PRODUCT SPECIFICATION

PRIAM AUX 1 (QIC-02)

AUXILIARY CONTROLLER BOARD

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PREFACE

SCOPE

This specification describes the operation of the QIC auxiliary controller board with the PRIAM DS101 Controller.

It is assumed that the reader of this document is already familiar with the **PRIAM DS101 Product Specification.**

APPLICABLE DOCUMENTS

Depending on your system configuration, one or more of the following product specifications will be applicable:

PRIAM Product Specification 3350, 6650, and 15450
PRIAM Product Specification 3450 and 7050
PRIAM Interface Specification
PRIAM DS101 Product Specification

CONTENTS

Section 1 gives an overview of the capabilities provided by the QIC auxiliary controller boards.

Section 2 describes the physical characteristics, power requirements, and environmental requirements.

Section 3 discusses the DS101 interface to the host bus and the auxiliary controller boards' interface to the 1/4" tape drives.

Section 4 describes the functional host interface to the DS101, that is, how a programmer would issue commands and receive results.

Section 5 describes the command set for streamer tape operation.

Section 6 provides a Summary/Quick Reference for the AUX 1 Status and Command codes.

NOTATION

///	The field must be set to zeros in order to maintain compatibility with future products.
???	The contents of the field are undefined.
---	The field should not be read or written.
/	A signal is designated active low by placing a slash character (/) after the signal name.
HEX	Indicates that a number is a hexadecimal value.
MSB	Indicates the most significant byte of a multi-byte value.
LSB	Indicates the least significant byte of a multi-byte value.

Within a byte, Bit 7 is considered the most significant bit, Bit 0 is the least significant.

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1.0 INTRODUCTION

The auxiliary controller boards implement a flexible device connection mechanism for the support of a large variety of peripheral device types and device manufacturers. Once the devices have been initialized, a common command set may be used to transfer data to and from the devices independent of the particular device type. Such a command set allows the development of device independent host software.

This document discusses the QIC (quarter-inch cartridge) interface for streamer tape devices. Among the specific devices supported are:

- Archive Sidewinder (1/4-inch tape, 30/90 IPS)
- Cipher Quarterback (1/4-inch tape, 30/90 IPS)
- DEI Streamer (1/4-inch tape, 30/90 IPS)

2.0 PRODUCT DESCRIPTION

2.1 Physical Characterisics

Auxiliary controller boards for the DS101 mount piggyback on the main DS101 printed circuit board. Each DS101 can be fitted with zero, one, or two auxiliary controller boards.

These auxiliary boards are powered from the main DS101 board. The power and interface connections between the DS101 and each auxiliary board are made via a 36-pin connector.

Connection between the each auxiliary board and the devices that it controls is made via the appropriate connector, as shown in Table 2-1.

TABLE 2-1. DEVICE INTERFACE CONNECTORS

Device Type	Connector on Auxiliary Board	Connector on Interface Cable	Cable Type
Streamer Tape (QIC)	3M 3433-1302	3M 3425-7050 or equivalent	3M 3365/50 or equivalent

2.2 Power Requirements

The DS101 requires +5 VDC, +/- 5%, 6.0 AMP maximum. To power the auxiliary boards, it is necessary to increase the amount of current available through the DS101 power connector.

The QIC streamer tape auxiliary board requires an additional 1.5 AMP maximum.

2.3 Environmental Characterisitics

TEMPERATURE

Equipment Operational: 10° C to 45° C (50° F to 113° F).

Equipment Non-opertional: -40° C to 60° C (-40° F to 140° F).

HUMIDITY

Equipment Operational: 8% to 80% relative humidity, with a wet bulb temperature limit of 26 o C (78 o F) without condensation.

Equipment Non-operational: 8% to 90% without condensation.

ALTITUDE

Equipment Operational: From 1,000 feet below sea level to 12,000 feet above sea level.

Equipment Non-operational: From 1,000 feet below sea level to 40,000 feet above sea level.

2.4 Reliability

MTBF

All auxiliary controller boards have a mean time between failures (MTBF) of at least 16,000 power-on hours.

MTTR

All auxiliary controller boards are field replacable units with a mean time to repair (MTTR) of less than 1/2 hour.

2.5 Controls

The auxiliary controller boards have no manual switches or controls.

3.0 ELECTRICAL INTERFACE

The host interface to the DS101 is described in the Electrical Interface section of the PRIAM DS101 Product Specification.

This interface does not change as a result of adding the auxiliary controller boards.

The device interfaces on the auxiliary controller boards depend on the particular auxiliary board used, as detailed in Table 3-1.

TABLE 3-1. AUXILIARY BOARD DEVICE INTERFACES

Device Type	Interface Type
Streamer Tape	Standard QIC-02 Interface

4.0 FUNCTIONAL INTERFACE

The host issues commands and receives results via the host-accessible registers in the DS101.

Some of the commands may affect the operation of the auxiliary controller boards and their attached devices.

Such commands are issued (and results are received) in the normal manner, as described in the Functional Interface section of the PRIAM DS101 Product Specification.

5.0 STREAMER TAPE COMMAND SET

The streamer tape command set consists of a data transfer command set and a direct control command set. The data transfer command set is used for reading and writing tape data, while the direct control commands are used for controlling tape motion and performing other operations in which the host directly operates the tape drive.

5.1 Data Transfer Command Set

This section discusses commands used for reading and writing tape data, as they are implemented with the DS101.

The host system may direct the DS101 to perform two types of data transfers:

- Transfers between the host memory and a selected tape drive
- Transfers between a tape drive and another peripheral device without host memory utilization

A data transfer between the host memory and a tape drive is normally requested by issuing a Read Data or a Write Data command. However, such a transfer can also be requested with a Copy Data command, using a device address of 30 HEX to identify the host memory. A data transfer between a tape drive and another peripheral device is requested by issuing a Copy Data command.

5.1.1 Read Data and Write Data

The Read Data and Write Data commands are register based commands used to transfer data between the host and the selected tape drive. The data is transferred according to the parameters specified in the register file at the time the command is issued (see Figure 5-1).

Upon command initiation the DS101 verifies the parameters. In the case of a streamer tape drive, there is no addressing involved, and thus there is no implied motion control operation. Read and Write operations proceed forward from the current tape location.

Streamer tape always uses the buffered mode. There is no mode specification and no involvement of the DS101 mode byte with the streamer tape.

The streamer tape drives perform retries automatically. Retries can not be disabled.

