L = 0.14 mH T_j = 100 °C		2.5 0.2 0.7	4.5 0.5 1.5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 22 A I_{B1} = 0.72 A V_{BB} = -5 V V_{CC} = 50 V L = 0.1 mH R_{BB} = 0.6 Ω T_j = 125 °C	450			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuit in databook introduction

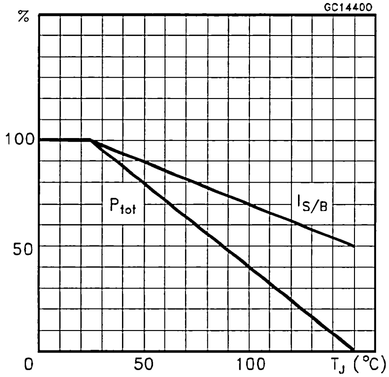
Safe Operating Areas



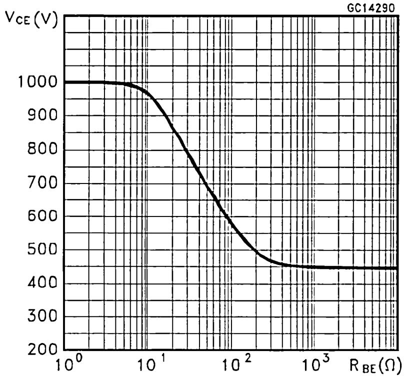
Thermal Impedance



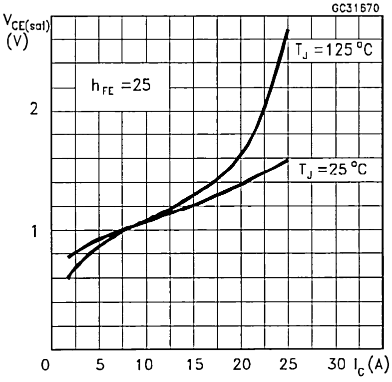
Derating Curve



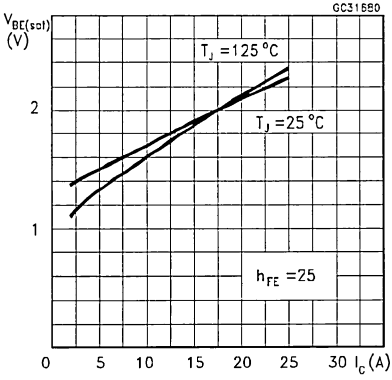
Collector-Emitter Voltage Versus Base-Emitter Resistance



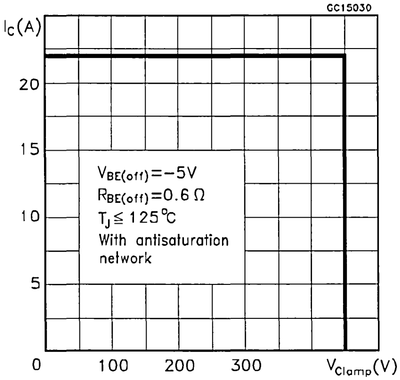
Collector-Emitter Saturation Voltage



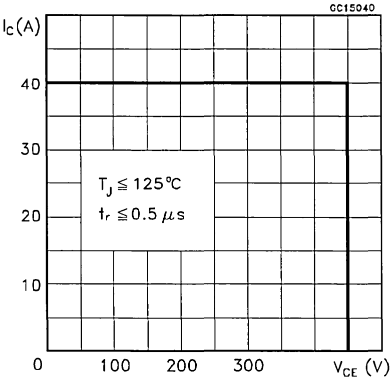
Base-Emitter Saturation Voltage



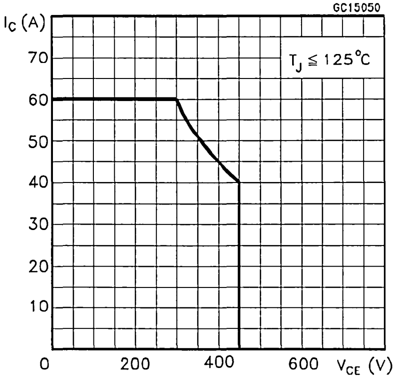
Reverse Biased SOA



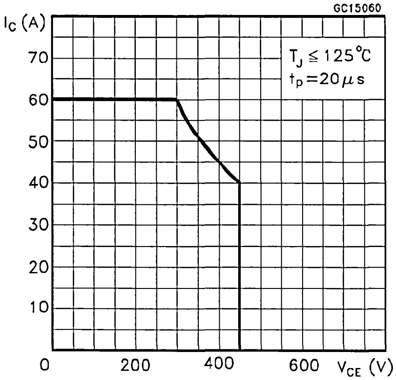
Forward Biased SOA



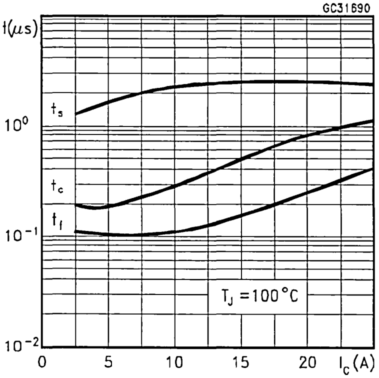
Reverse Biased AOA



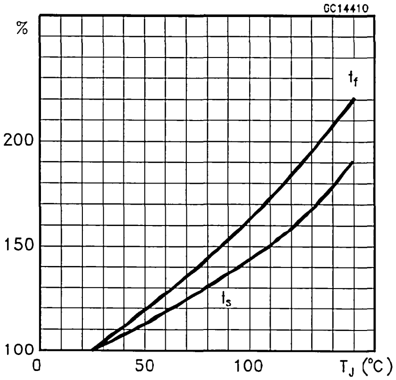
Forward Biased AOA



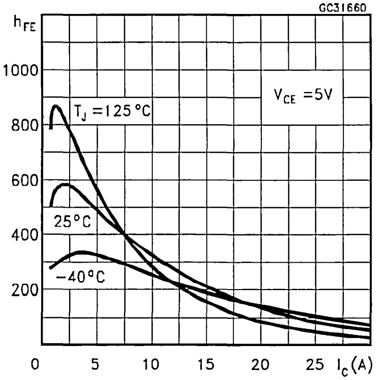
Switching Times Inductive Load



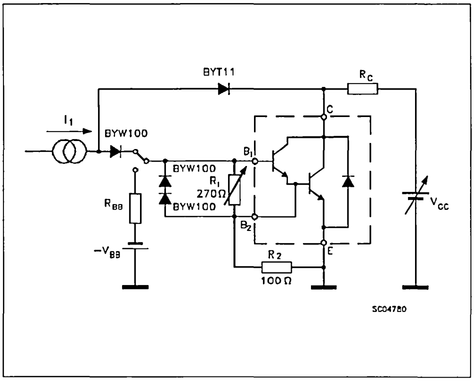
Switching Times Inductive Load Versus Temperature



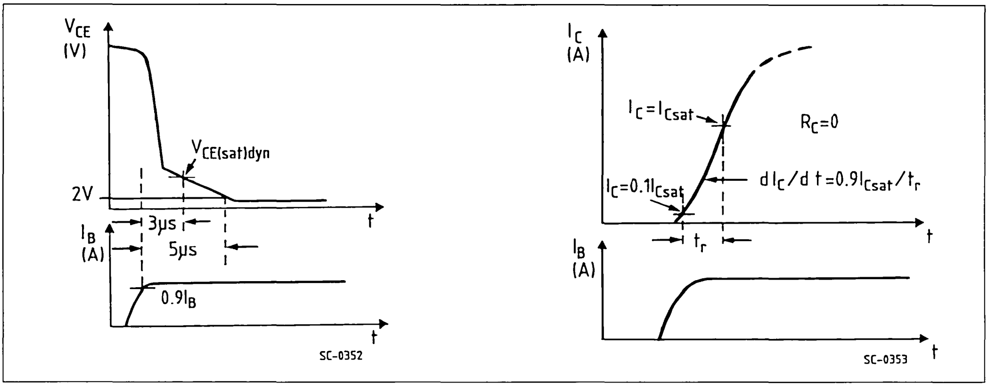
DC Current Gain



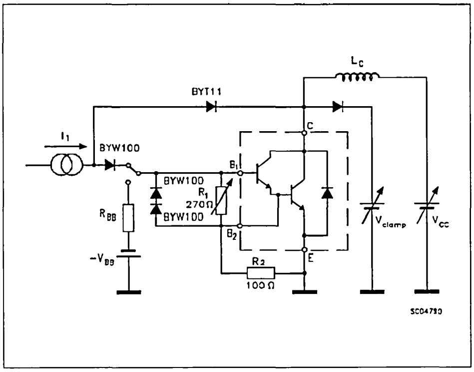
Turn-on Switching Test Circuit



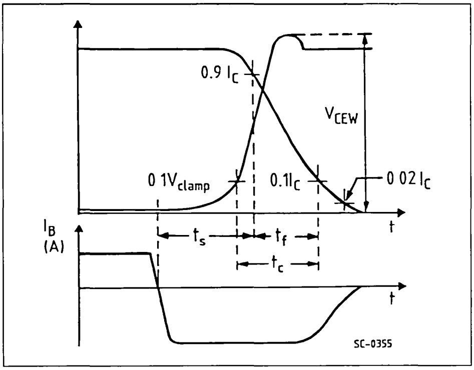
Turn-on Switching Waveforms



Turn-off Switching Test Circuit



Turn-off Switching Waveforms



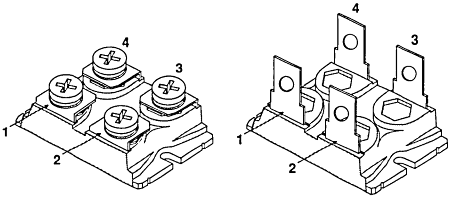
ESM3045DF
ESM3045DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

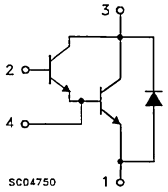
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS
- WELDING EQUIPMENT



ESM3045DV **ESM3045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	24	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	36	A
I_B	Base Current	2.5	A
I_{BM}	Base Peak Current (t_p = 10 ms)	5	A
P_{tot}	Total Dissipation at T_c = 25 °C	125	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor) Max	1	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 17	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 12	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 20 A V_{CE} = 5 V		120		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 15 A I_B = 0.3 A I_C = 15 A I_B = 0.3 A T_j = 100 °C I_C = 20 A I_B = 1.2 A I_C = 20 A I_B = 1.2 A T_j = 100 °C		1.2 1.3 1.4 1.6	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 20 A I_B = 1.2 A I_C = 20 A I_B = 1.2 A T_j = 100 °C		2.1 2.1	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 0.45 A T_j = 100 °C	125	160		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 20 Ω I_{B1} = 0.45 A T_j = 100 °C		4.5	8	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 20 Ω I_{B1} = 0.45 A T_j = 100 °C		2.5	4.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 15 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.3 A L = 0.17 mH T_j = 100 °C		2.1 0.15 0.5	4 0.4 1.2	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 24 A I_{B1} = 1.2 A V_{BB} = -5 V V_{CC} = 50 V L = 0.1 mH R_{BB} = 0.6 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 20 A T_j = 100 °C		1.7	2	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 20 A di_F/dt = -125 A/µs L < 0.05 µH T_j = 100 °C		11	14	A

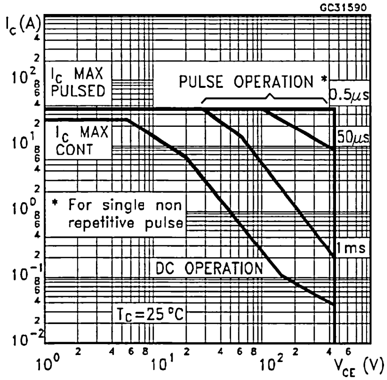
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

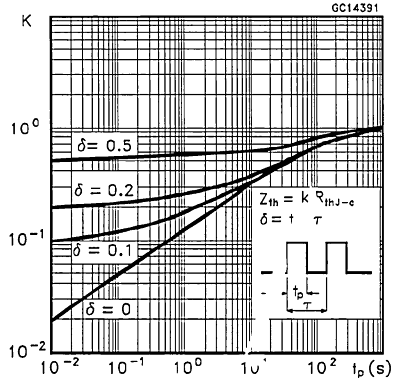
To evaluate the conduction losses of the diode use the following equations:

$V_F = 1.47 + 0.0026\ I_F$ $\quad P = 1.47\ I_{F(AV)} + 0.0026\ I^2_{F(RMS)}$

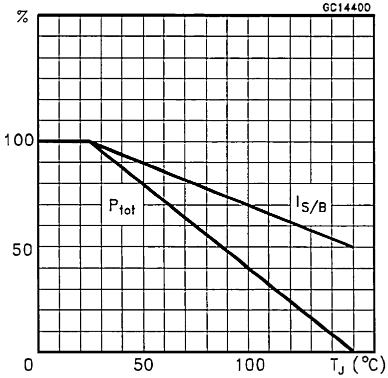
Safe Operating Areas



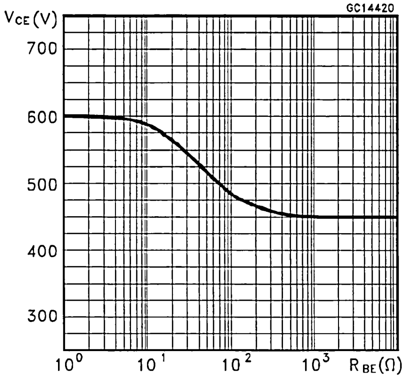
Thermal Impedance



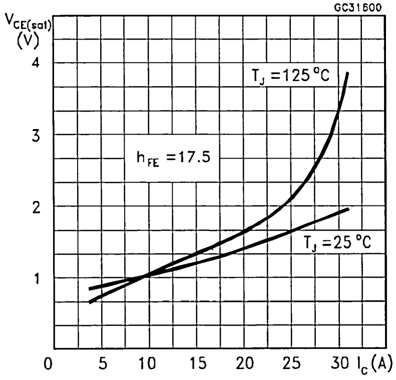
Derating Curve



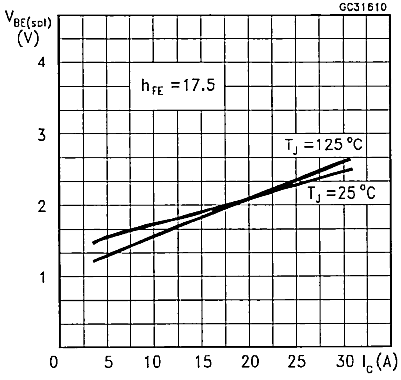
Collector-Emitter Voltage Versus Base-Emitter Resistance



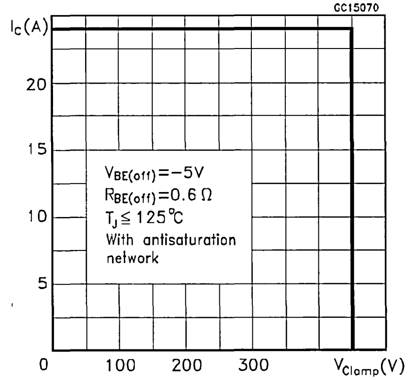
Collector-Emitter Saturation Voltage



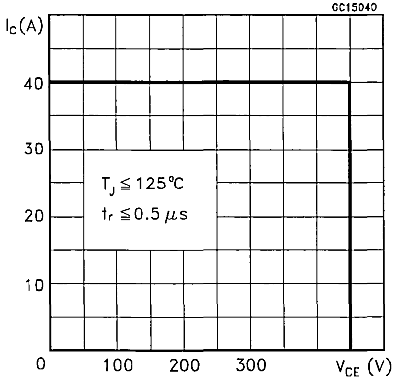
Base-Emitter Saturation Voltage



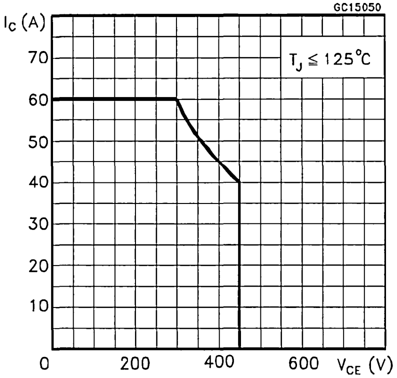
Reverse Biased SOA



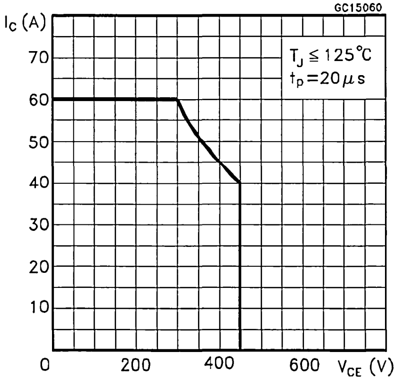
Forward Biased SOA



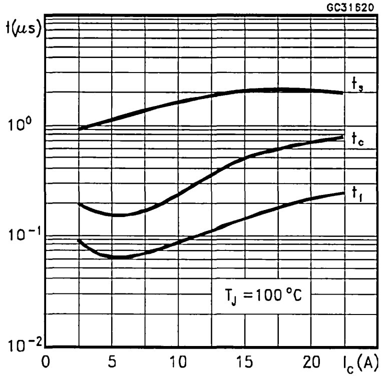
Reverse Biased AOA



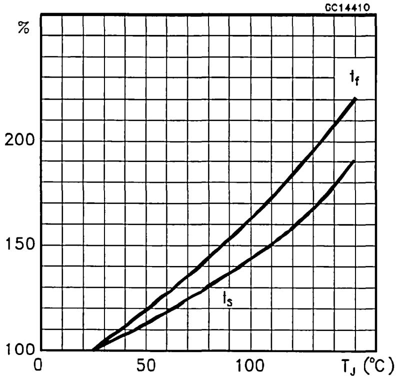
Forward Biased AOA



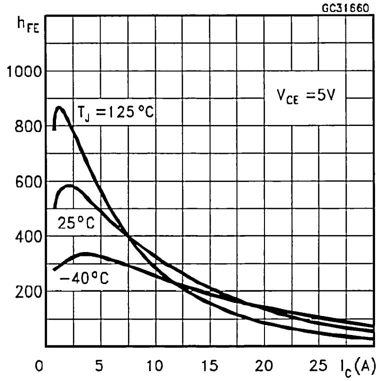
Switching Times Inductive Load



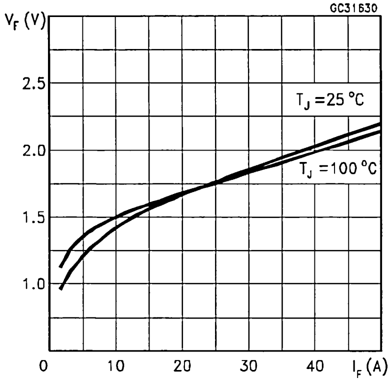
Switching Times Inductive Load Versus Temperature



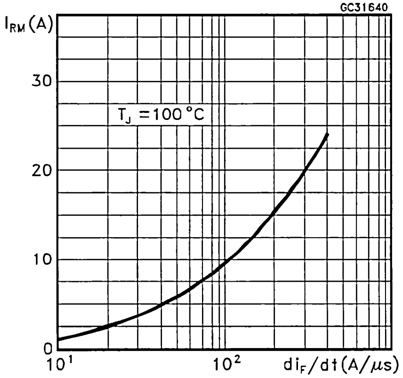
DC Current Gain



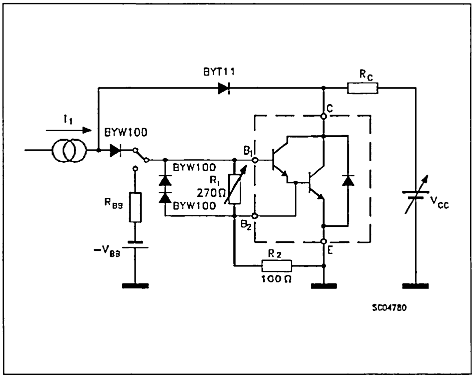
Typical V_F Versus I_F



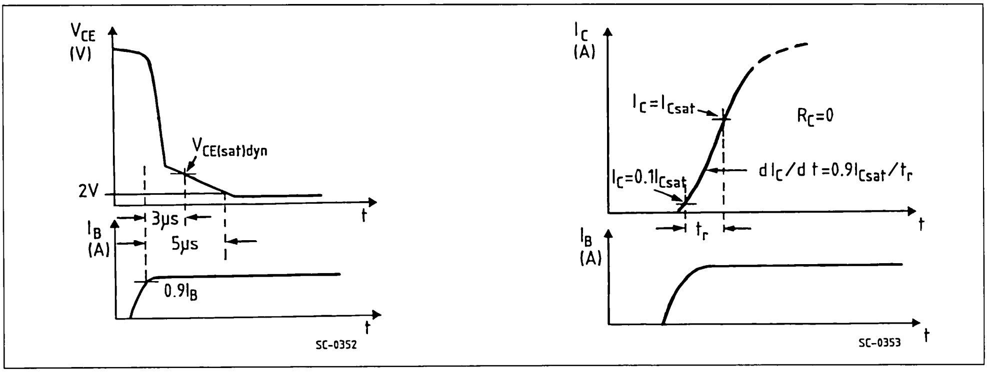
Peak Reverse Current Versus di_F/dt



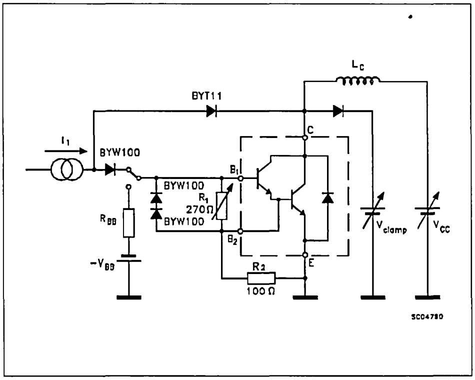
Turn-on Switching Test Circuit



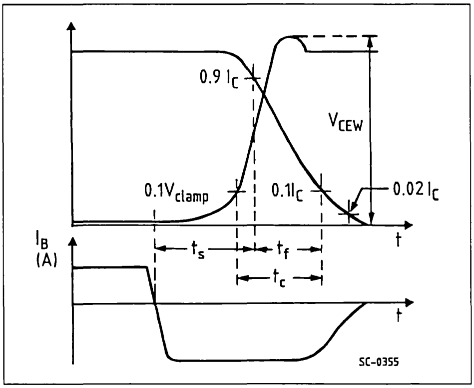
Turn-on Switching Waveforms



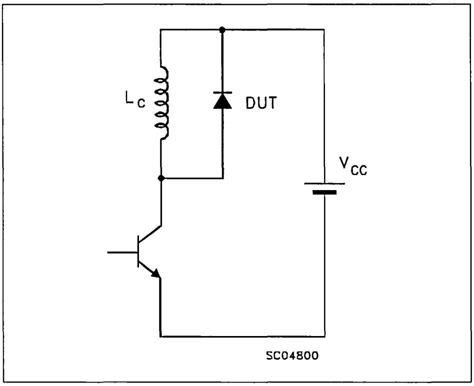
Turn-off Switching Test Circuit



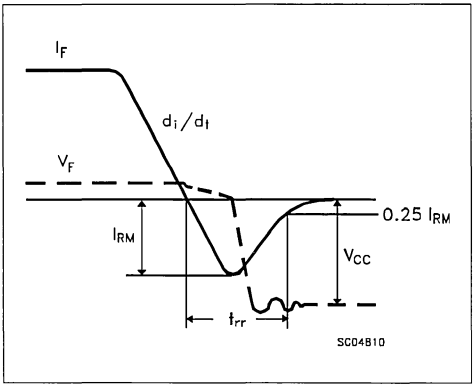
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

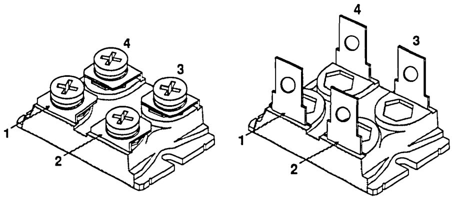
ESM4045AF
ESM4045AV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

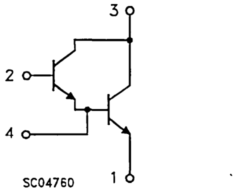
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ESM4045AV **ESM4045AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	36	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	54	A
I_B	Base Current	4	A
I_{BM}	Base Peak Current (t_p = 10 ms)	8	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case Max	0.83	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

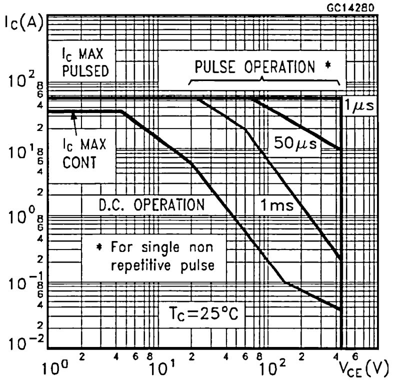
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$			1.5	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			20	mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$			1	mA
		$V_{CE} = V_{CEV}$ T_j = 100 °C			13	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 5 V		280		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 0.5 A		1.2		V
		I_C = 25 A I_B = 0.5 A T_j = 100 °C		1.3	2	V
		I_C = 30 A I_B = 1.2 A		1.3		V
		I_C = 30 A I_B = 1.2 A T_j = 100 °C		1.45	2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 30 A I_B = 1.2 A		2.1		V
		I_C = 30 A I_B = 1.2 A T_j = 100 °C		2.1	2.5	V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 1.8 A T_j = 100 °C	240	300		A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 10 Ω I_{B1} = 1.8 A T_j = 100 °C		4	7	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 10 Ω I_{B1} = 1.8 A T_j = 100 °C		2.5	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 1.2 A L = 80 μH T_j = 100 °C		3.6 0.3 1	5 0.6 1.8	μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 36 A I_{B1} = 1.2 A V_{BB} = -5 V V_{CC} = 50 V L = 0.07 mH R_{BB} = 0.6 Ω T_j = 125 °C	450			V

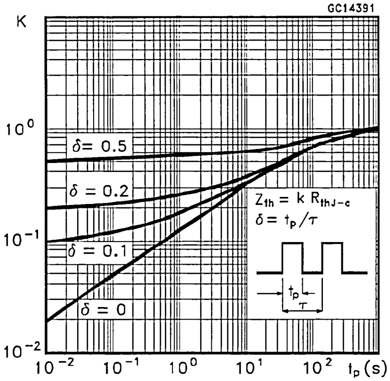
* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

\# See test circuits in databook introduction

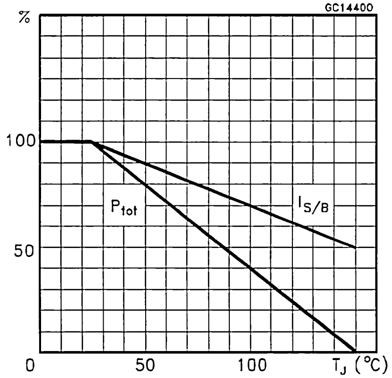
Safe Operating Areas



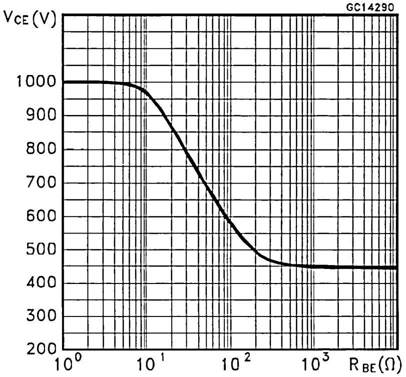
Thermal Impedance



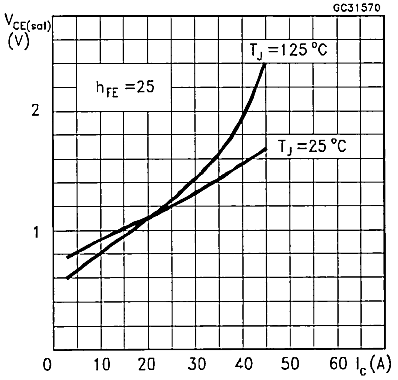
Derating Curve



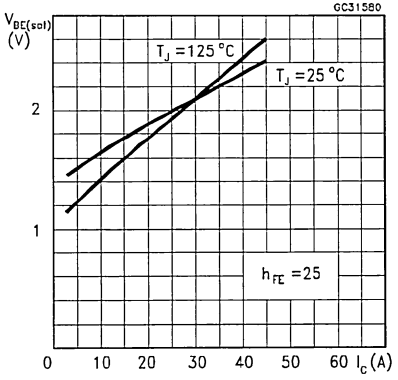
Collector-Emitter Voltage Versus Base-Emitter Resistance



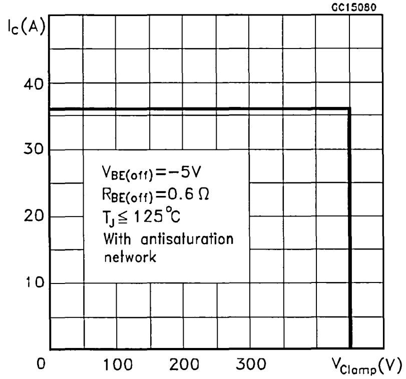
Collector-Emitter Saturation Voltage



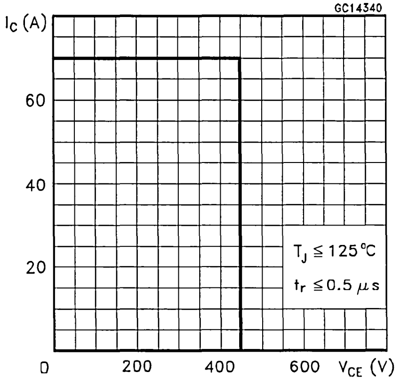
Base-Emitter Saturation Voltage



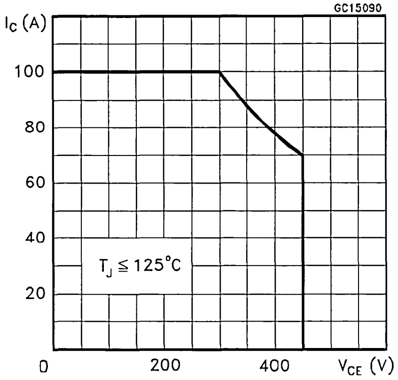
Reverse Biased SOA



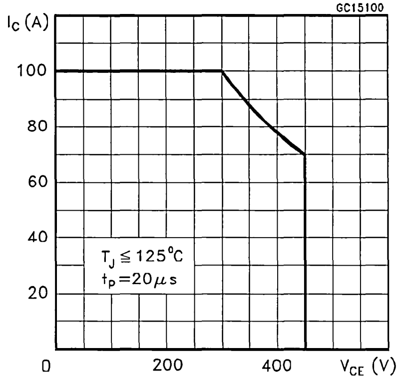
Forward Biased SOA



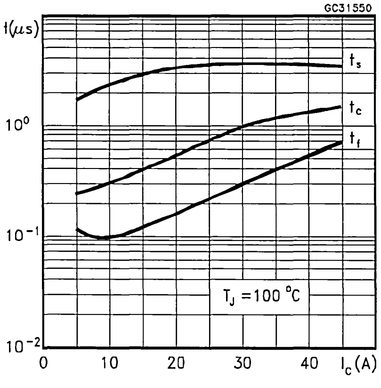
Reverse Biased AOA



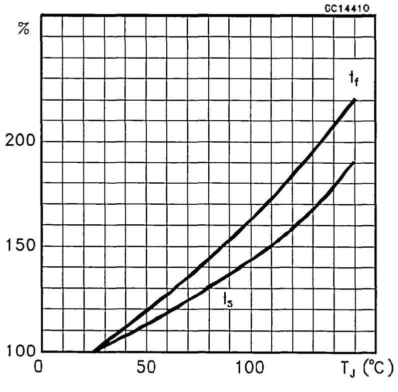
Forward Biased AOA



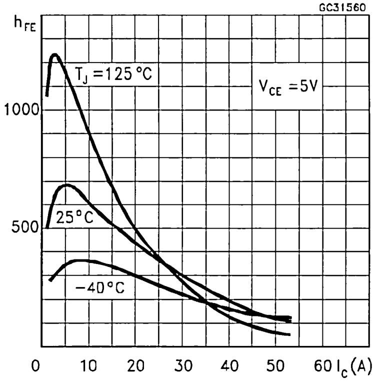
Switching Times Inductive Load



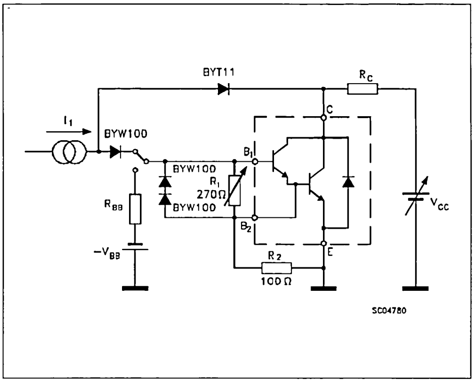
Switching Times Inductive Load Versus Temperature



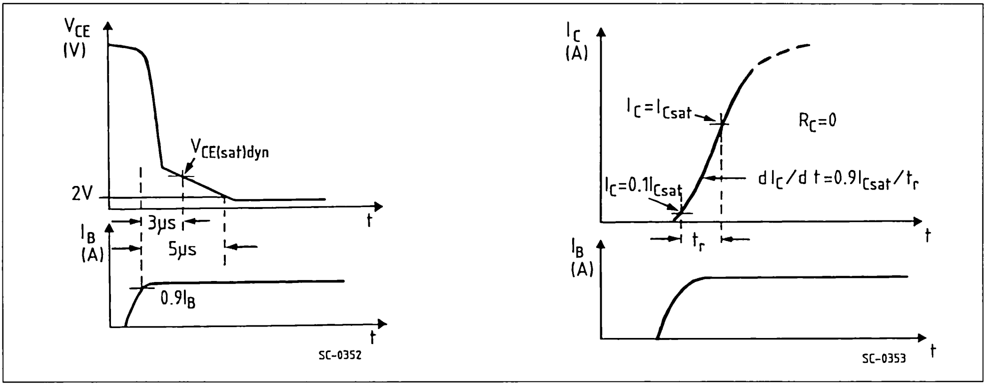
DC Current Gain



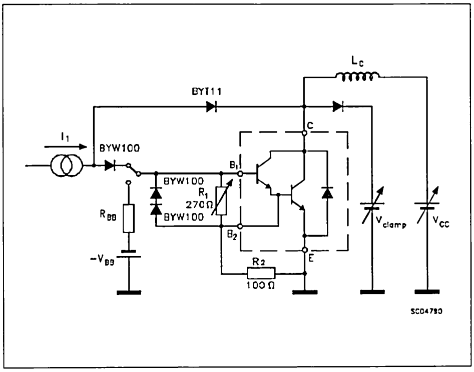
Turn-on Switching Test Circuit



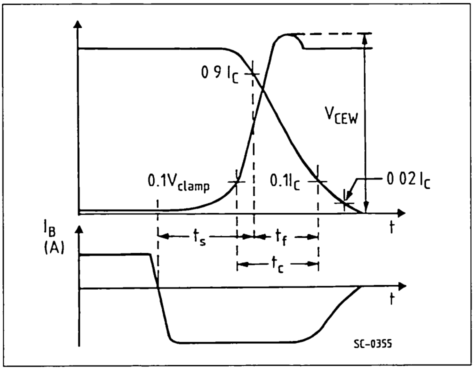
Turn-on Switching Waveforms



Turn-off Switching Test Circuit



Turn-off Switching Waveforms



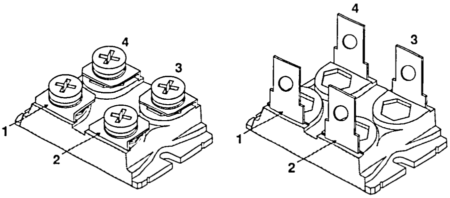
SGS-THOMSON
MICROELECTRONICS

ESM4045DF
ESM4045DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

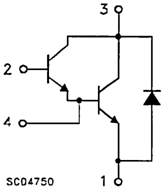
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS
- WELDING EQUIPMENT



ESM4045DV **ESM4045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	42	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	63	A
I_B	Base Current	4	A
I_{BM}	Base Peak Current (t_p = 10 ms)	8	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.83	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 20	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 13	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 35 A V_{CE} = 5 V		220		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 0.5 A I_C = 25 A I_B = 0.5 A T_j = 100 °C I_C = 35 A I_B = 2 A I_C = 35 A I_B = 2 A T_j = 100 °C		1.15 1.3 1.4 1.5	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 35 A I_B = 2 A I_C = 35 A I_B = 2 A T_j = 100 °C		2.3 2.3	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 0.75 A T_j = 100 °C	200	250		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 0.75 A T_j = 100 °C		4.5	8	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 0.75 A T_j = 100 °C		2.5	4.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 25 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.5 A L = 0.1 mH T_j = 100 °C		3 0.2 0.75	4.5 0.5 1.5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 42 A I_{B1} = 2 A V_{BB} = -5 V V_{CC} = 50 V L = 0.06 mH R_{BB} = 0.6 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 35 A T_j = 100 °C		1.5	1.85	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 35 A di_F/dt = -200 A/µs L < 0.05 µH T_j = 100 °C		20	24	A

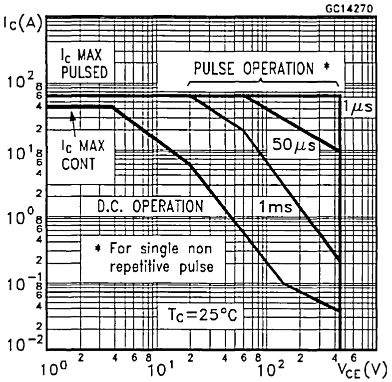
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

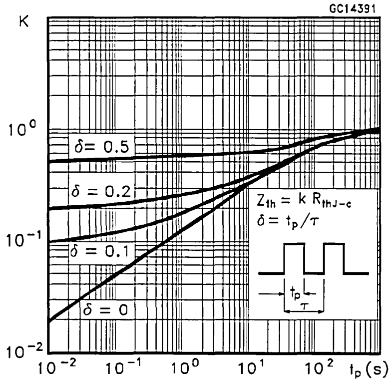
To evaluate the conduction losses of the diode use the following equations.

$V_F = 1.5 + 0.001\ I_F$ $\quad P = 1.5\ I_{F(AV)} + 0.001\ I^2_{F(RMS)}$

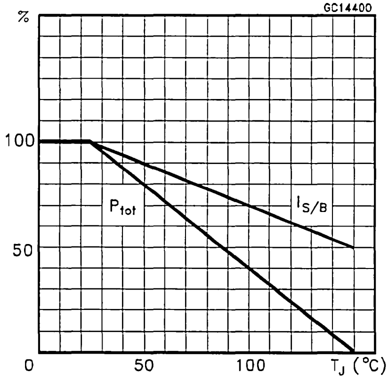
Safe Operating Areas



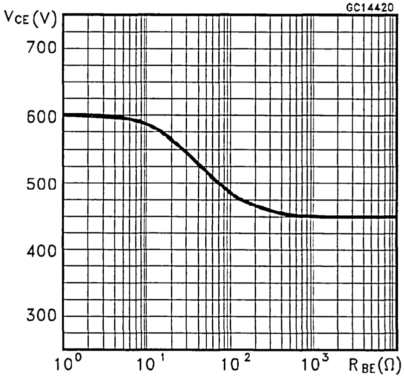
Thermal Impedance



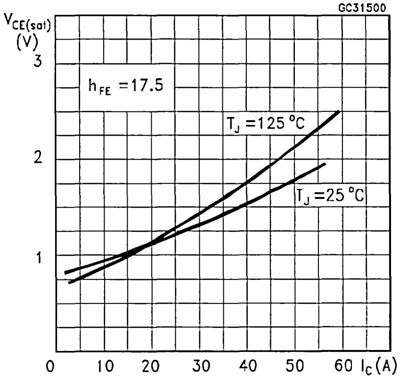
Derating Curve



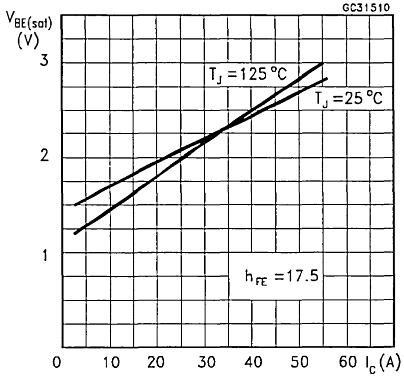
Collector-Emitter Voltage Versus Base-Emitter Resistance



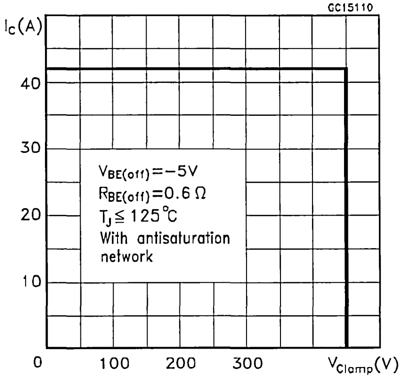
Collector-Emitter Saturation Voltage



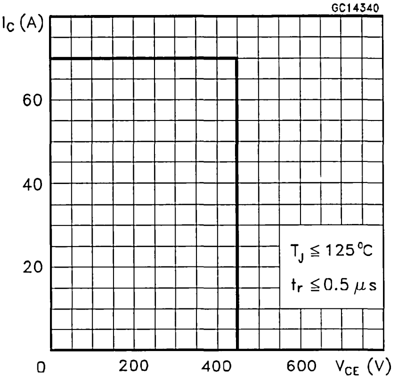
Base-Emitter Saturation Voltage



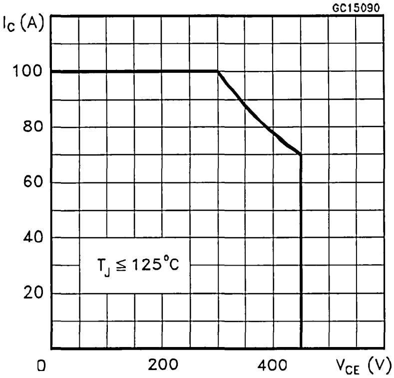
Reverse Biased SOA



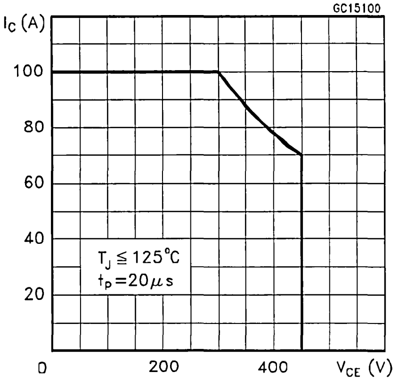
Forward Biased SOA



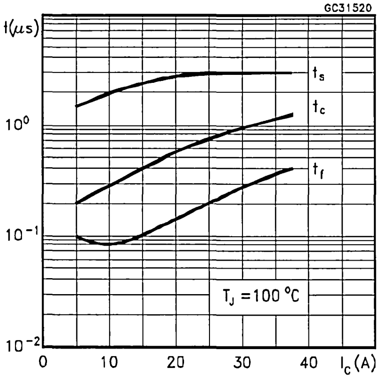
Reverse Biased AOA



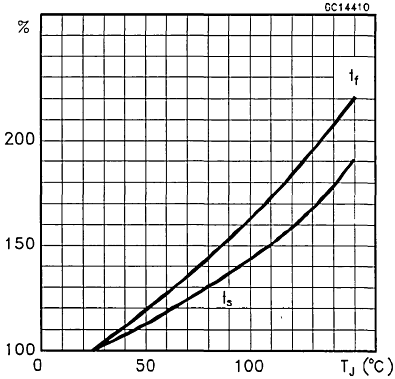
Forward Biased AOA



Switching Times Inductive Load

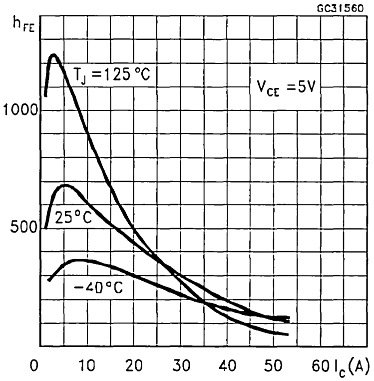


Switching Times Inductive Load Versus Temperature

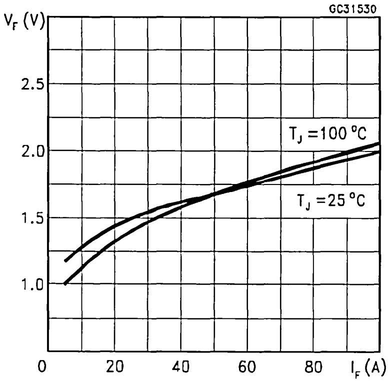


SGS-THOMSON MICROELECTRONICS

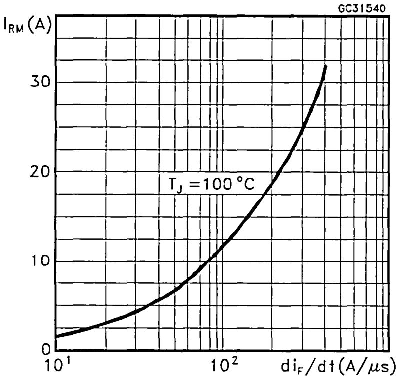
DC Current Gain



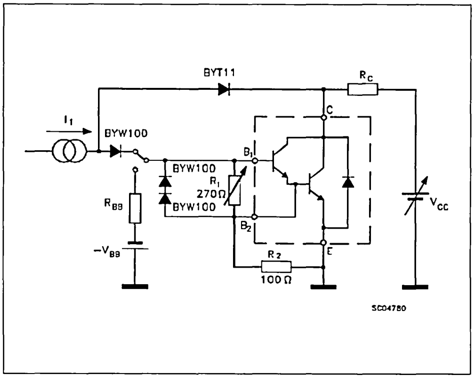
Typical V_F Versus I_F



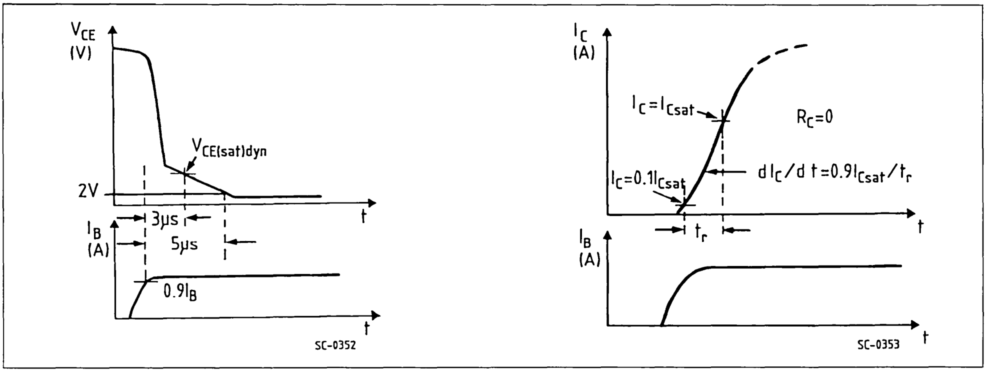
Peak Reverse Current Versus di_F/dt



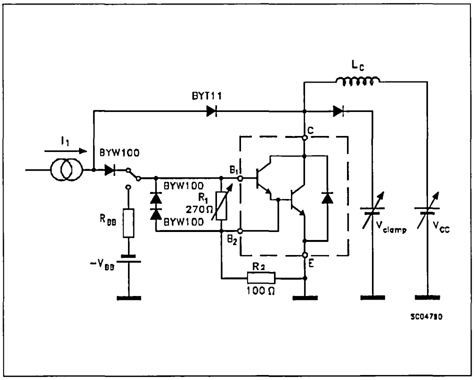
Turn-on Switching Test Circuit



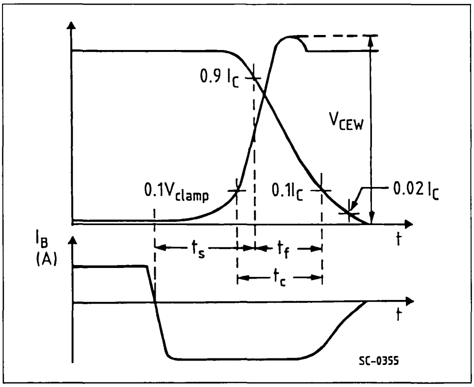
Turn-on Switching Waveforms



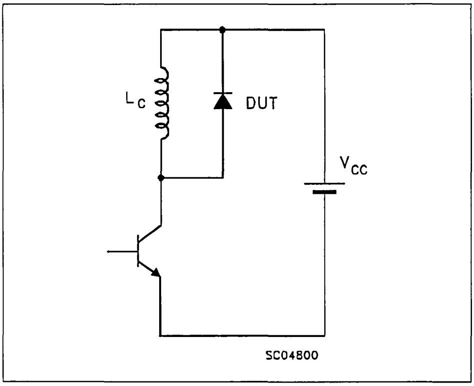
Turn-off Switching Test Circuit



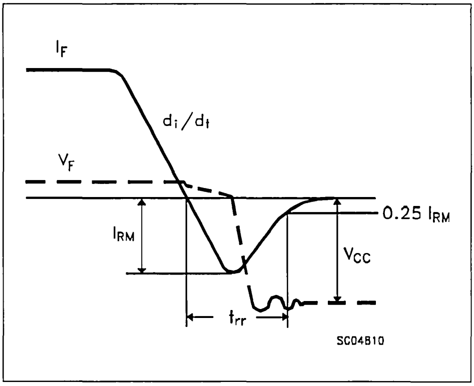
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



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INDUSTRIAL APPLICATIONS:

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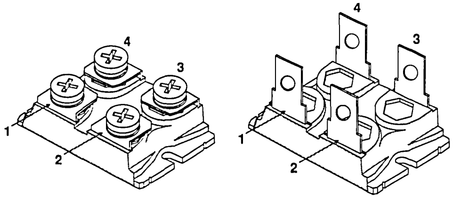
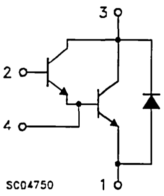


ESM5045DV **ESM5045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	60	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	90	A
I_B	Base Current	6	A
I_{BM}	Base Peak Current (t_p = 10 ms)	12	A
P_{tot}	Total Dissipation at T_c = 25 °C	175	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.71	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 20	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 13	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 5 V		150		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 35 A I_B = 0.7 A I_C = 35 A I_B = 0.7 A T_j = 100 °C I_C = 50 A I_B = 2.8 A I_C = 50 A I_B = 2.8 A T_j = 100 °C		1.2 1.4 1.4 1.6	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 2.8 A I_C = 50 A I_B = 2.8 A T_j = 100 °C		2.3 2.3	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 1.05 A T_j = 100 °C	300	400		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 8.5 Ω I_{B1} = 1.05 A T_j = 100 °C		4.5	8	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 8.5 Ω I_{B1} = 1.05 A T_j = 100 °C		2.5	4.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 35A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.7 A L = 0.07 mH T_j = 100 °C		3.2 0.25 0.75	5 0.5 1.5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 60 A I_{B1} = 2.8 A V_{BB} = -5 V V_{CC} = 50 V L = 42 µH R_{BB} = 0.6 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 50 A T_j = 100 °C		1.5	1.8	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 50 A di_F/dt = -300 A/µs L < 0.05 µH T_j = 100 °C		32	38	A

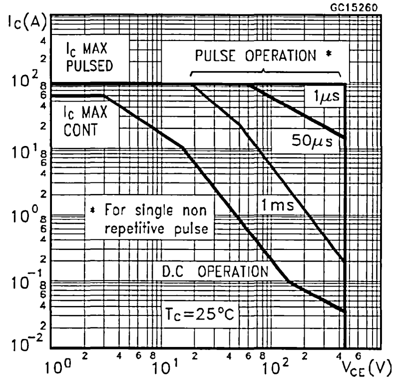
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

To evaluate the conduction losses of the diode use the following equations:

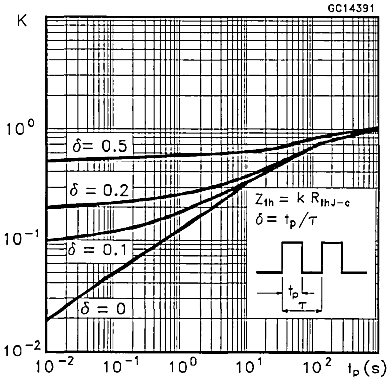
$V_F = 1.5 + 0.0055\ I_F$ $P = 1.5\ I_{F(AV)} + 0.0055\ I^2_{F(RMS)}$

See test circuits in databook introduction

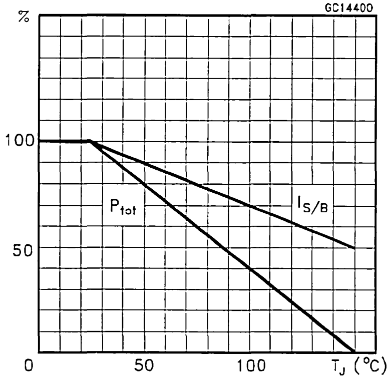
Safe Operating Areas



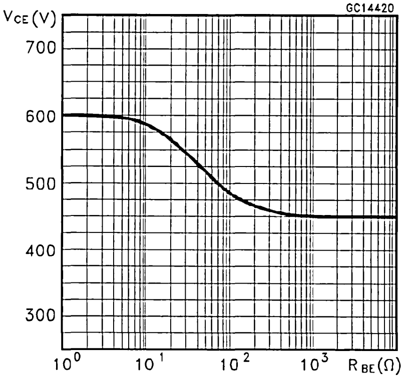
Thermal Impedance



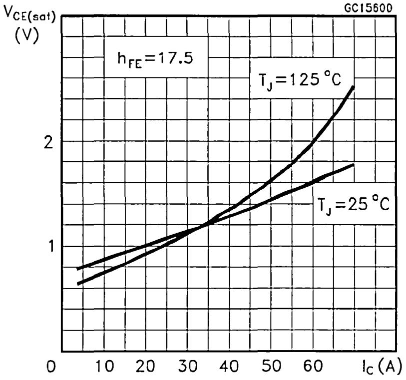
Derating Curve



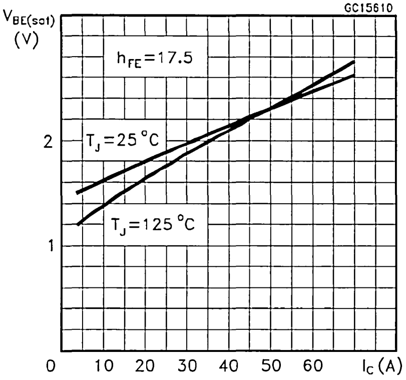
Collector-Emitter Voltage Versus Base-Emitter Resistance



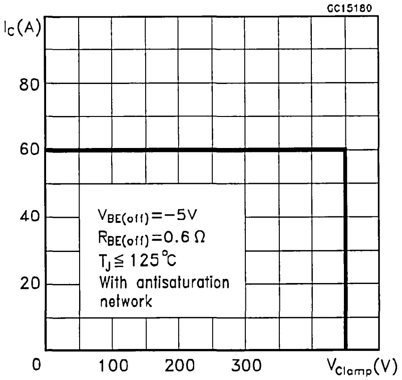
Collector-Emitter Saturation Voltage



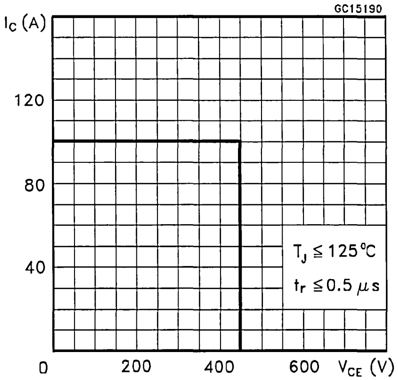
Base-Emitter Saturation Voltage



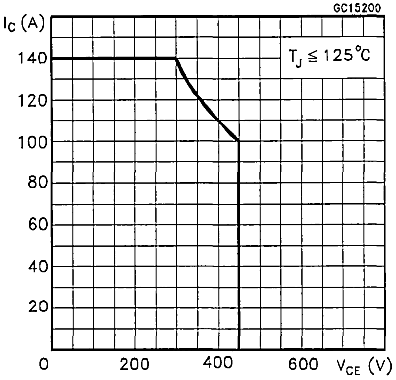
Reverse Biased SOA



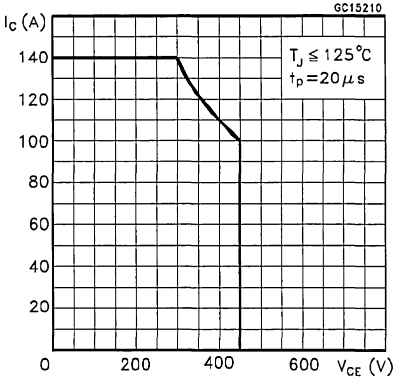
Forward Biased SOA



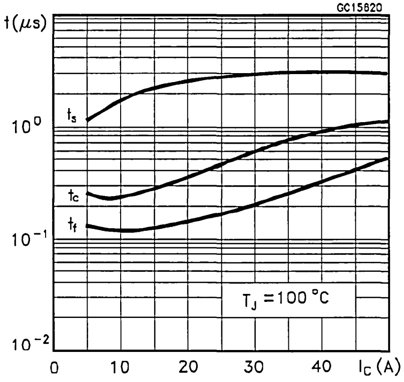
Reverse Biased AOA



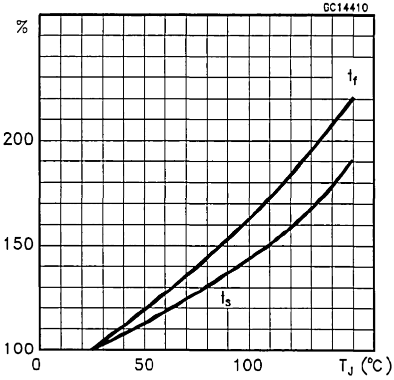
Forward Biased AOA



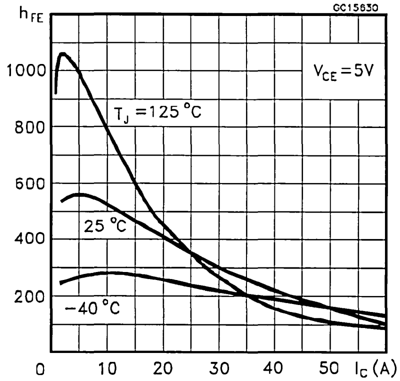
Switching Times Inductive Load



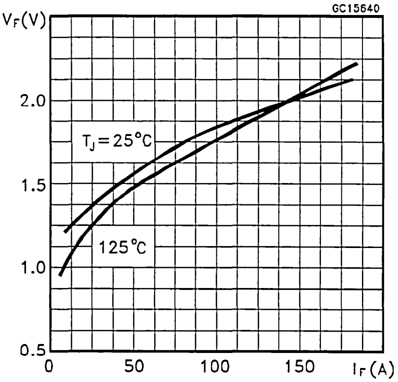
Switching Times Inductive Load Versus Temperature



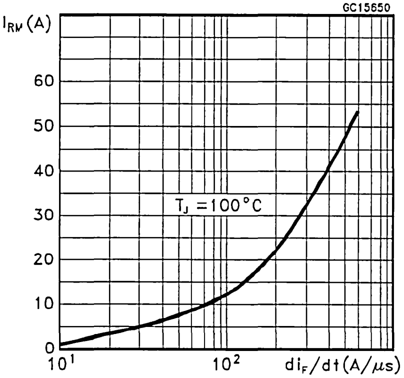
DC Current Gain



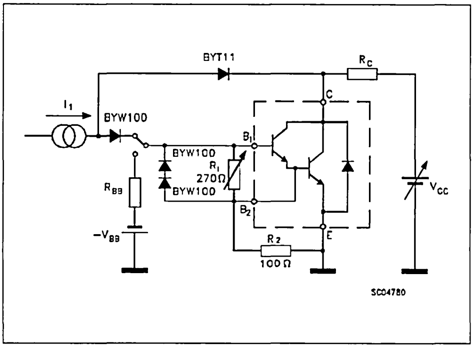
Typical V_F Versus I_F



Peak Reverse Current Versus di_F/dt

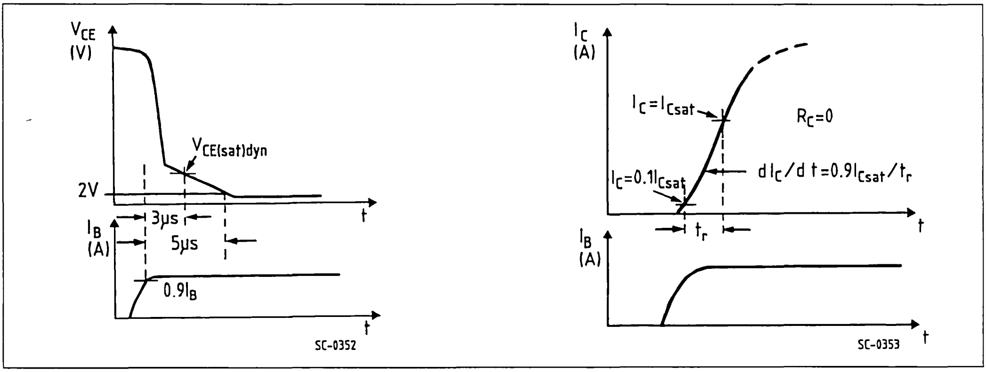


Turn-on Switching Test Circuit

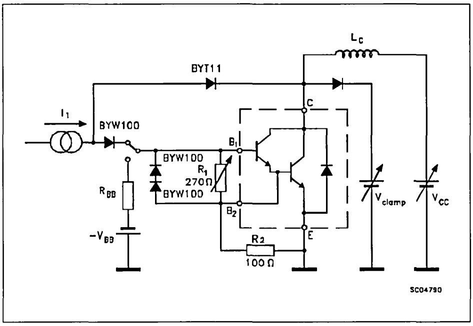


(1) Fast electronic switch (2) Non-inductive load

Turn-on Switching Waveforms

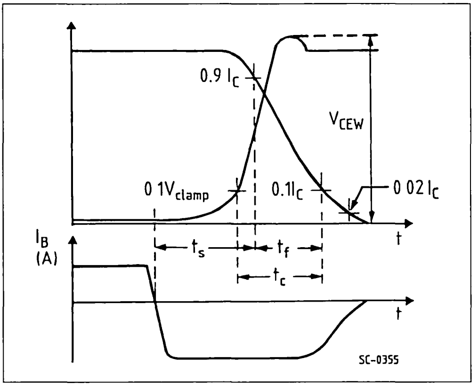


Turn-off Switching Test Circuit

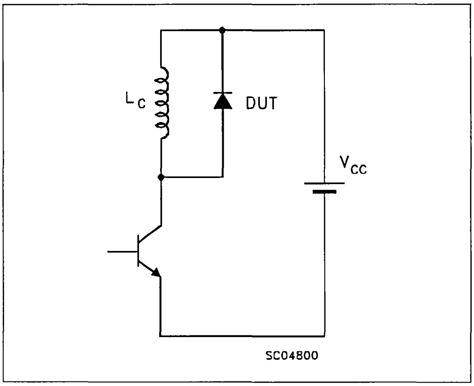


(1) Fast electronic switch (2) Non-inductive load
(3) Fast recovery rectifier

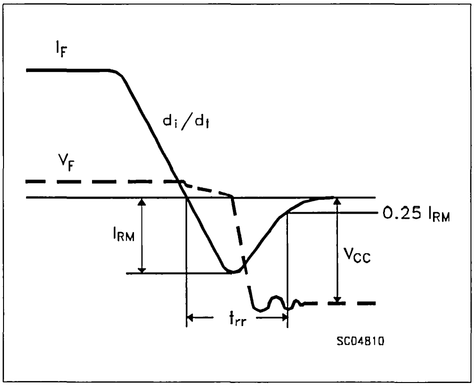
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



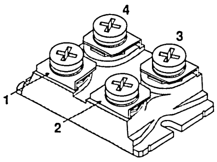
ESM6045AF
ESM6045AV

NPN DARLINGTON POWER MODULE

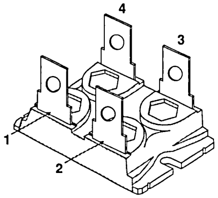
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



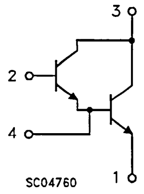
ESM6045AV



ESM6045AF

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	72	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	108	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

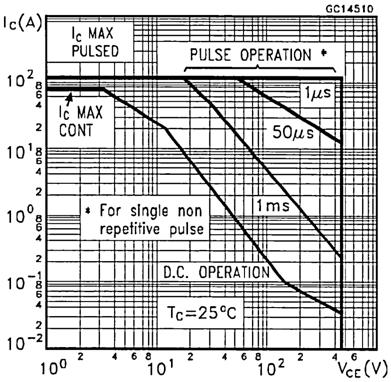
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

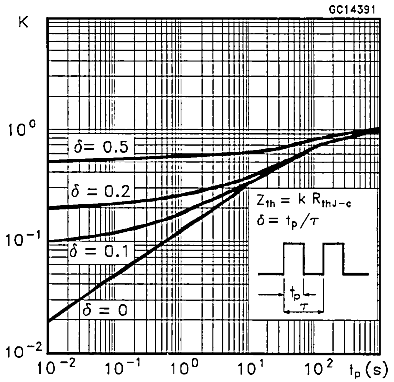
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 22	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 5 V		150		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 60 A I_B = 2.4 A I_C = 60 A I_B = 2.4 A T_j = 100 °C		1.2 1.6 1.3 1.55	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 2.4 A I_C = 60 A I_B = 2.4 A T_j = 100 °C		2.1 2.15	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 3.6 A T_j = 100 °C	450	500		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 3.6 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 3.6 A T_j = 100 °C		2.5	4	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.3 Ω V_{clamp} = 450 V I_{B1} = 2.4 A L = 0.04 mH T_j = 100 °C		4.6 0.4 1.2	6 0.6 2	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 72 A I_{B1} = 2.4 A V_{BB} = -5 V V_{CC} = 50 V L = 35 µH R_{BB} = 0.3 Ω T_j = 125 °C	450			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

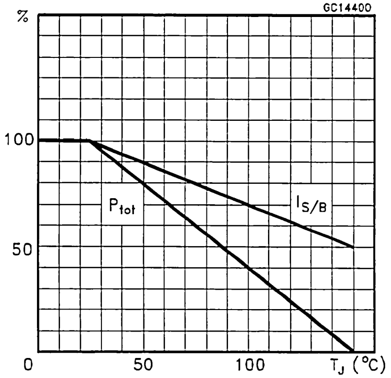
Safe Operating Areas



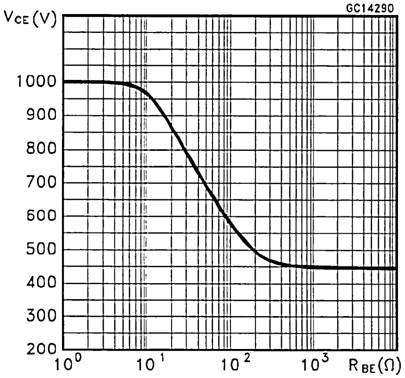
Thermal Impedance



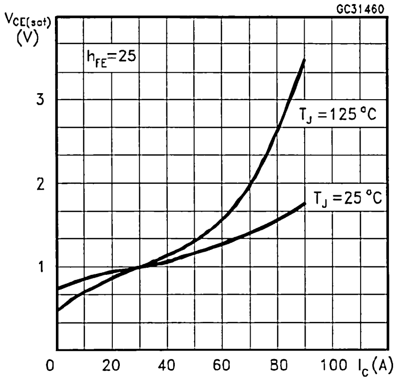
Derating Curve



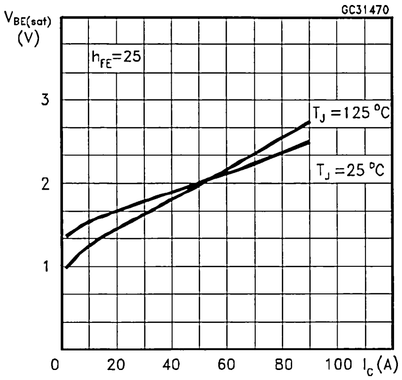
Collector-Emitter Voltage Versus Base-Emitter Resistance



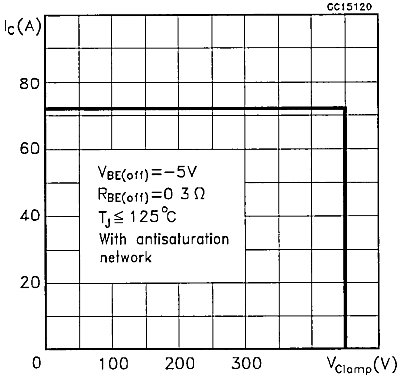
Collector-Emitter Saturation Voltage



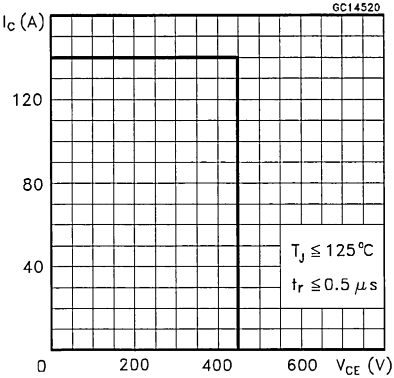
Base-Emitter Saturation Voltage



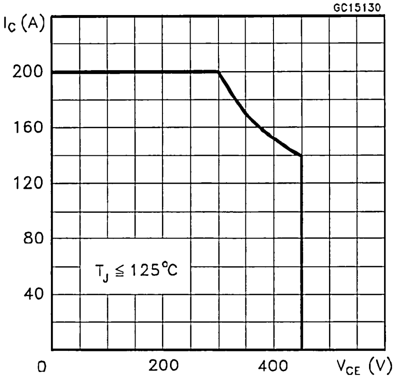
Reverse Biased SOA



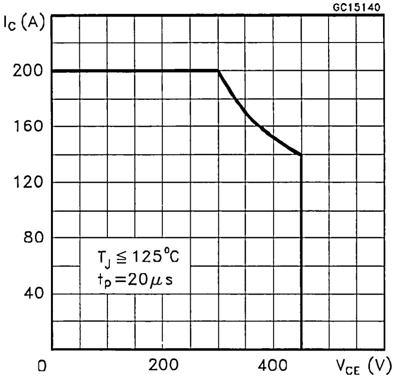
Forward Biased SOA



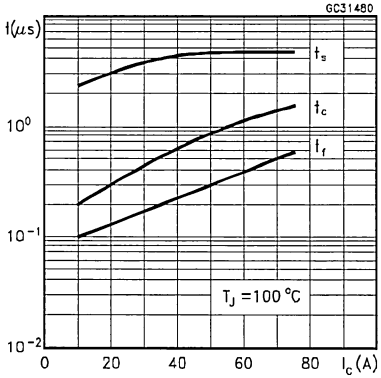
Reverse Biased AOA



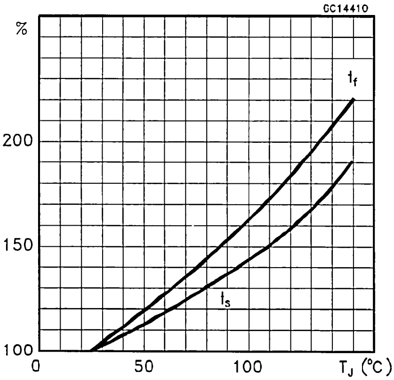
Forward Biased AOA



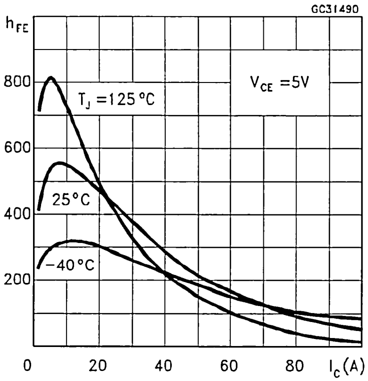
Switching Times Inductive Load



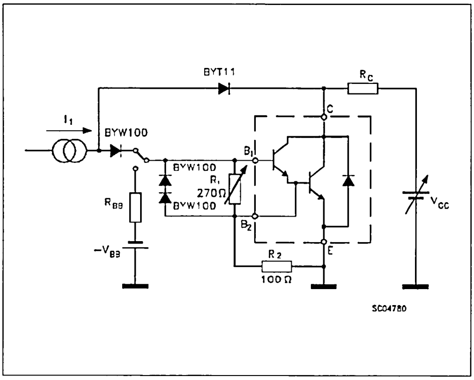
Switching Times Inductive Load Versus Temperature



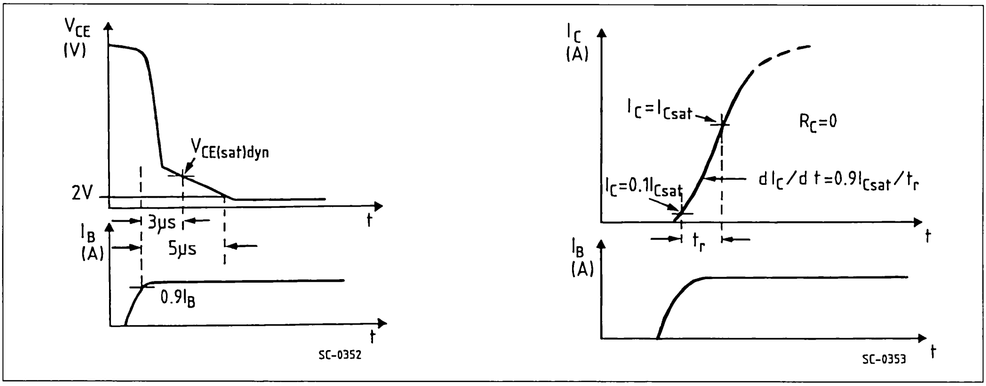
DC Current Gain



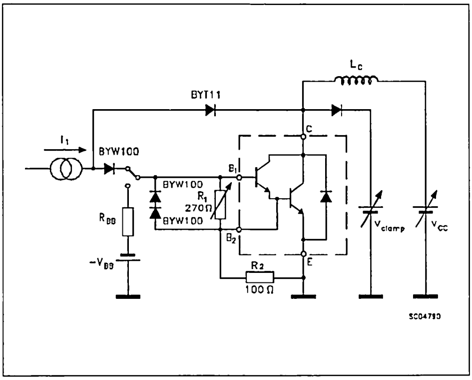
Turn-on Switching Test Circuit



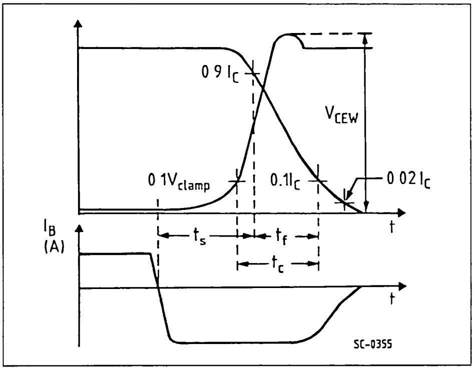
Turn-on Switching Waveforms



Turn-off Switching Test Circuit



Turn-off Switching Waveforms



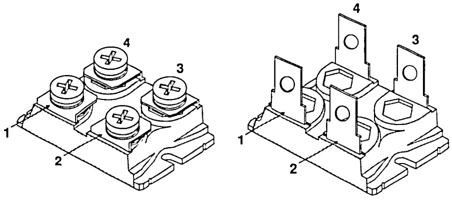
SGS-THOMSON
MICROELECTRONICS

ESM6045DF
ESM6045DV

NPN DARLINGTON POWER MODULE

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

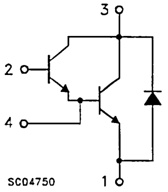
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- DC/DC & DC/AC CONVERTERS
- WELDING EQUIPMENT



ESM6045DV **ESM6045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	84	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	126	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.5	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1.5 22	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 70 A V_{CE} = 5 V		120		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 70 A I_B = 4 A I_C = 70 A I_B = 4 A T_j = 100 °C		1.2 1.6 1.35 1.7	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 70 A I_B = 4 A I_C = 70 A I_B = 4 A T_j = 100 °C		2.3 2.4	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 1.5 A T_j = 100 °C	375	450		A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 1.5 A T_j = 100 °C		6	9	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 1.5 A T_j = 100 °C		3	4.5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 50 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.3 Ω V_{clamp} = 450 V I_{B1} = 1 A L = 0.05 mH T_j = 100 °C		3.5 0.3 0.8	5.5 0.5 1.7	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 84 A I_{B1} = 4 A V_{BB} = -5 V V_{CC} = 50 V L = 0.03 mH R_{BB} = 0.3 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 70 A T_j = 100 °C		1.6	1.9	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 70 A di_F/dt = -375 A/µs L < 0.05 µH T_j = 100 °C		38	45	A

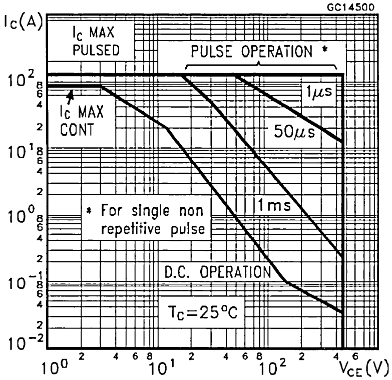
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

\# See test circuits in databook introduction

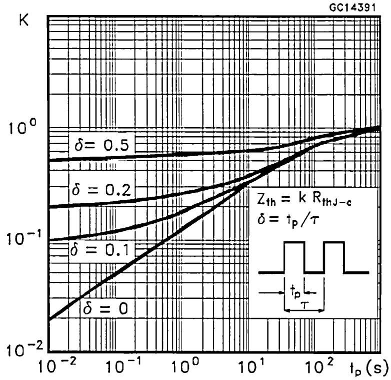
To evaluate the conduction losses of the diode use the following equations:

