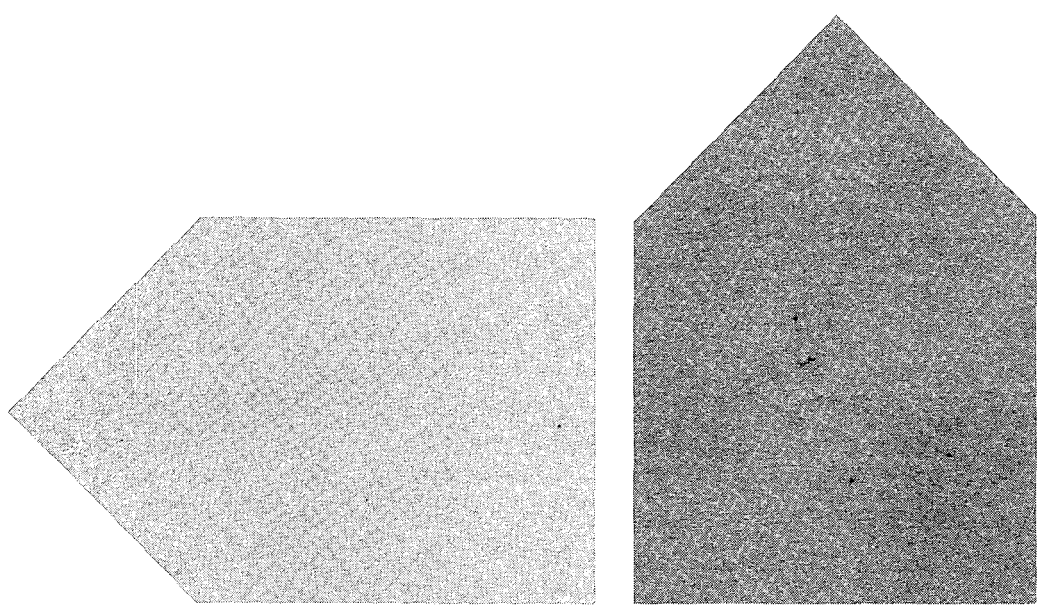

SYNCHRONOUS COMMUNICATION FEATURE REFERENCE MANUAL

BFC 5007

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INTRODUCTION

This manual describes the Synchronous Communication Feature, an optional enhancement to the BASIC/FOUR 400, 600 and 700 systems. The manual explains fundamental telecommunications concepts and terminology, as well as the facilities provided by the Synchronous Communication Feature which enable the user to write a communication application program. For effective use of the manual, the user should be familiar with the BASIC/FOUR operating systems.

GENERAL DESCRIPTION

The Synchronous Communication Feature (SCF) allows the BASIC/FOUR system to function as a component of a synchronous telecommunications network. The SCF is compatible in most respects with Binary Synchronous Communications, a procedure defined by IBM. The BASIC/FOUR system, therefore, can be programmed to communicate with either another BASIC/FOUR system or a foreign system which conforms to the rules defined in the Binary Synchronous Communications procedure.

The SCF provides a set of input/output directives which control the transmission and reception of data over communications lines. Data link control and message formatting functions are performed by the SCF; the user, therefore, can program the communication line much the same as other peripheral devices.

REFERENCES

For additional information on subjects discussed in this manual, the user is referred to the following publications:

- General Telecommunications Concepts

  Telecommunications and the Computer. James Martin. Prentice-Hall, Inc. Englewood Cliffs, N.J. 1969.

  The Communications Handbook. Microdata Corporation. Irvine, California. 1973.

  Data Communications Primer. IBM Corporation. 1973.

- Binary Synchronous Communications

  IBM SRL General Information — Binary Synchronous Communications. GA27-3004.

  IBM 2780 Data Transmission Terminal, Component Description. GA27-3005.

- Communications Hardware

  Bell System Data Communications Technical Reference Manuals

  Data Set 201A/B Interface Specification
  Data Set 201C Interface Specification
  Data Set 208B Interface Specification

- BASIC/FOUR Systems

  BASIC/FOUR Reference Manual for Business BASIC II. Basic/Four Corporation. 1975.

TELECOMMUNICATIONS CONCEPTS

This chapter describes fundamental aspects of data communication systems of the type supported by the SCF. It also defines some basic communication terminology used throughout this manual.

COMMUNICATION LINES

The communication line, used to carry data from one location to another, can be classified by several attributes, which are described in the following sections.

SWITCHED AND LEASED LINES

In a *switched* network, the data link is established by standard dialing procedures in the same way an ordinary telephone call is made.

A *leased* or *private* line permanently connects the stations in the communication network. Dialing procedures, therefore, are not required to establish the data link.

The SCF supports both line configurations.

POINT-TO-POINT AND MULTIPOINT DATA LINKS

A *point-to-point* network consists of only two stations. The point-to-point data link can be established through the switched network or on a leased line, in which case transmission is always between the same two stations.

A *multipoint* line connects two or more stations. In multipoint operation, one station in the network is designated the control station, which directs all transmissions in the network. The remaining stations are designated as tributaries. A multipoint data link is usually established over a leased line.

The SCF supports both station configurations.

HALF DUPLEX AND FULL DUPLEX

Half duplex lines can transmit data in either direction, but only in one direction at a time. *Full duplex* lines can transmit data in both directions at the same time.

Regardless of the capability of the line, the SCF always operates in half duplex mode, i.e., transmissions are in only one direction at a time.

LINE RESERVATION

Two fundamental procedures are used to establish contact between stations in a communication network after the line connection has been made.

In a point-to-point network, both stations may simultaneously attempt to transmit data; this type of system is called a *contention system*. The SCF supports a line control procedure which allows contention conflicts to be resolved according to a priority level defined in the system configuration for each station in the network.

After one station in a point-to-point network has gained control of the line (that is, has *reserved* the line) by means of a procedure called *bidding*, the other station is prohibited from sending data until the transmitter releases control of the line by transmitting end-of-transmission.

When communicating over the switched network, the SCF provides optional station *identification verification* to prevent an unauthorized station from establishing contact with the other station in the network. In this procedure, sometimes called IAM/WRU, message transmission can occur only if the station identification sequence issued by the transmitter matches the sequence expected by the receiver.

