IBM

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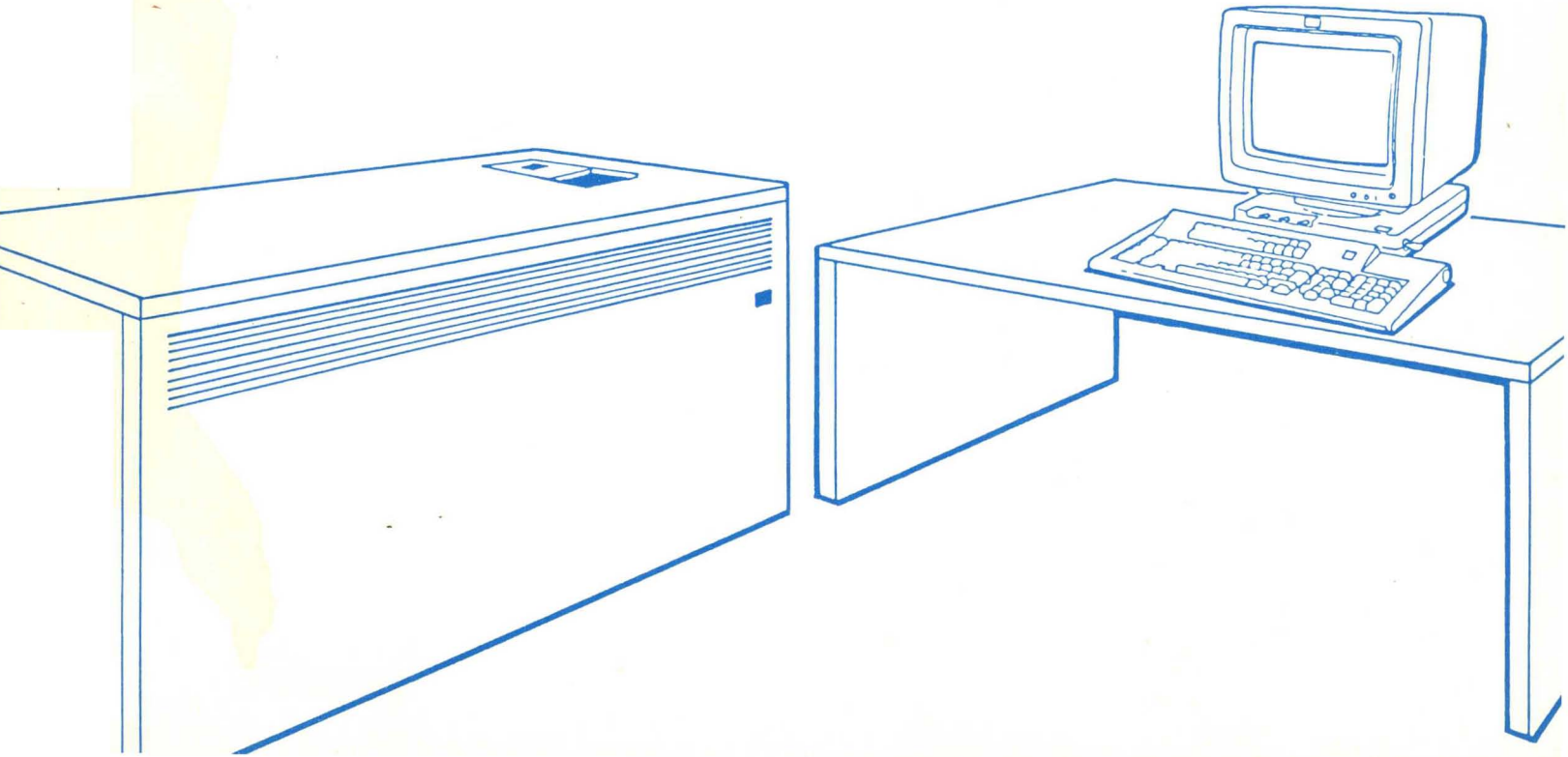
IBM 4361 Processor Communications Adapter Reference Manual



IBM 4361 Processor Communications Adapter Reference Manual

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Second Edition (September 1984)

This a major revision of GA-1571-0 which is now obsolete. This revision contains information about the X.21 Switched Facility and the X.25 Packet Switched Facility. Both are new features which support public data networks that are offered in many countries. The X.21 Switched Facility also affects the chapter 'Synchronous Data Link Control'. All changes are marked with vertical bars in the left margin.

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Preface

This publication describes the operations of the communications adapter (CA) optional feature on the channel command and procedure level. The information is intended as reference for system programmers and system analysts. It will help them to understand the hardware support which is available to the controlling software.

The publication describes the line control characters, transmission codes, commands, status reports, and sense information for each CA line procedure. The procedures are:

- IBM Terminal Control - Type 1
- US Telegraph Terminal Control - Type 2
- Binary Synchronous Communications Control
- Synchronous Data Link Control (with X.21 Switched Facility)
- X.25 Packet Switched Facility

Associated Publications

- *IBM System /370 Principles of Operation*, GA22-7000
- *IBM 4300 Processors Principles of Operation for ECPS: VSE Mode,*

The following manuals are related to this publication and are recommended for further reading:

- *IBM 4361 Processor Functional Characteristics*, GA33-1566
- *IBM 4361 Processors Summary*, GA33-1572

The following manuals are prerequisite for readers of Chapter 5 "Synchronous Data Link Control".

- *Synchronous Data Link Control General Information*, GA27-3093
- *Systems Network Architecture General Information*, GA27-3102
- *IBM Implementation of X.21 Interface, General Information Manual*, GA27-3287
- *The X.25 Interface for Attaching SNA Nodes to Packet-Switched Data Networks, General Information Manual*, GA 27-3345
- *Advanced Communications for VTAM Entry, General Information: Concepts*, GC27-0451.

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Chapter 1. Introduction

The communications adapter (CA) is an optional feature. It provides communication between the 4361 processor and data terminal equipment at remote locations. The communications adapter appears to the software like a channel-attached communication controller with functions similar to those of an IBM 2701, 3704 or 3705 communications controller, although it is built into the 3641 host processor. For this reason, no separate piece of apparatus is required.

For a list of the attachable data terminal equipment, see *IBM 4361 Processors Summary*, GA33-1572.

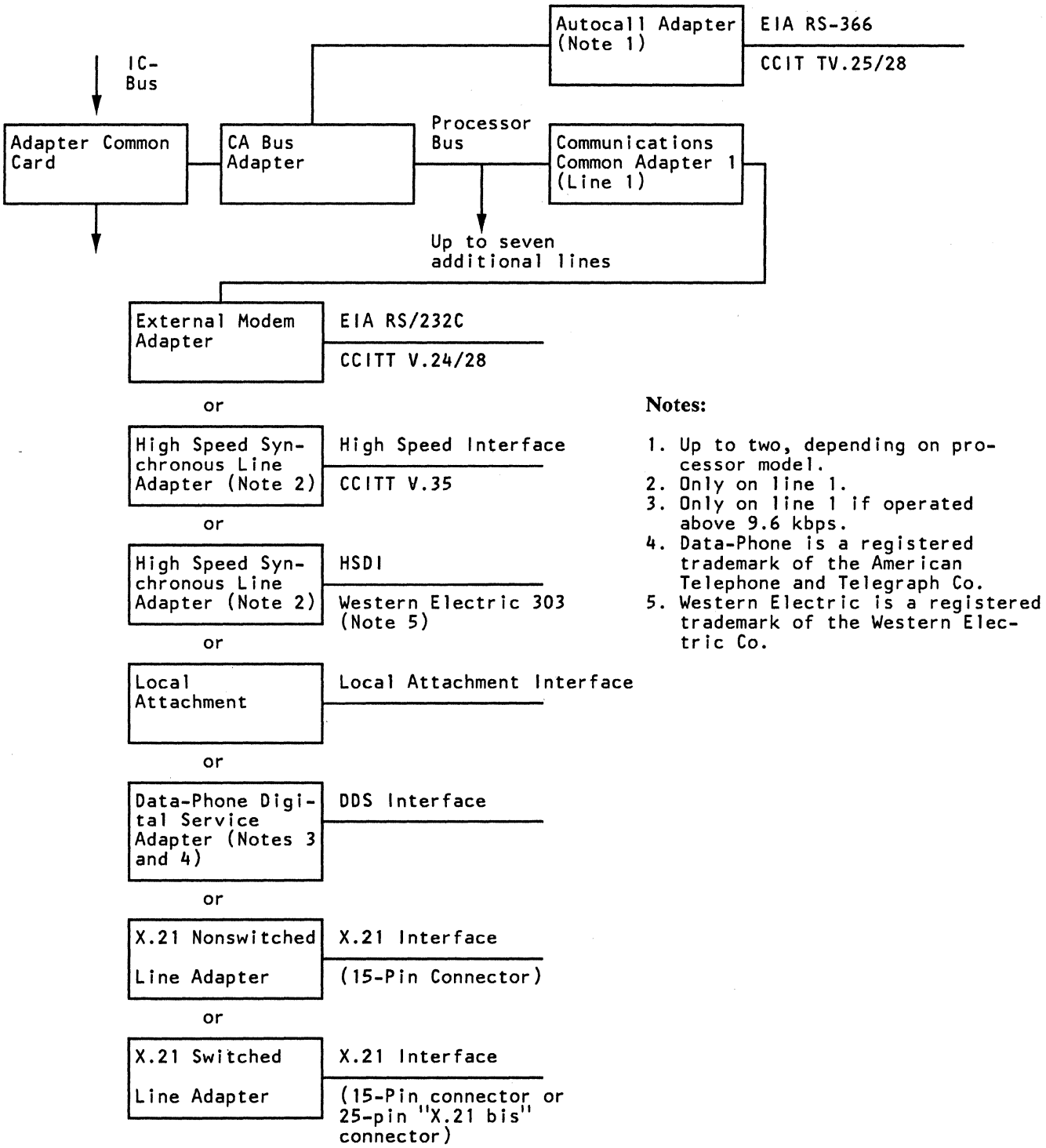
Functions

The communications adapter operates up to eight communication lines which are logically integrated into the byte multiplexer channel (channel 0) of the 4361 processor. Thus these lines appear as eight subchannels of the byte multiplexer and one subchannel is dedicated to an internal trace feature which permits detailed error recovery (should it be necessary).

Five different line control procedures (Start/Stop, BSC, SDLC, X.25 and TTY) are available to control the data transfer. In addition, eight different interfaces are available to facilitate connection to many networks either directly or via suitable external modems.

Data Rate

The CA allows for a total aggregate data rate of 64 kbps. Speeds above 9,600 bps are limited to line number 1. If low-speed lines are operating at the same time as the high-speed line, the maximum speed of the high-speed line is reduced to 50,000 bps. Lines using X.25 protocol pose twice their nominal data rate as a load.



Notes:

1. Up to two, depending on processor model.
2. Only on line 1.
3. Only on line 1 if operated above 9.6 kbps.
4. Data-Phone is a registered trademark of the American Telephone and Telegraph Co.
5. Western Electric is a registered trademark of the Western Electric Co.

Figure 1. Physical Interfaces of Communications Adapter. This figure shows the various physical interfaces that can be ordered (via feature code). Up to two autocall unit interfaces are available. These interfaces can be associated with any switched lines, that may need them, via menu at the operator console.

Line Control Procedures

The lines of the communicating adapter can be divided in two groups as far as the general method of line control is concerned: asynchronous lines and synchronous lines. The control procedures are selected at installation time of the system via a menu technique. Details about this configuration process are described in the *IBM 4361 Processor, Operating Procedures* manual, GA33-1570. The following procedures are available.

Asynchronous Line Controls

- IBM Terminal Control Type 1: for BCD code transmission at speeds ranging from 75 to 1200 bits per second (bps). The controlling method is suitable for data communication systems such as IBM 1050, 1060, 2740, 3767, and others.

- US Telegraph Terminal Control Type 2: for ASCII code transmission at speeds ranging from 75 to 2400 bps. The controlling method is suitable for terminals (teleprinters) using TWX code 33/35 and IBM 3101 ASCII display stations.

Synchronous Line Controls

- Binary Synchronous Communication (BSC) Control: for transmission of EBCDIC, ASCII or any code at speeds ranging from 600 to 56,000 or 64,000 bps.

- Synchronous Data Link Control (SDLC): for the transmission of EBCDIC or any code at speeds ranging from 600 to 56,000 or 64,000 bps.

  Note: SDLC-configured lines may be fitted with the X.21 leased or switched interface which allows connection to leased or circuit-switched public data networks.

- X.25 Packet-Switched Control: for the transmission of EBCDIC or any code at speeds ranging from 600 to 9600 bps. This allows connection to a packet-switched public data network.

Table 1 shows how line control procedures (also called "protocols") correlate with the various interfaces.

	Line Interfaces						
	EIA RS 232C CCITT V.24/28 CCITT X.21 bis	HDSI	CCITT V.35	DDS	LA	Switched	Leased
Maximum Number of Lines: S/S, BSC, SDLC: X.25:	8 7	1 -	1 -	8 -	8 -	8 -	8 7
Start/Stop (S/S) (IBM-1,TTY-2) Data rate: Clocking:	75...2400 int./ext.	- -	- -	- -	- -	- -	- -
Binary Synchronous Control (BSC) Maximum data rate: Clocking:	9600 int./ext.	56000 ext.	64000 ext.	56000 ext.	9600 ext.	- -	- -
Synchronous Data Link Control (SDLC) Maximum data rate: Clocking:	9600 int./ext.	56000 ext.	64000 ext.	56000 ext.	9600 ext.	9600 ext.	48000 ext.
Packet-Switched X.25 (HDLC-LAPB) Maximum data rate: Clocking:	9600 int./ext.	- -	- -	- -	- -	- -	48000 ext.

Table 1: Line Control-to-Interface Correlation

Legend:

HDSI	High Speed Digital Service Interface
CCITT V.35	High-Speed Interface
DDS	Data-Phone Digital Service
LA	Local Attachment (no modem)

Chapter 2. IBM Terminal Control - Type 1

The command set, the line control characters, and the transmission code comprising the IBM Terminal Control - Type 1 are designed for asynchronous start/stop communication with remote data terminal equipment (DTE) such as the following:

- IBM 1050 Data Communication System (using 6-bit BCD code with shift)
- IBM 1060 Data Communication System (using 6-bit BCD code without shift)
- IBM 2740 Communication Terminal (using 6-bit BCD code with shift)
- IBM 2741 Communication Terminal (using 6-bit BCD code with shift)
- IBM 3767 Communication Terminal
- IBM 5100 Portable Computer
- IBM 5110 Computer Model 3

The code structures are shown in Appendix A, Figure 12 on page 147 to Figure 14 on page 150.

Line Control Characters

Six line control characters are used for Type 1 terminals:

(B) End of Block X '3D'

The (B) (circle B) character indicates the end of a block of text.

(C) End of Transmission X '1F'

The (C) (circle C) character indicates the end of a transmission or the beginning of either a polling or a selection operation.

(D) End of Address X '16'

The (D) (circle D) character indicates the end of an address (if any) and, consequently, the beginning of text. It is a positive response to polling.

(N) Negative Response X '40'

In control mode, the (N) (circle N) character indicates for polling that a polled terminal has nothing to send, or for addressing, that the terminal cannot receive. In text mode, the (N) character indicates that the terminal has detected a transmission error.

(S) Start of Address X '37'

The (S) (circle S) character indicates a start-of-address and is used, for example, when the Station Control feature is installed in a 2740 Communication Terminal. (S) is used during addressing and concerns only the remote station.

(Y) Positive Response X '76'

The (Y) (circle Y) character indicates that the addressed terminal is ready to receive or has accepted a block of text.

> **Note:** For a listing of all applicable characters see "Appendix A, CA Code Tables."

Transmission Code

The transmission code for Type 1 terminals is a six-bit BCD code. The code structure is shown in the following table:

Storage Byte:	0	1	2	3	4	5	6	7	
Interpreted as:	S	B	A	8	4	2	1	C	
Transmission code:	start	B	A	8	4	2	1	C	stop

The S represents the shift bit, which indicates upper case when set, and lower case when zero. During transmission, the line attachment inspects the shift bit of each character before it is stripped off. The inspection shows whether or not the shift bit is the same as that of the preceding character.

If a shift change is detected (a change from upper case to lower case, or vice versa), the line attachment generates an appropriate shift character (upshift or downshift) which is transmitted ahead of the character that caused the shift change. This allows the remote DTE to operate its shift mechanism.

When the line attachment is receiving, it inspects incoming shift characters but does not transfer them to processor storage. The characters that follow the shift character are stored with a shift bit that reflects the change effected by the shift character. The start and stop bits are added for transmission and deleted upon reception.

Commands

Hex	Command Code CCW Bits 0	1	2	3	4	5	6	7	Command
01	0	0	0	0	0	0	0	1	Write
02	0	0	0	0	0	0	1	0	Read
03	0	0	0	0	0	0	1	1	Control No-op
04	0	0	0	0	0	1	0	0	Sense
06	0	0	0	0	0	1	1	0	Prepare
08	0	0	0	0	1	0	0	0	Transfer-in-Channel
09	0	0	0	0	1	0	0	1	Poll
0A	0	0	0	0	1	0	1	0	Inhibit
0D	0	0	0	0	1	1	0	1	Break
13	0	0	0	1	0	0	1	1	No-op (Sadzero)
17	0	0	0	1	0	1	1	1	No-op (Sadone)
1B	0	0	0	1	1	0	1	1	No-op (Sadtwo)
1F	0	0	0	1	1	1	1	1	No-op (Sadthree)
27	0	0	1	0	0	1	1	1	Enable
29	0	0	1	0	1	0	0	1	Dial
2B	0	0	1	0	1	0	1	1	No-op (Set Line Mode)
2F	0	0	1	0	1	1	1	1	Disable
E4	1	1	1	0	0	1	0	0	Sense I/O

Note: The Sadzero, Sadone, Sadtwo, Sadthree, and Set Line Mode commands (hex 13, 17, 1B, 1F, and 2B) are accepted and treated as no-operations.

Read

The Read command causes data to be transferred from the addressed line to the processor storage address specified in CCW bits 8 to 31. Data transfer continues in ascending order of this address.

To ensure that data is actually received on the communication line, a three-second timeout is started when a Read command is given. If the time elapses before data is received, the Read command ends with unit check (bit 38 in the CSW) set and the timeout complete bit is set in sense byte 0. If a character is received before the three-second timeout has elapsed, a 25-50 second timeout is started for each subsequent character.

The data received is normally in the form of a stream that consists of line control characters and text characters. The operations within the CA and the way in which the Read command is terminated depend on the data received, as described in the following text.

(D) Received: If a (D) is received, it is recognized as a line control character if the line attachment is in control mode (the line attachment is in control mode after enable, disable, or end of transmission (circle C)). Recognition of a (D) causes the line attachment to set text-in and lower case modes. The data that follows (D) is text.

In text-in mode, when the next incoming character is received, the line attachment begins to accumulate the longitudinal redundancy check (LRC) character. Each text character causes the LRC to be updated. Reception continues as long

as successive text characters arrive within 25-50 seconds. All characters are stripped of their start and stop bits (these bits do not enter processor storage). Shift bits are inserted into the byte prior to storing the byte into processor storage.

In text-in mode, further (D), (N) or (Y) characters are not recognized as line control characters, but are treated as text characters.

Delete and Idle Characters Received: If delete (BA8421C equal to 111 1111) and idle characters (BA8421C equal to 1011110) are received, they are included in the LRC accumulation, but are not transferred to processor storage.

Shift Characters Received: If a shift character is received it is inspected but not transferred to processor storage. The following characters received are stored with a shift bit that corresponds to the shift change effected by the shift character. The shift character is included in LRC accumulation.

(B) Received: Receipt of (B) indicates that the end of the text block has been reached and the line attachment stops LRC accumulation. The next character received is assumed to be the LRC character from the remote terminal. This LRC character is compared with the LRC accumulated in the line attachment and if both are the same, channel end and device end are presented for the Read command, otherwise unit check is presented together with channel end and device end, and the data check bit is set in sense byte 0. The attachment remains in text-in mode.

(C) Received: Receipt of (C) indicates the end of transmission, and channel end, device end, and unit exception are presented to terminate the Read command. The line attachment goes back to control mode and lower case mode. The accumulated LRC is reset.

The read operation continues until a timeout occurs, a (B) or (C) is received, or the length count is exhausted.

Write

The Write command causes data from the processor storage location specified in CCW bits 8 to 31 to be transmitted over the addressed communication line. One or more characters can be sent. If more than one character is sent, the additional characters are taken from processor storage in ascending order of address. The action taken by the CA depends on the data being transmitted, as described in the following text.

(D) Transmitted: If a (D) is transmitted, any data that follows will be text. Transmission of (D) places the line attachment in text-out mode, provided that it was previously in control mode or text-in mode. If the line attachment is in any other mode, the transmitted (D) is treated as text. The (D) also puts the line attachment in lower case mode.

When the text-out mode is set, the line attachment begins to accumulate an LRC character. The LRC character is updated with each additional character that is transmitted. Text-out mode causes the shift bit of each text character to be inspected before it is removed. If a text character has its shift bit set and the immediately preceding character had its shift bit at 0, the line attachment generates, and transmits, an upshift character. Simultaneously, it sets upper case mode

before the next text character is transmitted. If the line attachment detects a change to lower case, a shift to lower case occurs. The LRC character is also updated with the shift characters.