$V_F = 1.5 + 0.0055\ I_F$ $P = 1.5\ I_{F(AV)} + 0.0055\ I^2_{F(RMS)}$

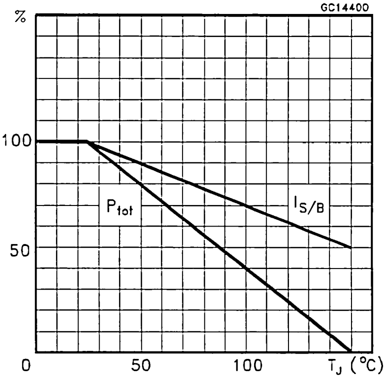
Safe Operating Areas



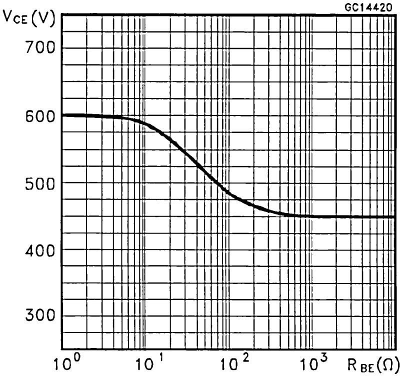
Thermal Impedance



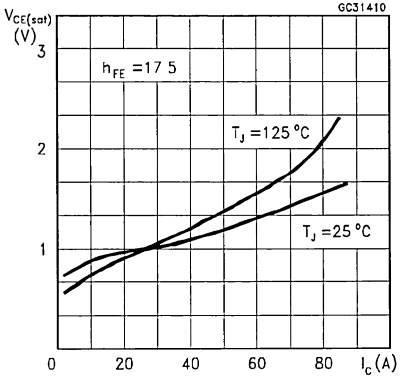
Derating Curve



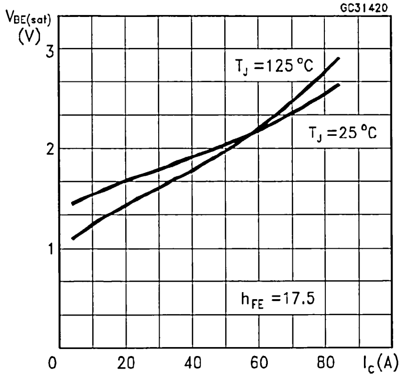
Collector-Emitter Voltage Versus Base-Emitter Resistance



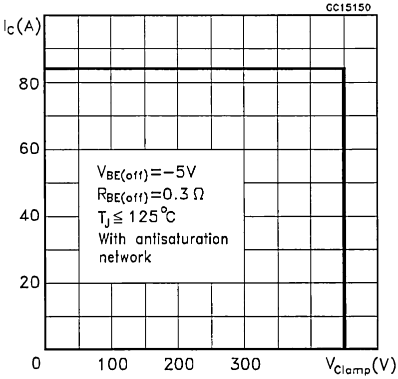
Collector-Emitter Saturation Voltage



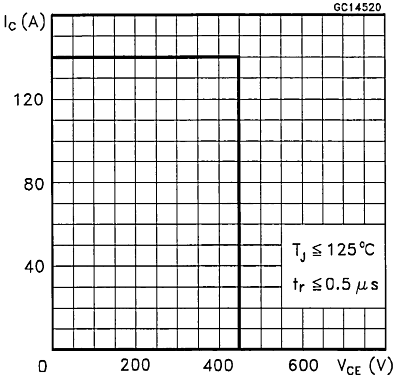
Base-Emitter Saturation Voltage



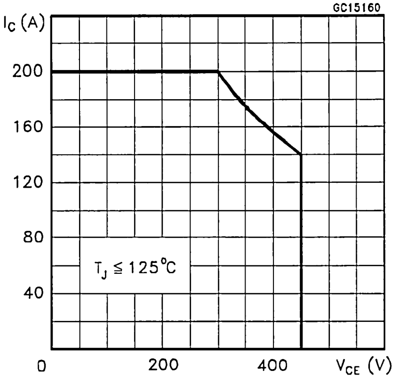
Reverse Biased SOA



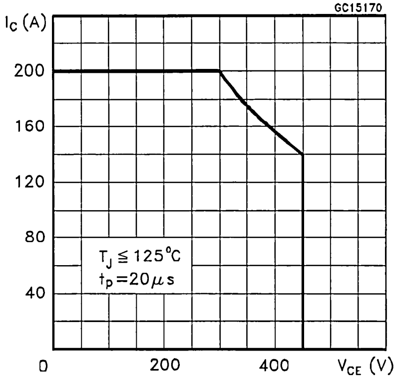
Forward Biased SOA



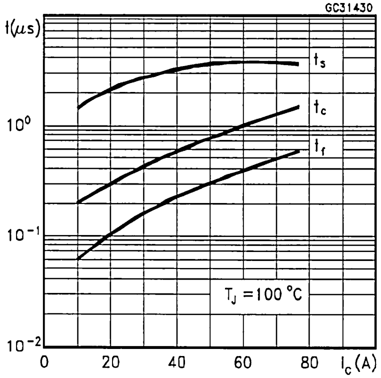
Reverse Biased AOA



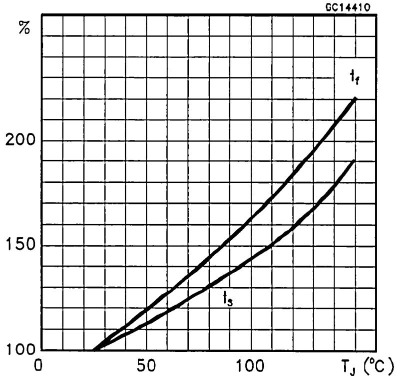
Forward Biased AOA



Switching Times Inductive Load

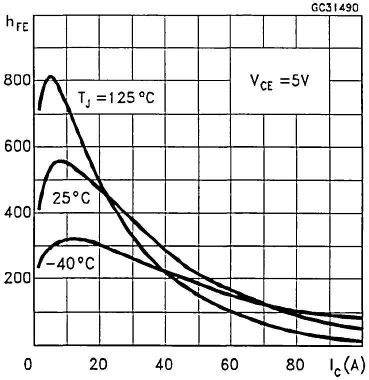


Switching Times Inductive Load Versus Temperature

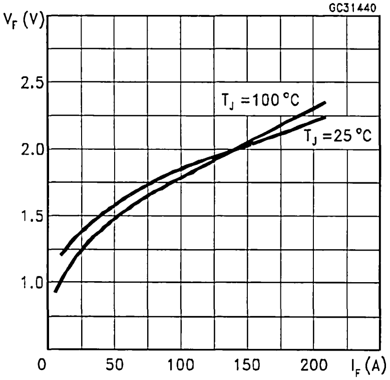


SGS-THOMSON MICROELECTRONICS

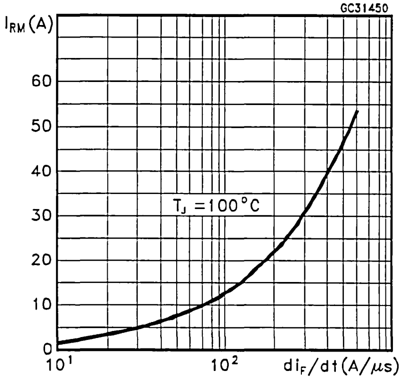
DC Current Gain



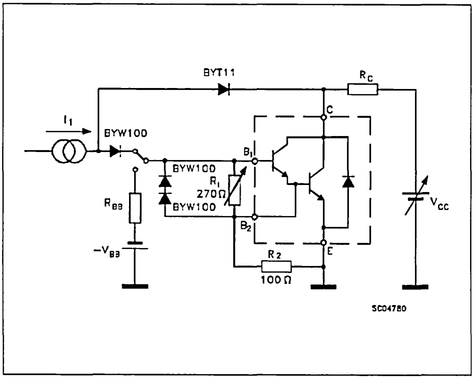
Typical V_F Versus I_F



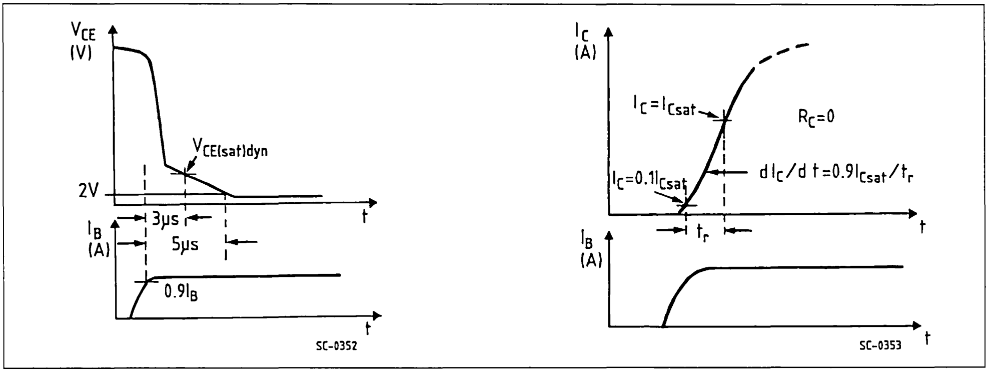
Peak Reverse Current Versus di_F/dt



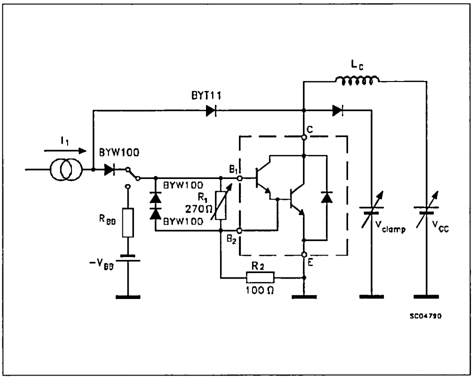
Turn-on Switching Test Circuit



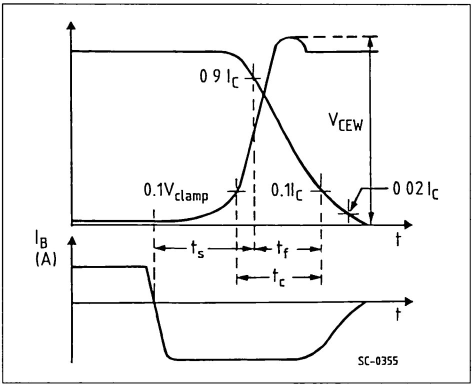
Turn-on Switching Waveforms



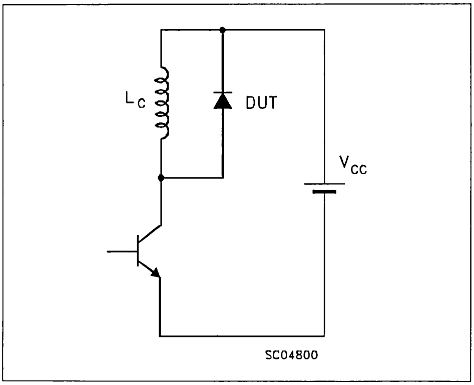
Turn-off Switching Test Circuit



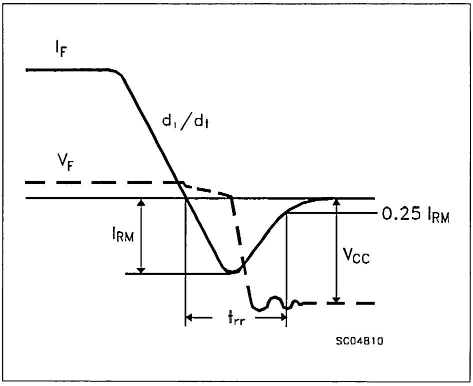
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



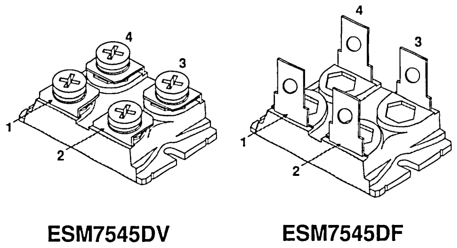
SGS-THOMSON
MICROELECTRONICS

ESM7545DF
ESM7545DV

NPN DARLINGTON POWER MODULE

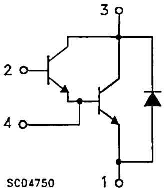
- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	75	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	112	A
I_B	Base Current	5	A
I_{BM}	Base Peak Current (t_p = 10 ms)	7	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.5	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			2 25	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			2 25	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			200	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 75 A V_{CE} = 5 V		500		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 75 A I_B = 1.5 A I_C = 75 A I_B = 1.5 A T_j = 100 °C		1.3 1.5 1.5 2.5	 2.7 5	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 75 A I_B = 1.5 A I_C = 75 A I_B = 1.5 A T_j = 100 $_o$C		2 1.9 2.3 2.4	 2.6 3.8	V V V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 1.5 A T_j = 100 °C	300			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 4 Ω I_{B1} = 1.5 A T_j = 100 °C		6	9	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 4 Ω I_{B1} = 1.5A T_j = 100 °C		3.6	6	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 75 A V_{CC} = 50 V I_{B1} = 1.5 A I_{B2} = -4 A V_{clamp} = 400 V R_{BB} = 0.3 Ω L = 50 µH T_j = 100 °C		5 0.8	8 1.5	µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 75 A I_{B1} = 1.5 A V_{CC} = 50 V I_{B2} = -4 A L = 50 µH R_{BB} = 0.3 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 75 A T_j = 100 °C			2	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 30 A di_F/dt = 375 A/µs L < 50 nH T_j = 100 °C			45	A

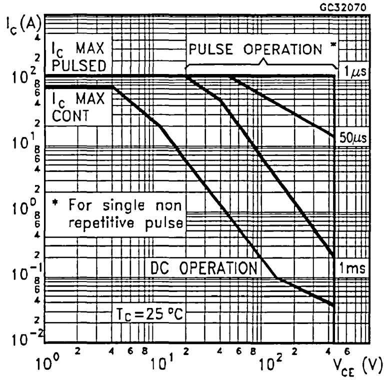
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

To evaluate the conduction losses of the diode use the following equations:

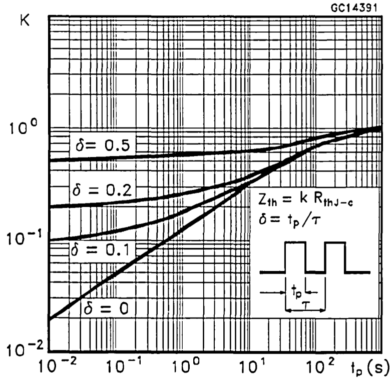
$V_F = 0.66 + 0.0034\ I_F$ $P = 0.66\ I_{F(AV)} + 0.0034\ I^2_{F(RMS)}$

See test circuits in databook introduction

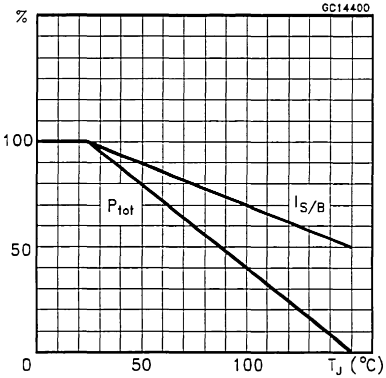
Safe Operating Areas



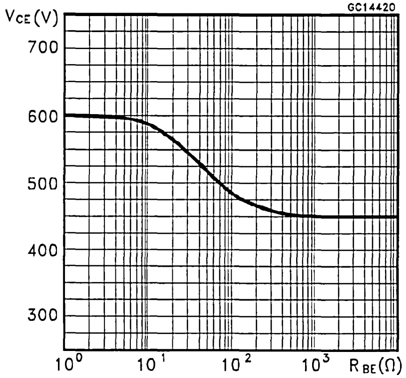
Thermal Impedance



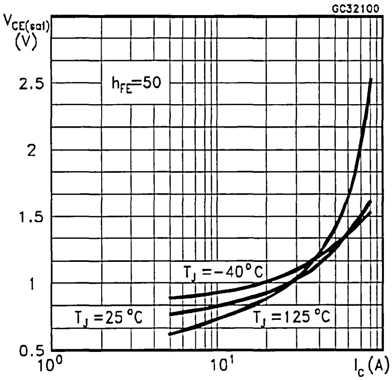
Derating Curve



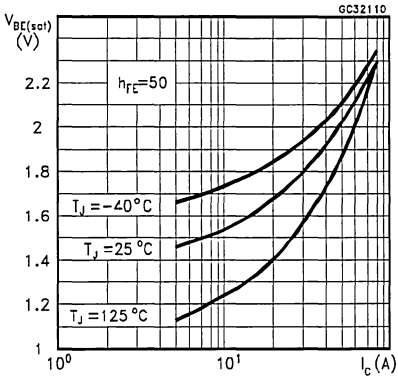
Collector-Emitter Voltage Versus Base-Emitter Resistance



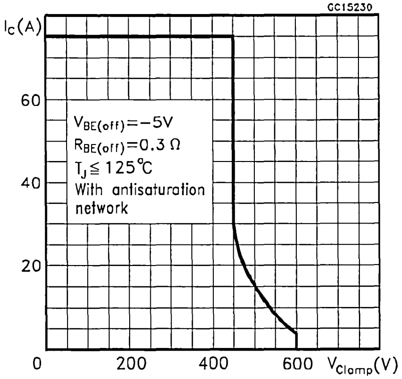
Collector-Emitter Saturation Voltage



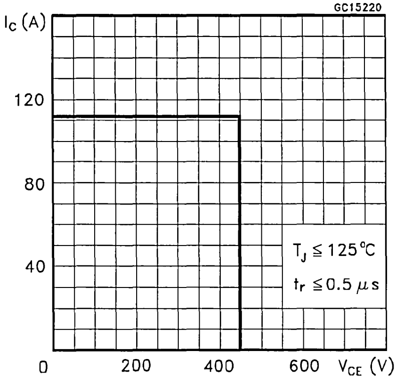
Base-Emitter Saturation Voltage



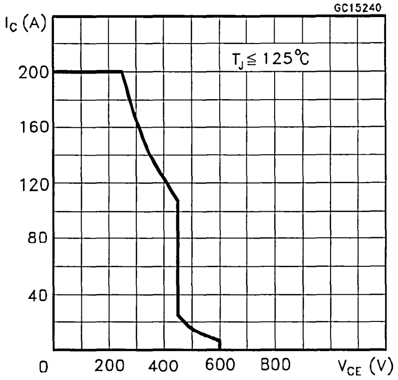
Reverse Biased SOA



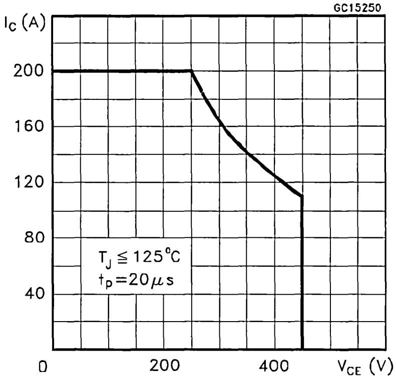
Forward Biased SOA



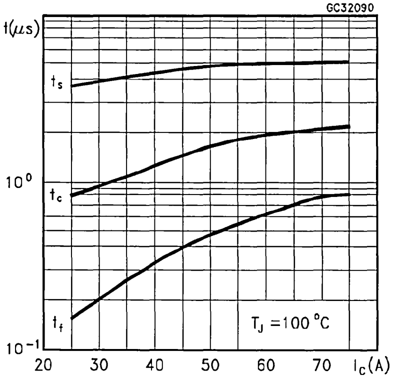
Reverse Biased AOA



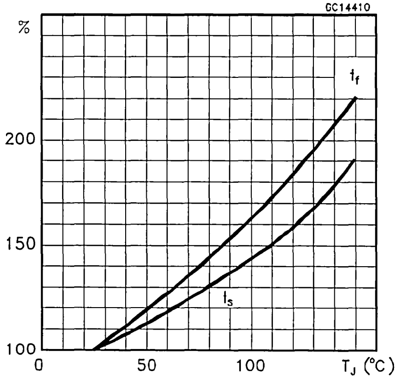
Forward Biased AOA



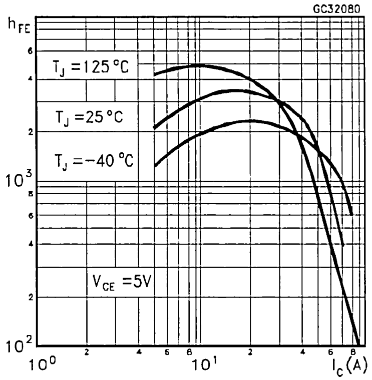
Switching Times Inductive Load



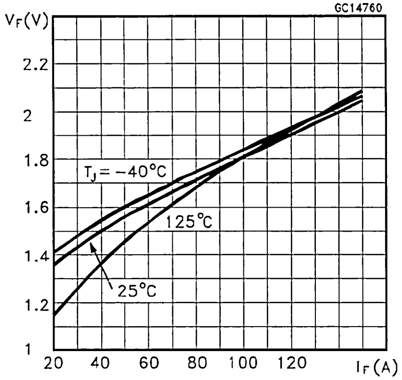
Switching Times Inductive Load Versus Temperature



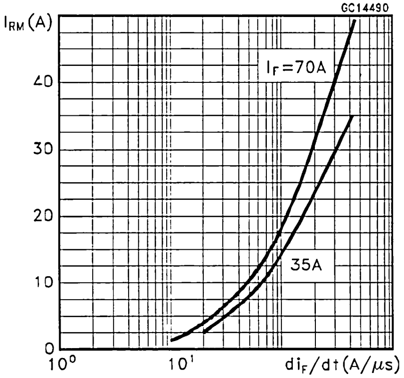
DC Current Gain



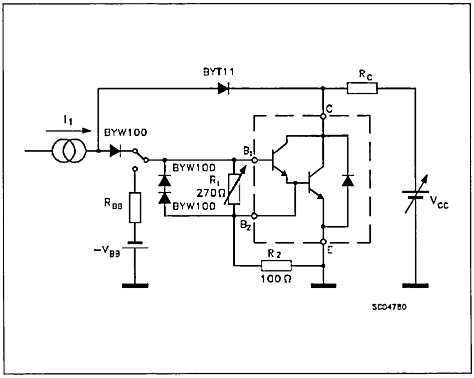
Typical V_F Versus I_F



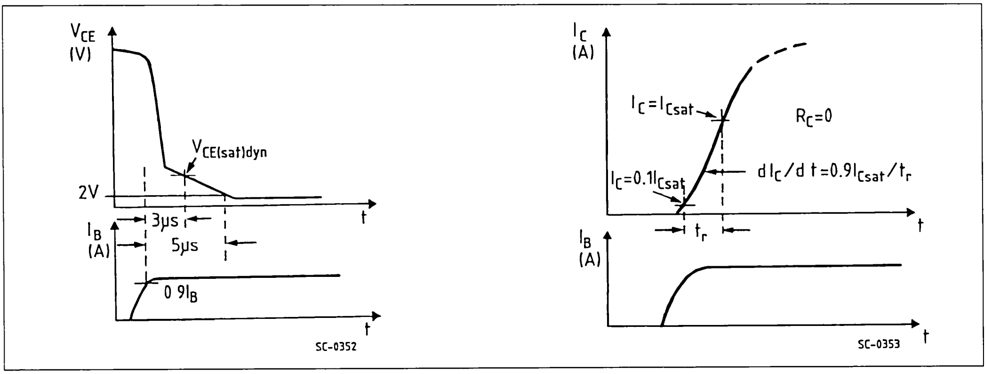
Peak Reverse Current Versus di_F/dt



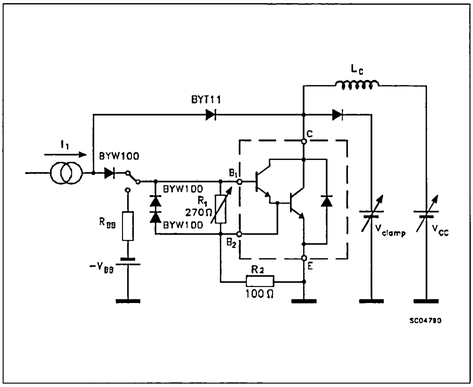
Turn-on Switching Test Circuit



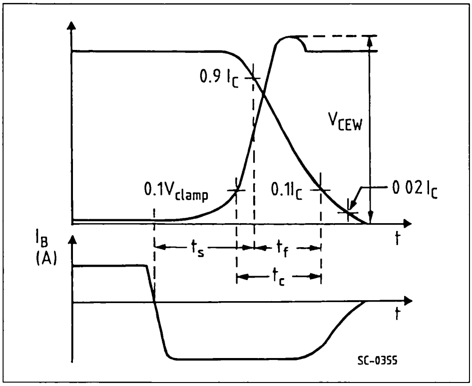
Turn-on Switching Waveforms



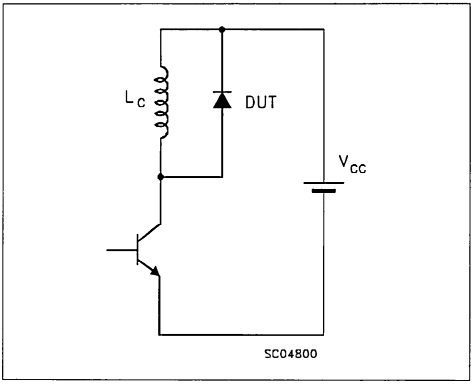
Turn-off Switching Test Circuit



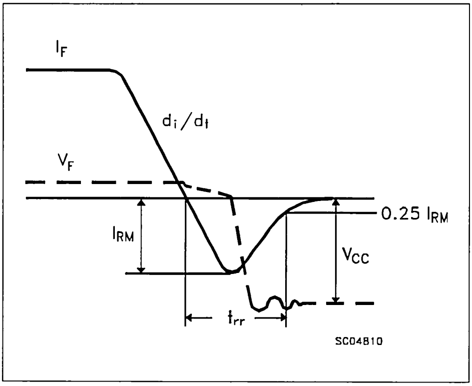
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

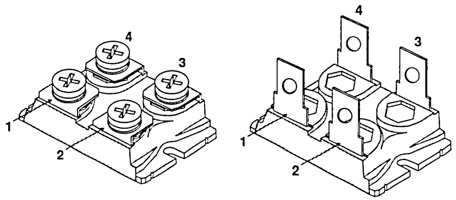
ESMT5070DF
ESMT5070DV

NPN THREE STAGE DARLINGTON POWER MODULE

ADVANCE DATA

- HIGH CURRENT POWER BIPOLAR MODULE
- VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

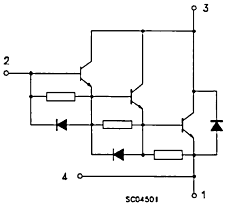
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



ESMT5070DV **ESMT5070DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	700	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	75	A
I_B	Base Current	5	A
I_{BM}	Base Peak Current (t_p = 10 ms)	7	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor) Max	0.41	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER}	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			2 25	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			2 25	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			200	mA
$V_{CEO(SUS)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 700 V	700			V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 4 V		200		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 0.3 A I_C = 30 A I_B = 0.3 A T_j = 100 °C I_C = 50 A I_B = 0.5 A I_C = 50 A I_B = 0.5A T_j = 100 °C		2.6 2.8 3 10	 3.5 	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 30 A I_B = 0.3 A I_C = 30 A I_B = 0.3 A T_j = 100 °C I_C = 50 A I_B = 0.5 A I_C = 50 A I_B = 0.5 A T_j = 100 $_{o}$C		2.6 2.8 2.9 3.1	 3.2 4	V V V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 0.5 A T_j = 100 °C	300			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 0.75 A T_j = 100 °C			10	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 0.75 A T_j = 100 °C			5	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 50 A V_{CC} = 50 V I_{B1} = 0.5 A I_{B2} = -0.5 A R_{BB} = 10 Ω V_{clamp} = 400 V L = 40 µH T_j = 100 °C		14 1.5 5.5		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 50 A V_{CC} = 50 V I_{B1} = 0.5 A I_{B2} = -0.5 A L = 40 µH R_{BB} = 10 Ω T_j = 125 °C	600			V
V_F*	Diode Forward Voltage	I_F = 50 A T_j = 100 °C			2	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 35 A di_F/dt = 200 A/µs L < 50 nH T_j = 100 °C			24	A

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

To evaluate the conduction losses of the diode use the following equations.

$V_F = 1.1 + 0.006\ I_F$ $P = 1.1\ I_{F(AV)} + 0.006\ I^2_{F(RMS)}$

SGS-THOMSON
MICROELECTRONICS

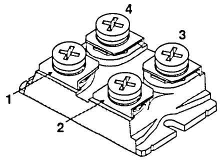
STF4045AF
STF4045AV

NPN DARLINGTON POWER MODULE

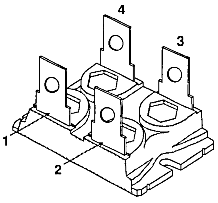
- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



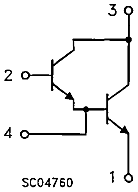
STF4045AV



STF4045AF

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	36	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	54	A
I_B	Base Current	4	A
I_{BM}	Base Peak Current (t_p = 10 ms)	8	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

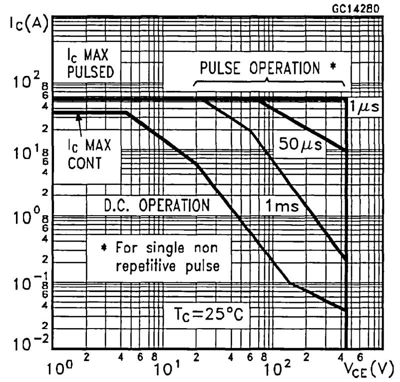
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.83	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

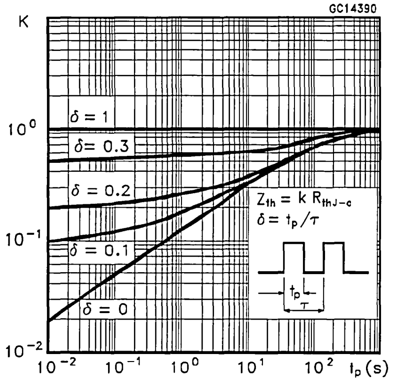
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 2	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 2	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 5 V		300		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 0.5 A I_C = 25 A I_B = 0.5 A T_j = 100 °C I_C = 30 A I_B = 1.2 A I_C = 30 A I_B = 1.2 A T_j = 100 °C		1.2 1.3 1.3 1.45	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 30 A I_B = 1.2 A I_C = 30 A I_B = 1.2 A T_j = 100 °C		2.1 2.1	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 1.8 A T_j = 100 °C	240			A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 1.8 A T_j = 100 °C		3	5	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 1.8 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 1.2 A L = 80 μH T_j = 100 °C		3.6 0.16 0.7	5 0.3 1.4	μs μs μs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 30 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 1.2 A L = 80 μH T_j = 100 °C		5.4 0.35 1.4		μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 36 A I_{B1} = 1.2 A V_{BB} = -5 V V_{CC} = 50 V L = 70 μH R_{BB} = 0.6 Ω T_j = 125 °C	400			V

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
# See test circuits in databook introduction

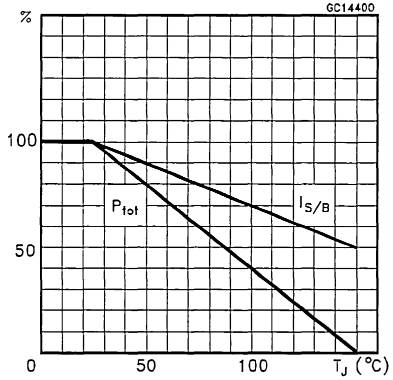
Safe Operating Areas



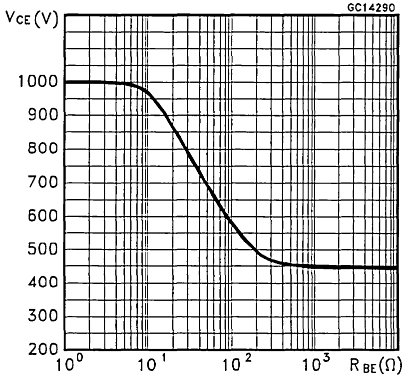
Thermal Impedance



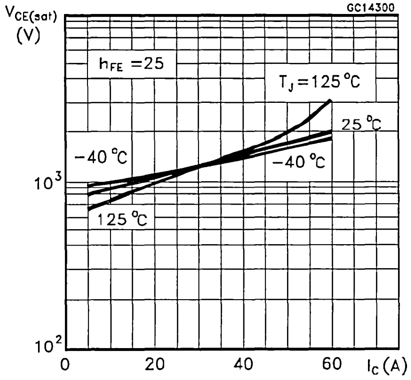
Derating Curve



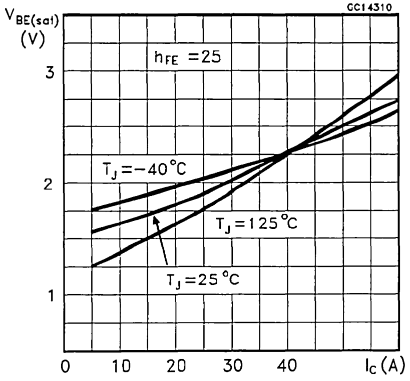
Collector-Emitter Voltage Versus Base-Emitter Resistance



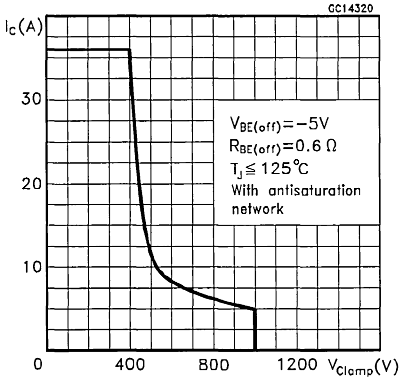
Collector-Emitter Saturation Voltage



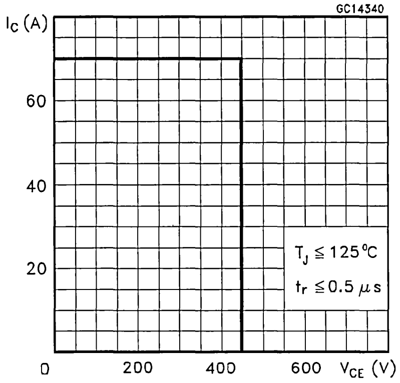
Base-Emitter Saturation Voltage



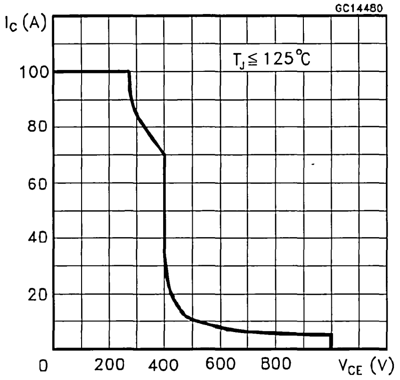
Reverse Biased SOA



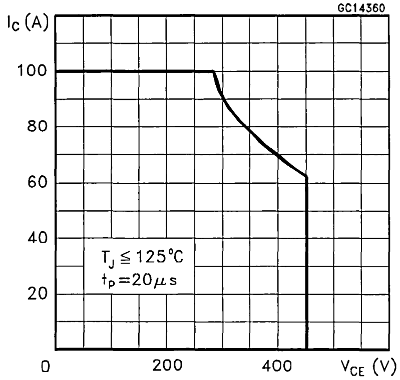
Forward Biased SOA



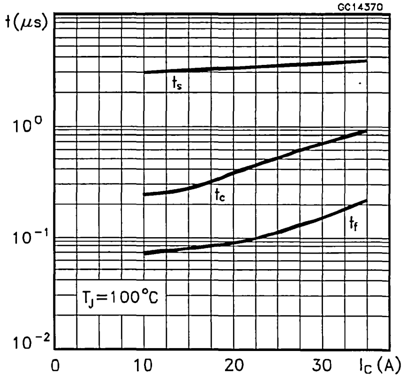
Reverse Biased AOA



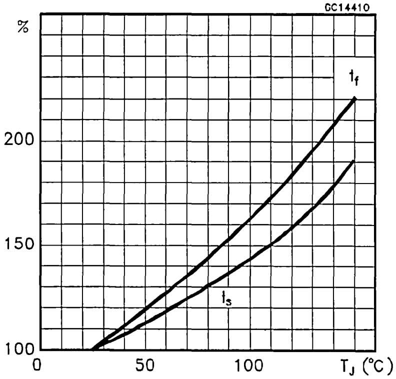
Forward Biased AOA



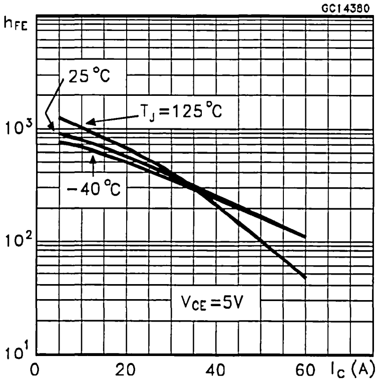
Switching Times Inductive Load



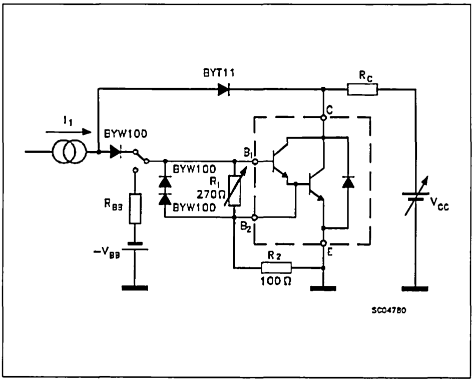
Switching Times Inductive Load Versus Temperature



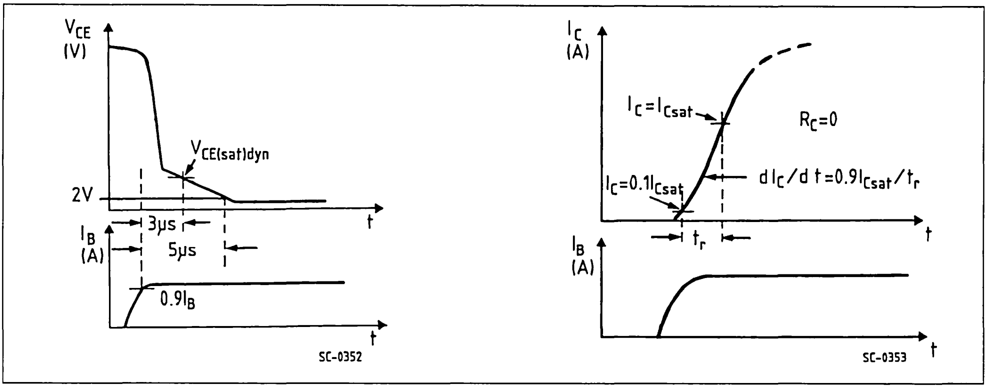
DC Current Gain



Turn-on Switching Test Circuit

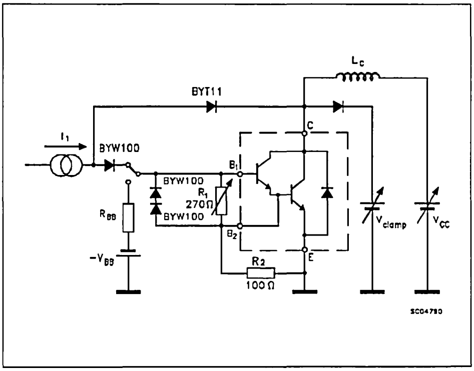


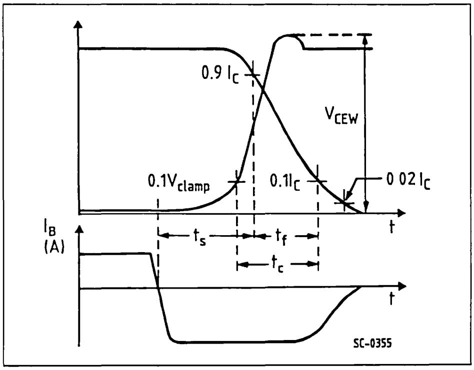
Turn-on Switching Waveforms



Turn-off Switching Test Circuit

Turn-off Switching Waveforms





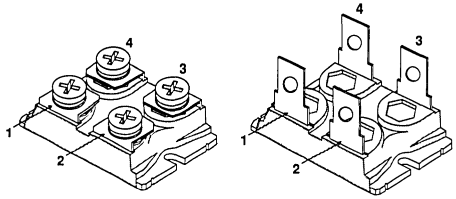
STF4045DF
STF4045DV

NPN DARLINGTON POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

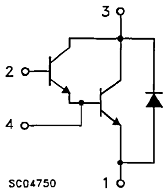
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



STF4045DV **STF4045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	42	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	63	A
I_B	Base Current	4	A
I_{BM}	Base Peak Current (t_p = 10 ms)	8	A
P_{tot}	Total Dissipation at T_c = 25 °C	150	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.83	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 7	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 7	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 35 A V_{CE} = 5 V		300		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 0.5 A I_C = 25 A I_B = 0.5 A T_j = 100 °C I_C = 35 A I_B = 2 A I_C = 35 A I_B = 2 A T_j = 100 °C		1.2 1.3 1.4 1.4	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 35 A I_B = 2 A I_C = 35 A I_B = 2 A T_j = 100 °C		2.3 2.3	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 0.75 A T_j = 100 °C	200			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 0.75 A T_j = 100 °C		2	4	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 12 Ω I_{B1} = 0.75 A T_j = 100 °C		1.6	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 25 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.5 A L = 0.1 mH T_j = 100 °C		3 0.1 0.3	4.5 0.3 1	µs µs µs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 25 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.6 Ω V_{clamp} = 450 V I_{B1} = 0.5 A L = 0.1 mH T_j = 100 °C		5.4 0.22 0.6		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 42 A I_{B1} = 2 A V_{BB} = -5 V V_{CC} = 50 V L = 60 µH R_{BB} = 0.6 Ω T_j = 125 °C	400			V
V_F*	Diode Forward Voltage	I_F = 35 A T_j = 100 °C			1.85	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 35 A di_F/dt = -200 A/µs L < 0.05 µH T_j = 100 °C			24	A

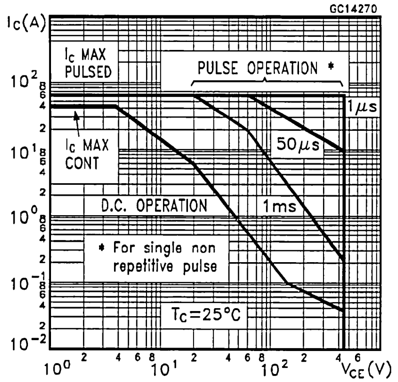
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

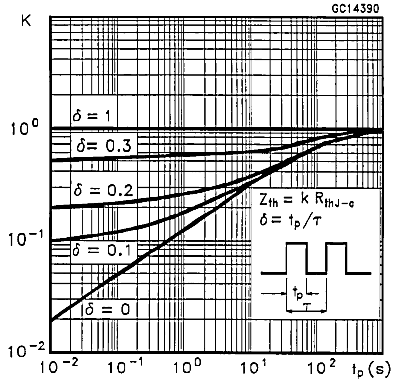
To evaluate the conduction losses of the diode use the following equations:

$V_F = 1.1 + 0.007\ I_F$ $\quad P = 1.1\ I_{F(AV)} + 0.007\ I^2_{F(RMS)}$

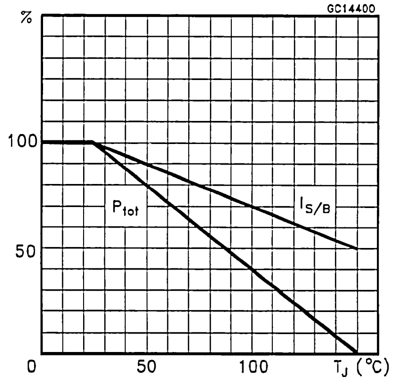
Safe Operating Areas



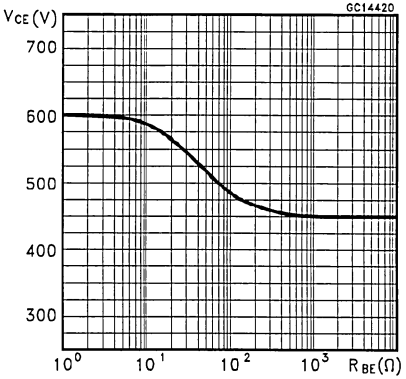
Thermal Impedance



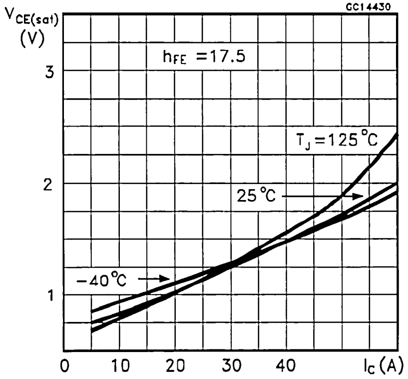
Derating Curve



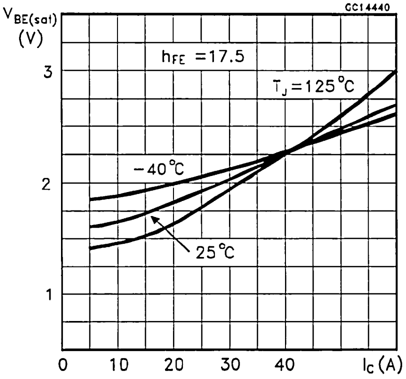
Collector-Emitter Voltage Versus Base-Emitter Resistance



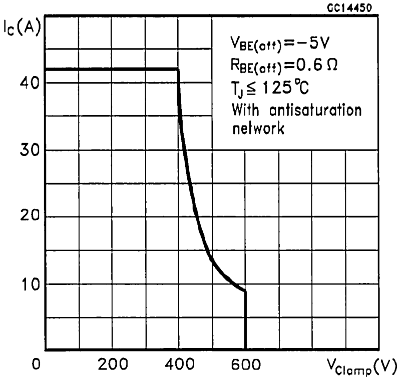
Collector-Emitter Saturation Voltage



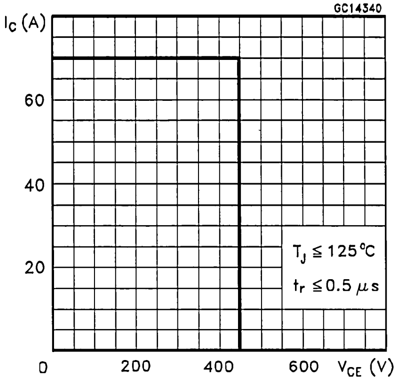
Base-Emitter Saturation Voltage



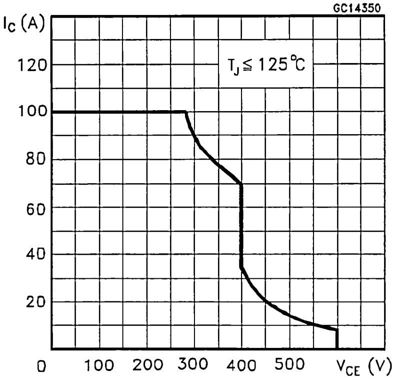
Reverse Biased SOA



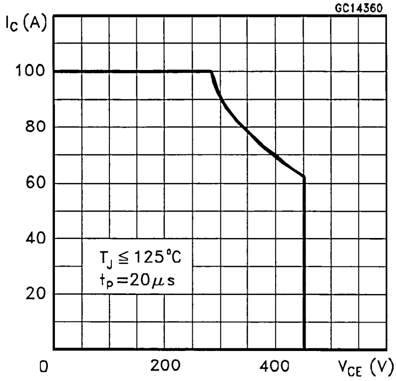
Forward Biased SOA



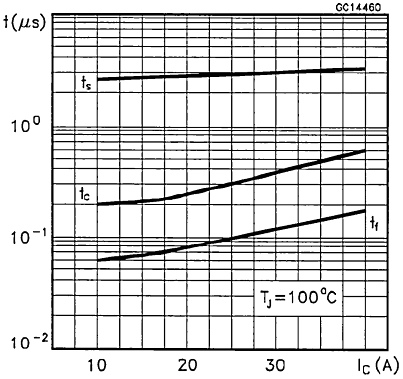
Reverse Biased AOA



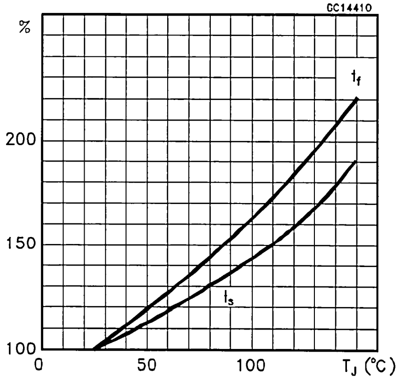
Forward Biased AOA



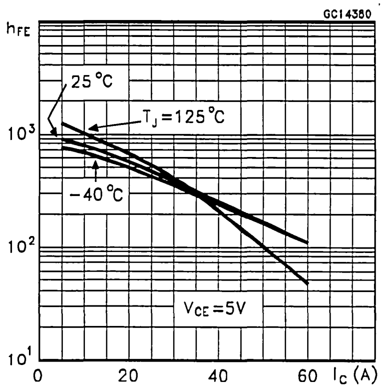
Switching Times Inductive Load



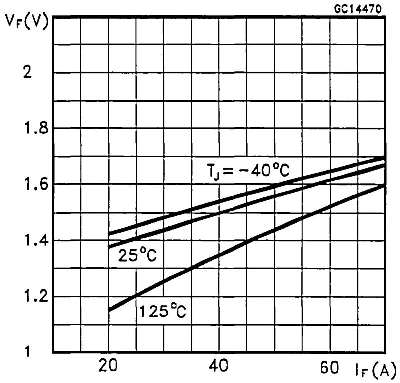
Switching Times Inductive Load Versus Temperature



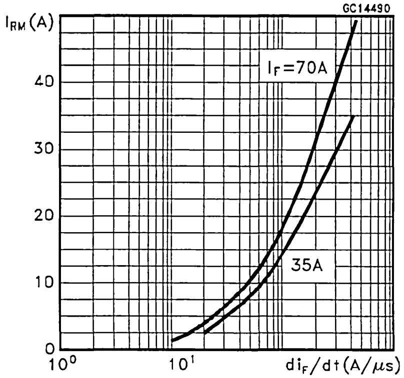
DC Current Gain



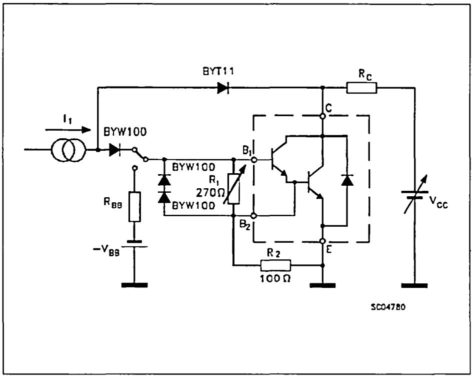
Typical V_F Versus I_F



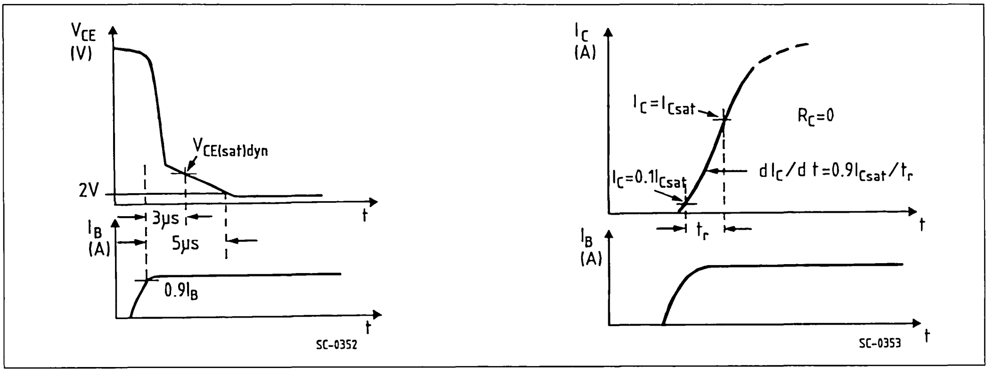
Peak Reverse Current Versus di_F/dt



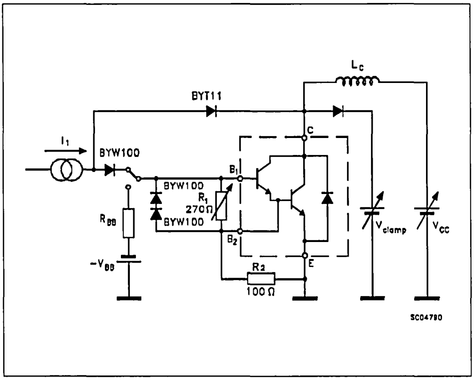
Turn-on Switching Test Circuit



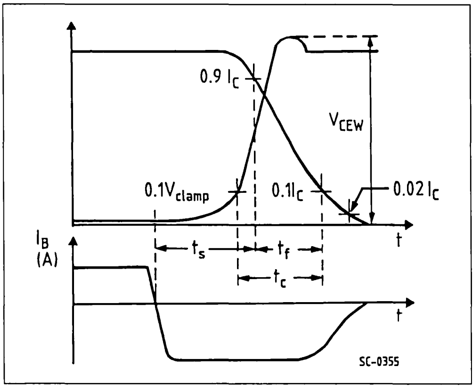
Turn-on Switching Waveforms



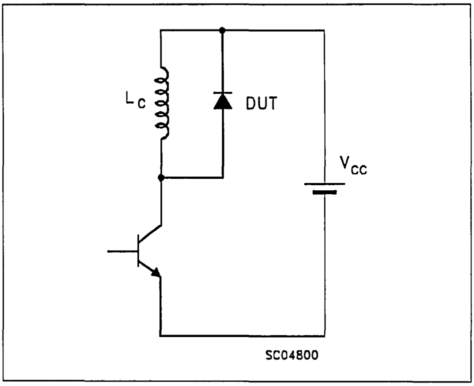
Turn-off Switching Test Circuit



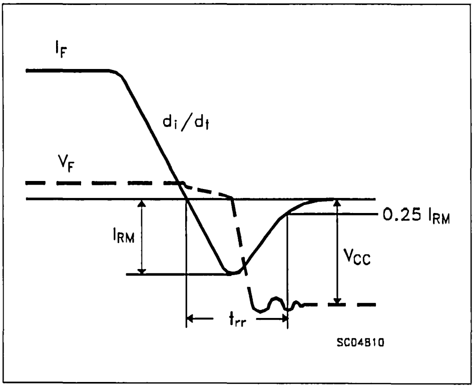
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

STF6045AF
STF6045AV

NPN DARLINGTON POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
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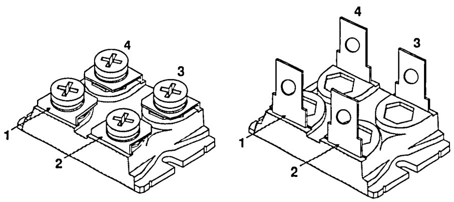
- LOW INTERNAL PARASITIC INDUCTANCE

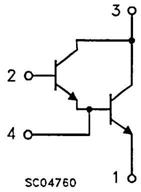
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



STF6045AV **STF6045AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	72	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	108	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

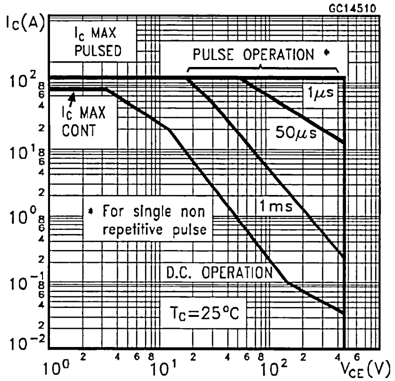
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

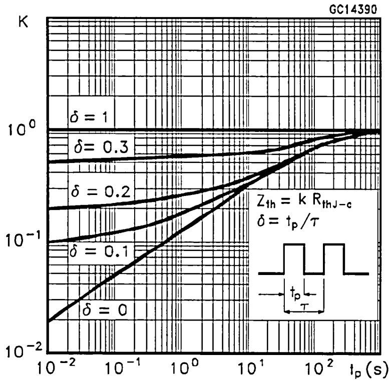
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 5 V		180		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 60 A I_B = 2.4 A I_C = 60 A I_B = 2.4 A T_j = 100 °C		1.2 1.6 1.3 1.55	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 2.4 A I_C = 60 A I_B = 2.4 A T_j = 100 °C		2.1 2.15	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 3.6 A T_j = 100 °C	200			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 3.6 A T_j = 100 °C		2.7	5	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 5 Ω I_{B1} = 3.6 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 2.4 A L = 40 µH T_j = 100 °C		3.5 0.17 0.55	6 0.4 1.4	µs µs µs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 2.4 A L = 40 µH T_j = 100 °C		6 0.44 1.1		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 72 A I_{B1} = 2.4 A V_{BB} = -5 V V_{CC} = 50 V L = 35 µH R_{BB} = 0.3 Ω T_j = 125 °C	400			V

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

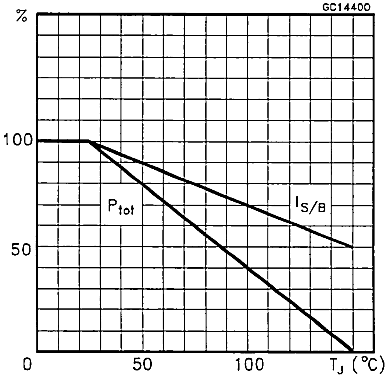
Safe Operating Areas



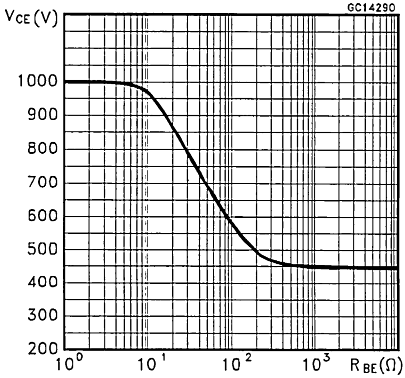
Thermal Impedance



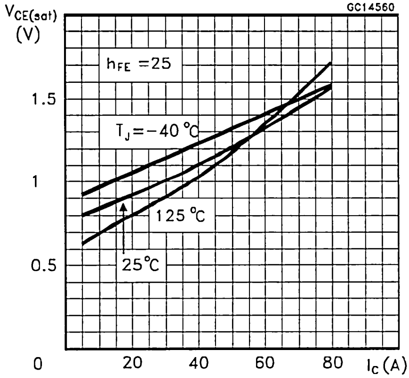
Derating Curve



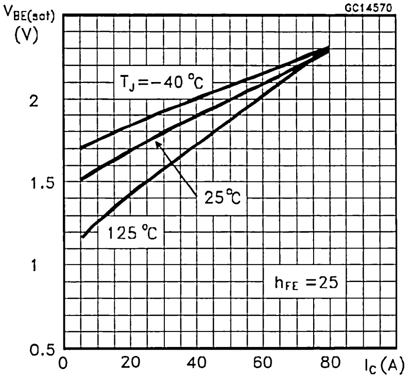
Collector-Emitter Voltage Versus Base-Emitter Resistance



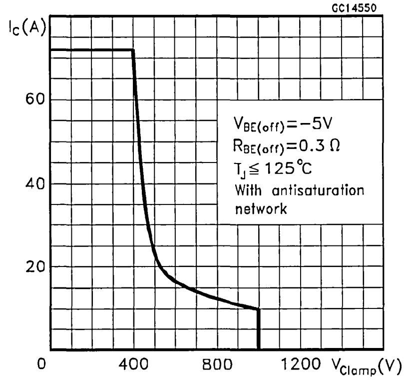
Collector-Emitter Saturation Voltage



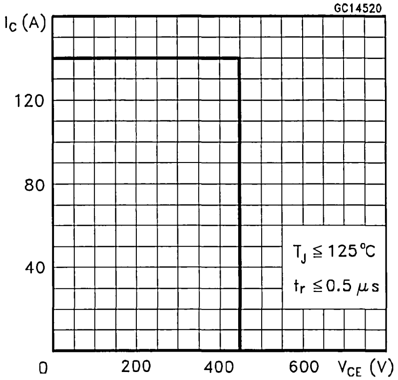
Base-Emitter Saturation Voltage



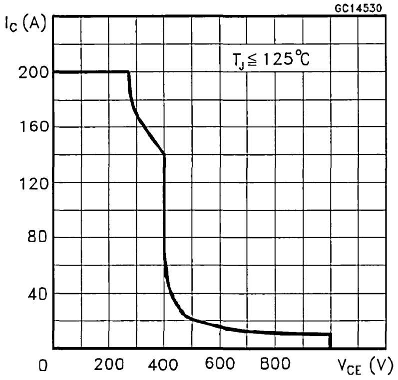
Reverse Biased SOA



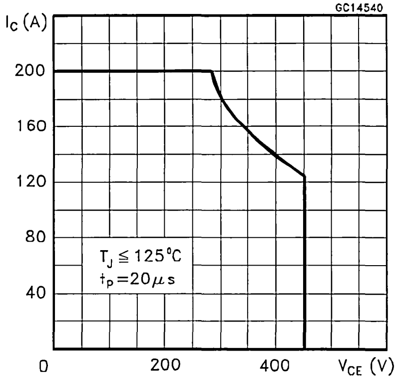
Forward Biased SOA



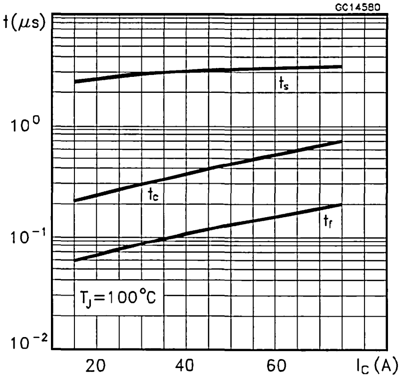
Reverse Biased AOA



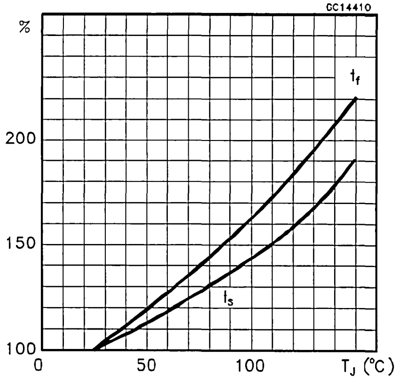
Forward Biased AOA



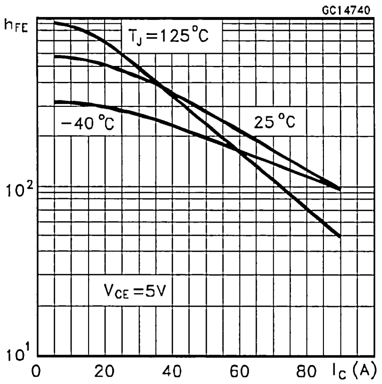
Switching Times Inductive Load



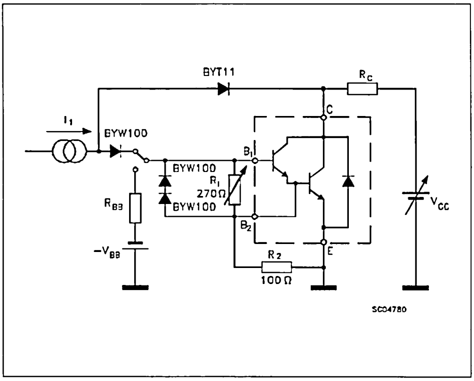
Switching Times Inductive Load Versus Temperature



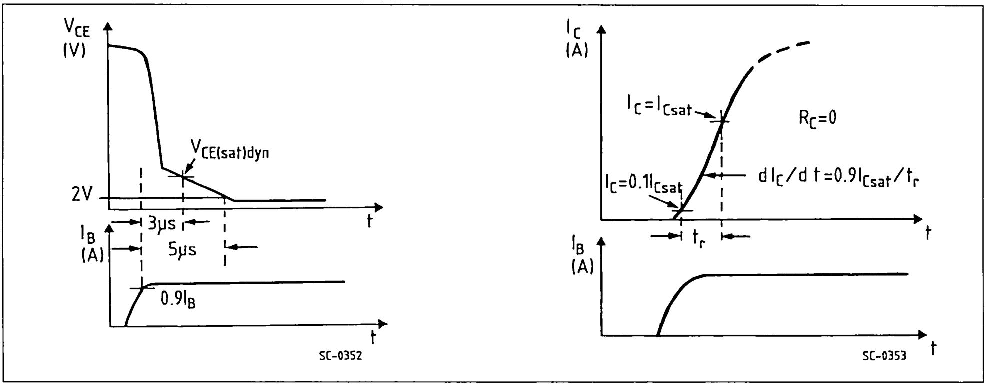
DC Current Gain



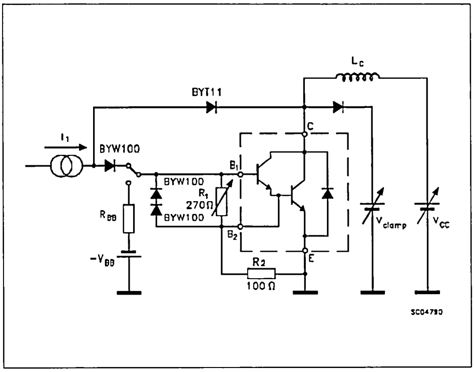
Turn-on Switching Test Circuit



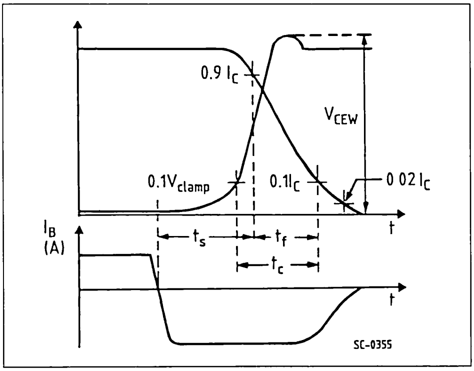
Turn-on Switching Waveforms



Turn-off Switching Test Circuit



Turn-off Switching Waveforms



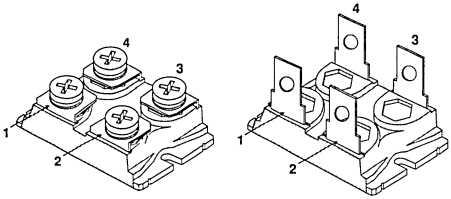
SGS-THOMSON
MICROELECTRONICS

STF6045DF
STF6045DV

NPN DARLINGTON POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

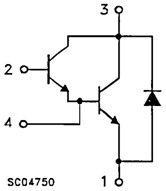
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



STF6045DV **STF6045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	84	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	120	A
I_B	Base Current	8	A
I_{BM}	Base Peak Current (t_p = 10 ms)	16	A
P_{tot}	Total Dissipation at T_c = 25 °C	250	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

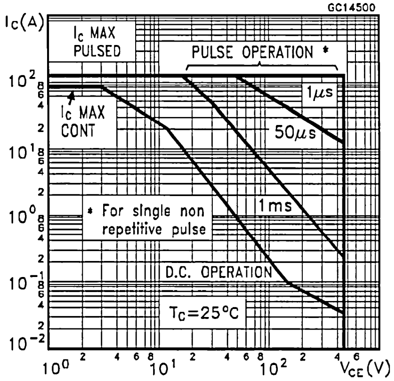
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.5	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.5	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

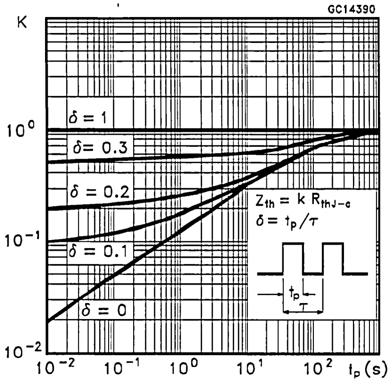
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 70 A V_{CE} = 5 V		160		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 1 A I_C = 50 A I_B = 1 A T_j = 100 °C I_C = 70 A I_B = 4 A I_C = 70 A I_B = 4 A T_j = 100 °C		1.2 1.3 1.4 1.5	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 70 A I_B = 4 A I_C = 70 A I_B = 4 A T_j = 100 °C		2.3 2.3	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 μs I_{B1} = 1.5 A T_j = 100 °C	375			A/μs
V_{CE}(3 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 1.5 A T_j = 100 °C		4	7	V
V_{CE}(5 μs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 6 Ω I_{B1} = 1.5 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 50 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.6 Ω V_{clamp} = 400 V I_{B1} = 1A L = 50 μH T_j = 100 °C		3.2 0.15 0.5	5 0.4 1.2	μs μs μs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 50 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.6 Ω V_{clamp} = 400 V I_{B1} = 1A L = 50 μH T_j = 100 °C		4.8 0.35 1.1		μs μs μs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 80 A I_{B1} = 4 A V_{BB} = -5 V V_{CC} = 50 V L = 30 μH R_{BB} = 0.3 Ω T_j = 125 °C	400			V
V_F*	Diode Forward Voltage	I_F = 70 A T_j = 100 °C			1.9	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 70 A di_F/dt = -375 A/μs L < 0.05 nH T_j = 100 °C			45	A

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
# See test circuits in databook introduction
To evaluate the conduction losses of the diode use the following equations:
$V_F = 1.1 + 0.007\ I_F$ $P = 1.1\ I_{F(AV)} + 0.007\ I^2_{F(RMS)}$

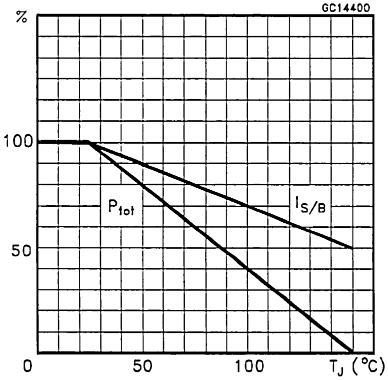
Safe Operating Areas



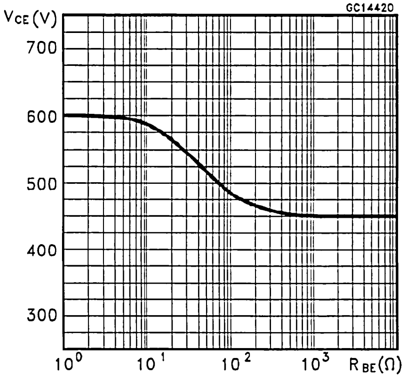
Thermal Impedance



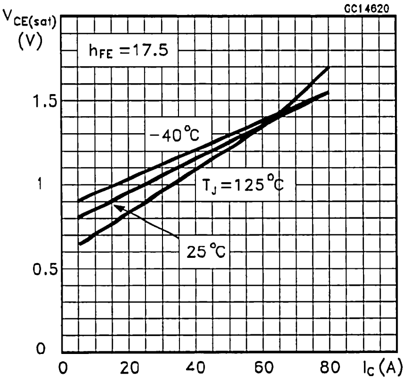
Derating Curve



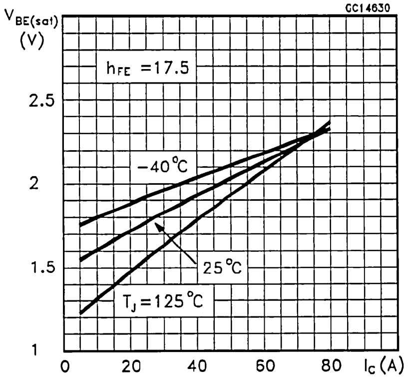
Collector-Emitter Voltage Versus Base-Emitter Resistance



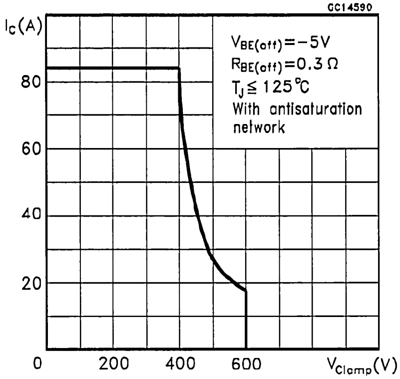
Collector-Emitter Saturation Voltage



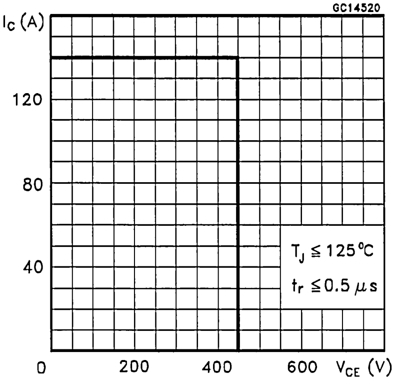
Base-Emitter Saturation Voltage



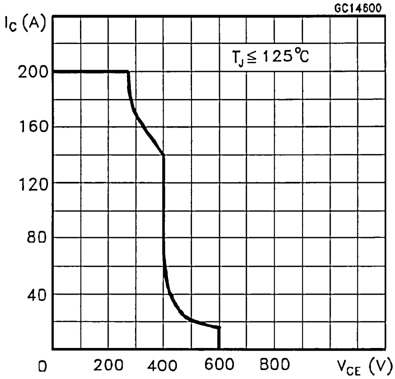
Reverse Biased SOA



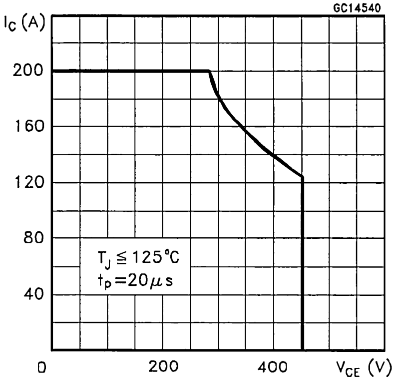
Forward Biased SOA



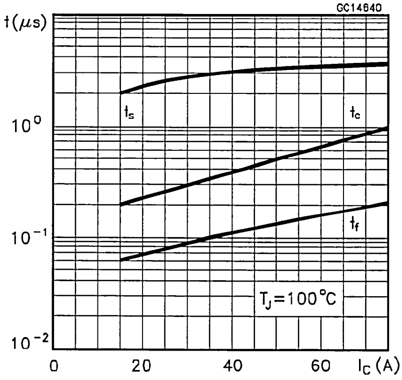
Reverse Biased AOA



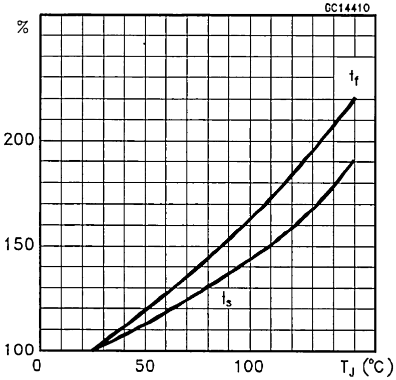
Forward Biased AOA



Switching Times Inductive Load

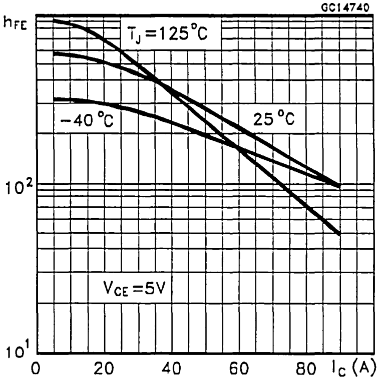


Switching Times Inductive Load Versus Temperature

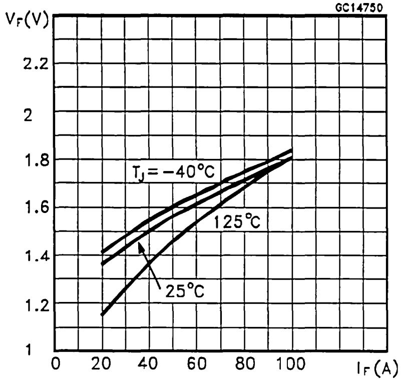


SGS-THOMSON MICROELECTRONICS

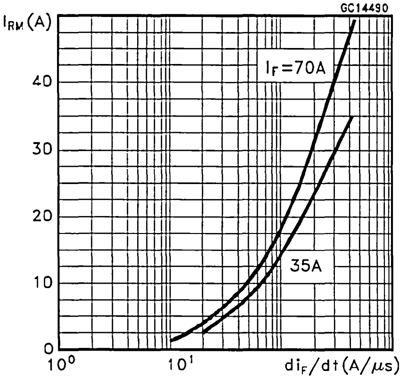
DC Current Gain



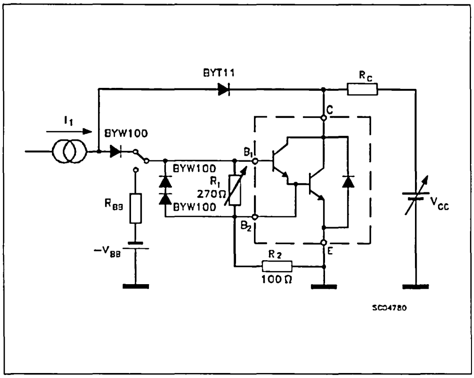
Typical V_F Versus I_F



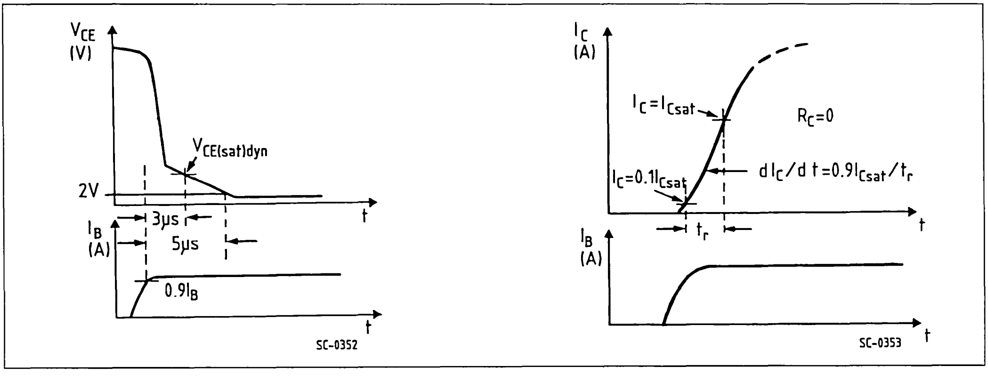
Peak Reverse Current Versus di_F/dt



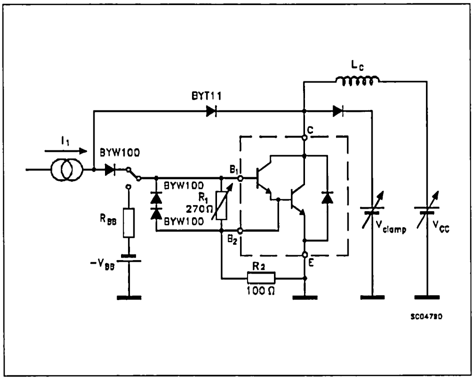
Turn-on Switching Test Circuit



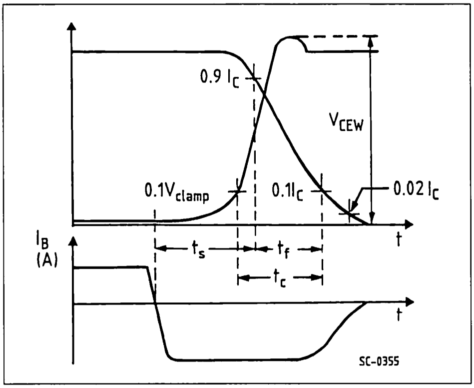
Turn-on Switching Waveforms



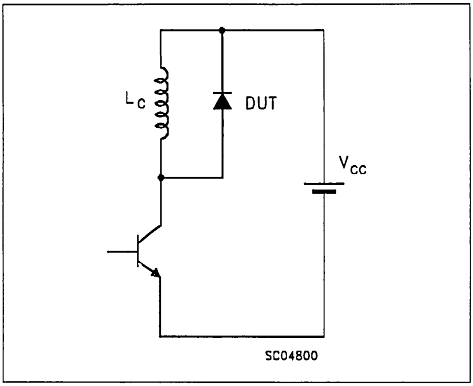
Turn-off Switching Test Circuit



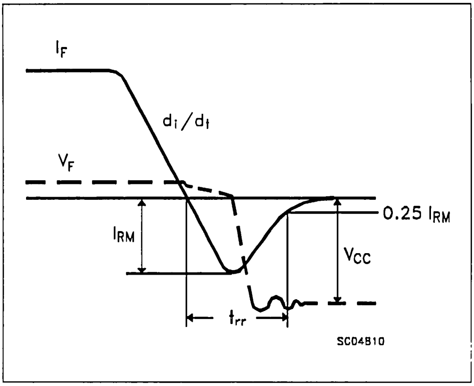
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



