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Chapter 6. Remote Operations -- BSC

Introduction

When using Binary Synchronous Communications (BSC) operating mode, the 3271 Models 1 and 2, 3274 (Model 1C), 3275 Models 1 and 2 and 3276 Models 1, 2, 3 and 4 units can communicate with the program via an IBM 2701, 2703, 3704, 3705, or an equivalent Integrated Communications Adapter (hereafter called TCU) and appropriate data sets as specified for the control unit.

Note: *In the following paragraphs, the term "3270 CU" is used in statements that apply to the 3271, 3274, 3275, and 3276 BSC units. If a statement applies to only one 3270 unit, the appropriate unit number is used.*

The 3270 CU uses BSC procedures over duplex or half-duplex facilities (nonswitched or privately owned); these communications use the Multipoint Data Link mode of operation only. A 3275 with the Dial feature uses the BSC Point-to-Point Data Link procedure over a switched line.

A 3274 Model 1C and 3276 Models 1, 2, 3, and 4 function like a 3271 Control Unit. They accept the same data stream and provide the same responses as the 3271 unit. Operational differences are noted where they occur in the following text.

Code Structures

Each 3270 CU can operate with one or two code structures: EBCDIC (Extended Binary-Coded Decimal Interchange Code) or ASCII (American National Standard Code for Information Interchange). The choice of code depends on the application. However, for system compatibility, the same code must be chosen for all units on a particular communications line.

Channel Program Concepts

In remote configurations, the TCU becomes the intermediary between the 3270 CU and the channel program. As such, the TCU, not the 3270 CU, executes channel commands and initiates I/O interrupts. At the start of each I/O operation involving the TCU, the Start I/O instruction addresses the TCU and a communications line attached to that TCU; it does not address an individual remote control unit on that line. Subsequent CCWs in the channel program initiate TCU operations; they specify TCU commands, not 3270 commands.

Selection of a 3270 CU and all subsequent command operations are specified by character sequences in TCU Write CCW data streams. Write CCW data to the TCU communications line selected by Start I/O can contain (1) address bytes to select a control unit on that line, (2) the code of a command (such as Erase/Write or Write) to initiate a control unit operation, or (3) orders and/or display/print data for the control unit buffer. In addition, this write data will contain the appropriate data-link control characters. Thus, all characters sent by the TCU to a 3270 CU, with the exception of SYN, pad, and BCC characters, originate from the data stream of a Write CCW addressed to the TCU.

Programming Note: *All Write commands should be set for CCW chaining to a Read command when a response is expected. (This prevents a loss of data received by the TCU in response to Write command operations.) An exception to this requirement is when the Write command is used to issue EOT to the 3270.*

Text Blocking

The 3270 CU performs inbound text blocking. Each block of data can contain a maximum of 256 text characters. Of that total, each block contains the STX and ETB (or ETX) data link control characters. Two address bytes (CU poll address and device address) precede the read heading in the first block only and are included in the 256 character total. The last block of a message is terminated with ETX, which is also included in the 256 character total.

Programming Note: *If the automatic polling facility (Auto Poll) is used by the TCU, the Auto Poll index byte will add one byte to the text block created by the 3270 CU.*

Block check characters (BCC) are transmitted as the last characters of a data stream. (See "Redundancy Checking.") BCC is not counted as text because it follows the ETX and ETB data link characters. Upon successful comparison of the received BCC with the accumulated BCC, the program should respond with ACK to read the next block of text; each subsequent block is preceded by STX to initiate BCC accumulation by the TCU.

Text blocking does not disjoin the three-byte SBA order sequence (SBA code and two-byte field address) generated during the execution of a Read Modified command. Therefore, the last characters of a block ending with an SBA sequence would be . . . SBA, Address, Address, ETB (or ETX).