Transmission (writing) continues until a (B) is detected in the output stream or until the length count reaches zero. Transmission occurs at the speed associated with the addressed line. The line attachment converts the processor storage data to the appropriate code (6-bit BCD) and provides the start bit at the beginning and the stop bit at the end of each character.

(C) Transmitted: If a (C) is transmitted the LRC character is reset in the line attachment. The Write command does not end. (Usually a polling or addressing character follows a (C).)

(B) Transmitted: If a (B) is transmitted in text-out mode, LRC accumulation stops and the LRC character is transmitted immediately after the (B). Then channel end and device end are presented for the Write command. (B) is the only character that ends a Write command.

Write Interruption Feature: If a steady space level for the time span of more than two characters is sensed on the 'received data' line and the CA is configured for write interruption, the Write command ends with unit check, and intervention required is set in sense byte 0.

Notes:

1. The write interruption feature requires a full-duplex communication facility.

2. A Write command, may be used to transmit a positive or negative acknowledgement, such as (Y) or (N), instead of an address and text.

Polling and Addressing with Alternate Read and Write Commands: Read and Write commands can be used alternatively to poll or address Type 1 terminals in a multipoint network. The line control sequences for IBM Terminal Control-Type 1 are shown in Figure 2 on page 10 to Figure 5 on page 12.

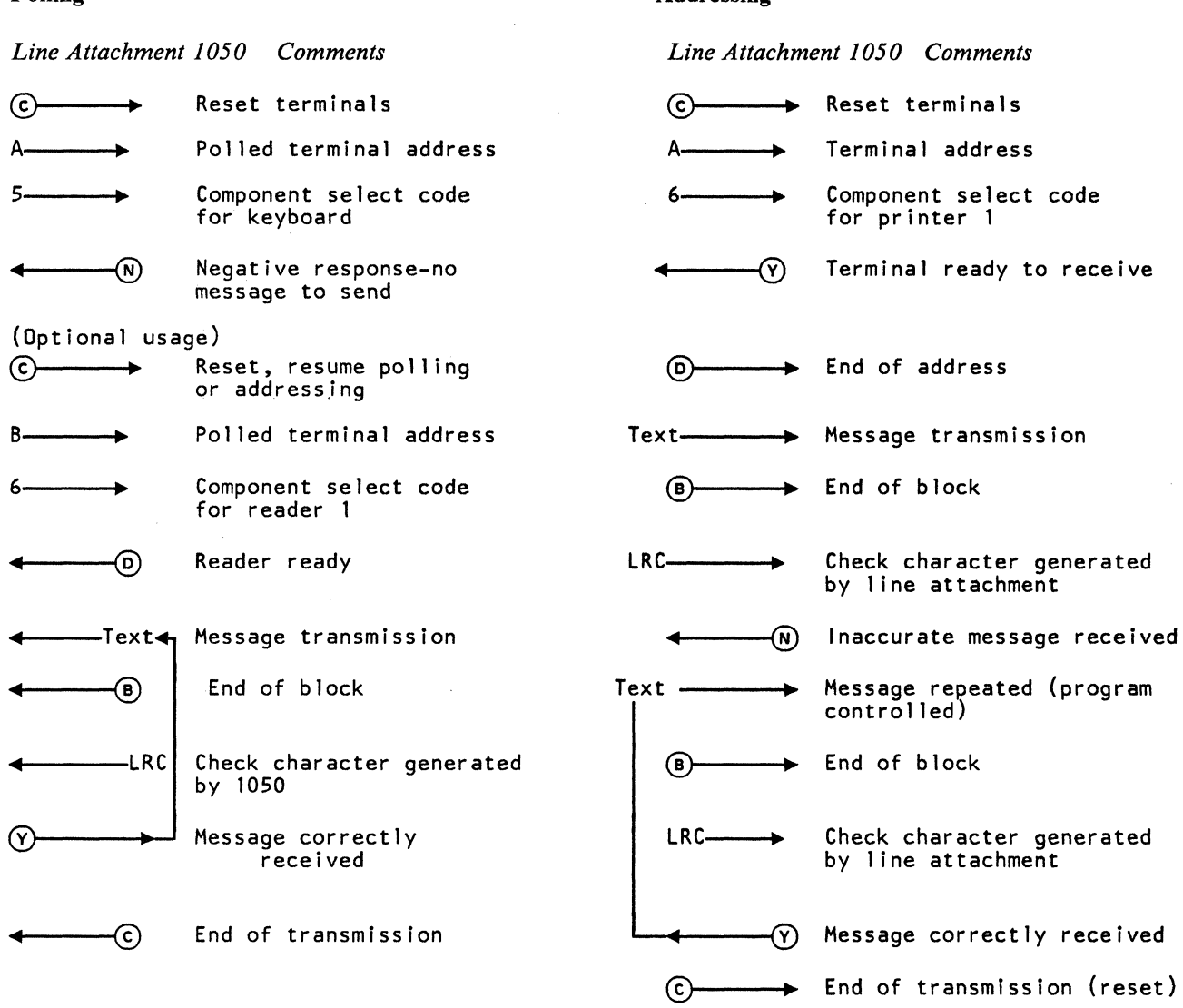


Figure 2. Line Control Sequences for IBM Terminal Control-Type 1 with 1050 Data Communication System

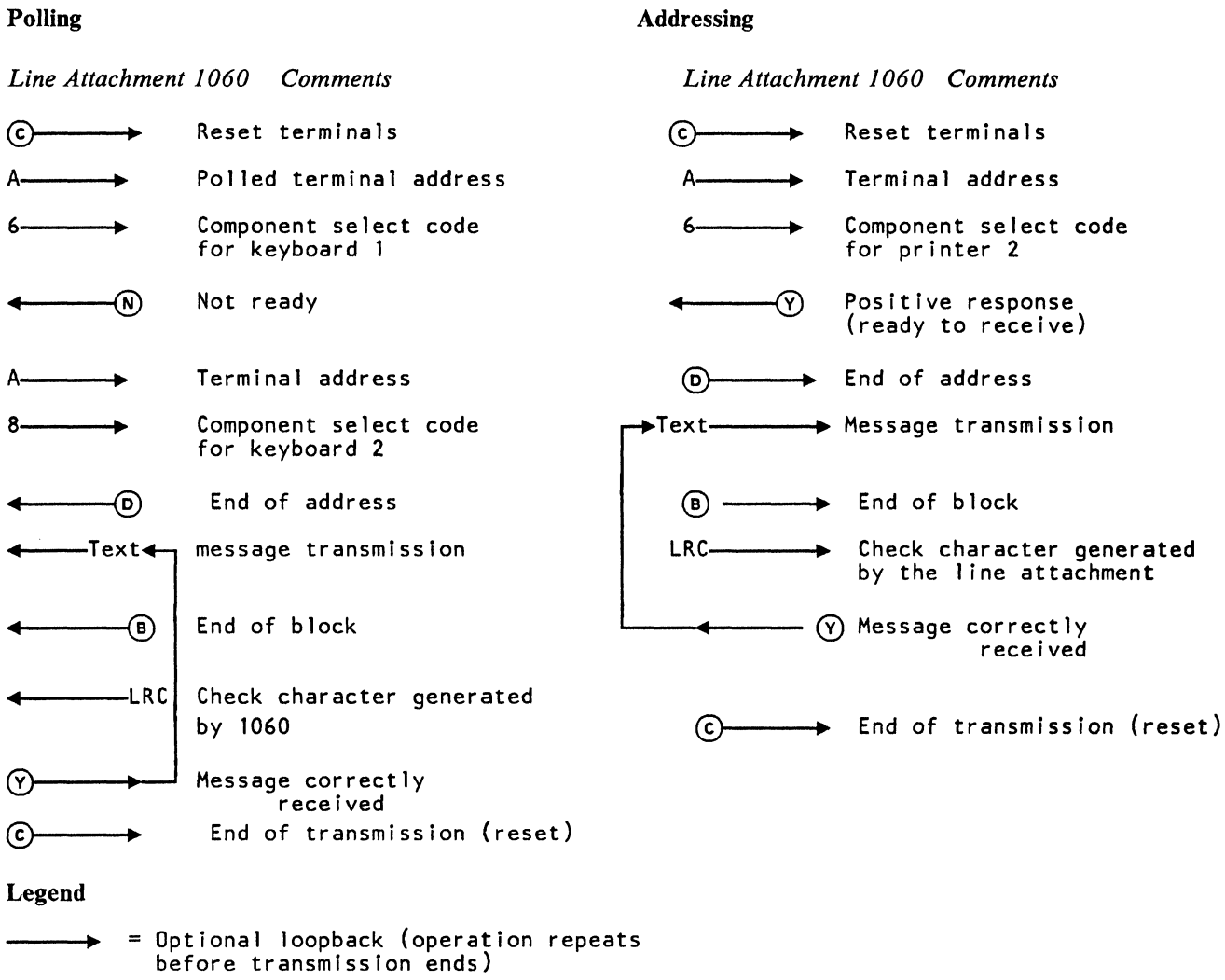
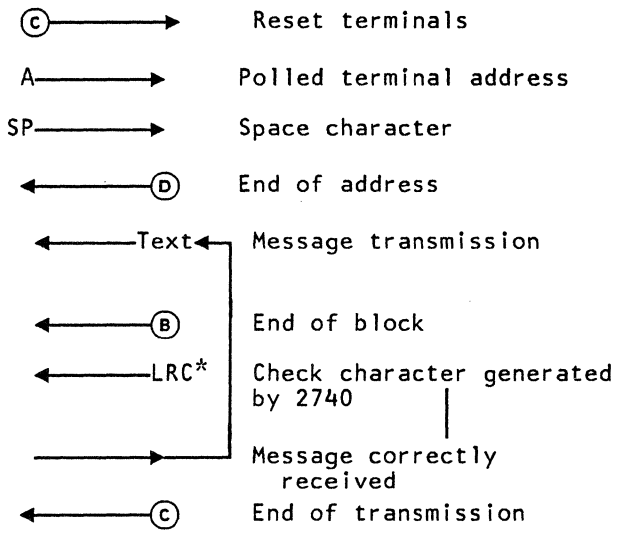


Figure 3. Line Control Sequences for IBM Terminal Control-Type 1 with 1060 Data Communication System

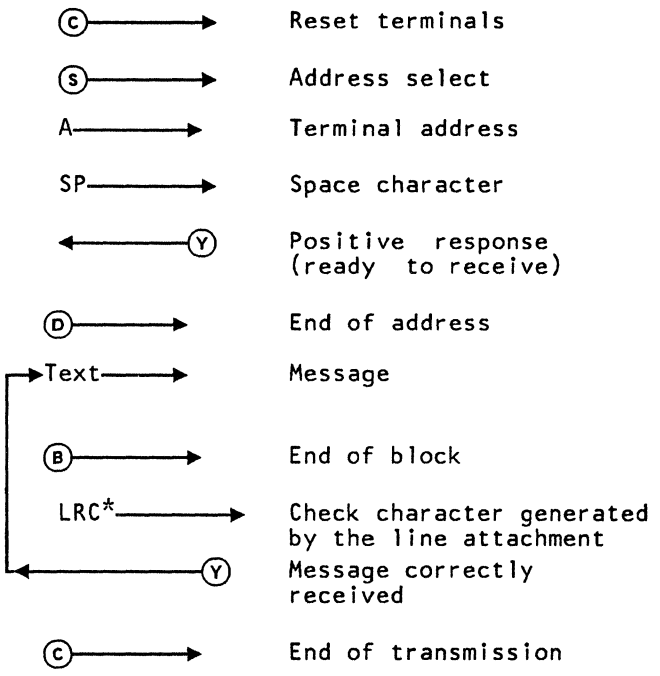
Polling

Line Attachment 2740 *Comments*



Addressing

Line Attachment 2740 *Comments*



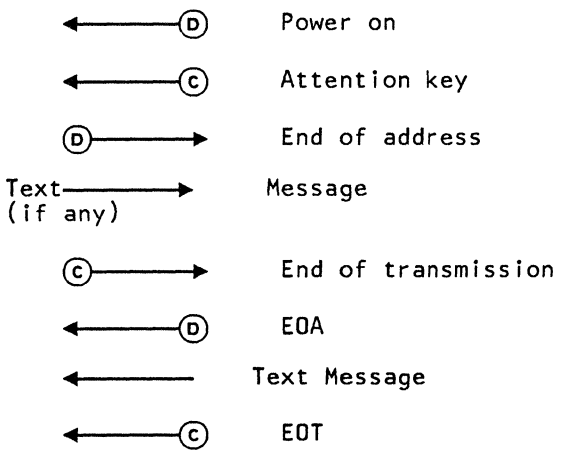
Legend

* Used only on 2740 equipped with the Record Checking feature

→ = Optional loopback (operation repeats before transmission ends)

Figure 4. Line Control Sequences for IBM Terminal Control-Type 1 with 2740 Data Communication Terminal

Line Attachment· 2741 *Comments*



Note:
This sequence must be followed for transmit or receive

Figure 5. Line Control Sequences for IBM Terminal Control-Type 1 with 2741 Communication Terminal

Addressing: Addressing is used to find out if a terminal is ready to receive data. Before addressing can be performed, the line attachment must be in control mode. This can be accomplished by giving a Write command that transmits a (C) (end of transmission) followed by the terminal address. The Write command must be chained to a Read command so that the response can be received as soon as possible. If (N) is received (negative response), the remote DTE cannot receive and the Read command ends with channel end, device end, and unit exception set. If a (Y) is received, the remote DTE is ready to receive and the Read command ends with channel end and device end.

Polling: Polling is used to find out if any remote DTE has a message to send. Before polling can be performed, the line attachment must be in control mode. This can be accomplished by giving a Write command that transmits a (C) followed by the polling address. The Write command should be chained to a Read command to obtain the response as quickly as possible. If an (N) is received, the remote terminal has nothing to transmit and the Read command ends with channel end, device end, and unit exception set. If nothing is received within three seconds, the command ends with channel end, device end, and unit check. In either case, the line attachment remains in control mode so that polling (or addressing) can continue. If a (D) is received, however, the polled terminal will transmit text. The line attachment therefore goes to text-in and lower case modes, and starts the 25-50 second timeout for the next character.

Inhibit

The Inhibit command is similar to the Read command, except that neither the three-second timeout at the beginning nor the 25-50 second timeouts between characters are started. The Inhibit command may be used whenever it is necessary for the line attachment to wait for data.

Prepare

The Prepare command allows the program to check for meaningful signals on the addressed communication line, and thus find out when a Read command should be given. The command is similar to a Read although no data is transferred to processor storage. When given, the Prepare command checks the communication line for a valid start bit. After a character can be assembled, channel end and device end are presented. The assembled character, however, is lost (not transferred to processor storage).

Enable

The Enable command puts the line attachment into the operational state. If the line attachment is not enabled, all commands (except Control No-op, Enable and Dial) are rejected with unit check set in the CSW and the command reject bit set in sense byte 0.

If the Enable command is issued to a privately-owned or leased line, channel end and device end are presented when the line attachment detects the 'data set ready' signal being raised by the modem. If 'data set ready' is not detected within three seconds of the line attachment raising the 'data terminal ready' signal, the Enable command ends with unit check set and the intervention required bit is set in sense byte 0.

If the Enable command is given to a switched line, the modem is then conditioned to answer an incoming call automatically, assuming that the modem has auto-answer capability. Channel end and device end are presented when an incoming call is received. No timeout is associated with the Enable command for a switched line.

Disable

The Disable command sets the addressed line attachment into the non-operational state. The disabled line attachment no longer executes any command (except Control No-op, Enable, Dial, Sense, Sense I/O, or Disable), nor reacts to incoming calls.

If the Disable command is given to a private or leased line, channel end and device end are presented after one second.

If given to a switched line, the command causes the modem to disconnect. A 25-second timeout (for modems using the CCITT option - Connect Data Set to Line (CDSTL) function) or a one-second timeout (for all other modems) is started, and if the modem has not disconnected before the timeout expires, the Disable command ends with unit check set and the timeout complete bit set in sense byte 0.

Dial

The Dial command causes the line attachment to be enabled and a data transfer from processor storage to the automatic calling unit (ACU) to be performed. If the Autocall feature is not installed in the CA or if the line attachment is not defined as switched, the Dial command is rejected and the line attachment is not enabled. The Dial command is also rejected if the line has not been disabled.

The access method is responsible for sending to the ACU the following characters only:

1. The correct number of dial digits, which are decimal values from 0 to 9.

2. The end of number (EON) or separator (SEP) character, if this character is required by the ACU.

The data is transferred from the location specified in CCW bits 8 to 31 and ascending locations until the count in CCW bits 48 to 63 is reduced to zero. In the data thus transferred, only bits 4 to 7 of each byte are actually placed on the interface (the digit lines) of the calling unit. The line attachment does not check the validity of the data sent to the ACU. The following table shows the relationship between the processor storage byte and the dial digit:

	Storage Byte								Equivalent Dial Digit
	0	1	2	3	4	5	6	7	
	x	x	x	x	0	0	0	0	0
	x	x	x	x	0	0	0	1	1
	x	x	x	x	0	0	1	0	2
The dial	x	x	x	x	0	0	1	1	3
operation	x	x	x	x	0	1	0	0	4
ignores	x	x	x	x	0	1	0	1	5
bits 0, 1	x	x	x	x	0	1	1	0	6
2, and 3	x	x	x	x	0	1	1	1	7
	x	x	x	x	1	0	0	0	8
	x	x	x	x	1	0	0	1	9
	x	x	x	x	1	1	0	0	EON
	x	x	x	x	1	1	0	1	SEP

The EON (end of number) character is an optional character which marks the end of the dial-digit group for those ACUs that require such an end character. Whether or not EON is used therefore depends on the type of ACU connected. Some ACUs recognize EON, some do not, and some can be set either to recognize or not recognize EON. ACUs which recognize EON may use the character as a signal that an answer may be expected from the remote station, or as a signal that dialing is complete (avoiding a timeout). The EON character should be inserted in processor storage as the last dial digit. EON is not required in the USA.

The separator character (SEP) can optionally be inserted in processor storage and included with the dial digits, following an access digit. For a private automatic branch exchange (PABX) extension, this character delays dialing to allow the dial tone to be returned from the public exchange.

The dial digits are presented to the ACU at a rate set by the ACU.

If a connection is not established before the timeout set by the ACU elapses, the 'abandon call and retry' (ACR) signal is activated by the ACU. This condition initiates a one-second delay. After the delay, the Dial command ends with unit check set in the CSW and the timeout complete bit set in sense byte 0.

A long timeout (60 seconds) is set in the Autocall feature to monitor the progress of the ACU. If this timeout expires, the Dial command ends with unit check set and intervention required in sense byte 0.

If the ACU has its power indicator off, or if the 'data line occupied' (DLO) signal is active during command initiation, the Dial command ends with unit check in the initial status and intervention required in sense byte 0.

Certain other error conditions in the ACU or associated modem cause the Dial command to terminate with unit check set and the lost data bit set in sense byte 0. "Error Information" in this chapter describes all error conditions which cause sense bits to be set.

Break

The Break command is used to stop transmission from a remote DTE. The Read type command in progress must be terminated with a Halt Device instruction, then the Break command can be given. The Break command causes a steady space level to be placed on the line for a duration that is determined by the count

in CCW bits 48 to 63. The count causes an appropriate number of bytes to be fetched from processor storage for timing purposes: at least five bytes must be specified. These bytes may contain any bit pattern because they are not transmitted over the line. When the count is reduced to zero, channel end and device end are presented.

> **Note:** The Break command must only be used if the remote DTE is equipped with a receive interrupt feature, which allows detection of the Break signal. For this reason, use of the Break command for Type 1 terminals should be established individually for each line when the CA is installed.

Poll

The Poll command allows the program to search a multipoint network for remote terminals that have a message to transmit. The Poll command provides an automatic procedure that relieves the program from having to give alternate Read and Write commands.

The Poll command causes data to be transferred from the processor storage location specified in CCW bits 8 to 31 to the addressed communication line. The data thus transmitted is a 'polling character sequence', which usually consists of a character that sets the control mode, the terminal address, and a character that specifies an I/O device such as a card reader or card punch (if any) at the remote station.

After transmission of the polling characters, the line attachment is put into receive status until either a reply is received or a timeout occurs. If a negative response (N) is received, the next polling character is fetched from processor storage and transmitted over the line. The line attachment again checks for a reply. This continues until the polling list is exhausted (all polling characters have been transmitted, which is detected by the length count reaching zero). The command will then be terminated with channel end and device end set. At this point it is recommended to branch back to the Poll command via a TIC command to keep a polling loop running until a reply is received.

If a timeout occurs before a reply is received, channel end, device end, and unit check are presented. If, however, a (D) is received, the Poll command ends with channel end, device end, and the status modifier (bit 33) set in the CSW. If command chaining has been specified, the current CCW address is incremented by 16 and the CCW at this location is fetched (this should be a Read because (D) indicates that a message will arrive). The first character thus read in will be the index character (which is excluded from LRC accumulation). The index character identifies the terminal from which the message is being received.

Examples of polling and addressing are shown in Figure 2 on page 10 to Figure 5 on page 12 .

Control No-Op

The Control No-op command performs no function at the line attachment. Channel end, device end, and any other status conditions that may exist are presented in the initial status.