In multipoint operation, all data transmission is directed by the control station. Each tributary station in the network is assigned a unique identifier, which when sent by the control station, causes the tributary station to respond either by sending a message in response to a *poll sequence* or receiving data in response to a *selection or address* sequence. In this network configuration (sometimes called *centralized multipoint* operation), all communication takes place between the control and tributary stations; no direct contact can be made between two tributary stations in the network. After contact has been established between the control station and a tributary, the communication line is reserved until the control station receives or transmits end-of-transmission.

TRANSMISSION MODES

The two primary modes of transmission are asynchronous and synchronous. These modes differ in the way the data appear on the communication line.

In *asynchronous* or start-stop transmission, each character is synchronized by means of a start bit preceding the data bits and a stop bit following them.

In *synchronous* transmission, there are no start-stop bits with which to synchronize each character. Instead, the entire data block is synchronized with a unique code which, when recognized by the receiver, causes the station to count the incoming bits and assemble a character. Synchronous transmission permits more data to be passed over the line in a given time, since no transmission time is required for the insertion of the start-stop bits.

Binary Synchronous Communications, described in detail in the following chapter, is a set of rules defined by IBM for the synchronous transmission of data. The SCF conforms in most respects to these rules.

The SCF supports only the synchronous transmission technique. Asynchronous support is a standard feature of the BASIC/FOUR operating system.

BINARY SYNCHRONOUS COMMUNICATIONS

The Binary Synchronous Communications (BSC) procedure is a set of rules defined by IBM to govern the synchronous transmission of data. This chapter describes the features of BSC which are supported by the SCF.

TRANSMISSION CODES

The SCF supports either the ASCII or EBCDIC code set, depending upon a parameter specified in the system configuration. ASCII, used internally by the BASIC/FOUR system, is the standard code set of the SCF. EBCDIC support, if required, uses additional memory to accommodate the code conversion logic.

Either of these code sets can be used with the transparent mode, in which all possible bit configurations are treated as data. This mode of operation is described in the section Transparent Text Mode.

DATA LINK CONTROL

The special control characters and sequences described in this section are used to maintain control of the data link.

SYN: Synchronous Idle

The SYN character is used to establish and maintain station synchronization. A minimum of two SYN characters must precede each message to insure that the receiving station is in step with the transmitter. A sync-idle sequence SYN SYN (or DLE SYN for transparent data) is also inserted in the data at one second intervals to maintain synchronization during transmission of the entire message.

SOH: Start Of Header

The SOH character identifies the following data as a message header, which normally consists of information required by the system to process the text of the message.

STX: Start of Text

The STX character precedes the text of the message. STX also terminates the header.

ETB: End of Transmission Block

The ETB character defines the end of a block of characters started with SOH or STX. The transmitter, after sending a block terminated by ETB, must await a response from the receiving station.

ITB: End of Intermediate Transmission Block

The ITB character is used to divide a message for error checking purposes but does not require a response from the receiving station. The receiving station responds to the entire transmission after the last intermediate block, terminated by ETB or ETX, is received.

The SCF can receive and process the ITB character (IUS in the EBCDIC code or US in the ASCII code) but cannot transmit an ITB.

ETX: End of Text

The ETX character is used to terminate a block of characters started with STX. The transmitter, after sending a block terminated by ETX, must await a response from the receiving station. The ETX defines the end of a message; ETB defines the end of a block within a message.

EOT: End Of Transmission

This character is used for three purposes:

- to indicate the end of message transmission.
- to respond to a poll when the station has nothing to transmit (multi-point).
- to signal an abort condition.

The EOT character cancels the reservation status of the line.

ENQ: Enquiry

This character is used for three purposes:

- to obtain retransmission of a response to a message block if the response was unrecognized.
- to bid for the line (point-to-point).
- to indicate the end of a poll or select sequence (multipoint).

ACK O/ACK 1: Affirmative Acknowledgement

These control sequences are transmitted in alternating sequence to indicate that the previous message block was received without error. ACK O is also the positive response to a line bid (point-to-point) or station selection (multipoint).

WACK: Wait-Before-Transmit Positive Acknowledgement

WACK, a positive acknowledgement to data, indicates that the transmitter is temporarily not prepared to receive data.

The SCF can receive but not transmit the WACK control sequence.

NAK: Negative Acknowledgement

The NAK character is used for three purposes:

- to indicate that the previous block was received in error and that the receiver is ready to accept retransmission of the block.
- to indicate that the station is not prepared to receive data in response to a line bid (point-to-point).
- to indicate that the station is not prepared to receive data in response to a select sequence (multipoint).

DLE: Data Link Escape

The DLE control character is used to provide supplementary line control characters and transparent mode control characters.

RVI: Reverse Interrupt

The RVI control sequence can be used in place of the ACK 0 or ACK 1 response to data to request termination of transmission by the sending station. The station which transmits the RVI sequence cannot assume that the transmitter will immediately release control of the line.

TTD: Temporary Text Delay

This control sequence is transmitted by the sending station when it is temporarily not prepared to transmit data.

DLE EOT: Switched Line Disconnect

The DLE EOT sequence, normally transmitted when all data transmission is complete, causes the switched line to be disconnected. Further attempts to access the communication line require a telephone call.

ERROR CHECKING

Due to the error-prone nature of communications equipment, each block of data transmitted must be checked by the receiving station using one of several techniques, depending upon the code set and transmission mode. After each transmission, the receiving station normally responds with ACK O or ACK 1 to indicate that the data was accepted, or NAK to indicate that a transmission error was detected.

Two error checking methods are used by the SCF.

VRC/LRC

This error checking method is used when communicating with the ASCII code set, except when the data are in transparent mode. VRC (vertical redundancy checking) is an odd parity check performed on each character in the transmission, including the LRC character.

The LRC (longitudinal redundancy check) is a check on the total data bits in the message block. The LRC character is accumulated by both the sending and receiving stations during transmission of each block and is transmitted after ITB, ETB, or ETX.

The received message is positively acknowledged only if the LRC accumulated by the receiver matches the LRC transmitted with the block and if each character in the transmission has the correct parity.