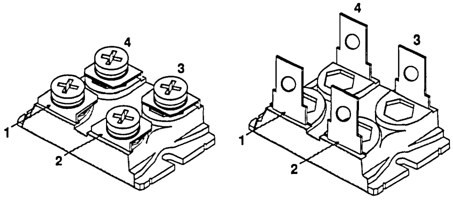
SGS-THOMSON
MICROELECTRONICS

STF8045AF
STF8045AV

NPN DARLINGTON POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

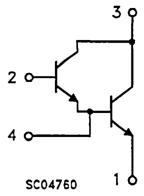
INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



STF8045AV **STF8045AF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	1000	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	100	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	150	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	20	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor) Max	0.45	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

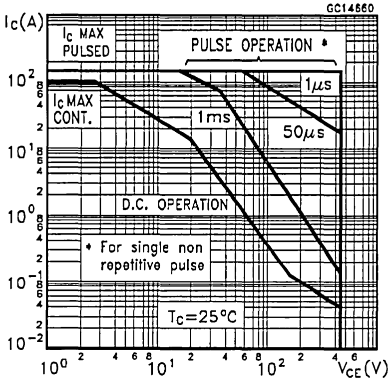
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 5	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 72 A V_{CE} = 5 V		190		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 60 A I_B = 1.2 A I_C = 60 A I_B = 1.2 A T_j = 100 °C I_C = 72 A I_B = 2.9 A I_C = 72 A I_B = 2.9 A T_j = 100 °C		1.5 1.6 1.6 1.7	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 72 A I_B = 2.9 A I_C = 72 A I_B = 2.9 A T_j = 100 °C		2.1 2.2	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 5 A T_j = 100 °C	375			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 3.7 Ω I_{B1} = 5 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 3.7 Ω I_{B1} = 5 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 72 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 3 A L = 50 µH T_j = 100 °C		4.5 0.3 1.2	6 0.6 1.6	µs µs µs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 72 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 3 A L = 50 µH T_j = 100 °C		6.5 0.66 2.4		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 86 A I_{B1} = 3.3 A V_{BB} = -5 V V_{CC} = 50 V L = 35 µH R_{BB} = 0.3 Ω T_j = 125 °C	400			V

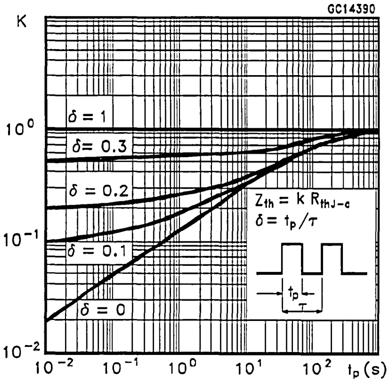
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

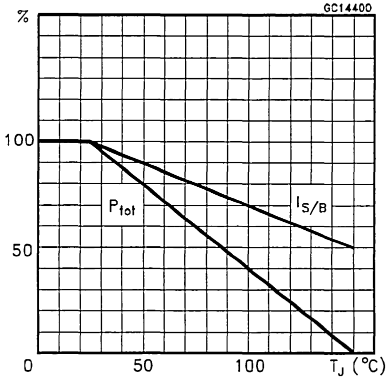
Safe Operating Areas



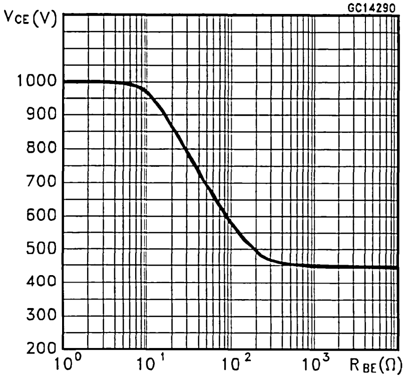
Thermal Impedance



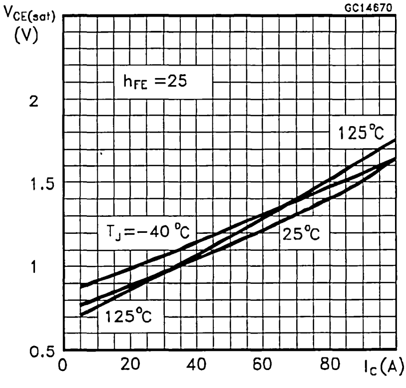
Derating Curve



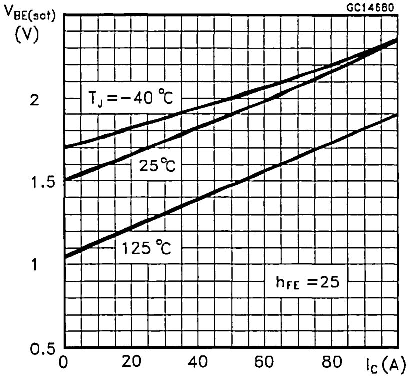
Collector-Emitter Voltage Versus Base-Emitter Resistance



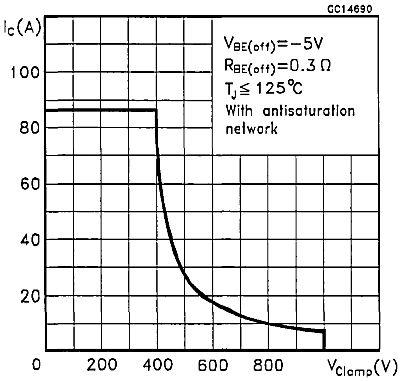
Collector-Emitter Saturation Voltage



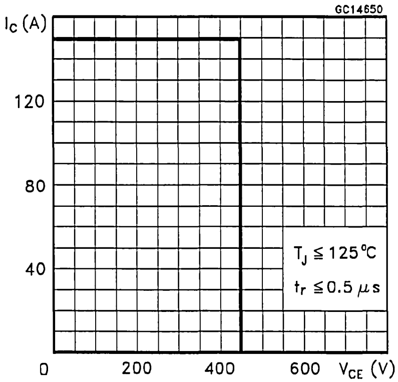
Base-Emitter Saturation Voltage



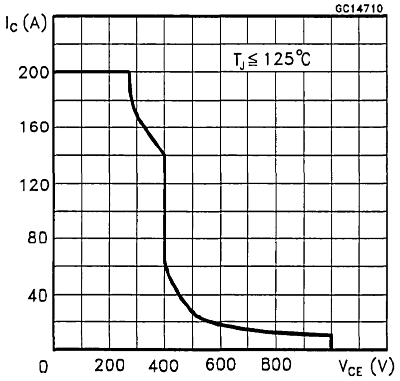
Reverse Biased SOA



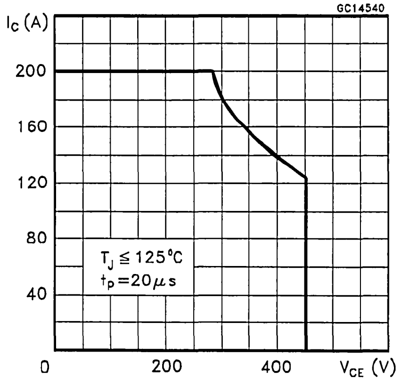
Forward Biased SOA



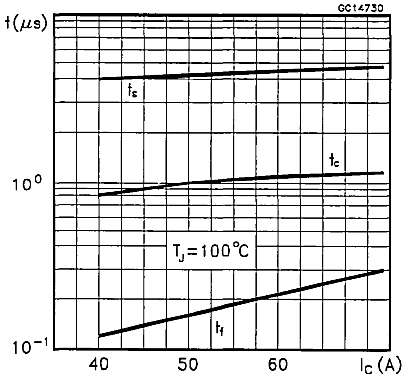
Reverse Biased AOA



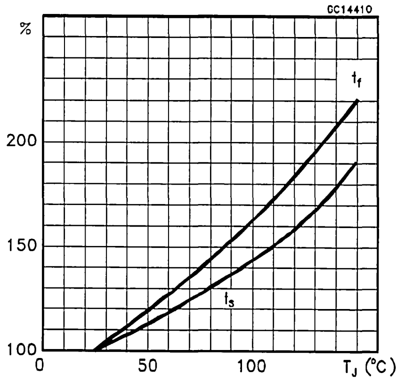
Forward Biased AOA



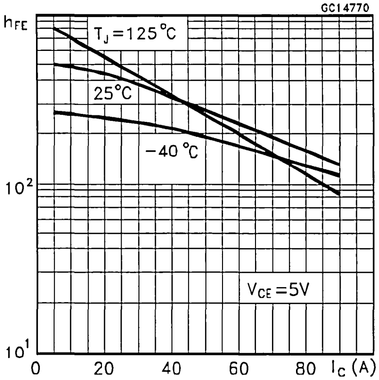
Switching Times Inductive Load



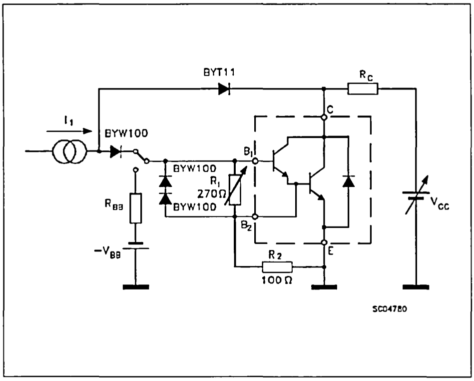
Switching Times Inductive Load Versus Temperature



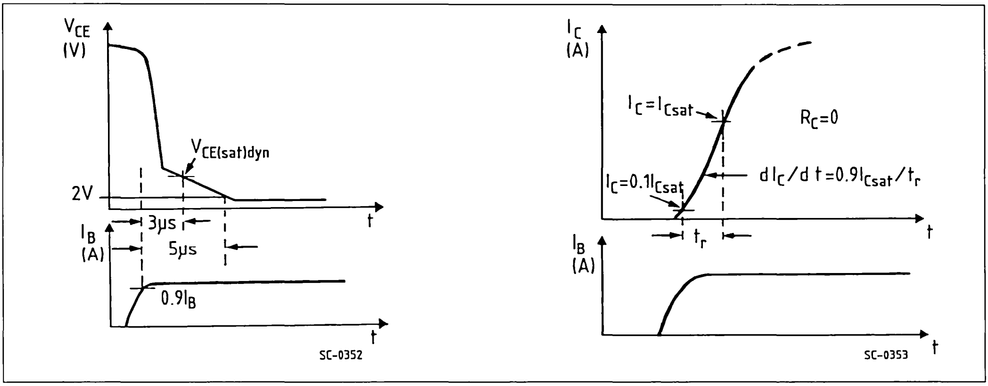
DC Current Gain



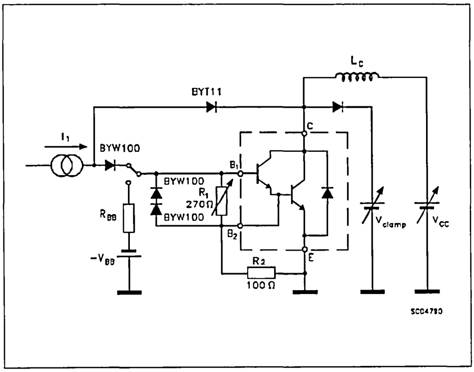
Turn-on Switching Test Circuit



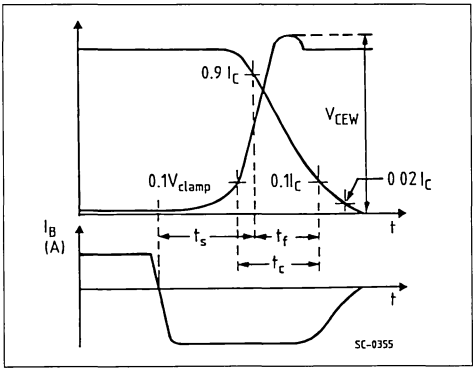
Turn-on Switching Waveforms



Turn-off Switching Test Circuit



Turn-off Switching Waveforms



SGS-THOMSON
MICROELECTRONICS

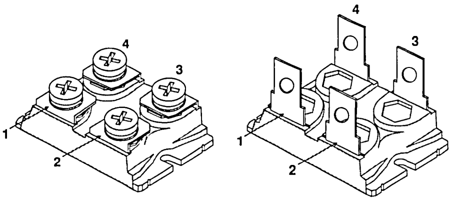
STF8045DF
STF8045DV

NPN DARLINGTON POWER MODULE

- EASY TO DRIVE TECHNOLOGY (ETD)
- HIGH CURRENT POWER BIPOLAR
- MODULE VERY LOW R_{th} JUNCTION CASE
- SPECIFIED ACCIDENTAL OVERLOAD AREAS
- ULTRAFAST FREEWHEELING DIODE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE

INDUSTRIAL APPLICATIONS:

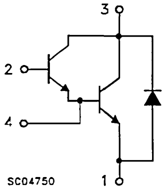
- MOTOR CONTROL
- SMPS & UPS
- WELDING EQUIPMENT



STF8045DV **STF8045DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -5 V)	600	V
$V_{CEO(sus)}$	Collector-Emitter Voltage (I_B = 0)	450	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	100	A
I_{CM}	Collector Peak Current (t_p = 10 ms)	150	A
I_B	Base Current	10	A
I_{BM}	Base Peak Current (t_p = 10 ms)	20	A
P_{tot}	Total Dissipation at T_c = 25 °C	270	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case (transistor)	Max	0.45	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE} = 5 Ω)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -5)	$V_{CE} = V_{CEV}$ $V_{CE} = V_{CEV}$ T_j = 100 °C			1 15	mA mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage	I_C = 0.2 A L = 25 mH V_{clamp} = 450 V	450			V
h_{FE}*	DC Current Gain	I_C = 85 A V_{CE} = 5 V		150		
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 60 A I_B = 1.2 A I_C = 60 A I_B = 1.2 A T_j = 100 °C I_C = 85 A I_B = 4.9 A I_C = 85 A I_B = 4.9 A T_j = 100 °C		1.2 1.3 1.4 1.5	 2 2	V V V V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 85 A I_B = 4.9 A I_C = 85 A I_B = 4.9 A T_j = 100 °C		2.3 2.3	 3	V V
di_C/dt	Rate of Rise of On-state Collector	V_{CC} = 300 V R_C = 0 t_p = 3 µs I_{B1} = 5 A T_j = 100 °C	375			A/µs
V_{CE}(3 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 3.7 Ω I_{B1} = 5 A T_j = 100 °C		4	7	V
V_{CE}(5 µs)	Collector-Emitter Dynamic Voltage	V_{CC} = 300 V R_C = 3.7 Ω I_{B1} = 5 A T_j = 100 °C		2	3	V
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = -5 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 1.2 A L = 50 µH T_j = 100 °C		5 0.25 1.3	5.5 0.5 1.6	µs µs µs
t_s t_f t_c	Storage Time Fall Time Cross-over Time	I_C = 60 A V_{CC} = 50 V V_{BB} = 0 V R_{BB} = 0.3 Ω V_{clamp} = 400 V I_{B1} = 1.2 A L = 50 µH T_j = 100 °C		7.5 0.55 2.6		µs µs µs
V_{CEW}	Maximum Collector Emitter Voltage Without Snubber	I_{CWoff} = 86 A I_{B1} = 5.6 A V_{BB} = -5 V V_{CC} = 50 V L = 30 µH R_{BB} = 0.3 Ω T_j = 125 °C	450			V
V_F*	Diode Forward Voltage	I_F = 86 A T_j = 100 °C			1.9	V
I_{RM}	Reverse Recovery Current	V_{CC} = 200 V I_F = 86 A di_F/dt = -375 A/µs L < 0.05 µH T_j = 100 °C			48	A

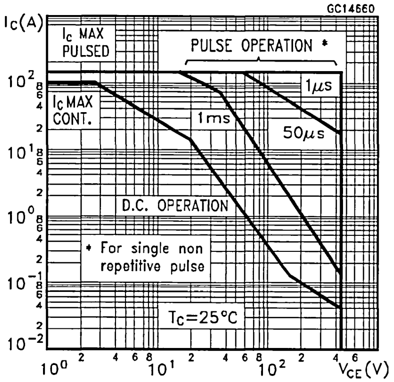
∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

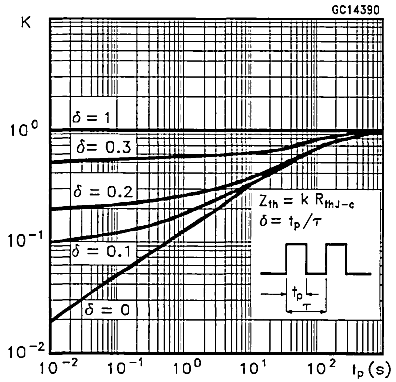
To evaluate the conduction losses of the diode use the following equations:

$V_F = 1\ 1 + 0.007\ I_F$ $P = 1\ 1\ I_{F(AV)} + 0.007\ I^2_{F(RMS)}$

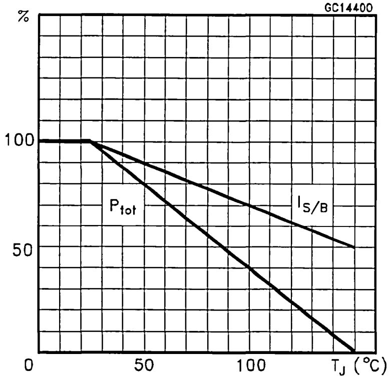
Safe Operating Areas



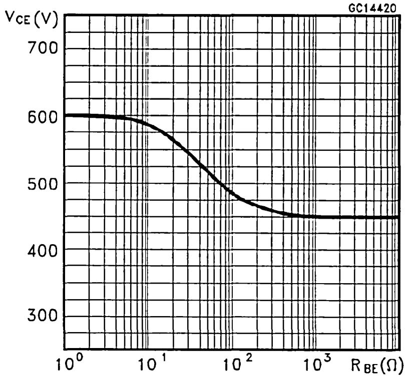
Thermal Impedance



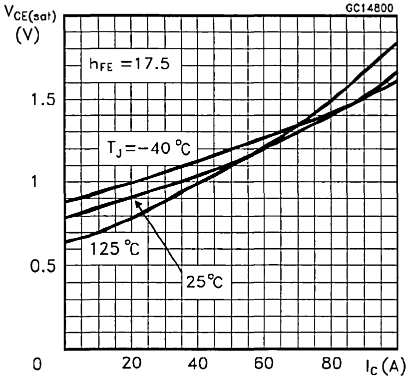
Derating Curve



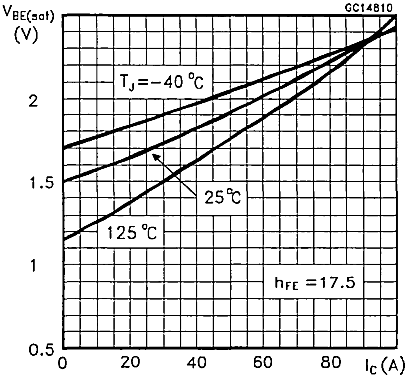
Collector-Emitter Voltage Versus Base-Emitter Resistance



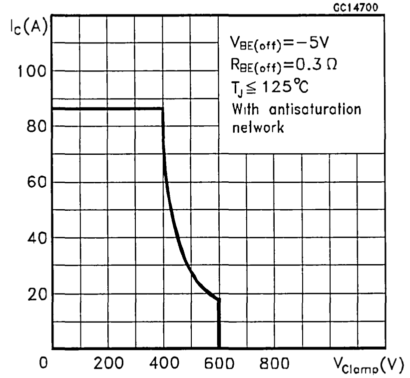
Collector-Emitter Saturation Voltage



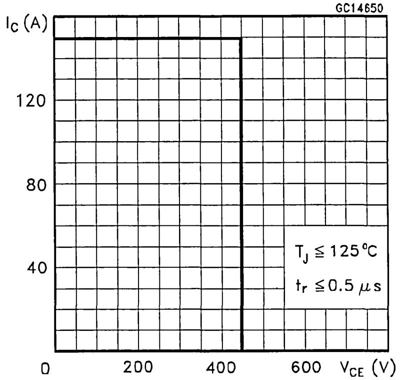
Base-Emitter Saturation Voltage



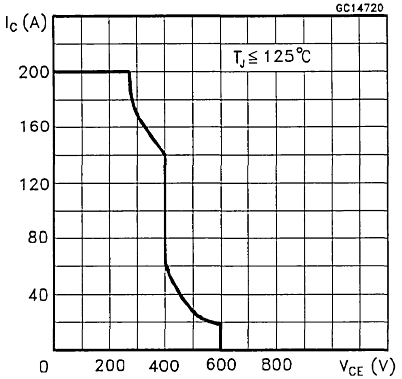
Reverse Biased SOA



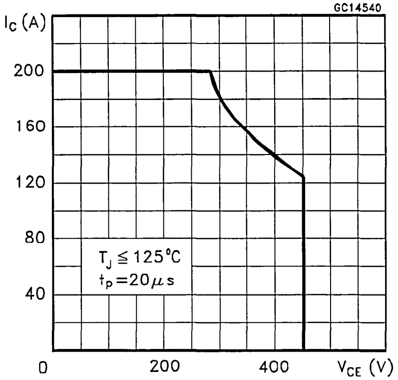
Forward Biased SOA



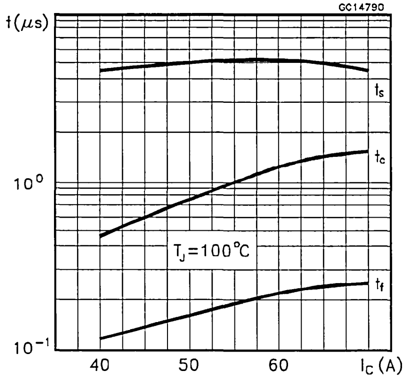
Reverse Biased AOA



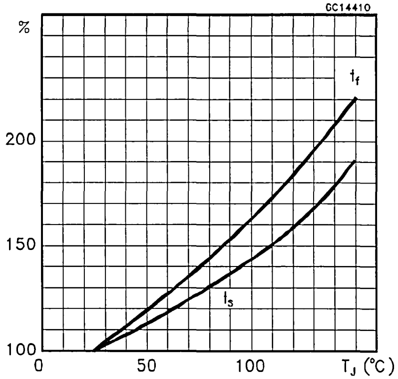
Forward Biased AOA



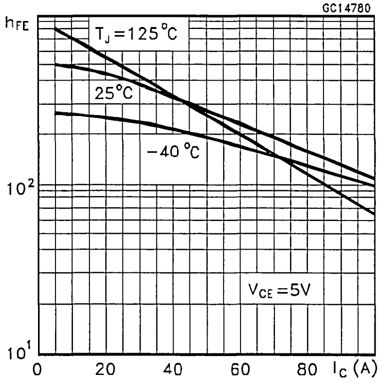
Switching Times Inductive Load



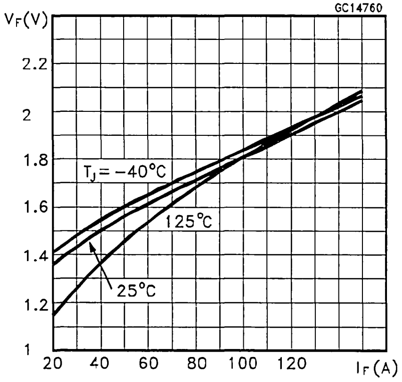
Switching Times Inductive Load Versus Temperature



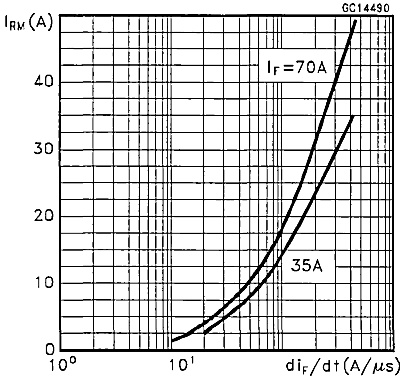
DC Current Gain



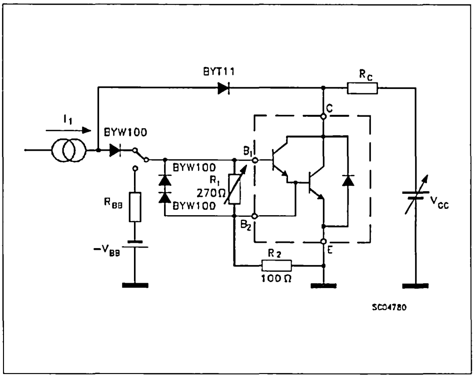
Typical V_F Versus I_F



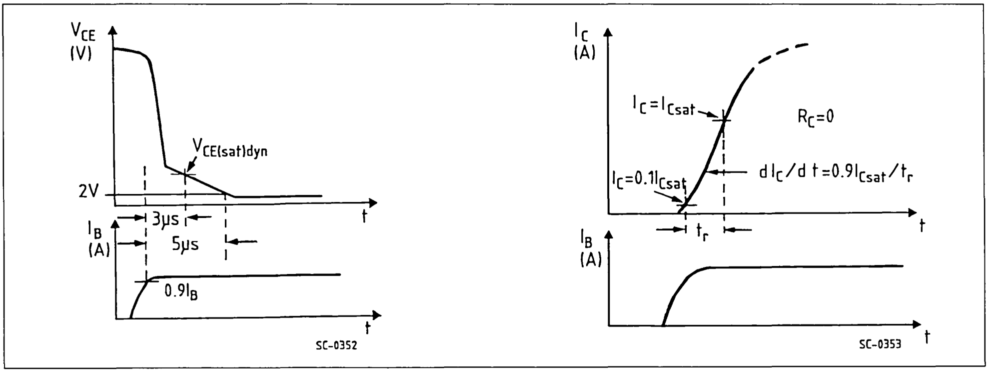
Peak Reverse Current Versus di_F/dt



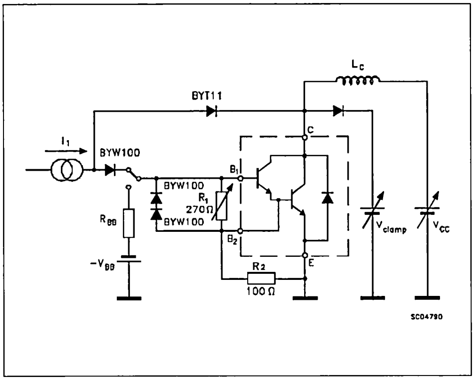
Turn-on Switching Test Circuit



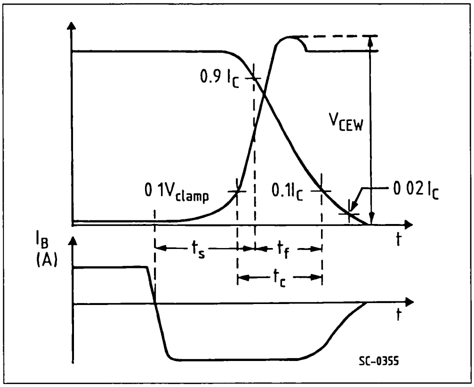
Turn-on Switching Waveforms



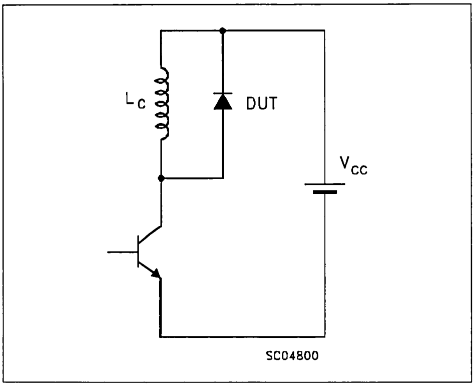
Turn-off Switching Test Circuit



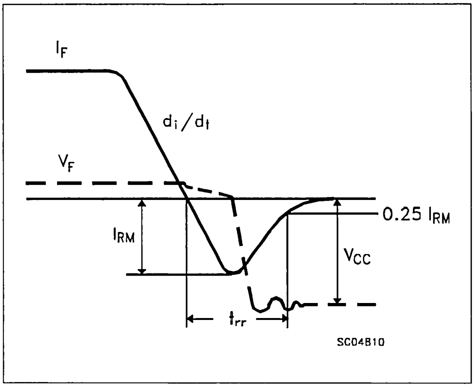
Turn-off Switching Waveforms



Turn-off Switching Test Circuits of Diode



Turn-off Switching Waveform of Diode



SGS-THOMSON
MICROELECTRONICS

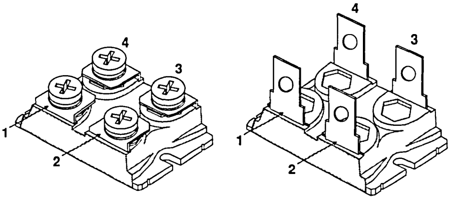
TSG25N100DF
TSG25N100DV

ISOLATED GATE BIPOLAR TRANSISTOR (IGBT) ISOTOP POWER MODULE

PRELIMINARY DATA

- VOLTAGE-CONTROLLED GATE
- LOW ON-VOLTAGE DROP $V_{CE(sat)}$
- ANTI-PARALLEL FAST DIODE INCLUDED
- FAST SWITCHING SPEED
- EXELLENT THERMAL STABILITY
  VERY LOW R_{th} JUNCTION CASE

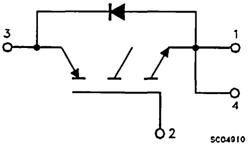
INDUSTRIAL APPLICATION:
- MOTOR DRIVES
- UPS CONVERTERS
- POWER SUPPLIES
- RESONANT POWER CONVERTERS



TSG25N100DV **TSG25N100DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CES}	Collector-Emitter Voltage (V_{GE} = 0)	1000	V
V_{CER}	Collector-Emitter Voltage (R_{GE}= 20 kΩ)	1000	V
V_{GE}	Gate-Emitter Voltage	± 20	V
I_C	Collector Current (continuous) at T_c = 25 °C	50	A
I_C	Collector Current (continuous) at T_c = 100 °C	25	A
I_{CM}(•)	Collector Current (pulsed)	100	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
	Derating Factor	2.4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case (IGBT)	Max	0.41	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-Case (Diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	I_C = 2 mA V_{GE} = 0	1000			V
I_{CES}	Collector Cut-off Current (V_{GE} = 0)	V_{CE} = Max Rating			2	mA
I_{GES}	Gate-Emitter Leakage Current (V_{CE} = 0)	V_{GE} = ± 20 V V_{CE} = 0			300	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GE(th)}$	Gate Threshold Voltage	V_{CE} = V_{GE} I_C = 2 mA	2		4	V
I_N	Nominal Current For Measurement	T_C = 100 °C			25	A
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	V_{GE} = 15 V I_C = 25 A V_{GE} = 15 V I_C = 25 A T_C = 100 °C			3.5 3.5	V V

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{CE} = 25 V I_C = 25 A		14		mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{CE} = 25 V f = 1 MHz V_{GE} = 0		3600 350 100		pF pF pF

SWITCHING ON RESISTIVE LOAD

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r	Delay Time Rise Time	I_C = 25 A V_{CC} = 450 V V_{GE} = 15 V R_G = 47 Ω		60 220	100 350	ns ns
di_C/dt	Turn-on Current Slope	V_{CC} = 450 V V_{GE} = 15 V R_G = 47 Ω R_L = 0 T_C = 100 °C		430		A/μs
$V_{CE}(1\mu s)$	Collector-Emitter Dynamic Voltage	I_C = 25 A V_{CC} = 450 V V_{GE} = 15 V R_G = 47 Ω T_C = 100 °C		7	10	V
$V_{CE}(2\mu s)$	Collector-Emitter Dynamic Voltage	I_C = 25 A V_{CC} = 450 V V_{GE} = 15 V R_G = 47 Ω T_C = 100 °C		2.5	3.7	V

(*) Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

ELECTRICAL CHARACTERISTICS (continued)

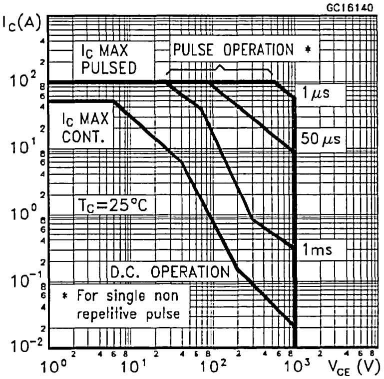
SWITCHING OFF INDUCTIVE LOAD

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_c	Cross-Over Time	V_{Clamp} = 800 V I_C = 25 A R_{GE} = 100 Ω V_{GE} = 15 V L = 0.1 mH		1.5		µs
$t_{r(Voff)}$	Off Voltage Rise Time			0.65		µs
t_f	Fall Time			0.7		µs
E_{off}	Turn-off Switching Loss			12.5		mJ
t_c	Cross-Over Time	V_{Clamp} = 800 V I_C = 25 A R_{GE} = 100 Ω V_{GE} = 15 V L = 0.1 mH T_j = 100 °C		2.2		µs
$t_{r(Voff)}$	Off Voltage Rise Time			0.8		µs
t_f	Fall Time			1.2		µs
E_{off}	Turn-off Switching Loss			18		mJ

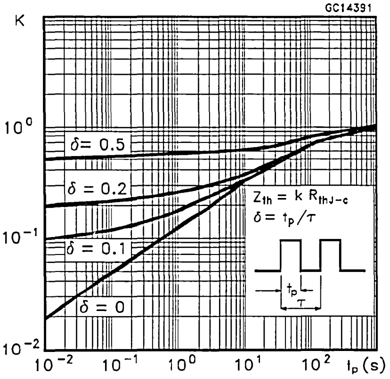
COLLECTOR EMITTER DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_F	Forward Current	T_c = 25 °C T_c = 100 °C			50 25	A A
I_{FM}	Forward Current (pulsed)				100	A
I_{RM}	Reverse Recovery Current	I_F = 25 A di/dt = 120 A/µs T_c = 100 °C		20		A
V_F	Forward On Voltage	I_F = 25 A V_{GE} = 0 T_c = 100 °C		1.35	1.8	V
t_{rr}	Reverse Recovery Time	I_F = 25 A di/dt = 100 A/µs T_c = 100 °C		350		ns

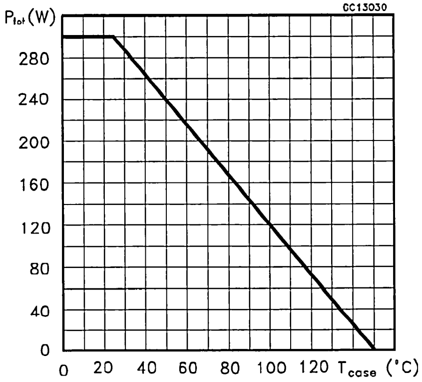
Safe Operating Areas



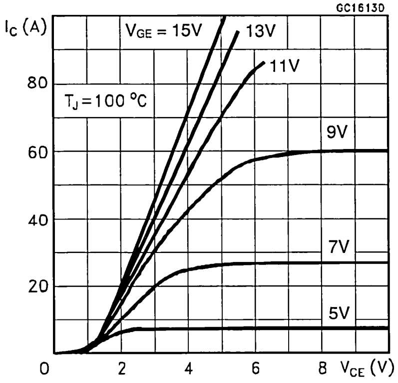
Thermal Impedance



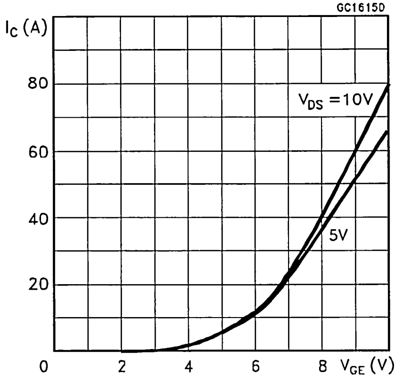
Derating Curves



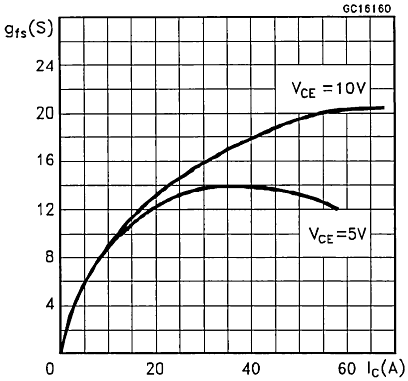
Output Characteristics



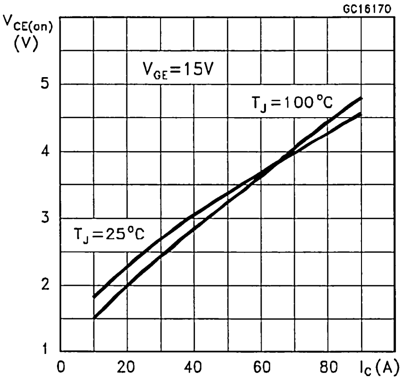
Transfer Characteristics



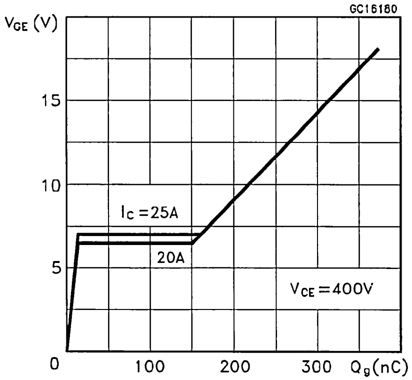
Transconductance



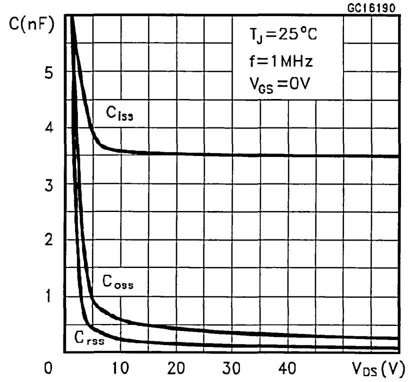
Static Collector-Emitter On Voltage



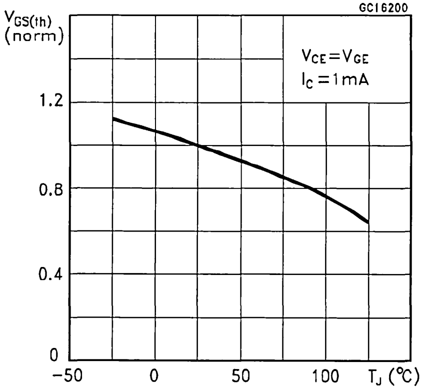
Gate Charge vs Gate-Emitter Voltage



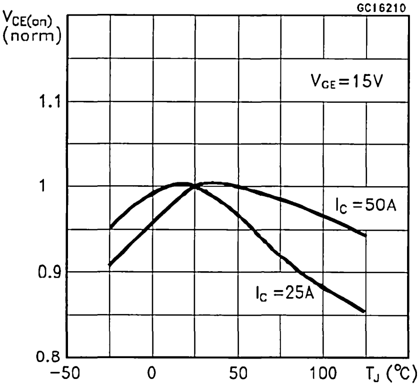
Capacitance Variation



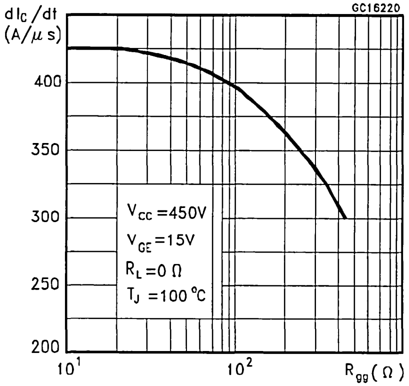
Normalized Gate Threshold Voltage vs Temperature



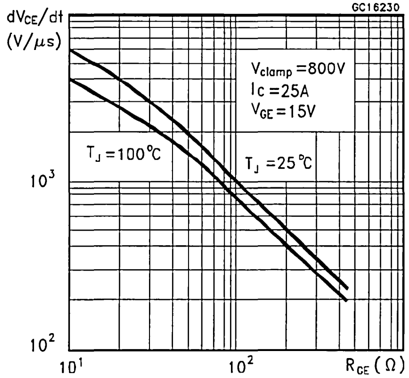
Normalized On Voltage vs Temperature



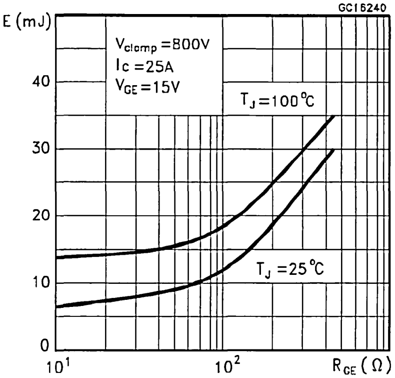
Turn On Current Slope vs Gate-Emitter Resistance



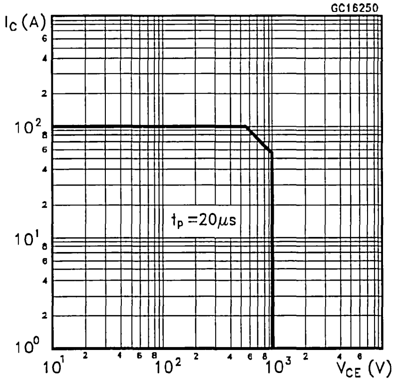
Off Voltage Slope vs Gate-Emitter Resistance



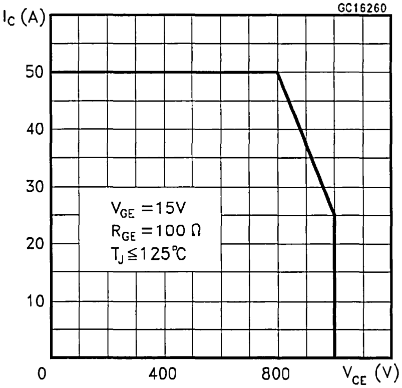
Off Losses vs Gate-Emitter Resistance



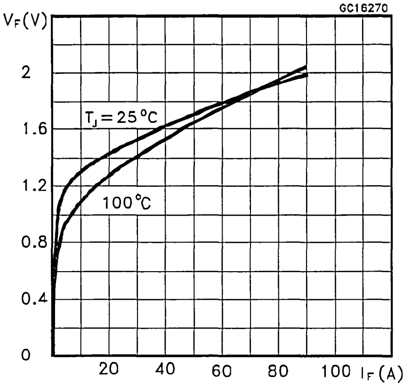
Accidental Overload Areas



Reverse Biased SOA



Typical V_F Versus I_F



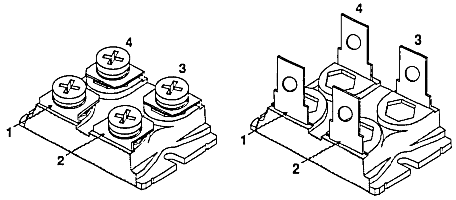
TSG50N50DF
TSG50N50DV

ISOLATED GATE BIPOLAR TRANSISTOR (IGBT) ISOTOP POWER MODULE

TENTATIVE DATA

- VOLTAGE-CONTROLLED GATE
- LOW ON-VOLTAGE DROP $V_{CE(sat)}$
- ANTI-PARALLEL FAST DIODE INCLUDED
- FAST SWITCHING SPEED
- EXELLENT THERMAL STABILITY
- VERY LOW R_{th} JUNCTION CASE

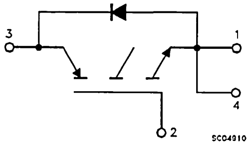
INDUSTRIAL APPLICATION:
- MOTOR DRIVES
- UPS CONVERTERS
- POWER SUPPLIES
- RESONANT POWER CONVERTERS



TSG50N50V **TSG50N50F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CES}	Collector-Emitter Voltage (V_{GE} = 0)	500	V
V_{CER}	Collector-Emitter Voltage (R_{GE}= 20 kΩ)	500	V
V_{GE}	Gate-Emitter Voltage	± 20	V
I_C	Collector Current (continuous) at T_c = 25 °C	75	A
I_C(•)	Collector Current at T_c = 100 °C	50	A
I_{CM}(•)	Collector Current (pulsed)	200	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
	Derating Factor	2.4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case (IGBT)	Max	0.41	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-Case (Diode)	Max	1.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage	I_C = 2 mA V_{GE} = 0	500			V
I_{CES}	Collector Cut-off Current (V_{GE} = 0)	V_{CE} = Max Rating			2	mA
I_{GES}	Gate-Emitter Leakage Current (V_{CE} = 0)	V_{GE} = ± 20 V V_{CE} = 0			200	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GE(th)}$	Gate Threshold Voltage	V_{CE} = V_{GE} I_C = 2 mA	2		4	V
I_N	Nominal Current For Measurement	T_C = 100 °C			50	A
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	V_{GE} = 15 V I_C = 50 A V_{GE} = 15 V I_C = 50 A T_C = 100 °C			3.3 3.3	V V

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{CE} = 25 V I_C = 25 A	15			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{CE} = 25 V f = 1 MHz V_{GE} = 0		4000 550 120		pF pF pF

SWITCHING ON RESISTIVE LOAD

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r	Delay Time Rise Time	I_C = 50A V_{CC} = 350V V_{GE} = 15 V R_G = 47Ω		140 250	220 400	ns ns
di_C/dt	Turn-on Current Slope	I_C = 50A V_{CC} = 350V V_{GE} = 15V R_G = 47Ω R_L = 0 T_C = 100 °C		400		A/μs
V_{CE}(0.6μs)	Collector-Emitter Dynamic Voltage	I_C = 50A V_{CC} = 350V V_{GE} = 15V R_G = 47Ω T_C = 100 °C		7	10	V
V_{CE}(1.2μs)	Collector-Emitter Dynamic Voltage	I_C = 50A V_{CC} = 350V V_{GE} = 15V R_G = 47Ω T_C = 100 °C		2.5	3.7	V

(*) Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

ELECTRICAL CHARACTERISTICS (continued)

SWITCHING OFF INDUCTIVE LOAD

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_c $t_{r(Voff)}$ t_f E_{off}	Cross-Over Time Off Voltage Rise Time Fall Time Turn-off Switching Loss	V_{CC} = 400 V I_C = 50 A R_{GE} = 100 Ω V_{GE} = 15 V L = 0.1 mH		0.85 0.4		µs µs µs mJ
t_c $t_{r(Voff)}$ t_f E_{off}	Cross-Over Time Off Voltage Rise Time Fall Time Turn-off Switching Loss	V_{CC} = 400 V I_C = 50 A R_{GE} = 100 Ω V_{GE} = 15 V L = 0.1 mH T_j = 100 °C		1.1 0.6		µs µs µs mJ

COLLECTOR EMITTER DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_F	Forward Current	T_c = 25 °C T_c = 100 °C			75 50	A A
I_{FM}	Forward Current (pulsed)				200	A
I_{RM}	Reverse Recovery Current	T_c = 100 °C				A
V_F	Forward On Voltage	I_F = 50 A V_{GE} = 0 T_c = 100 °C			1.9	V
t_{rr}	Reverse Recovery Time	I_F = 50 A di/dt = 100 A/µs T_c = 100 °C			400	ns

SGS-THOMSON
MICROELECTRONICS

TSD2M350F
TSD2M350V

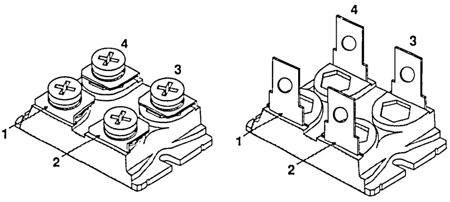
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD2M350F/V	400 V	0.150 Ω	30 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ns)

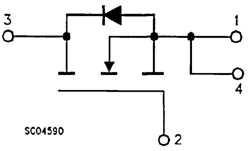
INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TSD2M350V **TSD2M350F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	400	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	400	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	30	A
I_D	Drain Current (continuous) at T_c = 100 °C	19	A
I_{DM}(•)	Drain Current (pulsed)	120	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
	Derating Factor	2.4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj-case}$	Thermal Resistance Junction-Case	Max	0.41	°C/W
R_{thc-h}	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	400			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			200 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 200	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 18 A			0.150	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 18 A	12			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			6000 1200 500	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 200 V I_D = 18 A R_{GS} = 25 Ω V_{GS} = 10 V L = 100µH		180 150 3 300		ns A/µs µs ns

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				30 120	A A
V_{SD}	Forward On Voltage	I_{SD} = 30 A V_{GS} = 0			1.6	V
t_{rr}	Reverse Recovery Time	I_{SD} = 30 A di/dt = 100 A/µs		1000		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD2M450F
TSD2M450V

N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

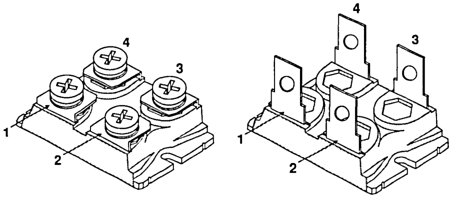
ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD2M450F/V	500 V	0.2 Ω	26 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACT
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TIPICALLY < 5 ns)

INDUSTRIAL APPLICATIONS:

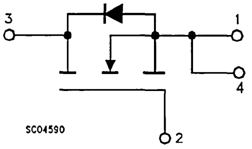
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TSD2M450V **TSD2M450F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	26	A
I_D	Drain Current (continuous) at T_c = 100 °C	16	A
I_{DM}(•)	Drain Current (pulsed)	100	A
P_{tot}	Total Dissipation at T_c = 25 °C	300	W
	Derating Factor	2.4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.41	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			200 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 200	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 13 A			0.2	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 13 A	12			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			6000 1200 500	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 250 V I_D = 15 A R_{GS} = 25 Ω V_{GS} = 10 V L = 100 µH		180 150 3 300		ns A/µs µs ns

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				26 100	A A
V_{SD}	Forward On Voltage	I_{SD} = 26 A V_{GS} = 0			1.4	V
t_{rr}	Reverse Recovery Time	I_{SD} = 26 A di/dt = 100 A/µs		1300		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD4M150F
TSD4M150V

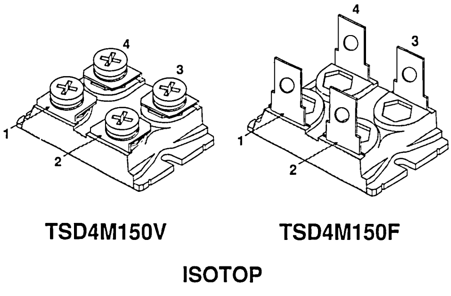
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M150F/V	100 V	0.014 Ω	135 A

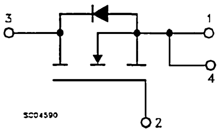
- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP150 FOR RATING)

INDUSTRIAL APPLICATIONS:

- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	135	A
I_D	Drain Current (continuous) at T_c = 100 °C	85	A
I_{DM}(•)	Drain Current (pulsed)	500	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj-case}$ R_{thc-h}	Thermal Resistance Junction-Case Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max Max	0.25 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	100			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 70 A			0.014	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 70 A	20			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			11200 4200 1700	pF pF pF

SWITCHING (INDUCTIVE LOAD)

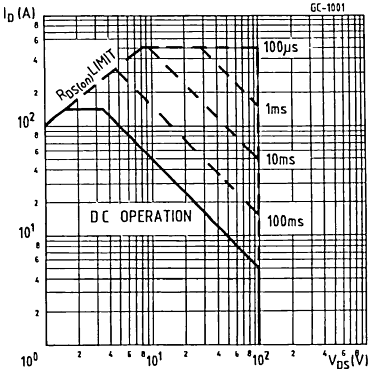
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 50 V I_D = 50 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		100 250 1100 130		ns A/µs ns ns

SOURCE DRAIN DIODE

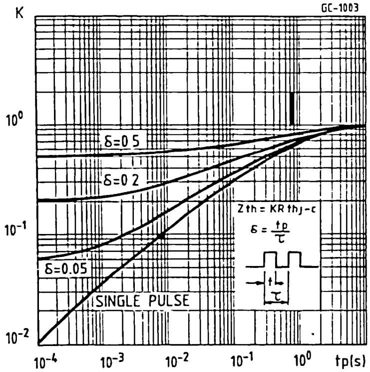
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				135 500	A A
V_{SD}	Forward On Voltage	I_{SD} = 135 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 135 A , di/dt = 100 A/µs		400		ns

(*) Pulsed· Pulse duration = 300 µs, duty cycle 1 5 %
(•) Pulse width limited by safe operating area

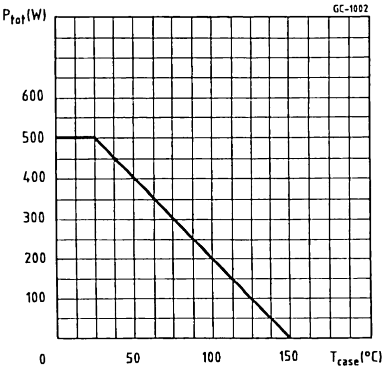
Safe Operating Areas



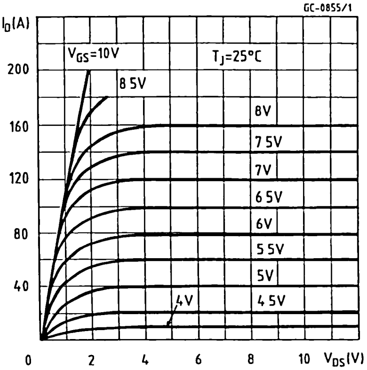
Thermal Impedance



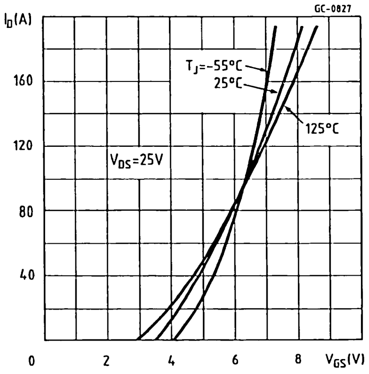
Derating Curve



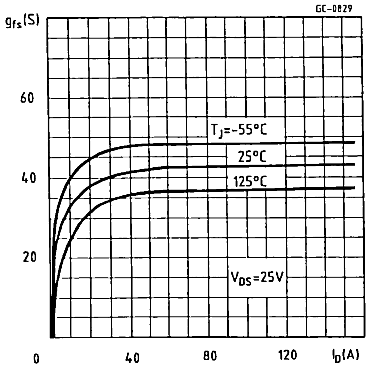
Output Characteristics



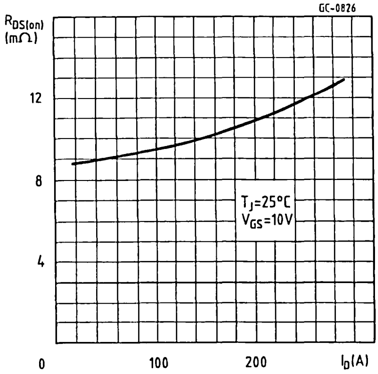
Transfer Characteristics



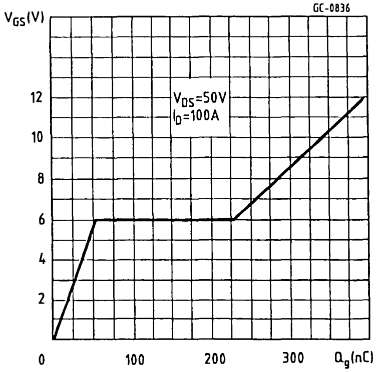
Transconductance



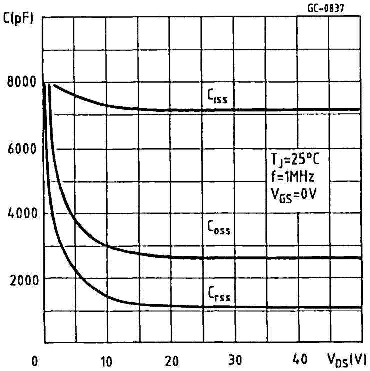
Static Drain-Source On Resistance



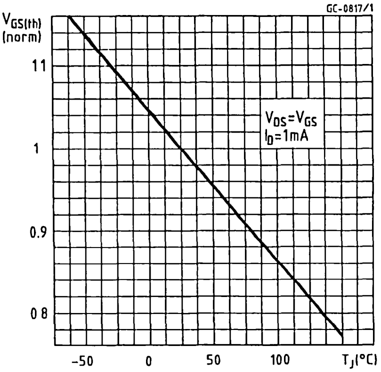
Gate Charge vs Gate-source Voltage



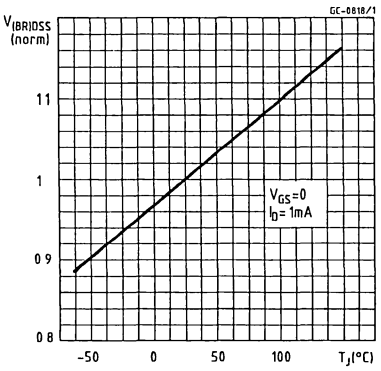
Capacitance Variation



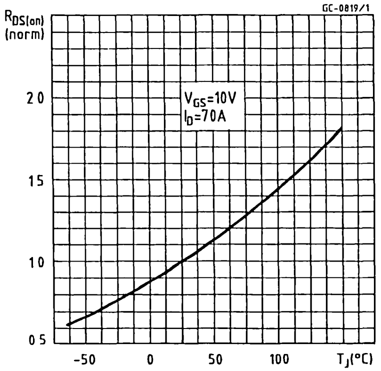
Normalized Gate Threshold Voltage vs Temperature



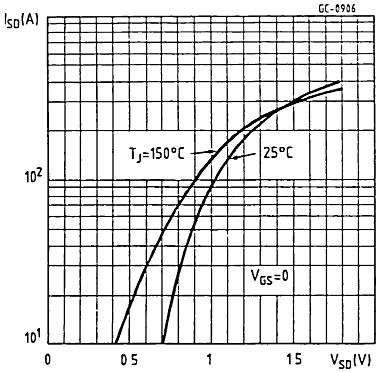
Normalized Breakdown Voltage vs Temperature



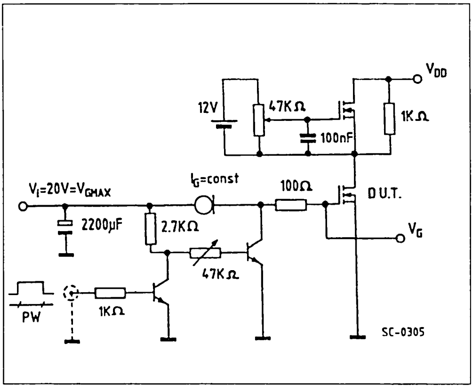
Normalized On Resistance vs Temperature



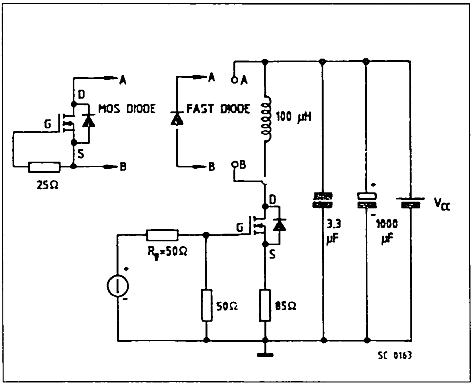
Source-Drain Diode Forward Characteristics



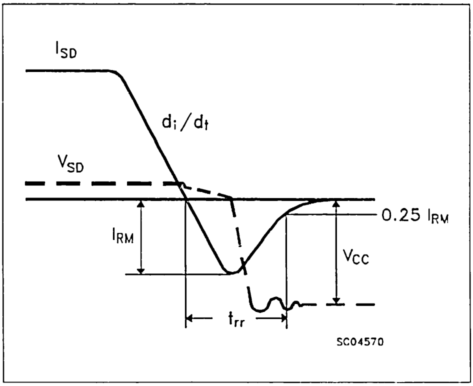
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

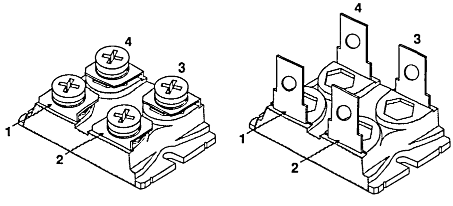
TSD4M151F
TSD4M151V

N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M151F/V	80 V	0.014 Ω	135 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP150 FOR RATING)

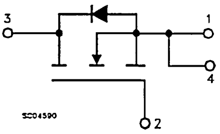
INDUSTRIAL APPLICATIONS:
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M151V **TSD4M151F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	80	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	80	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	135	A
I_D	Drain Current (continuous) at T_c = 100 °C	85	A
$I_{DM}(\bullet)$	Drain Current (pulsed)	500	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease APllied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	80			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 70 A			0.014	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 70 A	20			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			11200 4200 1700	pF pF pF

SWITCHING (INDUCTIVE LOAD)

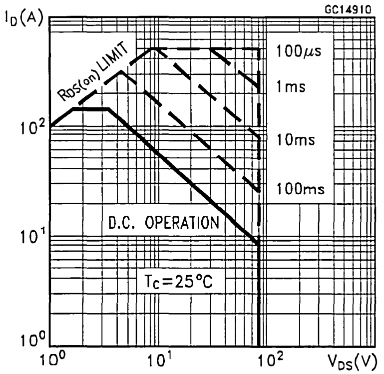
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 50 V I_D = 50 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		100 250 1100 130		ns A/µs ns ns

SOURCE DRAIN DIODE

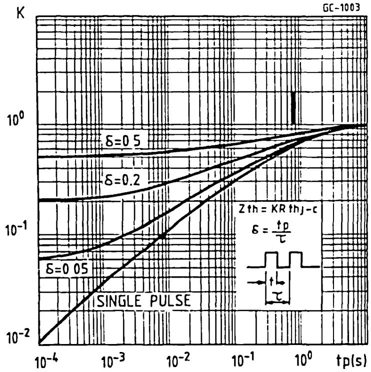
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				135 500	A A
V_{SD}	Forward On Voltage	I_{SD} = 135 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 135 A di/dt = 100 A/µs		400		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

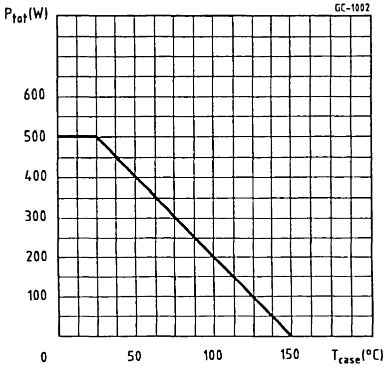
Safe Operating Areas



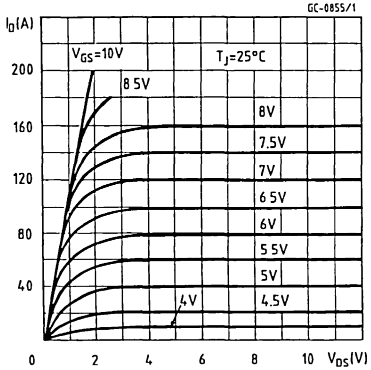
Thermal Impedance



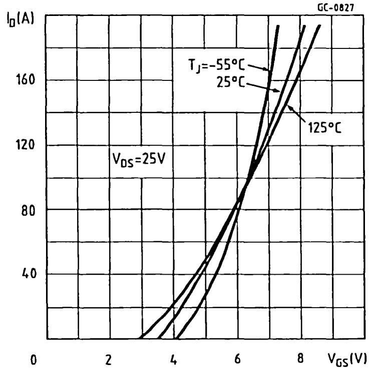
Derating Curve



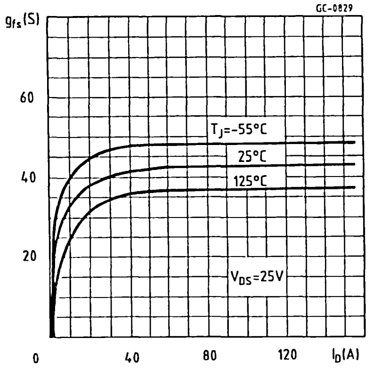
Output Characteristics



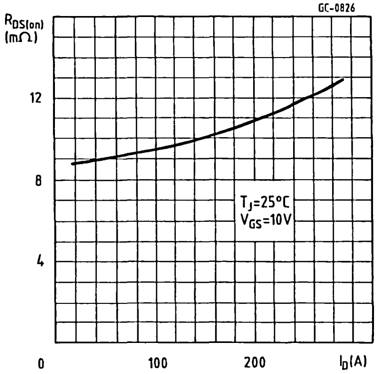
Transfer Characteristics



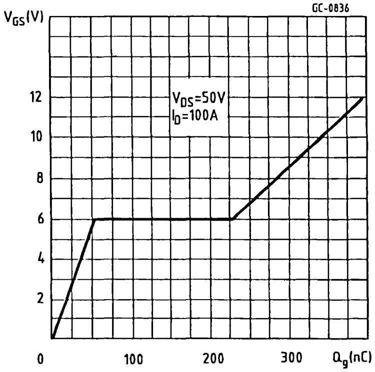
Transconductance



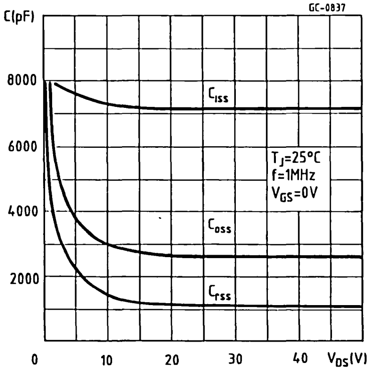
Static Drain-Source On Resistance



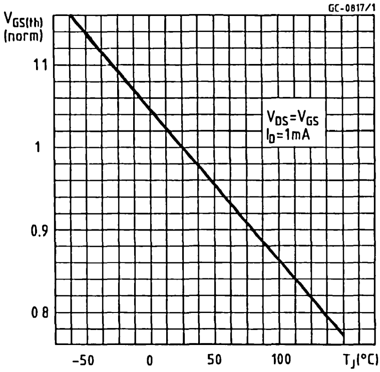
Gate Charge vs Gate-source Voltage



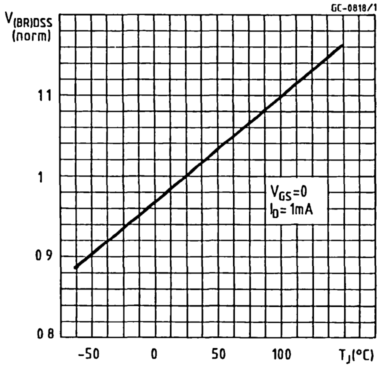
Capacitance Variation



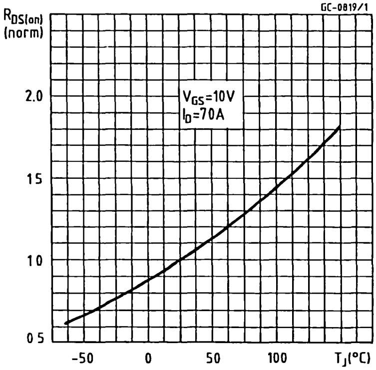
Normalized Gate Threshold Voltage vs Temperature



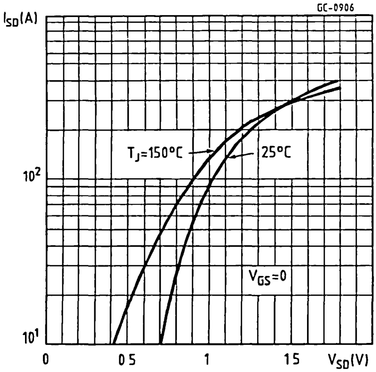
Normalized Breakdown Voltage vs Temperature



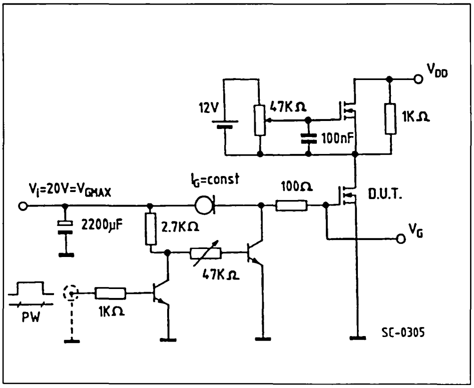
Normalized On Resistance vs Temperature



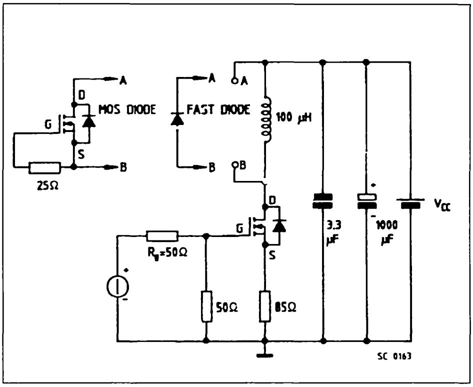
Source-Drain Diode Forward Characteristics



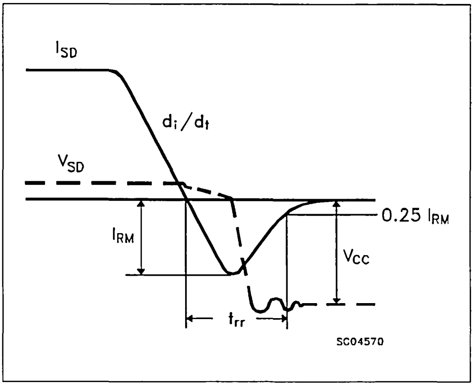
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

TSD4M250F
TSD4M250V

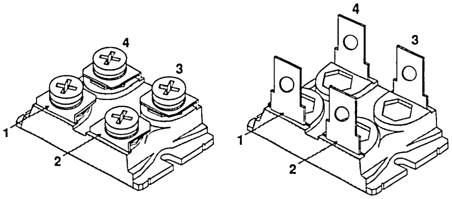
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M250F/V	200 V	0.021 Ω	110 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ms)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE STH33N20FI FOR RATING)

INDUSTRIAL APPLICATIONS:

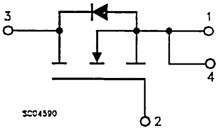
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M250V **TSD4M250F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	200	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	200	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	110	A
I_D	Drain Current (continuous) at T_c = 100 °C	69	A
I_{DM}(•)	Drain Current (pulsed)	440	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	200			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (∗)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 60 A			0.021	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 60 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 4500 2500	pF pF pF

SWITCHING (INDUCTIVE LOAD)

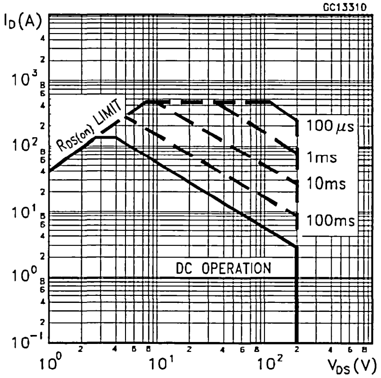
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 100 V I_D = 60 A R_{GS} = 25 Ω V_{GS} = 10 V			260 100 2000 750	ns A/µs ns ns

SOURCE DRAIN DIODE

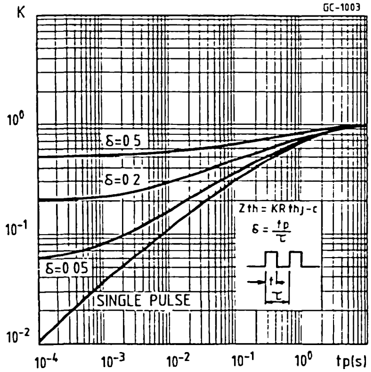
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				110 440	A A
V_{SD}	Forward On Voltage	I_{SD} = 110 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 110 A di/dt = 100 A/µs		800		ns

(∗) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

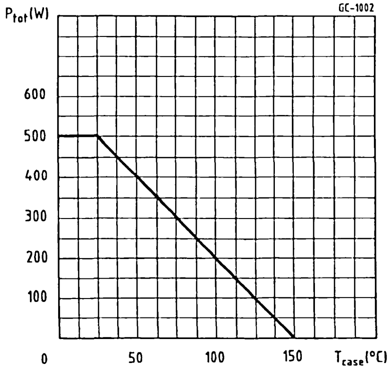
Safe Operating Areas



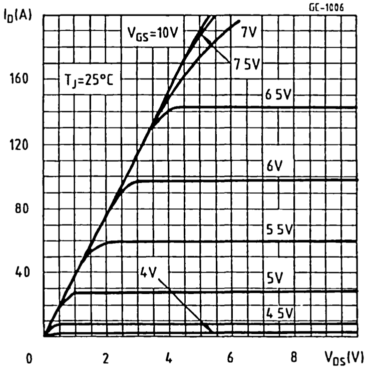
Thermal Impedance



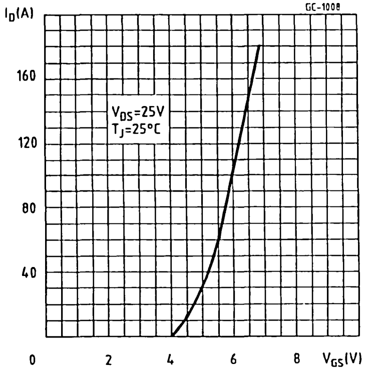
Derating Curve



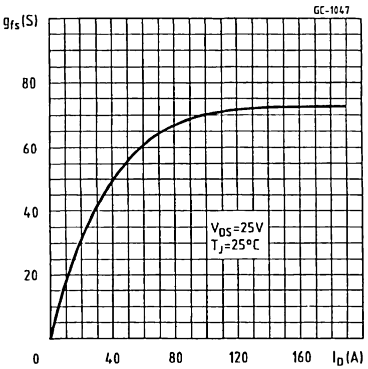
Output Characteristics



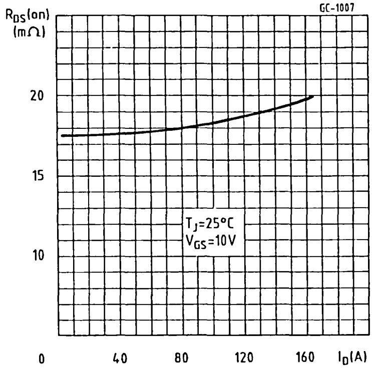
Transfer Characteristics



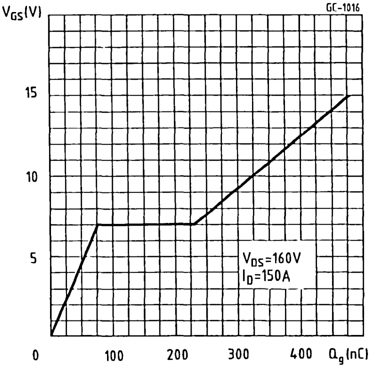
Transconductance



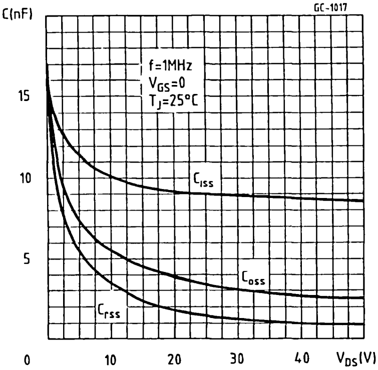
Static Drain-Source On Resistance



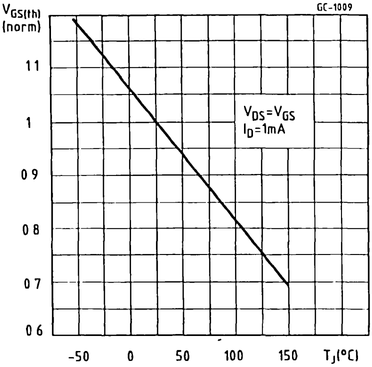
Gate Charge vs Gate-source Voltage



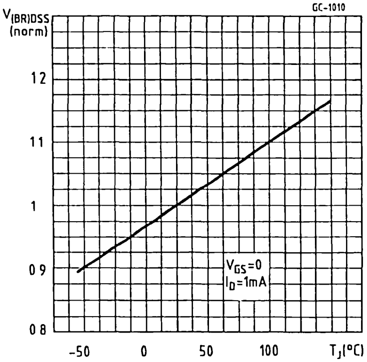
Capacitance Variation



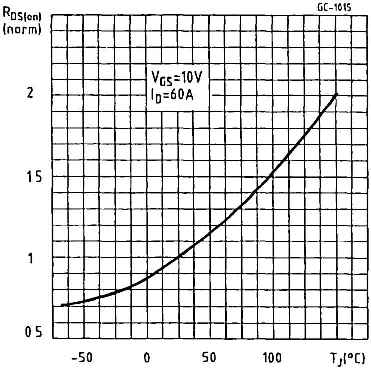
Normalized Gate Threshold Voltage vs Temperature