Sense

The Sense command causes up to two bytes of sense information to be transferred from the line attachment to processor storage for inspection. A Sense command can be given at any time but should always be given when unit check is set in the CSW. For details of the sense information available see "Sense Information" in this chapter. Channel end and device end are set when the transfer of sense information to processor storage is complete.

Sense I/O

The Sense I/O operation transfers up to seven bytes defining the line configuration, as follows:

Byte	Meaning
0	Always hex FF
1	CPU Identification 1
2	CPU Identification 2
3	CPU Identification 3
4	Hex CA for communications adapter
5	Bit 0: zero Bit 1: zero Bit 2: one Bit 3: zero Bit 4: Not used Bit 5: Not used Bit 6: Autocall unit installed Bit 7: Not used
6	Bit 0: Permanent request to send Bit 1: Switched line Bit 2: Unit exception suppress Bit 3: Write interrupt Bit 4: Read interrupt Bit 5: Delay select 2 Bit 6: Delay select 1 Bit 7: Integrated modem with manual answer

Unit Status

The unit status shows the state of the addressed line attachment (which works as a subchannel).

The handling of the unit status is the same as in the 2703 with one notable difference. The CA presents exceptional situations relatively early. The ending conditions that are reported with condition code setting on the SIO instruction may, therefore, be different from those occurring with a 2703. For instance, an 'intervention required' (causing a 'unit check'), may be presented in response to an SIO instruction with initial status. In the 2703 the same situation would be reported by a separate interruption.

When the CA presents the 'unit check' bit in response to an SIO operation, this bit is not accompanied by 'channel end' and 'device end'. The unit status is recorded in bits 32 to 39 of the CSW. The bits have the following assignments:

Bit	Meaning
32	Attention (not used)
33	Status modifier
34	Control unit end
35	Busy
36	Channel end
37	Device end
38	Unit check
39	Unit exception

Status Modifier (Bit 33): The status modifier bit is set (together with channel end and device end) when a Poll command ends because a (D) is received from the polled terminal. The (D) indicates that text will follow. If command chaining is in progress, the status modifier causes the current CCW address to be incremented by 16, to indicate the CCW after the next sequential CCW to be fetched. This should be a Read or Inhibit command.

If an inline test is active on a line addressed by a Start I/O instruction, the busy and status modifier bits are presented (control unit busy indication). Secondary interrupt and control unit end follow.

Control Unit End (Bit 34): The control unit end bit is used to show that an inline test is over. The bit is presented by secondary interruption after busy has been reported in response to an SIO instruction (see status modifier above).

Busy (Bit 35): The busy bit is set if an inline test is running and the subchannel is busy. If a Start I/O or Test I/O instruction is given, condition code 1 is set in response.

Channel End and Device End (Bits 36 and 37): The channel end and device end bits are always presented together when the line attachment becomes available for a new command. Depending on the command, this may occur at an initial selection or later. Channel end and device end, with or without the status modifier, indicate normal or successful completion of a command. If unit check accompanies this status, a Sense command must be given to find the exact circumstances in which the command was completed.

Unit Check (Bit 38): The unit check bit, when set, shows that sense data is available. A Sense command must be given to retrieve the actual error condition. For a more detailed description of the causes of unit check being set, see "Sense Information" in this chapter.

Unit Exception (Bit 39): The unit exception bit, when set, indicates either a specific response or a situation that is unexpected. The meaning of unit exception is specific for each of the following commands:

1. For Write and Poll commands, unit exception indicates that the line was receiving at the time the command was issued.

2. For a Read or Inhibit command, unit exception indicates that a circle (C) (end of transmission) or circle (N) (negative response for polling/selection) has been received.

Note: To allow command chaining, unit exception must be inhibited. The CA configuration tool allows you to define whether or not unit exception is to be presented on reception of a circle (C) (end of transmission) character.

3. For a Prepare command, unit exception indicates that the command was ended prematurely by a Halt I/O or Halt Device instruction.

4. For an Enable or Dial command in switched network operation, unit exception indicates that the command was successfully halted by a Halt I/O instruction before the call was established.

Sense Information

Two bytes of sense information are available.

Sense Bytes 0 and 1

The bits in sense byte 0 have the assignments shown in the following table. See the last part of each bit description for the meaning of sense byte 1, which contains a check code associated with the bit last set in sense byte 0.

Bit	Meaning
0	Command reject
1	Intervention required
2	Bus out check (not used)
3	Equipment check
4	Data check
5	Overrun
6	Lost data
7	Timeout complete

A Sense command with a length count of one transfers this sense byte only, and no incorrect length indication is given. A Sense command with a length count of two or more transfers the two sense bytes.

However, an incorrect length indication is given if the length count is greater than two when the SLI bit (suppress length indication) is not set. All conditions indicated in sense byte 0 set unit check in the CSW.

Sense byte 1 consists of a CA check code (in hex), which indicates the reason (or the last reason, if more than one) for setting a bit in sense byte 0. These reasons are listed below under the relevant bit of sense byte 0.

Command Reject (Bit 0): This bit is set during command initialization if an invalid command is issued to a line attachment, or if the line attachment is in a state that does not allow the command to be executed. The command is immediately terminated, and unit check status is set in the CSW. The conditions causing command rejection are indicated by the hex code in sense byte 1 as follows:

Hex	
01	The Break command is issued to a line that does not have the read interrupt bit specified.
04	The Dial command is issued but autocall unit interface feature or switched network is not specified in the configuration table.
05	The Dial command is issued to a line attachment that has not been disabled (data terminal ready (DTR) was found on).
08	Eight immediate commands, for example No-op or Sense, are executed consecutively.
09	The command code in the CCW is invalid.

Intervention Required (Bit 1): The intervention required bit, when set, causes termination of the current command, and channel end, device end, and unit check are set in the CSW. The conditions causing intervention required to be set are indicated by the hex code in sense byte 1 as follows:

Hex	
20	The signal 'data set ready' is inactive during a Read, Inhibit, Write, Break, Prepare, or Poll command; or the signal 'receive line signal detect' is inactive during the execution of a Read, Inhibit, Prepare, or Poll command in the read state.
21	The 'data set ready' signal is inactive at command initiation of a Read, Inhibit, Break, Prepare, Write, or Poll command.
22	The 'clear to send' signal is not activated by the modem before the ten second timeout ends during Write or Poll command initiation, or during turnaround from read to write within the Poll command.
23	The 'clear to send' signal is inactive during execution of a Write or Break command, or during execution of the Write part of a Poll command.
25	In half-duplex operation (not 'permanent request to send'), the 'clear to send' signal is not dropped before the ten-second timeout occurs either at Write command termination, or at turnaround from write to read within a Poll command.
26	A continuous space signal is received for the time span of one character or longer during a Read, Inhibit, Prepare, or Poll command.
27	A timeout occurs on a switched line with permanent 'request to send' and no 'receive line signal detect'.

28 — A 'break' signal is received while a Write command is active. A 'break' signal is a continuous space condition lasting for two character cycles. The intervention required bit is set only if write interruption has been selected in the CA configurator. This is not an error condition.

29 — 'Data line occupied' (DLO) signal of the ACU is on during initiation or has turned off during execution of a Dial command.

2A — The ACU's 'power indicator' signal is inactive at initiation or execution of a Dial command.

2C — During the execution of the Dial command the ACU does not turn off or on 'present next digit', or does not turn on 'abandon call and retry', within 25 seconds in the following cases:

1. 'Call request' to the ACU is on, and 'present next digit' is not presented.
2. 'Digit present' to the ACU is on, and 'present next digit' has not dropped.
3. 'Digit present' to the ACU is off, and 'present next digit' is not presented.

2D — The ACU and modem present neither 'distant station connected' nor 'data set ready' nor 'abandon call and retry' within 60 seconds after all dialing digits and the 'digit present' off signal are presented to the ACU during execution of the Dial command.

2E — The 'data set ready' signal is not activated by the modem within three seconds after the 'data terminal ready' signal is presented to the modem during the execution of an Enable command on a non-switched line configuration.

30 — The line attachment is not enabled during the initiation of a Write, Poll, Break, Read, Inhibit, or Prepare command.

31 — An Enable command is issued to an already enabled line but 'data set ready' is not active, or 'data set ready' is on when Enable is issued to a switched line.

Bit 2: Not used.

Equipment Check (Bit 3): This bit is set if a CA or integrated modem hardware check is detected. A detected equipment check causes termination of the current command, and channel end, device end, and unit check to be set in the CSW. The hex code in sense byte 1 shows the reason for setting the equipment check bit as follows:

Hex

61 — A hangup occurs in the adapter.

62 — A machine check is detected indicating an error on the processor bus.

63 The loss of the internal clock signal is detected during the execution of a Write or Poll command.

64 Invalid adapter status.

Data Check (Bit 4): This bit is never set during execution of an Enable, Disable, Break, Sense I/O, Control No-op, or Dial command. It is set in the following situations, as indicated by the hex code in sense byte 1:

Hex

80 An LRC error is detected during execution of a Read or Inhibit command. The command continues to its normal end. This failure can be caused by noise on the transmission line or by an overrun condition.

82 A VRC error is detected in a character fetched from program storage during execution of a Write or Poll command. The command continues to its normal end.

84 While receiving during a Read, Inhibit, or Poll operation, either

- a VRC error is detected, or
- the data received is at space level at stop bit time.

The Poll command is terminated immediately, but the other commands continue to their normal ends.

85 The response to polling characters in a Poll command is neither circle (N) nor circle (D). The command is terminated immediately.

86 Circle (N) is received in text-out mode, indicating that the remote terminal received data with incorrect parity or an LRC error. The command is terminated immediately.

Overrun (Bit 5): The overrun bit can only be set, together with data check, during execution of a Read or Inhibit command. The setting of the overrun bit does not cause the command to terminate immediately but allows it to continue to its normal end. The bit is set in the following condition as indicated by the hex code in sense byte 1:

Hex

A0 A character overrun is detected in the line attachment at stop bit time during execution of a Read or Inhibit command.

Lost Data (Bit 6): This bit is never set during an Enable, Disable, Sense I/O, No-op, Write, Break, or Prepare operation. The conditions under which the lost data bit is set are as indicated by the hex code in sense byte 1:

Hex	
C0	A lost data condition is detected during the initiation of a Read or Inhibit command, indicating that at least one full character was received and lost before the command was issued. The command continues to its normal end.
C2	During the initiation of a Dial command, 'present next digit' is found on.
C4	During the initiation of a Dial command, 'distant station connected' is found on.
C5	During the execution of a Dial command, 'data set ready' goes on during the dialing sequence before the last digit is presented to the ACU.
C6	A channel stop (see Note), program check, or protection check occurs during the execution of a Read or Inhibit command, or the read part of a Poll command. The command is terminated immediately. **Note:** Channel stop during data transfer means that the length count has been reduced to zero without an ending character being received (assuming chain data is not specified).
C7	A Halt I/O instruction is issued when the line attachment is processing a Read or Inhibit command. This is not an error condition.

Timeout Complete (Bit 7): This bit is never set during execution of a Sense I/O, Control No-Op, Write, or Break command. When the timeout complete bit is set for the other commands, the command is terminated immediately. The conditions under which the bit is set are indicated by the hex code in sense byte 1 as follows:

Hex	
E2	'Receive data' is not stable, without change of level, for one or two character times before the end of the 25-50 second timeout. This timeout is started during the execution of a Read command.
E5	A three-second timeout occurs during the execution of a Read or Poll command while control mode is still set. A 25-50 second timeout occurs during the execution of a Read command while text mode is set. 'Timeout complete' is not set if 'data set ready' drops; intervention required is set instead. Similarly, if 'receive line detect' drops on a line which is connected to a switched network with 'permanent request to send' on, (that is, a duplex modem is installed) 'intervention required' is set, not timeout. The cause is a failure in the program or operator handling, resulting in an out of sequence situation with the remote terminal.

E6	The 'abandon call and retry' signal of the ACU turns on during initiation of a Dial command.
E7	The 'abandon call and retry' signal of the ACU turns on during execution of a Dial command. The cause is that the remote terminal has not answered the call.
E8	'Data set ready' does not fall before the end of the 25-second timeout during execution of the Disable command on a line connected to a switched network.
E9	'Receive line signal detect' or 'clear to send' is not activated by the modem before the end of the 25-second timeout. This timeout is initiated after 'data set ready' is activated during execution of an Enable command on a line connected to a switched network with 'permanent request to send'.
ED	The space ('break' signal) is received for more than 25 seconds when the Prepare command is active.

Chapter 3. US Telegraph Terminal Control - Type 2

The Telegraph Terminal Control - Type 2 (abbreviated TTC-2 in this manual) enables the communications adapter to communicate with asynchronous (start/stop) terminals under the ASCII line protocol. Such terminals are, for example, the Common Carrier Teletypewriter Exchange Service (TWX) Models 33/35/43 and the IBM 3101 Display Terminal, that operate at the remote end of switched or non-switched point-to-point communication lines. These terminals use the eight-level TWX code. The IBM 3101 is handled as a CPT-TWX 33/35 type terminal. The code structures are shown in Appendix A, Figure 15 on page 152.

TTC-2 supports up to eight communication lines and transmission speeds of 75, 110, 134.5, 300, 600, 1200, or 2400 bps. The desired speed, determined during planning, is specified during installation.

The five standard line control characters WRU, XON, ACK, XOFF and EOT can be used. These characters are selected by means of the TTC-2 configuration tool described in the system operator guide, or, where this tool is not available, by a manual operation.

In addition to the five standard line control characters, the carriage return (CR) character and one other character can be selected for line control.

Line Control Characters

Each line control character can be deactivated by the configuration tool, or, where this tool is not available, by a manual operation. Deactivated control characters are treated as data characters.

The line control characters are as follows:

WRU (Who are you?) (A1)

The WRU character is a request for station identification. Upon reception of this character, the remote terminal's automatic generator responds by sending the assigned identification. WRU, when received during a read operation, causes normal termination of the Read command.

XON (Transmitter On) (89)

XON causes a Read command to end normally.

ACK (Acknowledge) (61)

The ACK character is a positive reply to a received message. ACK causes normal ending of a Read command.

XOFF (Transmitter Off) (C8)

XOFF causes normal ending of a Read command.

EOT (End of Transmission) (20)

The EOT character indicates that transmission is completed. EOT causes a Read command to end with unit exception (plus channel end and device end) set in the channel status word (CSW).

CR (Carriage Return) (B0)

The CR character indicates end of line. CR, when selected as a control character causes a Read command to end (with channel end and device end).

Additional Control Character

One additional control character, consisting of any valid hex combination, can be specified at the operator's console (through the configuration tool, where available, otherwise by a manual operation). The additional character causes normal ending of a Read command.

Transmission Code

The transmission code used is the eight-level TWX code. The code structure is shown in the following table:

```
Storage Byte:                0  1  2  3  4  5  6  7
Interpreted as:              1  2  3  4  5  6  7  8
Transmission Code:  start    1  2  3  4  5  6  7  parity  stop  (stop)
```

The start bit and the stop bit(s) are added by the line attachment when the byte is transmitted and are deleted by the remote terminal when the byte is received. One or two stop bits can be selected by means of the configuration tool or a manual operation.

Note: The line attachment does not perform parity checking. The parity must be handled by the program support or by the application program according to the requirements of the remote terminal.

Commands

Hex	Command Code CCW BITS 0	1	2	3	4	5	6	7	Command
01	0	0	0	0	0	0	0	1	Write
02	0	0	0	0	0	0	1	0	Read
03	0	0	0	0	0	0	1	1	Control No-op
04	0	0	0	0	0	1	0	0	Sense
06	0	0	0	0	0	1	1	0	Prepare
08	0	0	0	0	1	0	0	0	Transfer-in-Channel
0A	0	0	0	0	1	0	1	0	Inhibit
0D	0	0	0	0	1	1	0	1	Break
13	0	0	0	1	0	0	1	1	No-op (Sadzero)
17	0	0	0	1	0	1	1	1	No-op (Sadone)
1B	0	0	0	1	1	0	1	1	No-op (Sadtwo)
1F	0	0	0	1	1	1	1	1	No-op (Sadthree)
27	0	0	1	0	0	1	1	1	Enable
29	0	0	1	0	1	0	0	1	Dial
2B	0	0	1	0	1	0	1	1	No-op (Set Line Mode)
2F	0	0	1	0	1	1	1	1	Disable
E4	1	1	1	0	0	1	0	0	Sense I/O

Note: The Sadzero, Sadone, Sadtwo, Sadthree, and Set Line Mode commands (hex 13, 17, 1B, 1F, and 2B) are accepted and treated as No-operations.

Read

The Read command causes data to be transferred from the addressed line to the processor storage address specified in bits 8 to 31 of the channel command word (CCW). Data transfer continues in ascending order of this address. To ensure that data is received on the communication line, a 25-second timeout is started when the Read command is given. If the time elapses before data is received, the Read command ends with unit check (bit 38 in the CSW) set and the timeout complete bit is set in sense byte 0. If a character is received before the 25-second timeout has elapsed, a 25-50 second timeout is started for each subsequent character.

As each character is received, the start and stop bits are removed. The operations within the CA and the way in which the Read command ends depend on the characters received, as described in the following text.

WRU, XON, ACK, or XOFF Received: If one of these characters is received, the Read command ends with channel end and device end.

EOT Received: If EOT is received, the Read command ends with channel end, device end, and unit exception.

Delete Characters Received: If delete characters (all 1-bits) are received, they are not transferred to the processor storage. They do, however, restart the timeout like all other characters.

Write

The Write command causes data to be transferred from the processor storage location specified in CCW bits 8 to 31 to the addressed communication line. Data transfer continues in ascending order of this address until the count in CCW bits 48 to 63 is reduced to zero or a 'break' signal (see Note 2 under 'WRITE INTERRUPTION FEATURE') is detected.

As the characters are transmitted, they are provided with one start bit and up to two stop bits. None of the control characters have any influence on the Write command.

The hexadecimal byte 'DF' (equal to ASCII code point 7/11, 'left brace character' with parity bit on), used as a pad character during Write command execution, causes the line attachment to send all write marks for one character time. It is used to maintain the line in mark-hold state for a number of character times (as specified by byte count in the CCW).

Write Interruption Feature: If a steady level for a time span of more than two characters (speed dependent see note 3) is sensed on the 'received data' line and the CA is configured for write interruption, the Write command ends with unit check, and intervention required is set in sense byte 0.

Notes:

1. The write interruption feature requires a full-duplex communication facility.

2. The 'break' signal is detected only if the write interruption configuration parameter is set.

3.

Line Speed in bps	**Equivalent space level in milliseconds for two characters**
75	293
110	200
134.5	164
300	73
600	37
1200	18
2400	9

Break

The Break command is used to stop transmission from the remote data terminal equipment (DTE). The Read type command in progress must be terminated with a Halt Device instruction, then the Break command can be given. The Break command causes a steady space level to be placed on the line for a duration that is determined by the count in CCW bits 48 to 63. The count causes an appropriate number of bytes to be fetched from processor storage for timing purposes: at least five bytes must be specified. These bytes may contain any bit pattern because they are not transmitted over the line. When the count is reduced to zero, channel end and device end are presented.

Note: The Break command must only be used if the remote DTE is equipped with a receive interrupt feature, which allows detection of the 'break' signal. For this reason, use of the Break command for TTC-2 terminals should be established for each line when the CA is installed.

Inhibit

The Inhibit command is similar to the Read command, except that neither the three-second timeout at the beginning nor the 25-50 second timeouts between characters are started. The Inhibit command may be used whenever it is necessary for the line attachment to wait for data.

Prepare

The Prepare command allows the program to check for meaningful signals on the addressed communication line, and thus find out when a Read command should be given. The command is similar to a Read although no data is transferred to processor storage. When given, the Prepare command checks the communication line for a valid start bit. After a character can be assembled, channel end and device end are presented. The assembled character, however, is lost (not transferred to processor storage).

Enable

The Enable command puts the line attachment into the operational state. If the line attachment is not enabled, all commands (except Control No-op, Enable and Dial) are rejected with unit check set in the CSW and the command reject bit set in sense byte 0.

If the Enable command is issued to a privately-owned or leased line, channel end and device end are presented when the line attachment detects the 'data set ready' signal being raised by the modem. If 'data set ready' is not detected within three seconds of the line attachment raising the 'data terminal ready' signal, the Enable command ends with unit check set and the intervention required bit is set in sense byte 0.

If the Enable command is given to a switched line, the modem is then conditioned to answer an incoming call automatically, assuming that the modem has auto-answer capability. Channel end and device end are presented when an incoming call is received. No timeout is associated with the Enable command for a switched line.

Disable

The Disable command sets the addressed line attachment into the non-operational state. The disabled line attachment no longer executes any command (except Control No-op, Enable, Dial, Sense, Sense I/O, or Disable), nor reacts to incoming calls.

If the Disable command is given to a private or leased line, channel end and device end are indicated after one second.

If given to a switched line, the command causes the modem to disconnect. A 25-second timeout (for modems using the CCITT option - Connect Data Set to

Line (CDSTL) function) or a one-second timeout (for all other modems) is started, and if the modem has not disconnected before the timeout expires, the Disable command ends with unit check set and the timeout complete bit set in sense byte 0.

Dial

The Dial command causes the line attachment to be enabled and a data transfer from processor storage to the automatic calling unit (ACU) to be performed. If the Autocall feature is not installed in the CA or if the line attachment is not defined as switched, the Dial command is rejected and the line attachment is not enabled. The Dial command is also rejected if the line has not been disabled.