CRC-16

The CRC (cyclic redundancy check) is used when communicating either in the EBCDIC code or in transparent mode. The CRC, which consists of two bytes treated as a single sequence, is accumulated by both the sending and receiving stations during transmission of each block and is transmitted after ITB, ETB, or ETX.

The received message is positively acknowledged only if the CRC accumulated by the receiver matches the CRC transmitted with the block.

The LRC and CRC characters are referred to as the block-check character (BCC).

To insure that the first and last characters of a transmission are sent by the data set, the SCF, in conformance with BSC requirements, adds a pad character before and after each transmission. The leading pad character may consist of alternating 0 and 1 bits or may be a SYN character. The trailing pad consists of all 1 bits (hexadecimal 'FF').

MESSAGE FORMATS

In order to achieve successful communication between stations in a network, each message must contain the proper line and error control characters. Because the SCF removes control characters from incoming messages and inserts them in outgoing messages, the SCF programmer need not be directly concerned with the message formats. Knowledge of these formats can be useful, however, if an otherwise unexplained communication problem arises.

TEXT

The text, which is the most significant portion of the message, is transmitted in complete units initiated by STX and terminated by ETX. For error checking purposes, the message can be divided into smaller blocks, each started with STX and terminated by ETB (except the final block which is terminated by ETX). The block-check character (BCC) accumulation includes all characters after STX including ETB or ETX.

Control characters cannot be included in the text. A message containing an embedded control character or sequence will probably be negatively acknowledged.

The format of text blocks is shown in Figure 1.

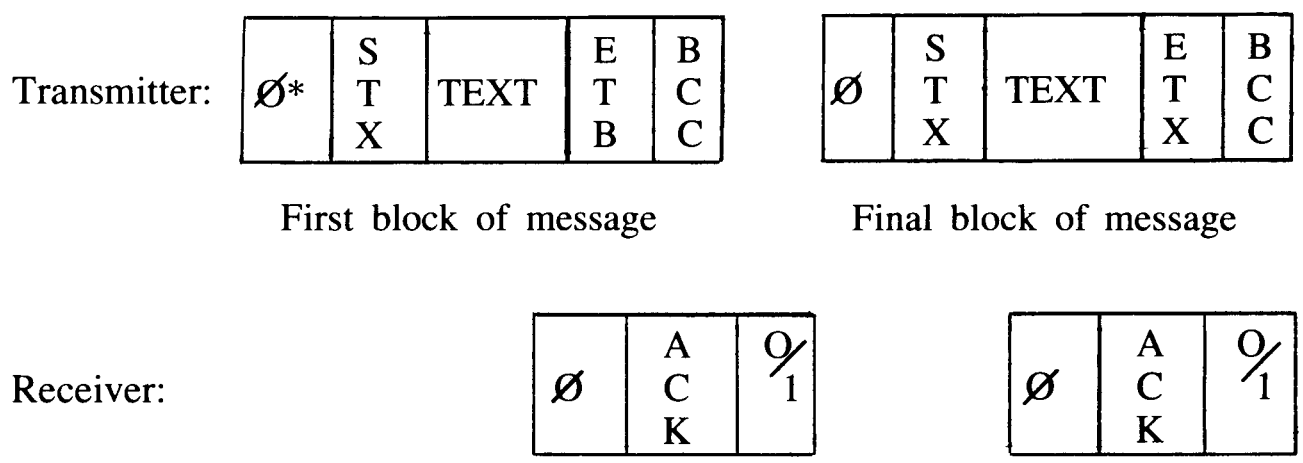

Figure 1. Format of Text Blocks

HEADER

The header, typically used for message control purposes, is a block of data initiated by SOH and terminated by STX, if text is included in the transmission, or ETB if block checking is required for the header alone. The BCC accumulation includes all characters after SOH.

The use of headers is optional; the processing headers, if present, is dependent on the requirements of the application.

Examples of header formats are shown in Figures 2 and 3.