Normalized Breakdown Voltage vs Temperature

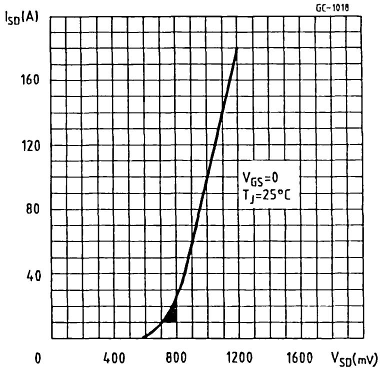


Normalized On Resistance vs Temperature

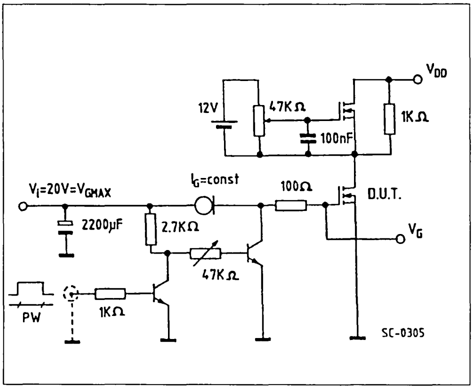


SGS-THOMSON MICROELECTRONICS

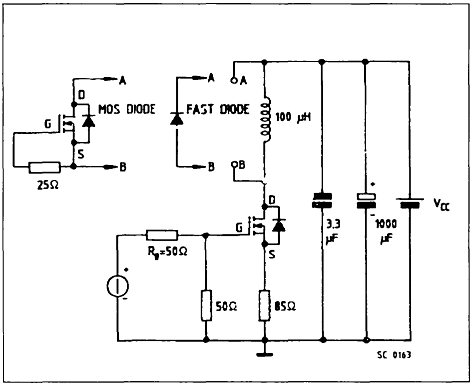
Source-Drain Diode Forward Characteristics



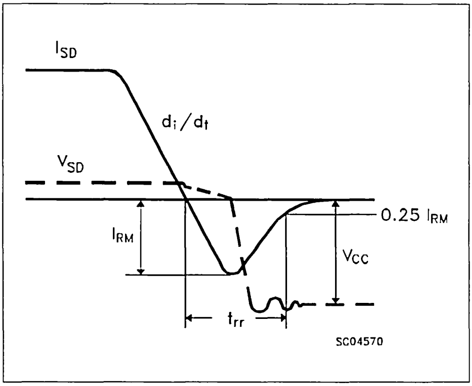
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

TSD4M251F
TSD4M251V

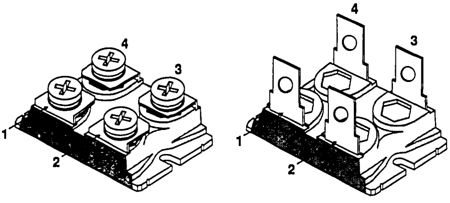
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M251F/V	150 V	0.021 Ω	110 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ms)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE STH33N20FI FOR RATING)

INDUSTRIAL APPLICATIONS:

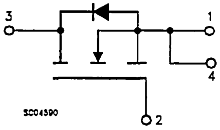
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M251V **TSD4M251F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	150	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	150	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	110	A
I_D	Drain Current (continuous) at T_c = 100 °C	69	A
I_{DM}(•)	Drain Current (pulsed)	440	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	150			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	μA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 60 A			0.021	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 60 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 4500 2500	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 75 V I_D = 60 A R_{GS} = 25 Ω V_{GS} = 10 V			260 100 2000 750	ns A/μs ns ns

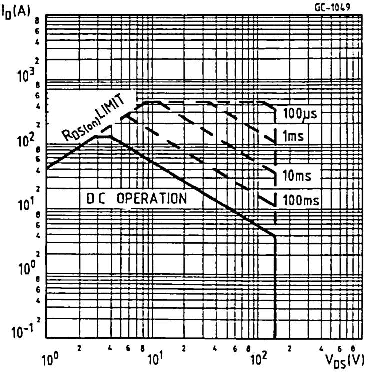
SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				110 440	A A
V_{SD}	Forward On Voltage	I_{SD} = 110 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 110 A di/dt = 100 A/μs		800		ns

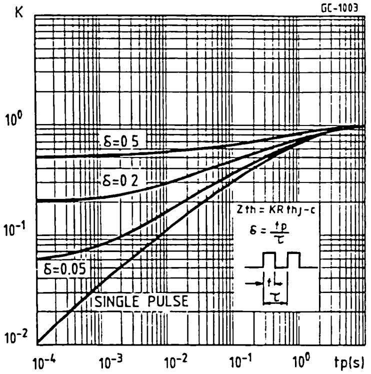
(*) Pulsed. Pulse duration = 300 μs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

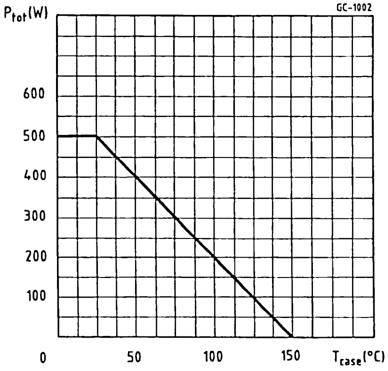
Safe Operating Areas



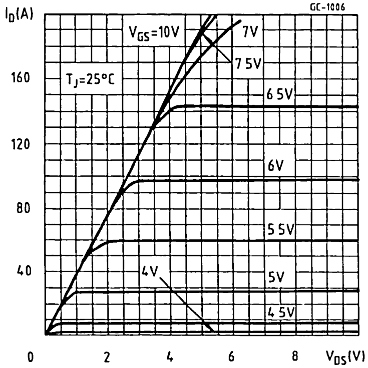
Thermal Impedance



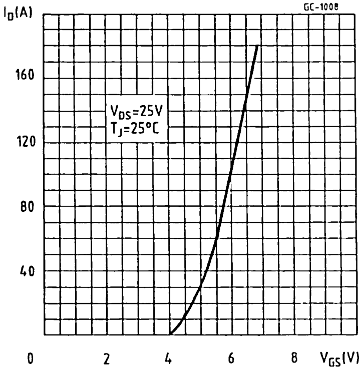
Derating Curve



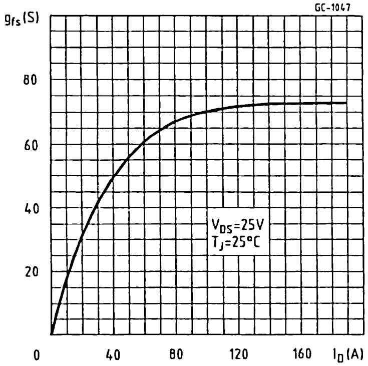
Output Characteristics



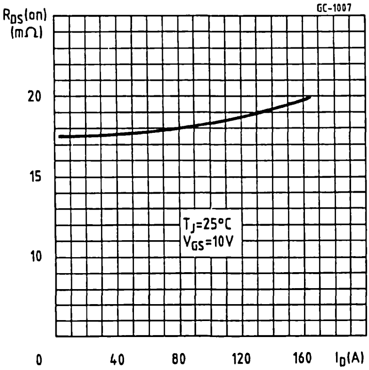
Transfer Characteristics



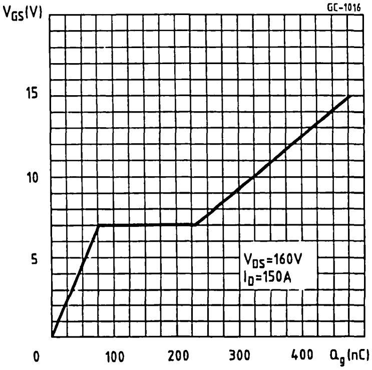
Transconductance



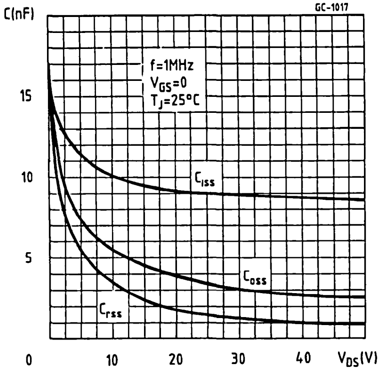
Static Drain-Source On Resistance



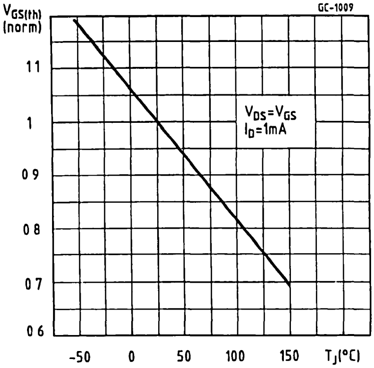
Gate Charge vs Gate-source Voltage



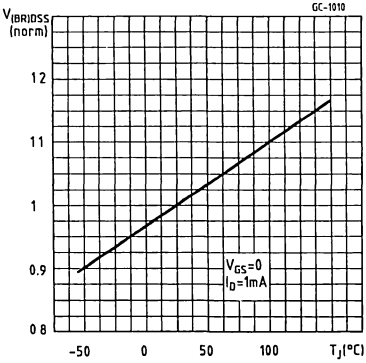
Capacitance Variation



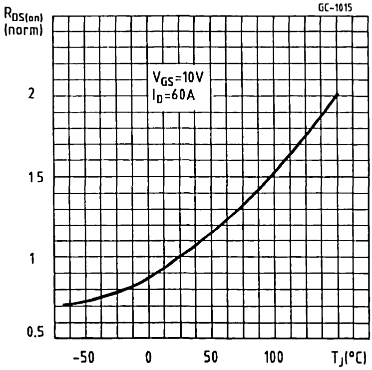
Normalized Gate Threshold Voltage vs Temperature



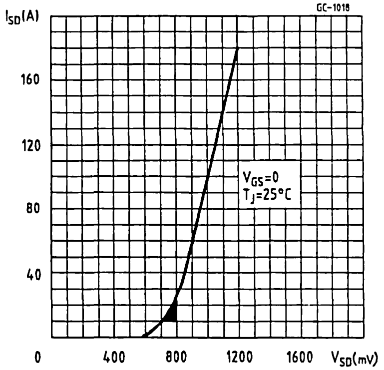
Normalized Breakdown Voltage vs Temperature



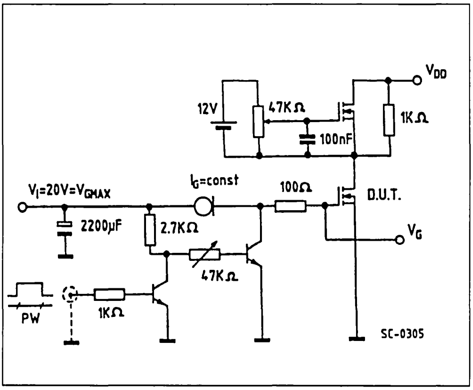
Normalized On Resistance vs Temperature



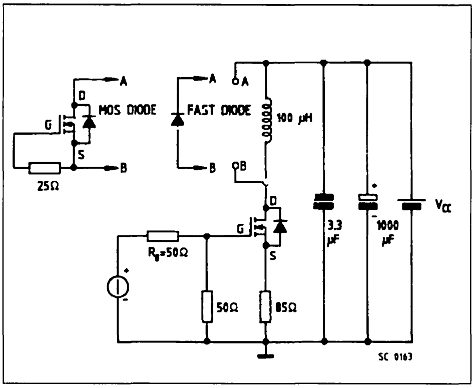
Source-Drain Diode Forward Characteristics



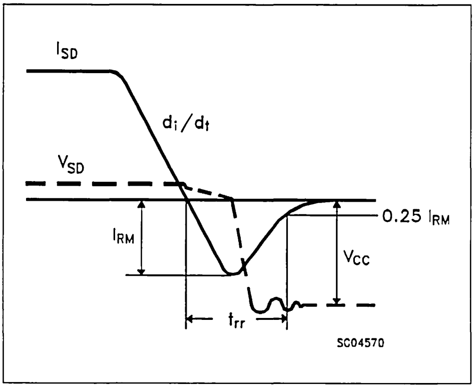
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

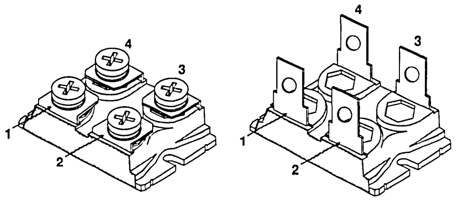
TSD4M350F
TSD4M350V

N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M350F/V	400 V	0.075 Ω	50 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP350 FOR RATING)

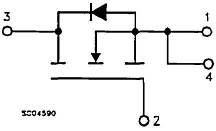
INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M350V **TSD4M350F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	400	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	400	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	50	A
I_D	Drain Current (continuous) at T_c = 100 °C	31	A
I_{DM}(•)	Drain Current (pulsed)	200	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	400			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 30 A			0.075	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 30 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 2400 1000	pF pF pF

SWITCHING (INDUCTIVE LOAD)

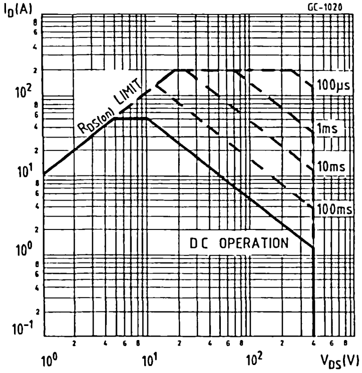
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 200 V I_D = 30 A R_{GS} = 25 Ω V_{GS} = 10 V			180 150 3000 300	ns A/µs ns ns

SOURCE DRAIN DIODE

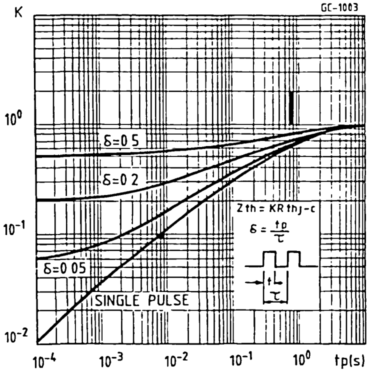
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				50 200	A A
V_{SD}	Forward On Voltage	I_{SD} = 50 A V_{GS} = 0			1.6	V
t_{rr}	Reverse Recovery Time	I_{SD} = 50 A di/dt = 100 A/µs		1000		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

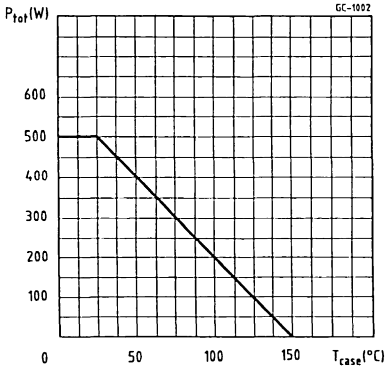
Safe Operating Areas



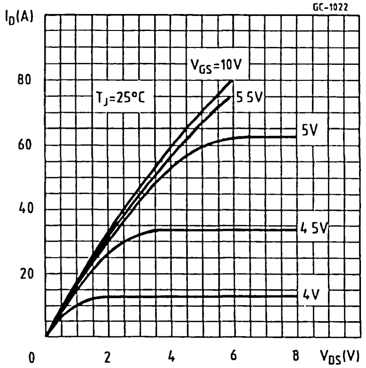
Thermal Impedance



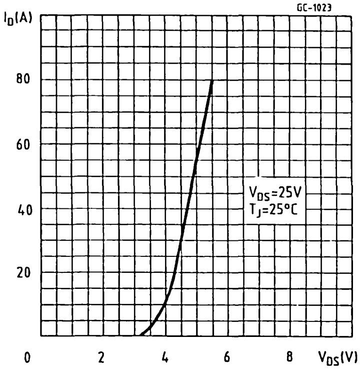
Derating Curve



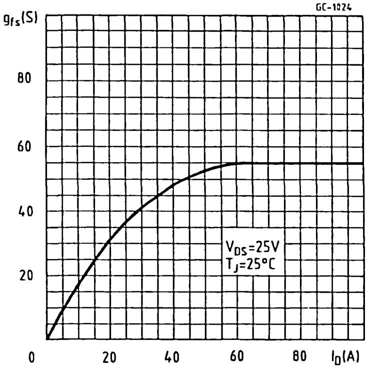
Output Characteristics



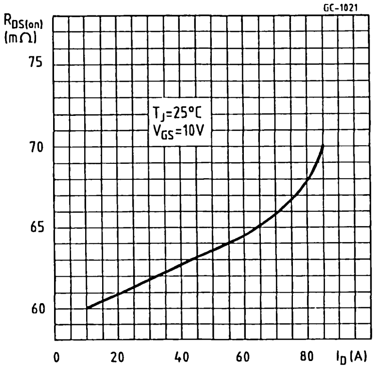
Transfer Characteristics



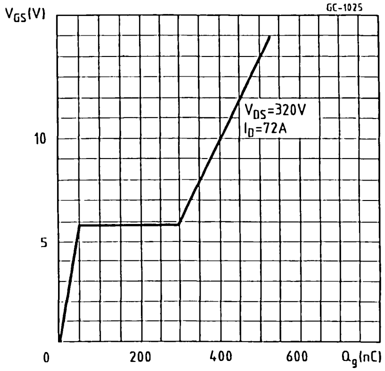
Transconductance



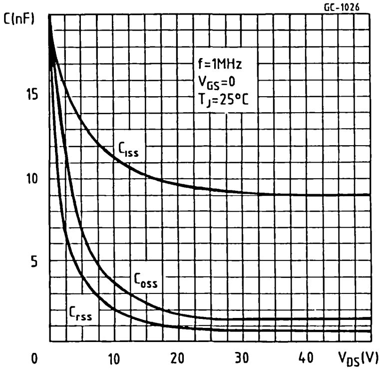
Static Drain-Source On Resistance



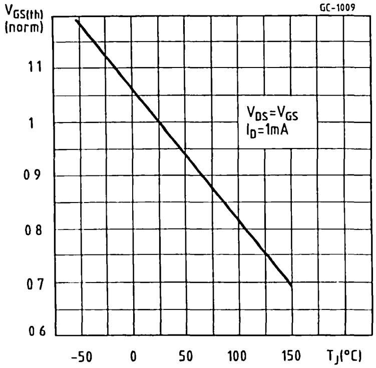
Gate Charge vs Gate-source Voltage



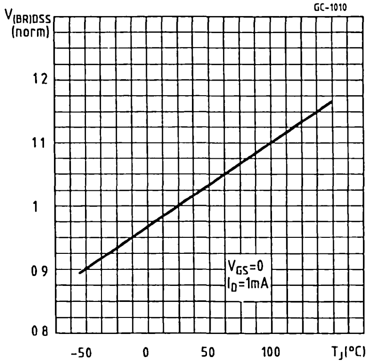
Capacitance Variation



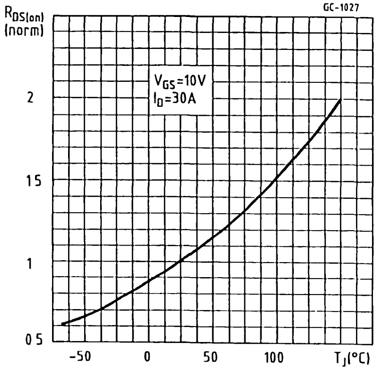
Normalized Gate Threshold Voltage vs Temperature



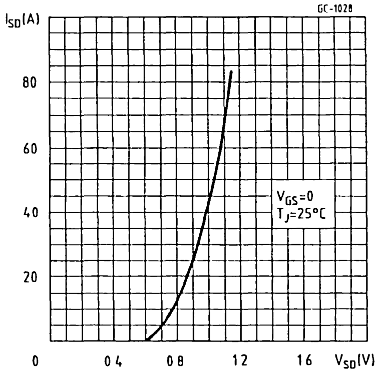
Normalized Breakdown Voltage vs Temperature



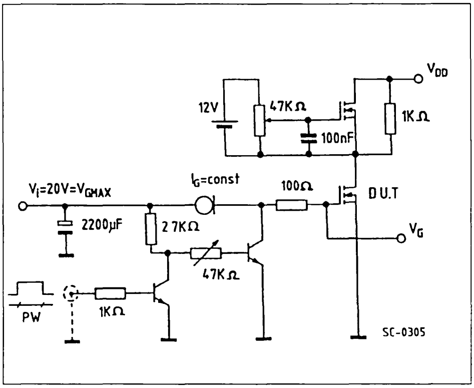
Normalized On Resistance vs Temperature



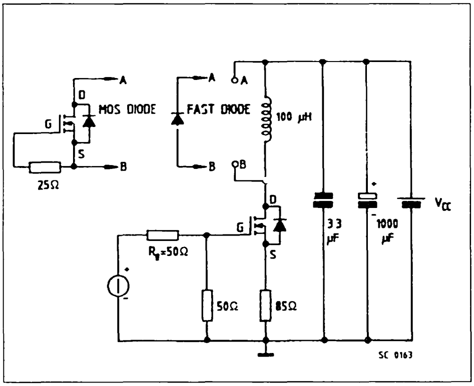
Source-Drain Diode Forward Characteristics



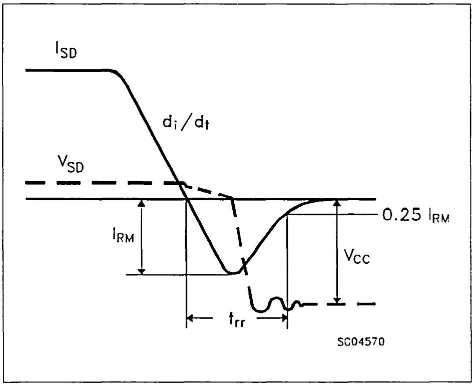
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

TSD4M351F
TSD4M351V

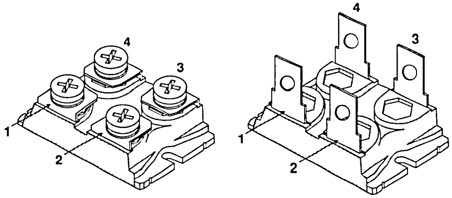
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M351F/V	350 V	0.075 Ω	50 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ms)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP350 FOR RATING)

INDUSTRIAL APPLICATIONS:

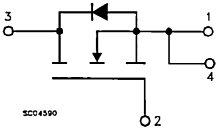
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M351V **TSD4M351F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	350	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	350	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	50	A
I_D	Drain Current (continuous) at T_c = 100 °C	31	A
I_{DM}(•)	Drain Current (pulsed)	200	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj-case}$ R_{thc-h}	Thermal Resistance Junction-Case Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max Max	0.25 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	350			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 30 A			0.075	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 30 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 2400 1000	pF pF pF

SWITCHING (INDUCTIVE LOAD)

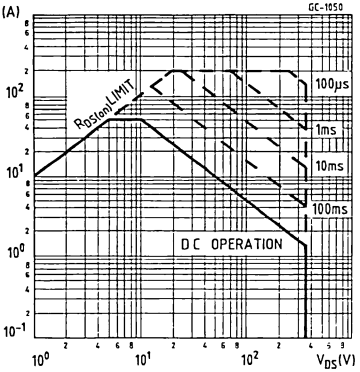
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 175 V I_D = 30 A R_{GS} = 25 Ω V_{GS} = 10 V			180 150 3000 300	ns A/µs ns ns

SOURCE DRAIN DIODE

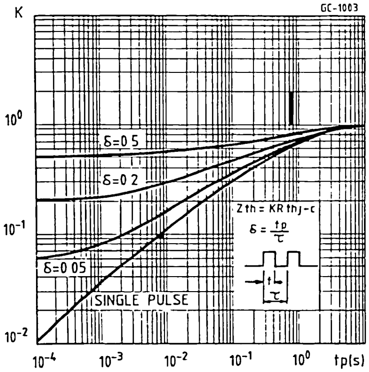
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				50 200	A A
V_{SD}	Forward On Voltage	I_{SD} = 50 A V_{GS} = 0			1.6	V
t_{rr}	Reverse Recovery Time	I_{SD} = 50 A di/dt = 100 A/µs		1000		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

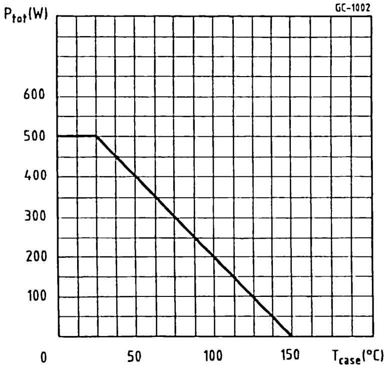
Safe Operating Areas



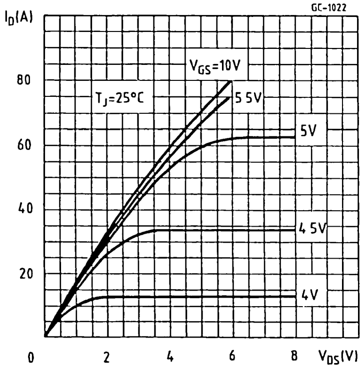
Thermal Impedance



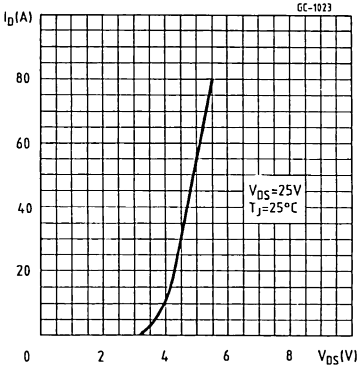
Derating Curve



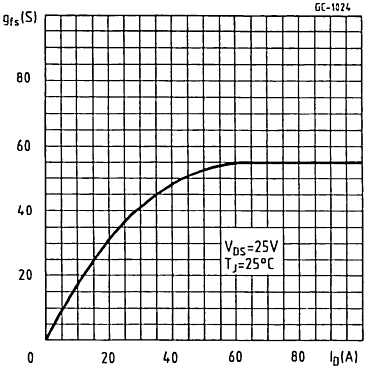
Output Characteristics



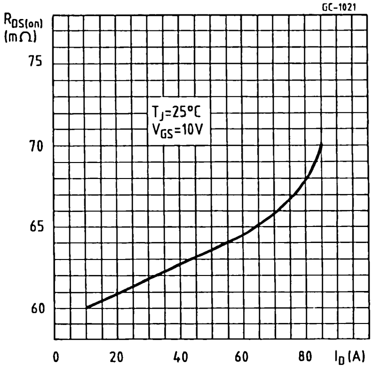
Transfer Characteristics



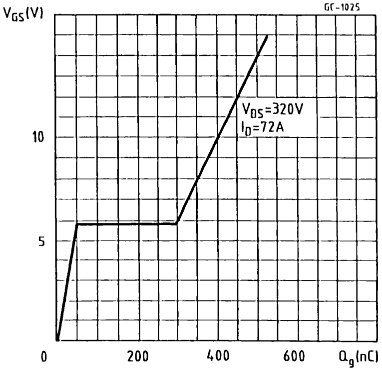
Transconductance



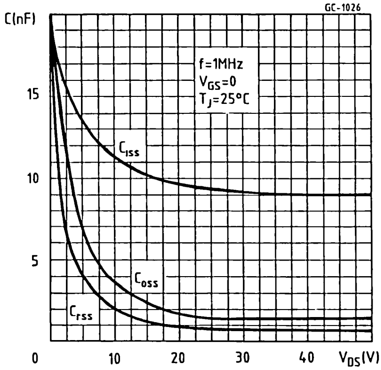
Static Drain-Source On Resistance



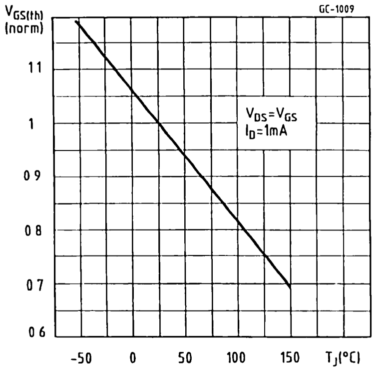
Gate Charge vs Gate-source Voltage



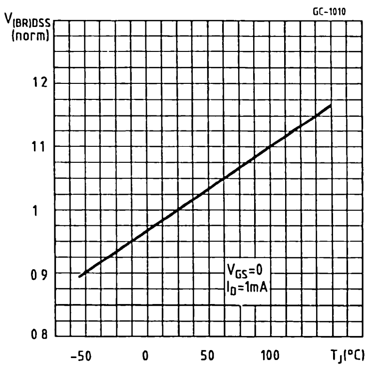
Capacitance Variation



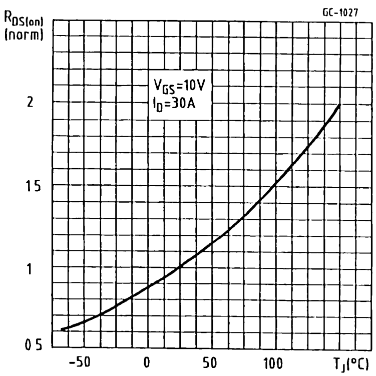
Normalized Gate Threshold Voltage vs Temperature



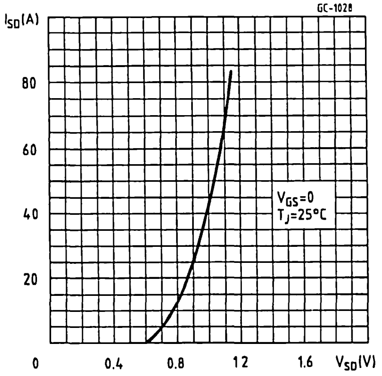
Normalized Breakdown Voltage vs Temperature



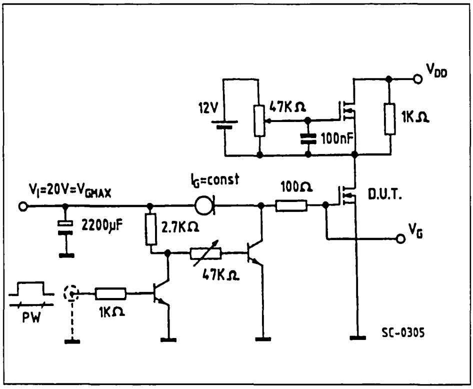
Normalized On Resistance vs Temperature



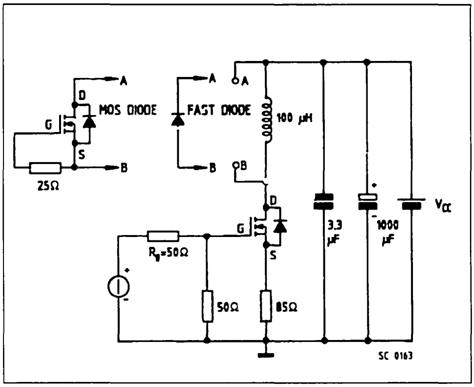
Source-Drain Diode Forward Characteristics



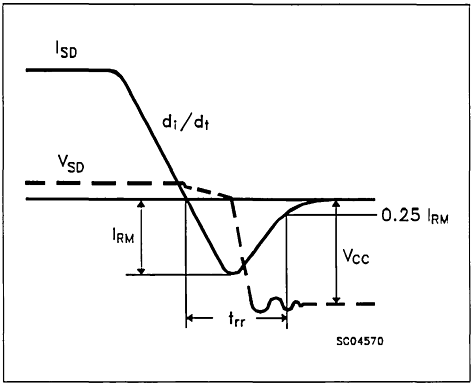
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



TSD4M450F
TSD4M450V

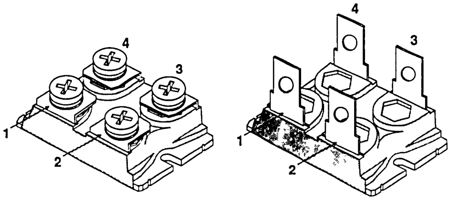
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M450F/V	500 V	0.1 Ω	45 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5 < ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP450 FOR RATING)

INDUSTRIAL APPLICATIONS:

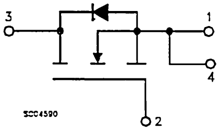
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD4M450V **TSD4M450F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	45	A
I_D	Drain Current (continuous) at T_c = 100 °C	28	A
I_{DM}(•)	Drain Current (pulsed)	180	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 28 A			0.1	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 28 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 2400 1000	pF pF pF

SWITCHING (INDUCTIVE LOAD)

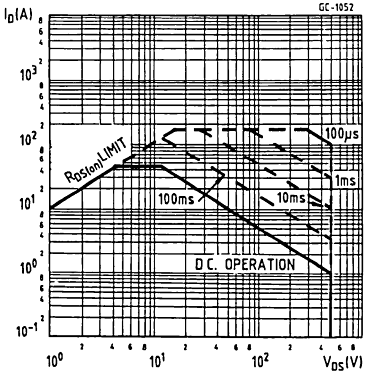
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 250 V I_D = 28 A R_{GS} = 25 Ω V_{GS} = 10 V			180 150 3000 300	ns A/µs ns ns

SOURCE DRAIN DIODE

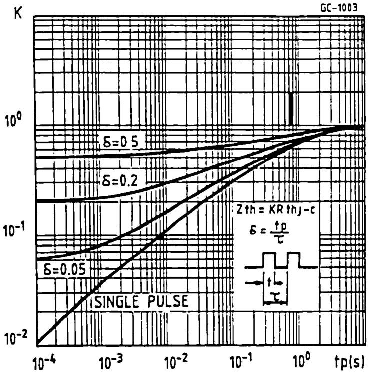
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				45 180	A A
V_{SD}	Forward On Voltage	I_{SD} = 45 A V_{GS} = 0			1.4	V
t_{rr}	Reverse Recovery Time	I_{SD} = 45 A di/dt = 100 A/µs		1300		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

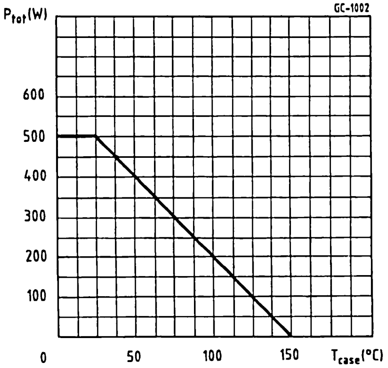
Safe Operating Areas



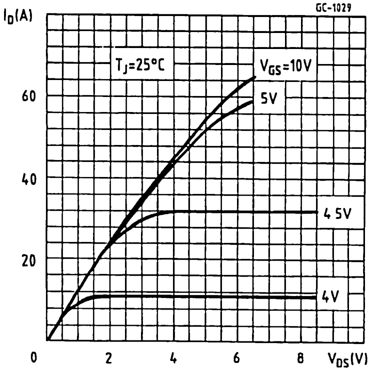
Thermal Impedance



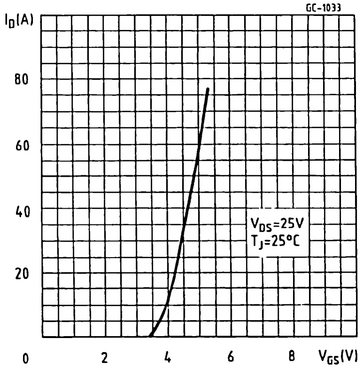
Derating Curve



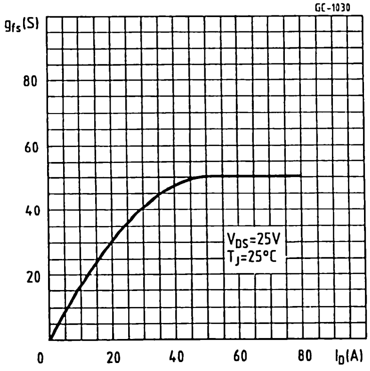
Output Characteristics



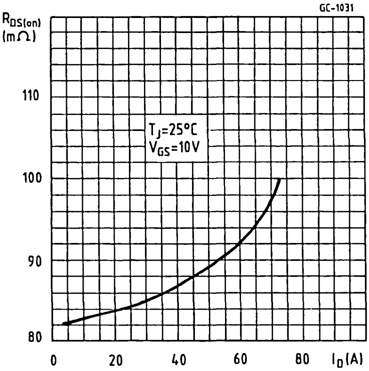
Transfer Characteristics



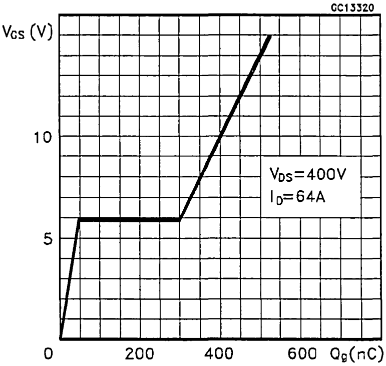
Transconductance



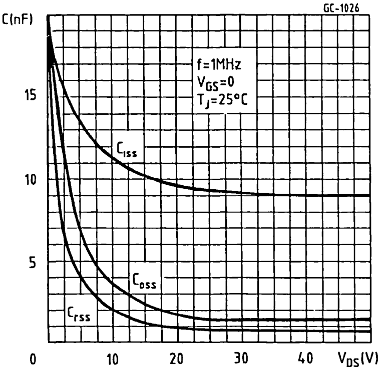
Static Drain-Source On Resistance



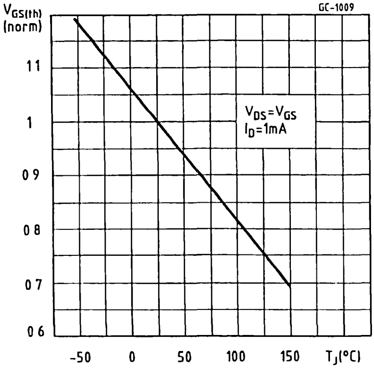
Gate Charge vs Gate-source Voltage



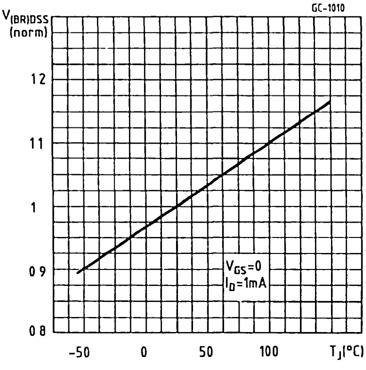
Capacitance Variation



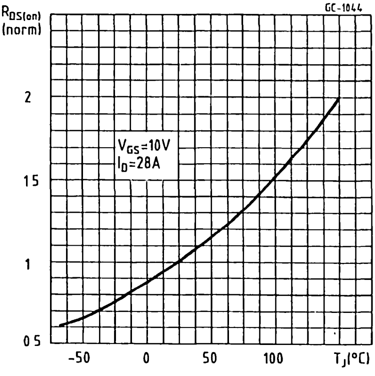
Normalized Gate Threshold Voltage vs Temperature



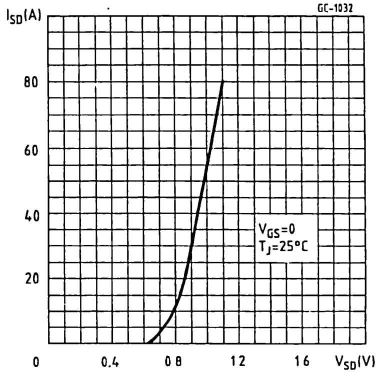
Normalized Breakdown Voltage vs Temperature



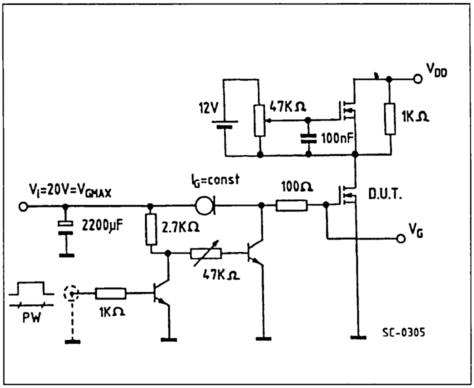
Normalized On Resistance vs Temperature



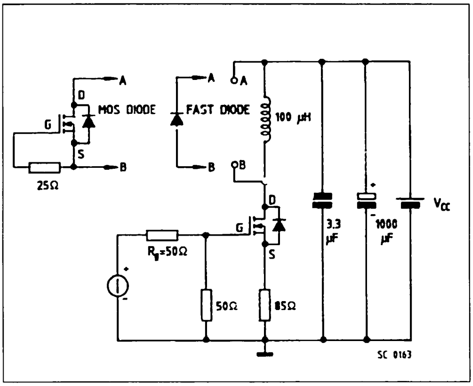
Source-Drain Diode Forward Characteristics



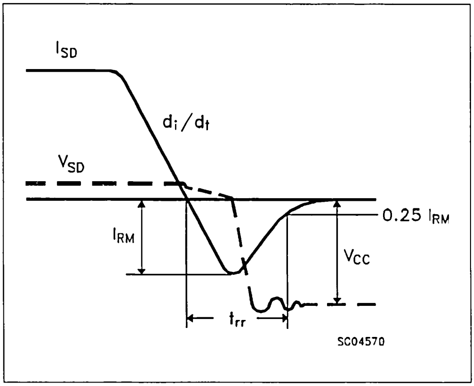
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

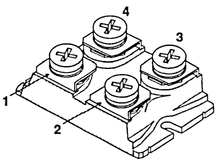
TSD4M451F
TSD4M451V

N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

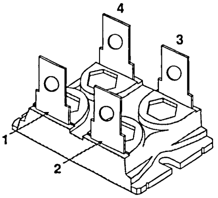
TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD4M451F/V	450 V	0.1 Ω	45 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE IRFP450 FOR RATING)

INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



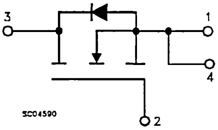
TSD4M451V



TSD4M451F

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	450	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	450	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	45	A
I_D	Drain Current (continuous) at T_c = 100 °C	28	A
$I_{DM}(\bullet)$	Drain Current (pulsed)	180	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-Case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-Heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	450			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	μA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 28 A			0.1	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 28 A	28			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 2400 1000	pF pF pF

SWITCHING (INDUCTIVE LOAD)

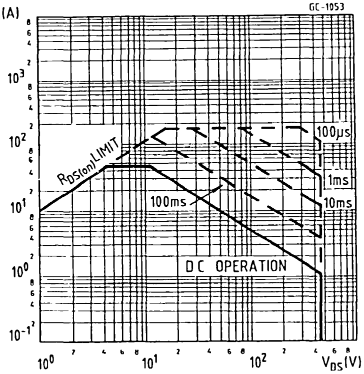
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 225 V I_D = 28 A R_{GS} = 25 Ω V_{GS} = 10 V			180 150 3000 300	ns A/μs ns ns

SOURCE DRAIN DIODE

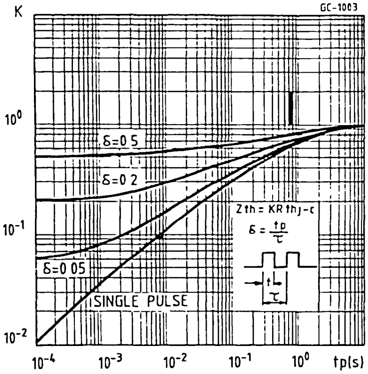
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				45 180	A A
V_{SD}	Forward On Voltage	I_{SD} = 45 A V_{GS} = 0			1.4	V
t_{rr}	Reverse Recovery Time	I_{SD} = 45 A di/dt = 100 A/μs		1300		ns

(*) Pulsed. Pulse duration = 300 μs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

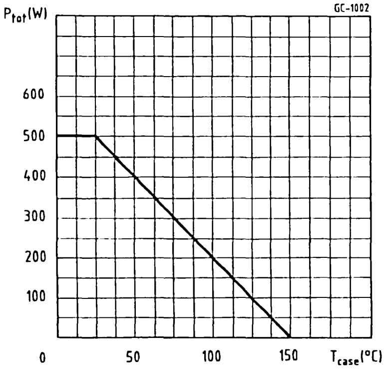
Safe Operating Areas



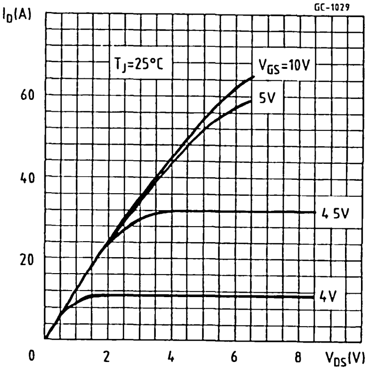
Thermal Impedance



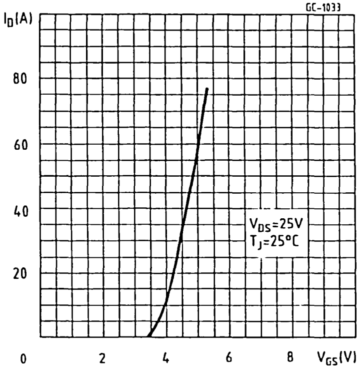
Derating Curve



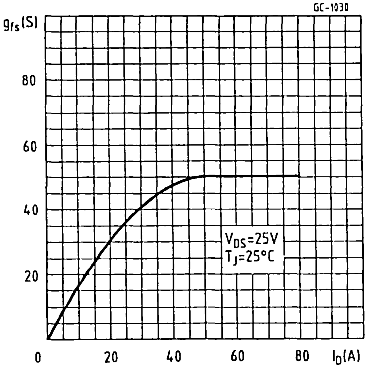
Output Characteristics



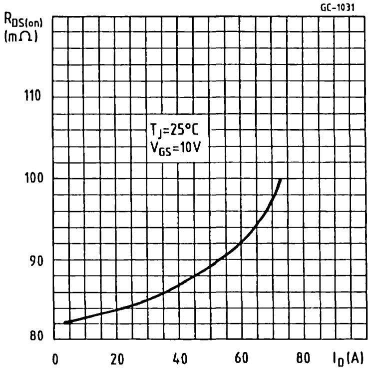
Transfer Characteristics



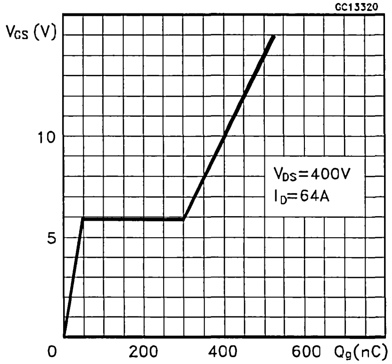
Transconductance



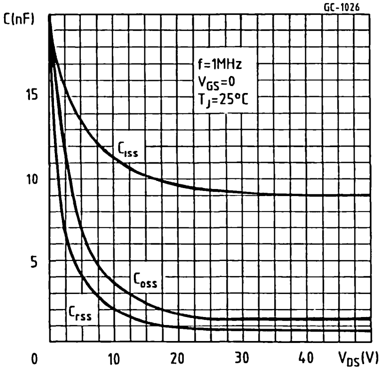
Static Drain-Source On Resistance



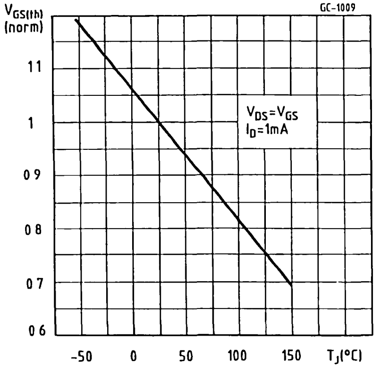
Gate Charge vs Gate-source Voltage



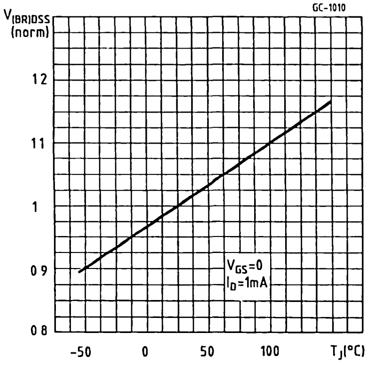
Capacitance Variation



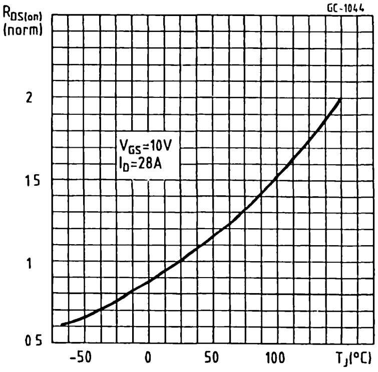
Normalized Gate Threshold Voltage vs Temperature



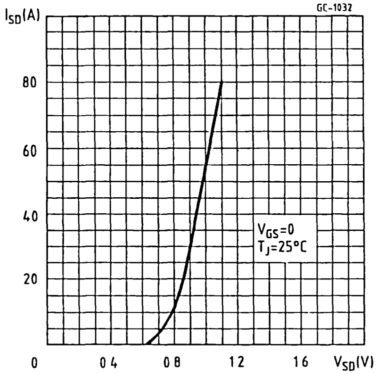
Normalized Breakdown Voltage vs Temperature



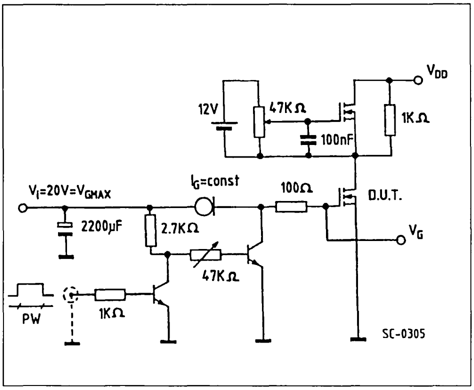
Normalized On Resistance vs Temperature



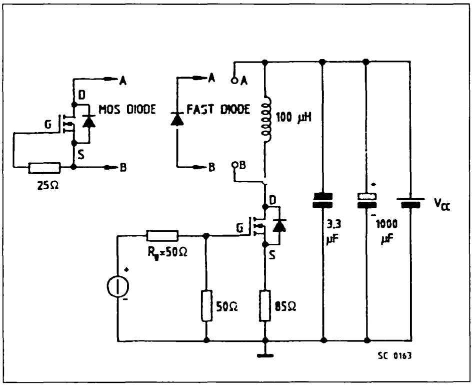
Source-Drain Diode Forward Characteristics



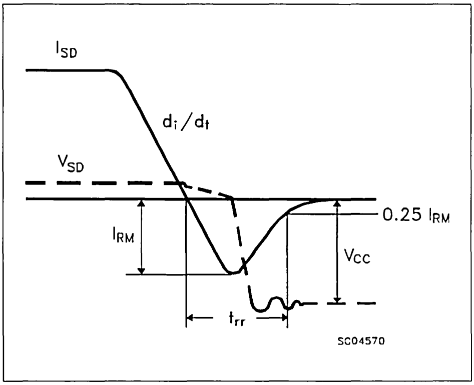
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

TSD5MG40F
TSD5MG40V

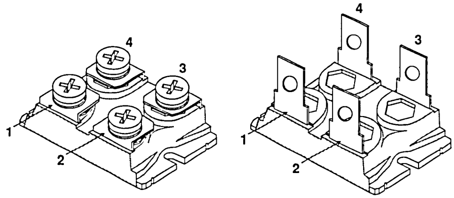
N - CHANNEL ENHANCEMENT MODE ISOFET POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD5MG40F/V	1000 V	0.7 Ω	17 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 ns)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE STHV102 FOR RATING)

INDUSTRIAL APPLICATIONS:

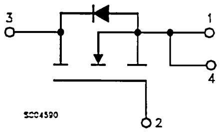
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT
- OUTPUT STAGE FOR PWM, ULTRASONIC CIRCUITS



TSD5MG40V **TSD5MG40F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	1000	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	1000	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	17	A
I_D	Drain Current (continuous) at T_c = 100 °C	10.7	A
I_{DM}(•)	Drain Current (pulsed)	60	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	1000			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			500 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 9 A			0.7	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 15 V I_D = 9 A	5			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			7000 1250 660	pF pF pF

SWITCHING (INDUCTIVE LOAD)

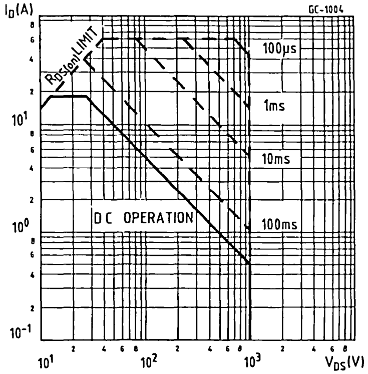
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 500 V I_D = 15 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		60 100 1200 200		ns A/µs ns ns

SOURCE DRAIN DIODE

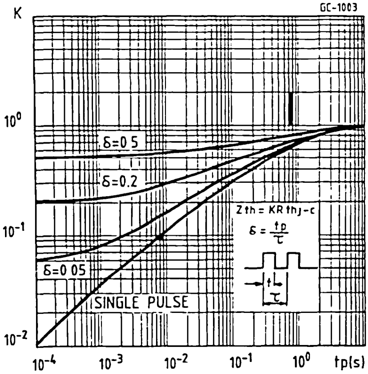
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				17 60	A A
V_{SD}	Forward On Voltage	I_{SD} = 17 A V_{GS} = 0			2.5	V
t_{rr}	Reverse Recovery Time	I_{SD} = 17 A di/dt = 100 A/µs			2.5	µs

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

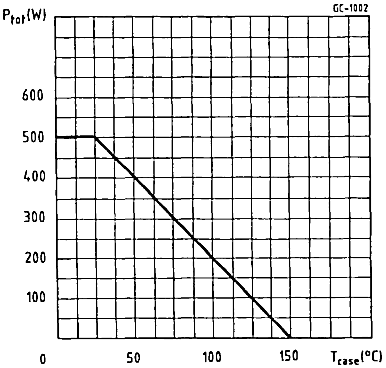
Safe Operating Areas



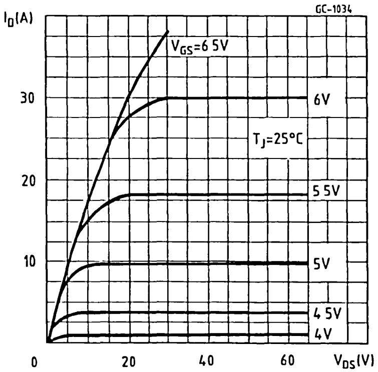
Thermal Impedance



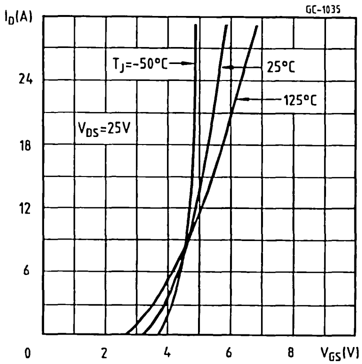
Derating Curve



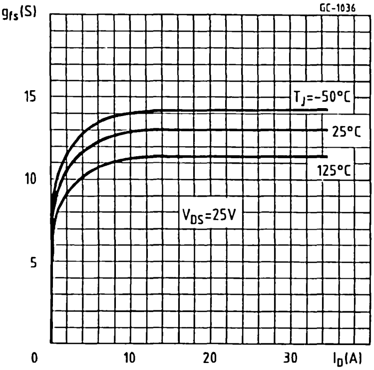
Output Characteristics



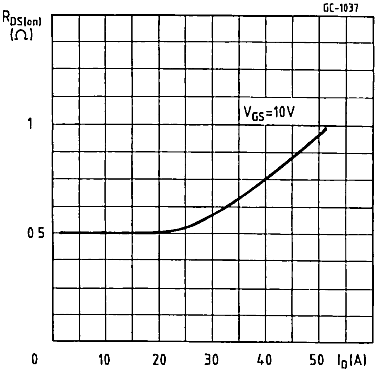
Transfer Characteristics



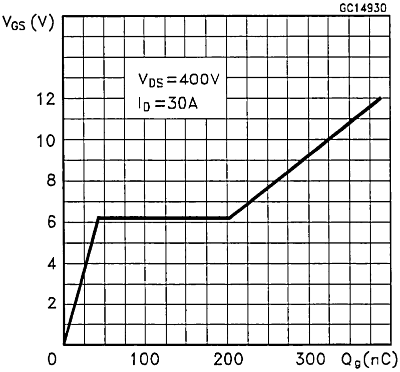
Transconductance



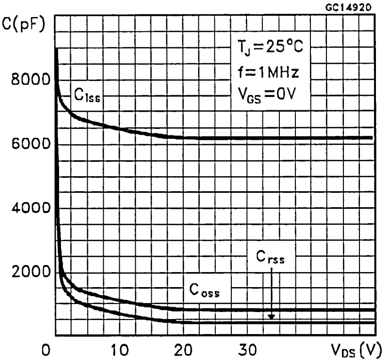
Static Drain-Source On Resistance



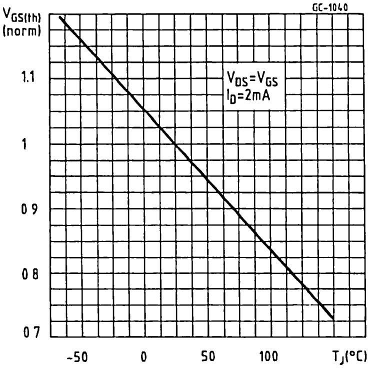
Gate Charge vs Gate-source Voltage



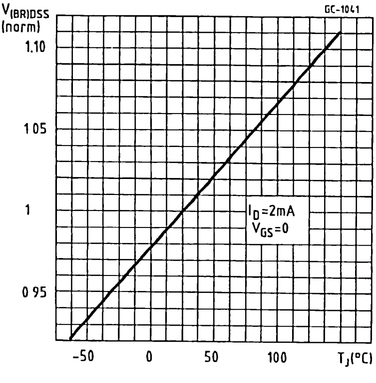
Capacitance Variation



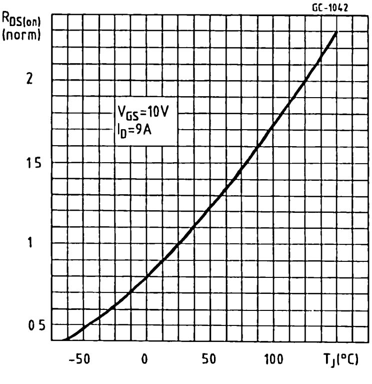
Normalized Gate Threshold Voltage vs Temperature



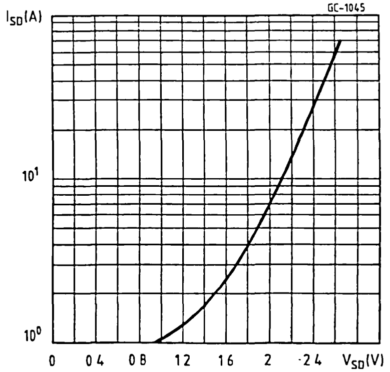
Normalized Breakdown Voltage vs Temperature



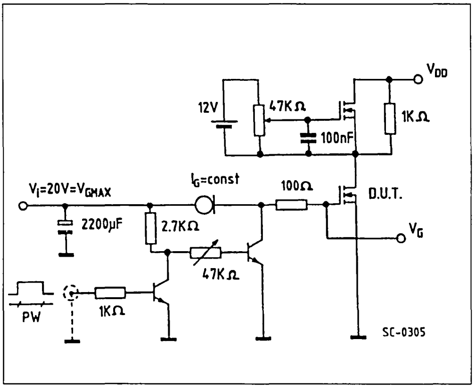
Normalized On Resistance vs Temperature



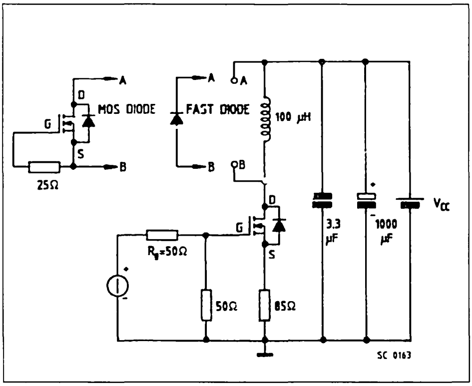
Source-Drain Diode Forward Characteristics



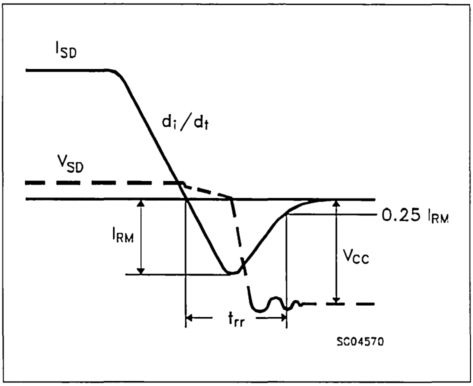
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

TSD20N100F
TSD20N100V

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

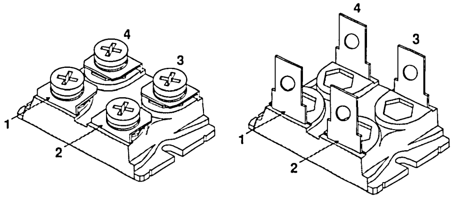
TENTATIVE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD20N100F/V	1000 V	0.5 Ω	20 A

- HIGH VOLTAGE POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5nH)

INDUSTRIAL APPLICATIONS:

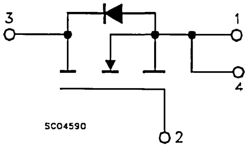
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TSD20N100V **TSD20N100F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	1000	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	1000	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	20	A
I_D	Drain Current (continuous) at T_c = 100 °C	12.5	A
I_{DM}(•)	Drain Current (pulsed)	70	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD22N80F
TSD22N80V

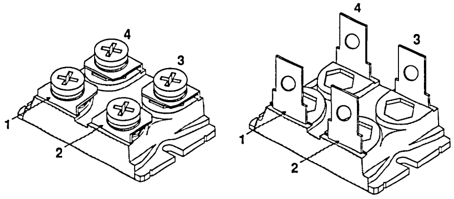
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD22N80F/V	800 V	0.4 Ω	22 A

- HIGH VOLTAGE, HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- VERY LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY < 5 nH)
- AVALANCHE RUGGEDNESS TECHNOLOGY (SEE STH8N80 FOR RATING)

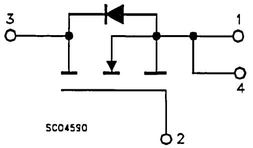
INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TSD22N80V **TSD22N80F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	800	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	800	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	22	A
I_D	Drain Current (continuous) at T_c = 100 °C	13.7	A
I_{DM}(•)	Drain Current (pulsed)	77	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj-case}$ R_{thc-h}	Thermal Resistance Junction-case Thermal Resistance Case-heatsink With Conductive Grease Applied	Max Max	0.312 0.05	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	800			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			300 1.5	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 300	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 12 A			0.4	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 12 A	9			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		6000 800 350		pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} =V I_D =A R_{GS} = 50 Ω V_{GS} = 10 V				ns ns ns ns

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				22 77	A A
V_{SD}	Forward On Voltage	I_{SD} = 22 A V_{GS} = 0			2.5	V
t_{rr}	Reverse Recovery Time	I_{SD} = 22 A di/dt = 100 A/µs		2		µs

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD40N50DF
TSD40N50DV

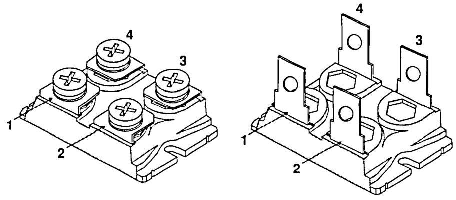
N - CHANNEL ENHANCEMENT MODE FREDFET MODULE

TENTATIVE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD40N50DF/DV	500 V	0.12 Ω	40 A

- POWER MOS TRANSISTOR MODULE WITH FAST RECOVERY BULK DIODE: $t_{rr} < 300$ ns @ $T_j = 150\ ^{o}C$
- HIGH CURRENT POWER MOS MODULE
- SPECIFIED COMMUTATING SOA
- PARTICULARLY SUITABLE FOR BRIDGE CONFIGURATION
- AVALANCHE RUGGEDNESS TECHNOLOGY
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5nH)

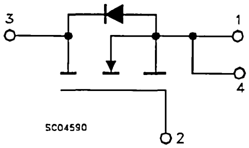
INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TSD40N50DV **TSD40N50DF**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	40	A
I_D	Drain Current (continuous) at T_c = 100 °C	24	A
I_{DM}(•)	Drain Current (pulsed)	160	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD180N10F
TSD180N10V

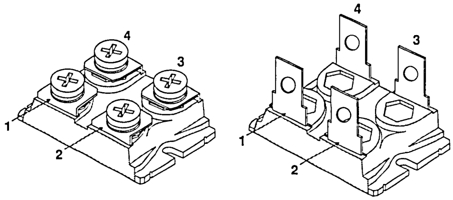
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TENTATIVE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD180N10F/V	100 V	0.007 Ω	180 A

- VERY HIGH DENSITY POWER MOS TECHNOLOGY
- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5nH)

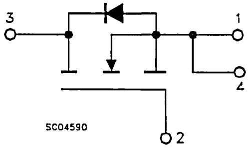
INDUSTRIAL APPLICATIONS:
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL



TSD180N10V TSD180N10F

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	180	A
I_D	Drain Current (continuous) at T_c = 100 °C	112	A
I_{DM}(•)	Drain Current (pulsed)	540	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD200N05F
TSD200N05V

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

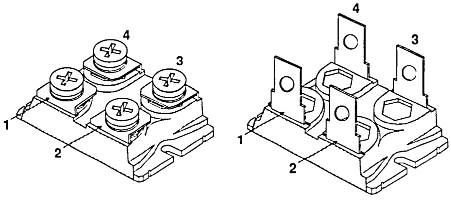
ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD200N05F/V	50 V	0.006 Ω	200 A

- VERY HIGH DENSITY POWER MOS TECHNOLOGY
- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5nH)

INDUSTRIAL APPLICATIONS:

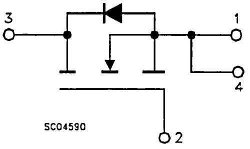
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL



TSD200N05V **TSD200N05F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	50	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	50	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	200	A
I_D	Drain Current (continuous) at T_c = 100 °C	126	A
I_{DM}(•)	Drain Current (pulsed)	600	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case Max	0.31	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.20	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	50			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			400 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 2 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 100 A			0.006	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 100 A	20			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 4000 720	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on Time	V_{DD} = 40 V I_D = 100 A		200		ns
$(di/dt)_{on}$	Turn-on Current Slope	R_{GS} = 25 Ω V_{GS} = 10 V				ns
$t_{d(off)}$	Turn-off Delay Time			1500		ns
t_f	Fall Time			600		ns

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				200 600	A A
V_{SD}	Forward On Voltage	I_{SD} = 200 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 200 A di/dt = 100 A/µs		80		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

TSD250N05F
TSD250N05V

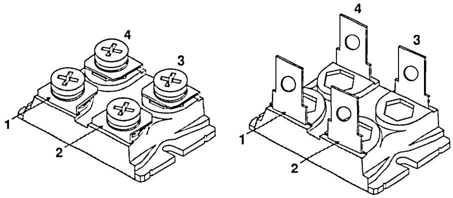
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TENTATIVE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
TSD250N05F/V	50 V	0.004 Ω	250 A

- VERY HIGH DENSITY POWER MOS TECHNOLOGY
- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- ISOLATED CASE (2500V RMS)
- EASY TO MOUNT
- LOW INTERNAL PARASITIC INDUCTANCE (TYPICALLY 5nH)

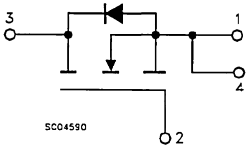
INDUSTRIAL APPLICATIONS:
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL



TSD250N05V **TSD250N05F**

ISOTOP

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	50	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	50	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	250	A
I_D	Drain Current (continuous) at T_c = 100 °C	155	A
I_{DM}(•)	Drain Current (pulsed)	750	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

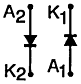
SGS-THOMSON
MICROELECTRONICS

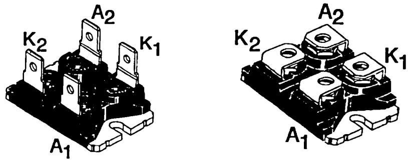
BYT 230PI(V)-200 →400

FAST RECOVERY RECTIFIER DIODES

- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

Insulating voltage 2500 V_{RMS}





Fast-on version

Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \le 10\mu s$	500	A
$I_{F(RMS)}$	RMS Forward Current	per leg	50	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 60°C$ $\delta = 0.5$ per leg	30	A
I_{FSM}	Surge non Repetitive Forward Current	$t_p = 10ms$ Sinusoidal	350	A
P	Power Dissipation	$T_{case} = 60°C$ per leg	50	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

Symbol	Parameter	BYT 230PI(V)-			Unit
		200	300	400	
V_{RRM}	Repetitive Peak Reverse Voltage	200	300	400	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	250	350	450	V

THERMAL RESISTANCES

Symbol	Test Conditions		Value	Unit
$R_{th\ (j-c)}$	Junction-case	per leg total	1.5 0.8	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			35	µA
	T_j = 100°C				6	mA
V_F	T_j = 25°C	I_F = 30A			1.5	V
	T_j = 100°C				1.4	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A di_F/dt = – 15A/µs V_R = 30V			100	ns
		I_F = 0.5A I_R = 1A I_{rr} = 0.25A			50	

TURN -OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	di_F/dt = – 120A/µs	V_{CC} = 200V I_F = 30A $L_p \leq$ 0.05µH T_j = 100°C See Figure 11			75	ns
	di_F/dt = – 240A/µs			50		
I_{RM}	di_F/dt = – 120A/µs				9	A
	di_F/dt = – 240A/µs			12		

TURN -OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 60V $I_F = I_{F(AV)}$ See note di_F/dt = – 30A/µs L_p = 1µH See Figure 12		3.3		

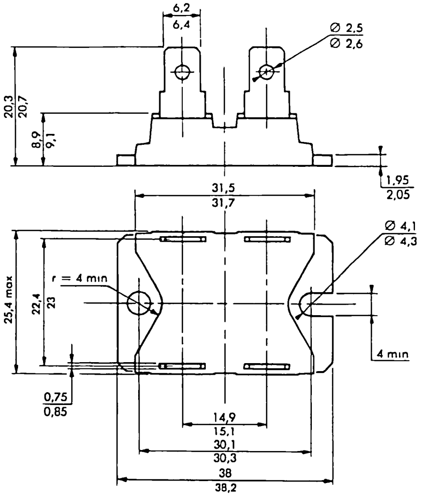
Note : Applicable to BYT 230PI(V)-400 only

To evaluate the conduction losses use the following equations :

$V_F = 1.1 + 0.0095\ I_F$ $P = 1.1 \times I_{F(AV)} + 0.0095\ I_F^2{}_{(RMS)}$

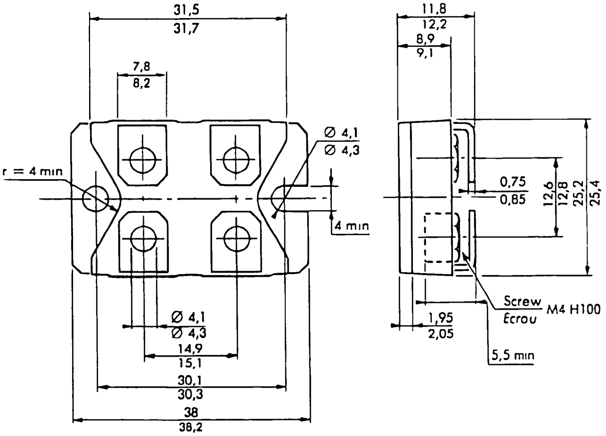
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + suffix V

Recommended screw torque value : 13 ± 2kg cm
Maximum screw torque value : 15kg cm

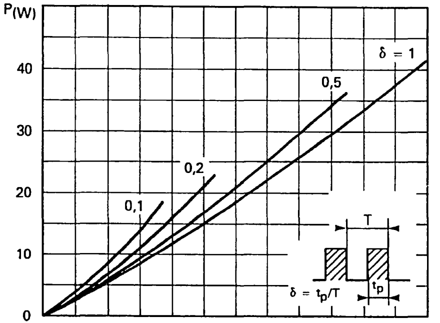


FIGURE 1 : Low frequence power losses versus average current.

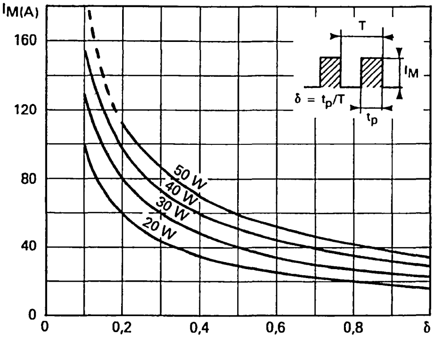


FIGURE 2 : Peak current versus form factor.

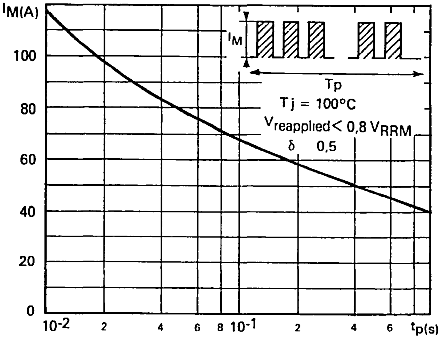


FIGURE 3 : Non repetitive peak surge current versus overload duration.

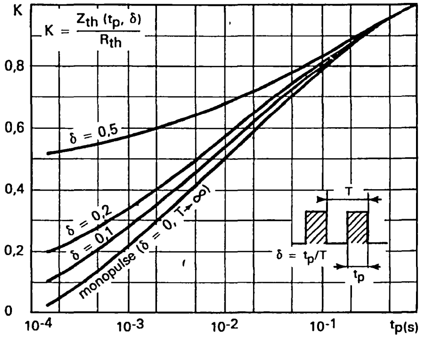


FIGURE 4 : Thermal impedance versus pulse width.

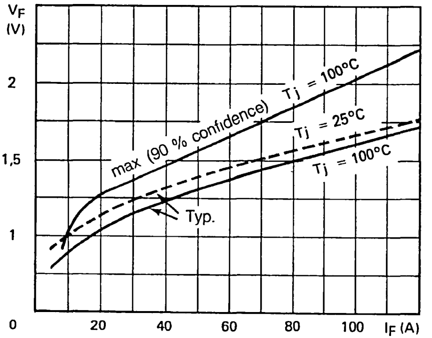


FIGURE 5 : Voltage drop versus forward current.

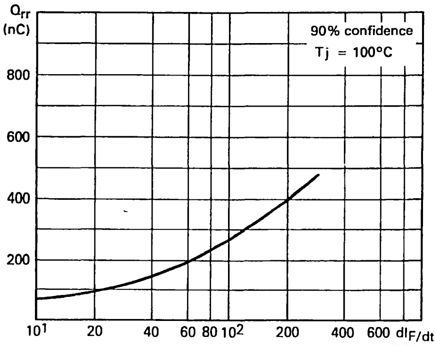


FIGURE 6 : Recovery charge versus dIF/dt.