The access method is responsible for sending to the ACU the following characters only:

1. The correct number of dial digits, which are decimal values from 0 to 9.

2. The end of number (EON) or separator (SEP) character, if this character is required by the ACU.

The data is transferred from the location specified in CCW bits 8 to 31 and ascending locations until the count in CCW bits 48 to 63 is reduced to zero. In the data thus transferred, only bits 4 to 7 of each byte are actually placed on the interface (the digit lines) of the calling unit. The line attachment does not check the validity of the data sent to the ACU. The following table shows the relationship between the processor storage byte and the dial digit:

	Storage Byte	**Equivalent Dial Digit**
	0 1 2 3 4 5 6 7	
	x x x x 0 0 0 0	0
	x x x x 0 0 0 1	1
	x x x x 0 0 1 0	2
The dial	x x x x 0 0 1 1	3
operation	x x x x 0 1 0 0	4
ignores	x x x x 0 1 0 1	5
bits 0, 1	x x x x 0 1 1 0	6
2, and 3	x x x x 0 1 1 1	7
	x x x x 1 0 0 0	8
	x x x x 1 0 0 1	9
	x x x x 1 1 0 0	EON
	x x x x 1 1 0 1	SEP

The EON (end of number) character is an optional character which marks the end of the dial-digit group for those ACUs that require such an end character. Whether or not EON is used therefore depends on the type of ACU connected. Some ACUs recognize EON, some do not, and some can be set either to recognize or not recognize EON. ACUs which recognize EON may use the character as a signal that an answer may be expected from the remote station, or as a signal that dialing is complete (avoiding a timeout). The EON character should be inserted in processor storage as the last dial digit. EON is not required in the USA.

The separator character (SEP) can optionally be inserted in processor storage and included with the dial digits, following an access digit. For a private automatic branch exchange (PABX) extension, this character delays dialing to allow the dial tone to be returned from the public exchange.

The dial digits are presented to the ACU at a rate set by the ACU.

If a connection is not established before the timeout set by the ACU elapses, the 'abandon call and retry' (ACR) signal is activated by the ACU. This condition initiates a one-second delay. After the delay, the Dial command ends with unit check set in the CSW and the timeout complete bit set in sense byte 0.

A long timeout (60 seconds) is set in the Autocall feature to monitor the progress of the ACU. If this timeout expires, the Dial command ends with unit check set and intervention required in sense byte 0.

If the ACU has its power indicator off, or if the 'data line occupied' (DLO) signal is active during command initiation, the Dial command ends with unit check in the initial status and intervention required in sense byte 0.

Certain other error conditions in the ACU or associated modem cause the Dial command to terminate with unit check set and the lost data bit set in sense byte 0. "Error Information" in this chapter describes all error conditions which cause sense bits to be set.

Sense

The Sense command causes up to two bytes of sense information to be transferred from the line attachment to processor storage for inspection. A Sense command can be given at any time but should be issued when unit check is set in the CSW. For details of the information transferred, see "Sense Information" in this chapter. Channel end and device end are set when transfer of the sense information to processor storage is complete.

Sense I/O

The Sense I/O command will return up to 7 bytes showing the appropriate line configuration.

Byte	Meaning
0	Always X'FF'
1	CPU identification 1
2	CPU identification 2
3	CPU identification 3
4	X'CA' for CA
5	Bit 0: SDLC line
	Bit 1: BSC line
	Bit 2: S/S line
	Bit 3: not used
	Bit 4: S/S, not used
	Bit 5: S/S, not used
	Bit 6: Autocall Unit installed
	Bit 7: S/S, not used
6	Bit 0: Permanent request to send
	Bit 1: Switched line
	Bit 2: Receive timeout inhibit
	Bit 3: S/S, Write interrupt
	Bit 4: S/S, Read interrupt
	Bit 5: S/S, Delay select 2
	Bit 6: S/S, Delay select 1
	Bit 7: S/S, Integrated modem with manual answer

Control No-Op

The Control No-op command performs no function at the line attachment. Channel end, device end, and any other status conditions that may exist are presented in the initial status.

Line Control Sequences

Examples of line control sequences for US Telegraph Terminal Control - Type 2 with Paper Tape Reader and TWX models 33/35 are shown in Figure 6 on page 33.

Keyboard Unattended, TWX Models 33 and 35

Line Attachment	*TWX 33/35*	*Comments*
Dial terminal	→	CA dials terminal to perform WRU function.
	← ID, XON	TPWX terminal gives identification code and go-ahead signal.
Text	→	Message sent.
XOFF, WRU	→	Go-ahead signal to TWX terminal.
	← ID, XON	TWX terminal identification and go-ahead.
Text	→	Message sent.
XOFF, EOT	→	Transmission finished; go on-hook.

Keyboard Attended, TWX Models 33 and 35

Line Attachment	*TWX 33/35*	*Comments*
Dial terminal	→	CA dials terminal to perform WRU function,
	← ID, XON	Identification code and go-ahead signal.
Text	→	Message sent.
XOFF	→	End of text.
CR, LF, DEL, XOFF	→	Go-ahead signal to terminal.
	← Text	Message sent.
	← XOFF	End of text.
Text	→	Message sent.
XOFF, EOT	→	End of text, end of transmission.

Paper Tape Reader Operation

Line Attachment	*Paper Tape Reader*	*Comments*
Dial terminal	→	CA dials tape terminal to perform WRU function.
	← ID, XON	Tape terminal identification and go-ahead to CA.
Text	→	Message sent.
XOFF	→	End of text.
XON, (1 to 4 chars), XOFF	→	Establishes need-to-know to terminal.
	← Text	Message sent.
	← XOFF	End of text.
Text	→	Message sent.
XOFF, EOT	→	End of text, end of transmission.

Figure 6. Examples of Line Control for US Telegraph Terminal Control - Type 2, with Paper Tape Reader and TWX Models 33/35

Unit Status

The unit status shows the state of the addressed line attachment (which works as a subchannel).

The handling of the unit status is the same as in the 2703 with one notable difference. The CA presents exceptional situations relatively early. The ending conditions that are reported with condition code setting on the SIO instruction may, therefore, be different from those occurring with a 2703. For instance, an 'intervention required' (causing a 'unit check'), may be presented in response to an SIO instruction with initial status. In the 2703 the same situation would be reported by a separate interruption.

When the CA presents the 'unit check' bit in response to an SIO operation, this bit is not accompanied by 'channel end' and 'device end'. The unit status is recorded in bits 32 to 39 of the CSW. The bits have the following assignments:

Bit	Meaning
32	Attention (not used)
33	Status modifier
34	Control unit end
35	Busy
36	Channel end
37	Device end
38	Unit check
39	Unit exception

Status Modifier (Bit 33): If an inline test is active on a line addressed by a Start I/O instruction, the busy and status modifier bits are presented (control unit busy indication). Secondary interrupt and control unit end follow.

Control Unit End (Bit 34): The control unit end bit is used to show that an inline test is over. The bit is presented by secondary interruption after busy has been reported in response to an SIO instruction (see status modifier above).

Busy (Bit 35): The busy bit is set if an inline test is running and the subchannel is busy. If a Start I/O or Test I/O instruction is given, condition code 1 is set in response.

Channel End and Device End (Bits 36 and 37): The channel end and device end bits are always presented together when the line attachment becomes available for a new command. Depending on the command, this may occur at an initial selection or later. Channel end and device end, with or without the status modifier, indicate normal or successful completion of a command. If unit check accompanies this status, a Sense command must be given to find the exact circumstances in which the command was completed.

Unit Check (Bit 38): The unit check bit, when set, shows that sense data is available. A Sense command must be given to retrieve the actual error condition. For a more detailed description of the causes of unit check being set, see "Sense Information" in this chapter.

Unit Exception (Bit 39): The unit exception bit, when set, indicates either a specific response or a situation that is unexpected. The meaning of unit exception is specific for each of the following commands:

1. For a Write command, unit exception indicates that the line was receiving at the time that the command was issued.

2. For a Read or Inhibit command, unit exception indicates that EOT (end of transmission) has been received.

3. For a Prepare command unit exception indicates that the command was ended prematurely by a Halt I/O or Halt Device instruction.

4. For an Enable or Dial command in switched network operation, unit exception indicates that the command was successfully halted by a Halt I/O before the call was established.

Sense Information

Two bytes of sense information are available. The bits in sense byte 0 have the following assignments:

Bit	Designation
0	Command reject
1	Intervention required
2	Bus out check (not used)
3	Equipment check
4	Data check
5	Overrun
6	Lost data
7	Timeout complete

A Sense command with a length count of one will transfer this sense byte only, and no incorrect length indication is given. A Sense command with a length count of two or more will transfer the two sense bytes. However, an incorrect length indication is given if the length count is greater than two and the SLI-bit (suppress length indication) is not set.

All conditions indicated in sense byte 0 set unit check in the CSW.

Sense byte 1 consists of a CA check code (in hex), which indicates the reason (or the last reason, if more than one) for setting the bit in sense byte 0. These reasons are listed below under the relevant bit of sense byte 0.

Command Reject (Bit 0): The command reject bit is set during command initialization if an invalid command is issued to a line attachment, or if the line attachment is in a state that does not allow the command to be executed. The command is immediately terminated, and unit check status is set in the CSW. The conditions causing command rejection are indicated by the hex code in sense byte 1 as follows:

Hex	
01	The Break command is issued to a line that does not have the read interrupt bit or permanent request to send bit set in the configuration table.
04	The Dial command is issued but autocall unit interface feature or switched network is not specified in the configuration table.
05	The Dial command is issued to a line attachment that has not been disabled (data terminal ready (DTR) was found on).
08	Eight immediate commands, for example No-op or Sense, are executed consecutively.
09	The command code in the CCW is invalid.

Intervention Required (Bit 1): The intervention required bit, when set, causes immediate termination of the current command, and channel end, device end, and unit check are set in the CSW when stored at I/O interruptions. The conditions causing intervention required to be set are indicated by the hex code in sense byte 1 as follows:

Hex	
20	The signal 'data set ready' is inactive during a Read, Inhibit, Write, Break or Prepare command; or the signal 'receive line signal detect' is inactive during the execution of a Read, Inhibit or Prepare command in the read state.
21	The 'data set ready' signal is inactive at command initiation of a Read, Inhibit, Break, Prepare, or Write command.
22	The 'clear to send' signal is not activated by the modem before the ten second timeout ends during Write command initiation.
23	The 'clear to send' signal is inactive during execution of a Write or Break command.
25	In half-duplex operation (not 'permanent request to send'), the 'clear to send' signal is not dropped before the ten-second timeout occurs at Write command termination.
26	A continuous space signal is received for one character time or longer during a Read, Inhibit or Prepare command.
27	A timeout occurs on a switched line with permanent 'request to send' and no 'receive line signal detect'.
28	A 'break' signal is received while a Write command is active. A 'break' signal is a continuous space condition lasting for two character cycles. The intervention required bit is set only if write interruption is selected in the CA configurator. This is not an error condition.

29	'Data line occupied' (DLO) signal of the ACU is on during initiation or has turned off during execution of a Dial command.
2A	The ACU's 'power indicator' signal is inactive at initiation or execution of a Dial command.
2C	During the execution of the Dial command the ACU does not turn off or on 'present next digit', or does not turn on 'abandon call and retry', within 25 seconds in the following cases: 1. 'Call request' to the ACU is on, and 'present next digit on' is not presented. 2. 'Digit present' to the ACU is on, and 'present next digit off' is not presented. 3. 'Digit present' to the ACU is off, and 'present next digit on' is not presented.
2D	The ACU and modem present neither 'distant station connected' nor 'data set ready' nor 'abandon call and retry' within 60 seconds after all dialing digits and the 'digit present off' signal are presented to the ACU during execution of the Dial command.
2E	The 'data set ready' signal is not activated by the modem within three seconds after the 'data terminal ready' signal is presented to the modem during the execution of an Enable command on a non-switched line configuration.
30	The line attachment is not enabled ('data terminal ready' bit is off in the UCW) during the initiation of a Write, Break, Read, Inhibit, or Prepare command.
31	An Enable command is issued to an already enabled line ('data terminal ready' on in the UCW), but 'data set ready' is not active, or 'data set ready' is on when Enable is issued to a switched line.

Equipment Check (Bit 3): The equipment check bit is set if a CA or integrated modem hardware check is detected. A detected equipment check causes immediate termination of the current command, and channel end, device end, and unit check to be set in the CSW when stored at I/O interruptions.

Hex	
61	A hangup occurs in the adapter.
62	A machine check is detected indicating an error on the processor bus.
63	The loss of the internal clock signal is detected during the execution of a Write command.
64	Invalid adapter status.

Data Check (Bit 4): The data check bit is never set during execution of an Enable, Disable, Break, Sense I/O, Control No-op, or Dial command. It is set only in the following situation, as indicated by the hex code in sense byte 1:

Hex	
80	An LRC error is detected during execution of a Read or Inhibit command. The command continues until its normal end. This failure can be caused by noise on the transmission line or by an overrun condition.
82	A VRC error is detected in a character fetched from program storage during execution of a Write command. The command continues to its normal end.
84	A VRC error is detected or the receive data is found to be at space level at stop bit time while receiving during a Read or Inhibit command. The commands continue to their normal ends.
86	Circle (N) is received in text-out mode, indicating that the remote terminal received data with incorrect parity or an LRC error. The command is terminated immediately.

Overrun (Bit 5): The overrun bit can only be set, together with data check, during execution of a Read or Inhibit command. The setting of the overrun bit does not cause the command to terminate immediately but allows it to continue to its normal end. It is set in the following condition as indicated by the hex code in sense byte 1:

Hex	
A0	A character overrun is detected in the line attachment at stop bit time during execution of a Read or Inhibit command.

Lost Data (Bit 6): The conditions under which the lost data bit is set are as follows, as indicated by the hex code in sense byte 1:

Hex	
C0	A lost data condition is detected during the initiation of a Read or Inhibit command, indicating that at least one full character was received and lost before the command was issued. The command continues to its normal end.
C2	During the initiation of a Dial command, 'present next digit' is found on.
C4	During the initiation of a Dial command, 'distant station connected' is found on.
C5	During the execution of a Dial command, 'data set ready' goes on during the dialing sequence before the last digit is presented to the ACU.

C6 — A channel stop (see Note), program check, or protection check occurs during the execution of a Read or Inhibit command. The command is terminated immediately.

Note: Channel stop means that during data transfer the length count is reduced to zero without an ending character being received (assuming chain data is not specified).

C7 — A Halt I/O instruction is issued when the line attachment is processing a Read or Inhibit command. This is not an error condition.

Timeout Complete (Bit 7): The timeout complete bit is never set during execution of a Sense I/O, Control No-op, Write, or Break command. When the timeout complete bit is set for the other commands, the command is terminated immediately. The conditions under which the timeout complete bit is set are indicated by the hex code in sense byte 1 as follows:

Hex

E2 — 'Receive data' is not steady, without change of level, for one or two character times before the end of the 25-second timeout. This timeout is started during the execution of a Read command.

E5 — A ten-second timeout occurs during the execution of a Read command while control mode is still set. A 25-50 second timeout occurs during the execution of a Read command while text mode is set. 'Timeout complete' is not set if 'data set ready' drops; intervention required is set instead. Similarly, if 'receive line detect' drops on a line which is connected to a switched network with 'permanent request to send' on, (that is, a duplex modem is installed) 'intervention required' is set, not timeout. The cause is a failure in the program or operator handling, resulting in an out of sequence situation with the remote terminal.

E6 — The 'abandon call and retry' signal of the ACU turns on during initiation of a Dial command.

E7 — The 'abandon call and retry' signal of the ACU turns on during execution of a Dial command. The cause is that the remote terminal has not answered the call.

E8 — 'Data set ready' does not fall before the end of the 25-second timeout during execution of the Disable command on a line connected to a switched network.

E9	'Line signal detect' or 'clear to send' is not activated by the modem before end of the 25-second timeout. This timeout is initiated after 'data set ready' is activated during execution of an Enable command on a line connected to a switched network with 'permanent request to send'.
ED	The space ('break' signal) is received for more than 25 seconds when the Prepare command is active.

Chapter 4. Binary Synchronous Communication Control

The binary synchronous communication (BSC) line control procedure comprises the command set and the line control characters and sequences required to communicate with BSC terminals or processor attachments. Figure 16 on page 153 and Figure 17 on page 154 in Appendix A show the code structures, including those of the line control characters.

Line Control Characters

SOH (Start of Heading) X'01', STX (Start of Text) X'02'

SOH and STX both cause the same action in receive as well as transmit operations: they set the line attachment to text mode. In text mode, block check character (BCC) accumulation is started and subsequent SOH or STX characters are treated as data. With the CA configuration tool (if available), a manual selection can be made to allow the first SOH or STX character to be included in BBC accumulation.

ETX (End of Text) X'03', ETB (End of Transmission BLOCK) X'26'

ETX and ETB both cause the same action in receive as well as transmit operations: they end text mode at the line attachment. The current operation is ended unless transparent mode is set. If error index byte (EIB) mode was specified (by a Set Mode command), reception of ETX or ETB causes an EIB to be stored next to ETX or ETB as described under "Read" command in this chapter.

ENQ (Inquiry) X'2D'

ENQ ends a Read command but has no effect on a Write command. When used in the data string transmitted during a Poll command, ENQ causes a line turnaround (a change from transmit to receive mode).

ACK0 (Acknowledgement) X'1070', ACK1 X'1061'

ACK0 and ACK1 end a Read command and cause channel end and device end to be set. The line attachment remains in receive mode; ACK0 and ACK1 have no effect on a Write command. For the character sequences ACK0 and ACK1, see "(DLE) Data Link Escape" under "Line Control Characters" in this chapter.

NAK (Negative Acknowledgement) X'3D'

NAK ends a Read command and causes channel end and device end to be set. The line attachment remains in receive mode; NAK has no effect on a Write command.

EOT (End of Transmission) X'37'

EOT ends a Read command (if received while the line attachment is not in text mode) but has no effect on Write.

ITB (Intermediate Text Block) X'1F'

The ITB character does not end a Read or Write command but resets block check character accumulation, causing the accumulated value to be transmitted (during a Write command) or an EIB to be stored (during a Read command if error index byte mode was specified). Transmission or reception then continues with new BBC accumulation.

DLE (Data Link Escape) X'10'

The DLE character has no function when transmitted or received alone. If one specific character immediately follows DLE, a sequence with control functions is recognized. For example, DLE coupled with 70 (hex) is the ACK-0 reply; DLE coupled with 61 (hex) is the ACK-1 reply; DLE with 6B (hex) is the wait before transmit (WACK) reply. All of these sequences terminate a Read command. DLE/STX sets transparent mode (EBCDIC only). (For details, see the descriptions of individual commands in this section.)

SYN (Synchronization) X'32'

The SYN character is used ahead of a transmission and is inserted into the message stream at one-second intervals to establish and maintain synchronization.

Transmission Code

The transmission code used for binary synchronous communication is either EBCDIC or ASCII (ISO 646 or CCITT No. 5). The code structure is:

```
Storage byte:          0 1 2 3 4 5 6 7
EBCDIC character:      0 1 2 3 4 5 6 7
ASCII relation:        - 7 6 5 4 3 2 1
```

When ASCII characters are transmitted, the bit position shown as a dash (this bit is zero while in storage) is replaced by an odd parity bit. When ASCII characters are received, the parity bit is stripped off and zero is stored in its bit position. Regardless of the code used, the low-order bit (bit 7 in EBCDIC, bit 1 in ASCII) is always transmitted first.

Commands

Hex	Command Code CCW BITS 0	1	2	3	4	5	6	7	Command
01	0	0	0	0	0	0	0	1	Write
02	0	0	0	0	0	0	1	0	Read
03	0	0	0	0	0	0	1	1	Control No-op
04	0	0	0	0	0	1	0	0	Sense
06	0	0	0	0	0	1	1	0	Prepare
08	0	0	0	0	1	0	0	0	Transfer-in-Channel
09	0	0	0	0	1	0	0	1	Poll
13	0	0	0	1	0	0	1	1	No-op (Sadzero)
17	0	0	0	1	0	1	1	1	No-op (Sadone)
1B	0	0	0	1	1	0	1	1	No-op (Sadtwo)
1E	0	0	0	1	1	1	1	0	Address Prepare (Adprep)
1F	0	0	0	1	1	1	1	1	No-op (Sadthree)
23	0	0	1	0	0	0	1	1	Set Mode
27	0	0	1	0	0	1	1	1	Enable
29	0	0	1	0	1	0	0	1	Dial
2B	0	0	1	0	1	0	1	1	No-op (Set Line Mode)
2F	0	0	1	0	1	1	1	1	Disable
E4	1	1	0	1	0	1	0	0	Sense I/O

Note: The Sadzero, Sadone, Sadtwo, Sadthree, and Set Line Mode commands (hex 13, 17, 1B, 1F, and 2B) are treated as no-operations.

Read

Whenever the binary synchronous line attachment is enabled and is not executing a write-type command, it monitors the 'receive data' for activity. The line attachment decodes the last eight bits received. If these eight bits do not represent a SYN character, monitoring continues. If a SYN character is decoded, the next eight bits are gated in and are subsequently checked for their identity with a SYN character. If the second byte thus received is a SYN character, then the line attachment has established character phase, which is a prerequisite for read operations.

When a Read command is given, the line attachment may or may not have character phase. If character phase has already been established, execution of the Read command progresses. If, however, more than one non-SYN character comes in before the Read command is given, the command ends with unit check and the lost data bit is set in sense byte 0.