Related Publications

Readers who are unfamiliar with the binary synchronous method of communications should review the following publications, as applicable:

- *General Information – Binary Synchronous Communications,* GA27-3004
- *IBM 2701 Data Adapter Unit Component Description,* GA22-6864 (especially the section that describes the Synchronous Data Adapter – Type II)
- *IBM 2703 Transmission Control Component Description,* A27-2703 (especially the section on BSC capabilities)
- *Introduction to the IBM 3704 and 3705 Communications Controller,* GA27-3051

Multipoint (Nonswitched Line) Data Link Control

Each 3270 CU can operate on a nonswitched communications line with multiple stations. Time-sharing of the line is accomplished by interleaving transmissions between the TCU and all units on the line. A 3271, 3274, 3275 (without the Dial feature), or 3276 operates multidropped on the same line with other properly featured units, such as other 3270 units, IBM 2770s, and IBM 2780s. [Differences for a 3275 with the Dial feature are discussed under "Point-to-Point (Switched Line) Data Link Control."]

The TCU is the *control station* of the multipoint, centralized network. All units attached by communications lines to the TCU are called *tributary stations.* The control station is the focal point of the network and maintains, under program control, an orderly flow of network traffic by initiating all data transfers. The control station is either the transmitter or receiver of every communication.

3270 Modes of Operation

In the multipoint environment, the 3270 CU is always in one of four modes of operation: control mode, text mode, transparent-monitor mode, or transparent mode.

Control Mode

The 3270 CU enters control mode whenever it transmits or receives a valid EOT sequence. While in control mode, the unselected 3270 CU monitors the communications line for the following:

1. A valid selection or poll addressing sequence, by which the 3270 CU will become selected for entry into text mode.
2. A DLE-STX sequence, placing the 3270 CU in transparent-monitor mode.

Text Mode

Once a 3270 CU is successfully selected, it enters text mode. In text mode, the 3270 CU is either a master station or a slave station, as is the TCU. This status depends on the operation being performed. The station that is transmitting a message is called the *master station*, whereas the station that is receiving and acknowledging the message is called the *slave station*.

The 3270 CU becomes the master station (and the TCU the slave station) once it sends STX to the TCU while executing a Read command or a poll operation. As the master station, it can (1) transmit text messages and (2) transmit ENQ to request a reply or retransmission from the TCU. After transmission of the message is completed, the 3270 CU returns to control mode.

The 3270 CU becomes the slave station (and the TCU the master station) when executing a write-type command. As a slave station, it responds appropriately to master-station (TCU) transmissions.

Transparent Monitor Mode

Except for the 3274 Model 1C, 3270 CUs do not operate in transparent mode, but can operate on a communications line with other types of terminals that can operate in transparent mode.

Transparent-monitor mode is provided with EBCDIC 3270 CUs only. It permits the transmission of data in any of the 256 possible EBCDIC bit patterns between the TCU and another unit on the same communications line with the 3270 CU. This data may be independent of the selected transmission code (EBCDIC). Examples of such format-independent data are packed-decimal data, programs (both source and object), core images, and other binary data. Thus, link control characters within this data will not inadvertently initiate a 3270 CU operation.

When an EBCDIC 3270 CU decodes a DLE STX sequence while in control mode, it enters transparent-monitor mode. While in this mode, the 3270 CU disregards *all* data configurations that may appear on the communications line except for (1) a transparent text sync sequence (DLE SYN) or (2) a transparent text-terminating sequence (DLE ITB, DLE ETX, DLE ETB, or DLE ENQ). The 3270 CU leaves transparent-monitor mode and returns to control mode (1) if a transparent text sync sequence is not received within any 3-second period or (2) if a transparent text-terminating sequence is decoded.

Transparent Mode

The 3274 Model 1C provides transparent-mode transmission support (inbound and outbound) for the displays and printers that use the Extended Highlighting, Color, or Programmed Symbols function. Any data link control characters transmitted while the control unit is in transparent mode must be preceded by a DLE to be recognized as control functions. The following control functions are used:

- DLE STX – Initiates transparent mode for the following text.
- DLE ETB – Terminates a block of transparent text, returns the link to normal mode, and calls for a reply.