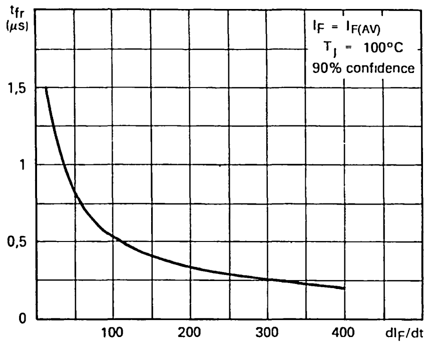


FIGURE 7 : Recovery time versus $dI_{F/dt}$. (A/µs)

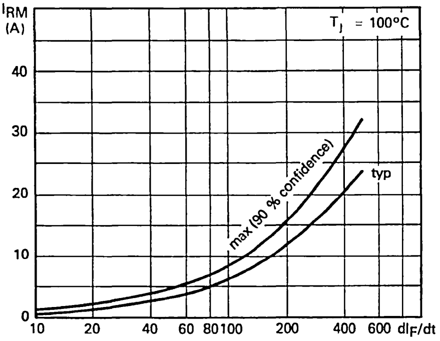


FIGURE 8 : Peak reverse current versus $dI_{F/dt}$. (A/µs)

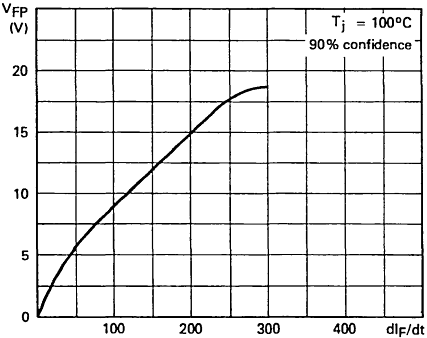


FIGURE 9 : Peak forward voltage versus $dI_{F/dt}$. (A/µs)

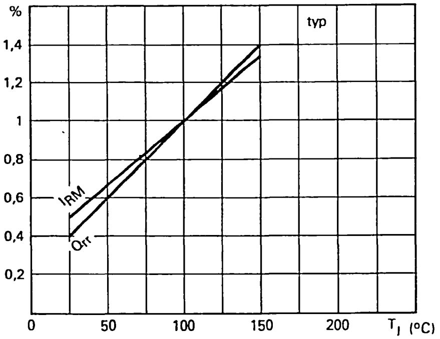


FIGURE 10 : Dynamic parameters versus junction temperature.

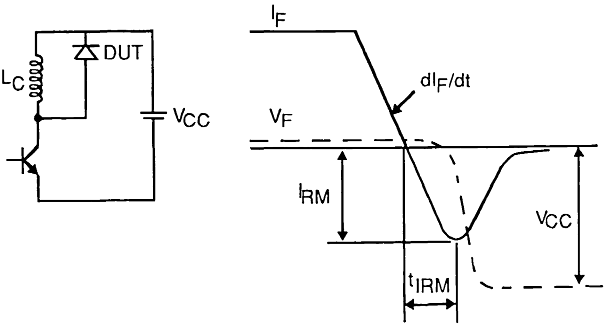


Figure 11 : Turn-off switching characteristics (without series inductance).

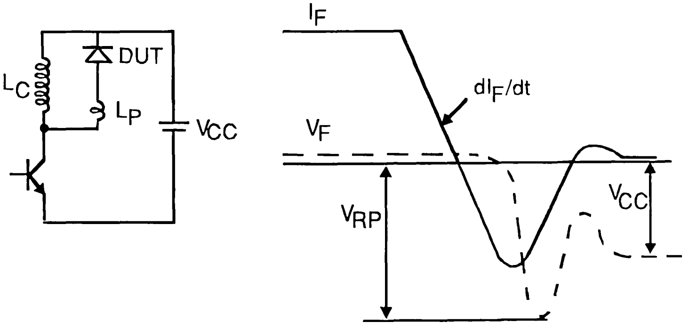


Figure 12 : Turn-off switching characteristics (with series inductance).

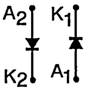
SGS-THOMSON
MICROELECTRONICS

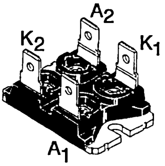
BYT 230 PI(V)-600/800

FAST RECOVERY RECTIFIER DIODES

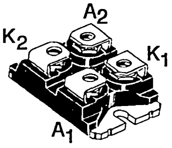
- HIGH REVERSE VOLTAGE CAPABILITY
- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

Insulating voltage 2500 V_{RMS}





Fast-on version



Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	375	A
$I_{F(RMS)}$	RMS Forward Current	per leg	70	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 50°C$ $\delta = 0.5$ per leg	30	A
I_{FSM}	Surge non Repetitive Forward Current	$t_p = 10ms$ Sinusoidal	200	A
P	Power Dissipation	$T_{case} = 50°C$ per leg	60	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

Symbol	Parameter	BYT 230 PI (V)-		Unit
		600	800	
V_{RRM}	Repetitive Peak Reverse Voltage	600	800	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	640	850	V

THERMAL RESISTANCES

Symbol	Parameter		Value	Unit
$R_{th\ (j-c)}$	Junction-case	per leg total	1.5 0.8	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				5	mA
V_F	T_j = 25°C	I_F = 30A			1.9	V
	T_j = 100°C				1.8	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A dI_F/dt = – 15A/µs V_R = 30V			130	ns
		I_F = 0.5A I_R=1A I_{RR} = 0.25A			55	

TURN -OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	dI_F/dt = – 120A/µs	V_{CC} = 200V I_F = 30A $L_p \leq$ 0.05µH T_j = 100°C See Figure 11			160	ns
	dI_F/dt = – 240A/µs			100		
I_{RM}	dI_F/dt = – 120A/µs				15	A
	dI_F/dt = – 240A/µs			19		

TURN -OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

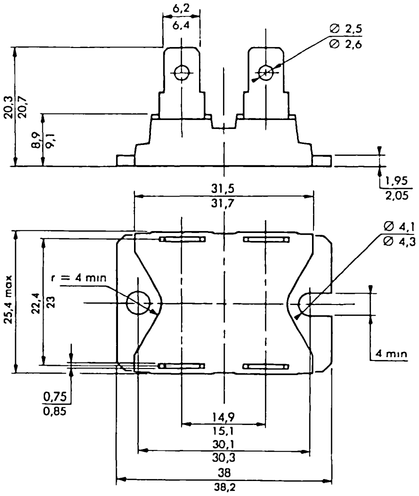
Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 150V $I_F = I_{F(AV)}$ dI_F/dt = – 30A/µs L_p = 4µH See Figure 12			4	

To evaluate the conduction losses use the following equation :

$V_F = 1.47 + 0.010\, I_F$ $\quad P = 1.47 \times IF(AV) + 0.010 I_F^2{}_{(RMS)}$

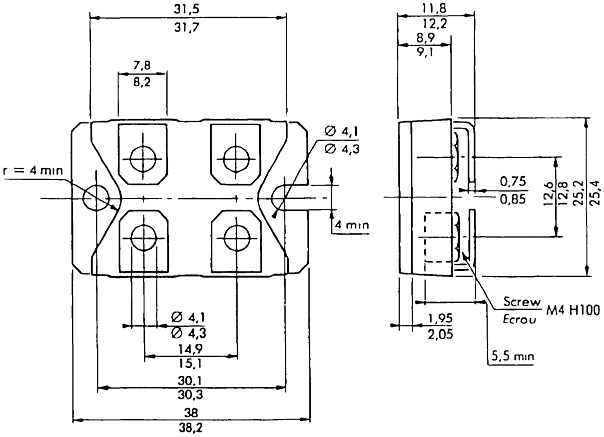
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + Suffix V

Recommended screw torque value : 13 ± 2kg.cm.
Maximum screw torque value · 15kg.cm.

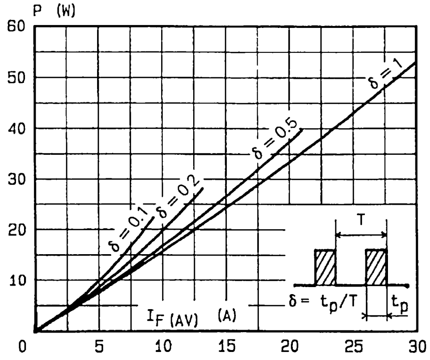


FIGURE 1 : Low frequency power losses versus average current.

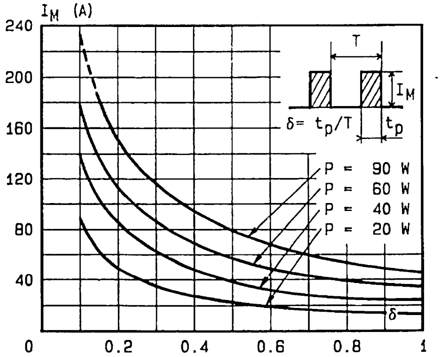


FIGURE 2 : Peak current versus form factor.

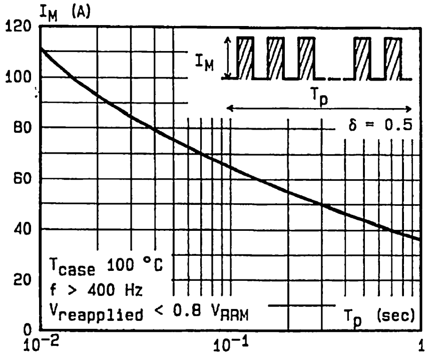


FIGURE 3 : Non repetitive peak surge current versus overload duration.

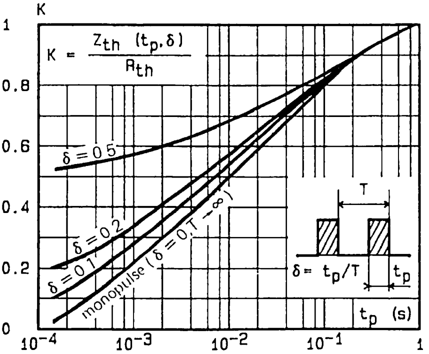


FIGURE 4 : Thermal impedance versus pulse width.

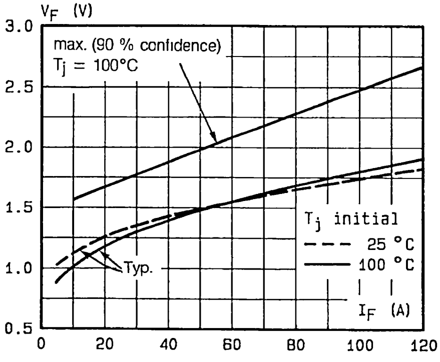


FIGURE 5 : Voltage drop versus forward current.

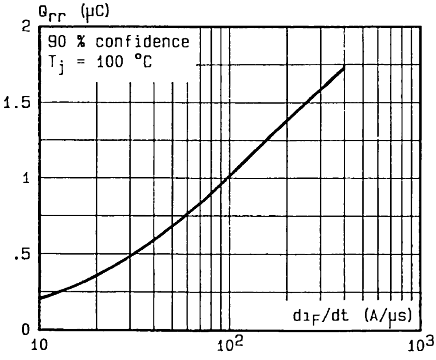


FIGURE 6 : Recovery charge versus di_F/dt.

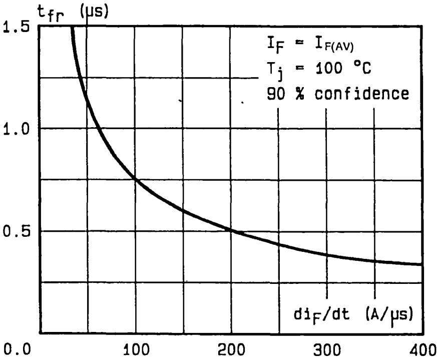


FIGURE 7 : Recovery time versus dI_F/dt.

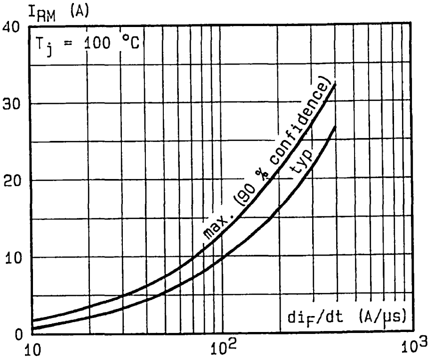


FIGURE 8 : Peak reverse current versus dI_F/dt.

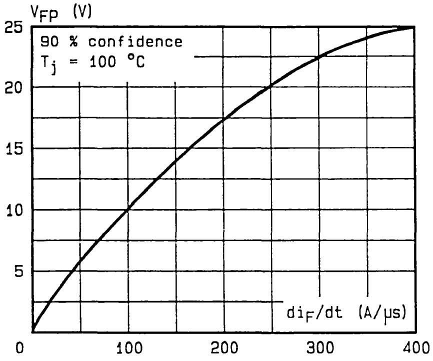


FIGURE 9 : Peak forward voltage versus dI_F/dt.

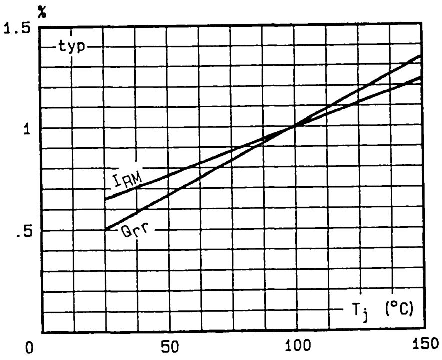


FIGURE 10 : Dynamic parameters versus junction temperature.

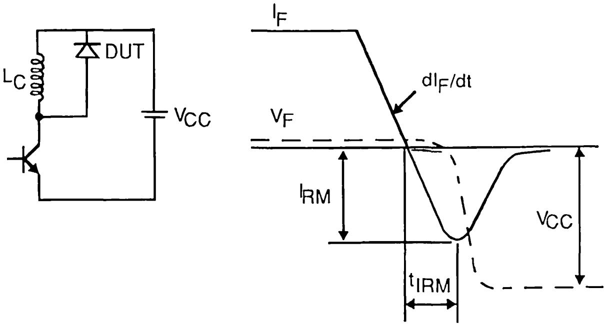


Figure 11 : Turn-off switching characteristics (without series inductance).

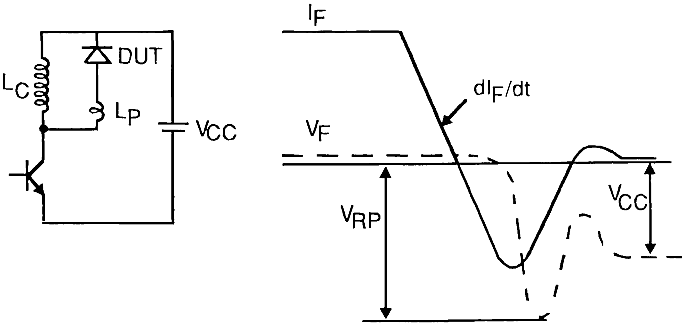


Figure 12 : Turn-off switching charcteristics (with series inductance).

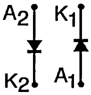
SGS-THOMSON
MICROELECTRONICS

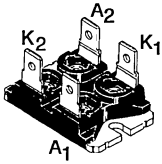
BYT 230 PI(V)-1000

FAST RECOVERY RECTIFIER DIODE

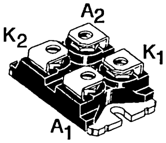
- VERY HIGH REVERSE VOLTAGE CAPABILITY
- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

Insulating voltage : 2500 V_{RMS}





Fast-on version



Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS

Symbol	Parameter		Value	Unit
V_{RRM}	Repetitive Peak Reverse Voltage		1000	V
V_{RSM}	Non Repetitive Peak Reverse Voltage		1000	V
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	375	A
$I_{F(RMS)}$	RMS Forward Current	per leg	70	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 50°C$ $\delta = 0.5$ per leg	30	A
I_{FSM}	Surge Non Repetitive Forward Current	$t_p = 10ms$ Sinusoïdal	200	A
P	Power Dissipation	$T_{case} = 50°C$ per leg	60	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

THERMAL RESISTANCES

Symbol	Parameter		Value	Unit
$R_{th\ (j-c)}$	Junction-case	per leg total	1.5 0.8	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				5	mA
V_F	T_j = 25°C	I_F = 30A			1.9	V
	T_j = 100°C				1.8	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A di_F/dt = – 15A/µs V_R = 30V			165	ns
		I_F = 0.5A I_R=1A I_{rr}=0.25A			70	

TURN-OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	di_F/dt = – 120A/µs	V_{CC} = 200V I_F = 30A $L_p \leq$ 0.05µH T_j = 100°C See figure 11			200	ns
	di_F/dt = – 240A/µs			120		
I_{RM}	di_F/dt = – 120A/µs				19.5	A
	di_F/dt = – 240A/µs			22		

TURN-OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

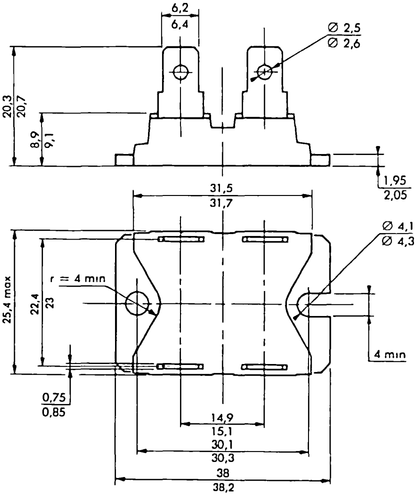
Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 200V $I_F = I_{F\,(AV)}$ di_F/dt = – 30A/µs L_p = 5µH See figure 12			4.5	

To evaluate the conduction losses use the following equation :

$V_F = 1.47 + 0.010\ I_F$ $\qquad$ $P = 1.47 \times IF(AV) + 0.010 I_F{}^2{}_{(RMS)}$

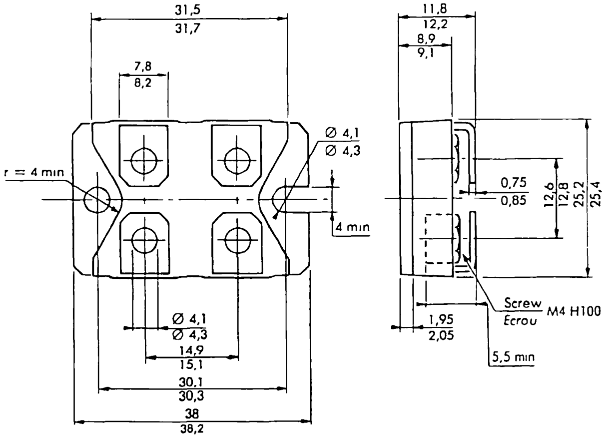
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Pastic : SCREW VERSION



Marking : type number + suffix V

Recommended screw torque value · 13 ± 2kg.cm
Maximum screw torque value : 15kg cm.

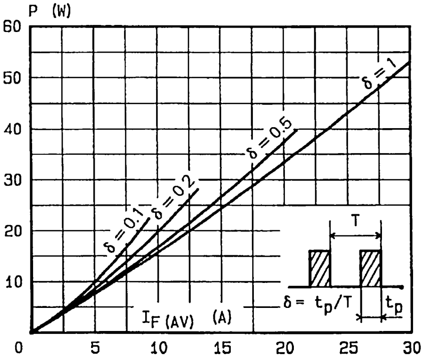


FIGURE 1 : Low frequency power losses versus average current.

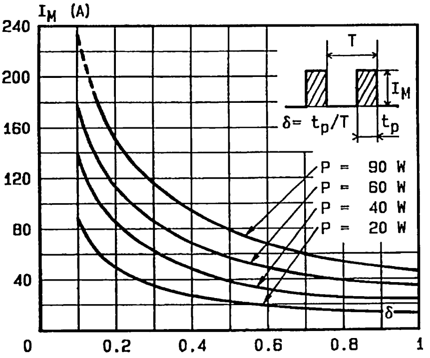


FIGURE 2 : Peak current versus form factor.

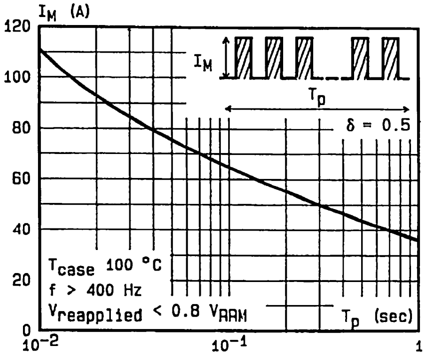


FIGURE 3 : Non repetitive peak surge current versus overload duration.

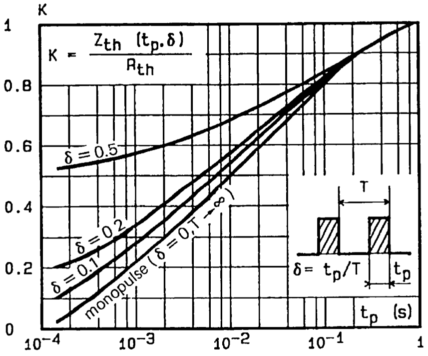


FIGURE 4 : Thermal impedance versus pulse width.

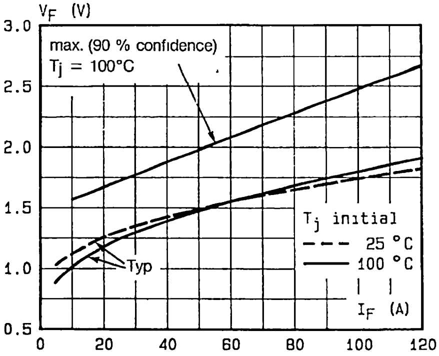


FIGURE 5 : Voltage drop versus forward current.

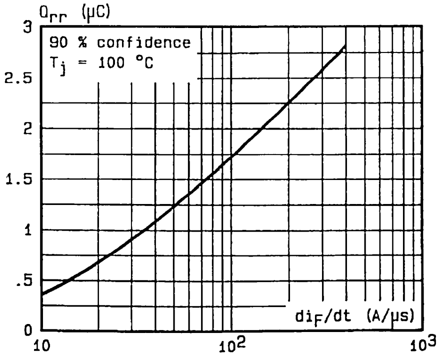


FIGURE 6 : Recovery charge versus di_F/dt.

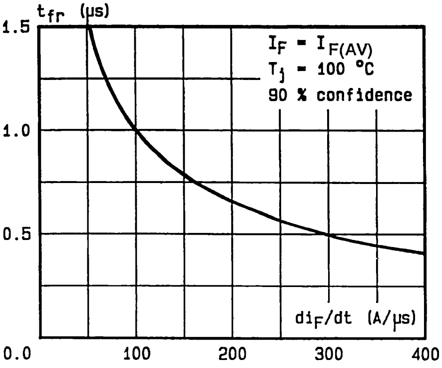


FIGURE 7 : Recovery time versus dI_F/dt.

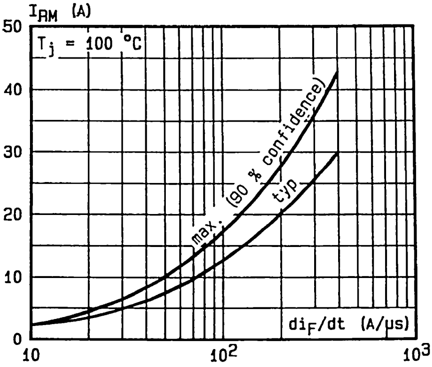


FIGURE 8 : Peak reverse current versus dI_F/dt.

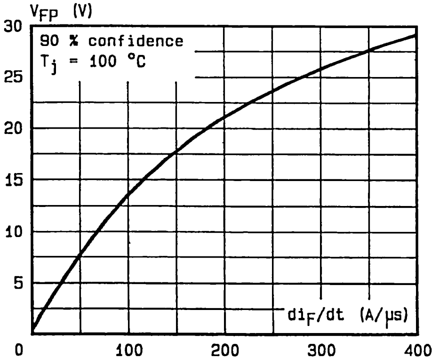


FIGURE 8 : Peak forward voltage versus dI_F/dt.

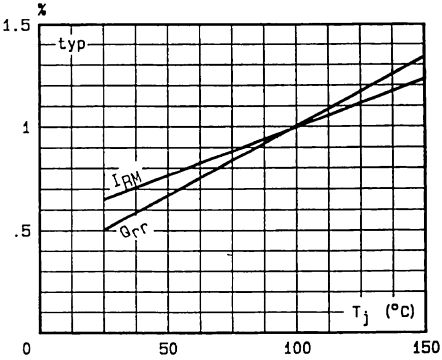


FIGURE 10 : Dynamic parameters versus junction temperature.

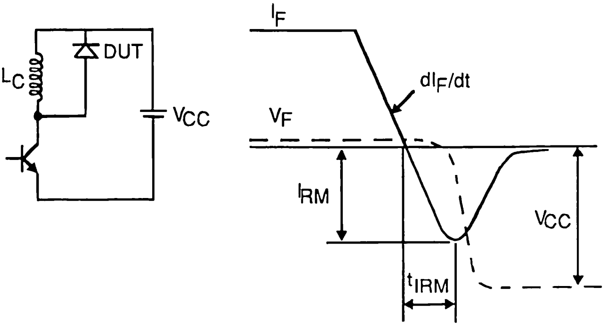


Figure 11 : Turn-off switching characteristics (without series inductance).

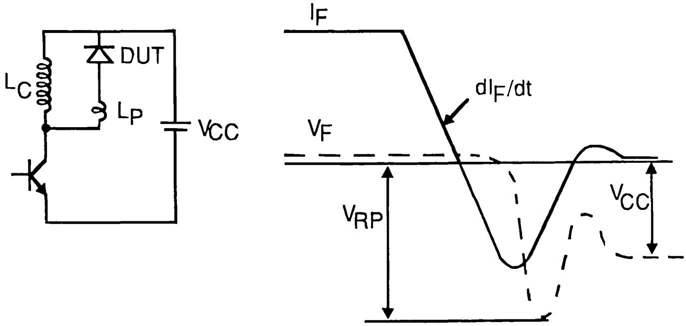


Figure 12 : Turn-off switching characteristics (with series inductance).

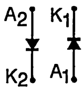
SGS-THOMSON
MICROELECTRONICS

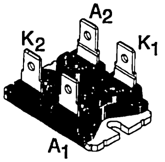
BYT 230 PI(V)-1200

FAST RECOVERY RECTIFIER DIODE

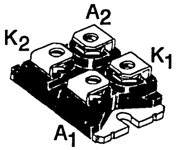
- VERY HIGH REVERSE VOLTAGE CAPABILITY
- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

Insulating voltage : 2500 V_{RMS}





Fast-on version



Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS

Symbol	Parameter		Value	Unit
V_{RRM}	Repetitive Peak Reverse Voltage		1200	V
V_{RSM}	Non Repetitive Peak Reverse Voltage		1200	V
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	375	A
$I_{F(RMS)}$	RMS Forward Current	per leg	70	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 55°C$ $\delta = 0.5$ per leg	30	A
I_{FSM}	Surge Non Repetitive Forward Current	$t_p = 10ms$ Sinusoïdal	200	A
P	Power Dissipation	$T_{case} = 55°C$ per leg	60	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

THERMAL RESISTANCES

Symbol	Parameter		Value	Unit
$R_{th\ (j-c)}$	Junction-case	per leg total	1.5 0.8	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

July 1989

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				5	mA
V_F	T_j = 25°C	I_F = 30A			1.9	V
	T_j = 100°C				1.8	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A di_F/dt = – 15A/µs V_R = 30V			165	ns
		I_F = 0.5A I_R = 1A I_{rr}=0.25A			70	

TURN-OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	di_F/dt = – 120A/µs	V_{CC} = 200V I_F = 30A L_p ≤ 0.05µH T_j = 100°C See figure 1			200	ns
	di_F/dt = – 240A/µs			120		
I_{RM}	di_F/dt = – 120A/µs				20	A
	di_F/dt = – 240A/µs			22		

TURN-OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

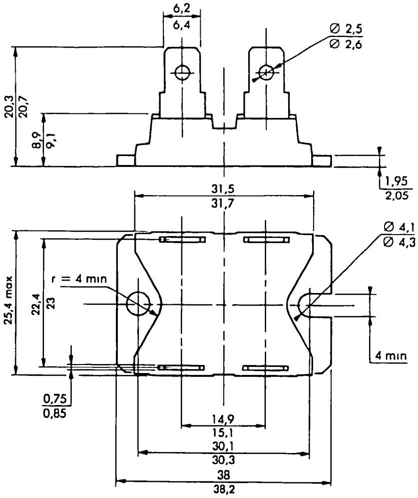
Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 200V $I_F = I_{F\,(AV)}$ di_F/dt = – 30A/µs L_p = 5µH See figure 2		3.3	4.5	

To evaluate the conduction losses use the following equations :

$V_F = 1.47 + 0.010\ I_F$ $\qquad P = 1.47 \times I_{F(AV)} + 0.010 I_F{}^2{}_{(RMS)}$

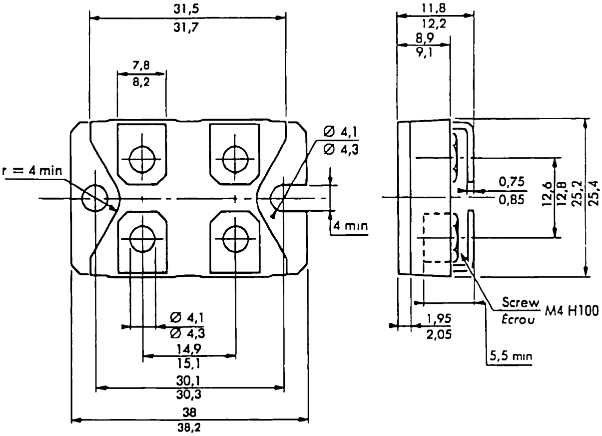
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + Suffix V

Recommended screw torque value : 13 ± 2kg cm.
Maximum screw torque value : 15kg.cm

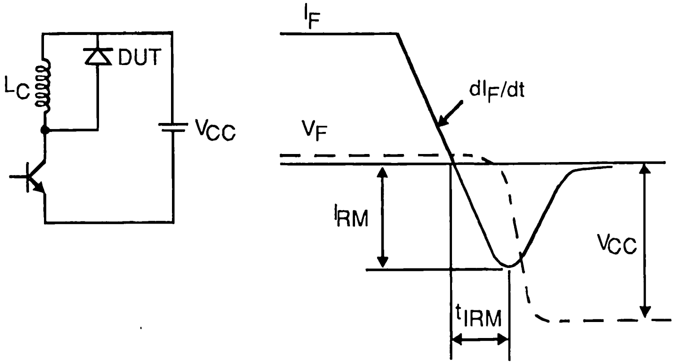


Figure 1 : Turn-off switching characteristics (without series inductance).

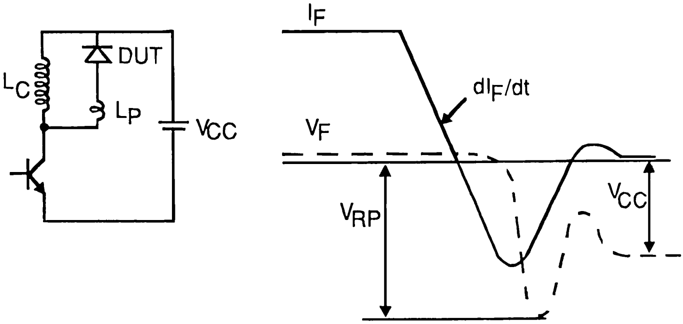


Figure 2 : Turn-off switching characteristics (with series inductance).

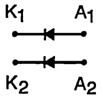
SGS-THOMSON
MICROELECTRONICS

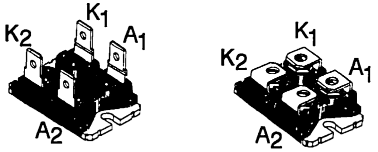
BYT 261PI(V)-200→400

FAST RECOVERY RECTIFIER DIODES

- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance4 5pF

Insulating voltage 2500 V_{RMS}





Fast-on version Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifier suited for switching mode power supply.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	800	A
$I_{F(RMS)}$	RMS Forward Current	per leg	140	A
$I_{F(AV)}$	Average Forward Current	T_{case} = 80°C δ = 0.5 per leg	60	A
I_{FSM}	Surge non Repetitive Forward Current	t_p = 10ms Sinusoidal	600	A
P	Power Dissipation	T_{case} = 80°C per leg	100	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

Symbol	Parameter	BYT 261PI(V)-			Unit
		200	300	400	
V_{RRM}	Repetitive Peak Reverse Voltage	200	300	400	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	250	350	450	V

THERMAL RESISTANCES

Symbol	Test Conditions		Value	Unit
$R_{th\ (j-c)}$	Junction-case	per leg total	0.7 0.4	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

ELECTRICAL CHARACTERISTICS (per leg)

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			60	µA
	T_j = 100°C				6	mA
V_F	T_j = 25°C	I_F = 60A			1.5	V
	T_j = 100°C				1.4	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A di_F/dt = – 15A/µs V_R = 30V			100	ns
		I_F = 0.5A I_R = 1A I_{rr} = 0.25A			50	

TURN-OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	di_F/dt = – 240A/µs	V_{CC} = 200V I_F = 60A $L_p \le 0.05$µH T_j = 100°C See figure 1			75	ns
	di_F/dt = – 480A/µs			50		
I_{RM}	di_F/dt = – 240A/µs				18	A
	di_F/dt = – 480A/µs			24		

TURN-OFF OVERVOLTAGE COEFFICIENT ((With Series Inductance)

Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 120V $I_F = I_{F(AV)}$ See note di_F/dt = – 60A/µs L_p = 0.8µH See figure 2		3.3	4	

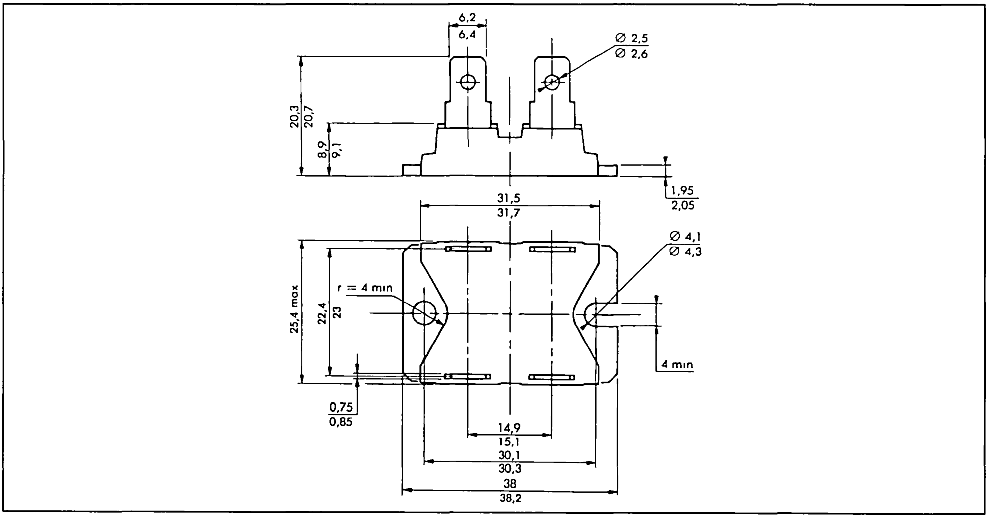
Note : Applicable to BYT 230PI(V)-400 only

To evaluate the conduction losses use the following equations :

$V_F = 1.1 + 0.0045\ I_F$ $P = 1.1 \times I_{F(AV)} + 0.0045 I_F{}^2{}_{(RMS)}$

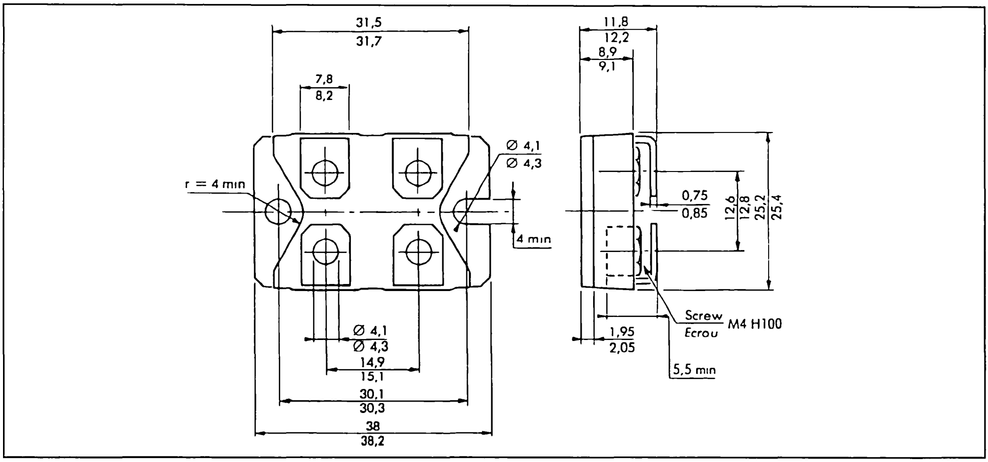
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + Suffix V

Recommended screw torque value : 13 ± 2kg.cm.
Maximum screw torque value : 15kg.cm.

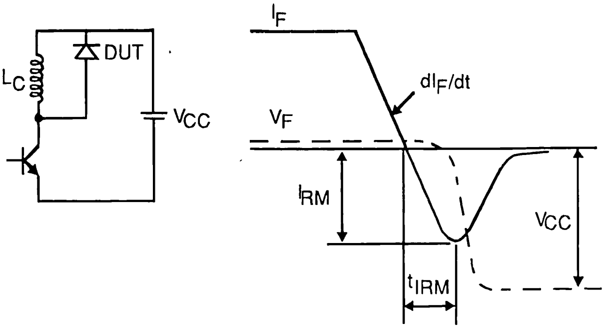


Figure 1 : Turn-off switching characteristics (without series inductance).

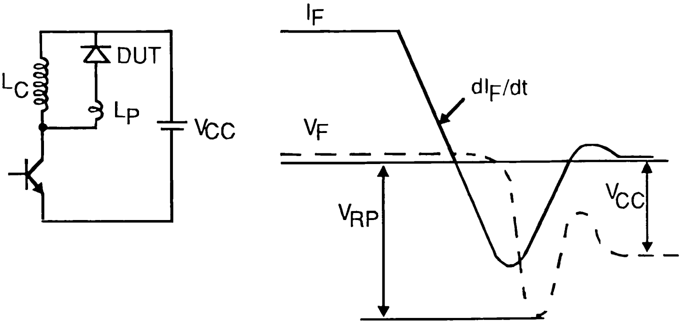


Figure 2 : Turn-off switching characteristics (with series inductance).

SGS-THOMSON
MICROELECTRONICS

BYT 261PI(V)-600/800

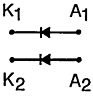
FAST RECOVERY RECTIFIER DIODES

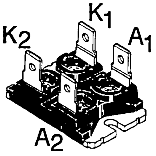
- HIGH REVERSE VOLTAGE CAPABILITY
- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

SUITABLE APPLICATIONS

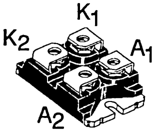
- FREE WHEELING DIODE IN CONVERTERS AND MOTOR CONTROL CIRCUITS
- RECTIFIER IN S.M.P.S.

Insulating voltage 2500 V_{RMS}





Fast-on version



Screw version

ISOTOP
(Plastic)

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	750	A
$I_{F(RMS)}$	RMS Forward Current	per leg	140	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 60°C$ $\delta = 0.5$ per leg	60	A
I_{FSM}	Surge non Repetitive Forward Current	$t_p = 10ms$ Sinusoidal	400	A
P	Power Dissipation	$T_{case} = 60°C$ per leg	130	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

Symbol	Parameter	BYT 261PI (V)-		Unit
		600	800	
V_{RRM}	Repetitive Peak Reverse Voltage	600	800	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	640	850	V

THERMAL RESISTANCES

Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$R_{th\ (j-c)}$	Per Leg			0.7	°C/W
	Total			0.4	
$R_{th\ (j1-j2)}$	Coupling			0.1	
$R_{th\ (c-f)}$*	Contact-between Case and Heatsink		0.05		

* Torque value of screw mounting on cooling fin : 13kg.cm.
Thermal compound shall be applied between case and cooling fin.

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				6	mA
V_F	T_j = 25°C	I_F = 60A			1.9	V
	T_j = 100°C				1.8	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A dI_F/dt = – 15A/µs V_R = 30V			135	ns
		I_F = 0.5A I_R=1A I_{rr} = 0.25A			65	

TURN -OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	dI_F/dt = – 240A/µs	V_{CC} = 200V I_F = 60A $L_p \leq$ 0.05µH T_j = 100°C See figure 1			160	ns
	dI_F/dt = – 480A/µs			100		
I_{RM}	dI_F/dt = – 240A/µs				30	A
	dI_F/dt = – 480A/µs			38		

TURN -OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

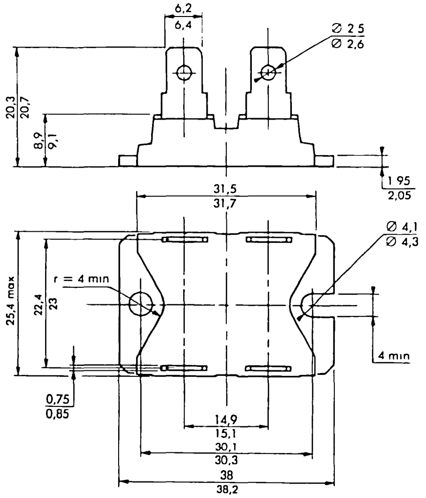
Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 150V $I_F = I_{F(AV)}$ dI_F/dt = – 60A/µs L_p = 2µH See figure 2		3.3	4	

To evaluate the conduction losses use the following equations :

$V_F = 1.47 + 0.005\ I_F$ $P = 1.47 \times I_{F(AV)} + 0.005 I_{F(RMS)}^2$

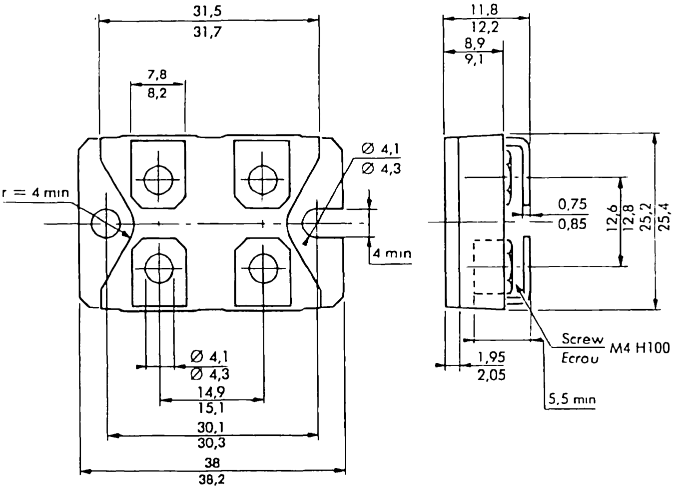
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking . type number

ISOTOP Plastic : SCREW VERSION



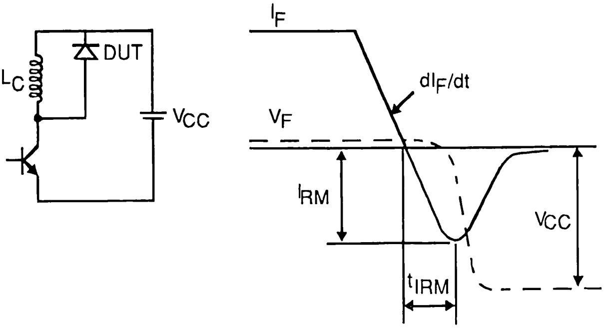


Figure 1 : Turn-off switching characteristics (without series inductance)

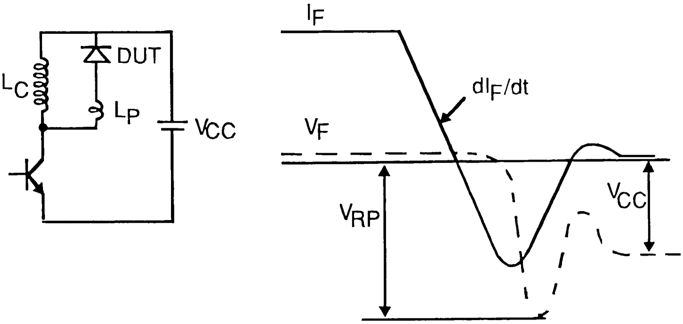


Figure 2 : Turn-off switching characteristics (without series inductance)

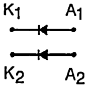
SGS-THOMSON
MICROELECTRONICS

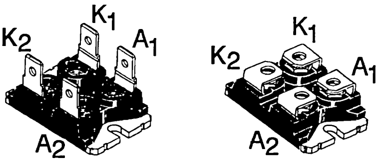
BYT 261 PI(V)-1000

FAST RECOVERY RECTIFIER DIODE

- VERY HIGH REVERSE VOLTAGE CAPABILITY
- VERY LOW REVERSE RECOVERY TIME
- VERY LOW SWITCHING LOSSES
- LOW NOISE TURN-OFF SWITCHING
- INSULATED : Capacitance 45pF

Insulating voltage : 2500 V_{RMS}





Fast-on version

Screw version

ISOTOP
(Plastic)

DESCRIPTION

Double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS

Symbol	Parameter		Value	Unit
V_{RRM}	Repetitive Peak Reverse Voltage		1000	V
V_{RSM}	Non Repetitive Peak Reverse Voltage		1000	V
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 10\mu s$	750	A
$I_{F(RMS)}$	RMS Forward Current	per leg	140	A
$I_{F(AV)}$	Average Forward Current	$T_{case} = 60°C$ $\delta = 0.5$ per leg	60	A
I_{FSM}	Surge Non Repetitive Forward Current	$t_p = 10ms$ Sinusoïdal	400	A
P	Power Dissipation	$T_{case} = 60°C$ per leg	130	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to + 150	°C

THERMAL RESISTANCES

Symbol	Parameter		Value	Unit
$R_{th\ (j\text{-}c)}$	Junction-case	per leg total	0.7 0.4	°C/W
$R_{th\ (c)}$	Coupling		0.1	°C/W

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				6	mA
V_F	T_j = 25°C	I_F = 60A			1.9	V
	T_j = 100°C				1.8	

RECOVERY CHARACTERISTICS

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C	I_F = 1A di_F/dt = – 15A/µs V_R = 30V			170	ns
		I_F = 0.5A I_R = 1A I_{rr}=0.25A			70	

TURN-OFF SWITCHING CHARACTERISTICS (Without Series Inductance)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
t_{IRM}	di_F/dt = – 240A/µs	V_{CC} = 200V I_F = 60A $L_p \leq$ 0.05µH T_j = 100°C See figure 1			200	ns
	di_F/dt = – 480A/µs			120		
I_{RM}	di_F/dt = – 240A/µs				40	A
	di_F/dt = – 480A/µs			44		

TURN-OFF OVERVOLTAGE COEFFICIENT (With Series Inductance)

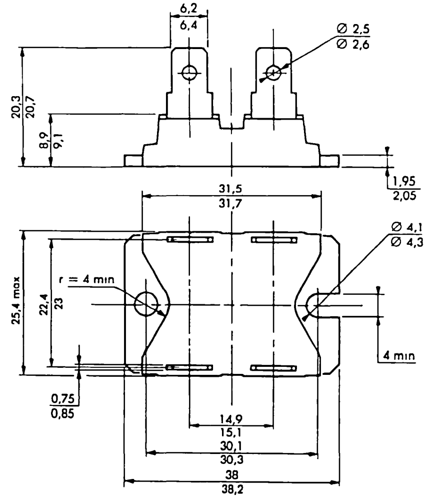
Symbol	Test Conditions	Min.	Typ.	Max.	Unit
$C = \frac{V_{RP}}{V_{CC}}$	T_j = 100°C V_{CC} = 200V $I_F = I_{F\,(AV)}$ di_F/dt = – 60A/µs L_p = 2.5µH See figure 2		3.3	4.5	

To evaluate the conduction losses use the following equations :

$V_F = 1.47 + 0.005\ I_F$ $P = 1.47 \times I_{F(AV)} + 0.005\ I_F^2{}_{(RMS)}$

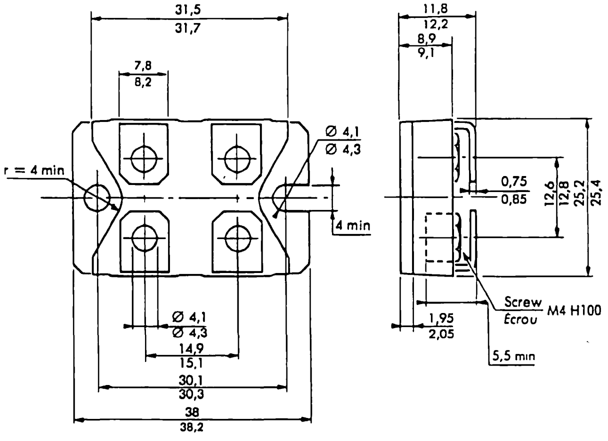
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + Suffix V

Recommended screw torque value : 13 ± 2kg.cm.
Maximum screw torque value : 15kg.cm.

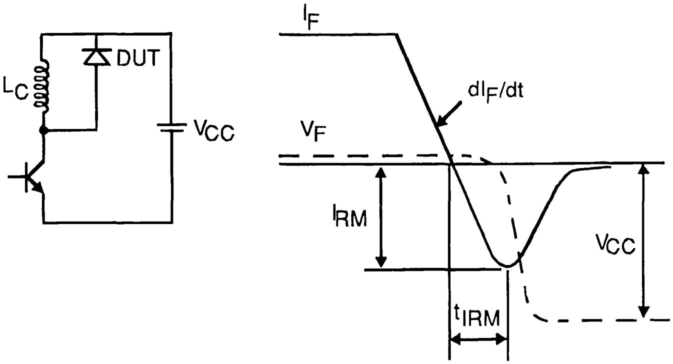


Figure 1 : Turn-off switching characteristics (without series inductance).

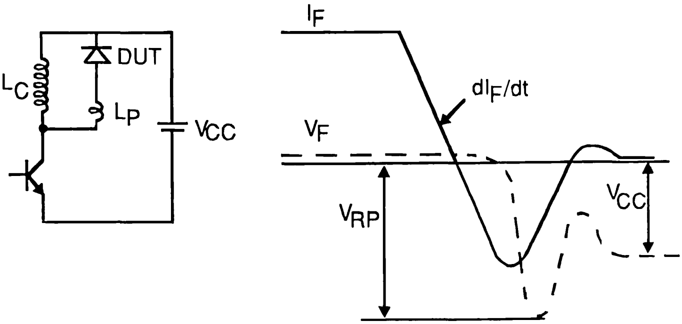


Figure 2 : Turn-off switching characteristics (with series inductance).

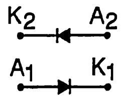
SGS-THOMSON
MICROELECTRONICS

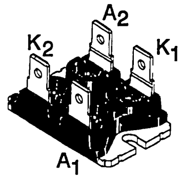
BYV 54(V)-50 → 200

HIGH EFFICIENCY FAST RECOVERY RECTIFIER DIODES

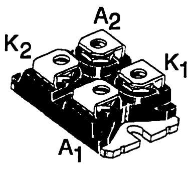
- VERY SMALL CONDUCTION LOSSES
- NEGLIGIBLE SWITCHING LOSSES
- LOW FORWARD AND REVERSE RECOVERY TIMES
- REDUCED SIZE
- INSULATED : capacitance 45pF

Insulating voltage 2500 V_{RMS}





Fast-on version



Screw version

ISOTOP
(Plastic)

DESCRIPTION

Low voltage drop double rectifiers suited for switching mode power supply.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 20\mu s$	1000	A
$I_{F(RMS)}$	RMS Forward Current		100 per leg	A
$I_{F(AV)}$	Average Forward Current	$T_C = 90°C$ $\delta = 0.5$	50 per leg	A
I_{FSM}	Surge non Repetitive Forward Current	$t_p = 10ms$ sinusoidal	1000	A
P_{tot}	Power Dissipation	$T_C = 90°C$	50 per leg	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to 150	°C

Symbol	Parameter	BYV 54 (V)–				Unit
		50	100	150	200	
V_{RRM}	Repetitive Peak Reverse Voltage	50	100	150	200	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	55	110	165	220	V

THERMAL RESISTANCES

Symbol	Parameter	Value	Unit
$R_{th\ (j-c)}$	Junction-case	1.2 per leg 0.85 total	°C/W
$R_{th\ (c)}$	Coupling	0.1	°C/W

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS (per leg)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			50	µA
	T_j = 100°C				5	mA
V_F	T_j = 25°C	I_F = 160A			1.25	V
	T_j = 100°C	I_F = 50A			0.85	

RECOVERY CHARACTERISTICS (per leg)

Symbol	Test Conditions			Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C V_R = 30V	I_F = 1A see figure 11	di_F/dt = – 50A/µs			60	ns
Q_{rr}	T_j = 25°C $V_R \le$ 30V	I_F = 2A	di_F/dt = – 20A/µs			30	nC
t_{fr}	T_j = 25°C Measured at 1.1 x V_F	I_F = 1A	t_r = 5ns		10		ns
V_{FP}	T_j = 25°C	I_F = 1A	t_r = 5ns		1.5		V

To evaluate the conduction losses use the following equations :

$V_F = 0.7 + 0.0027\ I_F$
1 leg : $P = 0.7 \times I_{F\,(AV)} + 0.0027\ I_{F}^{2}{}_{(RMS)}$
Total : $P = 0.7 \times I_{F\,(AV)} + 0.0013\ I_{F}^{2}{}_{(RMS)}$

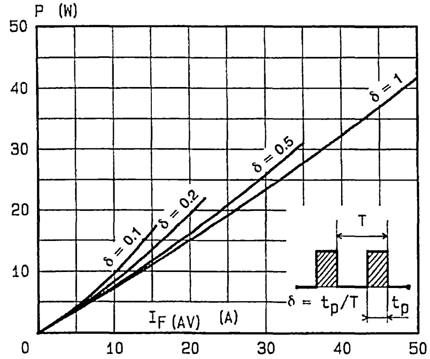


FIGURE 1 : Power losses versus average current.

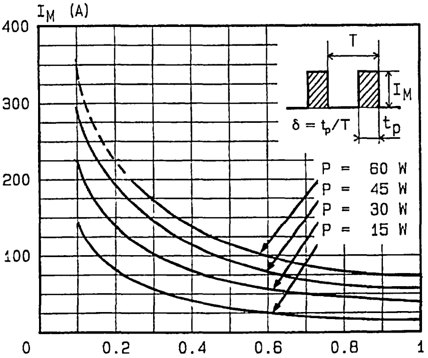


FIGURE 2 : Peak current versus form factor.

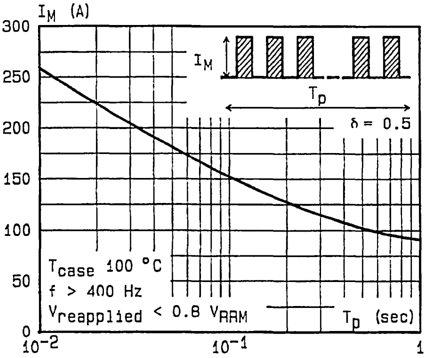


FIGURE 3 : Non repetitive peak surge current versus duration

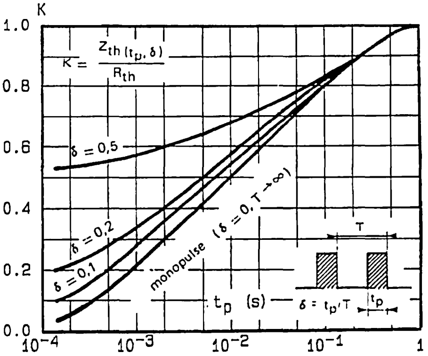


FIGURE 4 : Thermal impedance versus pulse width.

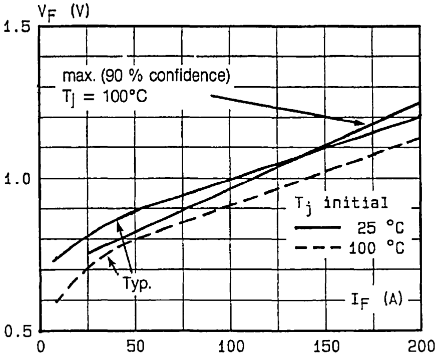


FIGURE 5 : Voltage drop versus forward current.

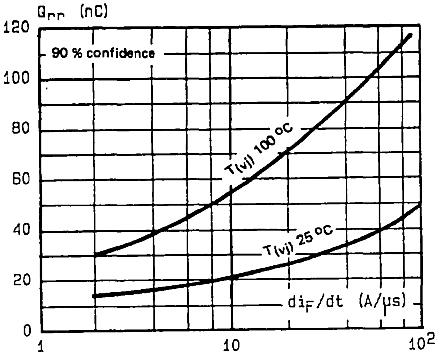


FIGURE 6 : Recovery charge versus di_F/dt.

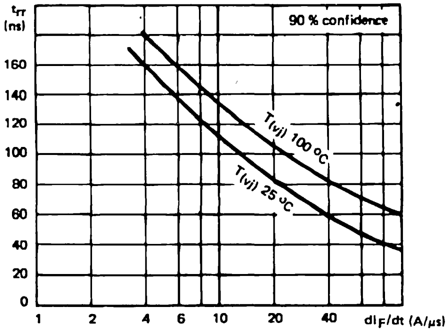


FIGURE 7 : Recovery time versus dI_F/dt.

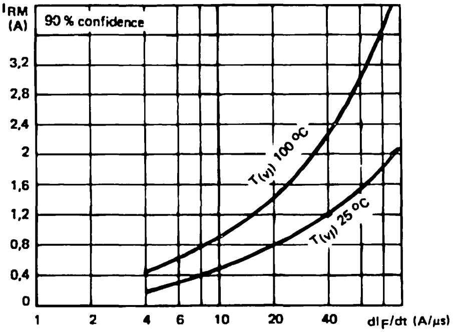


FIGURE 8 : Peak reverse current versus dI_F/dt.

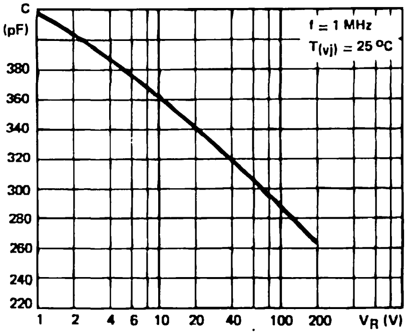


FIGURE 9 : Capacitance versus reverse voltage applied.

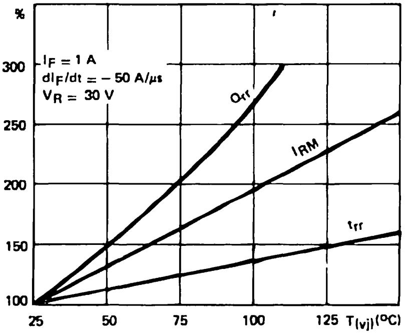


FIGURE 10 : Dynamic parameters versus junction temperature.

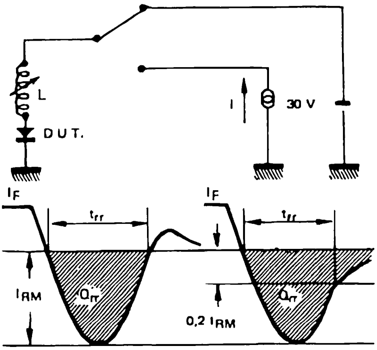
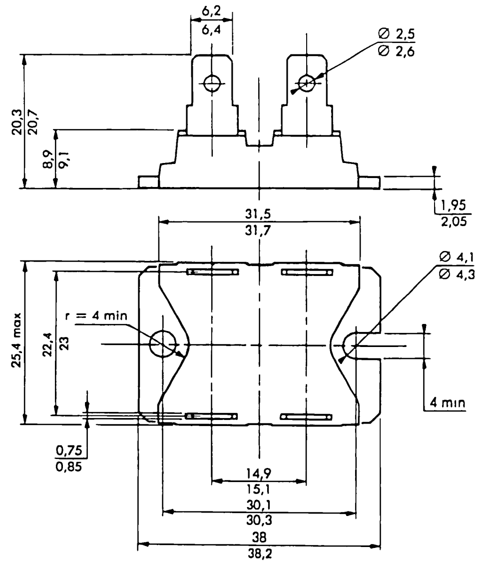


FIGURE 11 : Measurement of t_{rr} (fig.7) and I_{RM} (fig.8).

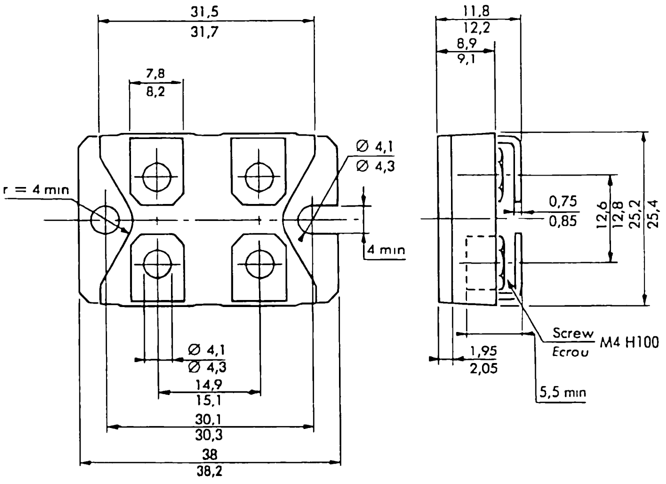
PACKAGE MECHANICAL DATA

ISOTOP : FAST-ON VERSION



Marking : type number

ISOTOP : SCREW VERSION



Marking : type number + suffix V

Recommended screw torque value : 13 ± 2kg cm
Maximum screw torque value : 15kg cm.

BYV 255(V)-50 → 200

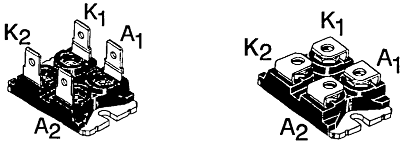
HIGH EFFICIENCY FAST RECOVERY RECTIFIER DIODES

- VERY SMALL CONDUCTION LOSSES
- NEGLIGIBLE SWITCHING LOSSES
- LOW FORWARD AND REVERSE RECOVERY TIMES
- INSULATED : capacitance 55pF
- DOUBLE TWIN CHIPS

SUITABLE APPLICATIONS

- FREE WHEELING DIODE IN CONVERTERS AND MOTOR CONTROL CIRCUITS
- RECTIFIER IN S.M.P.S.

Insulating voltage 2500 V_{RMS}



Fast-on version Screw version

ISOTOP
(Plastic)

DESCRIPTION

Low voltage drop double rectifiers.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
I_{FRM}	Repetitive Peak Forward Current	$t_p \leq 20\mu s$	1500	A
$I_{F(RMS)}$	RMS Forward Current		150 per leg	A
$I_{F(AV)}$	Average Forward Current	$T_C = 110°C$ $\delta = 0.5$	100 per leg	A
I_{FSM}	Surge non Repetitive Forward Current	$t_p = 10ms$ Sinusoidal	1600	A
P_{tot}	Power Dissipation	$T_C = 110°C$	100 per leg	W
T_{stg} T_j	Storage and Junction Temperature Range		– 40 to 150	°C

Symbol	Parameter	BYV 255(V) -				Unit
		50	100	150	200	
V_{RRM}	Repetitive Peak Reverse Voltage	50	100	150	200	V
V_{RSM}	Non Repetitive Peak Reverse Voltage	55	110	165	220	V

THERMAL RESISTANCES

Symbol	Parameter	Value	Unit
$R_{th\ (j-c)}$	Junction-case	0.4 per leg 0.25 total	°C/W
$R_{th\ (c)}$	Coupling	0.1	°C/W

July 1989

ELECTRICAL CHARACTERISTICS

STATIC CHARACTERISTICS (per leg)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_R	T_j = 25°C	$V_R = V_{RRM}$			100	µA
	T_j = 100°C				10	mA
V_F	T_j = 25°C	I_F = 320A			1.25	V
	T_j = 100°C	I_F = 100A			0.85	

RECOVERY CHARACTERISTICS (per leg)

Symbol	Test Conditions	Min.	Typ.	Max.	Unit
t_{rr}	T_j = 25°C I_F = 1A di_F/dt = - 50A/µs V_R = 30V see figure 11			80	ns
Q_{rr}	T_j = 25°C I_F = 2A di_F/dt = - 20A/µs $V_R \leq$ 30V			65	nC
t_{fr}	T_j = 25°C I_F = 1A t_r = 5ns Measured at 1.1 x V_F		10		ns
V_{FP}	T_j = 25°C I_F = 1A t_r = 5ns		1.5		V

TURN-OFF SWITCHING CHARACTERISTICS (per leg)

Symbol	Test Conditions		Min.	Typ.	Max.	Unit
I_{RM}	T_j = 100°C I_F = 100A $L_p \leq$ 0.05µH $V_{CC} \leq 0.6\ V_{RRM}$ See figure 12	di_F/dt = – 200A/µs			16	A
		di_F/dt = – 400A/µs		24		

To evaluate the conduction losses use the following equations :

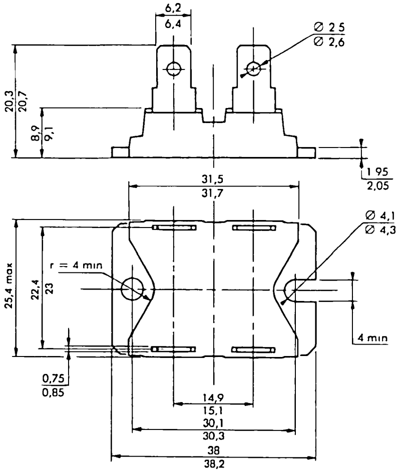
$V_F = 0.7 + 0.00135\ I_F$

1 leg : $P = 0.7 \times I_{F\,(AV)} + 0.00135\ I_{F\,(RMS)}^2$

Total : $P = 0.7 \times I_{F\,(AV)} + 0.0007\ I_{F\,(RMS)}^2$

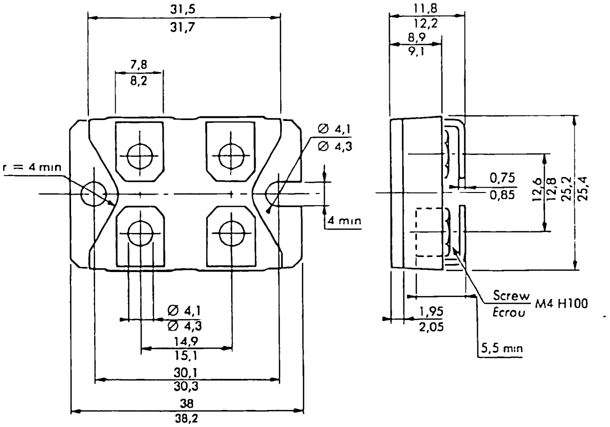
PACKAGE MECHANICAL DATA

ISOTOP Plastic : FAST-ON VERSION



Marking : type number

ISOTOP Plastic : SCREW VERSION



Marking : type number + suffix V

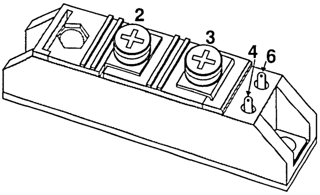
Recommended screw torque value . 13 ± 2Kg cm.
Maximum screw torque value : 15Kg.cm.