The Read command causes a three-second timeout to be started. If character phase cannot be established before the three seconds have elapsed, the command ends with unit check set and the timeout complete bit is set in sense byte 0.

If character phase can be established in time, the line attachment checks whether a control character is received within three seconds after reception of a SYN character. If a control character (other than SYN) cannot be found in time, the command ends with unit check set and the timeout complete bit set in sense byte 0. If character phase can be established and there is no timeout, further actions within the line attachment depend on the data that is actually received, as described in the following text:

1. If a DLE acknowledgement sequence (NAK or ENQ) is received, the Read command ends with channel end and device end set. If an EOT is received, unit exception is also set.

2. If an SOH or STX character is received, the line attachment sets text mode. In text mode, further SOH or STX characters are no longer recognized as control characters, but are treated as text. In addition, the BCC accumulation begins. If the CA configuration tool is available, the adapter can be configured to include the initial SOH or STX in BCC accumulation, or to exclude them. The SYN characters (which are included in the data stream at one-second intervals) are not transferred to processor storage but are used to maintain character phase. If characters are received while the line attachment is in text mode, a pattern of at least two SYN characters followed by a non-SYN character must be received before three seconds have elapsed. This is to prevent a situation in which the line attachment has lost character synchronization.

   As text reception continues, each character updates the BCC. Being in text mode, the line attachment is sensitive to the following ending characters:

   a. If ETX or ETB is received, the line attachment leaves text mode. Block check character accumulation stops and the attachment awaits the BCCs from the remote station. Upon reception, these characters are compared with the value accumulated locally. The block check characters are equal to two CRC bytes when EBCDIC characters are transferred, and one LRC byte in the case of ASCII characters. If the result is equal, channel end and device end are presented for the Read command. If the result shows not equal, unit check is also presented and the data check bit is set in sense byte 0. If EIB mode is specified when the CA is installed or is set by a Set Mode command, an error index byte is stored next to the ETX or ETB character.

   b. If ENQ is received, the line attachment leaves text mode but does not compare BCCs. Channel end and device end are presented for the Read command.

The foregoing description covers the basic aspects of a Read command. There are three variations, however, which alter the behavior of the line attachment during execution of a Read command.

1. If an ITB character is received, the attachment stops BCC accumulation, receives the BCCs from the remote station, and compares these with the accumulated value without ending the Read command. Reading continues with the next block for which BCC accumulation is started from an initial value. If the BCC comparison gives an unequal result, data check is set in the sense byte, but this data check is presented to the program only at the end of the read operation.

   If EIB mode is specified when the CA is installed, or is set by a Set Mode command, reception of an ITB character causes the same BCC comparison but, in addition, an EIB is stored following the ITB. This EIB may contain all zeros or have bit 4 (data check) and/or bit 5 (overrun) turned on, depending on the type of error. In this way, each data block has its own ITB character (and its own EIB, if EIB mode is in effect). The Read command ends when

ETX or ETB is received. If EIB mode is specified, an EIB is stored next to the ending character. At that time, unit check is set in the status (with data check and overrun in sense byte 0) if such an error occurs.

2. If the DLE/STX sequence is received, the line attachment sets transparent mode. In transparent mode, the line attachment is insensitive to all single control characters; which means that all possible codes are treated as text. However, in transparent mode the attachment is sensitive to the data link escape sequences, which all start with the DLE character. To differentiate between DLE as text data and a DLE sequence, the line attachment examines each DLE and the character that immediately follows it. The action depends on the character that follows DLE. Four control actions are specified:

   a. If DLE is followed by another DLE, the first DLE is ignored and the second DLE, inserted by the transmitting station, is transferred to processor storage. Transparent reading continues.

   b. If a SYN character follows DLE, the DLE and SYN characters are ignored. The three-second timeout is restarted and transparent reading continues. SYN characters that do not follow DLE characters are recognized as data.

   c. If an ITB character follows DLE, the line attachment leaves transparent mode but not text mode and continues reading. The BCC is compared and the EIB is stored (if EIB mode is specified). If, thereafter, DLE/STX is received again, the line attachment returns to transparent mode.

   d. If an ETB or ETX character follows DLE, the Read command ends with channel end and device end set. This terminates transparent mode. ETB or ETX characters that do not follow a DLE character are treated as data.

3. During execution of a Read command, the line attachment may not receive a character that sets text mode (or transparent text mode). When not in text mode, the line attachment is sensitive not only to the control characters that set text mode or end the command, but also to all DLE sequences that consist of DLE followed by any of the characters in column 3 of the ASCII code table Figure 17 on page 154 or columns 6 and 7 in the EBCDIC table Figure 16 on page 153. Most of these sequences have no particular assignment but some have been agreed upon as a programming convention in IBM support programs (access methods).

   ACK0, ACK1, WACK, RVI (reverse interruption), DLE/EOT (switched line disconnect signal), are examples of some of these conventions. All of these assignments, however, concern only the program. For example, ACK0 and ACK1 are positive acknowledgements with a built-in count that alternates 0, 1, 0, 1 so that the program can determine whether an acknowledgement is missing.

   Reverse interruption is a request from the remote station asking the program to stop transmitting and issue a Read command so that a message can be put through. The logical meaning of these DLE sequences is ignored by the line attachment.

When not in text mode, the line attachment recognizes any of the DLE sequences consisting of DLE followed by any of the characters in column 3 in the ASCII code table (or columns 6 and 7 in the EBCDIC table) as a signal to terminate the command with channel end and device end.

Write

The Write command causes data to be transferred from the processor storage location specified in CCW bits 8 to 31 to the line attachment, for transmission to the remote terminal. When the Write command is given, the line attachment stops its continuous search for synchronization unless it is in character phase. If character phase is already established (which is an exceptional condition), the Write command ends with unit exception. Unit exception in response to a Write command indicates that a Read command should be issued because of incoming data (some data may already have been lost).

If character phase has not been established at the time a Write command is given (which is the normal case), the line attachment transmits a pad character. If modem clocking is used, the pad character is followed by two SYN characters. If business-machine (internal clocking) is used, that is, the receiving line attachment maintains the bit synchronization, the pad character is followed by two bit-synchronization characters (hex 55), and two SYN characters.

The SYN characters are immediately followed by the data from processor storage. The data is interspersed with double SYN characters or a DLE-SYN sequence at one-second intervals. The detailed actions within the line attachment depend on the data transmitted, as follows:

1. If control characters such as ENQ, NAK or EOT, or character sequences such as ACK0, ACK1, WACK or RVI are transmitted, no action occurs and the Write command does not end. The receiving station, however, does terminate the corresponding Read command.

2. When the SOH or STX character is transmitted, the line attachment sets text mode, which means that BCC accumulation is reset and begins from an initial value. (If the CA configuration tool is available, the adapter can be configured to include the initial SOH or STX in BCC accumulation, or to exclude them.) Further SOH or STX characters are not treated as control characters, but as ordinary text data.

3. If an ETX or ETB character is transmitted, the line attachment leaves text mode and transmits the accumulated BCC characters. Channel end and device end are then presented for the Write command.

The foregoing text describes a basic Write operation. If, however, EIB mode or transparent text mode has been specified, the line attachment is sensitive to certain control characters as follows:

1. If an ITB character is transmitted, the line attachment transmits the BCC value accumulated up to this point. This value allows the receiving station to compare and to store the appropriate error index byte if EIB mode has been specified. Execution of the Write command continues, with a new BCC accumulation.

2. If the character sequence DLE/STX is transmitted, the line attachment sets transparent text mode. Transparent text mode has the following consequences:

   a. If the data string transmitted contains a DLE character, the line attachment generates a second DLE, which it sends out following the first DLE. This allows the receiving station to differentiate between a DLE control sequence and a DLE character that is treated as data.

   b. If a SYN character is fetched from processor storage and transmitted, no action occurs. The automatically inserted SYN characters for maintaining synchronization are, however, each preceded by a DLE. This allows the receiving station to differentiate between SYN characters that are data and SYN characters that are inserted for synchronization only.

   c. If the sequence DLE/ETX or DLE/ETB is transmitted, the block ending sequence is not recognized. Any DLE is automatically doubled by insertion of another DLE, thus altering the sequence to DLE/DLE ETX or DLE/DLE/ETB and this has no effect. For this reason, a Write command in transparent mode continues until the count in CCW bits 48 to 63 is reduced to zero. Another Write command must be given within three seconds unless the explicit Write command is chained to the first one. The line attachment is in the transparent wait state, in which it rejects all commands except Write and Control No-op. In the second Write command, the sequence DLE/ETX is not altered by the extra DLE and is, therefore, accepted as a block ending sequence by the remote station.

   d. If DLE/ITB is to be transmitted, this sequence must also be sent by a separate Write command. DLE/ITB ends transparency and must be followed by transparent or non-transparent text, or by ETX.

Prepare

The Prepare command provides the program with a means to find out when a Read command should be given. This Read should be chained to the Prepare command.

When the Prepare command is given, the attempts to obtain character phase are monitored. If character phase has already been established, channel end and device end are presented in the initial status for the Prepare command, otherwise they are given when character phase is actually obtained. No data transfer occurs and no timeouts are associated with the Prepare command. The first data byte of the incoming message is read into storage by the chained Read command.

Address Prepare

The Address Prepare command provides the means to monitor the receive line for a tributary station address.

All BSC-configured lines of the communication adapter have two tributary station addresses associated (per default). This allows any BSC line to connect to a multipoint network as a tributary station. The master station in such a network uses a tributary station address to poll or select a station. If several stations (on the same receive line) have the same address assigned, the master station can select them as a group simultaneously.

The Address Prepare command enables the line attachment to monitor the receive line for either of the assigned tributary station addresses. Since Address Prepare does not transfer any data, two Read commands must be chained to it to fetch either the selection address or the poll address into storage, whichever comes in.

When Address Prepare is issued, the line attachment monitors the line for SYN, SYN, EOT which indicates the end of any ongoing transmission and puts the attachment into a mode in which it can recognize its station addresses. Further actions depend on the type of address received:

1. If one of its selection addresses (an address with bit 2 set to 1) is received, Address Prepare completes with 'channel end' and 'device end', and will, therefore, chain to the adjacent Read (which fetches the selection address).

2. If one of its polling addresses (an address with bit 2 set to zero) is recognized, Address Prepare completes with the status modifier. This causes skipping of the adjacent Read and chaining to the next one (which fetches the polling address).

Tributary Station Address: Both addresses of a line are set to X'40' per default, but this can be changed using a menu at the processor's operator console. (See *"IBM 4361 Processors, Operating Procedures"*, Form No. GA33-1570.) One address may be the group address, the other may be used as individual station address (or as another group address). An address becomes a group address by being assigned to more than one station.

Because bit 2 in the address byte defines polling (when 0) or selection (when 1), only addresses with bit 2 set to zero, such as X'40', X'41', X'5F' and so forth may be assigned. When the line code is ASCII, only addresses with bit 0 and bit 2 set to zero (and not exceeding X'5F') are valid. Also, no codes representing BSC-control characters are allowed.

Enable

The Enable command puts the line attachment into the operational state. If the line attachment is not enabled, all commands (except Control No-op, Enable, Dial, Set Mode Sense, Sense I/O, and Disable) are rejected with unit check set in the CSW and the command reject bit set in sense byte 0.

If the Enable command is issued to a privately-owned or leased line, channel end and device end are presented when the line attachment detects the 'data set ready' signal being raised by the modem. If 'data set ready' is not detected within three seconds of the line attachment raising the 'data terminal ready' signal, the Enable command ends with unit check set and the intervention required bit is set in sense byte 0.

If the Enable command is given to a switched line, the modem is then conditioned to answer an incoming call automatically, assuming that the modem has auto-answer capability. Channel end and device end are presented when an incoming call is received. No timeout is associated with the Enable command for a switched line.

Disable

The Disable command sets the addressed line attachment into the non-operational state. The disabled line attachment no longer searches for character phase, nor executes any command (except Control No-op, Enable, Dial, Sense, Sense I/O, Disable or Set Mode), nor reacts to incoming calls.

If the Disable command is given to a private or leased line, channel end and device end are indicated after one second.

If given to a switched line, the command causes the modem to disconnect. A 25-second timeout (for modems using the CCITT option - Connect Data Set to Line (CDSTL) function) or a one-second timeout (for all other modems) is started, and if the modem has not disconnected before the timeout expires, the Disable command ends with unit check set and the timeout complete bit set in sense byte 0.

Poll

The Poll command provides a means of requesting several remote stations, one after the other, to transmit data to the line attachment. The command is normally used in a multipoint network where several satellite stations are connected to the same receive line, but it can also be used in a point-to-point installation.

When the Poll command is given, the line attachment transmits the pad characters followed by two SYN characters. The SYN characters are followed by data that is fetched from the processor storage location specified in CCW bits 8 to 31, and ascending addresses. This data usually consists of a station address and ends with the ENQ character. Up to this point there is no difference between the Poll command and a normal Write command.

As data is being transmitted, however, the line attachment monitors the outgoing data stream, and when ENQ is detected the next character is fetched from storage but not transmitted; it is retained in the line attachment as the index character. The line attachment goes into receive mode without ending the Poll command. A

three-second timeout is started and the search for character phase begins. Further actions by the line attachment depend on the state of the remote station, as described in the following text.

> **Note:** The Poll command must end with an EOT as the last character in the poll list.

Unsuccessful Poll: If the remote station is inactive, character phase cannot be obtained. The three-second timeout elapses in the line attachment, causing the Poll command to end with channel end, device end, and status modifier bits set.

If the Poll command is chained, the next command is skipped (because the status modifier is set) and the next sequential command after the skipped command (which is usually a Read) is terminated with unit check set and the timeout complete bit set in the sense byte. The index byte (previously fetched) is returned to processor storage to an address specified by the Read command.

Remote Station Has Nothing to Send: If the remote station is transmitting SYN characters, the line attachment obtains character phase before the timeout elapses. When character phase is obtained, the line attachment checks whether the first non-SYN character received is the EOT character.

If the first non-SYN character is EOT, the remote station has nothing to send. The line attachment goes back to transmit mode and starts again to transmit the pad character(s) followed by two SYN characters. The polling data is then fetched from processor storage and, when the ENQ character is detected, the line attachment fetches the next index byte and changes to receive mode as before.

Successful Poll: If character phase is obtained and the first non-SYN character is not EOT, the Poll command ends with channel end, device end, and status modifier bits set.

If the Poll command is chained, the status modifier bit causes the next sequential command to be skipped and the next sequential command after the skipped command is executed. Since this command is usually a Read command, the line attachment then reads in the message from the remote station.

Before the first character is transferred to processor storage, however, the line attachment returns the index byte (previously fetched) to processor storage as an identifier for the message that follows, so that the program knows which remote station has responded.

> **Note:** Polling can also be done by properly chained alternate Write and Read commands.

Dial

The Dial command causes the line attachment to be enabled and a data transfer from processor storage to the automatic calling unit (ACU) to be performed. If the Autocall feature is not installed in the CA or if the line attachment is not defined as switched, the Dial command is rejected and the line attachment is not enabled. The Dial command is also rejected if the line has not been disabled.

The access method is responsible for sending to the ACU the following characters only:

1. The correct number of dial digits, which are decimal values from 0 to 9.

2. The end of number (EON) or separator (SEP) character, if this character is required by the ACU.

The data is transferred from the location specified in CCW bits 8 to 31 and ascending locations until the count in CCW bits 48 to 63 is reduced to zero. In the data thus transferred, only bits 4 to 7 of each byte are actually placed on the interface (the digit lines) of the calling unit. The line attachment does not check the validity of the data sent to the ACU. The following table shows the relationship between the processor storage byte and the dial digit:

	Storage Byte	**Equivalent Dial Digit**
	0 1 2 3 4 5 6 7	
	x x x x 0 0 0 0	0
	x x x x 0 0 0 1	1
	x x x x 0 0 1 0	2
The dial operation ignores bits 0, 1 2, and 3	x x x x 0 0 1 1	3
	x x x x 0 1 0 0	4
	x x x x 0 1 0 1	5
	x x x x 0 1 1 0	6
	x x x x 0 1 1 1	7
	x x x x 1 0 0 0	8
	x x x x 1 0 0 1	9
	x x x x 1 1 0 0	EON
	x x x x 1 1 0 1	SEP

The EON (end of number) character is an optional character which marks the end of the dial-digit group for those ACUs that require such an end character. Whether or not EON is used therefore depends on the type of ACU connected. Some ACUs recognize EON, some do not, and some can be set either to recognize or not recognize EON. ACUs which recognize EON may use the character as a signal that an answer may be expected from the remote station, or as a signal that dialing is complete (avoiding a timeout). The EON character should be inserted in processor storage as the last dial digit. EON is not required in the USA.

The separator character (SEP) can optionally be inserted in processor storage and included with the dial digits, following an access digit. For a private automatic branch exchange (PABX) extension, this character delays dialing to allow the dial tone to be returned from the public exchange.

The dial digits are presented to the ACU at a rate set by the ACU.

If a connection is not established before the timeout set by the ACU elapses, the 'abandon call and retry' (ACR) signal is activated by the ACU. This condition initiates a one-second delay. After the delay, the Dial command ends with unit check set in the CSW and the timeout complete bit set in sense byte 0.

A long timeout (60 seconds) is set in the Autocall feature to monitor the progress of the ACU. If this timeout expires, the Dial command ends with unit check set and intervention required in sense byte 0.

If the ACU has its power indicator off, or if the 'data line occupied' (DLO) signal is active during command initiation, the Dial command ends with unit check in the initial status and intervention required in sense byte 0.

Certain other error conditions in the ACU or associated modem cause the Dial command to terminate with unit check set and the lost data bit set in sense byte 0.

Set Mode

The Set Mode command allows the program to specify whether or not the line attachment is to operate in EIB mode. See the Read command description in this chapter for more information on EIB mode. One byte is used for specifying EIB mode; the bits have the following meanings:

Bit	Meaning
0	Not used
1	EIB mode
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Not used

Control No-Op

This command terminates immediately with the channel end and device end bits set in the unit status.

Sense

The Sense command causes two bytes of sense information to be transferred to the processor storage location specified in bits 8 to 31 of the CCW. The contents of the sense bytes are described in "Sense Information" in this chapter.

Sense I/O

The Sense I/O operation transfers up to seven bytes defining the line configuration, as follows:

Byte	Meaning
0	Always hex FF
1	CPU Identification 1
2	CPU Identification 2
3	CPU Identification 3
4	Hex CA for communications adapter
5	Bit 0: zero Bit 1: one Bit 2: zero Bit 3: zero Bit 4: ASCII mode Bit 5: Business machine clocking Bit 6: Autocall unit installed Bit 7: Not used (can be 0 or 1)
6	Bit 0: Permanent request to send Bit 1: Switched line Bit 2: New synchronization Bit 3: Connect data set to line Bit 4: Not used (can be 0 or 1) Bit 5: Error index byte (EIB) mode Bit 6: High speed line Bit 7: Integrated modem with manual answer

Unit Status

The handling of the unit status is the same as in the 2703 with one notable difference. The CA presents exceptional situations relatively early. The ending conditions that are reported with condition code setting on the SIO instruction may, therefore, be different from those occurring with a 2703. For instance, an 'intervention required' (causing a 'unit check'), may be presented in response to an SIO instruction with initial status. In the 2703 the same situation would be reported by a separate interruption.

When the CA presents the 'unit check' bit in response to an SIO operation, this bit is not accompanied by 'channel end' and 'device end'.

The unit status is recorded in bits 32 to 39 of the CSW. The bits are assigned as follows:

Bit	Meaning
32	Attention (not used)
33	Status modifier
34	Control unit end
35	Busy
36	Channel end
37	Device end
38	Unit check
39	Unit exception

Status Modifier (Bit 33): The status modifier bit is set in specific cases during polling operations or during the execution of the Address Prepare command to allow chaining to the command after the next sequential command.

When a Poll command has progressed to the point where the polling data has been sent out and the line attachment is in receive mode, the status modifier is set if the first character received after the SYN characters is not an EOT character. The status modifier bit is also set if no response (neither positive nor negative) is received from the polled tributary station within three seconds following the poll transmit sequence. For an Address Prepare command this bit is set if one of the two possible polling addresses was detected after a valid EOT sequence.

If an inline test is active on a line addressed by a Start I/O instruction, busy and status modifier bits will be presented (control unit busy indication). Secondary interrupt and control unit end will follow.

Control Unit End (Bit 34): The control unit end bit is used to show that an inline test is over. The bit is presented by secondary interruption after busy has been reported in response to an SIO instruction (see status modifier bit 33 above).

Busy (Bit 35): The busy bit is set if an inline test is running and the subchannel is busy. If a Start I/O or Test I/O instruction is given, condition code 1 is set in response.

Channel End and Device End (Bits 36 and 37): The channel end and device end bits are always presented together when a command ends (that is, when the subchannel is free). For some commands, the presentation of 'channel end' and 'device end' is, in itself, an indication that a specific event has occurred. For example, when channel end and device end are presented for the Prepare command, this indicates that character phase has been established.

Unit Check (Bit 38): The unit check bit, when set, shows that sense data is available. A sense command must be given to retrieve the error condition. For more detailed information on the conditions that set unit check, see "Sense Information" in this chapter.

Unit Exception (Bit 39): The unit exception bit is set when certain conditions occur during the execution of a command. These conditions, which are described in the following list, are unique to each command.