If a Write Data command is issued, the DS101 will begin the write operation as soon as one complete block of data has been transferred from the host to the DS101's internal buffer. For a multi-record Read Data command the DS101 will begin sending data to the host as soon as one complete block of data has been transferred from the tape drive to the DS101's internal buffer. Subsequent blocks will be transferred in a similar manner. Data may be simultaneously entering and exiting the DS101. At the present time, the block size is fixed at 512 bytes.

FIGURE 5-1. READ DATA AND WRITE DATA COMMANDS

READ DATA

COMMAND INITIATION (7 … 0)	REGISTER ADDRESS	COMMAND COMPLETION (7 … 0)
COMMAND = 43 HEX	0	INTERFACE STATUS
---	1	BLOCK INPUT
DEVICE SELECT	2	TRANSACTION STATUS
	3	
///	4	???
	5	
OPERATION COUNT	6	RESIDUAL OPERATION COUNT
///	7	DEVICE SELECT RESULT

Prerequisite State: Neutral or Read
Ending State: Read *

WRITE DATA

COMMAND INITIATION (7 … 0)	REGISTER ADDRESS	COMMAND COMPLETION (7 … 0)
COMMAND = 42 HEX	0	INTERFACE STATUS
BLOCK OUTPUT	1	---
DEVICE SELECT	2	TRANSACTION STATUS
	3	
///	4	???
	5	
OPERATION COUNT	6	RESIDUAL OPERATION COUNT
///	7	DEVICE SELECT RESULT

Prerequisite State: Neutral or Write *
Ending State: Write

The parameters associated with the Read Data and Write Data commands are as described below.

DEVICE SELECT
The format of the device select field is shown in Figure 5-2. The tape devices are attached to Auxiliary Channel 0 or Auxiliary Channel 1. Within a channel, the specific tape drive is selected by the Unit Number which ranges from 0 to 3.

OPERATION COUNT
The Operation Count specifies the number of blocks to be read or written. Permissible values are 01 HEX through FF HEX. An operation count of 0 is illegal.

At the present time, the block size is fixed at 512 bytes.
* A write operation is also legal following a read operation if the read operation terminated with an auxiliary trap (14H) status, and a supplemental status of 02H (No recorded data).

TRANSACTION STATUS

The Transaction Status indicates the result of the requested command. During the command completion phase the Transaction Status should be read and tested by the host processor. If the completion type (see Figure 5-3) is zero the command was successfully completed.

A non-zero completion type indicates a fatal error. The completion code may be utilized to obtain information required for diagnosing errors. Table 5-1 defines the various completion codes that apply specifically to streamer tape.

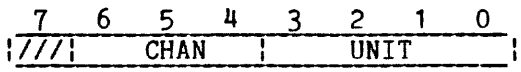
RESIDUAL OPERATION COUNT

The Residual Operation Count is zero if the command was successfully completed. Otherwise, this byte contains the number of records remaining to be transferred when the operation terminated.

DEVICE SELECT RESULT

The Device Select Result is returned so that host software may associate the reported status with the command issued in cases where multiple commands are outstanding at one time. This byte has the same format as the Device Select byte.

FIGURE 5-2. DEVICE SELECT

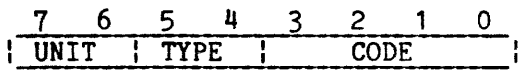


CHAN -- Devices connected to the DS101 are attached to a channel. Channel assignments are as follows:

Channel	
0	PRIAM Interface Bus
1	Auxiliary Bus 0
2	Auxiliary Bus 1
3	Host
4	Special Purpose

UNIT -- An ID number corresponding to the number determined by switches or some other physical configuration on the device. This number must be unique for each device on a given channel. Up to four units may be selected within a channel.

FIGURE 5-3. TRANSACTION STATUS



UNIT -- The unit field is a copy of the two least significant bits of the specified Device Select byte, and is included for SMART-E compatibility.

TYPE -- The completion type field indicates the major class of the completion status, as follows:

Type	
0	Good Completion
1	System Error or Initialization Complete
2	Operator Intervention
3	Command or Device Error

CODE -- The completion codes provide a detailed definition of the command completion. A summary of the completion codes that are specific to streamer tape is given in Table 5-1. Details are given in Sections 5.1.2 and 5.1.3.

5.1.2 **Transaction Status Detail**

This section provides a summary of the completion codes that are specific to streamer tape, and a detailed description of each code.

TABLE 5-1. STREAMER TAPE UNIQUE COMPLETION CODES

Completion Code (Transaction Status Bits 5-0)	Description
04	File Mark Detected This status code indicates that a tape Read Data operation was terminated due to the detection of a file mark (EOF). The tape is positioned after the file mark. This code will not be returned during a write operation.
05	End of Tape This status code indicates that a tape command was terminated due to the detection of the End of Tape. This code will be returned only during a write operation.
14	Auxiliary Trap (Supplemental Status) This status code indicates that an error has been detected by the Streamer Tape Auxiliary Controller Board. Supplemental status is reported in Register 3, as detailed in Section 5.1.3.

5.1.3 **Supplemental Status Detail**

This section defines the supplemental status information for the Auxiliary Trap (14 HEX) transaction status condition, as it applies to streamer tape. This supplemental information is reported in Register 3 upon command completion.

TABLE 5-2. AUXILIARY TRAP SUPPLEMENTAL STATUS CODES

00 Unrecoverable Data Error — Last Block
This status code indicates a hard data error on the last block during a Data Read or Data Write operation.

01 Unrecoverable Data Error — Block Unknown
This status code indicates a hard data error during a Data Read or Data Write operation, when it can not be determined in which block the error occurred.

02 No Recorded Data
This status code indicates that an absence of recorded data was detected. If this status is returned from a read operation, a write operation is then legal.

03 Tape Deck Position Error
This status code is returned if the correct deck status was not received after a motion control command was issued — for example, beginning of tape not detected after a Rewind command.

04 QIC Status Error
This status code indicates that the QIC interface reported an exception, and the device status received from the tape drive did not indicate an error. The two QIC status bytes are returned in Registers 4 and 5 (see Section 5.2.8).

05 Drive Reset
This status code indicates that a reset has occurred at the tape drive.

06 Operation Aborted
This status code indicates that an operation was aborted because the Auxiliary Controller Board was unable to execute a command.

07 Command Sequence Error
This status code indicates that the Auxiliary Controller Board received a command which could not be executed, because a prior read or write operation had not completed.

08 Tape Cartridge Not Present
This status code indicates that there is no tape cartridge fully inserted in the tape drive.