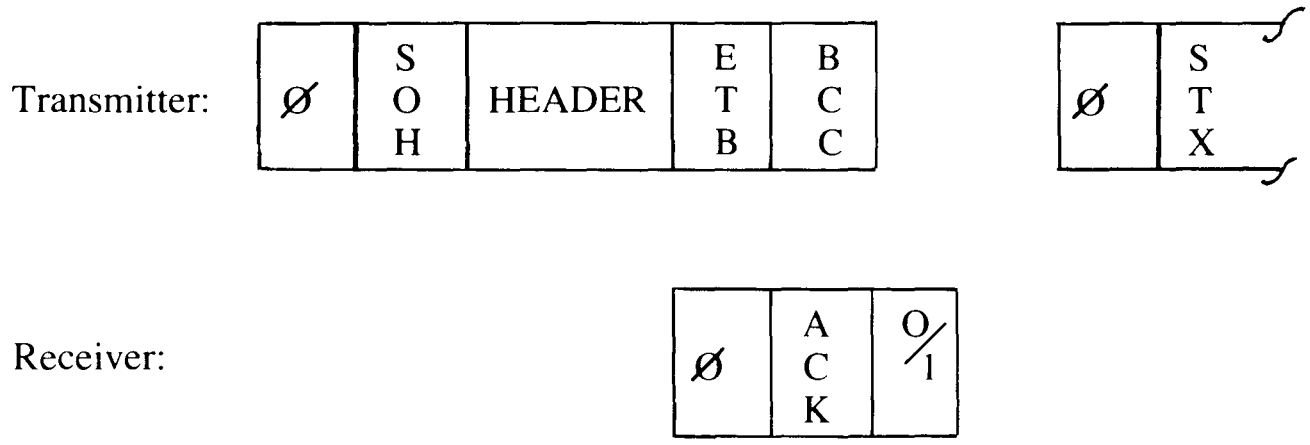

Figure 2. Header Terminated by ETB for Error Checking Purposes

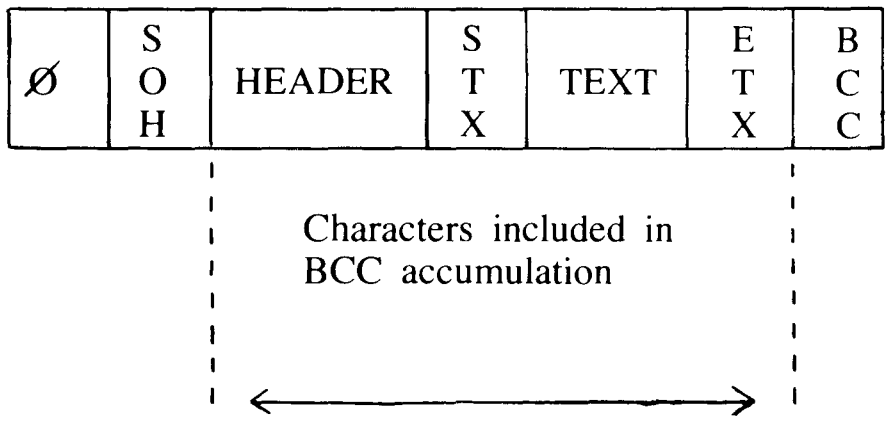

Figure 3. Block-Check Character Accumulation for Entire Transmission

POINT—TO—POINT OPERATION

The format for the line bid which must be issued by the station attempting to acquire use of the line is shown in Figure 4. The station receiving the bid sequence must respond with ACK O.

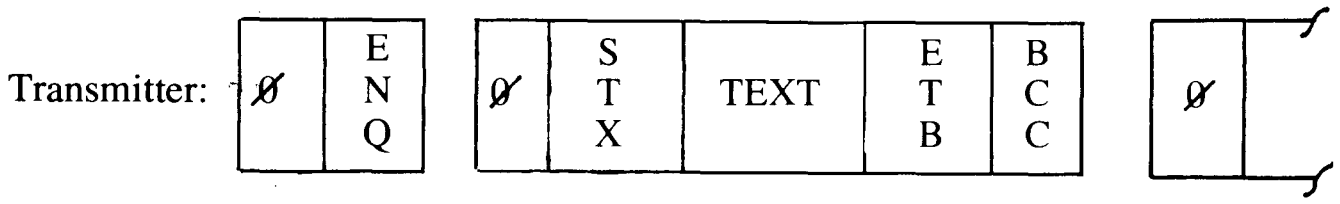

Figure 4. Line Bid Processing (Point-to-Point Operation)

CENTRALIZED MULTIPOINT OPERATION

In multipoint operation, the control station directs all data transmission by transmitting polling or selection sequences as shown in Figure 5. When polled, a tributary station must respond with either:

- the message to be sent to the control station.
- an EOT when the station has no data to send.

When selected, the tributary station must respond with ACK O if prepared to receive data.

Ø	EOT	PAD	Ø	POLL OR SELECT ADDRESS	ENQ

Figure 5. Poll/Select Sequence

TRANSPARENT-TEXT MODE

The transparent-text mode is provided to allow unrestricted coding of transmission data. In this mode, all data, including the line control characters, are treated only as specific bit patterns. Control characters can be embedded in the message text, therefore, without having control meaning. This mode of operation is typically used for transmitting packed decimal data, binary data, and specialized codes.

As when transmitting in normal mode, the SCF inserts the required line control functions in the outgoing message and strips them from the incoming message. To be recognized as control functions, the line control characters are preceded by DLE. The following sequences are used for line control when operating in transparent mode.

Control Sequence	*Function*
DLE STX	Initiates transparent mode for following text.
DLE ETB	Terminates a block of transparent text.
DLE ETX	Terminates a transparent message.
DLE SYN	Inserted as time fill in one second intervals in transparent text.
DLE ENQ	Indicates that the block of transparent text is to be disregarded.
DLE DLE	Permits transmission of DLE as data. One DLE is disregarded; the other is treated as data.
DLE ITB	Terminates an intermediate block of transparent text. This sequence can be processed but not transmitted by the SCF.

Regardless of the code set used, the SCF always uses the CRC-16 for error checking transparent data. The vertical parity check is suppressed when communicating with ASCII, making all eight bits available for data.

The SCF performs no data translation of transparent text even if EBCDIC is specified in the system configuration. *Data translation, if required, must be performed in the application program.*

TIMEOUTS

Four different timeout functions, which are used to prevent indefinite tieup of the communication link, are defined by BSC.

TRANSMIT TIMEOUT

This is a nominal one-second timeout that establishes the rate at which sync-idle sequences (SYN SYN for non-transparent data or DLE SYN for transparent data) are inserted in the transmitted data stream. The insertion of the sync-idle sequences is performed automatically by the SCF.

RECEIVE TIMEOUT

This is a nominal three-second timeout used to limit the time a station will wait for a reply to the previous transmission.

DISCONNECT TIMEOUT

This is a nominal twenty-second timeout used to prevent a station in a switched network configuration from holding the connection for prolonged periods of inactivity. When a disconnect timeout occurs, the SCF initiates error recovery procedures.

CONTINUE TIMEOUT

This is a nominal two-second timeout associated with the transmission of TTD (temporary text delay) or WACK (wait before transmit). The SCF does not support this timeout.

INPUT/OUTPUT OPERATIONS

Input/Output operations on the data link are performed by a set of directives with syntax similar to directives used to access local peripheral devices. A set of mnemonics is also provided to alter or bypass the default operation of the SCF.

OPENING AND CLOSING THE LINE

Before any data transmission can occur, the communication line must be activated by means of an OPEN directive. After all transmission has been completed, the line can be deactivated by means of A CLOSE directive.

OPEN Directive

```
OPEN (n {,ERR=errstno}) device name
```

n
Specifies the device number (1-7) used in subsequent I/O operations which access the communication line.

errstno
Specifies the number of statement to be executed if an error occurs during execution of OPEN.

device name
Specifies the string constant "SY" or name of variable containing "SY".

When the OPEN is executed, the Data Terminal Ready circuit in the modem is turned on. After connection to the line is established and the modem handshaking sequence is completed, the modem responds by turning on Data Set Ready. If the line connection is not made within approximately ten seconds, an error 0 occurs.