1. If a Write command is given when character phase is being established, unit exception is set because a transmission from the remote station has started or is in progress. The Write command is not executed, but is terminated immediately. The same applies to the Poll command under the same circumstances.

2. If the EOT character is recognized during execution of a Read command, the command is terminated with unit exception set.

3. For all other commands, unit exception is set whenever the command is terminated by a Halt I/O or a Halt Device instruction before any action could occur.

Sense Information

Two bytes of sense information are available. The bits in sense byte 0 are assigned as follows:

Bit	Meaning
0	Command reject
1	Intervention required
2	Bus out check (not used)
3	Equipment check
4	Data check
5	Overrun
6	Lost data
7	Timeout complete

A Sense command with a length count of one transfers only the first byte, and no incorrect length indication is given. A Sense command with a length count of two or more transfers the two sense bytes, however, an incorrect length indication is given if the length count is not equal to two and the SLI bit (suppress length indication) is not set. All the conditions indicated in sense byte 0 set unit check in the CSW.

Sense byte 1 consists of a CA check code (in hex) which indicates the reason (or the last reason, if more than one) for setting the bit in sense byte 0. The reasons are listed below under the relevant bit of sense byte 0.

Command Reject (Bit 0): This bit is set during command initiation if an invalid command is given to a line attachment, or if the line is in such a state that the command cannot be executed. The command is terminated immediately with only unit check set in the CSW. The following conditions (shown in hex code in sense byte 1) cause command rejection:

Hex	
04	A Dial command is given but the autocall adapter or a switched network is not specified in the CA configurator.
05	The 'data terminal ready' signal is detected when a Dial command is initiated (that is, the addressed line is not in the disabled state.
06	A Read, Write, Poll, or Prepare command is given to a BSC line that has not been enabled ('data terminal ready' off during command initiation).
07	'Data terminal ready' is off at chaining to a Read, Write, Prepare or Poll command.
08	Eight immediate commands (for example, No-op or Sense) are executed consecutively.
09	The command code in the CCW is invalid.

0A A command other than Write, Sense, or No-op is given to a BSC line while in transparent wait condition.

Intervention Required (Bit 1): The intervention required bit, when set, normally causes immediate termination of the current command, and channel end, device end, and unit check are set in the CSW when stored at I/O interruption. The conditions causing intervention required to be set are shown in sense byte 1 as follows:

Hex

20 The 'data set ready' signal is inactive during execution of a Write, Read, Prepare, or Poll command.

21 The 'data set ready' signal is inactive at initiation of a Read, Prepare, Write, or Poll command.

22 The 'clear to send' signal is not found active on the modem before the ten-second timeout ends during Write command initiation, or during read-to-write turnaround in a Poll command.

23 The 'clear to send' signal is inactive during execution of a Write command, or (in the write state) during execution of a Poll command, when there is no 'permanent request to send' specified.

24 In externally clocked applications, a clock-check is presented during the execution of a Write command or in the write state of a Poll command.

25 In half-duplex (not 'permanent request to send'), the 'clear to send' signal is not de-activated by the modem before the one-second timeout occurs either at Write command termination, or during write-to-read turnaround in a Poll command.

29 The ACU's 'data line occupied' signal is active when a Dial command is initiated or the signal has turned off during the execution of the command.

2A The ACU's 'power indicator' signal is inactive at initiation or execution of a Dial command.

2C During execution of the Dial command the ACU does not turn off or on 'present next digit', or does not turn on 'abandon call and retry' within 25 seconds in the following cases:

1. 'Call request' to the ACU is on, and 'present next digit on' is not presented.
2. 'Digit present' to the ACU is on, and 'present next digit off' is not presented.
3. 'Digit present' to the ACU is off, and 'present next digit on' is not presented.

2D	The ACU and/or modem does not present 'distant station connected' nor 'data set ready' nor 'abandon call and retry' within 60 seconds after all dialing digits are presented to the ACU and the 'digit present' signal is turned off during the execution of a Dial command.
2E	On a leased line 'data set ready' is not found on within 3 seconds after 'data terminal ready' is presented during the execution of an Enable command, or on a switched line with 'connect data set to line' on, the calling indicator comes up but 'data set ready' does not turn on within ten seconds.
31	An Enable command is given to an already enabled line ('data terminal ready' signal active), but the 'data set ready' signal is not active, or 'data set ready' is on when Enable is issued to a switched line.
A1	A character underrun condition is detected during a Write command. Intervention required is set together with the overrun bit. The command continues to its normal end.

Equipment Check (Bit 3): This equipment check bit is set if a CA or integrated modem hardware check is detected. A detected equipment check causes immediate termination of the current command, and channel end, device end, and unit check to be set in the CSW when it is stored at the next I/O interruption.

The hex code in sense byte 1 shows the reason for setting the equipment check bit as follows:

Hex	
61	A hangup occurs in the adapter or there is noise on modem signals. The line is disabled.
62	A machine check is detected indicating an error on the processor bus. The line is disabled.
63	The loss of the internal clock signal is detected during the execution of a Write or Poll command. The line is disabled.
64	Invalid adapter status.

Data Check (Bit 4): The data check bit is set during the execution of a Read command only.
It is set in the following situations:

Hex	
80	A BCC error is detected during the execution of a Read command. These errors can be caused by noise on the transmission line or by an overrun condition. The command is allowed to continue to its normal end. The data check condition may also occur in ASCII as VRC check during execution of a Poll command, but the unit check and data check sense bits do not appear until the next Read command.

84 A DLE character in transparent read operation is not followed by an ETB, ETX, ENQ, DLE, or SYN control character.

Overrun (Bit 5): The setting of the overrun bit does not cause the command to terminate immediately but allows it to continue to its normal end. It is set in the following conditions, as shown by hex codes in sense byte 1:

Hex

A0 An overrun condition is detected during execution of a Read command.

A1 An underrun condition is detected during execution of a Write command. Intervention required is set together with overrun.

Lost Data (Bit 6): The conditions under which lost data is set are shown by hex codes in sense byte 1 as follows:

Hex

C0 A lost data condition is detected during Read command initiation, indicating that at least one full character was received and lost before the command was given. The command is allowed to continue to its normal end.

C2 The 'present next digit' signal is active during initiation of a Dial command.

C4 The 'distant station connect' signal is active during initiation of a Dial command.

C5 The 'data set ready' or 'distant station connected' signal is active during the dialing sequence of a Dial command before the last digit has been presented to the ACU.

C6 Channel stop (see Note), program check, or protection check occurs during execution of a Read command or Poll in read state. The command is terminated immediately.

Note: Channel stop means that during data transfer the length count has become zero without an ending character being received (assuming data chaining is not set).

C7 A Halt I/O instruction is issued when the line attachment is processing a Read command. This is not an error condition.

Timeout Complete (Bit 7): This timeout complete bit is never set during execution of a Sense, a Sense I/O, No-op, or Write command. When set for other commands, the command is terminated immediately. The conditions under which it is set are shown by hex codes in sense byte 1 as follows:

Hex	
E3	The line attachment is executing a Read command and does not receive two consecutive SYN characters within three seconds of the beginning of the command. The cause is a failure in the program or in the operator's handling, resulting in incorrect sequence with the remote station.
E4	The line attachment is executing a Read command and does not receive a pattern of at least two SYN characters followed by a non-SYN character within three seconds while in text mode; or does not receive a DLE/SYN non-DLE/SYN sequence within three seconds while in transparent text mode.
E6	The 'abandon call and retry' signal of the ACU becomes active during initiation of a Dial command.
E7	The 'abandon call and retry' signal of the ACU becomes active during execution of a Dial command.
EA	The line attachment is operating as a control station on a data link executing a Poll command. After transmission of an Poll sequence to a tributary station, the control station (in the Poll receive state) waits for three seconds for an answer from the tributary station. If no answer is received within three seconds, the Poll command is ended and chained to a Read command. During initiation of the Read command, the index byte is transferred to processor storage and the Read command is immediately ended with the timeout complete bit set in sense byte 0.
EB	A second Write command is issued more than three seconds after termination of the Write command that placed the line attachment in transparent wait state. The second Write ends immediately with the timeout complete bit set.
EC	The 'data set ready' signal is not de-activated by the modem within one second (modems without CDSTL function), or 25 seconds (modems with CDSTL function) after the 'data terminal ready' signal has been dropped, during execution of a Disable command on a switched line.

Chapter 5. Synchronous Data Link Control

Synchronous data link control (SDLC) is supported by a group of channel commands described in the following pages. The SDLC commands and responses are not the subject of this text but are described in *IBM Synchronous Data Link Control General Information*, GA27-3093, which is prerequisite reading for this chapter. Of the commands and responses listed in the above publication, the following are supported by the Communications Adapter (CA).

Acronym	Command	Response	Meaning of Acronym
CMDR		X	Command reject
DISC	X		Disconnect
DM		X	Disconnected mode
I	X	X	Information
RNR	X	X	Receive not ready
RR	X	X	Receive ready
SNRM	X		Set normal response mode
TEST	X	X	Test
UA		X	Unsequenced acknowledgment
XID	X	X	Exchange station identification

The following text shows other features which are supported or not supported by the SDLC-CA.

Supported:

- Half duplex normal response mode only
- Broadcast and single unique station addresses only

Not Supported:

- Group addresses
- Format extensions
- Selective retransmission recovery
- Nonsequenced poll (NSP)
- Asynchronous response mode (ARM), asynchronous disconnect mode (ADM), and asynchronous balanced mode (ABM).

The CA channel commands for SDLC operation, together with the status and sense information, error recovery, and synchronization rules are specified in this chapter. There are two kinds of command in the SDLC-CA:

1. Basic commands, similar to corresponding binary synchronous communication (BSC) commands.

2. High-level commands for wider control of station polling and transfer of information frames. Details of each station are transferred from the access method to the line interface in the form of a station control block (SCB).

   An SCB contains the station's SDLC address, the number of frames sent (Ns) and received (Nr), and the station's status flags. With this information, the line interface builds an SDLC poll frame and interprets the response. A table of SCBs forms an Autopoll list which can be cycled repeatedly under channel-program control until a poll is successful. Thus the CA absorbs the overhead caused by negative polling.

The CA also builds the frames to be transmitted, and checks the frames received. The current SCB is used as the source for address and control information. Only the information field which forms the path information unit (PIU) defined in *Systems Network Architecture General Information*, GA27-3102, is transferred across the channel interface. A series of PIUs for one station can be transmitted or received without intervention from the access method.

In this text, the basic commands are described first, followed by the high-level commands. The description of the high-level commands is preceded by details of the station control block on which the commands are based.

Commands

Hex	Command Code CCW BITS 0	1	2	3	4	5	6	7	Command	Type
01	0	0	0	0	0	0	0	1	Write	Basic
02	0	0	0	0	0	0	1	0	Read	Basic
03	0	0	0	0	0	0	1	1	Control No-op	Basic
04	0	0	0	0	0	1	0	0	Sense	Basic
05	0	0	0	0	0	1	0	1	Write PIU	High level
06	0	0	0	0	0	1	1	0	Read PIU	High level
08	0	0	0	0	1	0	0	0	Transfer-in-Channel	Basic
09	0	0	0	0	1	0	0	1	Autopoll	High level
0B	0	0	0	0	1	0	1	1	Control SCB	High level
0F	0	0	0	0	1	1	1	1	Poll	High level
14	0	0	0	1	0	1	0	0	Sense SCB	High level
23	0	0	1	0	0	0	1	1	Set Mode	Basic
27	0	0	1	0	0	1	1	1	Enable	Basic
29	0	0	1	0	1	0	0	1	Dial	Basic
2F	0	0	1	0	1	1	1	1	Disable	Basic
E4	1	1	1	0	0	1	0	0	Sense I/O	Basic

Basic Commands

Write

The Write command causes data to be transferred to the line attachment from the processor storage location specified in the CCW.
The Write command is only accepted if:

- The line is enabled.
- The line is in outbound direction.
- The count field is greater than or equal to two.
- The CCW has the correct format.

Otherwise the command is rejected and the line status is not changed.

The data specified in the CCW by the address and count field is furnished with beginning and ending flags, as well as FCS bytes, to make a frame which is transmitted over the line. If a P/F bit is specified in the command field of the frame, the line is turned to the inbound direction.

Exceptional Conditions: If the line cannot be serviced in time by the CA, a unit check is generated with overrun set in sense byte 0. The transmission of the frame is terminated with the 'abort' sequence. The line stays in the outbound direction if working in primary mode. If working in secondary mode the line is turned to the inbound direction.

Read

The Read command transfers an incoming frame into processor storage. The command is only accepted if:

- The line is enabled.
- The line is set to inbound direction.
- The CCW has the correct format.

Otherwise the command is rejected and the line status is not changed.

Incoming data is transferred to the processor storage area defined in the command. Included is all data after the beginning flag, up to and excluding the frame check sequence (FCS) bytes. If a poll/final (P/F) bit is received, the line is turned to the outbound direction.

Exceptional Conditions

- Frame with wrong address received.: This condition applies only to a line in secondary mode. The address field of the incoming frame is compared with the address transferred by a Set Mode command or by a received SCB. If the address does not match, the frame is ignored. The line attachment starts searching for a new frame. The Read command remains active.

- Invalid frame or 'abort' sequence received.

  If the FCS bytes indicate an invalid frame, or if the frame is terminated with an 'abort' sequence, the frame is ignored. The line attachment starts searching for a new frame and the command remains active. A unit check (with data check set in sense byte 0) is generated for an abort sequence and for an FCS check.

- Buffer too short, overruns.

  If the count field is zero before all incoming data is transmitted into processor storage, or if the line cannot be serviced in time, a unit check (with data check or overrun set in sense byte 0) is generated.

Enable

The Enable command puts the line attachment into the operational state. If the line attachment is not enabled, all commands (except No-op, Sense, Sense I/O, Enable, Disable, Dial, and Set Mode) are rejected with unit check set in the CSW and the command reject bit set in sense byte 0. If the Enable command is issued to a privately-owned or leased line, channel end and device end are presented when the line attachment detects the 'data set ready' signal being raised by the modem. If 'data set ready' is not detected within three seconds of the line attachment raising the 'data terminal ready' signal, the Enable command ends with unit check set. If the Enable command is given to a switched line, the line

attachment is conditioned to answer an incoming call automatically, assuming the modem has auto-answer capability. Channel end and device end are then presented when an incoming call is received. No timeout is associated with the Enable command for a switched line.

Note: The Enable command has a different function when the line is connected to a circuit-switched public data net (see 'X.21 Switched Facility' for details).

Disable

The Disable command puts the addressed line attachment into the non-operational state. A disabled line attachment no longer searches for character phase, executes any command (except No-op, Enable, Disable, Dial, Sense, Sense I/O or Set Mode), or reacts to an incoming call. If the Disable command is given to a private or leased line, channel end and device end are presented after one second.

If given to a switched line, the command causes the modem to disconnect. A 25-second timeout (for modems using the CCITT option - Connect Data Set to Line (CDSTL) procedure) or a one second timeout (for all other modems) is started, and if the modem has not disconnected when the timeout elapses, the Disable command ends with unit check set and the timeout complete bit set in sense byte 0.

Dial

The Dial command causes the line attachment to be enabled and a data transfer from processor storage to the automatic calling unit (ACU) to be performed. If the Autocall feature is not installed in the CA or if the line attachment is not defined as switched, the Dial command is rejected and the line attachment is not enabled. The Dial command is also rejected if the line has not been disabled.

The access method is responsible for sending to the ACU the following characters only:

1. The correct number of dial digits, which are decimal values from 0 to 9.

2. The end of number (EON) or separator (SEP) character, if this character is required by the ACU.

The data is transferred from the location specified in CCW bits 8 to 31 and ascending locations until the count in CCW bits 48 to 63 is reduced to zero. In the data thus transferred, only bits 4 to 7 of each byte are actually placed on the interface (the digit lines) of the calling unit. The line attachment does not check the validity of the data sent to the ACU. The following table shows the relationship between the processor storage byte and the dial digit:

	Storage Byte								Equivalent Dial Digit
	0	1	2	3	4	5	6	7	
	x	x	x	x	0	0	0	0	0
	x	x	x	x	0	0	0	1	1
	x	x	x	x	0	0	1	0	2
The dial	x	x	x	x	0	0	1	1	3
operation	x	x	x	x	0	1	0	0	4
ignores	x	x	x	x	0	1	0	1	5
bits 0, 1	x	x	x	x	0	1	1	0	6
2, and 3	x	x	x	x	0	1	1	1	7
	x	x	x	x	1	0	0	0	8
	x	x	x	x	1	0	0	1	9
	x	x	x	x	1	1	0	0	EON
	x	x	x	x	1	1	0	1	SEP

The EON (end of number) character is an optional character which marks the end of the dial-digit group for those ACUs that require such an end character. Whether or not EON is used therefore depends on the type of ACU connected. Some ACUs recognize EON, some do not, and some can be set either to recognize or not recognize EON. ACUs which recognize EON may use the character as a signal that an answer may be expected from the remote station, or as a signal that dialing is complete (avoiding a timeout). The EON character should be inserted in processor storage as the last dial digit. EON is not required in the USA.

The separator character (SEP) can optionally be inserted in processor storage and included with the dial digits, following an access digit. For a private automatic branch exchange (PABX) extension, this character delays dialing to allow the dial tone to be returned from the public exchange. The dial digits are presented to the ACU at a rate set by the ACU.

If a connection is not established before the timeout set by the ACU elapses, the 'abandon call and retry' (ACR) signal is activated by the ACU. This condition initiates a one-second delay. After the delay, the Dial command ends with unit check set in the CSW and the timeout complete bit set in sense byte 0.

A long timeout (60 seconds) is set in the Autocall feature to monitor the progress of the ACU. If this timeout expires, the Dial command ends with unit check set and intervention required in sense byte 0.

If the ACU has its power indicator off, or if the 'data line occupied' (DLO) signal is active during command initiation, the Dial command ends with unit check in the initial status and intervention required in sense byte 0.

Certain other error conditions in the ACU or associated modem cause the Dial command to terminate with unit check set and the lost data bit set in sense byte 0. "Error Information" in this chapter describes all error conditions which cause sense bits to be set.

Note: The Dial command has a different function when the line is connected to a circuit-switched public data net (see 'X.21 Switched Facility' for details).

Set Mode

This command is used to change the status of a line attachment or the SDLC-CA. Up to eight bytes of control data are transferred, depending on the length count in the CCW. The control bytes are:

Byte	Meaning
0	Dynamic changes
1	Datapoll index
2	Contactpoll index
3	Contactpoll frequency
4	Service seeking pause
5	Timeouts
6	Mode setting
7	SDLC address
8	X.21 Retry Timeout (see Note)

Note: Byte 8 is required only when the line connects to a circuit-switched public data network. In that case four additional bytes (9...12) may be required (see 'X.21 Switched Facility' for details).

Dynamic Changes (Byte 0):

Bit	Setting	Meaning
0	1	Change the datapoll index. Byte 1 contains the new value of the datapoll index. If byte 1 is not provided, that is, the field length of the Set Mode is one, the datapoll index is reset to zero.
	0	Do not change the datapoll index. Byte 1, if provided, is not used.
1	1	Change the contactpoll index. Byte 2 contains the new value. The contactpoll is reset if byte 2 is not provided.
	0	Do not change the contactpoll index. Byte 2, if provided, is not used.
2-7	0	Reserved, must be zeros.

Datapoll Index (Byte 1): This byte defines an index start value. The index is used to point at a specific entry in a table of SCBs. The table is used during the data poll function of Autopoll operations. The index can have any value from 0 through 255.

Contactpoll Index (Byte 2): This byte defines an index start value. The index is used to point at a specific entry in a table of SCBs, to be used during the contact polling function of Autopoll operations. The index can have any value from 0 through 255.

Contactpoll Frequency (Byte 3): The value in this byte specifies how many times data polling operations of the Autopoll command are to be encountered before a contactpoll function on the line is performed. The contactpoll frequency can be set to any value from 0 through 255.

Service Seeking Pause (Byte 4): This byte specifies how long the line attachment will pause during the contactpoll function of an Autopoll command before it terminates when no contactpoll operation has been performed. No pause is made when a contactpoll operation is performed. The purpose is to reduce overhead from non-productive polling. The service seeking pause is specified in tenths of a second. Any time from 0 through 25.5 seconds can be specified.

Timeouts (Byte 5): This byte defines an idle detect timeout (primary station) or non-productive receive timeout (secondary station) as follows:

1. Operation as primary station.

   Whenever the line attachment detects the poll bit set to one in a transmitted frame, it turns to receive mode, starts an idle detect timer, and waits for an incoming frame.

   If no frame is received before the idle detect timeout elapses, the line is monitored for 15 marks. If they are received the line turns to outbound direction.

   The timeout is specified in tenths of a second. Any value from 0.1 through 25.5 seconds can be specified. A value of 0 indicates no timeout, and the line attachment waits indefinitely for incoming frames. A Halt I/O or Halt Device instruction should be issued if the channel program is to be terminated.

2. Operation as secondary station.

   Whenever the line attachment detects the final bit set to one in a transmitted frame, it turns to receive mode, starts an inactivity timer, and waits for an incoming frame. If no frame is received before the inactivity time elapses, the channel program terminates.

   The inactivity timeout is specified in seconds. Any value from 1 through 255 seconds can be specified. A value of 0 indicates no timeout, that is, the line attachment waits indefinitely for incoming frames. A Halt I/O or Halt Device instruction may now have to be issued to terminate the channel program.