SGS40TA045

NPN TRANSISTOR POWER MODULE

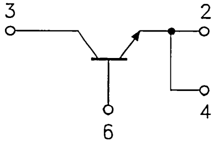
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



SC04510

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	450	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	850	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	850	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	850	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	5	V
I_C	Collector Current	40	A
$-I_C$	Reverse Collector Current	40	A
I_B	Base Current	12	A
$-I_{CSM}$	Collector Surge Current	400	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

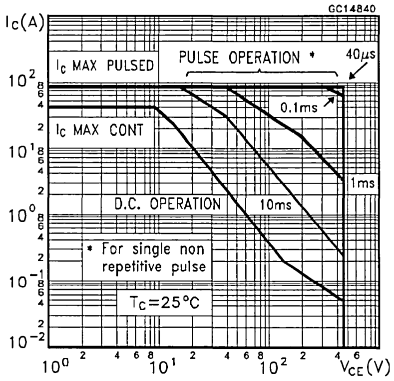
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

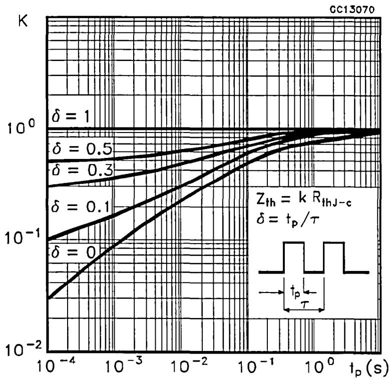
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CEO}	Collector Cut-off Current	V_{CE} = 450 V			5	mA
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 850 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 850 V V_{CE} = 450 V T_j = 125 °C			1 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 40 A I_B = 8 A		0.5	2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 40 A I_B = 8 A		1.1	2.2	V
h_{FE}*	DC Current Gain	I_C = 40 A V_{CE} = 2 V I_C = 40 A V_{CE} = 5 V	5 7			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 40 A I_{B1} = 8 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		2.3 0.28	5 0.55	μs μs

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

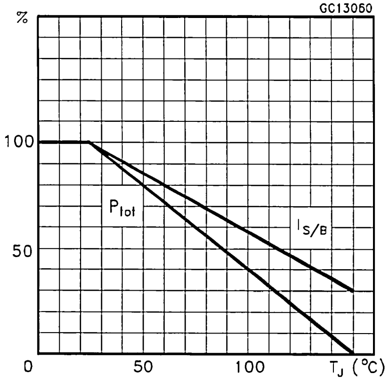
Safe Operating Areas



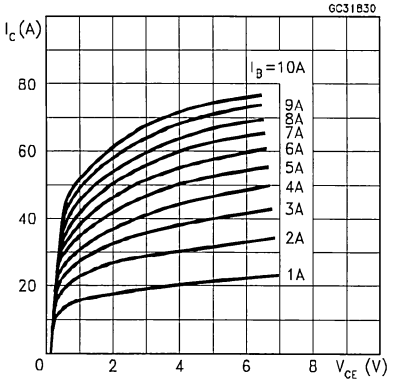
Thermal Impedance



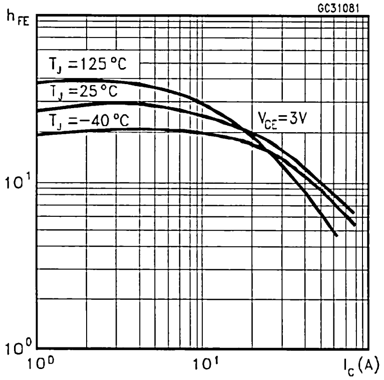
Derating Curve



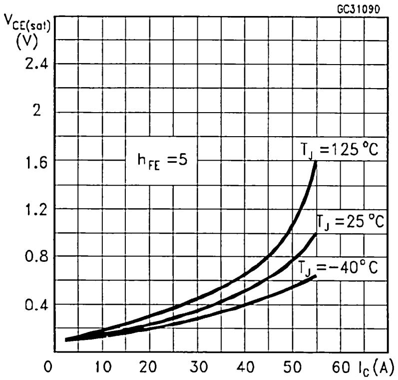
Output Characteristics



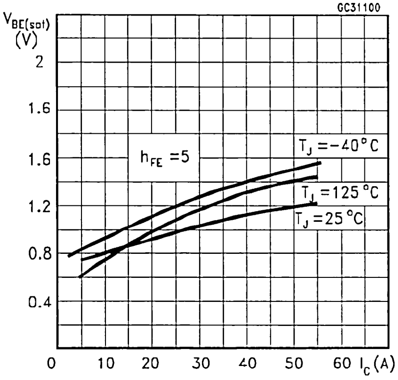
DC Current Gain



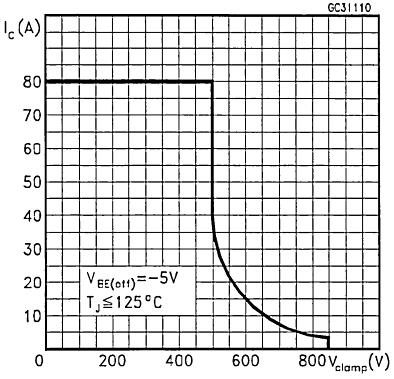
Collector-Emitter Saturation Voltage



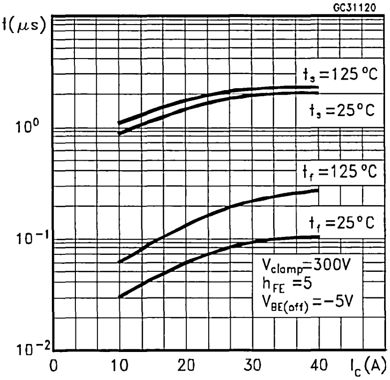
Base-Emitter Saturation Voltage



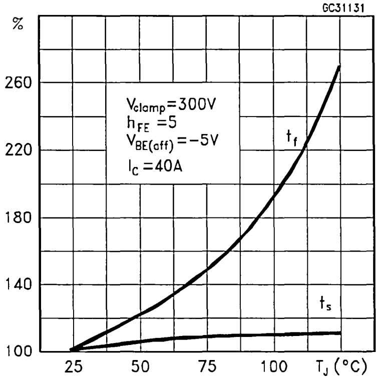
Reverse Biased SOA



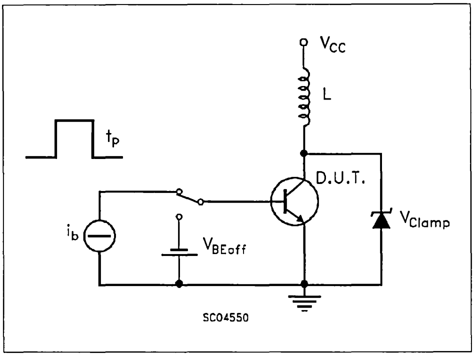
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

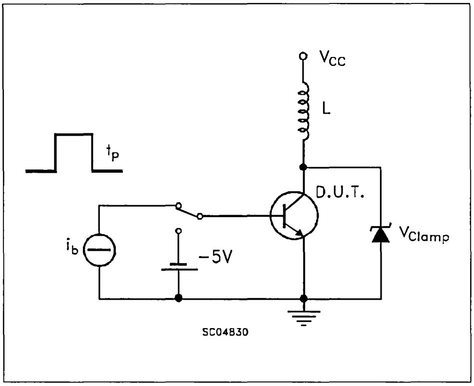


RBSOA Test Circuit



t_P adjusted for nominal I_C; I_C/I_B= 5

Switching Times Test Circuit

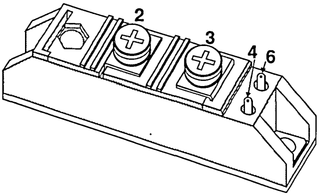


SGS40TA045D

NPN TRANSISTOR POWER MODULE

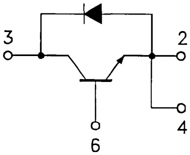
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



SC04520

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	450	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	850	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	850	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	850	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	5	V
I_C	Collector Current	40	A
$- I_C$	Reverse Collector Current	40	A
I_B	Base Current	12	A
$- I_{CSM}$	Collector Surge Current	400	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

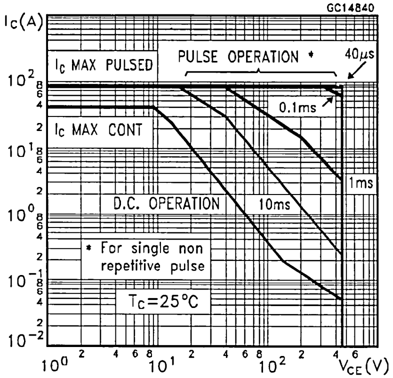
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

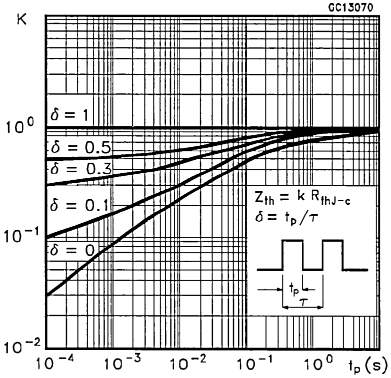
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CEO}	Collector Cut-off Current	V_{CE} = 450 V			5	mA
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 850 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CEX}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 850 V V_{CE} = 450 V T_j = 125 °C			1 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 40 A I_B = 8 A		0.5	2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 40 A I_B = 8 A		1.1	2.2	V
h_{FE}*	DC Current Gain	I_C = 40 A V_{CE} = 2 V I_C = 40 A V_{CE} = 5 V	5 7			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 40 A I_{B1} = 8 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		2.3 0.28	5 0.55	µs µs
V_F	Diode Forward Voltage	I_F = 40 A		1.5	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 40 A di/dt = 100 A/µs		0.2	0.5	µs

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

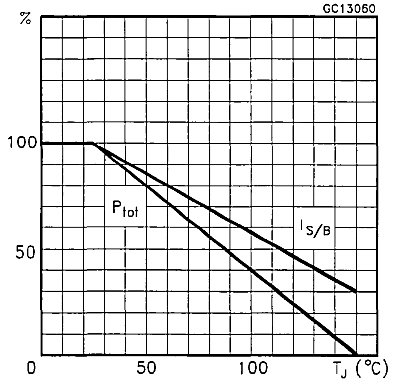
Safe Operating Areas



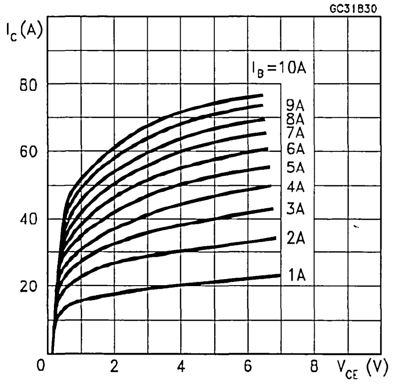
Thermal Impedance



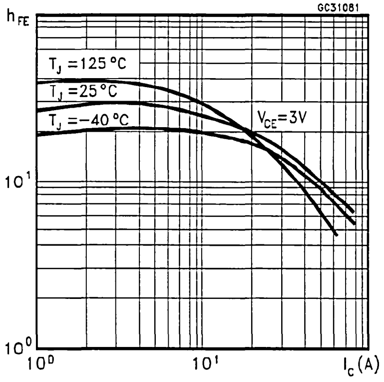
Derating Curve



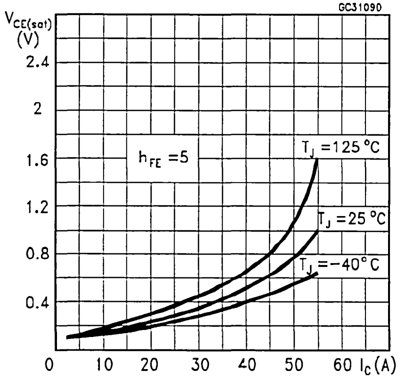
Output Characteristics



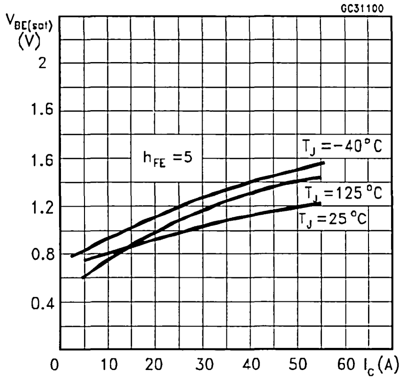
DC Current Gain



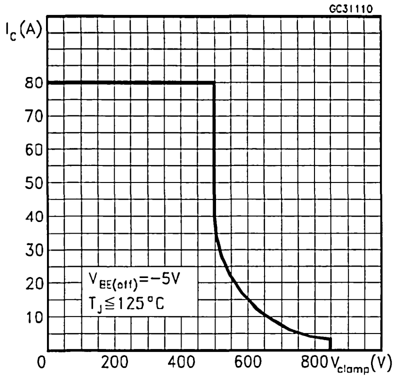
Collector-Emitter Saturation Voltage



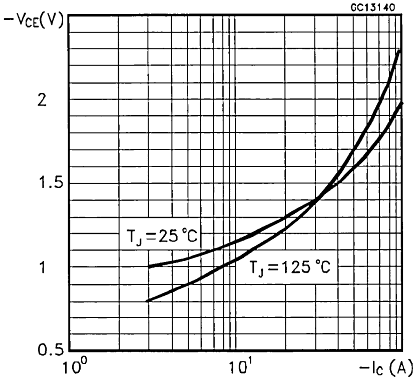
Base-Emitter Saturation Voltage



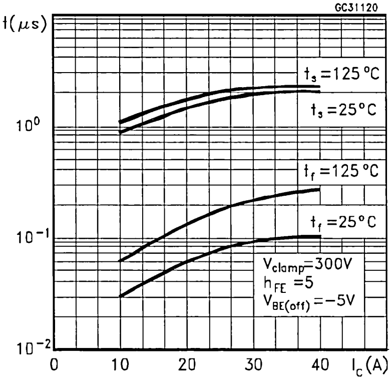
Reverse Biased SOA



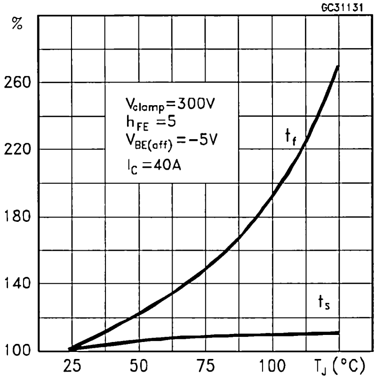
Typical V_F Versus I_F



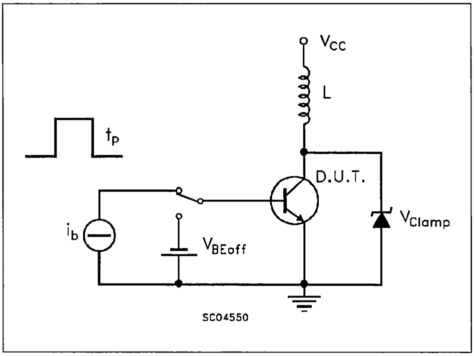
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

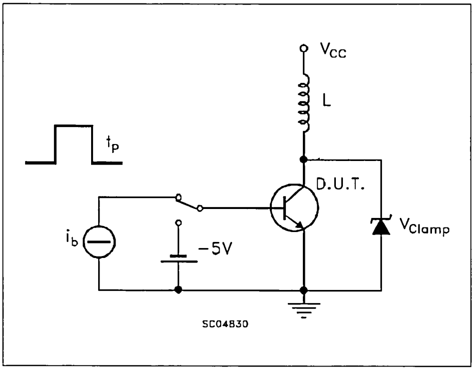


RBSOA Test Circuit



t_P adjusted for nominal I_C; $I_C/I_B=5$

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

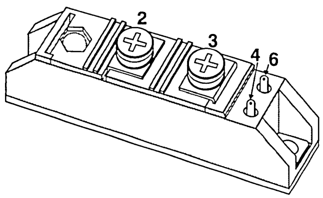
SGS25DA080D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

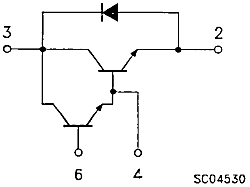
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	800	V
V_{CES}	Collector-Emitter Voltage ($V_{BE}= 0$)	1200	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	1200	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	1200	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	25	A
$- I_C$	Reverse Collector Current	25	A
I_B	Base Current	3	A
$- I_{CSM}$	Collector Surge Current	250	A
P_{tot}	Total Dissipation at $T_c = 25\ ^oC$	375	W
T_{stg}	Storage Temperature	-55 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

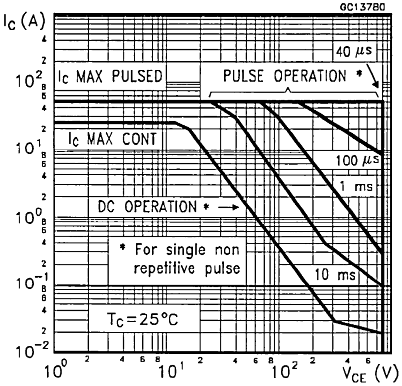
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 800 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1000 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1200 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A			3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A			3.5	V
h_{FE}*	DC Current Gain	I_C = 25 A V_{CE} = 3 V I_C = 25 A V_{CE} = 5 V	10 15			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 25 A I_{B1} = 1.3 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)			6 0.8	µs µs
V_F	Diode Forward Voltage	I_F = 25 A			2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 25 A di/dt = 100 A/µs			0.5	µs

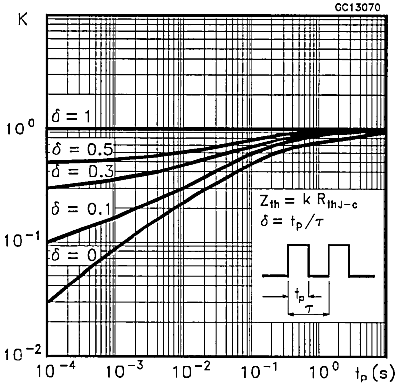
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

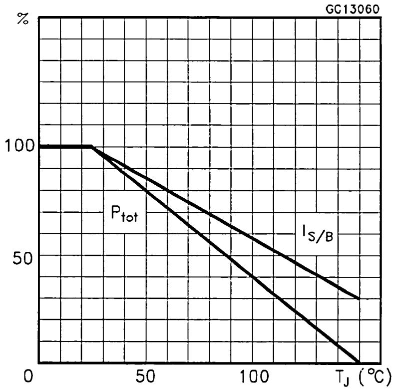
Safe Operating Areas



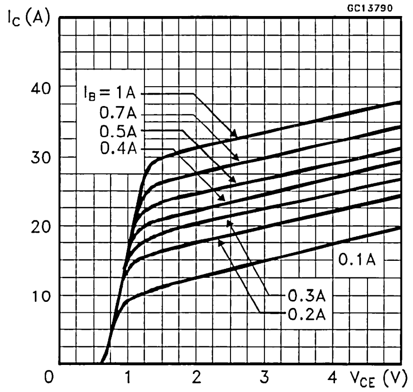
Thermal Impedance



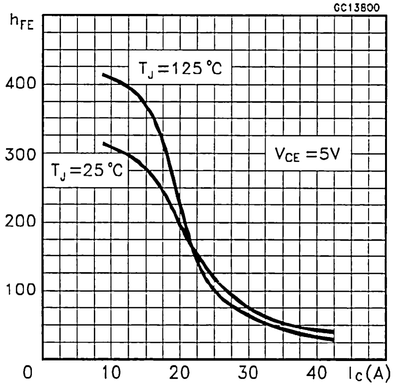
Derating Curve



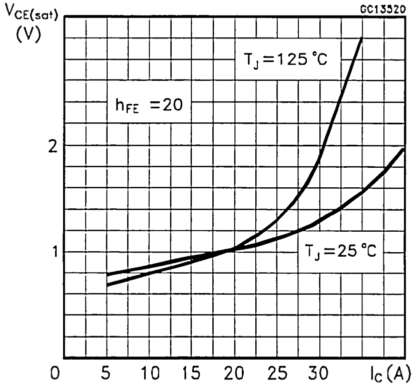
Output Characteristics



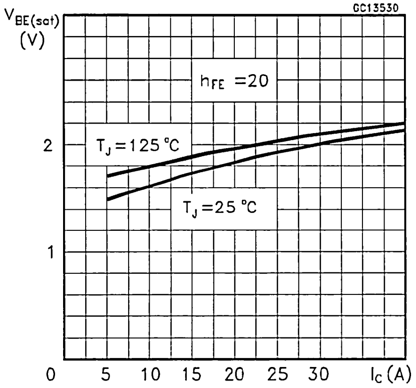
DC Current Gain



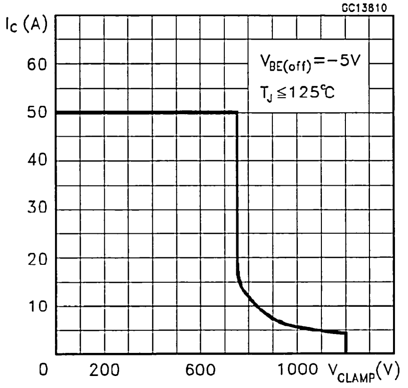
Collector-Emitter Saturation Voltage



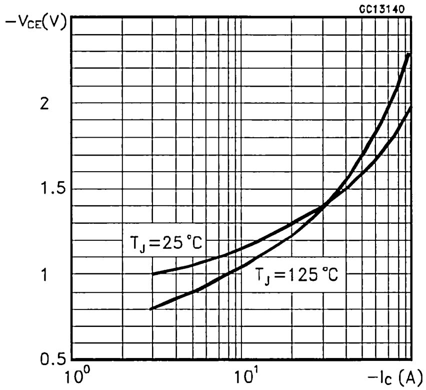
Base-Emitter Saturation Voltage



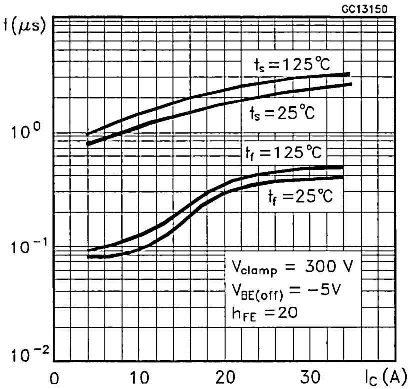
Reverse Biased SOA



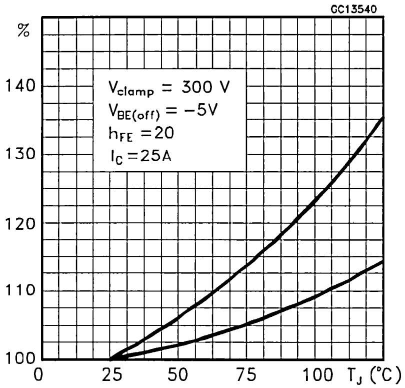
Typical V_F Versus I_F



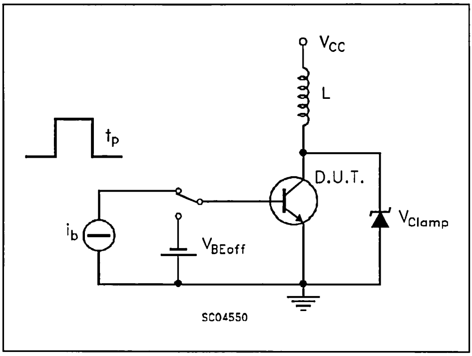
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

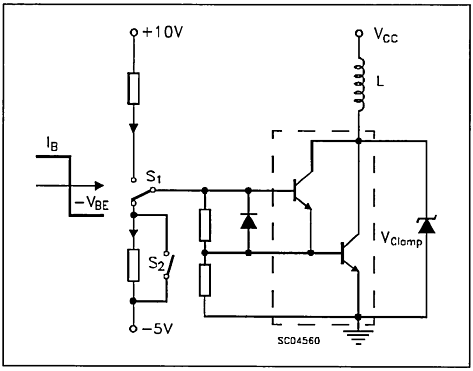


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 10

Switching Times Test Circuit



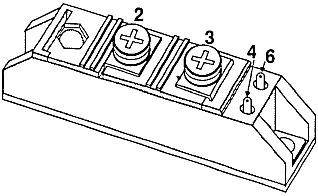
SGS30DA060D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

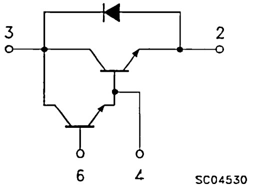
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	600	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	1000	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	1000	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	1000	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	30	A
- I_C	Reverse Collector Current	30	A
I_B	Base Current	3	A
- I_{CSM}	Collector Surge Current	300	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

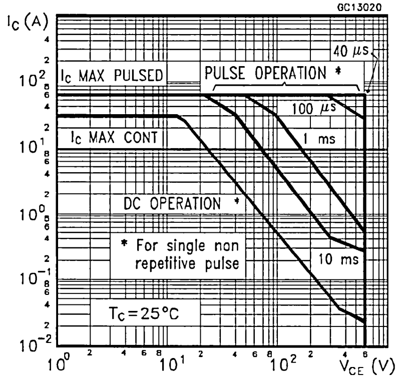
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

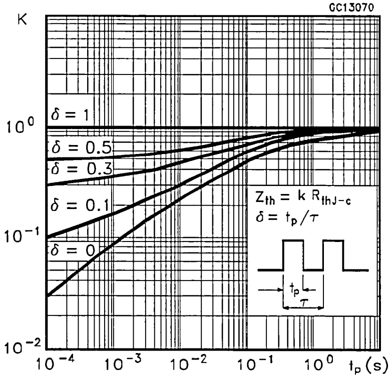
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 600 V V_{CE} = 600 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1000 V V_{CE} = 600 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1000 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 1.5 A		2.2	2.5	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 30 A I_B = 1.5 A		2	2.8	V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 2.5 V I_C = 30 A V_{CE} = 5 V	20 80	 100		
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 30 A I_{B1} = 1.5 A $V_{BE(off)}$= -5 V Vclamp = 300 V T_j ≤ 125 °C (see test circuits)		3 0.45	6 0.8	µs µs
V_F	Diode Forward Voltage	I_F = 30 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 30 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

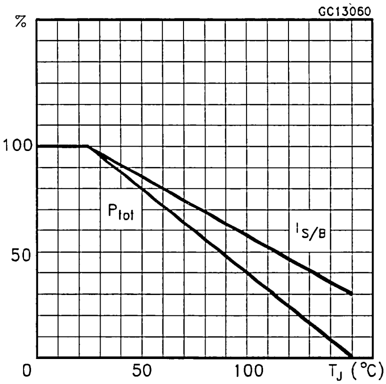
Safe Operating Areas



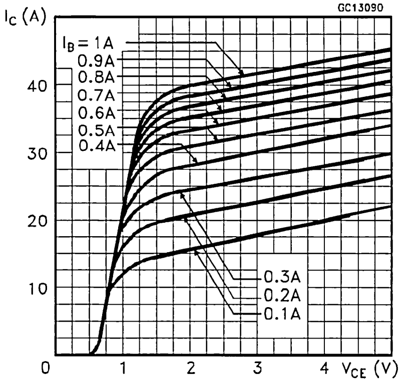
Thermal Impedance



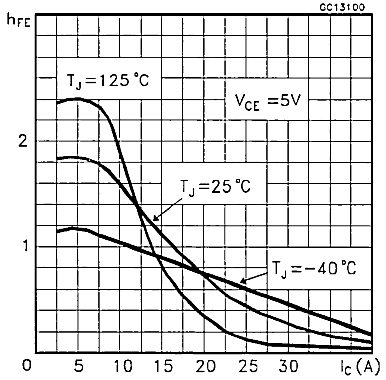
Derating Curves



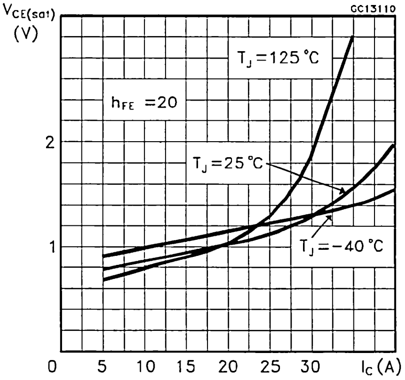
Output Characteristics



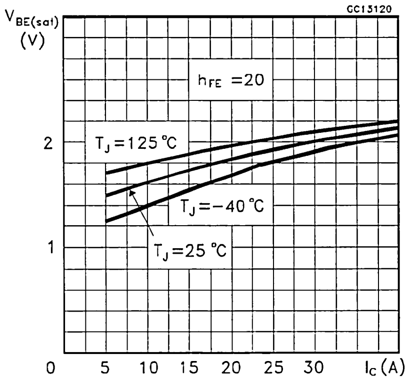
DC Current Gain



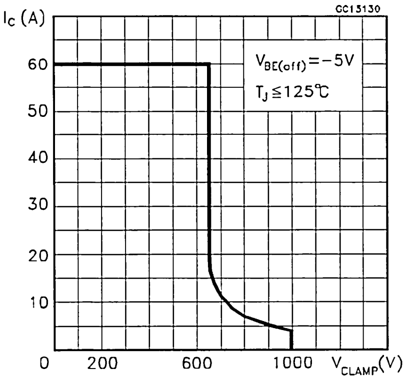
Collector-Emitter Saturation Voltage



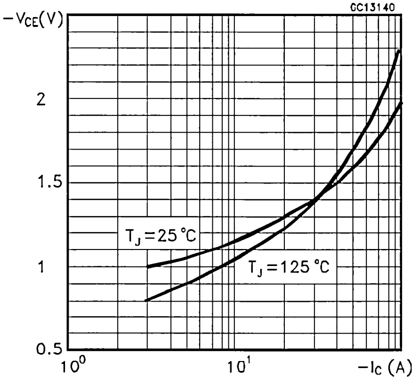
Base-Emitter Saturation Voltage



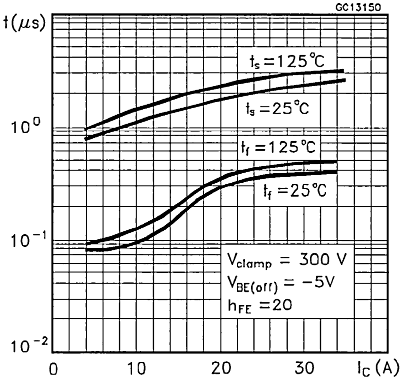
Reverse Biased SOA



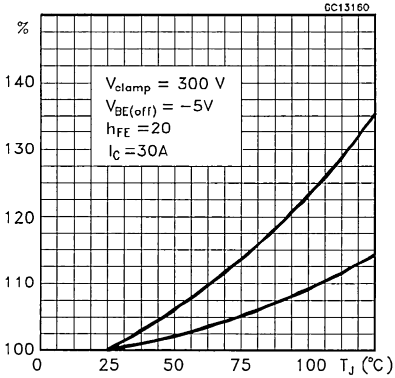
Typical V_F Versus I_F



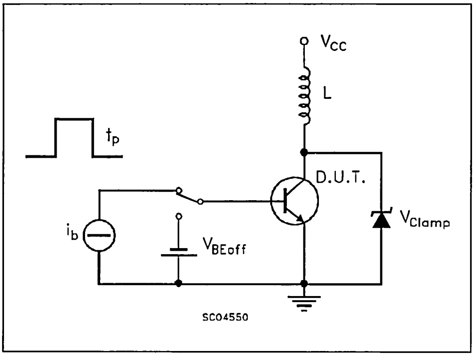
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

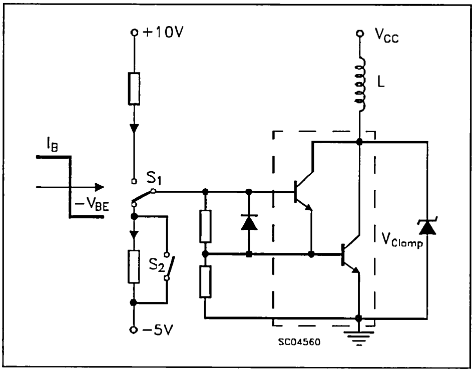


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 20

Switching Times Test Circuit



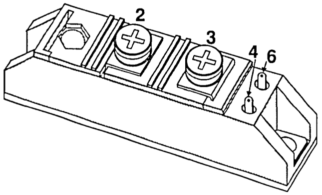
SGS-THOMSON
MICROELECTRONICS

SGS30DA070D

NPN DARLINGTON POWER MODULE

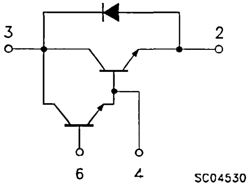
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	700	V
V_{CES}	Collector-Emitter Voltage ($V_{BE}= 0$)	1200	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	1200	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	1200	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	30	A
$- I_C$	Reverse Collector Current	30	A
I_B	Base Current	3	A
$- I_{CSM}$	Collector Surge Current	300	A
P_{tot}	Total Dissipation at $T_c = 25\ ^oC$	375	W
T_{stg}	Storage Temperature	-55 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

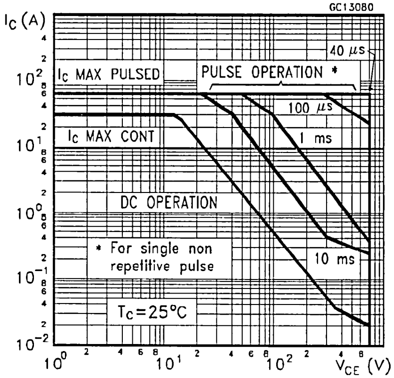
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

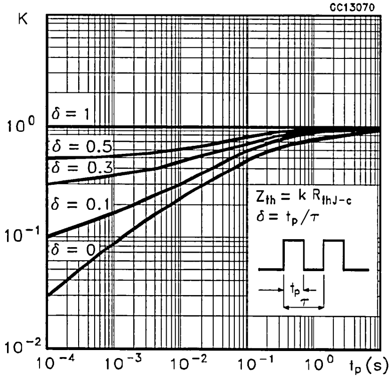
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 700 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1200 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (VBE = -2 V)	V_{CE} = 1200 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 1.5 A		2.2	2.5	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 30 A I_B = 1.5 A		2	2.8	V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 2.5 V I_C = 30 A V_{CE} = 5 V	20 80	 100		
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 30 A I_{B1} = 1.5 A $V_{BE(off)}$= -5 V V_{clamp} = 300 V $T_j \le 125$ °C. (see test circuits)		3 0.45	6 0.8	µs µs
V_F	Diode Forward Voltage	I_F = 30 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 30 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1 5 %
# See test circuits in databook introduction

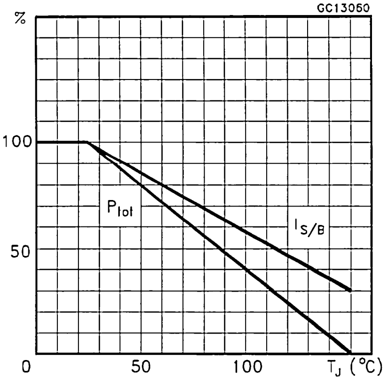
Safe Operating Areas



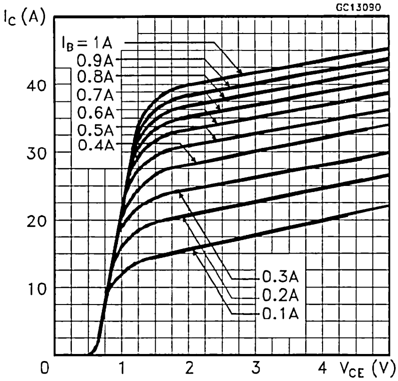
Thermal Impedance



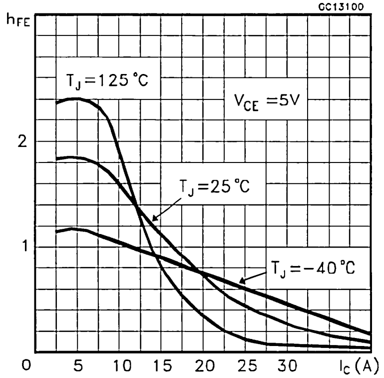
Derating Curves



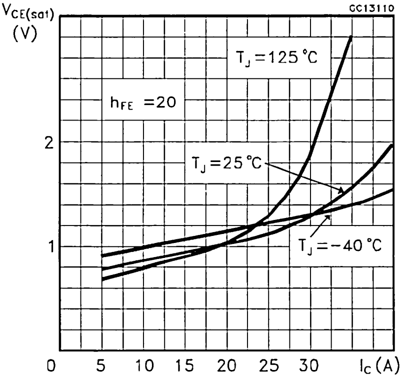
Output Characteristics



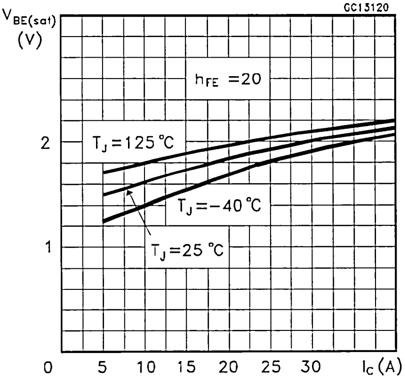
DC Current Gain



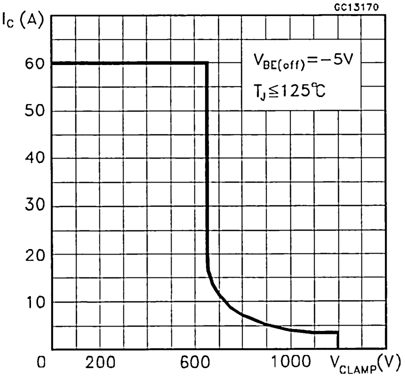
Collector-Emitter Saturation Voltage



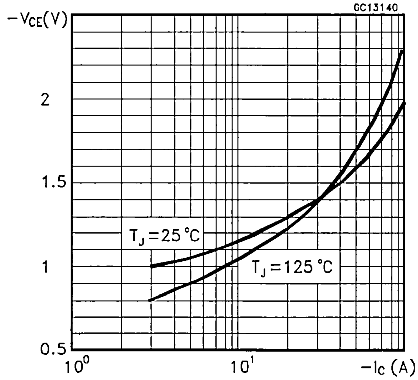
Base-Emitter Saturation Voltage



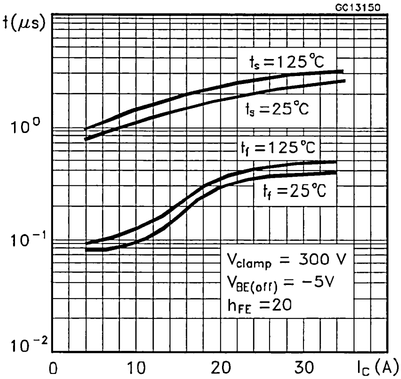
Reverse Biased SOA



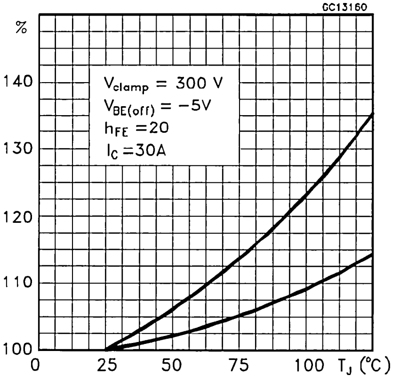
Typical V_F Versus I_F



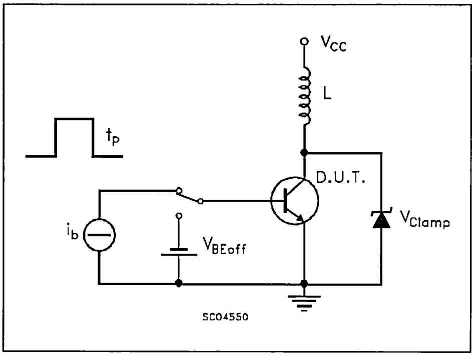
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

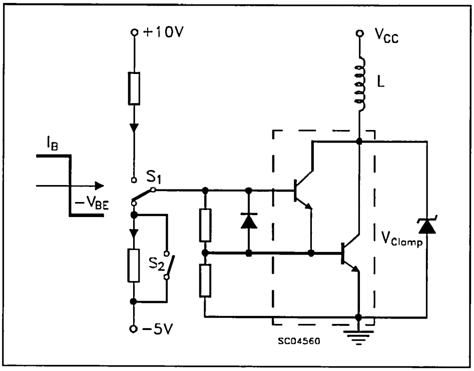


RBSOA Test Circuit



t_p adjusted for nominal I_C; $I_C/I_B = 20$

Switching Times Test Circuit

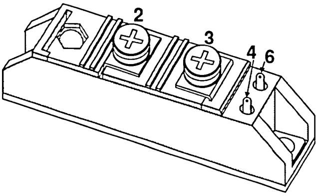


SGS50DA045D

NPN DARLINGTON POWER MODULE

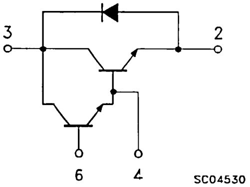
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	450	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	850	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	850	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	850	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
$- I_C$	Reverse Collector Current	50	A
I_B	Base Current	3	A
$- I_{CSM}$	Collector Surge Current	500	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

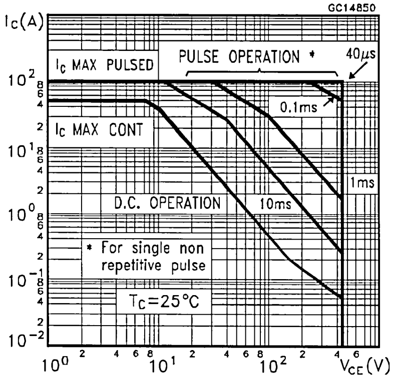
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

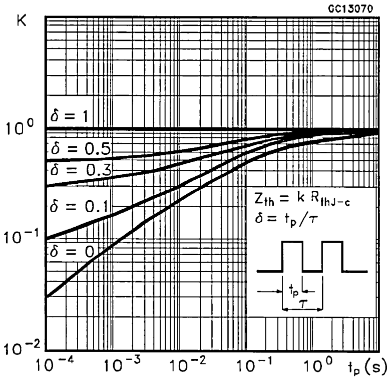
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 450 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 850 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 850 V			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 2 A		1.6	2.5	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 2 A		2.2	3	V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 5 V I_C = 50 A V_{CE} = 2.5 V	80 25	150		
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 50 A I_{B1} = 2 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)		2.2 0.3	5 0.6	µs µs
V_F	Diode Forward Voltage	I_F = 50 A		1.6	2.2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 50 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

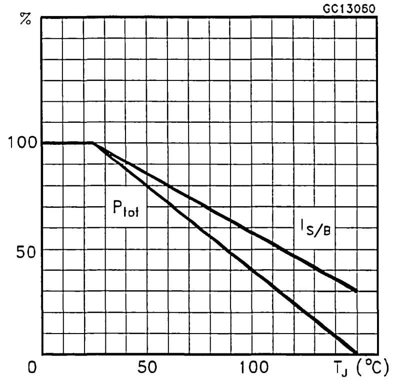
Safe Operating Areas



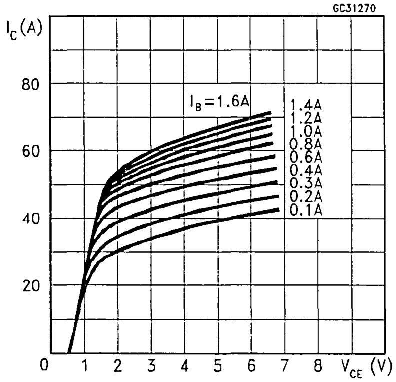
Thermal Impedance



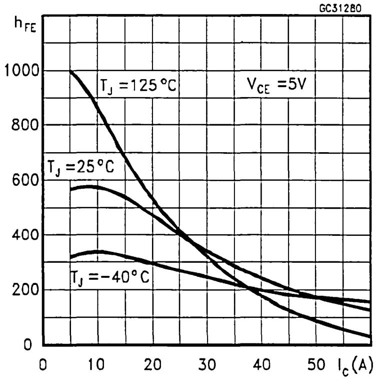
Derating Curve



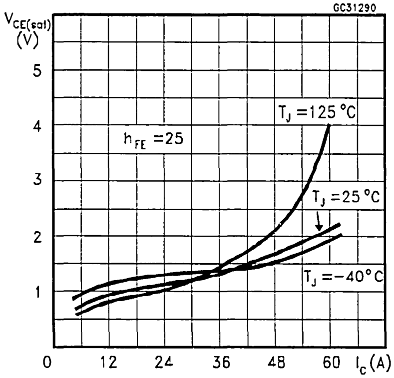
Output Characteristics



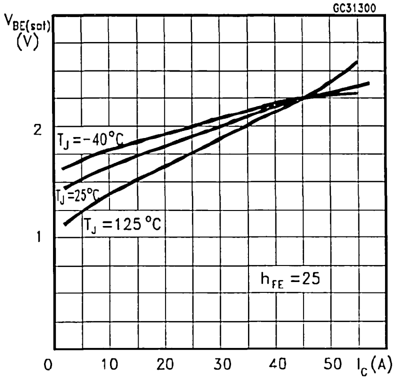
DC Current Gain



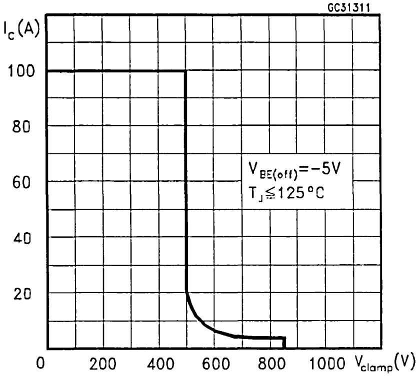
Collector-Emitter Saturation Voltage



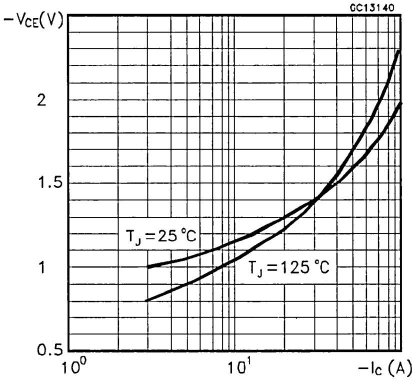
Base-Emitter Saturation Voltage



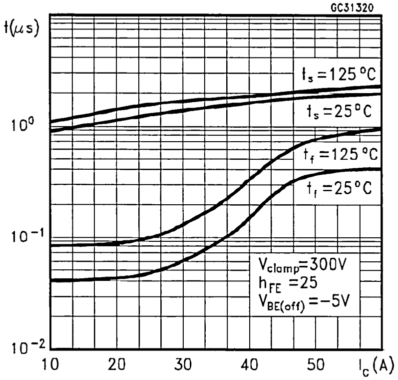
Reverse Biased SOA



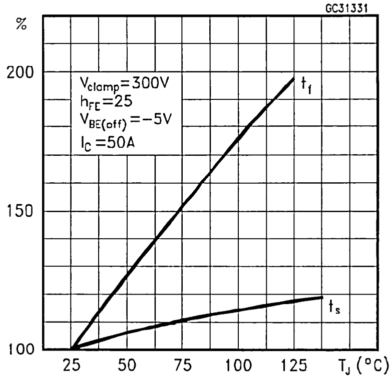
Typical V_F Versus I_F



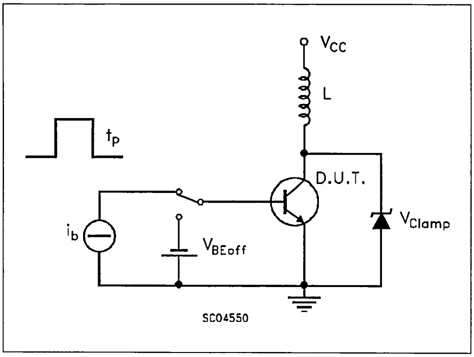
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

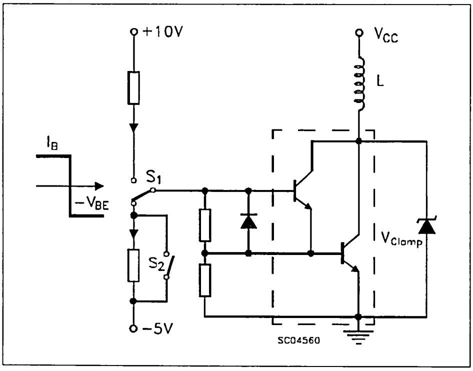


RBSOA Test Circuit



t_P adjusted for nominal I_C; I_C/I_B= 25

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

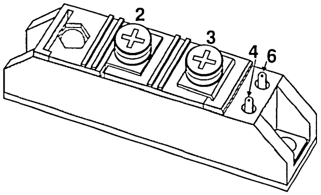
SGS50DA080D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

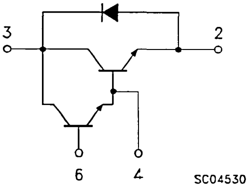
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	800	V
V_{CES}	Collector-Emitter Voltage ($V_{BE} = 0$)	1200	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	1200	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	1200	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	50	A
$- I_C$	Reverse Collector Current	50	A
I_B	Base Current	6	A
$- I_{CSM}$	Collector Surge Current	500	A
P_{tot}	Total Dissipation at $T_c = 25\,^{o}C$	400	W
T_{stg}	Storage Temperature	-55 to 150	^{o}C
T_j	Max. Operating Junction Temperature	150	^{o}C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

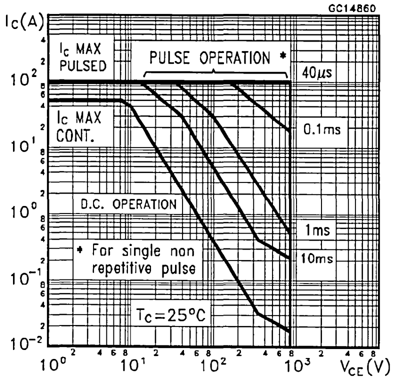
$R_{thj\text{-}case}$	Thermal Resistance Junction-case Max	0.31	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

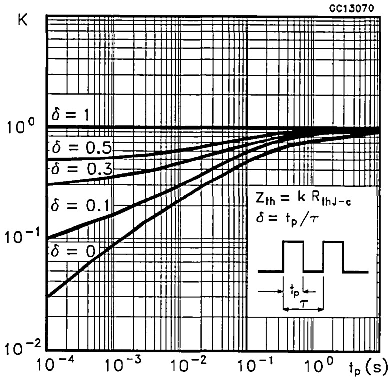
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 800 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1200 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1200 V			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 2.5 A			3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 2.5 A			3.5	V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 3 V I_C = 50 A V_{CE} = 5 V	20 70			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 50 A I_{B1} = 2.5 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)			6 0.8	µs µs
V_F	Diode Forward Voltage	I_F = 50 A			2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 50 A di/dt = 100 A/µs			0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

Safe Operating Areas

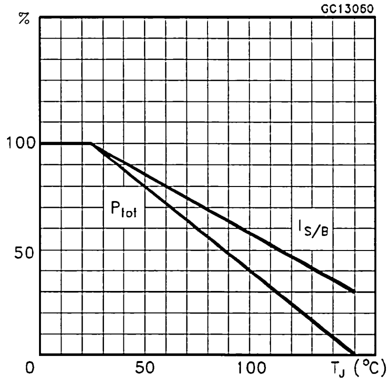


Thermal Impedance

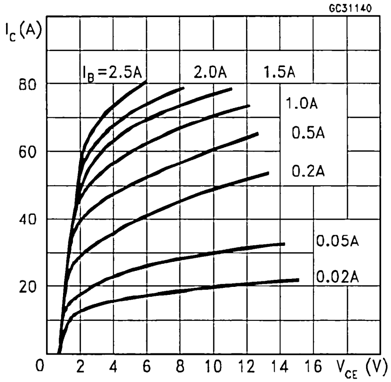


SGS-THOMSON MICROELECTRONICS

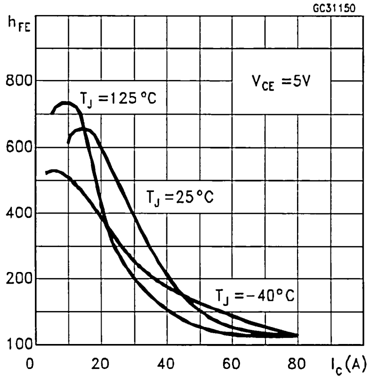
Derating Curve



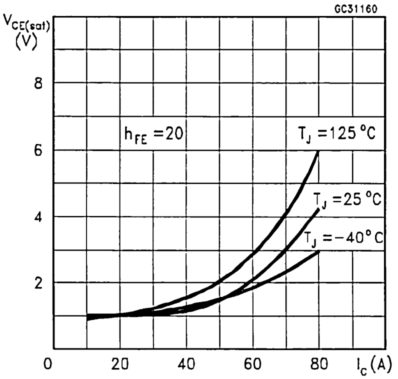
Output Characteristics



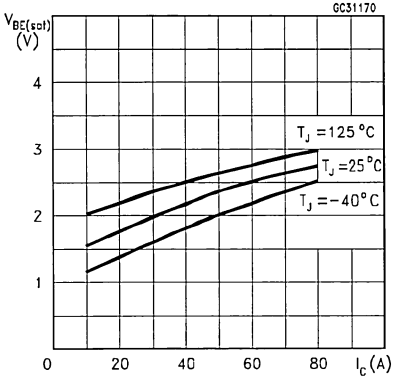
DC Current Gain



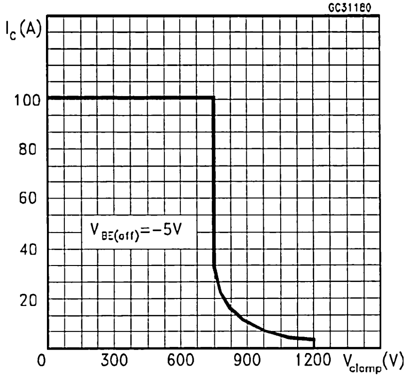
Collector-Emitter Saturation Voltage



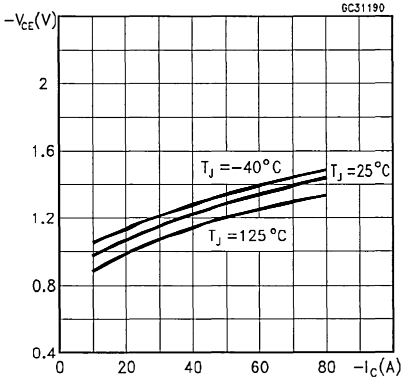
Base-Emitter Saturation Voltage



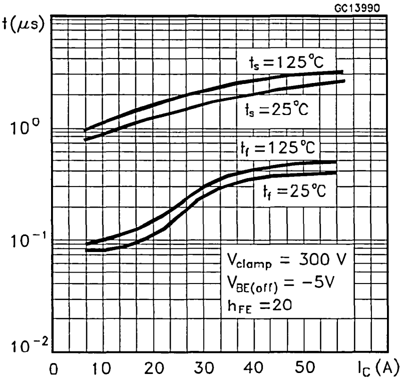
Reverse Biased SOA



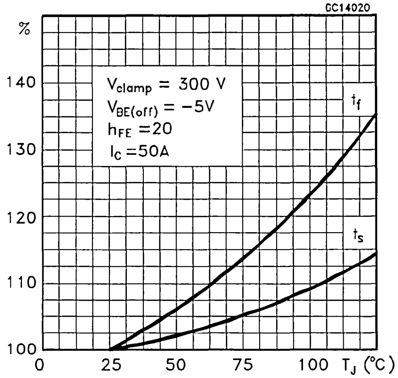
Typical V_F Versus I_F



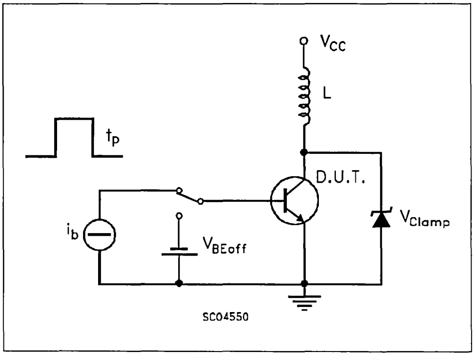
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

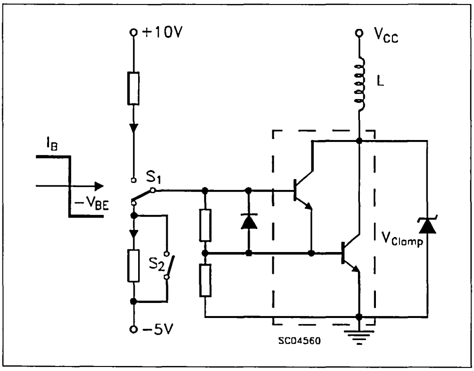


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 20

Switching Times Test Circuit



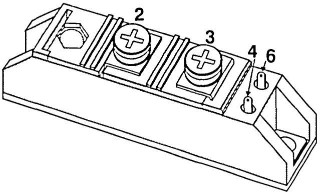
SGS-THOMSON
MICROELECTRONICS

SGS60DA070D

NPN DARLINGTON POWER MODULE

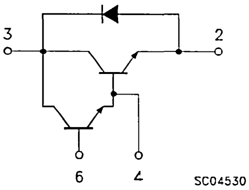
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	700	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	1200	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	1200	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	1200	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	60	A
$- I_C$	Reverse Collector Current	60	A
I_B	Base Current	6	A
$- I_{CSM}$	Collector Surge Current	60	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

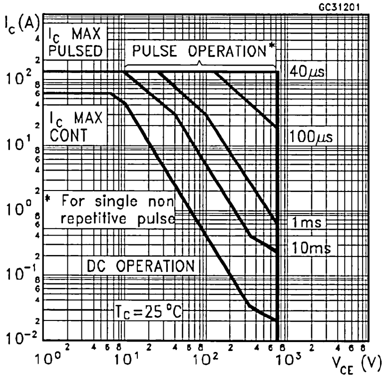
$R_{thj\text{-}case}$	Thermal Resistance Junction-case Max	0.31	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

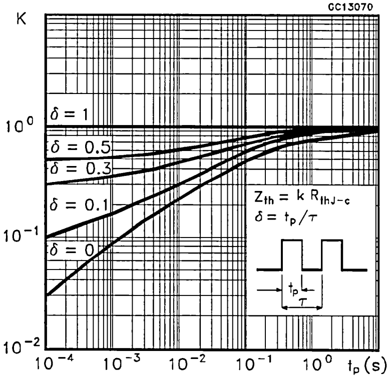
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 700 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1200 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1200 V			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 60 A I_B = 2 A			3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 60 A I_B = 2 A			3.5	V
h_{FE}*	DC Current Gain	I_C = 60 A V_{CE} = 3 V I_C = 60 A V_{CE} = 5 V	30 80			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 60 A I_{B1} = 2 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)			6 0.8	μs μs
V_F	Diode Forward Voltage	I_F = 60 A			2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 60 A di/dt = 100 A/μs			0.5	μs

* Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
# See test circuits in databook introduction

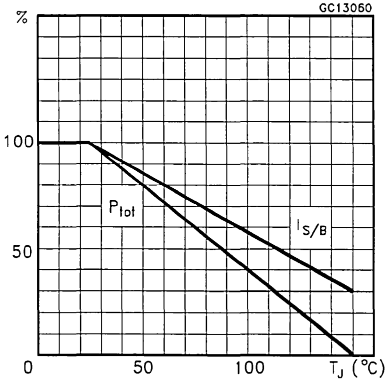
Safe Operating Areas



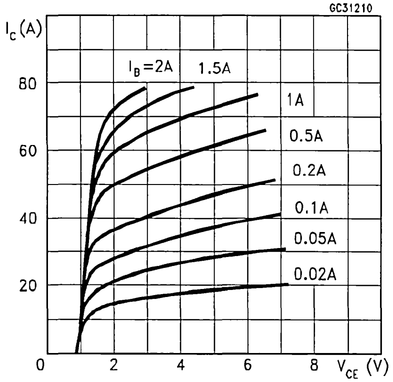
Thermal Impedance



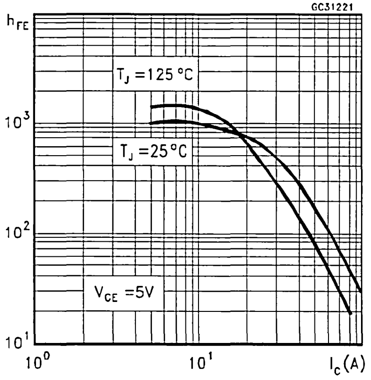
Derating Curve



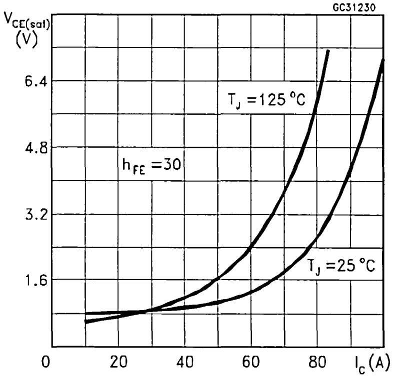
Output Characteristics



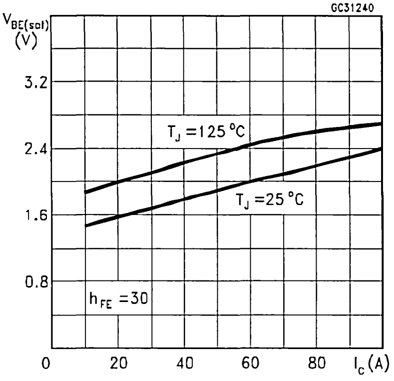
DC Current Gain



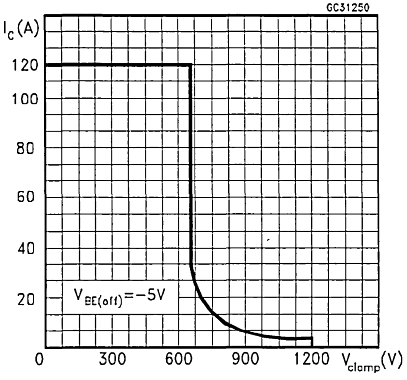
Collector-Emitter Saturation Voltage



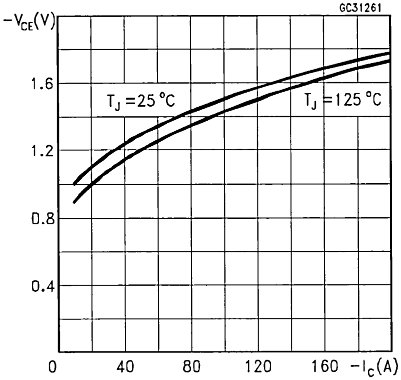
Base-Emitter Saturation Voltage



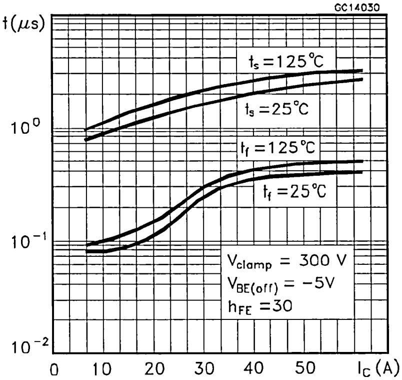
Reverse Biased SOA



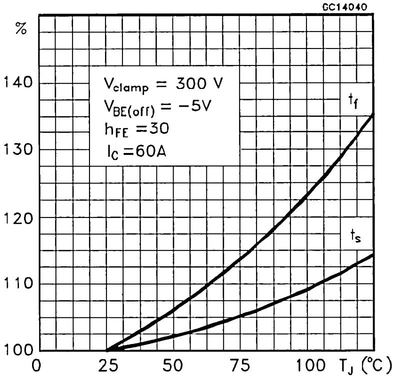
Typical V_F Versus I_F



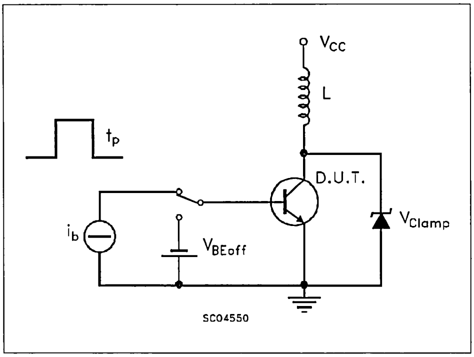
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

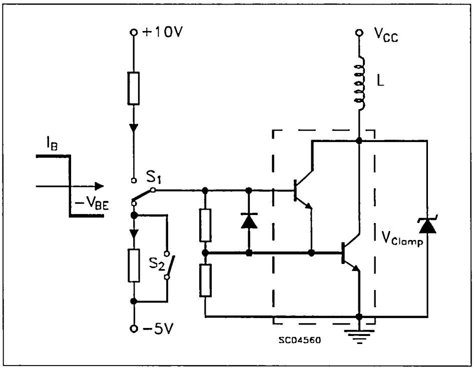


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B = 30

Switching Times Test Circuit

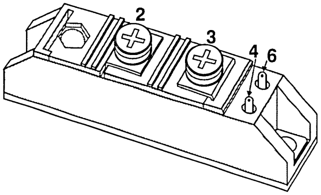


SGS80DA020D

NPN DARLINGTON POWER MODULE

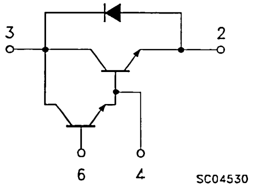
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	200	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	300	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	300	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	80	A
$- I_C$	Reverse Collector Current	80	A
I_B	Base Current	2	A
$- I_{CSM}$	Collector Surge Current	1200	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

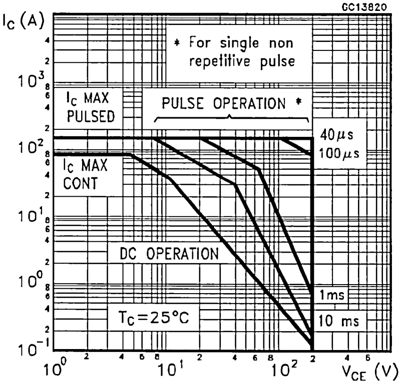
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

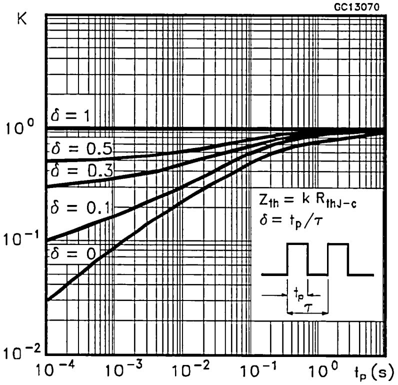
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 250 V V_{CE} = 250 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 300 V V_{CE} = 250 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 300 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 80 A I_B = 1 A		1.8	2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 80 A I_B = 1 A		2.5	3	V
h_{FE}*	DC Current Gain	I_C = 80 A V_{CE} = 2 V I_C = 80 A V_{CE} = 5 V	80 500	 1000		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 80 A I_{B1} = 1 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)		 1.85 0.3	 4 0.6	 µs µs
V_F	Diode Forward Voltage	I_F = 80 A		1.6	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 80 A dI/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

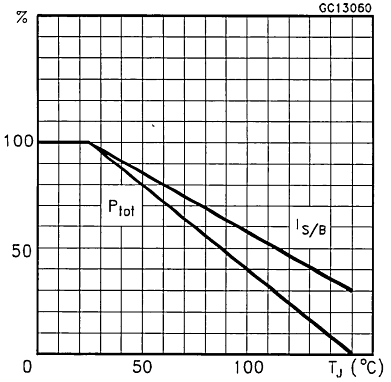
Safe Operating Areas



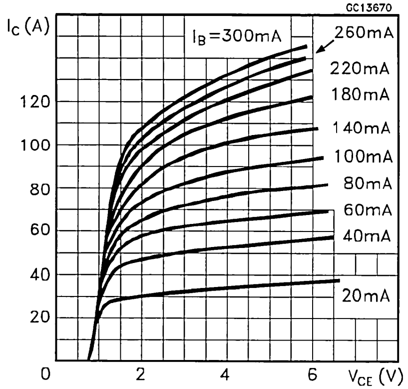
Thermal Impedance



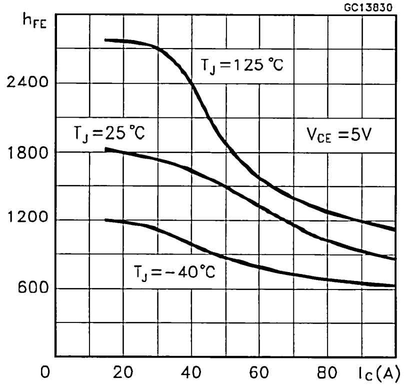
Derating Curve



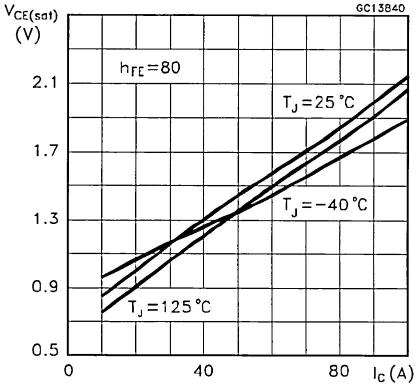
Output Characteristics



DC Current Gain

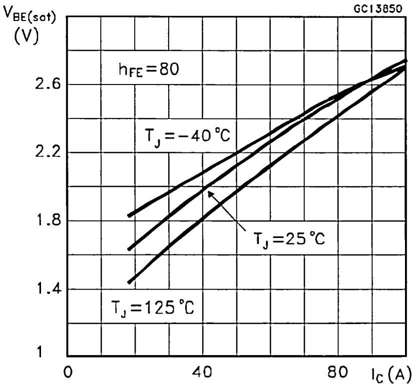


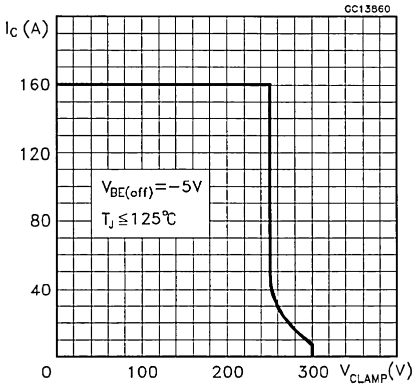
Collector-Emitter Saturation Voltage



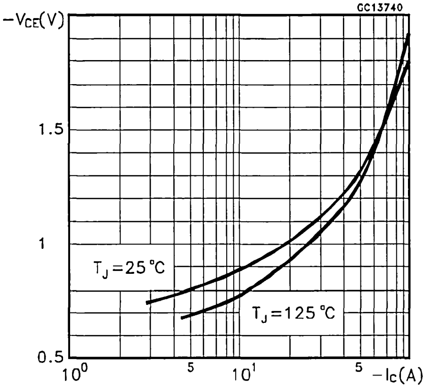
Base-Emitter Saturation Voltage

Reverse Biased SOA

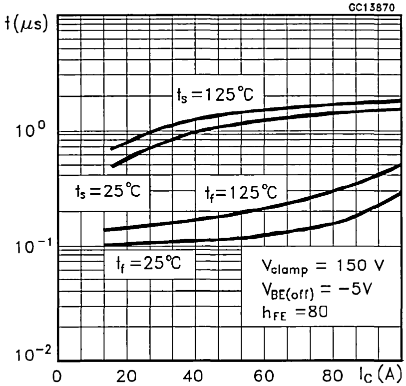




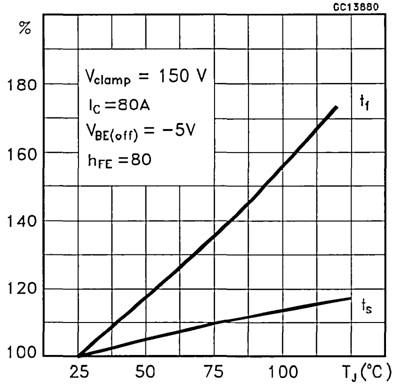
Typical V_F Versus I_F



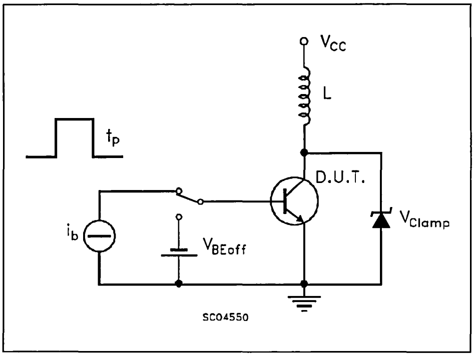
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

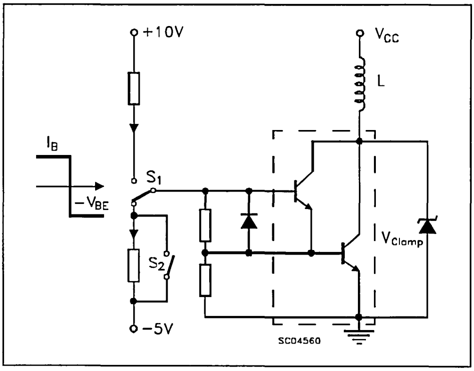


RBSOA Test Circuit



t_p adjusted for nominal I_C; $I_C/I_B = 20$

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

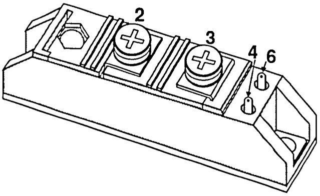
SGS100DA020D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

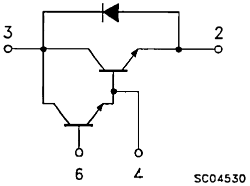
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	200	V
V_{CES}	Collector-Emitter Voltage ($V_{BE}= 0$)	300	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	300	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	300	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	100	A
$- I_C$	Reverse Collector Current	100	A
I_B	Base Current	3	A
$- I_{CSM}$	Collector Surge Current	1000	A
P_{tot}	Total Dissipation at $T_c = 25$ °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

April 1990

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.33	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

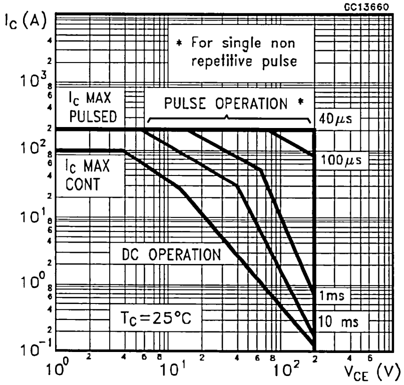
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 200 V V_{CE} = 200 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 300 V V_{CE} = 200 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 300 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 7 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 100 A I_B = 1 A		1.4	2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 100 A I_B = 1A		2.4	3	V
h_{FE}*	DC Current Gain	I_C = 100 A V_{CE} = 2 V I_C = 100 A V_{CE} = 5 V	100 500	 850		
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50V I_C = 100 A I_{B1} = 1 A $V_{BE(off)}$= -5 V V_{clamp} = 150 V $T_j \le$ 125 °C (see test circuits)		1.5 0.3	4 0.6	µs µs
V_F	Diode Forward Voltage	I_F = 100 A		1.9	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 100 A di/dt = 100 A/µs		0.3	0.5	µs

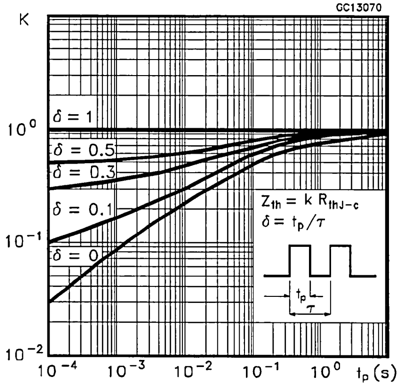
* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

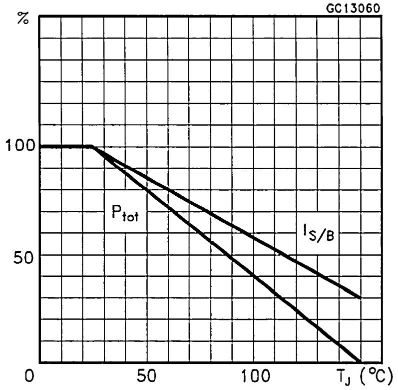
Safe Operating Areas



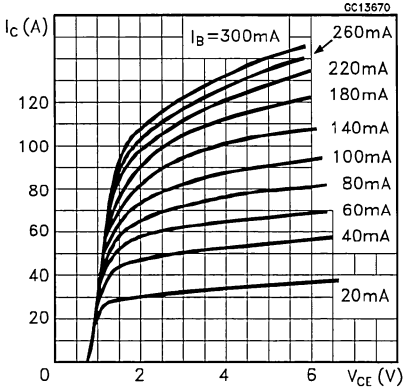
Thermal Impedance



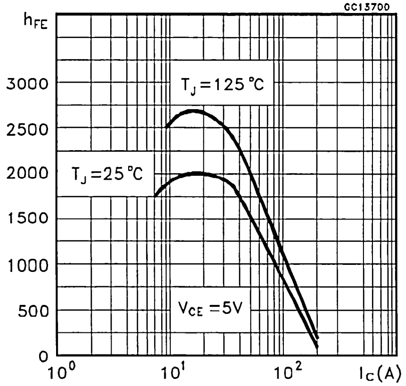
Derating Curves



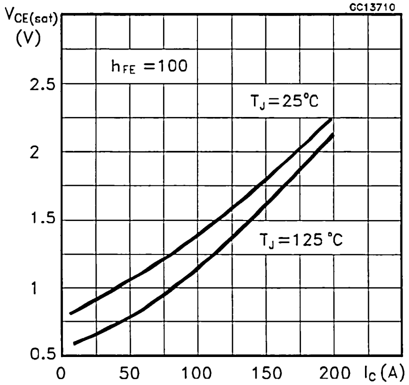
Output Characteristics



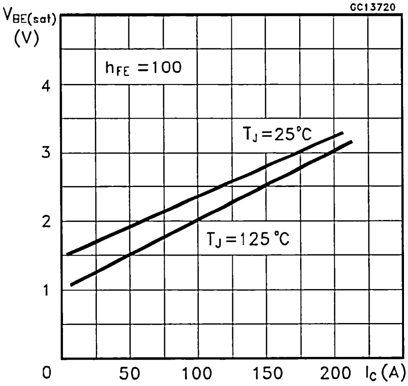
DC Current Gain



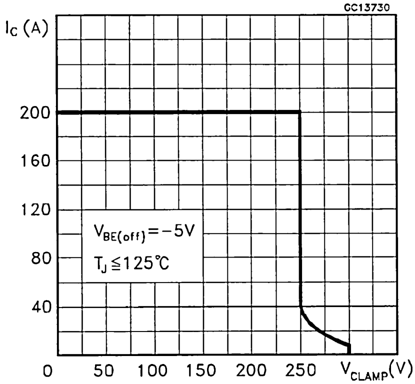
Collector-Emitter Saturation Voltage



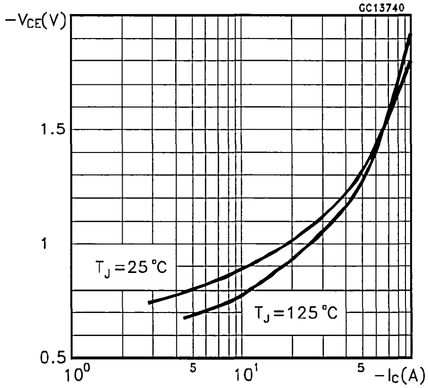
Base-Emitter Saturation Voltage



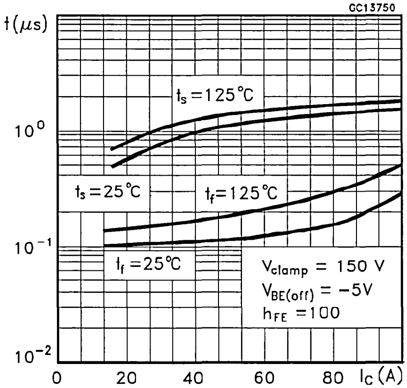
Reverse Biased SOA



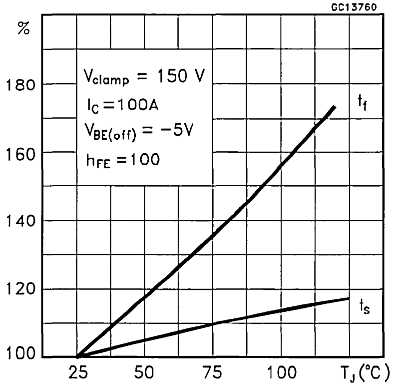
Typical V_F Versus I_F



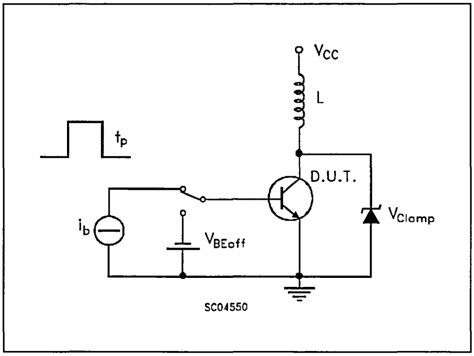
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

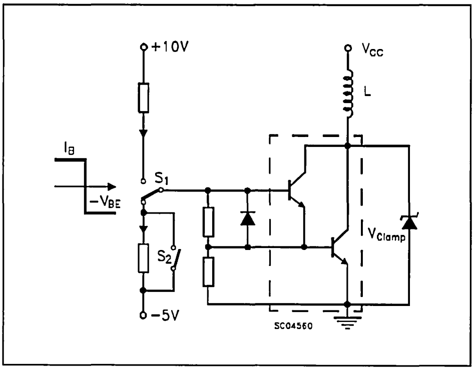


RBSOA Test Circuit



t_p adjusted for nominal I_C; $I_C/I_B = 100$

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

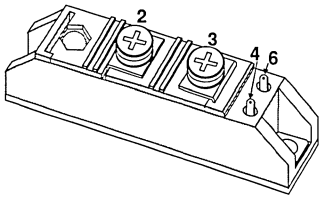
SGS150DA020D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

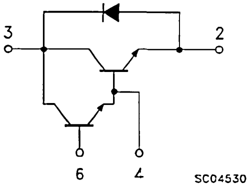
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	200	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	300	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2v)	300	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	300	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	150	A
$- I_C$	Reverse Collector Current	150	A
I_B	Base Current	4	A
$- I_{CSM}$	Collector Surge Current	1500	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

$R_{thj-case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thj-case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
R_{thc-h}	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

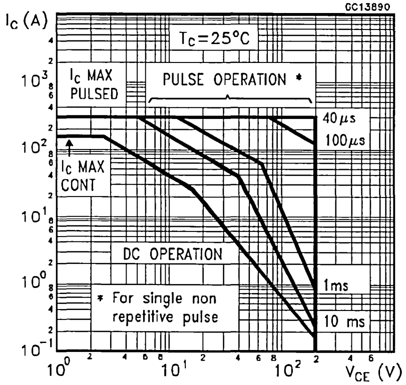
ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 200 V V_{CE} = 200 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 300 V V_{CE} = 200 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 300 V			2	mA
I_{EBO} #	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 150 A I_B = 2 A			2	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 150 A I_B = 2 A			3	V
h_{FE}*	DC Current Gain	I_C = 150 A V_{CE} = 2 V I_C = 150 A V_{CE} = 5 V	75 500			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 150 A I_{B1} = 2 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)			5 0.8	µs µs
V_F	Diode Forward Voltage	I_F = 150 A			2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 150 A di/dt = 100 A/µs			0.6	µs

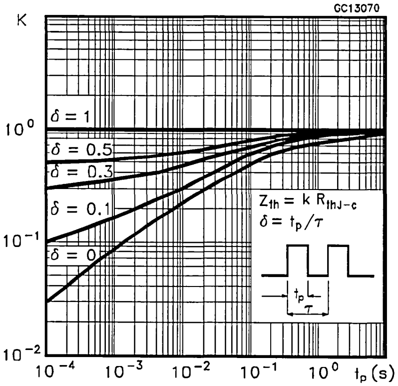
∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

See test circuits in databook introduction

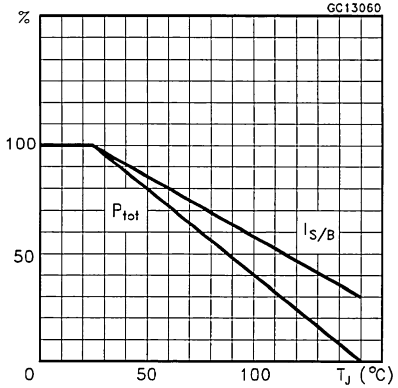
Safe Operating Areas



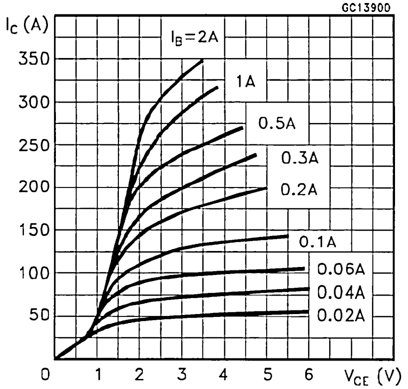
Thermal Impedance



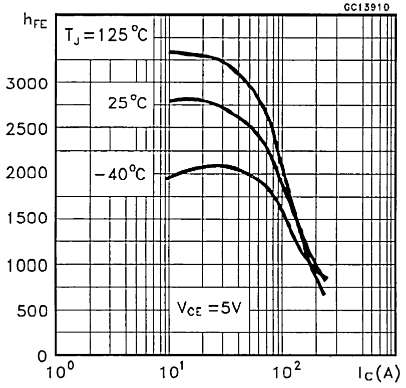
Derating Curve



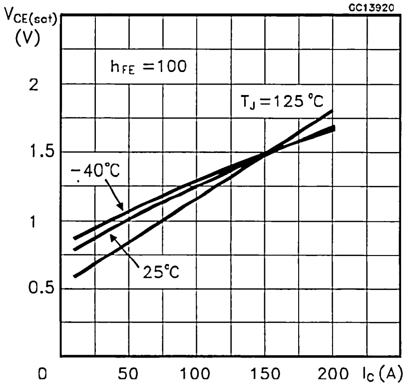
Output Characteristics



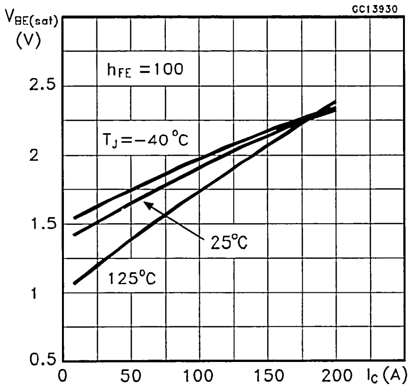
DC Current Gain



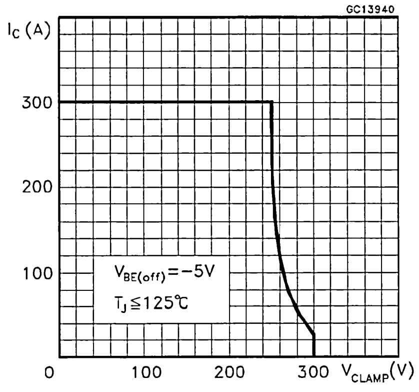
Collector-Emitter Saturation Voltage



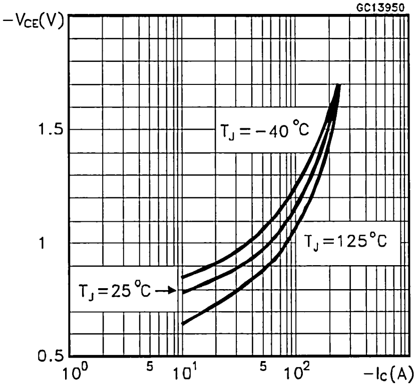
Base-Emitter Saturation Voltage



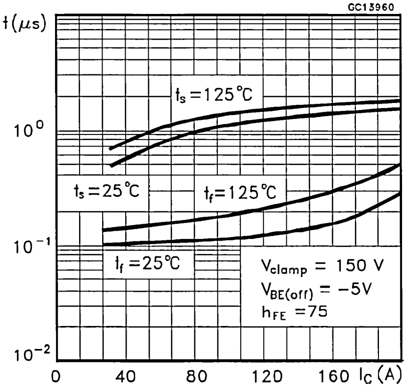
Reverse Biased SOA



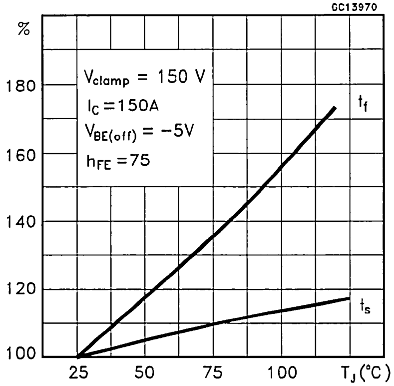
Typical V_F Versus I_F



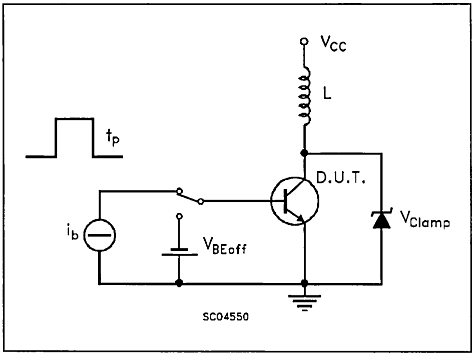
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