09 Undefined Command
This status code indicates that the Auxiliary Controller Board received an undefined command.

5.1.4 Copy Data

The Copy Data command is a packet based command that is used to transfer data between peripheral devices. When streamer tape is used it is almost always true that the Copy Data operation is between the streamer tape and a Winchester disc drive.

The Copy Data command is discussed in general terms in the DS101 product specification. This section presents some examples of Copy Data transfers between a Winchester disc and a streamer tape device.

To request a Copy Data operation, the host sends a Transfer Packet command, and then outputs the Copy Data packet, which contains the parameters used to control the Copy Data operation, to Register 1 of the DS101. The Copy Data packet contains 16 bytes for each Copy Data step. Figure 5-4 below shows the fields of the Transfer Packet Command. Figure 5-5 shows the structure of the Copy Data Packet Parameters for one Copy Data packet step.

FIGURE 5-4. TRANSFER PACKET COMMAND

COMMAND INITIATION (7 … 0)	REGISTER ADDRESS	COMMAND COMPLETION (7 … 0)
COMMAND = B0 HEX	0	INTERFACE STATUS
BLOCK OUTPUT	1	---
PACKET ID	2	TRANSACTION STATUS
///	3	SUPPLEMENTAL STATUS
PACKET MSB	4	???
LENGTH LSB	5	??? | TDF
///	6	TERMINATION DEVICE SELECT
	7	1 | 0 | PACKET ID

FIGURE 5-5. COPY DATA PACKET PARAMETERS

BYTE	7 6 5 4 3 2 1 0	
0	01 HEX	OPERATION CODE
1	///	
2	/// | OCD | /// | EOFACT | ERR ACT	STEP CONTROL 0
3	SR | ELM | IEC | /// | TIE | ///	STEP CONTROL 1
4	NUMBER OF SECTORS/RECORDS	TRANSFER LENGTH
5	TO TRANSFER LSB	
6	/// | SRC CH# | SRC UNIT #	SOURCE DEVICE SELECT
7	SOURCE (H/C) (S) MSB	SOURCE TRANSFER ADDRESS
8	TRANSFER (C) (S)	
9	ADDRESS (S) (S) LSB	
10	///	
11		
12	/// | DST CH# | DST UNIT #	DESTINATION DEVICE SELECT
13	DESTIN (H/C) (S) MSB	DESTINATION TRANSFER ADDRESS
14	TRANSFER (C) (S)	
15	ADDRESS (S) (S) LSB	

Prerequisite State: Refer to the Read Data and Write Data commands.
Ending State: Same

EXAMPLE 1 — NOMINAL MULTI-TAPE BACKUP OPERATION

The following steps describe a nominal disc to tape backup operation, using a packet based Copy Data command, and requiring multiple tapes to hold the contents of the entire disc.

1. The host issues a message to the operator to mount a cartridge in the drive to be used for the backup operation, and receives confirmation from the operator when this has been done.

2. The host issues a Rewind command (6A HEX) to the chosen drive.

3. Using the Write Data command (42 HEX) the host sends header information (a 512-byte record) to identify the mounted tape as the first backup tape (this step is optional but recommended).

4. The host issues a Transfer Packet command (B0 HEX), following the format shown in Figure 5-4 above. Prior to writing B0 HEX to Register 0 (the Command Register) the host writes 00 00 00 10 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and tells the DS101 to expect a packet of length equal to 16 bytes.

5. Following the format shown in Figure 5-5 above, the host sends the Copy Data Packet to Register 1. The 16 bytes are written as follows:

BYTE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	01	00	03	04	00	00	00	00	00	00	00	00	20	00	00	00	HEX

0: Byte 0 contains the Copy Data command code.
1: Byte 1 is not used.
2-3: Bytes 2 and 3 specify the desired Step Control action. Sectors containing ECC errors on the disc will not stop the Copy Data operation, and will be copied to tape. Physical addressing mode is used. The disc will be used for counting operations.
4-5: Bytes 4 and 5 specify 00 sectors to be transferred, which tells the DS101 to continue until the end of media.
6: Byte 6 selects the disc (device 00) as the source device.
7-9: Bytes 7, 8, and 9 specify that the transfer should start with Head 0, Cylinder 0, and Sector 0.
10-11: Bytes 10 and 11 are not used.
12: Byte 12 selects the tape (device 20) as the destination device.
13-15: Bytes 13, 14, and 15 are 0, since the streamer tape does not accept transfer addresses.

6. When the host has finished sending the Copy Data packet, the DS101 transfers data from disc to tape until the tape is full. The DS101 then interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0). The transaction status (Register 2) will equal 28 HEX, indicating that the packet execution has terminated, but is resumable. Primary termination status will be 05 (end of tape) and secondary termination status be 01 (destination device full).

7. The host writes an end of file (EOF) mark on the tape by issuing a Write File Mark command (62 HEX) to the tape drive. This step is necessary because the end of tape can not be sensed during a read operation. A file mark must be present in order to stop a Copy Data operation when the data on the tape is being restored to disc.

8. The host issues a Rewind command (6A HEX) to the tape drive. This assures that the tape will be at BOT.

9. The host issues a message to the operator to remove the cartridge and to mount another cartridge in its place, and receives confirmation from the operator when this has been done.

10. The host issues a Rewind command (6A HEX) to the tape drive. This assures that the new tape will be at BOT.

11. Using the Write Data command (42 HEX) the host sends header information (a 512-byte record) to identify the newly mounted tape (this step is optional but recommended).

12. The host issues a Resume Packet Execution command (B1 HEX). Prior to writing B1 to Register 0 (the Command Register) the host writes 00 FF FF FF 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and instructs the DS101 to resume data transfer at the disc address it was about to read when the packet terminated.

13. The DS101 transfers data from the disc to the tape until the tape is full. Then the DS101 interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0). The transaction status (Register 2) will equal 28 HEX, indicating that packet execution has terminated, but is resumable.

14. Steps 7 through 13 are repeated for as many tapes as are necessary to backup all the data on the disc. When the last user-accessible sector on the disc has been transferred to tape, packet execution terminates and the command completion shows a transaction status equal to 08, indicating that packet execution is not resumable. Primary termination status will be 05 (end of media) and secondary termination status will be 02 (source device empty).

15. The host writes an end of file (EOF) mark on the tape by issuing a Write File Mark command (62 HEX) to the tape drive. This step is required in order to write any residual data from the streamer tape's buffer onto the tape, if the disc sector size is anything other than a multiple of 512 bytes.

16. The host issues a Rewind command (6A HEX) to the tape drive.

EXAMPLE 2 — NOMINAL MULTI-TAPE RESTORE OPERATION

The following steps describe a nominal tape to disc restore operation, using a packet based Copy Data command, and requiring multiple tapes to provide the data for the entire disc.