- DLE ETX – Terminates the transparent text, returns the link to normal mode, and calls for a reply.
- DLE SYN – Used to maintain synchronization, or as a time-fill sequence for transparent mode.
- DLE ENQ – Indicates "disregard this block of transparent data" and returns the link to normal mode.
- DLE DLE – Used to transmit DLE as data when a bit pattern equivalent to DLE appears in the transparent text. One DLE is disregarded; the other is treated as data.
- DLE ITB – Terminates an intermediate block of transparent text, returns the data link to normal mode, and does not call for a reply. The BCC character follows DLE ITB.

The boundaries of transparent data are determined by the DLE STX and the DLE ITB, DLE ETB, or DLE ETX control functions, which initiate and terminate the transparent mode of operation. The controller and the displays or printers that support the Extended Highlighting, Color, and Programmed Symbols functions can accept data in transparent mode at any time; acceptance is not related to the use of the Extended Highlighting, Color, or Programmed Symbols functions.

For outbound transparent text transmissions:

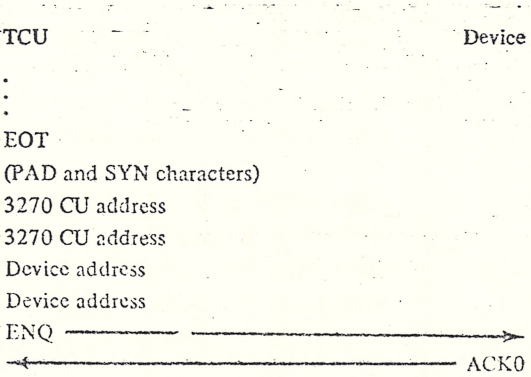
- Order splitting is permitted with a DLE ETB, meaning that the next block is a continuation of the text.
- DLE ETX processing is the same as in nontransparent mode; each block must start with a command sequence.
- On a teleprocessing line error, after a return of NAK by the 3274, either a retransmission of the block or an EOT is expected from the sender.
- When a program error is found in the data, or a device error occurs during the processing of a block, the 3274 returns an EOT.
- NAK is returned by the 3274 when a transmission has DLE ETX or DLE ETB missing.

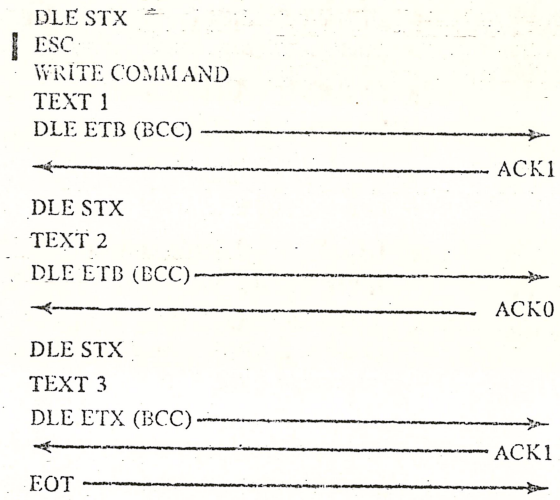
Note: *Block size is to be limited to 3,000 bytes of uncompressed data in a Write Structured Field (WSF) transmission containing the LPS structured field.*

Inbound Transparent Transmissions The 3274 Model 1C transmits inbound data in transparent mode only if:

- The inbound reply mode is extended field.
- The inbound reply mode is character.
- The inbound data stream includes structured fields.

Transparent Text Blocking (Outbound) The following example illustrates the sequence expected during outbound blocking.





Order sequences may be split in the blocking process. For example, one block may end with:

SBA
DLE ETB (BCC)

and the next block continue with:

DLE STX
ADDRESS
ADDRESS

Outside of transparent mode, ETB is treated as an ETX function. If the transmission for TEXT 2 in the example had omitted the DLE prefix, ETB would have been treated as ETX and the transmission acknowledged, but the transmission for TEXT 3 – not beginning with a command – would have been treated as an error.