Programming Notes

1. In order for an incoming call over the switched telephone network to be acknowledged, the application program must be executing an OPEN. Use of the ERR= operand can provide an unattended mode of operation in which the program on the unattended station executes an OPEN loop until the remote station calls, as shown in the following example.

```
10  PRINT "ESTABLISH LINE"
20  OPEN (1,ERR=10)"SY"
30  PRINT "LINE ESTABLISHED"
```

2. Since the line connection is permanent in a leased line configuration, no telephone call is required to activate Data Set Ready in the modem. An error occurring on the OPEN, therefore, indicates possible hardware malfunction.

CLOSE Directive

```
CLOSE (n{ ,ERR=errstno})
```

n
Specifies the device number used in corresponding OPEN statement.

errstno
Specifies the number of the statement to be executed if an error occurs during execution of CLOSE.

Execution of the CLOSE directive terminates the availability of the communication line.

Programming Note

1. In a switched network configuration, the CLOSE transmits the disconnect sequence DLE EOT to the remote terminal and terminates the telephone connection. Use of END or STOP also performs a CLOSE. A telephone call is required, therefore, to re-establish the line connection.

LINE CONTROL FUNCTIONS

ID VERIFICATION (POINT-TO-POINT LINE)

IL Mnemonic: Define Local ID

```
WRITE (n) 'IL',local station ID
```

n
Spcifies the device number used in the corresponding OPEN.

local station ID
Spcifies a 2-15 character string which identifies the local station.

This WRITE, which transmits no data over the line, defines the identification of the local station to SCF. The station ID is transmitted as part of all line bids by the local station for possible verification by the remote station.

IR Mnemonic: Define Remote ID

```
WRITE (n)'IR',remote station ID
```

n
Specifies the device number used in the corresponding OPEN.

remote station ID
Specifies a 2-15 character string which identifies the remote station.

This WRITE, which transmits no data over the line, defines the identification of the remote station to SCF. Line bids issued by the remote station which do not contain this identification sequence will be rejected by the local station.

Programming Notes

1. The use of identification sequence verification is optional.

2. The exchange of identification sequences is performed primarily in switched point-to-point operation to allow several different stations to use the same switched line.

3. The identification sequence defined by the mnemonic remains in effect until either the execution of a CLOSE or of another output with the same mnemonic which specifies binary zeroes as an ID.

POLLING/SELECTION (MULTIPOINT LINE)

MP Mnemonic: Define Control Station Poll Sequence

```
WRITE (n)'MP',polling sequence
```

n
Specifies the device number used in the corresponding OPEN statement.

polling sequence
Specifies a 1-7 character string establishing the station as a control station which generates the polling sequence defined by the string.

MS Mnemonic: Define Control Station Select Sequence

```
WRITE (n)'MS',select sequence
```

n
Specifies the device number used in the corresponding OPEN statement.

select sequence
Specifies a 1-7 character string establishing the station as a control station which generates the select sequence defined by the string.

These WRITE directives, which transmit no data over the line, establish the local station as the control station in a multipoint network. This station directs incoming traffic by polling each tributary station in the network and regulates outgoing traffic from the control station by selecting the desired tributary station to receive the message.

Programming Notes

1. The polling and selection sequences must be established prior to each attempt by the control station to reserve the line, i.e., prior to the first attempt to transmit or receive data after:
   - an OPEN has been issued.
   - an EOT has been transmitted by the control station.
   - an EOT has been received by the control station.
2. The polling and selection sequences cannot be changed on a control station if the line is reserved, i.e., before an EOT is transmitted or received by the control station.

TP Mnemonic: Define Tributary Station Poll Sequence

```
WRITE (n)'TP',polling sequence
```

n
Specifies the device number used in the corresponding OPEN statement.

polling sequence
Specifies a 1-7 character string establishing the station as a tributary station which transmits data to the control station upon recognition of the polling sequence defined by the string.

TS Mnemonic: Define Tributary Station Select Sequence

```
WRITE (n)'TS',select sequence
```

n
Specifies the device number used in the corresponding OPEN statement.

select sequence
Specifies a 1-7 character string establishing the station as a tributary station in a multipoint network which receives data from the control station upon recognition of the select sequence defined by the string.

These WRITE directives, which transmit no data over the line, establish the local station as a tributary station in a multipoint network. All transmission by the station is dependent upon recognition of poll or select sequences received from the control station.

Programming Notes

1. The poll or select sequences should be defined immediately after the line is OPENed.

2. The poll and select sequences remain in effect until the line is closed.

MONITOR LINE

```
READ (n) numeric variable
```

n
Specifies the device number used in the corresponding OPEN statement.

numeric variable
Specifies the name of the numeric variable which, upon completion of the read, contains one of the following values.

- numeric variable=1 if this station has been *polled* by the control station.
- numeric variable=2 if this station has been *selected* by the control station.
- numeric variable=3 if this station has not been polled or selected within the timeout value defined in the system configuration.

This special READ directive, provided for use by the tributary station in a multipoint network, monitors the line for poll or select sequences issued by the control station and returns a numeric value to the application program so that appropriate action can be taken.

Programming Notes

1. If *polled*, the station must either transmit:

   - EOT when the station has nothing to send.
   - all data to be sent, followed by EOT.

2. If *selected*, the station must perform an input operation to receive all data from the control station until EOT is detected.

3. If a timeout occurs, the program can either re-issue the line monitor directive or terminate.

4. Use of the ESCape key on the VDT will *not* be acknowledged until the line monitor read is completed, either as the result of a timeout or recognition of the expected poll or select sequences.

Programming Example

```
10      REM ''TRIBUTARY STATION''
20      OPEN(1)''SY''
30      REM ''ESTABLISH POLL/SELECT SEQUENCES''
40      WRITE(1) 'TP',''POLL''
50      WRITE(1)'TS',''SELECT''
60      REM ''MONITOR LINE''
70      READ(1)X
80      ON X-1 GOTO 90, 180, 240
90      REM ''STATION HAS BEEN POLLLED . . . TRANSMIT''
          .
          . Message transmission routine
          .
150     REM ''SEND EOT WHEN FINISHED TRANSMITTING''
160     WRITE(1)'TT'
170     GOTO 60
180     REM ''STATION HAS BEEN SELECTED . . . RECEIVE''
          .
          .  Message receive routine
          .
```

```
220     REM "WHEN EOT RECEIVED, TRANSMISSION FROM
          CONTROL STATION COMPLETE"
230     GOTO 60
240     REM "THIS STATION HAS NOT BEEN POLLED OR SE-
          LECTED IN N MINUTES"
250     GOTO 60
```

TRANSMISSION TERMINATION

TT Mnemonic: Transmit End of Transmission

```
WRITE (n)'TT'⟨,data variables⟩
```

n

Specifies the device number used in the corresponding OPEN statement.