1. The host issues a message to the operator to mount a cartridge in the drive to be used for the restore operation, and receives confirmation from the operator when this has been done.

2. The host issues a Rewind command (6A HEX) to the chosen drive.

3. Using the Read Data command (43 HEX) the host reads the header information (a 512-byte record) to identify the mounted tape as the first restore tape. This step is required if a header record was written when the tape was created, and must not be done if no header record was written.

4. The host issues a Transfer Packet command (B0 HEX), following the format shown in Figure 5-4 above. Prior to writing B0 HEX to Register 0 (the Command Register) the host writes 00 00 00 10 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and tells the DS101 to expect a packet of length equal to 16 bytes.

5. Following the format shown in Figure 5-5 above, the host sends the Copy Data Packet to Register 1. The 16 bytes are written as follows:

BYTE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	01	00	44	00	00	00	20	00	00	00	00	00	00	00	00	00	HEX

0: Byte 0 contains the Copy Data command code.
1: Byte 1 is not used.
2-3: Bytes 2 and 3 specify the desired Step Control action. The packet will terminate when EOF is detected, but will be resumable. The disc will be used for counting operations.
4-5: Bytes 4 and 5 specify 00 sectors to be transferred, which tells the DS101 to continue until the end of media.
6: Byte 6 selects the tape (device 20) as the source device.
7-9: Bytes 7, 8, and 9 are 0, since the streamer tape does not accept transfer addresses.
10-11: Bytes 10 and 11 are not used.
12: Byte 12 selects the disc (device 00) as the destination device.
13-15: Bytes 13, 14, and 15 specify that the transfer should start with Head 0, Cylinder 0, and Sector 0.

6. When the host has finished sending the Copy Data packet, the DS101 transfers data from the tape to the disc until an EOF mark is detected on the tape. Then the DS101 interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0) until the command completion bit is set. The transaction status (Register 2) will equal 28 HEX, indicating that the packet execution has terminated, but is resumable. Primary termination status will be 05 (end of tape) and secondary termination status be 02 (source device empty).

7. The host issues a Rewind command (6A HEX) to the tape drive.

8. The host issues a message to the operator to remove the cartridge and to mount another cartridge in its place, and receives confirmation from the operator when this has been done.

9. The host issues a Rewind command (6A HEX) to the tape drive.

10. Using the Read Data command (43 HEX) the host reads the header information (a 512-byte record) to identify the newly mounted tape. This step is required if a header record was written, and must not be done if no header record was written.

11. The host issues a Resume Packet Execution command (B1 HEX). Prior to writing B1 to Register 0 (the Command Register) the host writes 00 FF FF FF 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and instructs the DS101 to resume data transfer at the disc address it was about to write when the packet terminated.

12. The DS101 transfers data from the tape to the disc until an EOF mark is detected on the tape. Then the DS101 interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0). The transaction status (Register 2) will equal 28 HEX, indicating that the packet execution has terminated, but is resumable.

13. Steps 7 through 12 are repeated for as many tapes as are necessary to restore all the data on the disc. Then the packet execution terminates and the command completion shows a transaction status equal to 08, indicating that the packet execution has terminated and is not resumable.

14. The host issues a Rewind command (6A HEX) to the tape drive.

EXAMPLE 3 — MULTI-STEP COPY FROM DISC TO TAPE

This example shows how to perform a Copy Data operation from disc to tape, where the data to be copied exists in multiple segments which are not logically contiguous on the disc.

1. The host issues a message to the operator to mount a cartridge in the drive to be used for the copy operation, and receives confirmation from the operator when this has been done.

2. The host issues a Rewind command (6A HEX) to the chosen drive.

3. Using the Read Data command (43 HEX) until a "No Recorded Data" status (14 02 HEX) is returned, the host positions the tape to the desired location where the data from the disc is to be written. It is the host's responsibility to see that the tape is positioned properly before starting the Copy Data operation.

4. The host issues a Transfer Packet command (B0 HEX), following the format shown in Figure 5-4 above. Prior to writing B0 HEX to Register 0 (the Command Register) the host writes 00 00 00 30 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and tells the DS101 to expect a packet of length equal to 48 bytes.

5. Following the format shown in Figure 5-5 above, the host sends the Copy Data Packet (which consists of three 16-byte steps) to Register 1. The 48 bytes are written as follows:

BYTE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	01	00	03	04	01	64	00	21	34	03	00	00	20	00	00	00	HEX

BYTE	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
	01	00	03	04	00	64	00	00	10	05	00	00	20	00	00	00	HEX

BYTE	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	
	01	00	03	04	03	EB	00	31	AB	00	00	00	20	00	00	00	HEX

0: Byte 0 contains the Copy Data command code.
1: Byte 1 is not used.
2-3: Bytes 2 and 3 specify the desired Step Control action. Sectors containing ECC errors on the disc will not stop the Copy Data operation, and will be copied to tape. Physical addressing mode is used. The disc will be used for counting operations.
4-5: Bytes 4 and 5 specify 356 sectors (164 HEX) to be transferred.
6: Byte 6 selects the disc (device 00) as the source device.
7-9: Bytes 7, 8, and 9 specify that the transfer should start at Head 2, Cylinder 308 (134 HEX), Sector 3.
10-11: Bytes 10 and 11 are not used.
12: Byte 12 selects the tape (device 20) as the destination device.
13-15: Bytes 13, 14, and 15 are 0, since the streamer tape does not accept transfer addresses.

The second and third steps of the Copy Data packet are identical to the first step, except for the following:

- The second step transfers 100 sectors (64 HEX), as specified by Bytes 20 and 21.
- The data for the second step begins at Head 0, Cylinder 16 (10 HEX), Sector 5, as specified by Bytes 23, 24, and 25.
- The third step transfers 1000 sectors (3E8 HEX), as specified by Bytes 36 and 37.
- The data for the third step begins at Head 3, Cylinder 427 (1AB HEX), Sector 0, as specified by Bytes 39, 40, and 41.

6. When the host has finished sending the Copy Data packet, the DS101 transfers the data from the disc to the tape. Then the DS101 interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0). The transaction status (Register 2) will equal 08, indicating that the packet execution has terminated, and is not resumable. Other command completion fields (see Figure 5-4 above) should be 00 for primary termination status, indicating good completion; FE for secondary termination status, indicating no supplemental information; 3 for the termination device flag, indicating that the source device (the disc) caused the packet to terminate; 00 for the termination device select; and 80 HEX in Register 7 to indicate that the packet with ID = 0 has terminated.