Mode Setting During Initialization (Byte 6):

Bit	Setting	Meaning
0	1	Secondary station. The line attachment is to act as a secondary station on this line.
	0	Primary station. The line attachment is to act as a primary station on this line.
	1-7	Reserved, must be zeros.

SDLC Address as Secondary Station (Byte 7): This byte contains the SDLC address for which the line attachment as a secondary station will monitor in receive mode when a Read command has been given. (If an SCB was passed to the line attachment after the Set Mode command with secondary address, the station address of the SCB will be used.) This byte must be transferred if byte 6 specifies a secondary station.

Note: The SDLC address in byte 7 is ignored when the line is connected to a circuit-switched public data net (see 'X.21 Switched Facility' for details).

Termination of Set Mode Command: The command is terminated with data check if the data has invalid format; for example, if reserved fields are not zero or the secondary station address is not transferred although specified in byte 6. The secondary station address is not accepted in these cases.

Sense

The sense operation transfers up to 24 bytes of sense information to the processor storage location specified in bits 8 to 31 of the CCW. See "Sense Information" in this chapter.

Sense I/O

The Sense I/O command transfers up to seven bytes defining the line configuration, as follows:

Byte	Meaning
0	Always hex FF
1	CPU Identification 1
2	CPU Identification 2
3	CPU Identification 3
4	Hex CA (communications adapter)
5	Bit 0: one Bit 1: zero Bit 2: zero Bit 3: zero Bit 4: Not NRZI mode Bit 5: Business machine clocking Bit 6: Autocall unit installed Bit 7: Secondary station
6	Bit 0: Permanent request to send Bit 1: Switched line Bit 2: New synchronization Bit 3: Connect data set to line Bit 4: Integrated modem or local attachment Bit 5: zero Bit 6: High speed line Bit 7: Integrated modem with manual answer

Note: The Sense I/O data is different when the line connects to a circuit-switched (X.21) or packet-switched (X.25) public data network (see applicable chapter for details).

Control No-Op

This command terminates immediately with the channel end and device end bits set in the unit status.

High-Level Commands

Further SDLC functions are provided by high level commands. The line attachment can repeatedly poll all stations for outstanding messages or for initial contact. The line attachment can also handle the address and control fields of the SDLC frames transmitted or received. For each station being serviced, specific information is required in the line attachment. This information is contained in a station control block (SCB).

Station Control Block

The Autopoll, Control SCB, Read PIU, Write PIU, Poll, Sense SCB, and Sense commands require or use one or more SCBs. The Autopoll command points at a contiguous table of SCBs, which are sequentially fetched during polling. The Control-SCB command is used to transfer one specific SCB to the line attachment. The Read PIU , Write PIU, and Poll commands must be preceded by an Autopoll or Control SCB so that one SCB, called the *current SCB*, is available in the line attachment.

The current SCB is retrieved by the access method with a Sense SCB command. In addition the Sense command may be used to read out the sense information together with the current SCB after a unit check occurs.

SCB Format

Each SCB contains 20 bytes, 12 of which are transferred from the access method to the line attachment with the Autopoll, or Control SCB commands. The Sense SCB command retrieves all 20 bytes. The extra bytes reflect the outcome of the channel program executed with respect to the number of data buffers used and any exceptional conditions.

SCB Layout

Byte No.	Hex Value	Field Name
0	0	Offset
1	1	Address
2	2	Reserved (must be 0)
3	3	Control Flags (CTLFLAGS)
4	4	Number Sent Current (NSCUR)
5	5	Reserved (must be 0)
6	6	Number Sent and Acknowledged (NSACK)
7	7	Number Received and Accepted (NRACC)
8	8	Identifier (IDENT)
9	9	"
10	A	"
11	B	"
12	C	Command In (CMDIN)
13	D	Reserved (must be 0)
14	E	Count Frames Sent (CFRS)
15	F	Count Receive Buffers (CRBUF)
16	10	Reserved (must be 0)
17	11	Reserved (must be 0)
18	12	Exception Flags 1 (EXCFLAGS1)
19	13	Exception Flags 2 (EXCFLAGS2)

Note: Bytes 12 through 19 (hex 0C through 13) are only transferred from the line attachment to the access method (by the Sense SCB command or the Sense command). These bytes are never transferred in the reverse direction.

SCB Fields

Offset (Byte 0): This byte contains the buffer offset. When data is transferred to processor storage during the execution of a Read PIU command, the offset is added to the data address of the CCW and the data is stored beginning at this modified address.

Similarly, during a Write PIU operation the data is transferred from processor storage to the line attachment starting from an address formed by adding the offset to the CCW data address. The offset may range from 2 through 255. If an SCB is transferred to the line attachment with an offset of 0 or 1, the channel program terminates with data check.

> **Note:** This mechanism is provided mainly to handle I-frames, but it also applies to other frames.

Address (Byte 1): This byte contains the SDLC station address. The CA uses the address field when building outbound I-frames or poll frames. Inbound, the address field of frames received in response to poll is checked against the address field. In a mismatch, a soft error is indicated if the CA is running as primary station; the frame is ignored if the CA is running as secondary station.

Control Flags (Byte 3): The bits in the control flags are defined as follows:

Bit 0, Skip

1 = Inactive station, do not poll
0 = Active station, poll

Bit 1, Autopoll

1 = Datapoll this station during Autopoll commands
0 = Contactpoll this station during Autopoll commands

Bit 2, Slowout

1 = Send RNR poll
0 = Send RR poll

Bit 3, Slowin

1 = RNR reply to poll expected
0 = RR reply to poll expected

> **Note:** Whenever the expected reply is received from a station, the autopoll operation continues; it terminates with the channel end, device end, and status modifier bits set when an unexpected reply is received.

Bits 4-7, Reserved: Must be zeros.

NSCUR (Byte 4): This byte contains the SDLC number (modulo 8 number) of the next I-frame to be sent. The number is set into the I-frame control field during Write PIU operations. NSCUR is incremented by one modulo 8 as each I-frame is transmitted.

If NSCUR becomes equal to NSACK, this indicates that outstanding I-frames must be acknowledged before more can be sent. Any further Write PIU command is therefore terminated with 'command reject' and 'unit check' indicated.

NSACK (Byte 6): This field contains the SDLC number (modulo 8 number) of the latest I-frame acknowledged by the remote station. Whenever a response containing an Nr field is received from a station, the line attachment uses it to update NSACK. The absolute difference is also set into the CFRS field.

If the received No. is outside the range from NSACK to NSCUR (modulo 8), unit check is presented with sense information indicating an unexpected No. field. (The control byte received is set into the CMDIN field of the SCB.)

NRACC (Byte 7): This field contains the SDLC number plus one (modulo 8) of the last valid I-frame received. The line attachment sets the contents of this field into the Nr part of the SDLC control field during polling and I-frame transmission.

If I-frames are received, the line attachment compares the received Ns field with the contents of NRACC. The I-frame is accepted if they are equal. The NRACC field is then incremented by one modulo 8. If an invalid frame is received, NRACC is frozen and no more I-frames are accepted until a valid frame with the poll/final bit equal to one has been received or a timeout has occurred. If the received Ns does not correspond with the NRACC value and the CA is not skipping invalid frames, unit check is presented, with sense information indicating that received I-frames were out of order. CMDIN now contains the control field

from the erroneous frame. (The channel program is not terminated, however, until a valid frame with the poll/final bit equal to one is received or a timeout occurs.)

IDENT (Bytes 8-B): This field is used by the access method to identify each SCB-entry. It is passed without change between the access method and the line attachment.

CMDIN (Byte C): This byte is the command received field. If the frame received does not contain the control byte defined in the flags field, this field is stored in the CMDIN field for further examination by the access method.

CFRS (Byte E): This byte contains the count of frames sent and acknowledged. The field is zero based. When the line attachment changes NSACK because of a newly received Nr, the absolute difference is accumulated in the CFRS-field. The contents of this field are used by the access method to release the appropriate Write PIU buffers containing the frames acknowledged.

If CFRS is not equal to the number of frames transmitted, some frames have been lost. The access method must now back NSCUR to NSACK and modify the channel program to retransmit the lost frames.

CRBUF (Byte F): This byte contains the count of receive buffers used. The line attachment sets into this field the number of productive Read PIU commands executed by the channel program, that is, Read PIU commands with data transfer of valid frames. This field can be used by the access method to determine the number of unused buffers to be released.

EXCFLAGS1 (Byte 12): This field contains byte one of the exception flags, and stores information about exceptional conditions which occurred during the execution of the previous channel program. This field is inspected by the access method and if it is all zeros, no exceptional conditions occurred.

Bit 0, SOFTERR (soft error indicator). This bit is set to one by any soft error. The EXCFLAGS2 byte indicates the reason.

Bit 1, LFNSI (last frame contains non-sequenced information). This bit is set to one if non-sequenced information is received during the execution of the channel program. The information is set into the last receive buffer used so that the access method can interrogate.

Bit 2, STRANS (remote station transition occurred). This bit is set to one if RNR is received from the remote station when the CTLFLAGS field indicates that the station is expected to send RR, or vice versa.

Bit 3, CIUSE (CMDIN field used). This bit is set to one when an SDLC command is set into the CMDIN field. This occurs when any unexpected command is received.

Bit 4, DIRECTION (line direction). This bit is set to one when the line direction is outbound.

Bits 5-7 are zeros.

EXCFLAGS2 (Byte 13): This field represents byte two of the exception flags and contains (in encoded form) the reason for the soft error indicated in the summary bit SOFTERR. For the list of codes see "Soft Errors and Recovery" in this chapter.

All SCB fields transferred from the access method to the line attachment are initialized by the access method.

The ADDRESS, OFFSET, CTLFLAGS and IDENT fields are never altered by the line attachment.

The CFRS, CRBUF, EXCFLAGS and CMDIN fields are updated by the line attachment only.

The remaining fields (NSCUR, NSACK, and NRACC) are normally managed by the line attachment but are altered by the access method in exceptional situations.

The reserved fields must be zero and the offset must be greater than one. The five leading bits of the sequence count fields are ignored on outbound commands and are undefined on inbound commands and instructions.

Autopoll

This command provides two functions, which are executed in sequence: a data polling function and a contact polling function.

The command is only accepted if:

- The line is enabled.
- The line is set for outbound operation.
- The CCW has a valid format. The general rules are kept and data chaining is not specified.
- The data address is on a fullword boundary and the count is at least 12 and not greater than 2K.

Otherwise the command is rejected and the line status is not changed.

In the data polling function, several remote stations are requested in turn to transmit data to the line attachment. The command is normally used in a multipoint network (where several secondary stations are connected to the same line); it can also be used in a point-to-point installation.

A datapoll index per line attachment is used to point to the next SCB to be interrogated. This index is normally maintained by the line attachment; it may also be changed with the Set Mode command.

The contactpoll function is only executed for primary stations. It is used to invite disconnected stations to enter normal response mode.

The stations are specified in a table of SCBs. Flag bits in the SCB indicate whether a station is disconnected and should be contactpolled, or whether the station is in normal response mode (NRM) for datapoll operation.

There are two tuning parameters for the contactpoll function:

1. A frequency counter, which determines how often the stations should be contactpolled when they are found in the table of SCBs.
2. A service seeking pause, which defines a time to delay command termination during low traffic periods in order to reduce processor interference due to non-productive polling. See description of control byte 4 under "Set Mode" in this chapter.

Both parameters can be changed with the Set Mode command.

A contactpoll index per line attachment is used to point at the next SCB to be interrogated. This index is normally maintained by the line attachment but may also be changed with the Set Mode command.

Normal Flow of Data Polling Function: The Autopoll command points at a table of SCBs, one for each station on the line. The line attachment initially fetches the SCB indicated by the datapoll index, making it the current SCB. If the index points outside the SCB table, the index value is reset to zero, making the first SCB entry current.

If the SCB flags indicate that the station is inactive or a contactpoll operation is requested, the line attachment updates the datapoll index by one and fetches the next SCB. If the flags indicate datapolling for this station, a poll frame is sent.

The address and command fields are constructed using the information of the current SCB. The P/F bit is always set to one.

The line attachment then goes into receive mode. Further actions by the line attachment depend on the reply of the remote station, as described in the following text. The received reply may be one of the following:

1. RR or RNR received as specified in the SCB. This indicates that the remote station has nothing to send and has not changed its mode between slowdown and normal data transfer mode. The line attachment updates the datapoll index by one and repeats the same actions as described above, until the SCB table is exhausted.

2. Unexpected command, that is:

   - RR received when RNR was expected, or
   - RNR received when RR was expected, or
   - RR or RNR received as expected but the Nr value is different from the corresponding field of the current SCB, or
   - Any other command including I-frame and non-sequenced frame, or
   - Erroneous frames such as frames with a wrong address (primary mode only), invalid frames, and frames which terminate with an ABORT sequence. (**Note:** Frames with a wrong address are ignored in secondary mode.)

The command is terminated with the channel end, device end, and status modifier bits set. This situation normally causes a transfer of control in the channel program to a Read PIU or Sense SCB command which will process the incoming frame. (See Read PIU and Sense SCB commands.)

The datapoll index is not updated when the status modifier is presented. If, therefore, I-frames have been received from a remote station, this station will be the first polled the next time the datapoll operation is resumed. This is normally the correct mode of operation but the access method may turn to another station using the Set Mode command to change the datapoll index.

When the datapoll index returns to the value it had at the beginning of the datapoll operation, one complete scan has been made. The command now executes the contactpoll function.

Normal Flow of Contact Polling Function: The execution of the Autopoll command is as follows:

Each time the contactpoll function of an Autopoll command is executed the frequency counter is decremented by one until it reaches zero.

- If the counter is not zero, the Autopoll command is terminated without updating the contactpoll index.

- If the frequency counter has reached zero, the line attachment scans the SCB-table until it finds an entry to be contactpolled or until a complete scan of the table has been made. If the contactpoll index initially points outside the SCB table, the index is reset to zero before the scan begins. If possible, a contactpoll operation is performed, or if no station is found for contactpolling, a service seeking pause is made.

A contactpoll operation proceeds as follows:

1. An 'SNRM' frame with the station address of the current SCB is transmitted. The P/F bit is set.

2. The line attachment goes into receive mode. The idle detect timer is started. One of the following situations then arises:

   a. No reply: If the remote station is inactive, the idle timer elapses in the line attachment. This is the normal situation. The Autopoll command now ends with channel end and device end set. The contactpoll index is updated by one.

   b. Reply is disconnected mode (DM): The contact poll index is updated by one. The command ends with channel end and device end set.

   c. Any other reply: If any frame except DM is received, the command terminates with channel end, device end, and status modifier set. This normally causes a transfer in the channel program to a Read PIU or Sense SCB command to process the incoming frame. (See Read PIU and Sense SCB.)

Error Conditions of Data Polling and Contact Polling Function: If the CA cannot service the line in time, an overrun soft error indication is generated. If the overrun occurs during an outbound operation, the transmission of the frame is terminated with the ABORT sequence. In the contact polling function the line always stays set to the outbound direction. In the data polling function the line stays set to the outbound direction if working in primary mode. If working in secondary mode the line is turned to inbound.

All following line-affecting commands in the same channel program are treated as No-ops.

If errors occur during the fetching of the SCB, the channel program is terminated with the appropriate channel status.

A wrongly formatted SCB (the reserved fields are not zero or the offset is not greater than one) is indicated as a data check. A following Sense SCB or Sense operation delivers undefined values.

Poll

The Poll command is used after a chain of Write PIU commands to transmit a final 'RR' or 'RNR' (depending on the state of the line attachment). The poll/final bit is set; it is never set in I-frames transmitted by a Write PIU command. All information required is taken from the current SCB. The line is turned to inbound when the Poll command has been executed. The Poll command is accepted only if:

- The line is enabled.
- The line is set to outbound.
- An SCB was passed to the line attachment in the current channel program.
- The CCW has the right format.

Otherwise the command is rejected without change to the line status.

Exceptional Conditions: If the CA cannot service the line in time, an overrun soft error condition is generated.

The transmission of the frame is terminated with the abort sequence. The line stays set to outbound if operating in primary mode. In secondary mode the line is turned to inbound.

Read PIU

The Read PIU command transfers the path information unit of an incoming I-frame and the length of it into processor storage. The Read PIU command is only accepted if:

- The line is enabled.
- The line is set to inbound.
- An SCB was passed to the CA in the current channel program.
- The CCW has a valid format. In addition to the general rules, the first two bytes must not cross a page boundary and data chaining must not be specified.
- At least one byte of the I-field must be accommodated in the first buffer, that is, the CCW length must be at least equal to the offset plus 1.

Otherwise the command is rejected without change to the line status.

The normal flow of the command is:

- Valid I-Frame Received.

  The I-field is transferred to processor storage. The starting address is the command data address plus the offset field of the current SCB. The data transfer continues until the ending flag is found or the length count in the CCW becomes zero. The frame check sequence bytes are not transferred.

  If the storage area is exhausted before the frame ends, another Read PIU command must be chained. (This situation is referred to as 'data spanning'.) If so, the chained Read PIU command specifies the next data area to continue the data transfer, and the CRBUF field of the current SCB is incremented by

one. Otherwise, the frame is read up to the ending flag without further data transfer. In any case the total length of the frame plus offset is stored into the first two bytes of the first buffer.

The Nr count of the frame received is used to update the NSACK and CFRS fields of the SCB.

If the total frame was transferred into processor storage the CRBUF and NRACC fields of the current SCB are incremented by one.

The Read PIU command ends with channel end and device end set.

- Valid Non-I Frames Received: Unnumbered Frames

  The command field is stored into the CMDIN field of the current SCB. The CIUSE bit in the exception flag byte of the current SCB is set.

  If the frame has an I-field it is treated the same way as the I-field of an I-frame. Data spanning applies and the length field is stored into the first buffer. The LFRNSI bit in the exception flag byte of the current SCB is set.

  After one non-sequenced frame is received, all further inbound data is ignored except for a P/F bit and the remaining channel program is flushed.

  Programming Note: The term flushing means to execute all commands except for their line-affecting parts; that is to:

  - Perform chaining.
  - Test the validity of the command code and format (raising unit check and discontinuing flushing if any error is present), but not to test the data address and whether the data buffer is fixed.
  - For an Autopoll command, to set the status modifier.

- Valid Non-I Frames Received: Supervisory Frames

  The Nr count is used to update the NSACK and CFRS field in the current SCB. If an RR was expected but the RNR was received or vice versa, the STRANS bit in the exception flag byte of the current SCB is set.

  The command field is stored into the CMDIN field of the current SCB, and the CIUSE bit in the exception flag byte of the current SCB is set.

  When one supervisory frame is received, all further inbound data is ignored except for a P/F bit and the remaining channel program is flushed.

- P/F Bit Received

  When a P/F bit is received the line is turned to outbound. The remaining channel program is flushed.

Error Conditions: In the Read PIU command, the following errors can arise:

- Frame with Wrong Address Received

  The address field of the incoming frame is compared with the address in the current SCB. If the addresses do not match, the action depends on the line mode:

  1. If the CA is acting as a primary SDLC station, a soft error indication is generated.

  2. If the CA is acting as a secondary station, the frame is ignored. The line attachment starts searching for a new frame. The Read PIU command remains active.

- Erroneous I-Frame Received

  If the Ns field is out of sequence, that is, the NRACC field of the SCB does not match the Ns field, a soft error is generated. If the Nr field is out of sequence, that is, the Nr is not between the NSCUR and NSACK values (modulo 8), a unit check is generated.

- Invalid Frame Received

  If the FCS bytes indicate an invalid frame or if the frame is too short, a soft error indication is generated.

- Abort Sequence Received

  If a frame is terminated with an ABORT sequence, a soft error indication is generated.

- Overruns

  If the line cannot be serviced in time by the CA, a soft error indication is generated.

  In all cases except 2., the remaining channel program is flushed.

Write PIU

The Write PIU command transmits an I-frame. The address and control fields are generated by the line attachment using the current SCB. A Control SCB command must therefore precede the first Write PIU command in the channel program to transfer the appropriate SCB.

The length of the PIU plus offset contained in the first two bytes of the buffer area and the OFFSET field of the SCB is added to the data address field of the Write PIU command to form the starting address of the PIU to be transmitted. The command is only accepted if:

- The line is enabled.
- The line is set to outbound.
- An SCB was passed to the CA in the current channel program.
- The CCW has a valid format. In addition to the general rules, the first two bytes must not cross a page boundary, and data chaining must not be specified.
- The length of the I-field specified is at least one, and at least one byte is specified in the first buffer if data spanning applies, as specified in the following description.

Otherwise the command is rejected without a change to the line status.

The normal flow of the command is:

A complete I-frame is transmitted. The address byte comes from the current SCB. The control field is constructed using NSCUR and NRACC from the current SCB for Ns and Nr respectively. The P/F bit is always at zero.

The I-field is transferred from processor storage. The starting address consists of the command data address plus the OFFSET field of the current SCB. The I-field length plus offset is specified in the first two bytes of the data area.

The I-field may extend over more than one data area. Consecutive data areas are specified in chained Write PIU commands. Data is taken from the start of the succeeding areas, the offset scheme not being used. The length given in the first data area continues to apply (this situation is referred to as 'data spanning').

The FCS characters accumulated by the CA and the trailing flags are sent after the I-field. The NSCUR field of the current SCB is updated. The outbound direction of the line is maintained.