This mnemonic transmits the end of transmission sequence to the remote station, indicating that no more data will be transmitted by the local station at this time. The TT mnemonic dereserves the line, but does not terminate the connection. If the WRITE specifies data variables, the line is released following the receipt of a positive acknowledgement of the message.

Programming Note

1. The TT mnemonic can be used with any output directive, as described in the section titled Message Transmission.

DA Mnemonic: Destination Abort

```
READ(n)'DA',data variable name
```

n

Specifies the device number used in the corresponding OPEN statement.

This mnemonic, typically used to indicate an exceptional condition at the local station, transmits an EOT in response to the last message received from the remote station. The line is dereserved following successful completion of this operation.

Programming Note

1. The EOT response is transmitted to the remote station only if at least one data variable appears in the instruction. The variable, however, is not satisfied.

RI Mnemonic: Transmit Reverse Interrupt

```
READ(n)'RI',data variable names
```

n

Specifies the device number used in the corresponding OPEN statement.

A Reverse Interrupt is transmitted by a receiving station to request termination of transmission from the sending station because of a high priority message the receiving station wants to transmit.

Programming Notes

1. The receiving station cannot assume that the sending station will immediately relinquish control of the line and, therefore, must continue to receive data until an EOT is detected.

2. The RI mnemonic can be used with any input directive as described in the section titled Message Transmission.

MESSAGE TRANSMISSION

All message transmission is accomplished by read and write operations of various types.

READ OPERATIONS

```
READ (n ⟨,ERR=errstno⟩ ⟨,END=endstno⟩⟨,TBL=tblstno⟩⟨,SIZ=size⟩)
    expression list

READRECORD (n ⟨,ERR=errstno⟩ ⟨,END=endstno⟩ ⟨,TBL=tblstno⟩⟨,SIZ=size⟩)
    expression list

INPUT (n ⟨,ERR=errstno⟩⟨,END=endstno⟩ ⟨,TBL=tblstno⟩ ⟨,SIZ=size⟩)
    expression list
```

n
Specifies the device number used in the corresponding OPEN statement.

errstno
Specifies the number of the statement to be executed if an error occurs during execution of read operation.

endstno
Specifies number of the statement to be executed if end-of-transmission sequence is received.

tblstno
Specifies the number of the TABLE statement through which input data are translated. The translation occurs before the check for field terminators, but after the configured code set translation.

size
Specifies an integer value which defines the size of the input buffer. Use of this option can reduce the amount of time required for data transfer if the configured buffer size greatly exceeds the message size. Truncation will occur, however, if the length of the incoming message exceeds the size value.

expression list
Specifies a list containing mnemonics and/or variable names or a reference to an IOLIST statement. At least one variable name must be specified.

Although the three input directives perform the same functions, the READRECORD directive differs from READ and INPUT in two important respects.

- The expression list used with READRECORD is limited to mnemonics and/or *one* variable name, which receives all input data, including field terminators.

- A field terminator is not required at the end of the incoming data when READRECORD is used.

The READ and INPUT directives recognize the following field terminators.

IDENTIFIER	*HEXADECIMAL CODE*	*CTL VALUE*
LF	8A	0
CR	8D	0
FS	9C	1
GS	9D	2
RS	9E	3
US	9F	4
NUL	00	0

The first read operation issued after an OPEN or line dereservation performs several functions, depending upon the network configuration and station designation.

- Point-to-Point: The SCF monitors the line for a bid sent by the remote station, writes a positive response, and reads the message that follows.

- Multipoint control station: The SCF transmits the polling sequence previously defined by the 'MP' mnemonic, and reads the response (either an EOT if the polled station has nothing to send, or a message block).

- Multipoint tributary station: The SCF, having detected the select sequence for the station in a line monitor READ, writes a positive response to the select sequence and reads the message that follows.

In each subsequent read operation, the SCF performs the following functions.

- Responds to the previous message received from the remote station.

- Reads the message that follows.

- Determines whether data are normal or transparent.

- Computes block check character and compares it with the block check character received with the message.

- Strips communication control characters from message.
- Translates non-transparent EBCDIC data to ASCII if required.
- Sets high order parity bit on non-transparent ASCII data if required.

Programming Notes

1. Transparent data are transferred to the application program intact, i.e., no translation or parity bit setting is performed, regardless of the code set specified in the system configuration. Translation, if required, must be performed by the application program by means of a TABLE.
2. When communicating with a foreign system, it is highly recommended that READRECORD be used to eliminate the requirement for a field terminator at the end of the message.
3. ITB characters contained in the message are treated as field terminators.
4. When receiving transparent data, it is recommended that READ-RECORD be used.

```
MERGE (n {,ERR=errstno})
```

n
Specifies the device number used in corresponding OPEN statement.

errstno
Specifies number of the statement to be executed if an error occurs during execution of MERGE.

This directive is used to input a program from a remote BASIC/FOUR system which has executed LIST to the synchronous line.

WRITE OPERATIONS

```
WRITE (n {,ERR=errstno}{,END=endstno}{,TBL=tblstno})
    expression list

WRITERECORD (n {,ERR=errstno}{,END=endstno}{,TBL=tblstno})
    expression list

PRINT (n{,ERR=errstno}{,END=endstno}{,TBL=tblstno}) expression list
```

n
Specifies the device number used in the corresponding OPEN statement.

errstno
Specifies the number of the statement to be executed if an error occurs during execution of write operation.

endstno
Specifies the number of the statement to be executed if an EOT is received in response to data.

tblstno
Specifies the number of the TABLE statement through which all output data are translated. The translation occurs before the configured code set translation.

expression list
Specifies a list containing mnemonics, constants, and/or variable names or a reference to an IOLIST statement.

The three output directives differ only with respect to the generation of field terminators.