7. The host writes an end of file (EOF) mark on the tape by issuing a Write File Mark command (62 HEX) to the tape drive. This step is required in order to write any residual data from the streamer tape's buffer onto the tape, if the disc sector size is anything other than a multiple of 512 bytes.

8. The host issues a Rewind command (6A HEX) to the tape drive.

EXAMPLE 4 — MULTI-STEP COPY FROM TAPE TO DISC

This example shows how to perform a Copy Data operation from tape to disc, where the data is to be copied onto multiple segments which are not logically contiguous on the disc.

1. The host issues a message to the operator to mount a cartridge in the drive to be used for the copy operation, and receives confirmation from the operator when this has been done.

2. The host issues a Rewind command (6A HEX) to the chosen drive.

3. Using the Advance File Marks command (C0 HEX) the host positions the tape to the desired location from which the data for the disc is to be read. It is the host's responsibility to see that the tape is positioned properly before starting the Copy Data operation.

4. The host issues a Transfer Packet command (B0 HEX), following the format shown in Figure 5-4 above. Prior to writing B0 HEX to Register 0 (the Command Register) the host writes 00 00 00 40 00 00 HEX to registers 2 through 7, respectively. This establishes Packet ID = 0, and tells the DS101 to expect a packet of length equal to 64 bytes.

5. Following the format shown in Figure 5-5 above, the host sends the Copy Data Packet (which consists of four 16-byte steps) to Register 1. The 64 bytes are written as follows:

```
BYTE  0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
      01 00 40 00 00 C8 20 00 00 00 00 00 00 01 23 04 HEX

BYTE 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
      01 00 40 00 00 64 20 00 00 00 00 00 00 02 00 01 HEX

BYTE 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
      01 00 40 00 03 EB 20 00 00 00 00 00 00 00 FF 00 HEX

BYTE 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63
      01 00 40 00 00 9C 20 00 00 00 00 00 00 00 00 00 HEX
```

0: Byte 0 contains the Copy Data command code.
1: Byte 1 is not used.
2-3: Bytes 2 and 3 specify the desired Step Control action. The packet will terminate if an EOF is detected, and will not be resumable. Physical addressing mode is used. The disc will be used for counting operations.
4-5: Bytes 4 and 5 specify 200 sectors (C8 HEX) to be transferred.
6: Byte 6 selects the tape (device 20) as the source device.
7-9: Bytes 7, 8, and 9 are 0, since the streamer tape does not accept transfer addresses.
10-11: Bytes 10 and 11 are not used.
12: Byte 12 selects the disc (device 00) as the destination device.
13-15: Bytes 13, 14, and 15 specify that the transfer should start at Head 0, Cylinder 291 (123 HEX), Sector 4.

The second and third steps of the Copy Data packet are identical to the first step, except for the following:

- The second step transfers 100 sectors (64 HEX), as specified by Bytes 20 and 21.
- The disc addresses for the second step begin at Head 0, Cylinder 512 (200 HEX), Sector 1, as specified by Bytes 29, 30, and 31.
- The third step transfers 1000 sectors (3E8 HEX), as specified by Bytes 36 and 37.
- The disc addresses for the third step begin at Head 0, Cylinder 255 (FF HEX), Sector 0, as specified by Bytes 45, 46, and 47.
- The fourth step transfers 156 sectors (9C HEX), as specified by Bytes 52 and 53.
- The disc addresses for the fourth step begin at Head 0, Cylinder 0, Sector 0, as specified by Bytes 61, 62, and 63.

6. When the host has finished sending the Copy Data packet, the DS101 transfers the data from the tape to the disc. Then the DS101 interrupts the host to indicate command completion. If the command completion interrupt is not enabled, the host must poll the Interface Status register (Register 0). The transaction status (Register 2) will equal 08, indicating that the packet execution has terminated, and is not resumable. Other command completion fields (see Figure 5-4 above) should be 00 for primary termination status, indicating good completion; FE for secondary termination status, indicating no supplemental information; 3 for the termination device flag, indicating that the source device (the tape) caused the packet to terminate; 20 for the termination device select; and 80 in Register 7 to indicate that the packet with ID = 0 has terminated.

7. The host issues a Rewind command (6A HEX) to the tape drive.

EXAMPLE 5 — READING PACKET STATUS

After a Copy Data operation is complete, or at any time during the packet execution, the host may obtain information about the Copy Data operation by issuing a Read Packet Status command (B8 HEX). In this example, prior to writing B8 to Register 0 (the Command Register), the host writes 00 00 00 00 00 00 HEX to Registers 2 through 7, respectively. Writing 00 to Register 2 specifies that the report should be for the packet with ID = 0.

The Packet Status Report Structure consists of 36 bytes, as illustrated in Figure 5-6.

FIGURE 5-6. PACKET STATUS REPORT STRUCTURE

BYTE	7	6	5	4	3	2	1	0
0	PACKET ID							
1	PACKET STATE							
2	TERMINATION DEVICE FLAG							
3	PRIMARY TERMINATION STATUS							
4	SECONDARY TERMINATION STATUS							
5	???							
6	PACKET							MSB
7	OFFSET							LSB
8	PACKET							MSB
9	LENGTH							LSB
10	CURRENT STEP OPERATION CODE							
11	CURRENT STEP NUMBER							
12								MSB
13	TOTAL NUMBER OF							
14	SECTORS/RECORDS COPIED							
15								LSB
16	SOURCE DEVICE SELECT							
17	SOURCE DEVICE STATUS							
18	SUPPLEMENTAL SOURCE STATUS							
19	SOURCE			(H/C)	(S)			MSB
20	TRANSFER			(C)	(S)			
21	ADDRESS			(S)	(S)			LSB
22	NUMBER OF SOURCE							MSB
23	DEVICE SECTORS/RECORDS							
24	INPUTTED FOR							
25	CURRENT COPY STEP							LSB
26	DESTINATION DEVICE SELECT							
27	DESTINATION DEVICE STATUS							
28	SUPPLEMENTAL DESTINATION STATUS							
29	DESTINATION			(H/C)	(S)			MSB
30	TRANSFER			(C)	(S)			
31	ADDRESS			(S)	(S)			LSB
32	NUMBER OF DESTINATION							MSB
33	DEVICE SECTORS/RECORDS							
34	OUTPUTTED FOR							
35	CURRENT COPY STEP							LSB

The following example shows the Packet Status Report (obtained after completion) for the disc-to-tape transfer discussed in Example 3 above. The 36 bytes shown are returned to the host via Register 1, the Block Input register:

```
BYTE 0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
     00 0D FF 00 FE XX 39 EB 00 30 01 04 00 00 05 B0 HEX

BYTE16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
     00 00 FE 41 CC 04 00 00 03 EB 20 00 FE 00 00 00 HEX

BYTE32 33 34 35
     00 00 03 EB HEX
```

0: Byte 0 indicates that this report concerns Packet ID = 0.