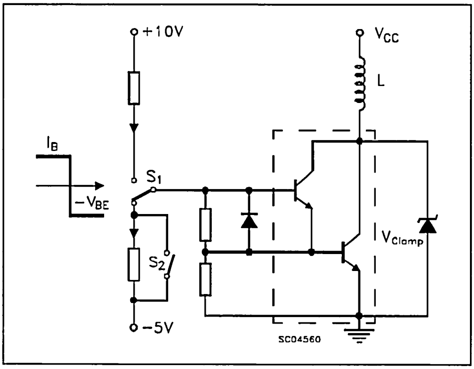


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B = 20

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

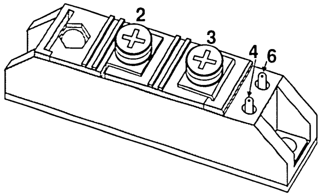
SGS250DA013D

NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

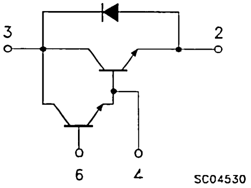
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVENTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
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V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	200	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	200	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	200	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	250	A
$-I_C$	Reverse Collector Current	250	A
I_B	Base Current	20	A
$-I_{CSM}$	Collector Surge Current	2500	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

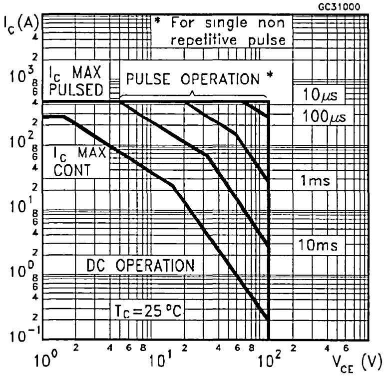
$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

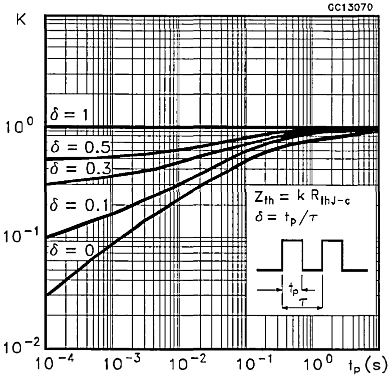
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CER} #	Collector Cut-off Current (R_{BE1} = 3.3 kΩ R_{BE2} = 100 Ω)	V_{CE} = 130 V V_{CE} = 130 V T_j = 125 °C			2 10	mA mA
I_{CES} #	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 200 V V_{CE} = 130 V T_j = 125 °C			2 10	mA mA
I_{CEV} #	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 200 V			2	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 250 A I_B = 3.3 A			2.5	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 250 A I_B = 3.3 A			3.5	V
h_{FE}*	DC Current Gain	I_C = 250 A V_{CE} = 2.5 V I_C = 250 A V_{CE} = 5 V	75 100			
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 250 A I_{B1} = 3.3 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)			6 1	µs µs
V_F	Diode Forward Voltage	I_F = 250 A			2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 250 A di/dt = 100 A/µs			0.6	µs

* Pulsed. Pulse duration = 300 µs, duty cycle 1.5 %
# See test circuits in databook introduction

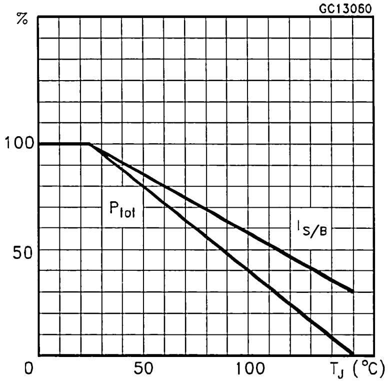
Safe Operating Areas



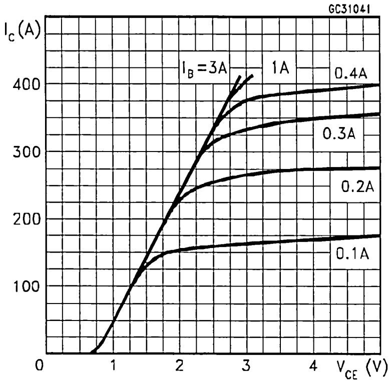
Thermal Impedance



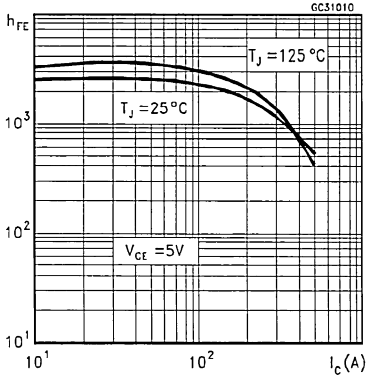
Derating Curve



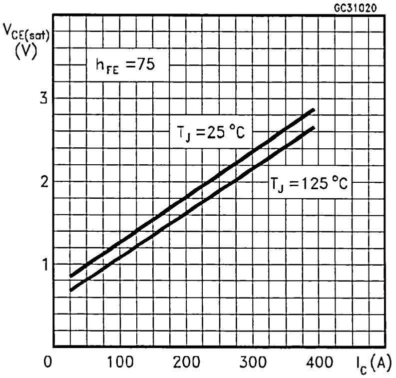
Output Characteristics



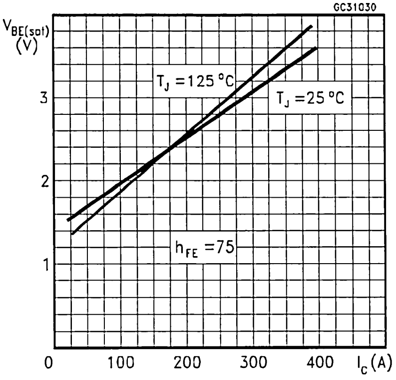
DC Current Gain



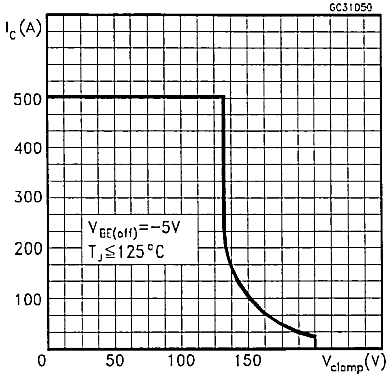
Collector-Emitter Saturation Voltage



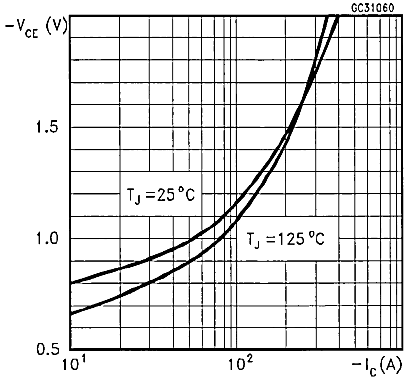
Base-Emitter Saturation Voltage



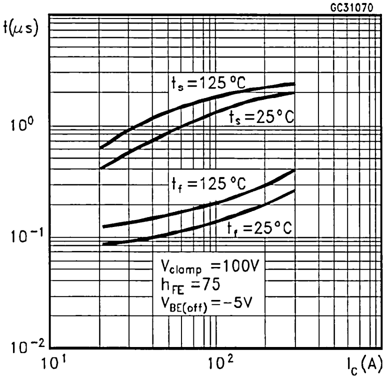
Reverse Biased SOA



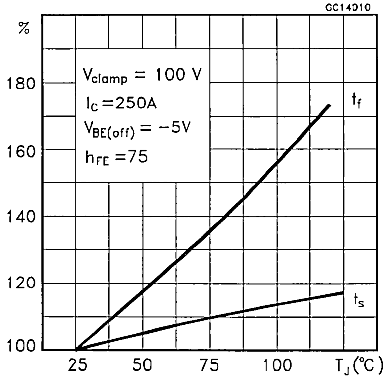
Typical V_F Versus I_F



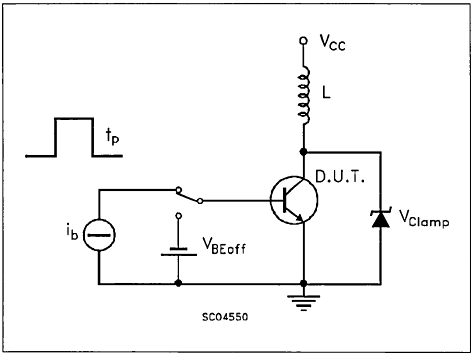
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

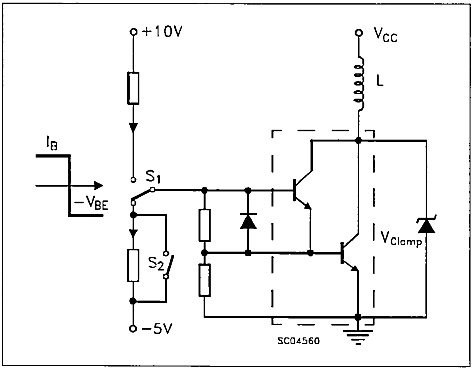


RBSOA Test Circuit



t_p adjusted for nominal I_C; $I_C/I_B = 75$

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

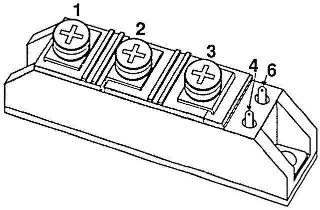
SGS25DB070D

HALF BRIDGE NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

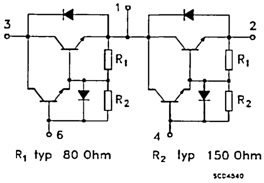
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPSAND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	700	V
V_{CES}	Collector-Emitter Voltage ($V_{BE}= 0$)	1000	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	1000	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	1000	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	25	A
$- I_C$	Reverse Collector Current	25	A
I_B	Base Current	9	A
$- I_{CSM}$	Collector Surge Current	250	A
P_{tot}	Total Dissipation at $T_c = 25\ ^oC$	375	W
T_{stg}	Storage Temperature	-55 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

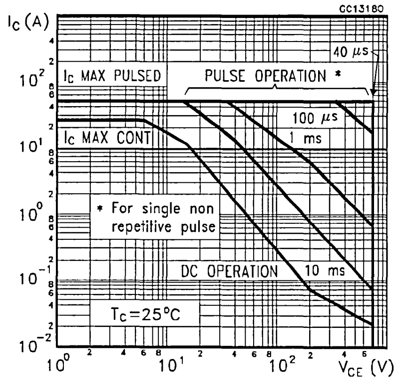
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

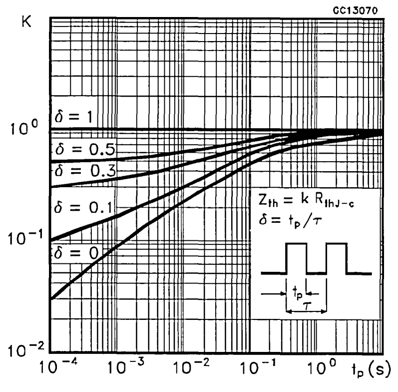
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1000 V V_{CE} = 700 V T_j = 125 °C			2 10	mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1000 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			120	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A		1.1	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A		1.9	3.5	V
h_{FE}*	DC Current Gain	I_C = 25 A V_{CE} = 3 V I_C = 25 A V_{CE} = 5 V	10 15	 90		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 300 V I_C = 25 A I_{B1} = 2.5 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)		 2.4 0.66	 5 1.5	 µs µs
V_F	Diode Forward Voltage	I_F = 25 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 25 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

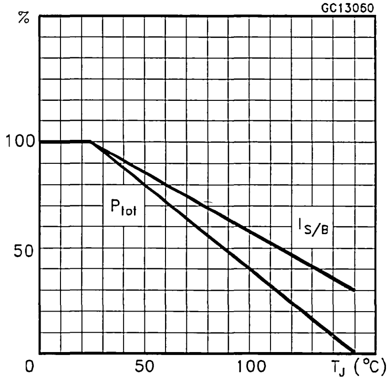
Safe Operating Areas



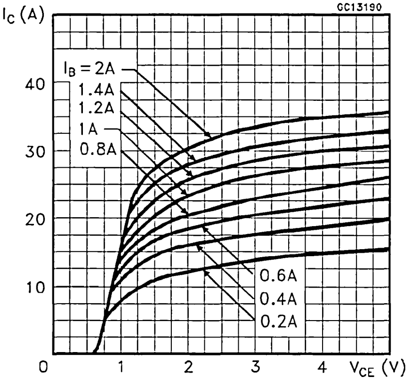
Thermal Impedance



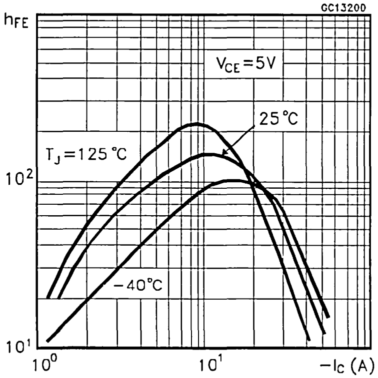
Derating Curves



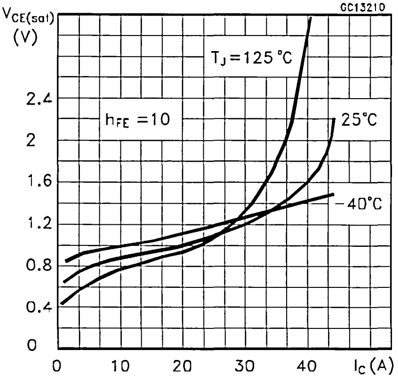
Output Characteristics



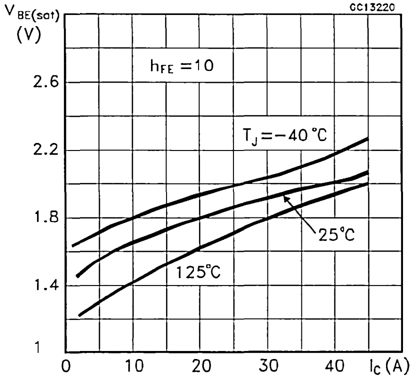
DC Current Gain



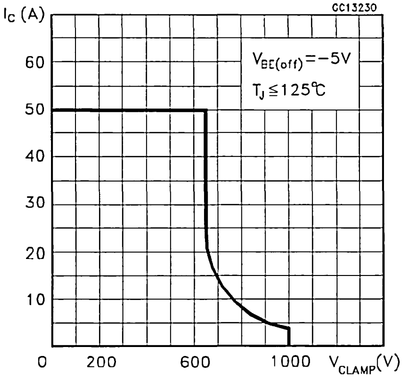
Collector-Emitter Saturation Voltage



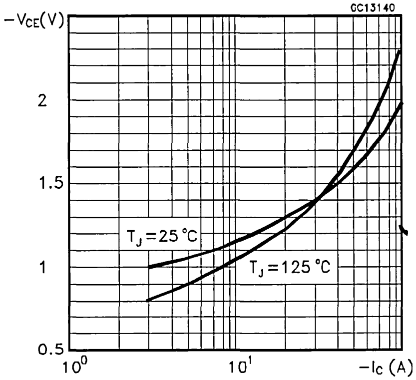
Base-Emitter Saturation Voltage



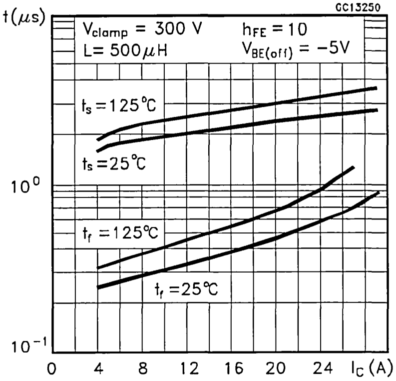
Reverse Biased SOA



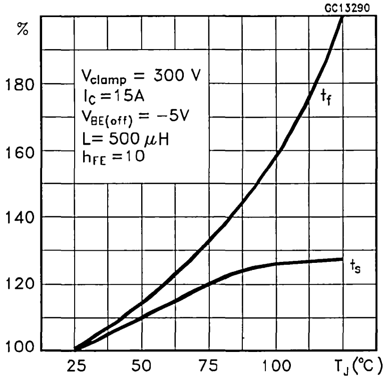
Typical V_F Versus I_F



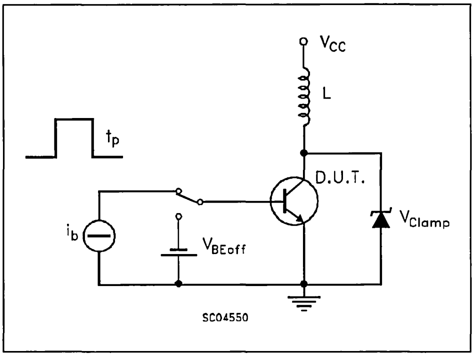
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

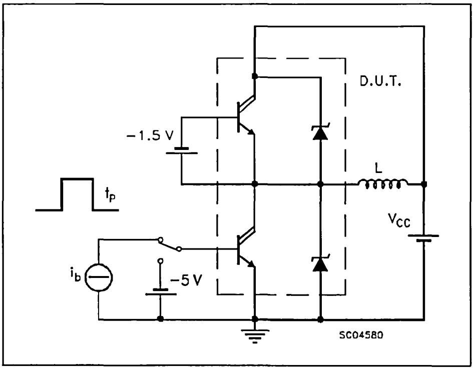


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 10

Switching Times Test Circuit



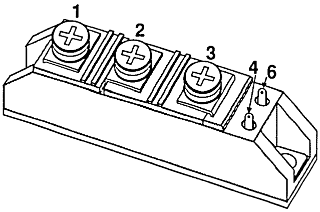
SGS-THOMSON
MICROELECTRONICS

SGS25DB080D

HALF BRIDGE NPN DARLINGTON POWER MODULE

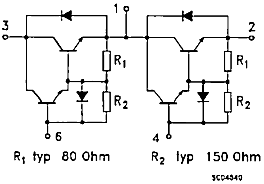
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	800	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	1200	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	1200	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	1200	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	25	A
$- I_C$	Reverse Collector Current	25	A
I_B	Base Current	9	A
$- I_{CSM}$	Collector Surge Current	250	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

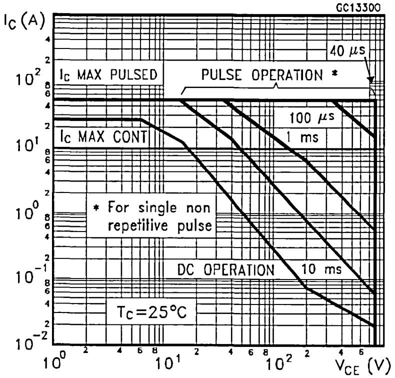
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

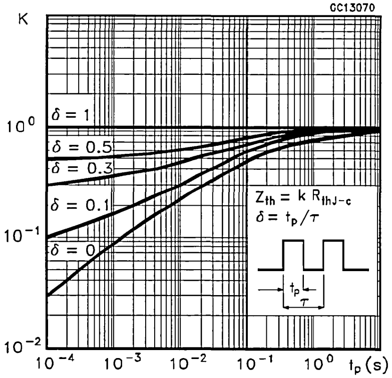
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1200 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CEX}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1200 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			120	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A		1.1	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 25 A I_B = 2.5 A		1.9	3.5	V
h_{FE}*	DC Current Gain	I_C = 25 A V_{CE} = 3 V I_C = 25 A V_{CE} = 5 V	10 15	 90		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 300 V I_C = 25 A I_{B1} = 2.5 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		 2.4 0.66	 5 1.5	 µs µs
V_F	Diode Forward Voltage	I_F = 25 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 25 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

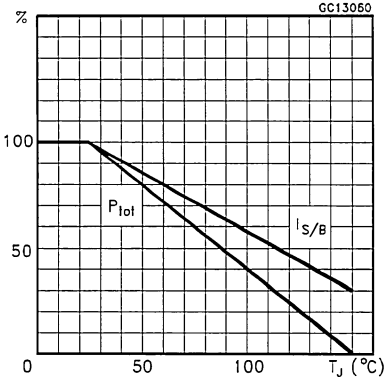
Safe Operating Areas



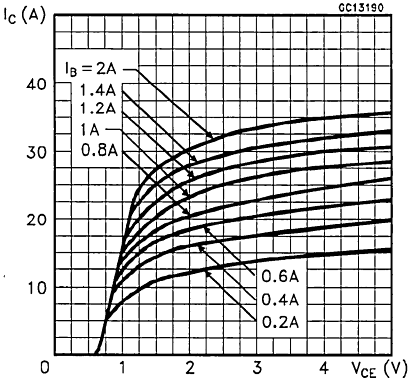
Thermal Impedance



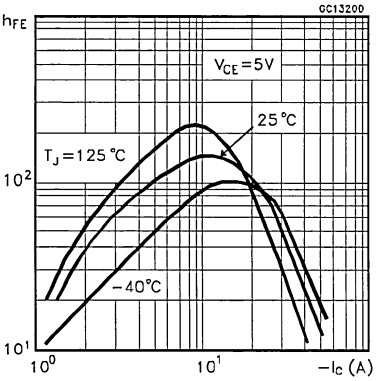
Derating Curves



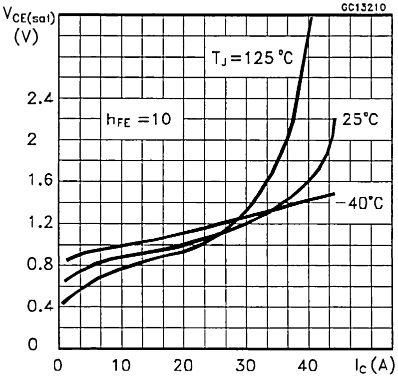
Output Characteristics



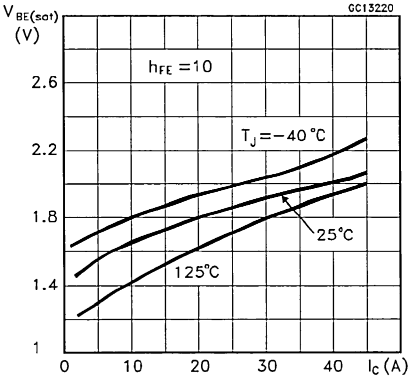
DC Current Gain



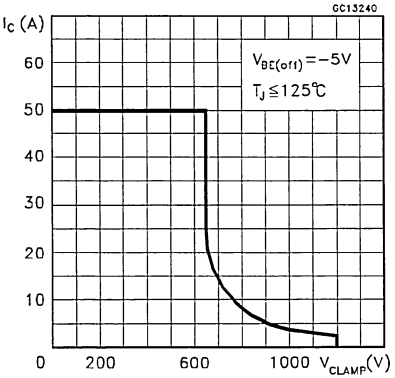
Collector-Emitter Saturation Voltage



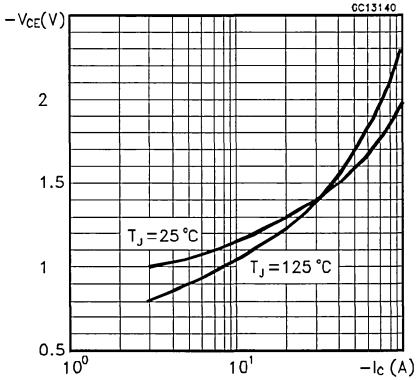
Base-Emitter Saturation Voltage



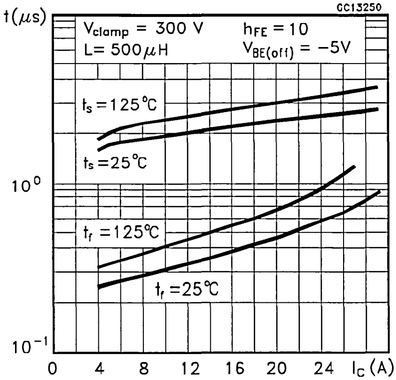
Reverse Biased SOA



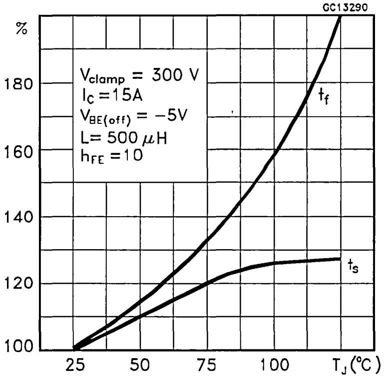
Typical V_F Versus I_F



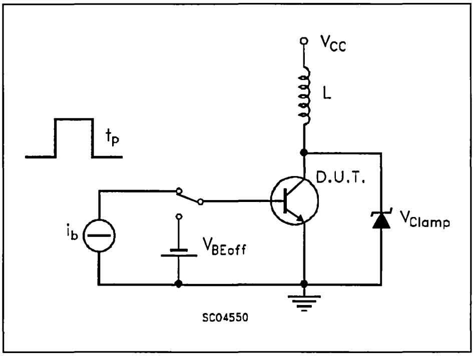
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

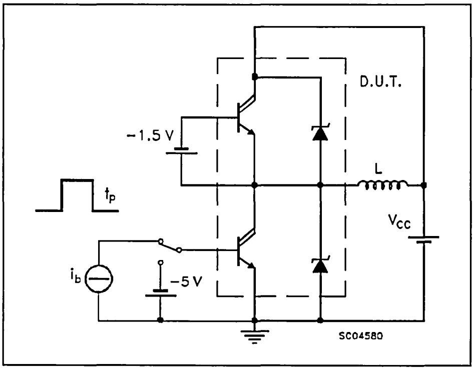


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B = 10

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

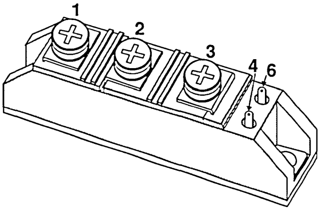
SGS30DB040D

HALF BRIDGE NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

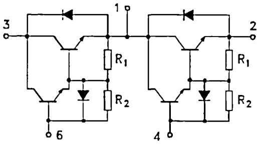
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVENTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



R_1 typ 80 Ohm R_2 typ 150 Ohm

SCC4540

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	400	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	500	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	500	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	500	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	30	A
$-I_C$	Reverse Collector Current	30	A
I_B	Base Current	6	A
$-I_{CSM}$	Collector Surge Current	300	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

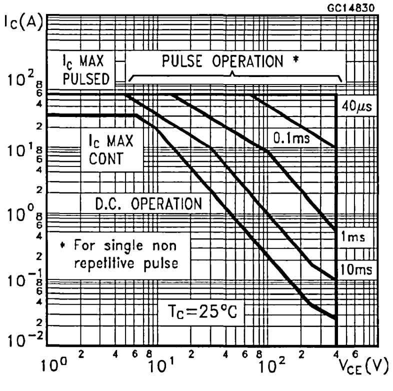
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarte bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

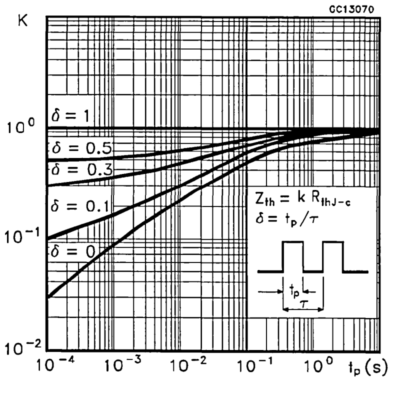
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 500 V V_{CE} = 400 V T_j = 125 °C		 3	2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 500 V V_{CE} = 400 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			90	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 2 A I_C = 40 A I_B = 4 A		1.5 1.9	3 2.5	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 40 A I_B = 4 A		2.6	3.3	V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 5 V I_C = 40 A V_{CE} = 3 V	40 16	50		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 50 V I_C = 30 A I_{B1} = 2 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		 1.3 0.2	 3 0.7	 µs µs
V_F	Diode Forward Voltage	I_F = 30 A		1.3	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 30 A di/dt = 100 A/µs		0.2	0.5	µs

∗ Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

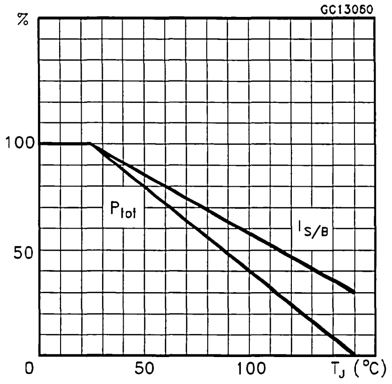
Safe Operating Areas



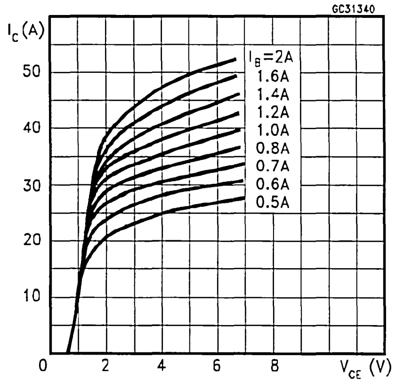
Thermal Impedance



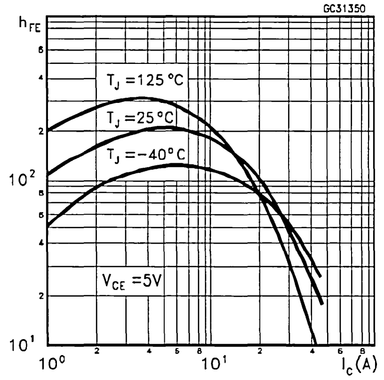
Derating Curve



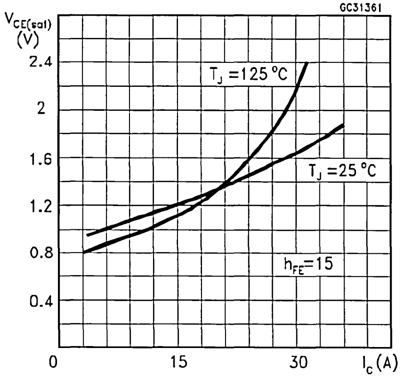
Output Characteristics



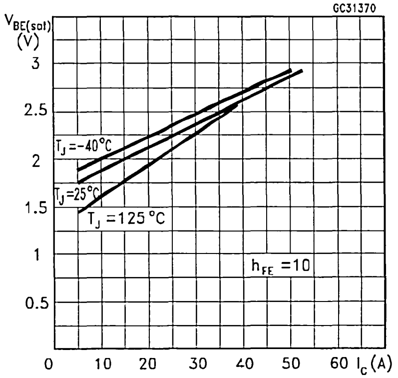
DC Current Gain



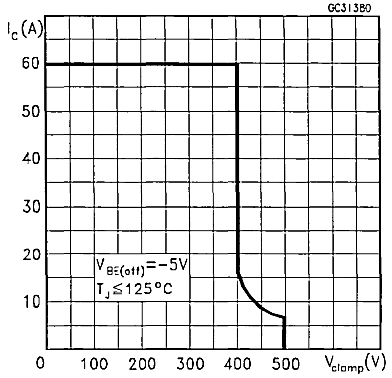
Collector-Emitter Saturation Voltage



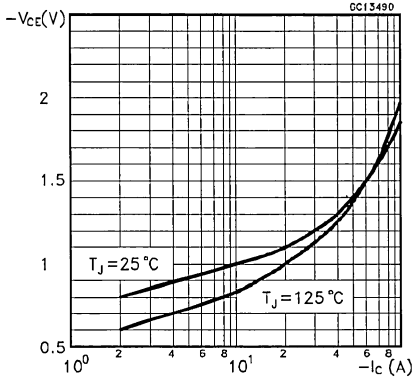
Base-Emitter Saturation Voltage



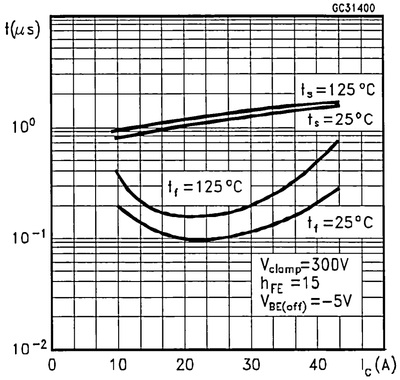
Reverse Biased SOA



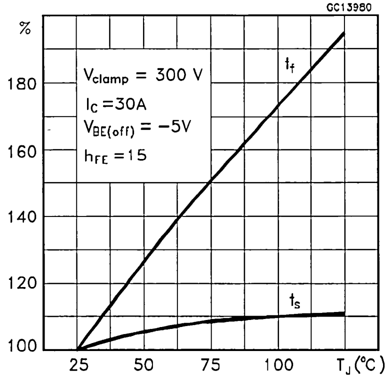
Typical V_F Versus I_F



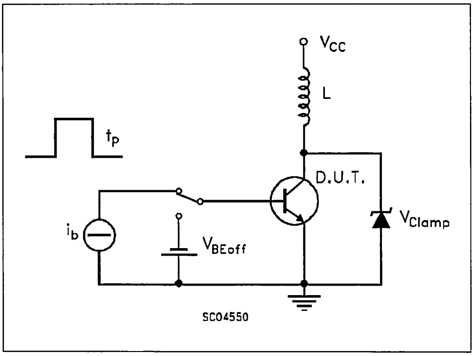
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

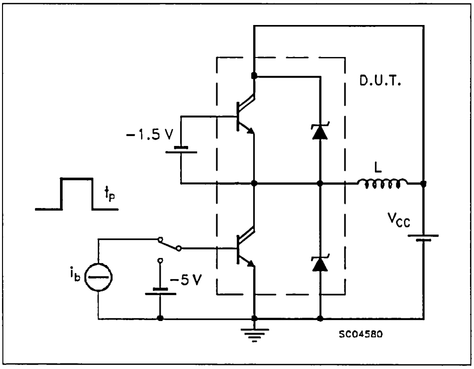


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 20

Switching Times Test Circuit



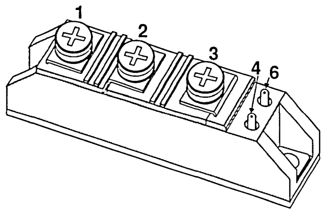
SGS-THOMSON
MICROELECTRONICS

SGS30DB045D

HALF BRIDGE NPN DARLINGTON POWER MODULE

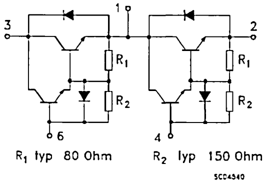
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	450	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	600	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	600	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	600	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	30	A
$- I_C$	Reverse Collector Current	30	A
I_B	Base Current	6	A
$- I_{CSM}$	Collector Surge Current	300	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

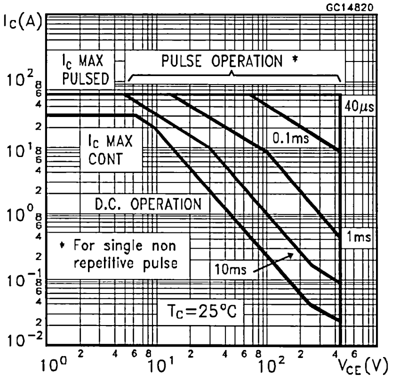
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

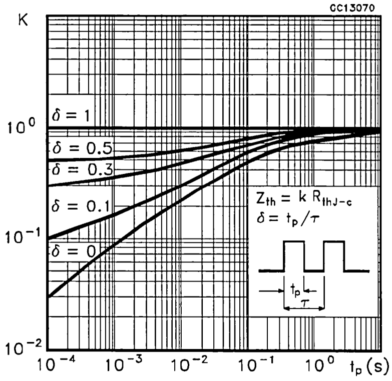
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 600 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 600 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			90	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 30 A I_B = 2 A I_C = 40 A I_B = 4 A		1.5 2	3 3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 40 A I_B = 4 A		2.6	3.3	V
h_{FE}*	DC Current Gain	I_C = 30 A V_{CE} = 5 V I_C = 40 A V_{CE} = 3 V	40 10	50		
	INDUCTIVE LOAD	V_{CC} = 50 V I_C = 30 A				
t_s	Storage Time	I_{B1} = 2 A $V_{BE(off)}$= -5 V		1.3	3	µs
t_f	Fall Time	T_j ≤ 125 °C (see test circuits)		0.2	0.7	µs
V_F	Diode Forward Voltage	I_F = 30 A		1.3	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 30 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

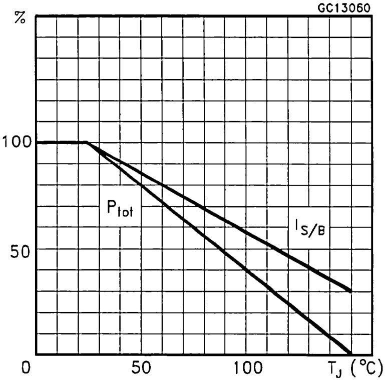
Safe Operating Areas



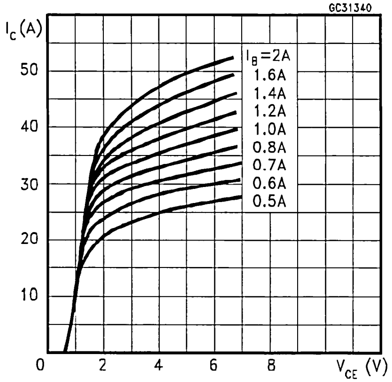
Thermal Impedance



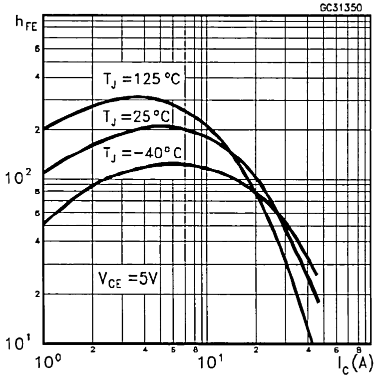
Derating Curve



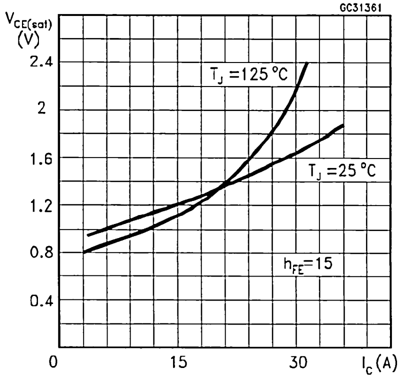
Output Characteristics



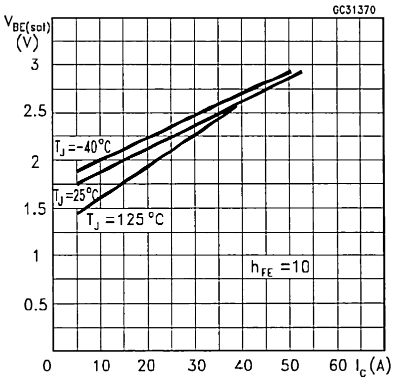
DC Current Gain



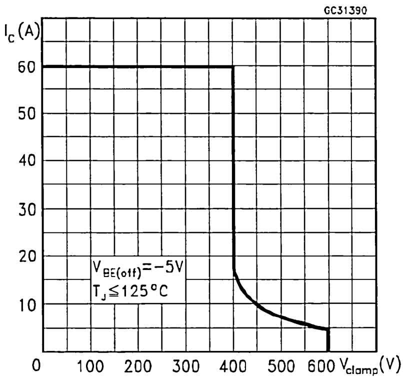
Collector-Emitter Saturation Voltage



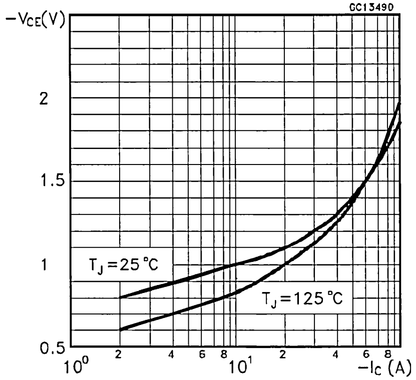
Base-Emitter Saturation Voltage



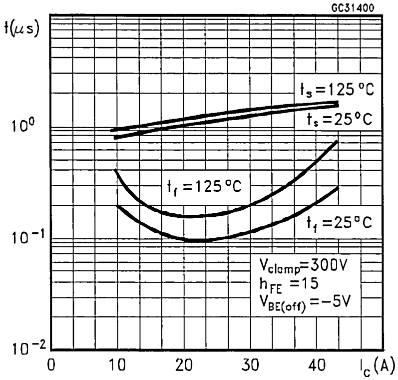
Reverse Biased SOA



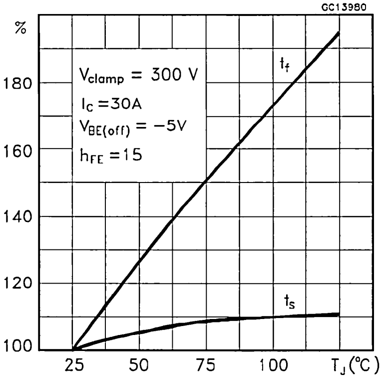
Typical V_F Versus I_F



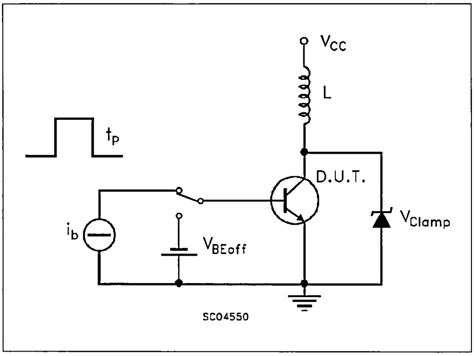
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

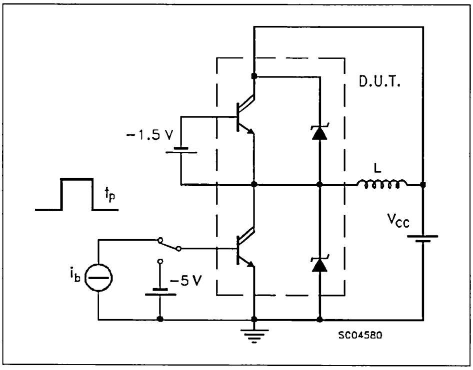


RBSOA Test Circuit



t_p adjusted for nominal I_C; $I_C/I_B = 20$

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

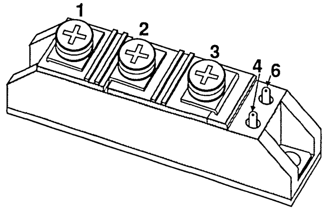
SGS35DB070D

HALF BRIDGE NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW R_{th} JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

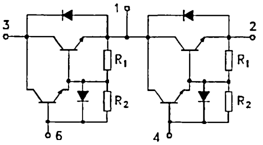
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



R_1 typ 80 Ohm R_2 typ 150 Ohm

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	700	V
V_{CES}	Collector-Emitter Voltage ($V_{BE} = 0$)	1000	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2V$)	1000	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	1000	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	35	A
$- I_C$	Reverse Collector Current	35	A
I_B	Base Current	10	A
$- I_{CSM}$	Collector Surge Current	350	A
P_{tot}	Total Dissipation at $T_c = 25\ ^oC$	400	W
T_{stg}	Storage Temperature	-55 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

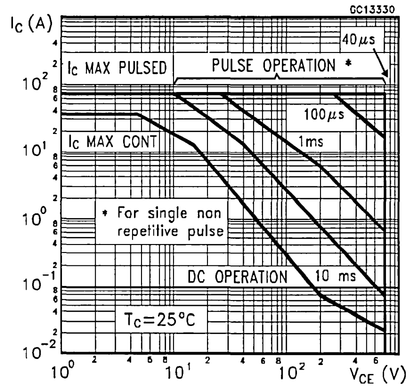
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.62	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

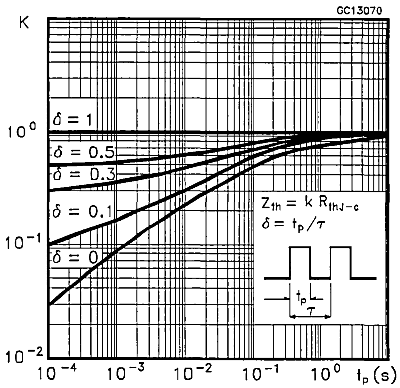
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1000 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1000 V V_{CE} = 700 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			150	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 35 A I_B = 3.5 A		1.7	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 35 A I_B = 3.5 A		2.1	3.5	V
h_{FE}*	DC Current Gain	I_C = 35 A V_{CE} = 3 V I_C = 35 A V_{CE} = 5 V	10 15	 35		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 300 V I_C = 35 A I_{B1} = 3.5 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		 3.2 0.9	 5 1.5	 µs µs
V_F	Diode Forward Voltage	I_F = 35 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 35 A di/dt = 100 A/µs		0.3	0.6	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

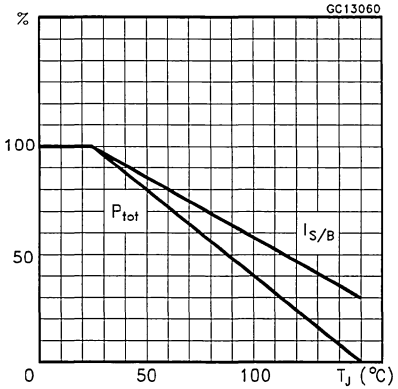
Safe Operating Areas



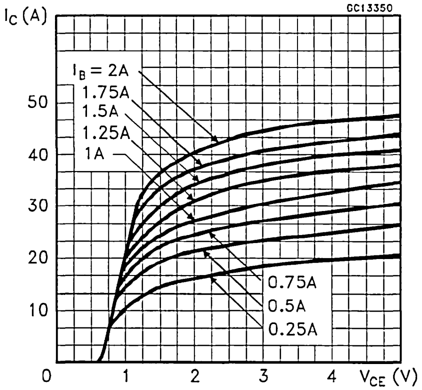
Thermal Impedance



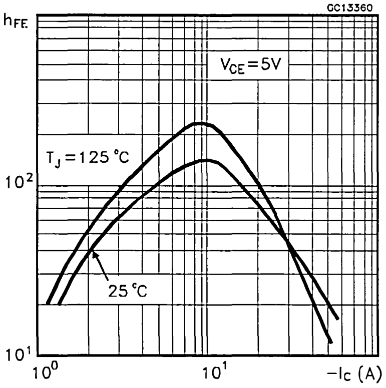
Derating Curves



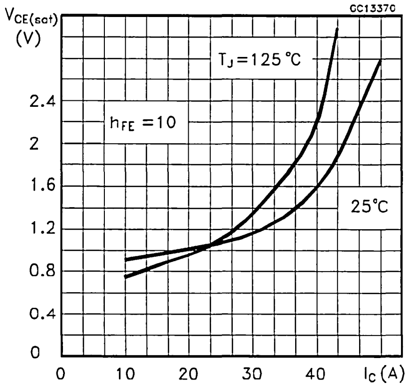
Output Characteristics



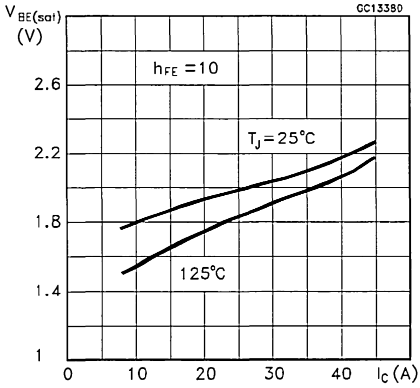
DC Current Gain



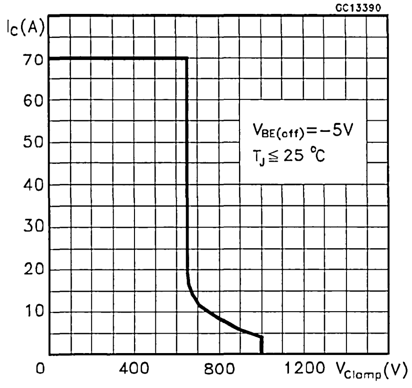
Collector-Emitter Saturation Voltage



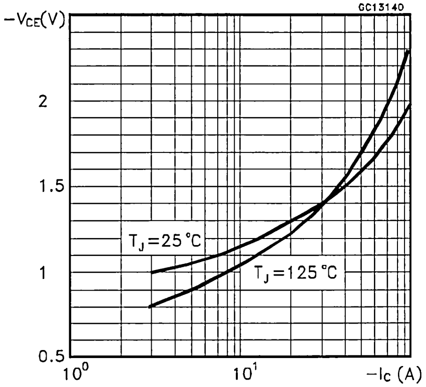
Base-Emitter Saturation Voltage



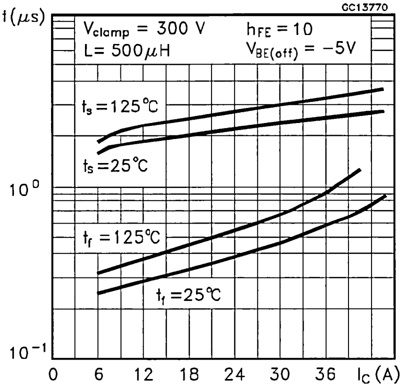
Reverse Biased SOA



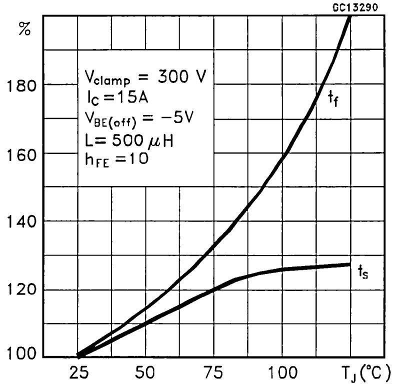
Typical V_F Versus I_F



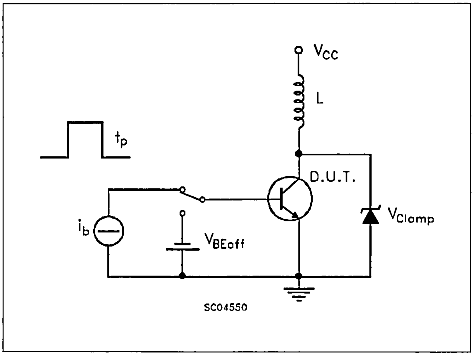
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

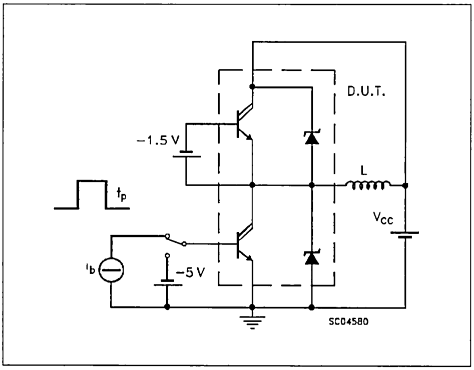


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 10

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

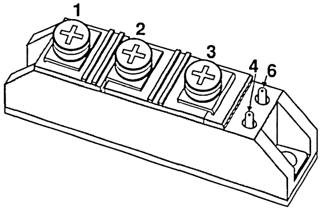
SGS35DB080D

HALF BRIDGE NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

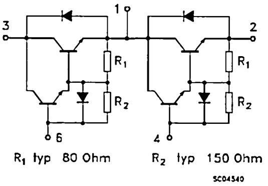
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	800	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	1200	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	1200	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	1200	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	35	A
- I_C	Reverse Collector Current	35	A
I_B	Base Current	10	A
- I_{CSM}	Collector Surge Current	350	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

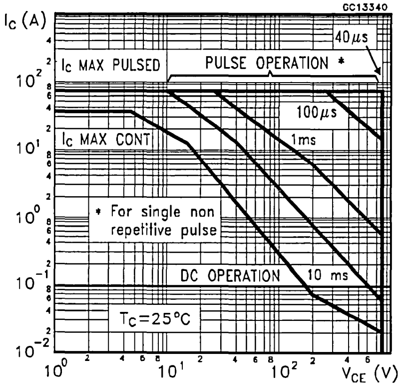
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge) Max	0.62	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode) Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

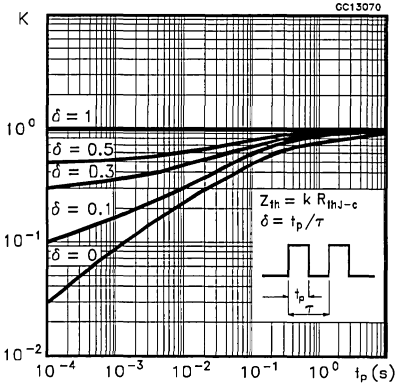
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 1200 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 1200 V V_{CE} = 800 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			150	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 35 A I_B = 3.5 A		1.7	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 35 A I_B = 3.5 A		2.1	3.5	V
h_{FE}*	DC Current Gain	I_C = 35 A V_{CE} = 3 V I_C = 35 A V_{CE} = 5 V	10 15	 35		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 300 V I_C = 35 A I_{B1} = 3.5 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)		 3.2 0.9	 5 1.5	 µs µs
V_F	Diode Forward Voltage	I_F = 35 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 35 A di/dt = 100 A/µs		0.3	0.6	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

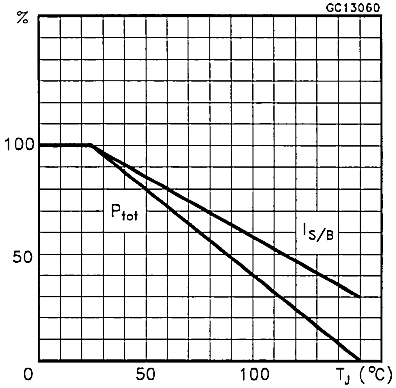
Safe Operating Areas



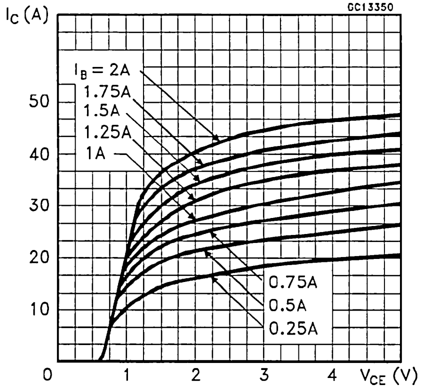
Thermal Impedance



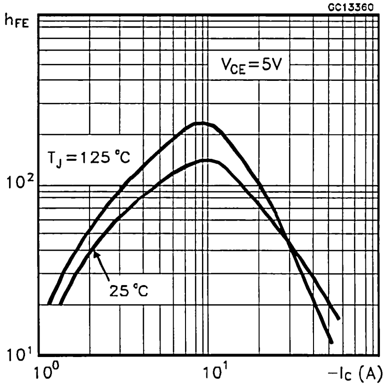
Derating Curve



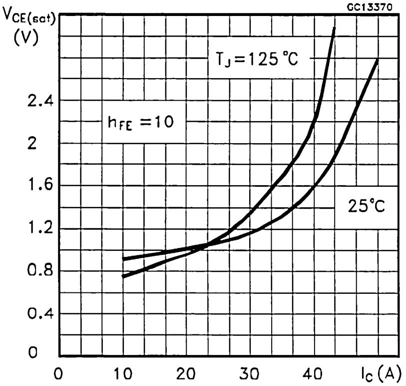
Output Characteristics



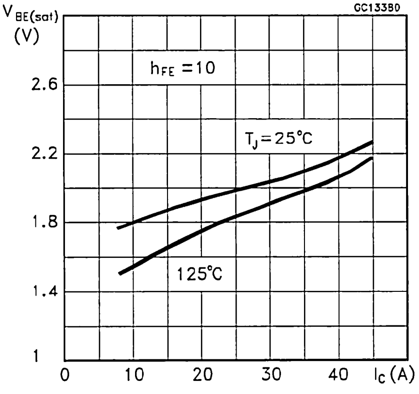
DC Current Gain



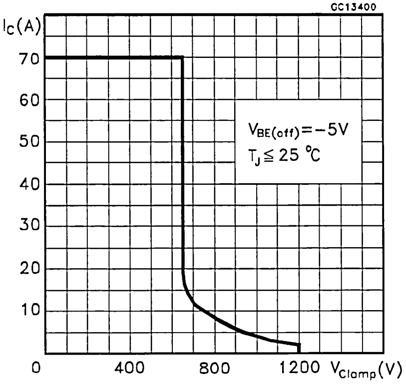
Collector-Emitter Saturation Voltage



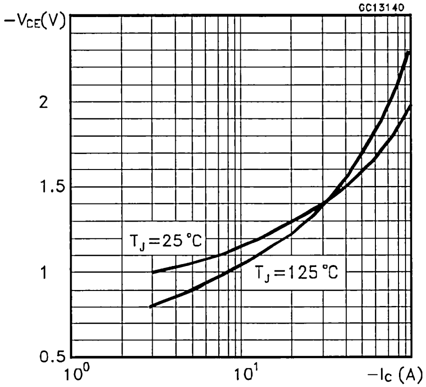
Base-Emitter Saturation Voltage



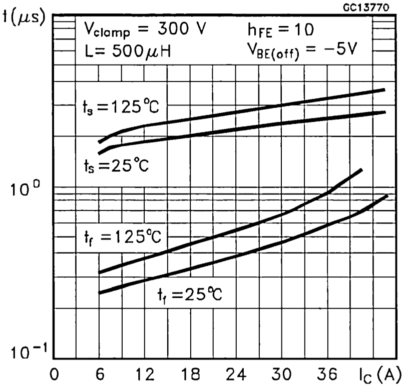
Reverse Biased SOA



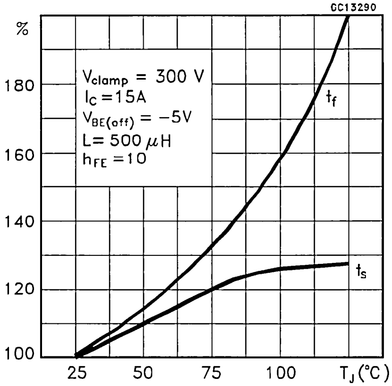
Typical V_F Versus I_F



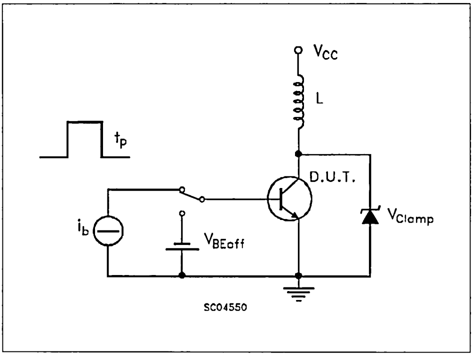
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

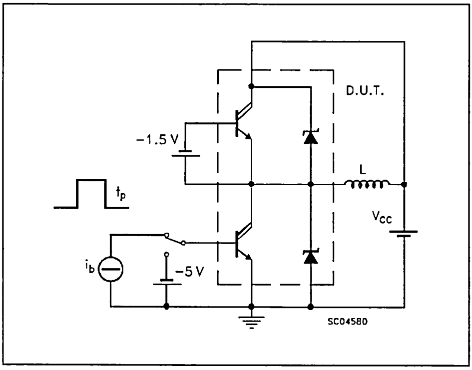


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 10

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

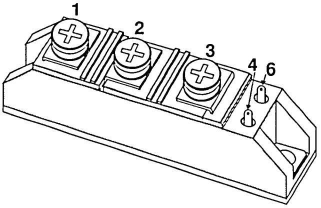
SGS50DB040D

HALF BRIDGE NPN DARLINGTON POWER MODULE

- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHEELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

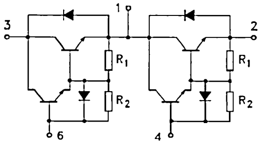
INDUSTRIAL APPLICATIONS:

- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



R_1 typ 80 Ohm R_2 typ 150 Ohm

SCC4540

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	400	V
V_{CES}	Collector-Emitter Voltage (V_{BE}= 0)	500	V
V_{CEV}	Collector-Emitter Voltage (V_{BE} = -2V)	500	V
V_{CBO}	Collector-Base Voltage (I_E = 0)	500	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	7	V
I_C	Collector Current	50	A
$- I_C$	Reverse Collector Current	50	A
I_B	Base Current	10	A
$- I_{CSM}$	Collector Surge Current	500	A
P_{tot}	Total Dissipation at T_c = 25 °C	375	W
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

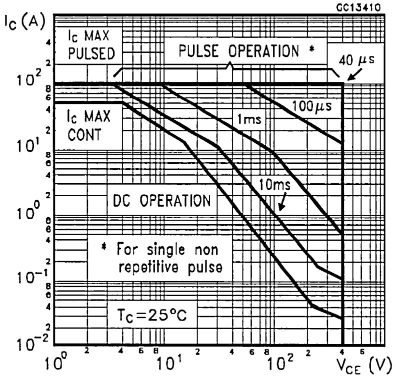
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

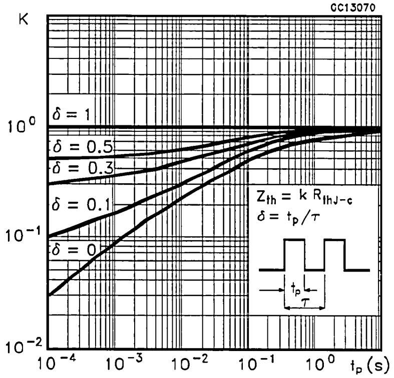
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 500 V V_{CE} = 400 V T_j = 125 °C			2 10	mA mA
I_{CEX}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 500 V V_{CE} = 400 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			90	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 5 A		1.5	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 5 A		2.3	3.3	V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 5 V I_C = 50 A V_{CE} = 3 V	70 10	130		
 t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 300 V I_C = 50 A I_{B1} = 4 A $V_{BE(off)}$= -5 V T_j ≤ 125 °C (see test circuits)		 1.5 0.4	 3 0.7	 µs µs
V_F	Diode Forward Voltage	I_F = 50 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 50 A di/dt = 100 A/µs		0.2	0.5	ms

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

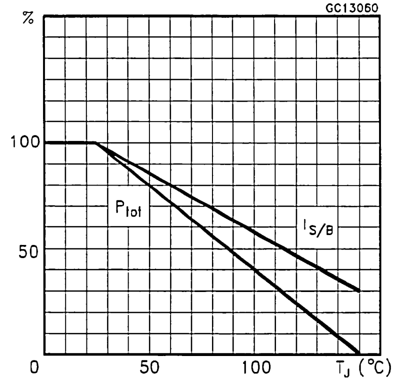
Safe Operating Areas



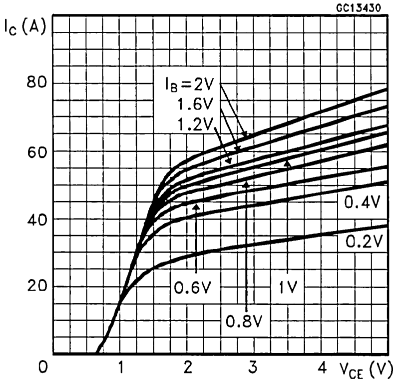
Thermal Impedance



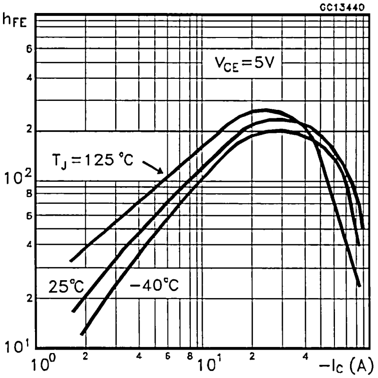
Derating Curves



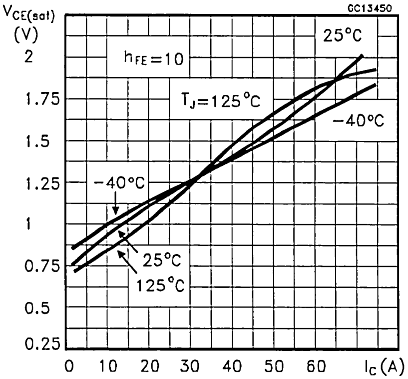
Output Characteristics



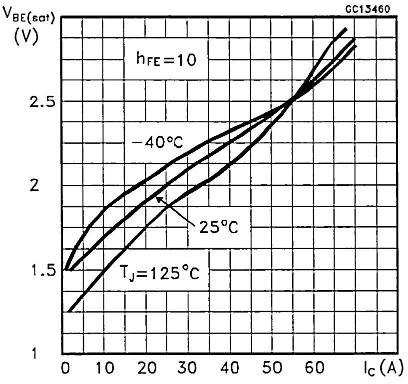
DC Current Gain



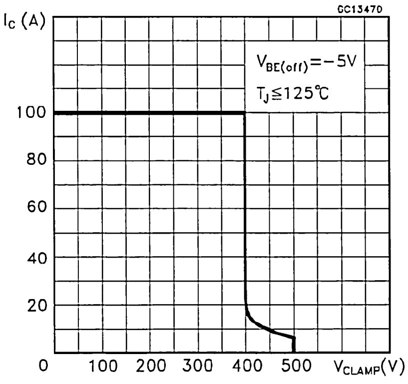
Collector-Emitter Saturation Voltage



Base-Emitter Saturation Voltage

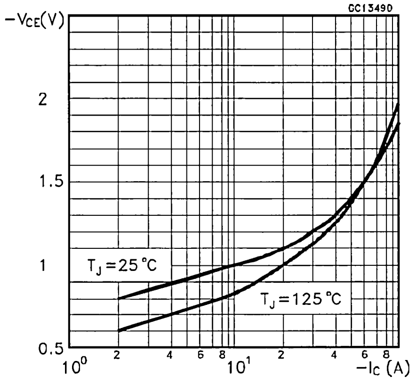


Reverse Biased SOA

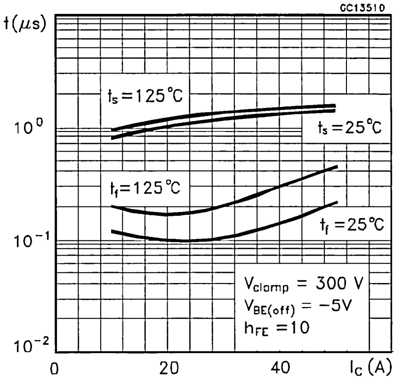


SGS-THOMSON
MICROELECTRONICS

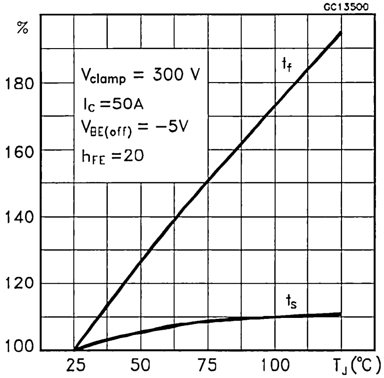
Typical V_F Versus I_F



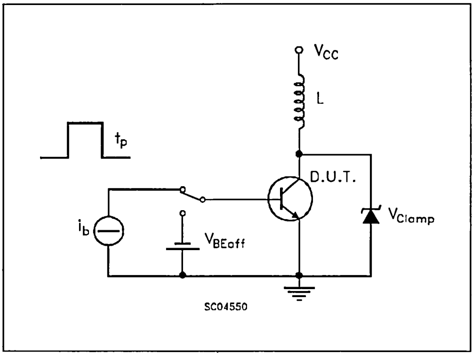
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

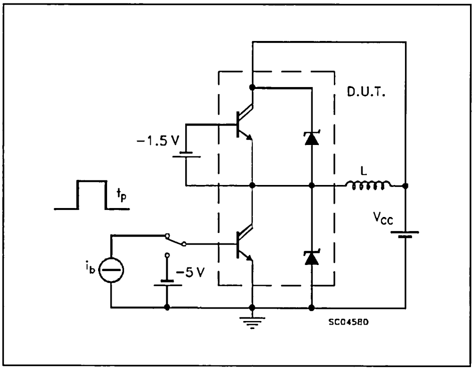


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B = 10

Switching Times Test Circuit



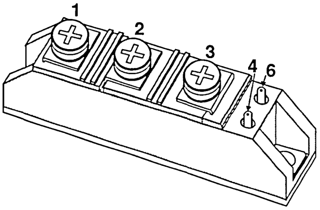
SGS-THOMSON
MICROELECTRONICS

SGS50DB045D

HALF BRIDGE NPN DARLINGTON POWER MODULE

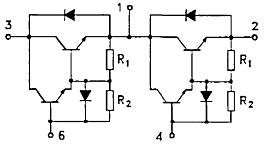
- POWER MODULE WITH INTERNAL ISOLATION (2500V RMS)
- LOW Rth JUNCTION TO CASE
- FREEWHELING DIODE
- ADAPTED FOR HIGH POWER SWITCHING APPLICATIONS

INDUSTRIAL APPLICATIONS:
- MOTOR CONTROL
- HIGH POWER SMPS AND UPS
- HIGH POWER DC/DC AND DC/AC CONVERTERS



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



R_1 typ 80 Ohm R_2 typ 150 Ohm

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	450	V
V_{CES}	Collector-Emitter Voltage ($V_{BE}= 0$)	500	V
V_{CEV}	Collector-Emitter Voltage ($V_{BE} = -2v$)	500	V
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	500	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	7	V
I_C	Collector Current	50	A
$- I_C$	Reverse Collector Current	50	A
I_B	Base Current	10	A
$- I_{CSM}$	Collector Surge Current	500	A
P_{tot}	Total Dissipation at $T_c = 25\ ^oC$	375	W
T_{stg}	Storage Temperature	-55 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

THERMAL DATA

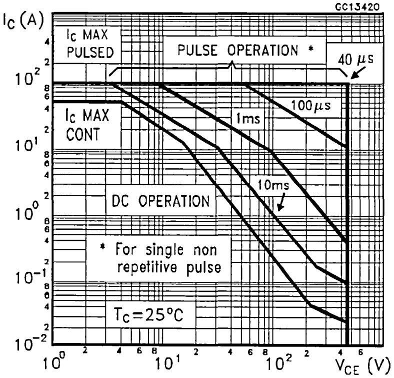
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (quarter bridge)	Max	0.66	°C/W
$R_{thj\text{-}case}$	Thermal Resistance Junction-case (diode)	Max	1.1	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.05	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

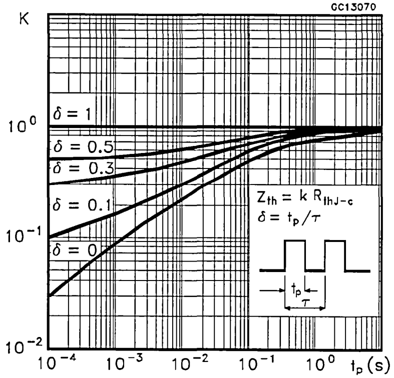
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = 600 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{CEV}	Collector Cut-off Current (V_{BE} = -2 V)	V_{CE} = 600 V V_{CE} = 450 V T_j = 125 °C			2 10	mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 2 V			90	mA
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 50 A I_B = 5 A		1.5	3	V
$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	I_C = 50 A I_B = 5 A		2.3	3.3	V
h_{FE}*	DC Current Gain	I_C = 50 A V_{CE} = 5 V I_C = 50 A V_{CE} = 3 V	70 10	130		
t_s t_f	INDUCTIVE LOAD Storage Time Fall Time	V_{CC} = 250 V I_C = 50 A I_{B1} = 4 A $V_{BE(off)}$= -5 V $T_j \leq$ 125 °C (see test circuits)		1.5 0.4	3 0.7	µs µs
V_F	Diode Forward Voltage	I_F = 50 A		1.4	2	V
t_{rr}	Diode Reverse Recovery Time	I_F = 50 A di/dt = 100 A/µs		0.2	0.5	µs

* Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

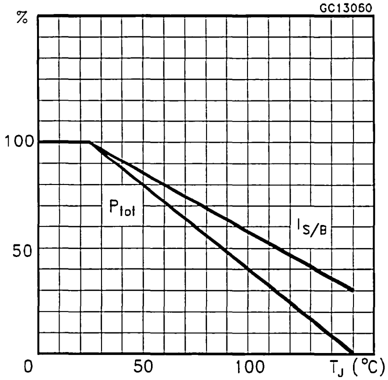
Safe Operating Areas



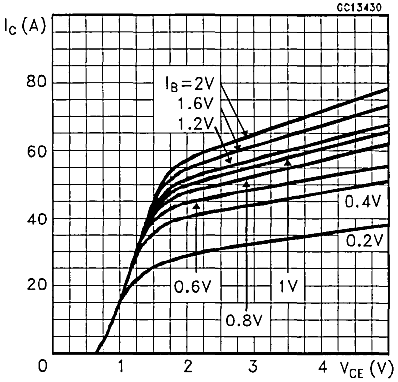
Thermal Impedance



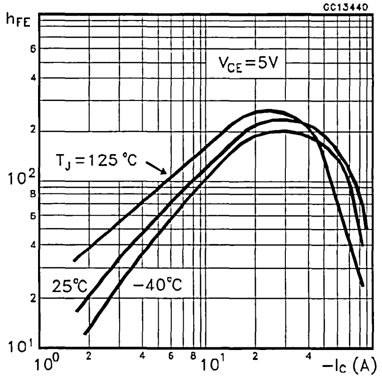
Derating Curves



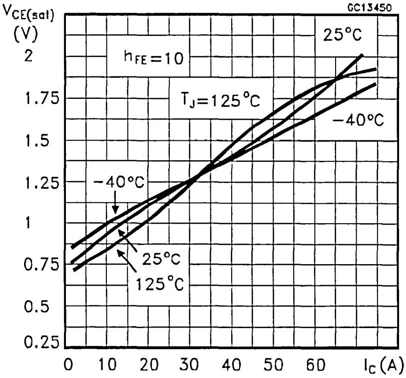
Output Characteristics



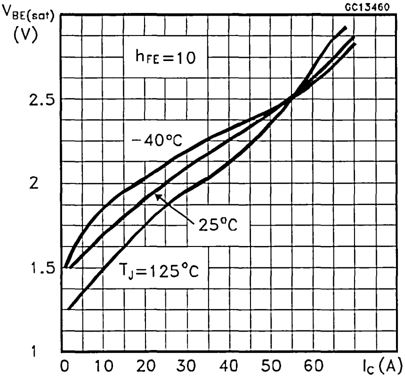
DC Current Gain



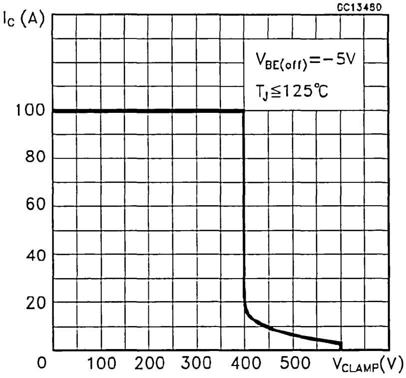
Collector-Emitter Saturation Voltage



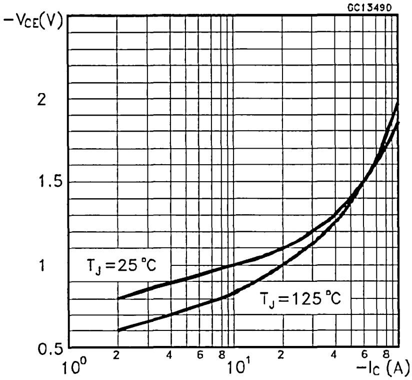
Base-Emitter Saturation Voltage



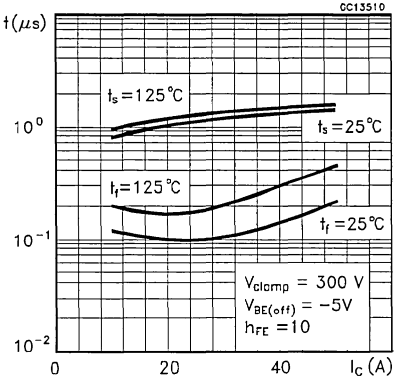
Reverse Biased SOA



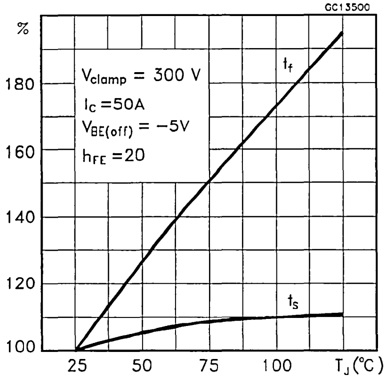
Typical V_F Versus I_F



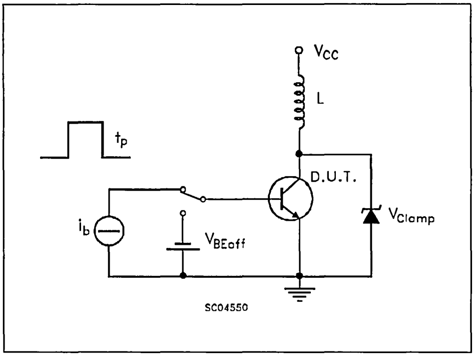
Switching Times Inductive Load



Switching Times Inductive Load Versus Temperature

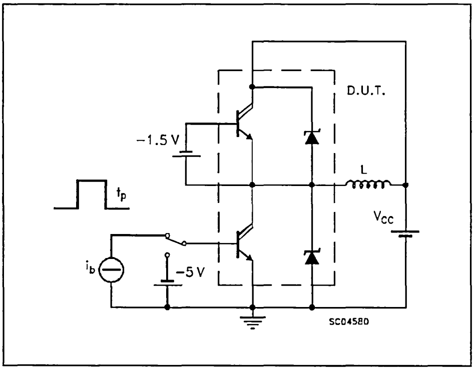


RBSOA Test Circuit



t_p adjusted for nominal I_C; I_C/I_B= 10

Switching Times Test Circuit



SGS-THOMSON
MICROELECTRONICS

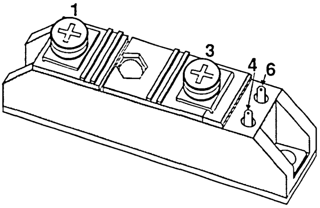
IRFK4H150

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK4H150	100 V	0.014 Ω	145 A

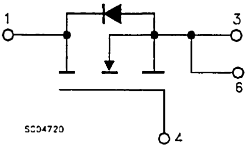
- HIGH CURRENT POWER MODULE
- VERY LOW Rth JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY

INDUSTRIAL APPLICATIONS:
- DC/DC AND DC/AC CONVENTERS
- SMPS & UPS
- MOTOR CONTROL



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	145	A
I_D	Drain Current (continuous) at T_c = 100 °C	90	A
I_{DM}(•)	Drain Current (pulsed)	500	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink	Typ	0.10	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	100			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1 4	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (∗)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 80 A			0.014	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 80 A	36			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12 6 2	nF nF nF

SWITCHING

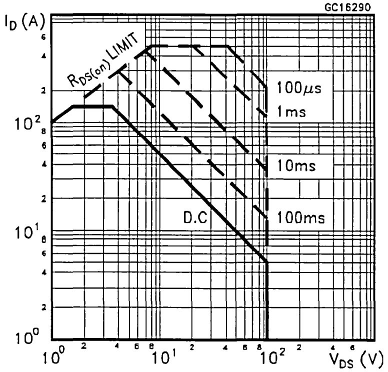
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 24 V I_D = 50 A R_{GS} = 3.3 Ω V_{GS} = 10 V		50 160 150 100		ns ns ns ns
Qg	Total Gate Charge	V_{GS} = 10 V I_D = 200 A V_{DS} = 80 V			480	nC

SOURCE DRAIN DIODE

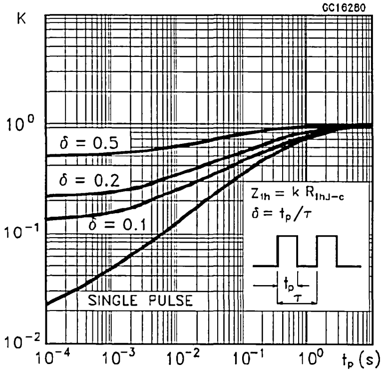
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				145 500	A A
V_{SD}	Forward On Voltage	I_{SD} = 160 A V_{GS} = 0			2.5	V
t_{rr}	Reverse Recovery Time	I_{SD} = 160 A di/dt = 100 A/µs		600		ns

(∗) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

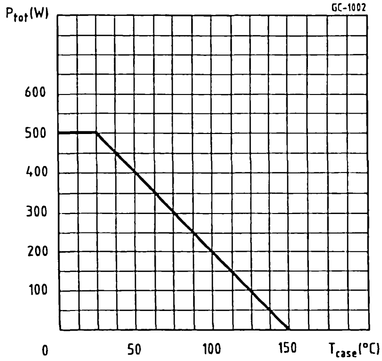
Safe Operating Areas



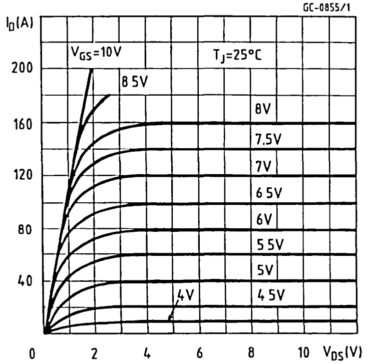
Thermal Impedance



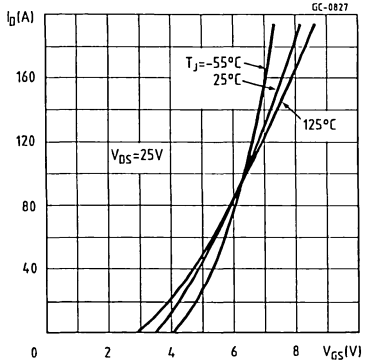
Derating Curve



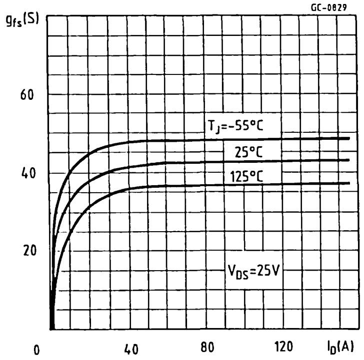
Output Characteristics



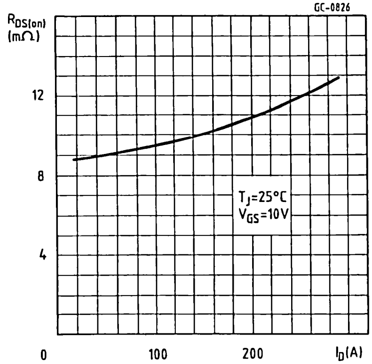
Transfer Characteristics



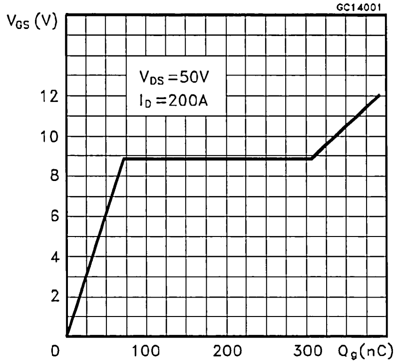
Transconductance



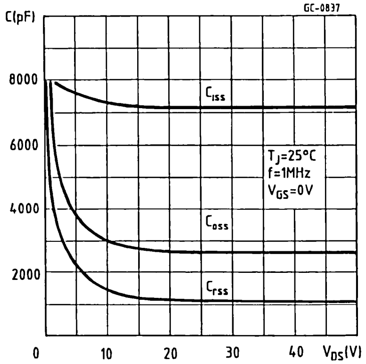
Static Drain-Source On Resistance



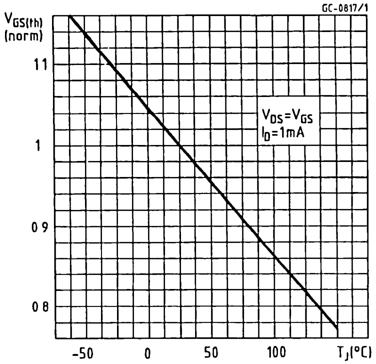
Gate Charge vs Gate-source Voltage



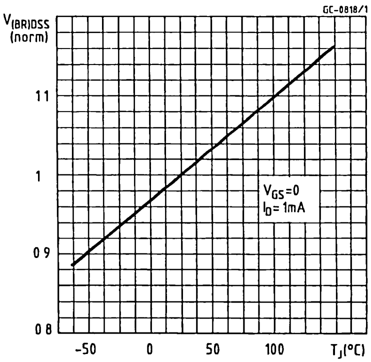
Capacitance Variation



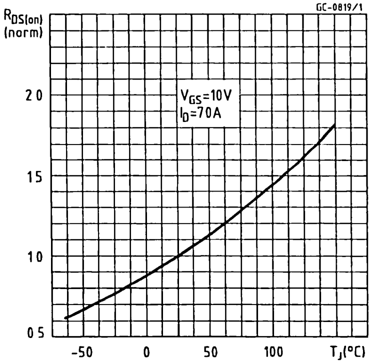
Normalized Gate Threshold Voltage vs Temperature



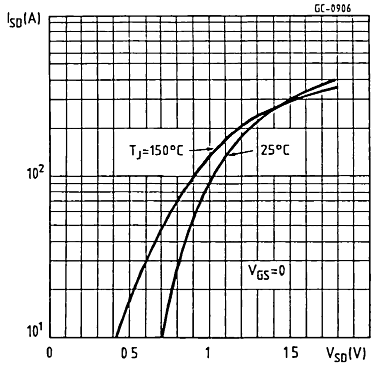
Normalized Breakdown Voltage vs Temperature



Normalized On Resistance vs Temperature



Source-Drain Diode Forward Characteristics



SGS-THOMSON
MICROELECTRONICS

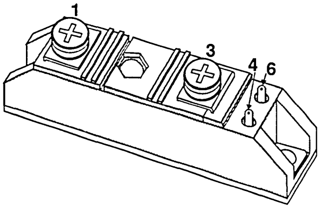
IRFK4H250

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK4H250	200 V	0.021 Ω	108 A

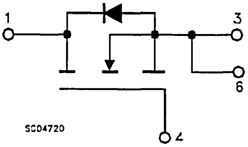
- HIGH CURRENT POWER MOS MODULE
- VERY LOW Rth JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

INDUSTRIAL APPLICATIONS:
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	200	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	200	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	108	A
I_D	Drain Current (continuous) at T_c = 100 °C	68	A
I_{DM}(•)	Drain Current (pulsed)	380	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$ $R_{thc\text{-}h}$	Thermal Resistance Junction-case Thermal Resistance Case-heatsink	Max Max	0.25 0.10	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	200			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1 4	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 64 A			21	mΩ

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 64 A	36			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12 4.5 2	nF nF nF

SWITCHING

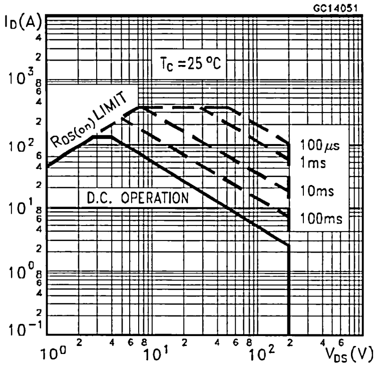
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 95 V I_D = 40 A R_{GS} = 3.3 Ω V_{GS} = 10 V		50 200 230 80		ns ns ns ns
Q_g	Total Gate Charge	V_{GS} = 10 V I_D = 152 A V_{DS} = 160 V			480	nQ

SOURCE DRAIN DIODE

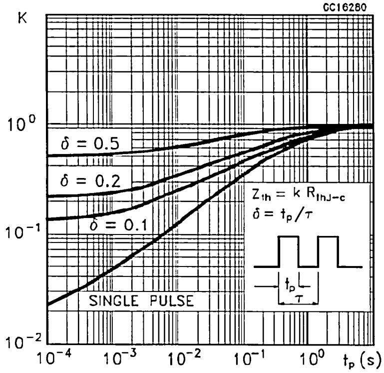
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				108 380	A A
V_{SD}	Forward On Voltage	I_{SD} = 120 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 120 A di/dt = 100 A/µs		600		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

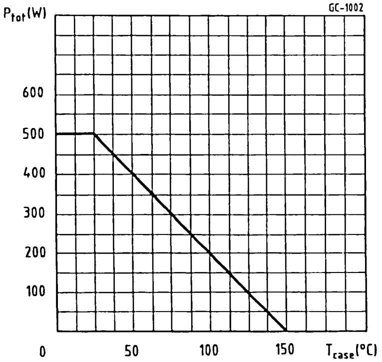
Safe Operating Areas



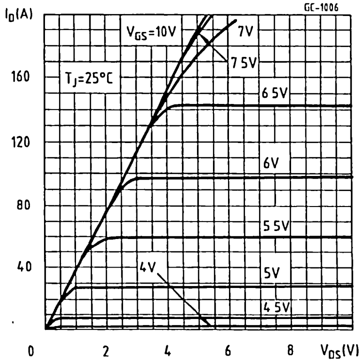
Thermal Impedance



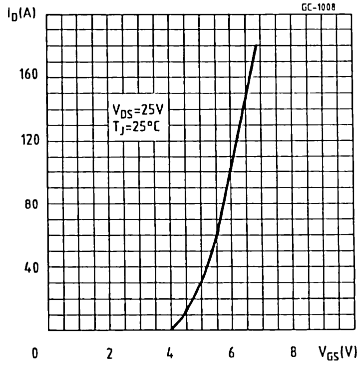
Derating Curve



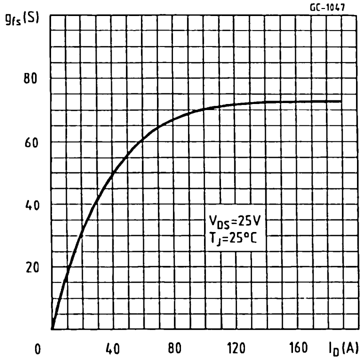
Output Characteristics



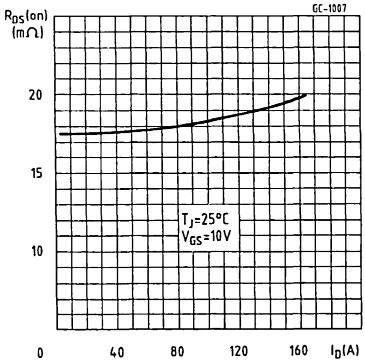
Transfer Characteristics



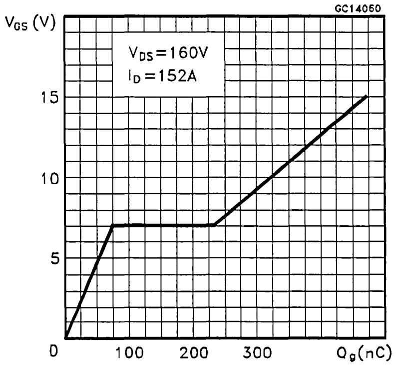
Transconductance



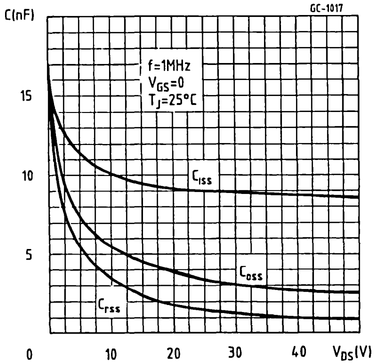
Static Drain-Source On Resistance



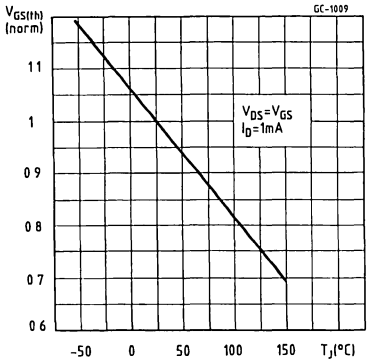
Gate Charge vs Gate-source Voltage



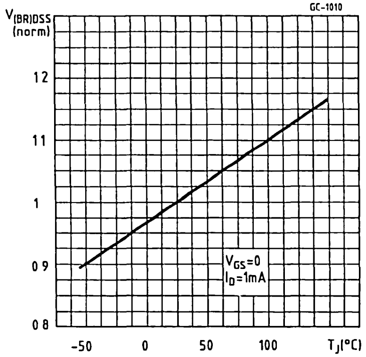
Capacitance Variation



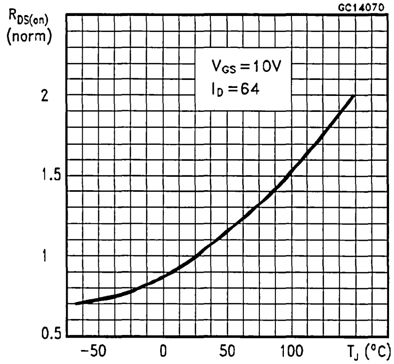
Normalized Gate Threshold Voltage vs Temperature



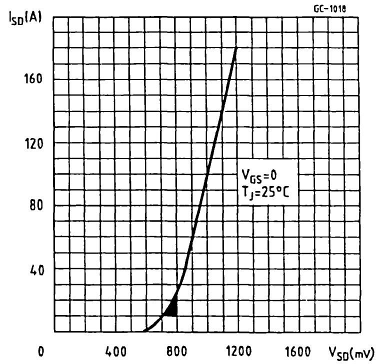
Normalized Breakdown Voltage vs Temperature



Normalized On Resistance vs Temperature



Source-Drain Diode Forward Characteristics



SGS-THOMSON
MICROELECTRONICS

IRFK4H450

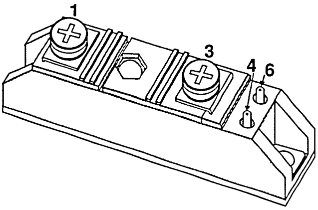
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK4H450	500 V	0.1 Ω	44 A

- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

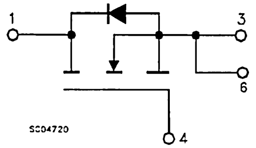
INDUSTRIAL APPLICATIONS:

- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	44	A
I_D	Drain Current (continuous) at T_c = 100 °C	28	A
I_{DM}(•)	Drain Current (pulsed)	165	A
P_{tot}	Total Dissipation at T_c = 25 °C	500	W
	Derating Factor	4	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.25	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink	Typ	0.10	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1 4	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 28 A			0.1	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 28 A	24			mho
C_{iss}	Input Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12	nF
C_{oss}	Output Capacitance				2.4	nF
C_{rss}	Reverse Transfer Capacitance				1	nF

SWITCHING

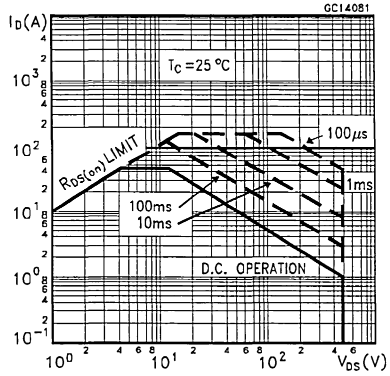
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on Time	V_{DD} = 210 V I_D = 28 A		50		ns
t_r	Rise Time	R_{GS} = 3.3 Ω V_{GS} = 10 V		80		ns
$t_{d(off)}$	Turn-off Delay Time			250		ns
t_f	Fall Time			100		ns
Qg	Total Gate Charge	V_{GS} = 10 V I_D = 64 A V_{DS} = 400 V		400		nC

SOURCE DRAIN DIODE

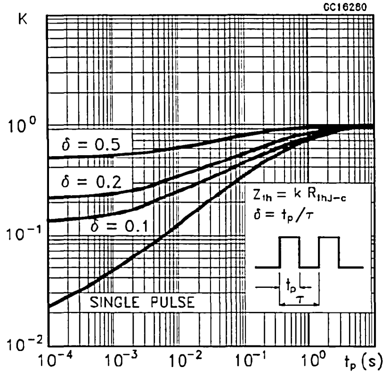
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-Drain Current				44	A
I_{SDM}(•)	Source-Drain Current (pulsed)				165	A
V_{SD}	Forward On Voltage	I_{SD} = 52 A V_{GS} = 0			1.4	V
t_{rr}	Reverse Recovery Time	I_{SD} = 52 A di/dt = 100 A/µs		1300		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

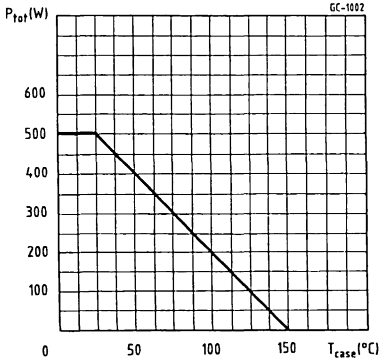
Safe Operating Areas



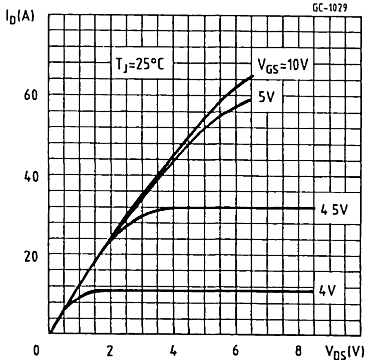
Thermal Impedance



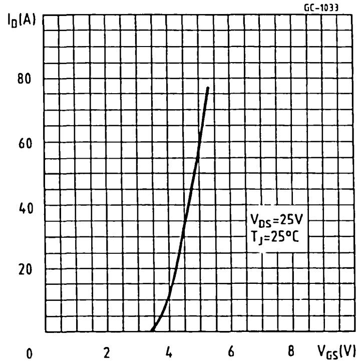
Derating Curve



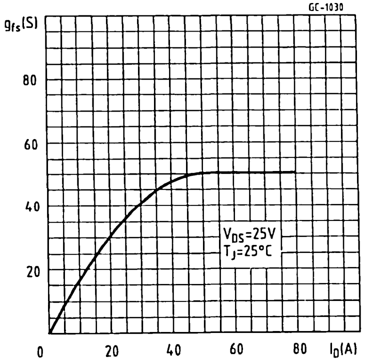
Output Characteristics



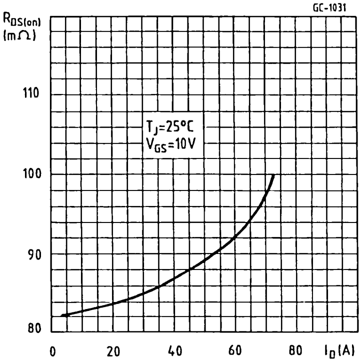
Transfer Characteristics



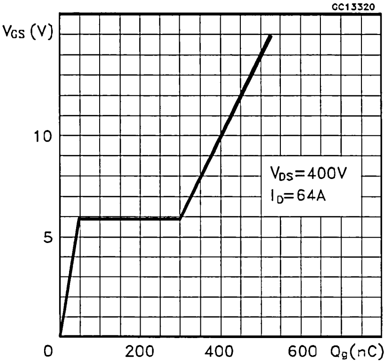
Transconductance



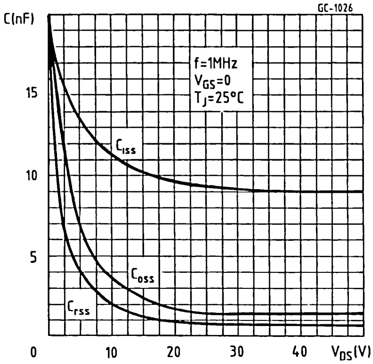
Static Drain-Source On Resistance



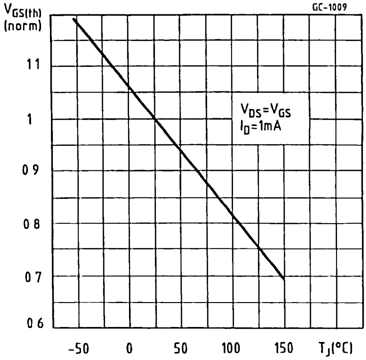
Gate Charge vs Gate-source Voltage



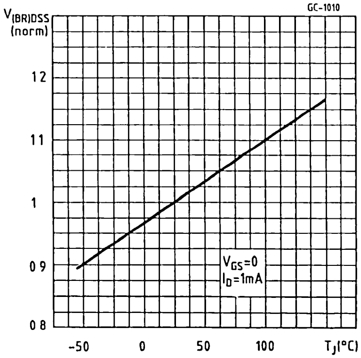
Capacitance Variation



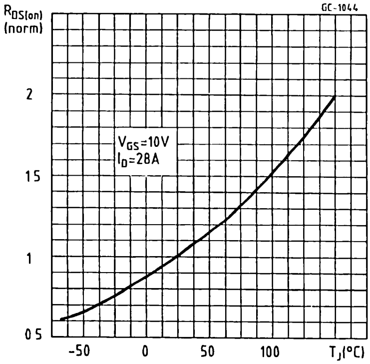
Normalized Gate Threshold Voltage vs Temperature



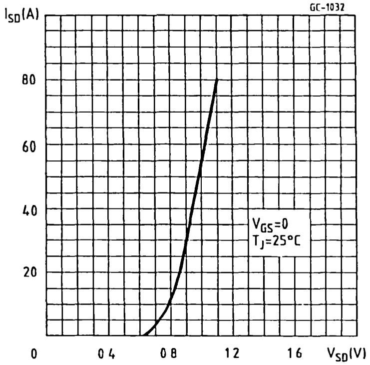
Normalized Breakdown Voltage vs Temperature



Normalized On Resistance vs Temperature



Source-Drain Diode Forward Characteristics



IRFK6H150

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

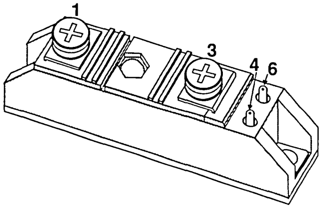
ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK6H150	100 V	0.010 Ω	150 A

- HIGH CURRENT POWER MODULE
- VERY LOW Rth JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

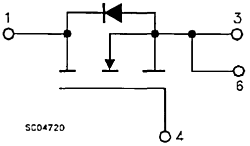
INDUSTRIAL APPLICATIONS:

- DC/DC AND DC/AC CONVENTERS
- SMPS & UPS
- MOTOR CONTROL



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	150	A
I_D	Drain Current (continuous) at T_c = 100 °C	120	A
$I_{DM}(\bullet)$	Drain Current (pulsed)	665	A
P_{tot}	Total Dissipation at T_c = 25 °C	625	W
	Derating Factor	5	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj-case}$ R_{thc-h}	Thermal Resistance Junction-case Thermal Resistance Case-heatsink	Max Typ	0.2 0.10	°C/W °C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1.5 mA V_{GS} = 0	100			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1.5 6	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 600	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1.5 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 120 A			0.010	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 120 A	75			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		16 6 1.5		nF nF nF

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 40 V I_D = 120 A R_G = 3.3 Ω V_{GS} = 10 V		130 400 350 80		ns ns ns ns
Qg	Total Gate Charge	V_{GS} = 10 V I_D = 190 A V_{DS} = 80 V		600		nC

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				150 665	A A
V_{SD}	Forward On Voltage	I_{SD} = 190 A V_{GS} = 0			2.5	V
t_{rr}	Reverse Recovery Time	I_{SD} = 190 A di/dt = 100 A/μs		600		ns

(*) Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

IRFK6H250

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

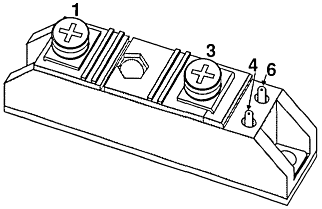
ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK6H250	200 V	0.015 Ω	140 A

- HIGH CURRENT POWER MODULE
- VERY LOW Rth JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

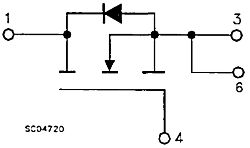
INDUSTRIAL APPLICATIONS:

- DC/DC AND DC/AC CONVENTERS
- SMPS & UPS
- MOTOR CONTROL



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	200	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	200	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	140	A
I_D	Drain Current (continuous) at T_c = 100 °C	90	A
I_{DM}(•)	Drain Current (pulsed)	490	A
P_{tot}	Total Dissipation at T_c = 25 °C	625	W
	Derating Factor	5	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink	Typ	0.10	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1.5 mA V_{GS} = 0	200			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1.5 6	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 600	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1.5 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 90 A			0.015	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 90 A	55			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		18 4 1		nF nF nF

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 95 V I_D = 90 A R_G = 3.3 Ω V_{GS} = 10 V		80 290 360 100		ns ns ns ns
Qg	Total Gate Charge	V_{GS} = 10 V I_D = 140 A V_{DS} = 160 V		600		nC

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				140 490	A A
V_{SD}	Forward On Voltage	I_{SD} = 140 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 140 A di/dt = 100 A/µs		550		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

IRFK6H350

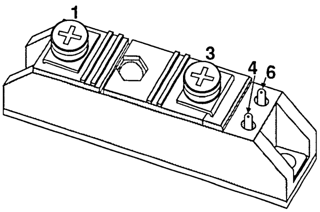
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK6H350	400 V	0.05 Ω	75 A

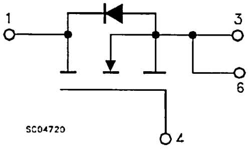
- HIGH CURRENT POWER MOS MODULE
- VERY LOW R_{th} JUNCTION CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

INDUSTRIAL APPLICATIONS:
- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	400	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	400	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	75	A
I_D	Drain Current (continuous) at T_c = 100 °C	48	A
I_{DM}(•)	Drain Current (pulsed)	260	A
P_{tot}	Total Dissipation at T_c = 25 °C	625	W
	Derating Factor	5	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.2	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink	Typ	0.10	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1.5 mA V_{GS} = 0	400			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			1.5 6	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 600	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1.5 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 48 A			0.05	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 48A	36			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		16 3 1.5		nF nF nF

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	V_{DD} = 180 V I_D = 48 A R_G = 3.3 Ω V_{GS} = 10 V		65 120 320 100		ns ns ns ns
Q_g	Total Gate Charge	V_{GS} = 10 V I_D = 75 A V_{DS} = 320 V		600		nQ

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				75 260	A A
V_{SD}	Forward On Voltage	I_{SD} = 75 A V_{GS} = 0			1.6	V
t_{rr}	Reverse Recovery Time	I_{SD} = 75 A di/dt = 100 A/μs		1200		ns

(*) Pulsed: Pulse duration = 300 μs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

IRFK6H450

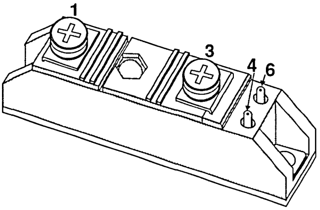
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

ADVANCE DATA

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRFK6H450	500 V	0.067 Ω	66 A

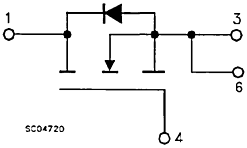
- HIGH CURRENT POWER MODULE
- VERY LOW Rth JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

INDUSTRIAL APPLICATIONS:
- DC/DC AND DC/AC CONVENTERS
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TRANSPACK (TO-240A)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	66	A
I_D	Drain Current (continuous) at T_c = 100 °C	42	A
I_{DM}(•)	Drain Current (pulsed)	230	A
P_{tot}	Total Dissipation at T_c = 25 °C	625	W
	Derating Factor	5	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.2	^{o}C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink	Typ	0.10	^{o}C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 ^{o}C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 1.5 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 ^{o}C			1.5 6	mA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 600	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 1.5 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 42 A			0.067	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} > $I_{D(on)}$ x $R_{DS(on)max}$ I_D = 42 A	36			mho
C_{iss}	Input Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		16		nF
C_{oss}	Output Capacitance			3		nF
C_{rss}	Reverse Transfer Capacitance			1.5		nF

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on Time	V_{DD} = 210 V I_D = 42 A		70		ns
t_r	Rise Time	R_G = 3.3 Ω V_{GS} = 10 V		110		ns
$t_{d(off)}$	Turn-off Delay Time			350		ns
t_f	Fall Time			110		ns
Q_g	Total Gate Charge	V_{GS} = 10 V I_D = 66 A V_{DS} = 400 V		600		nC

SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD}	Source-Drain Current				66	A
I_{SDM}(•)	Source-Drain Current (pulsed)				230	A
V_{SD}	Forward On Voltage	I_{SD} = 66 A V_{GS} = 0			1.4	V
t_{rr}	Reverse Recovery Time	I_{SD} = 66 A di/dt = 100 A/µs		1200		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

SGS-THOMSON
MICROELECTRONICS

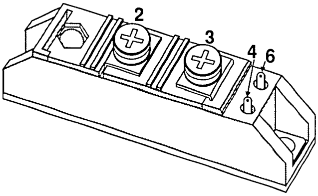
SGS30MA050D1

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
SGS30MA050D1	500 V	0.2 Ω	30 A

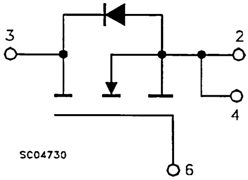
- HIGH CURRENT POWER MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500 V RMS)

INDUSTRIAL APPLICATIONS:
- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	30	A
I_D	Drain Current (continuous) at T_c = 100 °C	19	A
I_{DM}(•)	Drain Current (pulsed)	120	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.20	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			500 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 2 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 15 A			0.2	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 15 A	15			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			9100 1200 850	pF pF pF

SWITCHING (INDUCTIVE LOAD)

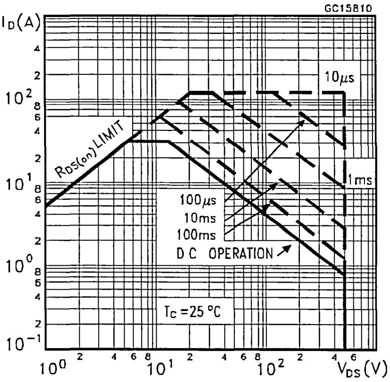
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 250 V I_D = 15 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		120 100 1500 300		ns A/µs ns ns

SOURCE DRAIN DIODE

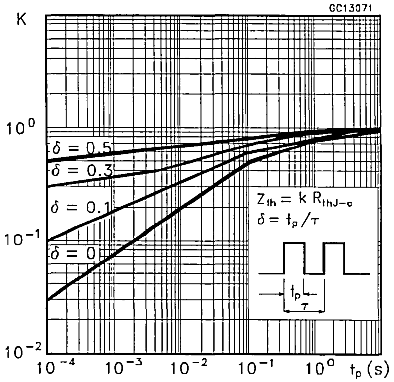
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				30 120	A A
V_{SD}	Forward On Voltage	I_{SD} = 30 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 30 A di/dt = 150 A/µs		600		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

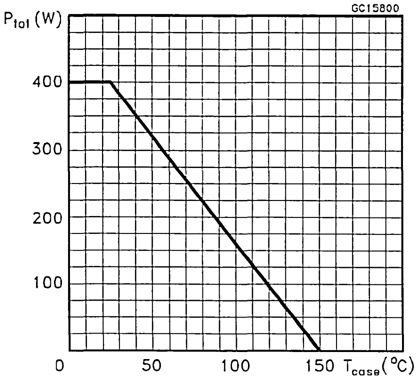
Safe Operating Areas



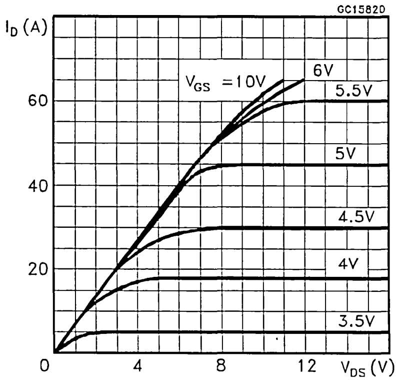
Thermal Impedance



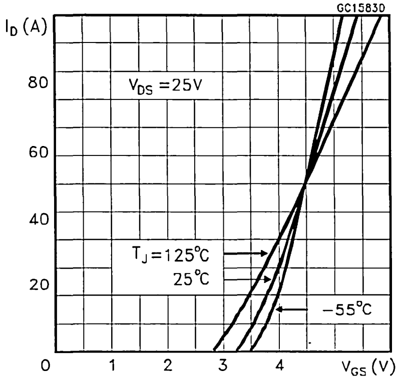
Derating Curve



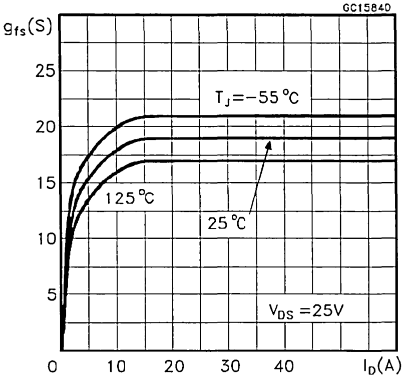
Output Characteristics



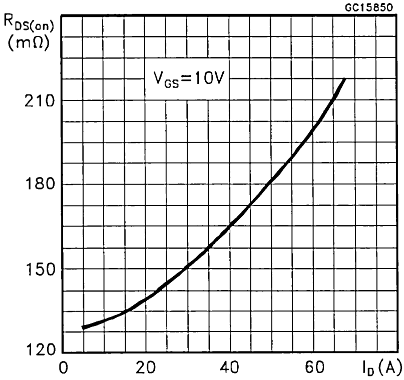
Transfer Characteristics



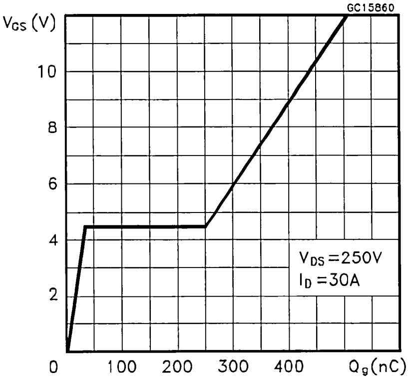
Transconductance



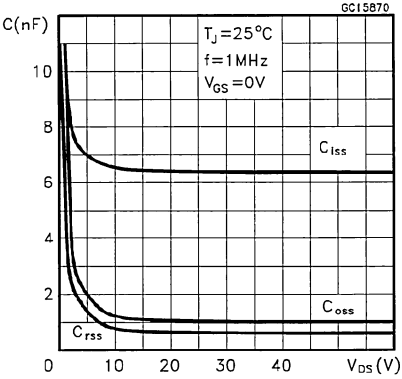
Static Drain-Source On Resistance



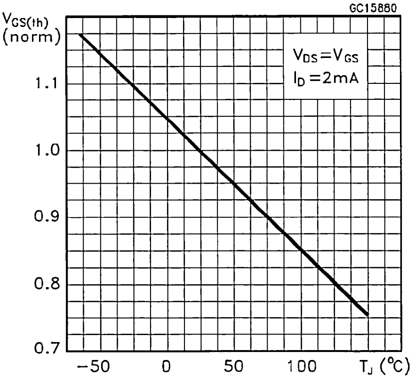
Gate Charge vs Gate-source Voltage



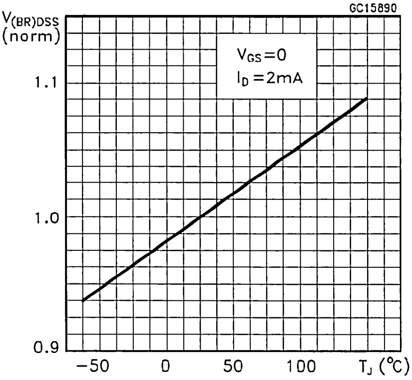
Capacitance Variation



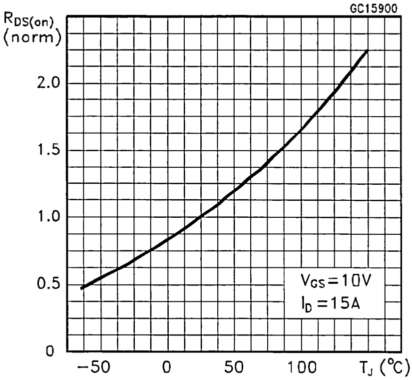
Normalized Gate Threshold Voltage vs Temperature



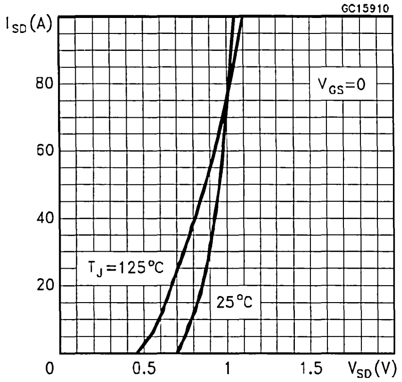
Normalized Breakdown Voltage vs Temperature



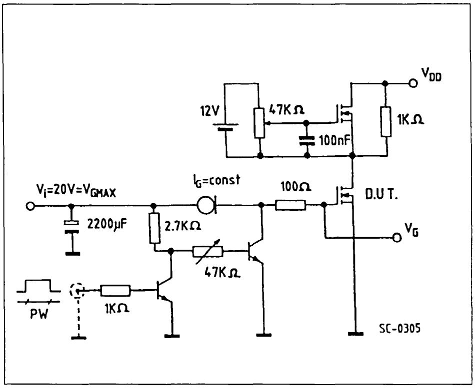
Normalized On Resistance vs Temperature



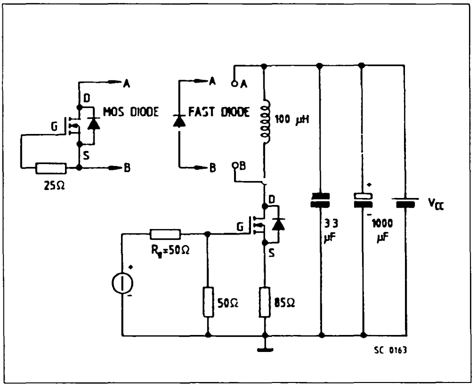
Source-Drain Diode Forward Characteristics



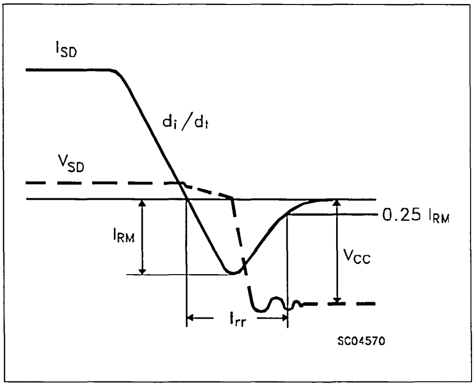
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

SGS35MA050D1

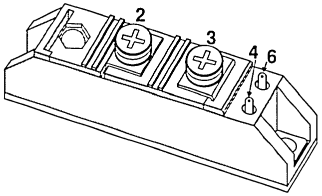
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
SGS35MA050D1	500 V	0.16 Ω	35 A

- HIGH CURRENT POWER MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

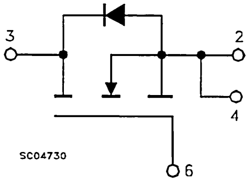
INDUSTRIAL APPLICATIONS:

- SMPS & UPS
- MOTOR CONTROL
- WELDING EQUIPMENT



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	500	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	500	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	35	A
I_D	Drain Current (continuous) at T_c = 100 °C	22	A
I_{DM}(•)	Drain Current (pulsed)	140	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.20	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	500			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			500 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 2 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10 V I_D = 17.5 A			0.16	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 17.5 A	15			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			12000 1500 1000	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 250 V I_D = 17.5 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		120 100 1500 300		ns A/µs ns ns

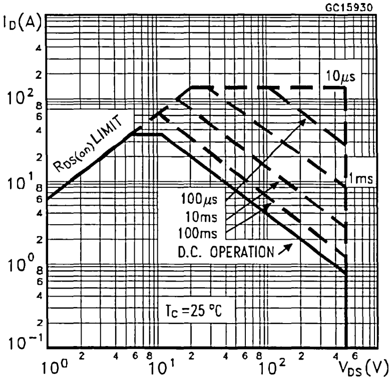
SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				35 140	A A
V_{SD}	Forward On Voltage	I_{SD} = 35 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 35 A di/dt = 150 A/µs		600		ns

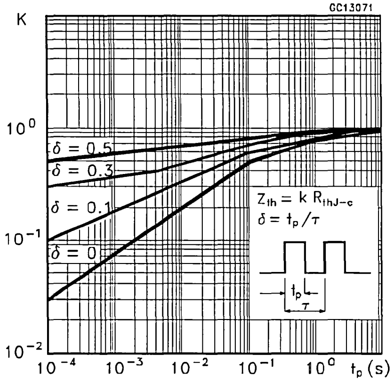
(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

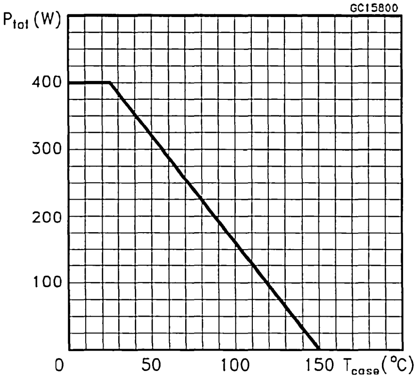
Safe Operating Areas



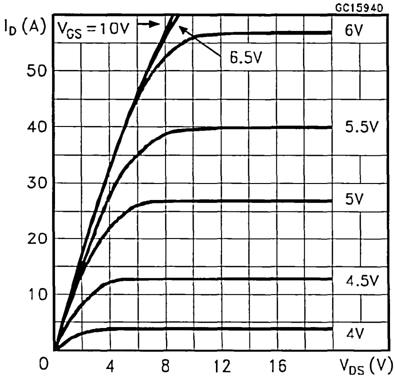
Thermal Impedance



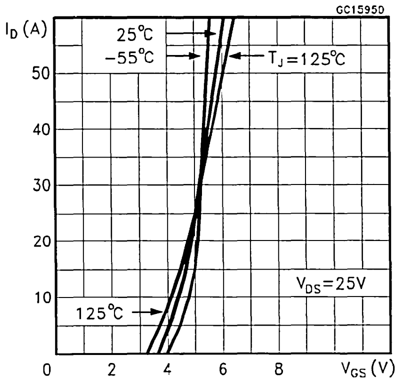
Derating Curve



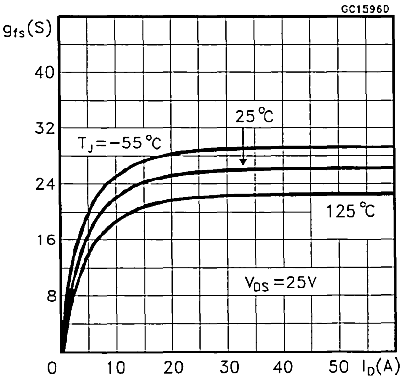
.Output Characteristics



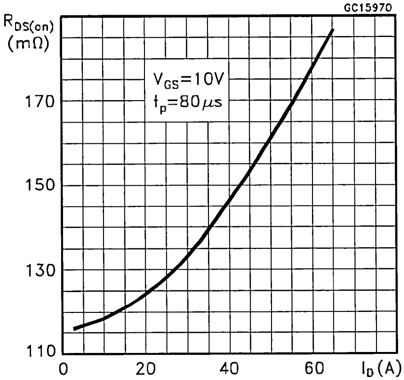
Transfer Characteristics



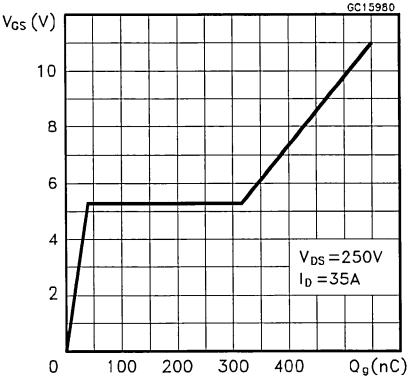
Transconductance



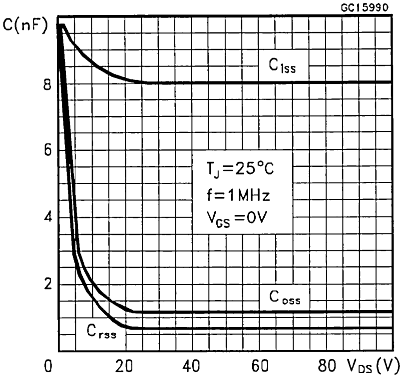
Static Drain-Source On Resistance



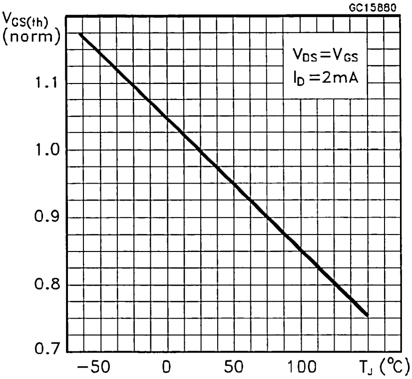
Gate Charge vs Gate-source Voltage



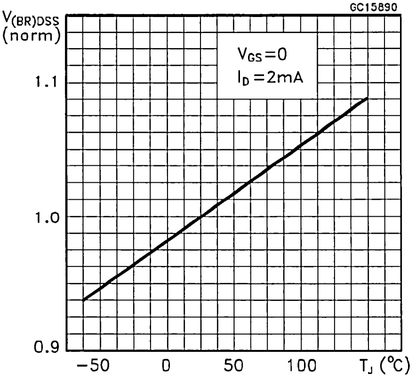
Capacitance Variation



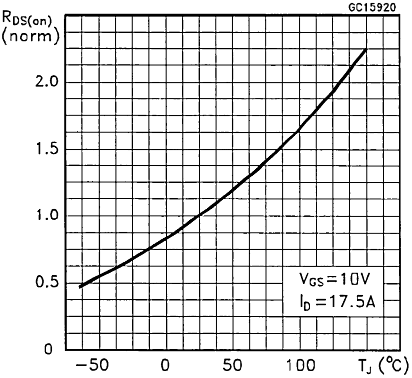
Normalized Gate Threshold Voltage vs Temperature



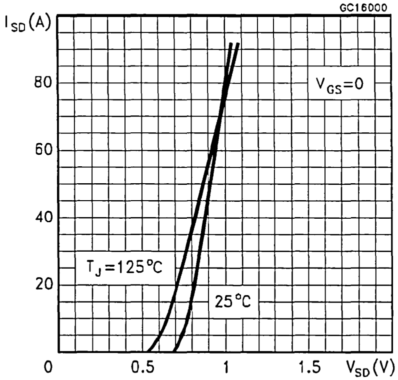
Normalized Breakdown Voltage vs Temperature



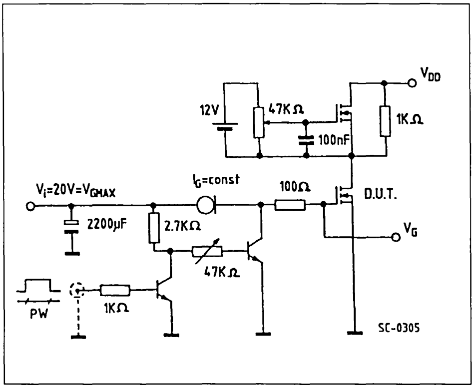
Normalized On Resistance vs Temperature



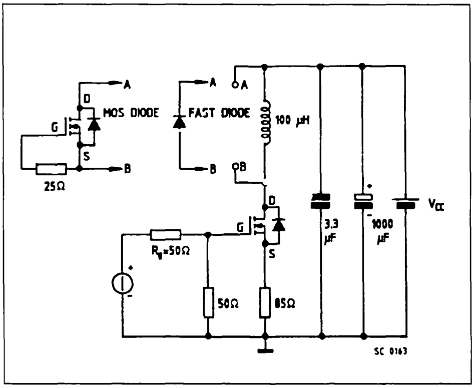
Source-Drain Diode Forward Characteristics



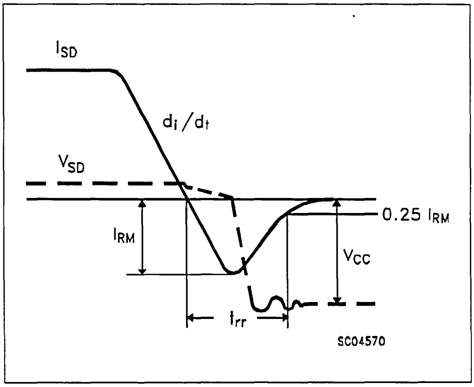
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS100MA010D1

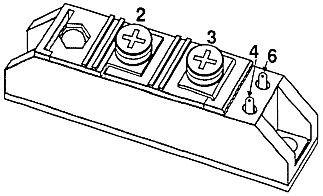
N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
SGS100MA010D1	100 V	0.014 Ω	120 A

- HIGH CURRENT POWER MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

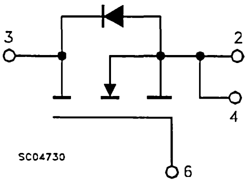
INDUSTRIAL APPLICATIONS:

- DC/DC & DC/AC CONVERTERS
- SMPS & UPS
- MOTOR CONTROL



(TRANSPACK) TO-240

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	120	A
I_D	Drain Current (continuous) at T_c = 100 °C	75	A
I_{DM}(•)	Drain Current (pulsed)	400	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.20	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	100			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			500 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 400	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 2 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 50 A			0.014	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 50 A	20			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			11200 4200 1700	pF pF pF

SWITCHING (INDUCTIVE LOAD)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 50 V I_D = 50 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		120 100 2000 300		ns A/µs ns ns

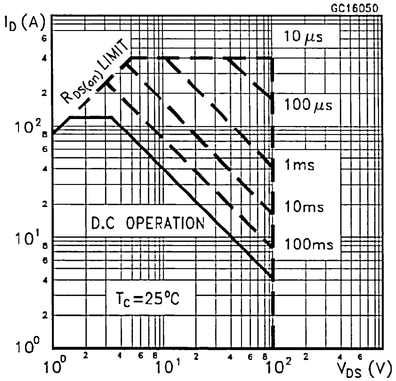
SOURCE DRAIN DIODE

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				120 400	A A
V_{SD}	Forward On Voltage	I_{SD} = 120 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 120 A di/dt = 100 A/µs		400		ns

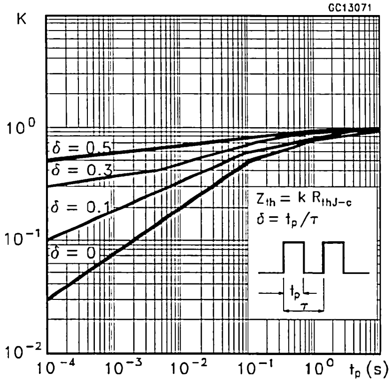
(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

(•) Pulse width limited by safe operating area

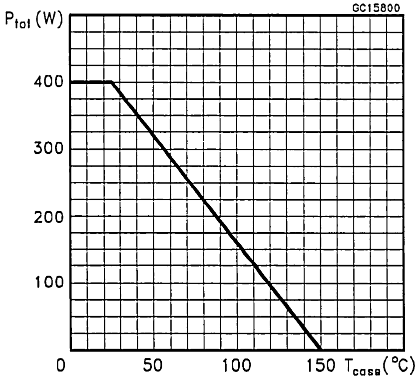
Safe Operating Areas



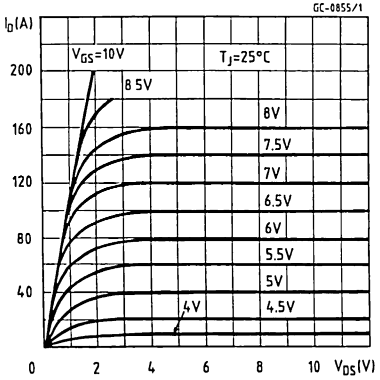
Thermal Impedance



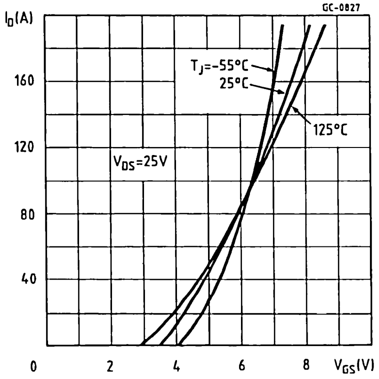
Derating Curve



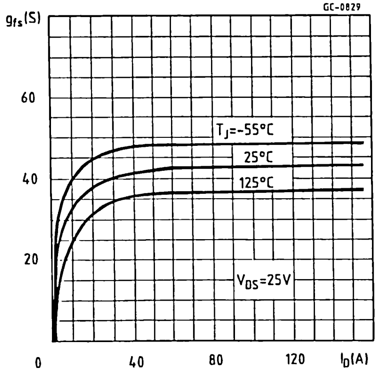
Output Characteristics



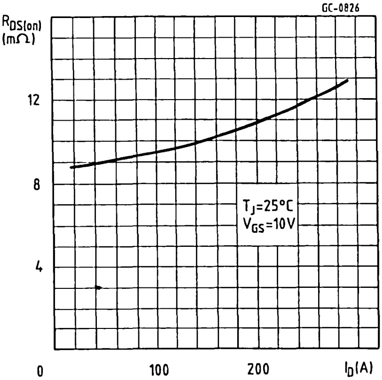
Transfer Characteristics



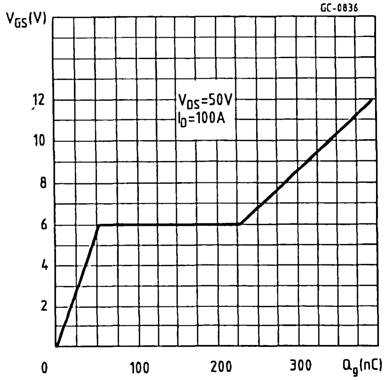
Transconductance



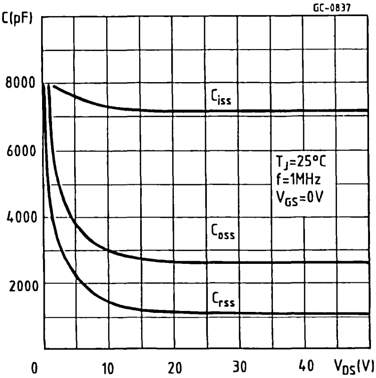
Static Drain-Source On Resistance



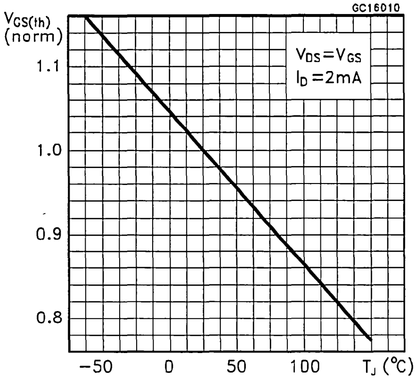
Gate Charge vs Gate-source Voltage



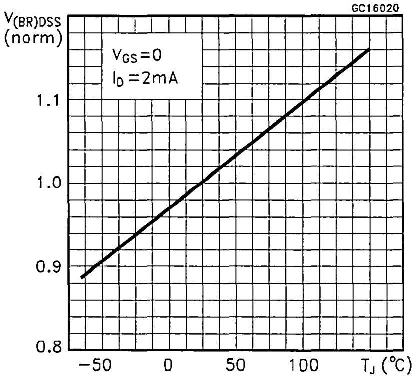
Capacitance Variation



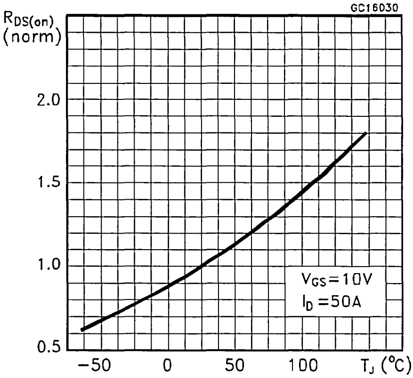
Normalized Gate Threshold Voltage vs Temperature



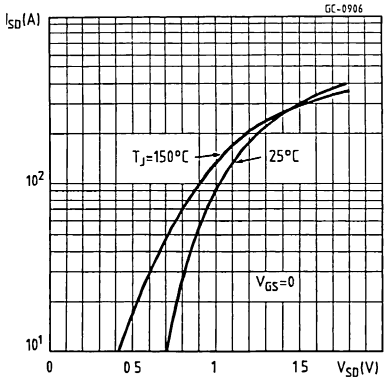
Normalized Breakdown Voltage vs Temperature



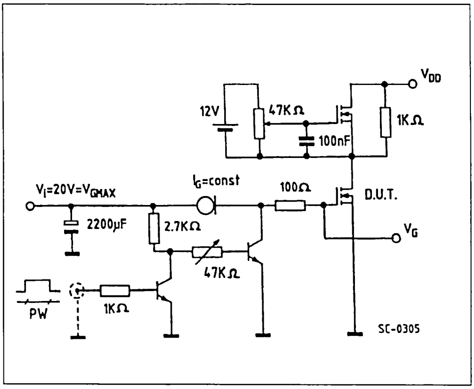
Normalized On Resistance vs Temperature



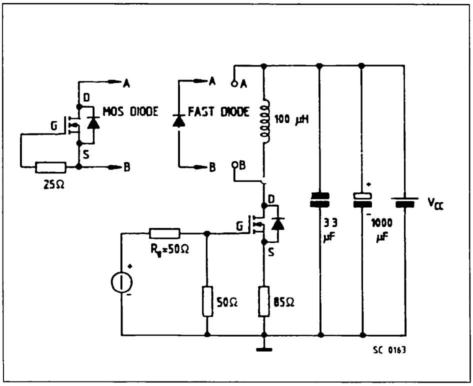
Source-Drain Diode Forward Characteristics



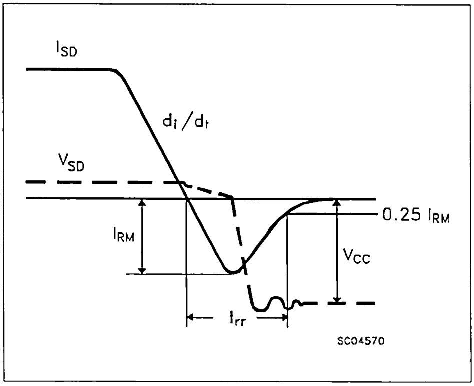
Gate Charge Test Circuit



Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



SGS-THOMSON
MICROELECTRONICS

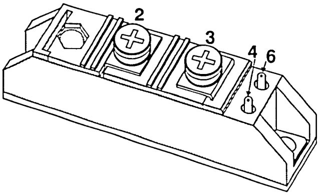
SGS150MA010D1

N - CHANNEL ENHANCEMENT MODE POWER MOS TRANSISTOR MODULE

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
SGS150MA010D1	100 V	0.009 Ω	150 A

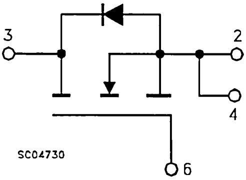
- HIGH CURRENT POWER MODULE
- VERY LOW R_{th} JUNCTION TO CASE
- DUAL SOURCE CONTACTS
- VERY LARGE SOA - LARGE PEAK POWER CAPABILITY
- ISOLATED CASE (2500V RMS)

INDUSTRIAL APPLICATION:
- DC/DC & DC/AC CONVERERS
- SMPS & UPS
- MOTOR CONTROL



TRANSPACK (TO-240)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-Source Voltage (V_{GS} = 0)	100	V
V_{DGR}	Drain-Gate Voltage (R_{GS} = 20 kΩ)	100	V
V_{GS}	Gate-Source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	150	A
I_D	Drain Current (continuous) at T_c = 100 °C	95	A
I_{DM}(•)	Drain Current (pulsed)	600	A
P_{tot}	Total Dissipation at T_c = 25 °C	400	W
	Derating Factor	3.2	W/°C
T_{stg}	Storage Temperature	-55 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C
V_{ISO}	Insulation Withstand Voltage (AC-RMS)	2500	V

(•) Pulse width limited by safe operating area

July 1990

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	0.31	°C/W
$R_{thc\text{-}h}$	Thermal Resistance Case-heatsink With Conductive Grease Applied	Max	0.20	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	I_D = 2 mA V_{GS} = 0	100			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating x 0.8 T_c = 125 °C			500 2	µA mA
I_{GSS}	Gate-Body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 500	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	V_{DS} = V_{GS} I_D = 2 mA	2		4	V
$R_{DS(on)}$	Static Drain-Source On Resistance	V_{GS} = 10V I_D = 75 A			0.009	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs}	Forward Transconductance	V_{DS} = 25 V I_D = 75 A	20			mho
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0			14000 5300 2200	pF pF pF

SWITCHING (INDUCTIVE LOAD)

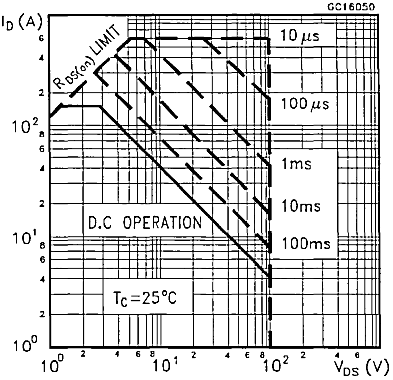
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ $(di/dt)_{on}$ $t_{d(off)}$ t_f	Turn-on Time Turn-on Current Slope Turn-off Delay Time Fall Time	V_{DD} = 50 V I_D = 75 A R_{GS} = 50 Ω V_{GS} = 10 V L = 100 µH		120 100 2000 300		ns A/µs ns ns

SOURCE DRAIN DIODE

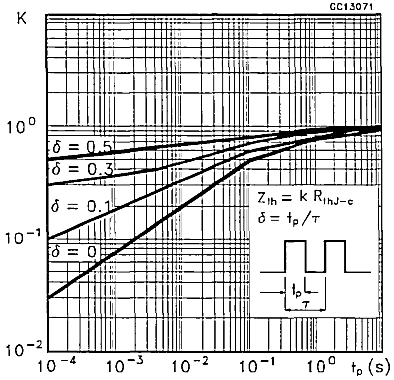
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}(•)	Source-Drain Current Source-Drain Current (pulsed)				150 600	A A
V_{SD}	Forward On Voltage	I_{SD} = 150 A V_{GS} = 0			2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 150 A di/dt = 250 A/µs		400		ns

(*) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %
(•) Pulse width limited by safe operating area

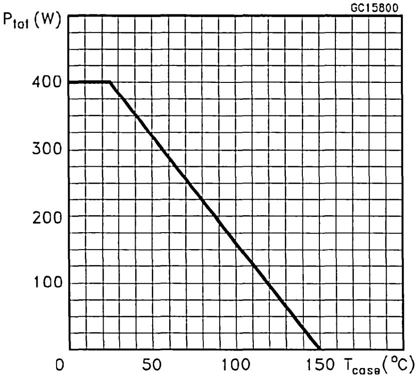
Safe Operating Areas



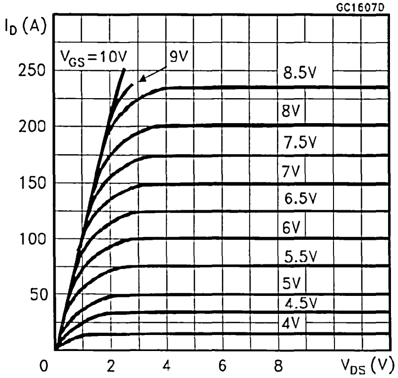
Thermal Impedance



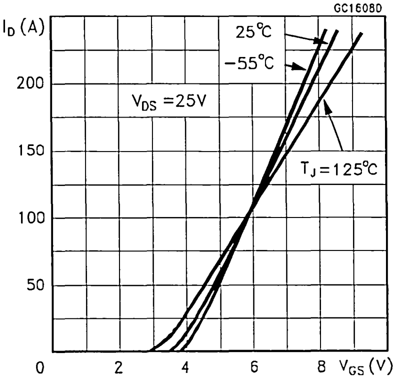
Derating Curve



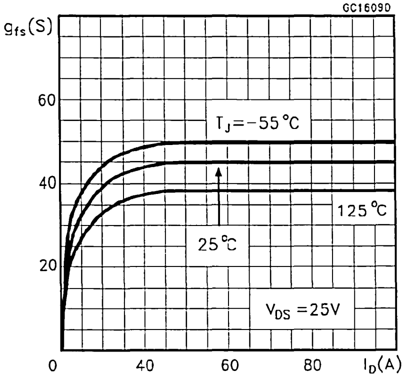
Output Characteristics



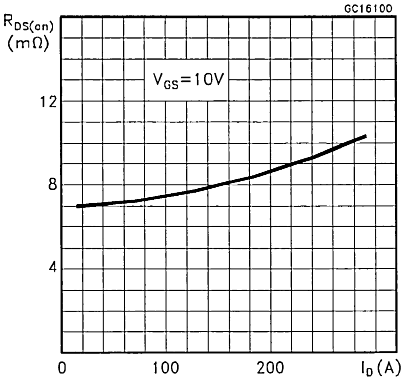
Transfer Characteristics



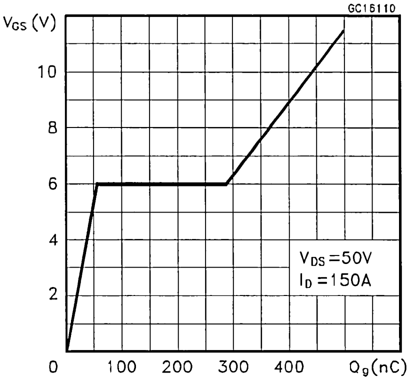
Transconductance



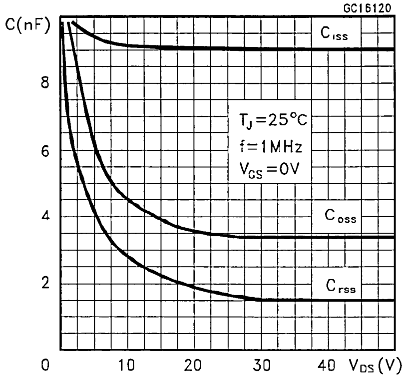
Static Drain-Source On Resistance



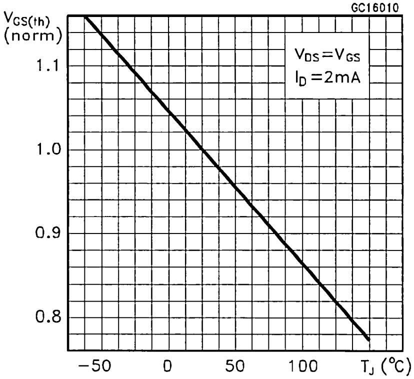
Gate Charge vs Gate-source Voltage



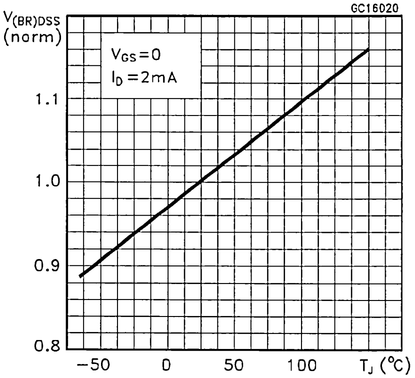
Capacitance Variation



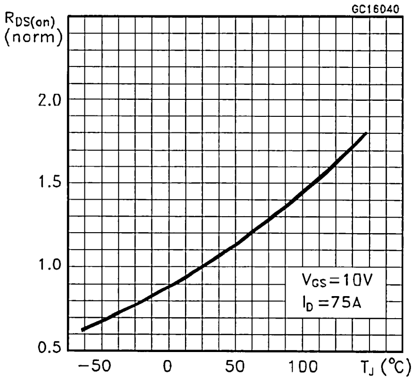
Normalized Gate Threshold Voltage vs Temperature



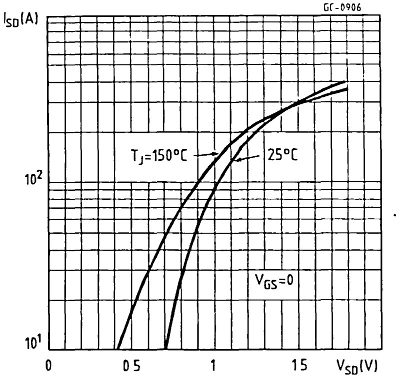
Normalized Breakdown Voltage vs Temperature



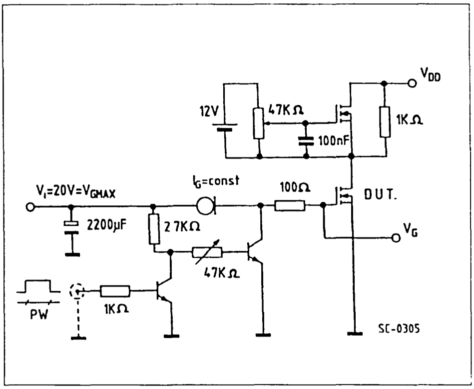
Normalized On Resistance vs Temperature



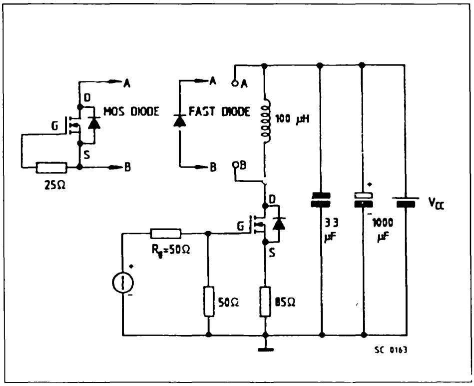
Source-Drain Diode Forward Characteristics



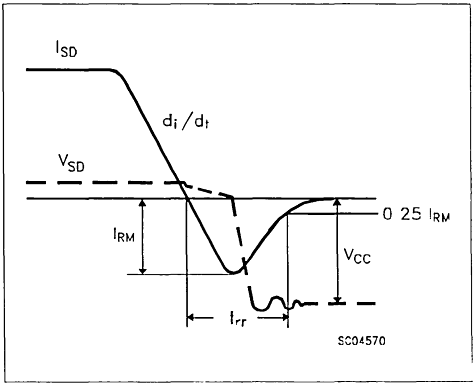
Gate Charge Test Circuit



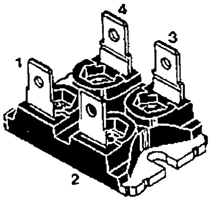
Test Circuit For Inductive Load Switching and Diode Reverse Recovery Times



Diode Reverse Recovery Time Waveform



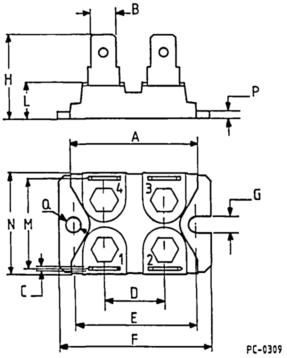
PACKAGES



ISOTOP
Fast-on version

sales types with the suffix F

MECHANICAL DATA



	DIMENSIONS			
	mm		inches	
	min.	max	min.	max
A	31.5	31.7	1.240	1.248
B	6.2	6.4	0.244	0.252
C	0.75	0.85	0.029	0.033
D	14.9	15.1	0.586	0.590
E	30.1	30.3	1.185	1.193
F	38	38.2	1.496	1.503
G	4	–	0.157	–
H	20.3	20.7	0.799	0.815
L	8.9	9.1	0.350	0.358
M	22.4	23	0.881	0.905
N	25.2	25.4	0.992	1.000
P	1.95	2.05	0.076	0.080
Q	4	–	0.157	–

PIN CONNECTIONS

MOSFET

pin 1: Source	pin 2: Gate
pin 3: Drain	pin 4: Source sensings

DARLINGTON

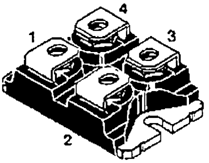
pin 1: Emitter	pin 2: Base1
pin 3: Collector	pin 4: Base 2

TRANSISTOR

pin 1: Emitter	pin 2: Base
pin 3: Collector	pin 4: Emitter sensing

Torque: Mounting 1.3 ± 0.2 N • m (max)
Weight: Package 25.5 g

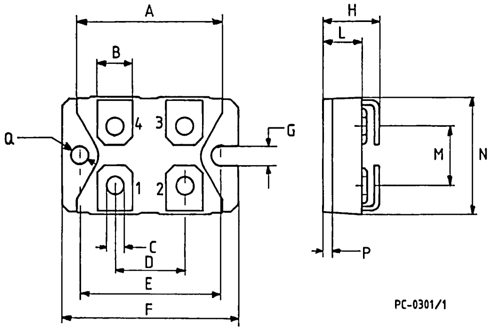
Note: The mechanical data are the same for the 3 pin version
(4th pin missing)



ISOTOP
Screw version

sales types with the suffix V

MECHANICAL DATA



	DIMENSIONS			
	mm		inches	
	min.	max	min.	max
A	31.5	31.7	1.240	1.248
B	7.8	8.2	0.307	0.322
C	4.1	4.3	0.161	0.169
D	14.9	15.1	0.586	0.590
E	30.1	30.3	1.185	1.193
F	38	38.2	1.496	1.503
G	4	–	0.157	–
H	11.8	12.2	0 464	0.480
L	8.9	9.1	0.350	0.358
M	12.6	12.8	0.496	0.503
N	25.2	25.4	0.992	1.000
P	1.95	2.05	0.076	0.080
Q	4	–	0.157	–

PIN CONNECTIONS

MOSFET

pin 1: Source	pin 2: Gate
pin 3: Drain	pin 4: Source sensings

DARLINGTON

pin 1: Emitter	pin 2: Base1
pin 3: Collector	pin 4: Base 2

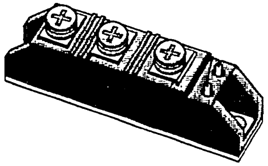
TRANSISTOR

pin 1: Emitter	pin 2: Base
pin 3: Collector	pin 4: Emitter sensing

Torque: Terminal 1.3 ± 0.2 N • m (max)
Mounting 1.3 ± 0.2 N • m (max)

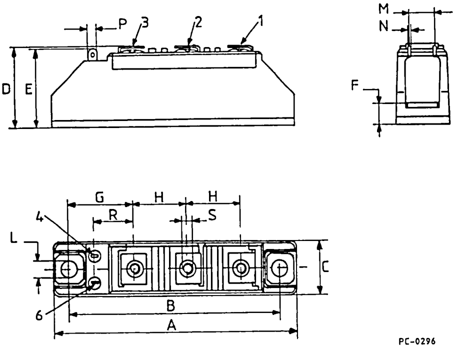
Weight: Package 29 g
4 Screws: 7.5 g

Note: The mechanical data are the same for the 3 pin version
(4th pin missing)



TRANSPACK (TO-240)

MECHANICAL DATA



	DIMENSIONS			
	mm		inches	
	min.	max	min.	max
A	91.5	92.5	3.602	3.641
B	79.75	80.25	3.140	3.160
C	19.5	20.55	0.767	0.809
D	29.00	31.00	1.141	1.220
E	28.8	30	1.134	1.181
F	8.5 typ.		0.334 typ.	
G	24.4 typ.		0.960 typ.	
H	19.5	20.5	0.767	0.807
L	6.2 typ.		0.244 typ.	
M	8.95	11.05	0 352	0 435
N	0.78	0.84	0.030	0.033
P	2.72	2.87	0 107	0.113
R	14	–	0.551	–
S	M5			

Torque: Terminal 2.2 ± 0.5 N • m (max)
Mounting 3.5 ± 0.5 N • m (max)

Weight: Package 110 g
Accessory 21 g

Note: The mechanical data are the same for the 2 power pin version (either pin 1 or pin 2 missing)

NOTES

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NOTES

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