If the outbound blocked transmission contains a read command, the ETB is treated as ETX. The read data stream is transmitted.

If a text block, other than the first in the transmission, contains a command, the second command sequence (ESC, CMMD) is treated as data. The device is in transparent mode, expecting a text block, and is not checking for a command sequence in the incoming transmission.

When a text block is expected, and another BSC control sequence, such as RVI or WACK, is received, the device ignores it. The effect is a timeout at the TCU.

Redundancy Checking

A redundancy check is performed on the following communications line data:

1. 3270 CU command-sequence characters (including the write data of a Write, Erase/Write, or Erase/Write Alternate command).
2. Data transmitted to the TCU in response to a read-type command or to a polling sequence.

A block check character (BCC) is accumulated for each block of data at both the TCU and the 3270 CU. If EBCDIC code is used, a two-byte BCC is generated (cyclic redundancy check accumulation); if ASCII code is used, a one-byte BCC is generated (longitudinal redundancy check accumulation).

BCC accumulation is initiated by, but does not include, the first STX or SOH framing character. All characters following this STX or SOH, up to and including the end-of-block character (ETB or ETX), are part of the accumulation. Following the ETB or ETX character, the transmitting unit transmits its BCC character(s). The receiving unit then compares this character(s) with the BCC it has accumulated. If the redundancy accumulations are different, a transmission error has occurred.

When the 3270 CU is the receiving unit and detects a BCC error, it responds to the transmission by sending EOT (3275) or NAK (3271, 3274, 3276) to the TCU. When the TCU is the receiving unit, it will set Unit Check in the ending status for the TCU command being executed when the BCC error was detected; also, it will set Data Check in the sense byte.

Note: *BCC characters are removed from the data stream when received for comparison by the TCU or by the 3270 CU; they are not stored in main storage or in the 3270 CU buffer.*

In both EBCDIC and ASCII, transmission formats (data link controls) are rigidly screened so that communication is orderly and accurate. Improper transmissions are ignored or rejected to avoid the acceptance of faulty messages. Received or transmitted data blocks are counted odd-even-odd-even, etc., by both the transmitter and receiver (by means of ACK 0's and ACK 1's), and their counts must agree at each block-check point.

Data-Link Control Characters

Two types of characters are transmitted between the TCU and the 3270: CU data-link control characters, and 3270 message data. Data-link control characters are used for such purposes as message framing, acknowledgment that received message data was valid or invalid, and identification of the start- or end-of-text transmission. Data link control characters are used (singly or in sequences) by the TCU (under program control) and by the 3270 CU to establish and control all data link operations in an orderly fashion. The 3270 message data consists of all address, command, order, and display/print characters sent to the 3270 CU and of all buffer data, AID bytes, and status/sense bytes read from the 3270 CU. Data-link control characters are described individually in the following paragraphs and are described with 3270 message data later in this section (under "Operational Sequences").

The data-link control characters, with their EBCDIC or ASCII codes, are as follows:

Data-Link Control Character	EBCDIC (hex)	ASCII (hex)
ACK 0 (two bytes)	1070	1030
ACK 1 (two bytes)	1061	1031
DLE	10	10
ENQ	2D	05
EOT	37	04
ESC	27	1B
ETB	26	17
ETX	03	03
ITB	1F	1F
NAK	3D	15
RVI (two bytes)	107C	103C
SOH	01	01
STX	02	02
SYN	32	16
TTD	022D	0205
WACK	106B	103B

All control characters transmitted by the TCU (except pad and SYN) are issued by the channel program as part of a TCU Write CCW data stream. All control characters transmitted by the 3270 to the TCU are generated by the control unit; a Read command to the TCU is used to store these characters (except pad and SYN) into main storage for subsequent analysis by the access method.

Pad

Pad characters, leading and trailing, are generated by TCU or 3270 CU hardware to ensure complete transmission or reception of the first and last significant character of each transmission.