1: Byte 1 indicates that the Packet State = 0D (Packet Completed).

2: Byte 2 indicates that the source device (the disc) caused the packet termination.

3: Byte 3 indicates that the primary termination status = 00 (good completion).

4: Byte 4 indicates that there is no supplemental status information.

5: Byte 5 is indeterminate.

6-7: Bytes 6 and 7 specify a Packet Offset of 39EB HEX from the beginning of the DS101's internal buffer to the first byte of the packet.

8-9: Bytes 8 and 9 specify a packet length of 48 bytes (30 HEX).

10: Byte 10 specifies an operation code of 01 HEX, indicating that the last step completed was a Copy Data step.

11: Byte 11 indicates that the operation is at step 4 (one step past the number of steps specified).

12-15: Bytes 12 through 15 indicate that 1456 sectors (5B0 HEX) were transferred for all steps in the packet.

16: Byte 16 indicates that the source device (for the last step) was the disc (device 00).

17: Byte 17 indicates that the source device status = 00.

18: Byte 18 indicates that there is no supplemental source device status.

19-21: Bytes 19 through 21 indicate that the last sector transferred was the sector at Head 4, Cylinder 460 (1CC HEX), Sector 3 (the address given is one more than that of the last sector transferred).

22-25: Bytes 22 through 25 indicate that all 1000 sectors (3E8 HEX) specified for the last copy step were read from the disc.

26: Byte 26 indicates that the destination device was the tape (device 20).

27: Byte 27 indicates that the destination device status = 00.

28: Byte 28 indicates that there is no supplemental destination device status.

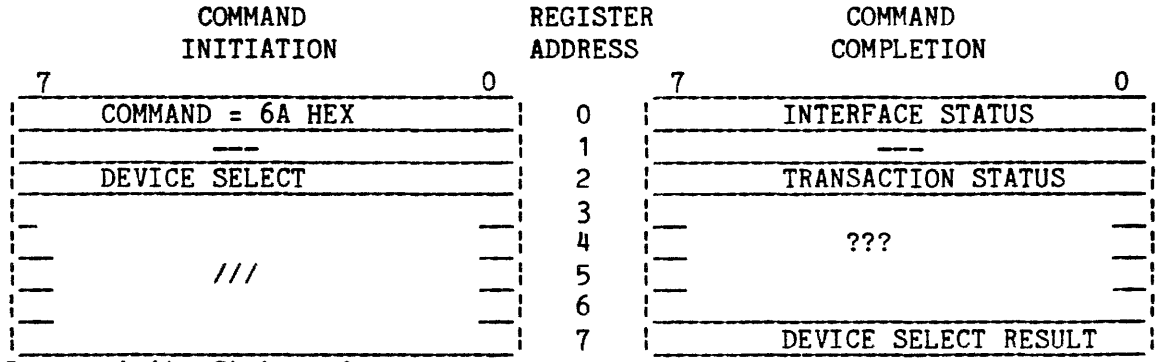
29-31: Bytes 29 through 31 are 0, since the streamer tape does not accept transfer addresses.

32-35: Bytes 32 through 35 indicate that all 1000 sectors (3E8 HEX) specified for the last copy step were written to the tape.

5.2 Streamer Tape Primitive Commands

This section describes the primitive commands that the host can use for direct control of streamer tape devices. Actual reading and writing of data is performed using the Nominal Operations command set described in Section 5.1.

5.2.1 Rewind



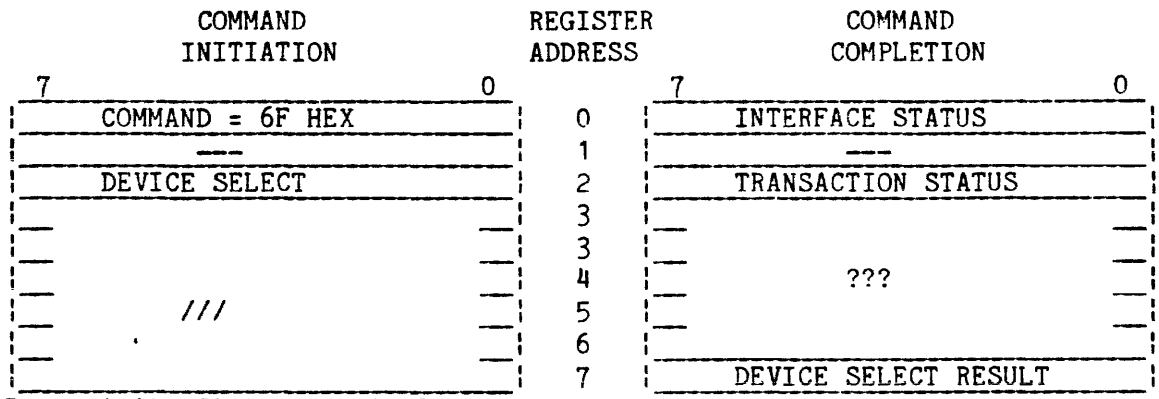
Prerequisite State: Any
Ending State: Neutral

FUNCTION

The Rewind command initiates reverse tape motion, which continues until the beginning of tape (BOT) is detected.

If the tape is already at BOT, the command terminates immediately with good status (completion code = 00 in the transaction status byte). This is the only command which will change the QIC state from read or write to neutral. Rewind must be performed when a new cartridge is installed, before a cartridge is removed, after power-on, and following any reset operation.