- Each data variable or constant specified in a WRITE statement is provided with a field terminator (LF).
- The WRITERECORD directive supplies no field terminators.
- The PRINT directive supplies only one terminator at the end of a string of data, which can be suppressed by terminating the statement with a comma.

The first write operation issued after an OPEN or line dereservation performs several functions, depending upon the network configuration and station designation.

- Point-to-point: The SCF writes a bid to gain control of the line, and if the bid is positively acknowledged, writes the message block and reads the response.
- Multipoint control station: The SCF transmits the select sequence previously defined by the 'MS' mnemonic and, if the response is positive, writes the message block and reads the response.
- Multipoint tributary station: The SCF, having detected the poll sequence for the station in an initial read, transmits either an EOT if there is no message to transmit or the message block. If a message block is sent, SCF reads the response.

In each subsequent write operation, the SCF performs the following functions.

- Inserts required data link and message control characters.
- Computes block check character and appends it to the message.
- Translates non-transparent ASCII data to EBCDIC if required.
- Generates odd parity for non-transparent ASCII data if required.
- Transmits the message.
- Reads the response and retransmits the message a maximum of six times if the response is NAK.

Programming Notes

1. When communicating with a foreign system, it is highly recommended that WRITERECORD be used.
2. When transmitting transparent data, it is recommended that WRITE-RECORD be used.
3. Translation of transparent data, if required, must be performed by the application program.

```
LIST (n {,ERR=errstno} )
```

n
Specifies the device number used in the corresponding OPEN statement.

errstno
Specifies the number of the statement to be executed if an error occurs during execution of LIST.

The LIST directive is used to transmit a program to a remote BASIC/FOUR system which is executing a MERGE.

Programming Note

1. Because no response is generated for the final statement received by the remote station, an error will always occur at the termination of LIST. The receiving station, therefore, should verify that all statements were received.

MESSAGE FORMAT CONTROL

HD Mnemonic: Generate Header Field

This mnemonic, used with an output directive, flags the first or only data expression specified in the output operation as a header field. For example, WRITE(1)'HD',''HEADER'',''TEXT'' will generate the following message:

SOH H E A D E R STX T E X T ETB BCC

Programming Notes

1. The use of headers is dependent on the requirements of the application.
2. The HD mnemonic, if used, must appear first in the expression list.
3. The header is always transmitted in non-transparent mode.

FR Mnemonic: Generate ETX

This mnemonic, used with an output directive, is used to signify the final transmission in a logical collection of messages by terminating the data specified in the output operation with ETX rather than ETB.

Programming Notes

1. The use of ETX is dependent on the requirements of the application.
2. The use of ETX does not affect line reservation.
3. The FR mnemonic must precede the data variables and/or constants in the expression list.

TR Mnemonic: Transparent-Text Mode

If used with an output directive, this mnemonic causes the data specified in the expression list to be transmitted in transparent mode, as defined in the section Transparent Text Mode.

The TR mnemonic may optionally be used with an input directive. If TR is specified, the incoming message *must* be in transparent mode to be positively acknowledged. If TR is not included with the input directive, both transmission modes are acceptable to SCF.

Programming Notes

1. If TR is used with FR, the TR mnemonic must appear first.
2. If TR is used with HD, the header field is transmitted in non-transparent mode.

3. Code translation, if required, must be performed by the application program.

4. Odd parity generation, if required, must be performed by the application program. The binary function GAP can be used to generate the parity.

NON-BSC OPERATION

The mnemonic UF has been provided to permit the application program to bypass all operations performed by the SCF except the actual transmission and receipt of data.

If UF is used with an input directive, all data on the line, including link and message control characters, are transferred to the application program. Error checking, code translation, and response transmission are suppressed.

If UF is used with an output directive, the exact character sequence specified in the expression list is transmitted. The application program, therefore, must supply the link and message control characters required by the remote system, as well as process the forthcoming message response.

The unformatted mode of operation (not to be confused with transparent text mode) is primarily used for testing purposes. If, for example, a message received from a remote terminal is consistently NAK'd, a program such as the one shown below can be used to receive the entire transmission which can then be examined off-line.

```
 10  REM''RECEIVE IN UNFORMATTED MODE''
 20  BEGIN
 30  LET A$='',R9$=$7061$,D=0
 40  OPEN(1)''SY''
 50  GOSUB 110
 60  REM''READ THE MESSAGE, AND QUICKLY TRANSMIT
       THE RESPONSE''
 70  READRECORD(1)'UF',T$
 80  WRITERECORD(1)'UF',R$
 90  A$=A$+T$+''LEN=''+STR(LEN(T$):''0000'')
100  GOTO50
110  REM''GENERATE A POSITIVE RESPONSE IN R$''
120  LET P=1
130  IF FPT(D/2) <> OP=2
140  REM''RESPONSE=SYN SYN DLE 0/1 PAD PAD''
150  LET R$=$3232$+$10$+R9$(P,1)+$FFFF$,D=D+1
160  RETURN
```

ERROR PROCESSING

The SCF provides error recovery procedures that diagnose certain error conditions which occur during data transmission and attempt to recover from these conditions so that communication can continue. The error recovery procedures attempt to clear temporary error conditions by retrying the operation six times before reporting the error conditions to the application program. Unrecoverable errors or exception conditions are reported to the application after only one attempt. All errors and exceptions are available for programmed control through use of the ERR= option.

! ERROR 0 DEVICE TIMEOUT

Explanation

OPEN:

The telephone connection was not made within approximately ten seconds of execution of the OPEN. The instruction should be re-issued until the connection is established (switched line only).

CLOSE:

The modem did not respond to the command which turns off Data Terminal Ready, possibly as the result of the previous termination of the telephone connection.

OUTPUT OPERATION:

1. A timeout occurred while waiting for carrier to drop prior to transmission. This error will not occur if the ''bypass carrier check'' option was specified in the system configuration.

2. A timeout occurred while waiting for carrier detect to drop.

3. A timeout occurred while waiting for Clear-to-Send to drop after transmission.

Action

The occurrence of this error, except on the OPEN of a switched line, can indicate a possible hardware malfunction.

! ERROR 1 RECORD SIZE EXCEEDED

Explanation

READ/INPUT:

The number of data variables specified in the statement exceeds the number of field teminators found in the message block.