SYN (Synchronous Idle)

Two consecutive SYN characters are generated by TCU or 3270 CU hardware to establish character synchronization. The TCU can also embed SYN characters in text for time-fill to maintain synchronization; the 3270 CU discards these SYN characters (does not store them in the buffer).

DLE (Data Link Escape)

DLE is always the first byte in the following two-byte control characters: ACK 0, ACK 1, WACK, and RVI. DLE is also used as the first character in several two-character sequences that are used in transparent-monitor mode (described earlier in this chapter under "Transparent Monitor Mode").

ACK 0 (Even Acknowledge)

ACK 0 is a two-byte character, as follows:

- EBCDIC: 1070 (hex)
- ASCII: 1030 (hex)

ACK 0 is transmitted by the 3270 CU after a successful selection addressing (not poll) sequence to indicate to the TCU that the 3270 CU is ready to accept transmission. ACK 0 is also transmitted by the 3270 CU or by the TCU upon receipt and validation of an even-numbered (second, fourth, etc.) text block.

ACK 1 (Odd Acknowledge)

ACK 1 is a two-byte character, as follows:

- EBCDIC: 1061 (hex)
- ASCII: 1031 (hex)

ACK 1 is transmitted by the 3270 CU or TCU upon receipt and validation of an odd-numbered (first, third, etc.) text block.

NAK (Negative Acknowledgment)

NAK is transmitted by the 3270 CU in response to a TCU text transmission that (1) terminates with ENQ, (2) has ENQ embedded in text, (3) has invalid BCC (3271, 3274, and 3276), (4) contains a TTD sequence (STX ENQ), or (5) has ETX missing (3271, 3274, and 3276). (The 3275 responds with EOT to a TCU text transmission that has invalid BCC or missing ETX.)

When NAK is received by the 3270 CU in response to a text transmission, the 3270 CU retransmits the last block of text.

Programming Note: *The TCU should be programmed to respond with NAK to an ENQ (that ends a text block) from the 3270 CU; this NAK causes the 3270 CU to send EOT and retain the status for error recovery.*

ENQ (Enquiry)

The 3270 CU transmits ENQ (1) to request a reply from the TCU following a 3-second timeout, (2) to request retransmission of the previous reply from the TCU, or (3) as the last character of a text message in which a data check was detected by the 3270 CU. (See "Programming Note" above.)

When the 3270 CU receives ENQ in response to a transmission, the last 3270 CU transmission to the TCU is repeated. The 3270 CU responds with NAK when ENQ is received (1) as the last character of a TCU-aborted text transmission, (2) embedded in text, or (3) as part of a TTD sequence (STX ENQ).

To be addressed successfully, the 3270 CU must receive ENQ as the last character of a polling or selection addressing sequence.

WACK (Wait before Transmit)

WACK is a two-byte character, as follows:

- EBCDIC: 106B (hex)
- ASCII: 103B (hex)

WACK is generated by the 3270 CU (1) in response to a selection addressing (not poll) sequence when a printer (attached to a 3270 CU) or a 3277 attached to a 3271 or 3274 is busy, and (2) in response to a Write or Copy (3271, or 3274, 3276) command text transmission when the Start Printer bit is set in the WCC or CCC. The 3270 CU responds with ENQ to a WACK from the TCU.

RVI (Reverse Interrupt)

RVI is a two-byte character, as follows:

- EBCDIC: 107C (hex)
- ASCII: 103C (hex)

RVI is generated by the 3270 CU in response to an attempted selection (not poll) by the TCU when the 3270 CU has a status and sense message to be transmitted. Whenever the 3270 CU accepts RVI from the TCU, the CU responds with EOT and resets all pending status and sense information. The 3274 and 3276 accept RVI in place of ACK 0 or ACK 1 and then only when they would have been valid. If RVI is received at the 3274 or 3276 in response to RVI, a timeout occurs at the 3274 or 3276 unit.