5.2.2 Erase

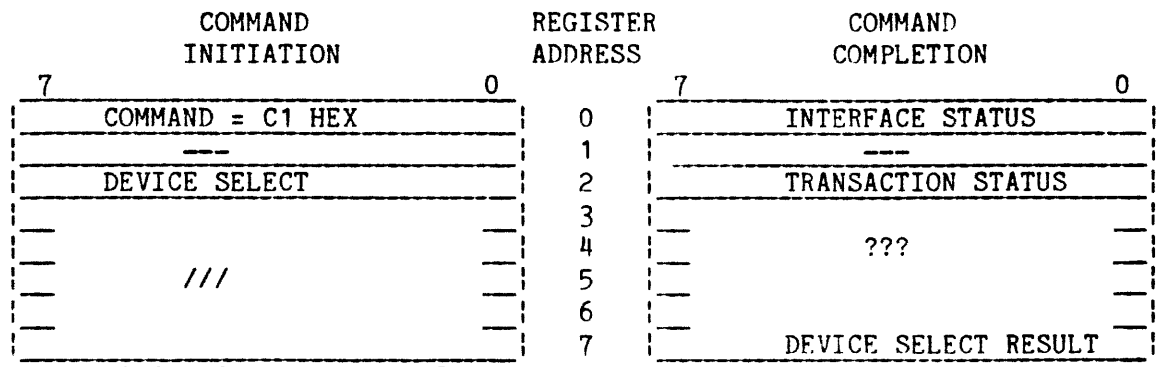


Perequisite State: Neutral
Ending State : No change

FUNCTION

The Erase command positions the tape to BOT (if it is not already there), then erases the tape from BOT to EOT, and then rewinds the tape to BOT.

5.2.3 **Retension Tape**



Prerequisite State: Neutral
Ending State: No Change

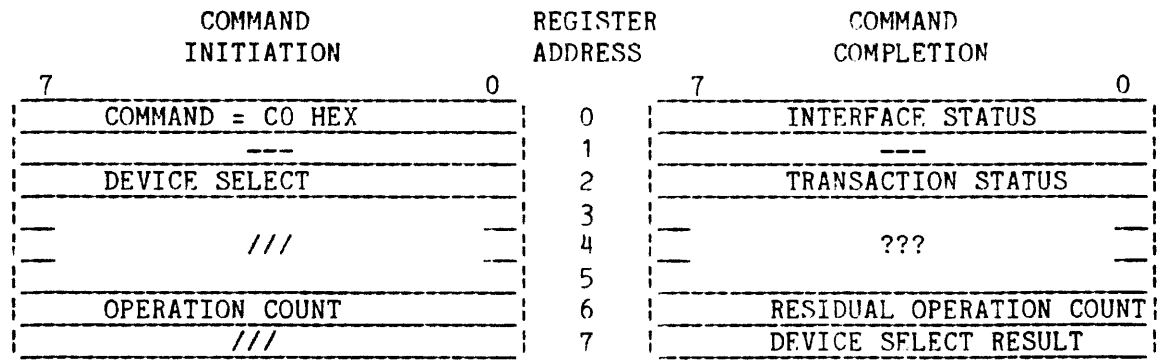
FUNCTION

The Retension Tape command causes to tape to be moved to BOT, then from BOT to EOT, and then back to BOT.

It is recommended that the Retension Tape command be issued in the following situations:

1. Prior to writing
2. When excessive read errors are encountered
3. When a new cartridge, or one that has been in storage for a long time, is placed in the tape drive

5.2.4 **Advance File Marks**

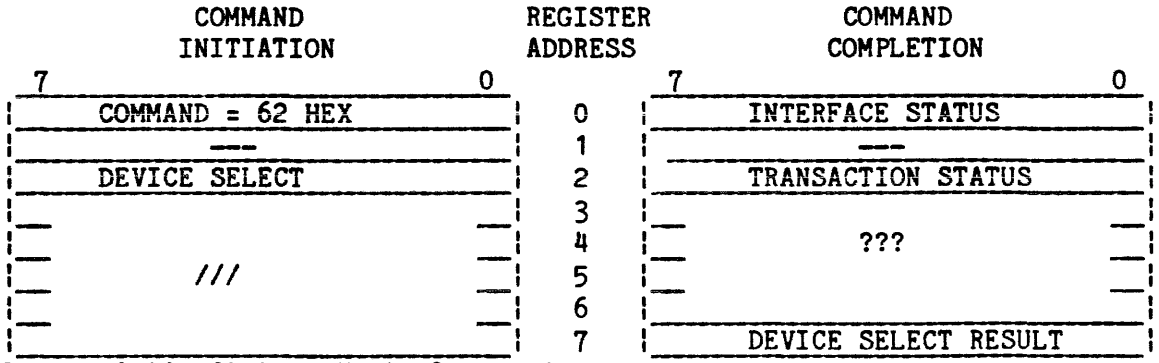


Prerequisiste State: Any
Ending State: Read

FUNCTION

The Advance File Marks command causes the DS101 to first perform a rewind and the to read forward until a file mark is detected. The process is repeated until the number of file marks specified by OPERATION COUNT have been found. At completion the tape will be positioned immediately after the file mark.

5.2.5 **Write File Mark**



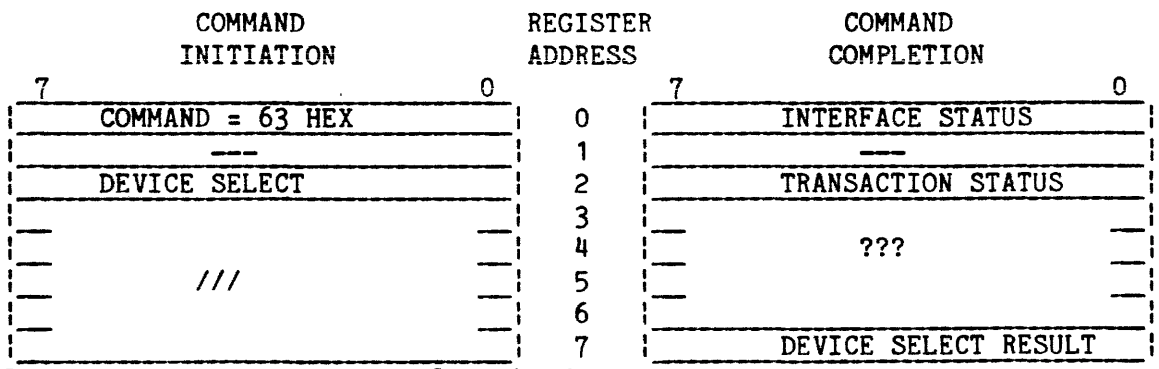
Prerequistie State: Neutral or write
Ending State: Write

FUNCTION

The Write File Mark command is used to install file marks on the tape. File marks are used to separate logical groups of data. Whenever a file mark is written, a short space immediately following it is erased.

The streamer tape drives perform retries automatically. Retries can not be disabled.