OUTPUT OPERATION:

The length of the message to be transmitted exceeds the configured buffer size.

Action

This is a probable programming error.

! ERROR 2 END OF TRANSMISSION RECEIVED

Explanation

INPUT OPERATIONS:

An EOT was received from the remote station. Data variables are not satisfied. Receipt of EOT dereserves the line. This exception condition can automatically be processed through use of the END= option in the input statement.

OUTPUT OPERATION:

An EOT was received from the remote station in response to data, indicating that the data was received but not positively acknowledged, and that the remote terminal will accept no more transmission.

Action

The processing of this error is dependent on the requirements of the application.

! ERROR 5 DEVICE ERROR

Explanation

INPUT OR OUTPUT OPERATIONS:

The Data Set Ready circuit in the modem has been disabled, possibly as the result of the remote station terminating the connection.

Action

If a switched line disconnect has occurred, the telephone connection should be re-established. Other occurrences of this error indicate a possible hardware malfunction.

! ERROR 13 ACCESS ERROR

Explanation

INPUT OR OUTPUT OPERATIONS:

An output operation has been attempted on a line reserved for input or vice versa. Reservation status of the line is cleared when EOT is sent or received. Note: Pseudo output operations, such as poll/select sequence definition, do not affect the reservation status of the line.

Action

This is a programming error.

! ERROR 72 ETX RECEIVED

Explanation

INPUT OPERATIONS:

The previous block received was terminated by ETX, which is sometimes used as an end-of-file indicator.

Action

The processing of this exception indicator is dependent on the requirements of the application. In most cases, the program should continue to execute the input operation.

! ERROR 75 NEGATIVE BID RESPONSE

Explanation

OUTPUT OPERATIONS:

The response to the line bid was NAK.

Action

The NAK response to the line bid indicates that the remote station is not prepared to receive data. The processing of this error is application dependent.

! ERROR 77 REVERSE INTERRUPT RECEIVED

Explanation

OUTPUT OPERATIONS:

The receiving station responded with a reverse interrupt (RVI) to the current record. The data variables are satisfied.

Action

A reverse interrupt is transmitted by a receiving station to request termination of transmission from the sending station, usually because of a high priority message the receiving station wants to transmit. The sending station should transmit EOT and prepare to receive the incoming message.

! ERROR 80 INVALID BID RECEIVED

Explanation

INPUT OPERATIONS:

1. A line bid was expected, but the data received by the local station did not contain a recognizable bid sequence (point-to-point only).

2. The ID sequence received as part of the line bid from the remote station did not match the ID sequence defined by use of the 'IR' mnemonic (point-to-point only).

Action

Possible causes of an unrecognized line bid are:

1. Misuse of the ID sequence (point-to-point only).

2. Code set discrepancy.

3. Line errors which cause garbled transmission.

! ERROR 81 BID RECEIVE TIMEOUT

Explanation

INPUT OPERATIONS:

A bid was not received from the remote station within approximately twenty seconds of execution of the input operation (point-to-point only).

Action

The processing of this error is application dependent. In many cases, the instruction should be re-executed, particularly if either station in the communication link is executing more than one task.

! ERROR 82 BID RESPONSE RETRY LIMIT EXCEEDED

Explanation

OUTPUT OPERATIONS:

1. An unrecognizable bid response was received by the remote station.

2. A response was not received from the remote station within approximately three seconds of the transmission of the line bid by the local station.

Action

The processing of this error is application dependent. In many cases, the instruction should be re-executed, particularly if either station in the communication link is executing more than one task.

! ERROR 83 INVALID ID, POLL, OR SELECT SEQUENCE

Explanation

POINT-TO-POINT OPERATION:

The length of the ID sequence defined by the 'IL' or 'IR' mnemonic was greater than fifteen or less than two characters.

MULTIPOINT OPERATION:

1. The length of the poll or select sequence defined by 'MP', 'MS', 'TP', or 'TS' was greater than seven or less than one character.

2. The local station has been established as both a control and a tributary station through incorrect use of the poll/select mnemonics.

3. An attempt was made to change the poll/select sequences on a line that had previously been reserved.

Action

This is a programming error.

! ERROR 84 PRIMARY/SECONDARY CONTENTION CONFLICT

Explanation

OUTPUT OPERATIONS:

A bid was received in response to a bid issued by the local terminal which was configured as secondary, indicating that both stations in the point-to-point network are attempting to transmit.

Action

This is a possible system design error. To resolve the contention conflict, the local station must execute an input operation.

! ERROR 85 DATA RECEIVE TIMEOUT

Explanation

INPUT OPERATIONS:

Data were not received from the remote station within approximately twenty seconds of the execution of the input operation.

Action

The processing of this error is application dependent. In many cases, the instruction should be re-executed, particularly if either station in the communication link is executing more than one task.

! ERROR 86 CONTENTION CONFLICT

Explanation

OUTPUT OPERATIONS:

A bid was received in response to bid issued by the local terminal which was configured as primary in a point-to-point network.

Action

This is a possible system design error. To resolve the contention conflict, one station must execute an input operation.

! ERROR 87 NEGATIVE RESPONSE TO DATA RECEIVED

Explanation

OUTPUT OPERATIONS:

The message transmitted by the local station has been negatively acknowledged (NAK'd) by the remote station.

Action

The processing of this error, which is issued after the output operation has been retried six times, is application dependent.

! ERROR 88 RETRANSMISSION RETRY LIMIT EXCEEDED

Explanation

OUTPUT OPERATIONS:

The retry limit has been reached on retransmission of the message following a NAK by the remote terminal.

Action

The processing of this error is application dependent.

! ERROR 89 ACKNOWLEDGEMENT PHASE ERROR

Explanation

OUTPUT OPERATIONS:

The acknowledgement (ACK) to the message was received by the local station, but it contained an incorrect phase character (either out of sequence or unrecognized).

Action

The processing of this error, which possibly indicates that a message has been lost, is application dependent.

! ERROR 95 DEVICE ERROR

Explanation

INPUT OR OUTPUT OPERATIONS:

An interrupt was not detected after the expected duration of the input/output operation had elapsed.

Action

This is a hardware malfunction.

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