STX (Start of Text)

The 3270 CU receives STX as the first character of a command or TTD sequence. The STX causes the 3270 CU to clear its BCC and start accumulating a new BCC (STX is not included in the accumulation). Subsequent STX (and SOH) characters are included in the BCC accumulation. STX is transmitted by the 3270 CU to the TCU as the first character of a read-data text block except in a status or test-request message; this STX causes the TCU to start accumulating a new BCC (STX is not included in the accumulation).

The first character in status and test-request messages is SOH, with STX following two header characters. With a message of this type, the TCU starts BCC accumulation upon receipt of the first SOH; the subsequent STX character is included in the BCC accumulation.

SOH (Start of Heading)

The 3270 CU generates SOH in a three-character heading sequence that identifies the accompanying data as a status message (SOH, %, R, STX, ———) or as a test-request message (SOH, %, /, STX, data ————). The TCU starts BCC accumulation upon receipt of SOH (SOH is not included in the accumulation).

ETB (End of Transmission Block)

During a message transfer operation, ETB informs the receiving unit that BCC follows. The 3270 CU treats ETB as though it were ETX by checking BCC and then generating the appropriate response; the 3270 CU does not accept conventionally blocked outbound text.

ETX (End of Text)

During a message transfer operation, ETX informs the receiving unit that BCC follows. The 3270 CU transmits ETX at the end of the last (or only) block of a text message. Then, upon successful comparison of the received BCC with the accumulated BCC, the program should respond with ACK to the 3270 CU. If the BCC comparison is unsuccessful, the TCU interrupts the program (Channel End, Device End, and Unit Check status, with Data Check set in the sense byte); the program should respond with NAK to the 3270 CU. Receipt of ETX by the 3270 CU initiates a BCC comparison, causes a line turnaround, and causes generation of an appropriate response to the TCU.

EOT (End of Transmission)

EOT is transmitted by the 3270 CU (1) when the 3270 CU is a slave station and is unable to perform an operation requested by the TCU; (2) when the 3270 CU is a master station, as normal termination of a read operation; (3) when the 3271, 3274, or 3276 has completed General Poll operations with each attached device; (4) as an answer to RVI sent by the TCU; (5) when the 3275 in text mode has invalid BCC; or (6) the 3275 ETX is missing. Line synchronization is dropped, and the 3270 CU is returned to control mode. Note that the program can also issue EOT to the 3270 CU in order to drop line synchronization and return the 3270 CU to control mode. EOT does not reset status and sense in the 3270 CU; therefore, it should not be sent as a response to a status message.

Following receipt of a valid selection addressing sequence, if an error occurs during buffer transfer, the 3274 and 3276 will provide a positive response to the selection sequence and internally set DC and US status. EOT is sent in response to the following 3270 command or poll.

ITB (End of Intermediate Transmission Block)

The 3270 CU does not accept conventionally blocked text. However, to coexist on a BSC multipoint line on which ITB may be used, the 3270 CU includes the ITB and associated BCC in its own BCC accumulation but then removes them from the data stream so that they are not stored in the buffer. The 3270 CU does not perform a BCC comparison at that time, but continues the receive operations until ETB or ETX is decoded.

ESC (Escape)

ESC must precede the command code in each command-sequence data stream transmitted to the 3270 CU, as follows: STX, ESC, CMD, ———. The 3270 CU does not generate ESC.

TTD (Temporary Text Delay)

TTD is a two-character sequence: STX ENQ. The 3270 CU responds to TTD by transmitting NAK to the TCU. The 3270 CU does not generate TTD. TTD may also be used by the master station to terminate an operation (that is, initiate a forward abort). The 3270 CU (slave station) will always respond with a NAK, expecting the master station to transmit EOT. In this case, the slave station interprets this sequence as a controlled forward abort rather than an end of transmission.

Operational Sequences (Nonswitched Line)

The following paragraphs describe the various data and control sequences that can be performed with the 3270 operating on a nonswitched line. Differences for a 3275 with a