5.2.6 **Read File Mark**



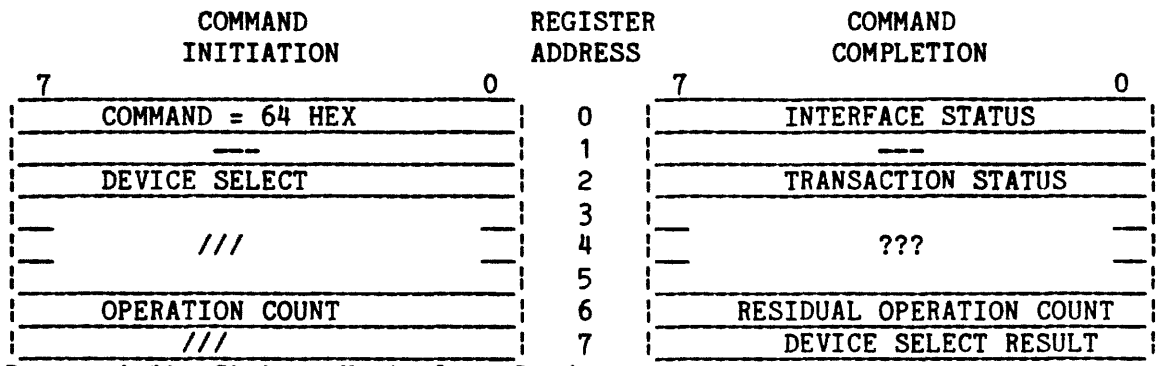
Prerequisite State: Neutral or Read
Ending State: Read

FUNCTION

The Read File Mark command advances the tape until a file mark is detected. At completion the tape will be positioned immediately after the file mark.

The streamer tape drives perform retries automatically. Retries can not be disabled.

5.2.7 **Verify Tape Data**



Prerequisite State: Neutral or Read
Ending State: Read

FUNCTION

The Verify Tape Data command is used to check that the specified tape records are readable. The tape is assumed to be positioned immediately in front of the records to be verified.

The OPERATION COUNT byte specifies the number of records to be verified. If OPERATION COUNT = 0 the verify operation proceeds until a file mark or EOT is found. If an error occurs, the operation is terminated and the RESIDUAL OPERATION COUNT byte indicates which record contains the error.

5.2.8 **Read Drive Status**

COMMAND INITIATION (7 … 0)	REGISTER ADDRESS	COMMAND COMPLETION (7 … 0)
COMMAND = 06 HEX	0	INTERFACE STATUS
---	1	---
DEVICE SELECT	2	TRANSACTION STATUS
	3	DRIVE STATUS
	4	QIC STATUS BYTE 0
///	5	QIC STATUS BYTE 1
	6	???
	7	DEVICE SELECT RESULT

Prerequisite State: Neutral
Ending State: No change

FUNCTION

The Read Drive Status command reads the two QIC status bytes from the tape drive, and returns them in Registers 4 and 5. The DS101 also compiles a summary tape drive status byte, which is returned in Register 3. Details of this byte are given in Figure 5-7.

FIGURE 5-7. STREAMER TAPE STATUS FORMAT

7	6	5	4	3	2	1	0
CRJ	WP	DF	BSY	???	BOT	CNP	RDY

CRJ — COMMAND REJECT
CRJ = 1 indicates that the tape drive received an undefined/illegal command. CRJ will remain set until the tape drive receives a defined legal command.

WR — WRITE PROTECT
WR = 1 indicates that the cartridge in the tape drive is write protected.

DF — DRIVE FAULT
DF = 1 indicates that a fault has occurred at the tape drive.

BSY — BUSY
BSY = 1 indicates that the tape drive is executing a command.

BOT — BEGINNING OF TAPE
BOT = 1 indicates that the tape is logically at BOT track 0. BOT is reset whenever the tape moves away from BOT.

CNP — CARTRIDGE NOT PRESENT
CNP = 1 whenever a cartridge is not fully inserted into the tape drive.

RDY — READY
RDY = 1 indicates that the tape drive is physically connected and receiving power.

5.3 Special Considerations

This section discusses some special considerations which must be taken into account when operating the DS101 with streamer tape.

5.3.1 End of Tape Warning

The End of Tape warning (transaction status 05 HEX) is reported in Register 2 during a Write Data operation, when the tape drive has detected the physical 'end of tape' warning point on the tape. This causes the tape drive to stop.
In response to this, the host should issue either a Write Data command or a Write File Mark command.

If a Write Data command is issued, the drive will accept a maximum of 1024 trailer bytes (two 512-byte blocks). If the file can not be completed within the 1024-byte trailer area, the host should use these bytes to reference another tape cartridge on which the file is continued.

If a Write Data command is issued in response to an End of Tape warning, it must be followed by a Write File Mark command after the trailer bytes have been written. This assures that the data bytes may be correctly recovered later, when the tape is read.

It is important to note that a Rewind command does not place a file mark on the tape. The Write File Mark command must be used, in order to avoid an error condition later, when the tape is read.

5.3.2 Completion of Copy Data Command

If a Winchester disc drive involved in a Copy Data operation has a sector size which is not an integral multiple of 512 bytes, the Copy Data command must be followed by a Rewind command. Any command other than Rewind will result in an error.

5.3.3 Writing Appendages to Existing Tape Data

To append data to a tape that already has some data on it, use the following procedure:

1. Use a Read File Mark or Advance File Marks command to get to the end of the already written data.
2. To be sure that the recording head is over an area that has no data recorded on it, issue a Read Data command. This should result in a transaction status of 14 02 HEX (transaction status 14 HEX, Auxiliary Trap, with supplemental status 02 HEX, No Recorded Data).
3. Issue a normal Write Data command. This will then record the data beginning immediately after the file mark.

6.0 SUMMARY/QUICK REFERENCE

TABLE 6-1. COMMAND SUMMARY (STREAMER TAPE)

COMMAND CODE (HEX)	COMMAND NAME
06	Read Drive Status
42	Write Data
43	Read Data
62	Write File Mark
63	Read File Mark
64	Verify Tape Data
6A	Rewind
6F	Erase
B0	Transfer Packet
C0	Advance File Marks
C1	Retension Tape

TABLE 6-2. COMPLETION CODE SUMMARY (AUX 1 ORIGINATED)
(See Table 5-1)

CODE (HEX)	DEFINITION
04	File Mark Detected
05	End of Tape
14	Auxiliary Trap (Supplemental Status)

TABLE 6-3. AUXILIARY TRAP SUPPLEMENTAL STATUS SUMMARY
(See Table 5-2)

CODE (HEX)	DEFINITION
00	Unrecoverable Data Error - Last Block
01	Unrecoverable Data Error - Block Unknown
02	No Recorded Data
03	Tape Deck Position Error
04	QIC Status Error
05	Drive Reset
06	Operation Aborted
07	Command Sequence Error
08	Tape Cartridge Not Present
09	Undefined Command