Error Conditions: In the Write PIU command, the following errors can arise:

- Invalid Frame Length

  If the data count becomes zero during transmission and the frame length specifies further I-field bytes, a test is made to determine whether data spanning is specified. If so, a Write PIU command must follow. If not, unit check and command reject are set.

  The transmission of the frame is terminated with the ABORT sequence. The line stays set to outbound if working in primary mode. If working in secondary mode, the line is turned to inbound.

- Overrun

  If the CA cannot service the line in time, a soft error indication is generated and the command is terminated.

  The transmission of the frame is terminated with the ABORT sequence. The line stays set to outbound if working in primary mode. If working in secondary mode, the line is turned to inbound.

- Too Many Frames to Be Sent

  If too many frames were sent without being acknowledged (NSCUR reaches NSACK) the next Write PIU command causes unit check and command reject.

Control SCB

The Control SCB command is used to transfer a specific SCB to the line attachment. It normally precedes a Write PIU or a chain of Write PIU commands, giving the line attachment the information necessary to build outbound I-frames. The line attachment must be enabled before a Control SCB command is accepted. Otherwise a unit check termination is generated with command reject set.

Twelve data bytes are transferred with the Control SCB command to form the current SCB. The data address specified must be on a fullword boundary and the length count must be at least twelve. Otherwise the command is terminated with unit check and command reject set.

Data chaining must not be specified.

Error Conditions: If errors occur during the fetching of the SCB, the channel program is terminated with the appropriate channel status.

An incorrectly formatted SCB (reserved fields not zero or offset not greater than one) is indicated as a data check. A following Sense SCB or Sense operation delivers undefined values.

Sense SCB

The Sense SCB command is used to retrieve the current SCB after a line-affecting operation is completed. Twenty bytes are transferred. They contain indications of errors and unusual conditions plus updates to the frame/buffer and Ns/Nr counts. Because the I/O operation may have started as a result of the datapoll or contactpoll operation of an Autopoll command, the current SCB has the only indication as to which station responded. The access method transfers appropriate fields to its copy before restarting the channel program.

If the line is set to the inbound direction, the Sense SCB command functions in addition as a Read PIU command with the exception that no incoming I-field is transferred to processor storage. For this reason, the Sense SCB is considered a line-affecting command.

If no SCB was transferred after an Enable operation, all zeros are transferred. The line attachment must be enabled before a Sense SCB command is accepted, otherwise the command is terminated with unit check and command reject set.

The data address specified must be on a fullword boundary and the length count must be at least twenty, otherwise the command is terminated with unit check and command reject set. Data chaining must not be specified.

Channel Program Rules

1. The line must be enabled for the following commands:

   - Control SCB
   - Sense SCB
   - Autopoll
   - Poll
   - Read
   - Write
   - Read PIU
   - Write PIU

2. Only No-ops and TICs are allowed between Read PIUs or Write PIUs during data spanning.
3. When the line is active (no P/F bit was received) any commands that do not affect the line may cause overruns.
4. No more than 127 channel commands will be accepted in a flushing situation.
5. No more than seven immediate commands (No-op, Set Mode, Sense, Sense I/O, Sense SCB, Control SCB) in sequence will be accepted.

Channel Program Examples

The examples in this section do not necessarily reflect actual use of the channel commands. They are valid sequences to illustrate operations.

Primary Station on a Multipoint Line During Normal Operation

Channel Program		Notes
START:	NOP	1
	TIC to AUTOP(TIC to XMIT)	2
AUTOP:	AUTOPOLL	1, 3
	TIC to START	
RECV:	READ PIU	1
	READ PIU	1
	READ PIU	1
	SENSE SCB	4
XMIT:	CONTROL SCB	1, 5
	WRITE PIU	1
	WRITE PIU	1
	WRITE PIU ...	1
	POLL	1, 6
	TIC to RECV	7

Notes:

1. Command chained.
2. This command becomes a TIC to the XMIT path when frames are ready to be sent.
3. Autopoll points to a table of SCBs. The SCB fields indicate the kind of poll to send to each station and the response expected. If the response is unexpected, the status modifier bit is set, causing the subsequent TIC to be skipped.
4. This Sense SCB command transfers the current SCB to processor storage. It shows:
   - Which station responded to the Autopoll command.
   - How many frames were received.
   - Whether any errors occurred.
   - If the RECV path followed XMIT, how many frames were successfully sent.
5. The Control SCB command provides a new current SCB. It indicates for the line attachment:
   - Where to send the data.
   - What Ns/Nr values to put in the I-frame control field.
6. The station is polled to find out how many of the frames just sent were successfully received.
7. The XMIT path transfers to the RECV path for the response to the outbound frames (the response may be in an I-frame).

Secondary Station During Initialization and Normal Operation

Channel Program		Notes
INIT:	SETMODE	1, 2
	ENABLE	1
	READ	3
INTA:	CONTROL SCB	1, 4
	SETMODE	7
	WRITE	1, 5
	TIC to RECV	
NORMAL:	NOP	1
	TIC to AUTOP	
	(TIC to XMIT)	
AUTOP:	AUTOPOLL	6
	TIC to NORMAL	
RECV:	READ PIU	1
	READ PIU	1
	READ PIU ...	1
	SENSE SCB	
XMIT:	CONTROL SCB	1
	WRITE PIU	1
	WRITE PIU	
	WRITE PIU...	
	POLL	
	TIC to RECV	

Notes:

1. Command chained.
2. A flag in the Set Mode parameters indicates that the line is to be operated as a secondary. The address used in the Read command as station address is transferred. The non-productive receive timer is set to infinite, so that the Read command will not terminate with timeout.
3. The Read operation is not completed until the primary station sends a frame, normally a contact poll frame (SNRM) with the address from the preceding Set Mode command.
4. A new channel program is started after an SNRM is received (to be checked by the access method).
5. The Write command sends an unnumbered acknowledgement (UA) in response to the SNRM. The station address in the SCB is the expected address for all subsequent inbound data read by Read PIU or Sense SCB commands.
6. This Autopoll command serves for the datapoll function only.
7. This command sets a new value for the non-productive receive timeout.

Primary Station Initialization on a Switched Autocall Line

Channel Program		Notes
CONNECT:	DISABLE	1, 2
	DIAL	1, 3
	WRITE	1, 4
	READ	5
CONTACT:	WRITE	1, 5
	READ	5
NORMAL:	....	6

Notes:

1. Command chained.
2. The Disable command protects against a race condition if a previous Enable command for an incoming call was halted.
3. The Dial command sends the dial digits to the autocall unit associated with this line. The Dial command also implies Enable.
4. The first Read/Write sequence sends the XID request and reads the terminal ID in the XID response. The ID information is used to build an SNRM and find or build the SCB for the station.
5. Write/Read can be used to send SNRM and read UA.
6. From this point on, operation is the same as for leased lines. The SCB table for this line will have only one entry since a switched line implies point to point.

Primary Station Error Recovery in Multipoint Operation

Error recovery involves retransmitting I-frames sent but not acknowledged or repolling for bad frames received. Errors in retriable operations are detected by the line attachment but the retries themselves are initiated by the access method. No new channel programs are necessary to perform retries but awareness is needed to avoid retrying indefinitely.

The first bad I-frame received stops the transfer of data into the buffers. The NRACC and CRBUF fields are frozen and the soft error indicator is set in the current SCB. The Read PIU command is terminated normally when a frame with the P/F bit set to one is correctly received, or when a timeout occurs.

In this situation the timeout is handled as a retriable condition because the P/F bit may have been missed in a bad frame. The line attachment continues to look at frames and examine block check characters even though no data is transferred.

The channel program ends with a Sense SCB command. The access method determines from the soft error indicator that an error has occurred. At this point everything is set up properly for repolling the station for the missed frames. The SCB must be updated with fields from the CA's copy and the channel program must be restarted. The Autopoll index still points to the SCB last used and NRACC acknowledges only the good frames received. Before restarting however, the access method must determine whether a retry limit has been exceeded or whether some other station should be serviced.

For outbound frames, acknowledgement is found in the Nr field of the next RR, RNR, or I-frame received from the station. The access method determines an error when a mismatch is found between the number of frames sent and the num-

ber acknowledged (NSCUR with NSACK). To retry, NSCUR is reset to NSACK and the Write PIUs are started from the first frame missed. In this case the access method must maintain its own retry count.

Unit Status

The unit status is indicated in bits 32 to 39 of the CSW. The unit status shows, for example, the conditions under which an I/O operation ended.

Bit	Meaning
32	Attention (not used)
33	Status modifier
34	Control unit end (not used)
35	Busy
36	Channel end
37	Device end
38	Unit check
39	Unit exception

Note: If the channel detects errors when fetching the first CCW or when fetching a chained command, program check is set in the channel status. No unit status such as device end or channel end is presented.

Status Modifier (Bit 33): The status modifier is presented together with channel end and device end at command end time in the following cases:

1. In the datapoll function of the Autopoll command. The Autopoll command ends with the status modifier set if the reply from a remote station is an unexpected command or an I-frame, or if no reply at all is received within the timeout period.
2. In the contactpoll function of the Autopoll command. The Autopoll command ends with the status modifier set if a reply other than a DM frame is received from the remote station within the timeout period.
3. The Autopoll command is flushed.

Busy (Bit 35): Busy is presented if an inline test is active on a line addressed by an SIO instruction. A secondary interruption with device end follows.

Channel End and Device End (Bits 36 and 37): Channel end and device end are always presented together to indicate that the channel program is terminated. The setting of channel end and device end without unit check indicates normal termination.

Unit Check (Bit 38): Unit check is presented in two different situations:

1. If, during the command initialization sequence, the line attachment detects that the first command cannot be executed, a CSW is presented with unit check set, but without channel end or device end. This unit status indicates that the line attachment does not accept the channel program for execution.

The situation may occur as a result of one or more errors detected before the channel program has become active and the first command is not a Sense, No-op, or Sense I/O.

2. Unit check is presented together with channel end and device end if the line attachment finds the first sense byte to be non-zero when a command is about to terminate. This happens if one or more errors are detected during execution of this command.

"General Synchronization Rules" in this chapter explains at what time (in relation to line activity and channel program) a unit check is generated.

Unit Exception (Bit 39): Unit exception is presented together with channel end and device end at command end time for Enable and Dial commands, as follows:

1. Enable
   In switched network operation, when the command is successfully halted by a Halt I/O or Clear I/O instruction before a call is answered.

2. Dial
   When the command is successfully halted by a Halt I/O or Clear I/O instruction before the channel stop signal is raised to signal the end of the dialing digits.

Channel Status

Bit	Meaning
40	Program controlled interruption (PCI)
41	Incorrect length
42	Program check
43	Protection check
44	Channel data check (not used)
45	Channel control check
46	Interface control check (not used)
47	Chaining check (not used)

Program Controlled Interruption (Bit 40): The PCI bit is set in the UCW of the addressed line when the PCI flag is found on during the initiation of a CCW.

The interruption condition due to the PCI is generated during the initiation of the command containing the PCI bit.

Incorrect Length (Bit 41): This bit is set in accordance with standard channel practice.

Programming Note: If the byte count is not decremented to zero at command termination, the incorrect length bit is set. This will suppress command chaining if the SLI bit is not set in the CCW.

All read and write-type commands, where the message length is either unknown or not as specified, must have the SLI bit set to avoid suppression of command chaining.

The Enable and Disable commands must always have the SLI bit set to avoid suppression of command chaining.

Program Check, Protection Check (Bits 42 and 43): These bits are set in accordance with standard channel practice.

Channel Control Check (Bit 45): This bit is set if a parity or trap check occurs in the adapter.

Sense Information

The line attachment transfers up to 24 bytes of sense data in response to a Sense command.

Sense byte 0 is the standard sense byte followed by a three byte extension field. This extension field is followed by the twenty bytes of the current SCB.

The first byte of the extension field (sense byte 1) is a check byte. Sense bytes 2 and 3 are reserved.

The check byte shows why a bit is set in sense byte 0. The check code notifies the access method of different classes of errors, such as errors with or without the possibility of a retry.

Sense Bytes 0 and 1

Descriptions of the bits in sense byte 0 follow. See the last part of each bit description for the meanings of the associated check codes in sense byte 1.

Bit	Meaning
0	Command reject
1	Intervention required
2	Bus out check (not used)
3	Equipment check
4	Data check
5	Overrun
6	Lost data
7	Timeout complete

Command Reject (Bit 0): This bit is set during command initiation if an invalid command is issued to a CA line, or if the state of the line does not allow the command to be executed. The command is terminated immediately with unit check set when the CSW is stored. Sense byte 1 shows additional information as follows:

Hex	
04	The Dial command is issued and there is no Autocall adapter for a switched network associated with the addressed line.
05	The 'data terminal ready' (DTR) signal is on when a Dial command is initiated, that is, the addressed line is not in the disabled state when the Dial command is initiated.
06	DTR is off at command initiation for a read-type command or write-type command on an SDLC line, that is, the line is not enabled.
07	DTR is off during chaining to a read- or write-type command.
08	Eight immediate type commands (No-op, Sense, Sense I/O, Set Mode, Sense SCB, or Control SCB) are executed consecutively.
09	The command is not a valid SDLC-CA command.
10	The line direction is outbound during a read-type operation.
11	The line direction is inbound during a write-type operation.
12	The first two bytes of the data area of a Read PIU or Write PIU operation cross a page boundary.
13	Seven outstanding I-frames in a Write PIU operation have not been acknowledged.
14	In a Read PIU or Write PIU command the offset exceeds the CCW length count, or in a Write PIU command the frame length field exceeds the CCW length count and data spanning is not specified.
15	No current SCB is defined for a Read PIU, Write PIU, or Poll operation.
16	The CCW length count is less than 12 in a Control SCB command, or less than 20 in a Sense SCB command, or not between 12 and 2K in an Autopoll command.
17	The data address is not on a fullword boundary in an Autopoll, Control SCB, or Sense SCB command.
18	More than 127 channel commands have been flushed consecutively.
19	The length count in a Write command is less than two.

Intervention Required (Bit 1): A detected intervention required condition normally causes immediate termination of the current operation. The channel end, device end, and unit check bits are set when the CSW is stored at the time of the I/O interruption.

The intervention required bit is set for errors in external modems (or in the channel service unit in case of the Digital Data Service attachment, or in the Digital Service Unit in case of the X21 attachment). For errors in integrated modems, equipment check is raised. Sense byte 1 shows additional information as follows:

Hex	
20	'Data set ready' is off during the execution of a read-type or write-type command. The line is disabled.
21	'Data set ready' is off at the initiation of a read-type or write-type command. The line is disabled.
22	'Clear to send' is not activated by the modem as a response to 'request to send on' before the ten-second timeout ends either in the initiation of a write-type command or an Autopoll Read to Autopoll Write turnaround. The line is disabled.
23	'Clear to send' is off during the execution of a write-type command or in the Autopoll Write state (not 'permanent request to send'). The line is disabled.
24	The loss of the external clock signal (modem clock) is detected during the execution of a write-type command. The line is disabled.
25	In 'switched request to send' operation (not 'permanent request to send') 'clear to send' is not de-activated as a response to 'request to send off' by the modem before the 1-second timeout expires either at the termination of a Write/Write PIU command or at Autopoll Write to Read turnaround. The line is disabled.
29	The ACU's 'data line occupied' signal is on when a Dial command is initiated or off when the command is executed.
2A	The ACU's power indicator signal is off at Dial command initiation or execution.
2C	During execution of a Dial command the ACU has not turned on or off 'present next digit' or turned on the 'abandon call and retry' signal within 25 seconds in the following cases: 1. 'Call request' to the ACU is on and 'present next digit' is not present. 2. 'Digit present' to the ACU is on and 'present next digit off' is not present. 3. 'Digit present off' to the ACU is present and 'present next digit on' is not presented by the ACU.
2D	The ACU and the modem do not present 'distant station connected' and 'data set ready' nor 'abandon call and retry' within 60 seconds after all dialing digits and the signal 'not digit present' have been presented to the ACU during the execution of a Dial command.

2E — On a leased line 'data set ready' is not found on within three seconds after 'data terminal ready' is presented during the execution of an Enable command, or on a switched line with 'connect data set to line' on, the calling indicator comes up but 'data set ready' does not turn on within ten seconds.

31 — An Enable command is issued to an already enabled line ('data terminal ready' found on), but the 'data set ready' signal is not active, or 'data set ready' is on during an Enable operation to a switched line, and 'data terminal ready is off.

Equipment Check (Bit 3): This bit is set if a hardware check is detected in the CA, including integrated modems or local attachment hardware. A detected equipment check causes immediate termination of the current command, and causes channel end, device end, and unit check' to be set at the time of an I/O interruption. Sense byte 1 shows additional information as follows:

Hex

60 — An unexpected adapter status occurs.

61 — A hangup occurs in the adapter. The line is disabled.

62 — A machine check is detected indicating an error on the processor bus. The line is disabled.

63 — The loss of the internal clock signal is detected during the execution of a read-type command or write-type command. The line is disabled.

64 — No valid basic status is available. The line is disabled.

70 — 'Data set ready' is off during the execution of a read-type or write-type command. The line is disabled.

71 — 'Data set ready' is off at the initiation of a read-type or write-type command. The line is disabled.

72 — 'Clear to send' is not activated by the modem in response to 'request to send' on before the ten-second timeout ends either in the initiation of a write-type command or in an Autopoll Read to Autopoll Write turnaround. The line is disabled.

73 — 'Clear to send' is off during execution of a write-type command or in the Autopoll Write state (not 'permanent request to send'). The line is disabled.

74 — In 'switched request to send' operation (not 'permanent request to send'), 'clear to send' is not de-activated by the modem in response to 'request to send' off before the one-second timeout expires, either at the termination of a Write/Write PIU command or at Autopoll Write to Read turnaround. The line is disabled.

75	'Request to send' is down while the line is in the outbound state although 'permanent request to send' is on. The line is disabled.
76	'Data terminal ready' is off while the line is enabled. The line becomes disabled.

Data Check (Bit 4): This bit is set in receive mode when commands are executed and frame check sequence errors or format errors occur. Sense byte 1 shows additional information as follows:

Hex	
90	A frame check sequence error is detected during the execution of a Read command. The check applies to both primary and secondary lines.
91	The offset value in an SCB transferred to the line attachment is specified as 0 or 1, or any reserved fields are not zero.
92	Any line receives an invalid frame (too short) or an abort sequence during the execution of a Read command. The invalid frame check applies to both primary and secondary lines.
95	Any reserved fields in the information provided by a Set Mode command are not zero, or the line is specified as secondary without the secondary station address being provided.
96	An 'Nr out of range' is received.

Overrun (Bit 5): The overrun bit is set if the line attachment is too late to serve a request for data transfer from the associated hardware. Sense byte 1 shows additional information as follows:

Hex	
A0	An overrun condition is detected during the execution of a read-type command.
A1	An underrun condition is detected during the execution of a write-type command.
A2	Data chaining is specified in a Read PIU or Sense SCB command.
A3	Data chaining is specified in a Write PIU, Control SCB, or Autopoll command.

Lost Data (Bit 6): This bit is set during the execution of commands when the line attachment has filled its buffer space with received data before a read-type command is active. Sense byte 1 shows additional information as follows:

Hex

C0 — At least one full character is received and lost because no inbound command was active. Unit check is not set if:

1. Some inbound data is already accepted in the current channel program, or
2. For a secondary station, no channel program is active.

C1 — The length count is decremented to zero without a flag for a Read command being received.

C2 — 'Present next digit' is on during the initiation of a Dial command.

C4 — 'Distant station connected' is on during the initiation of a Dial command.

C5 — The 'data set ready' or 'distant station connected' signal is active during a Dial operation. The command is terminated immediately.

C7 — A Halt I/O instruction is issued while a Read command is active. The command is terminated immediately.

Timeout Complete (Bit 7): This bit is set when an unexpected timeout occurs. Sense byte 1 shows additional information as follows:

Hex

E6 — The 'abandon call and retry' signal of the ACU becomes active during the initiation of a Dial command.

E7 — The ACR signal becomes active during the execution of a Dial command.

EC — 'Data set ready' is not de-activated by the data set within one second (modems with 'data terminal ready' procedure) or 25 seconds seconds with 'connect data set to line' procedure) after the signal 'data terminal ready' is dropped during the execution of a Disable command (valid only for switched networks).

F0 — A non-productive receive timeout occurs while a read-type command is active. In a primary station no leading flag is received after the line has turned to inbound. The line is not idling. In a secondary station no leading flag has been received after the line has turned to inbound. The line is either receiving garbage or is idling. See "Description of Timeouts" at the end of this chapter.

F1	An idle timeout occurs on a primary station when no current SCB exists or a Read command is active. No frame has been received after the line has turned to inbound and the line is idling.
F2	A fill character timeout occurs. A write-type command is outstanding after a frame has been transmitted with the P/F bit at zero.
F3	Too many SCBs have skip specified in the control flag during an Autopoll operation.

Sense Bytes 2 and 3

These two bytes are zero.

Sense Bytes 4-23

These bytes are the twenty bytes of the SCB. See "SCB Format" and "Sense SCB" in this chapter.

Soft Errors and Recovery

There is another group of errors, ('soft errors'), which do not cause an abnormal termination of the channel program. Although soft errors are communicated to the access method they are not given special recovery action. A soft error is indicated in bit 0 (SOFTERR) of the first exception flag byte of the SCB (EXFLAGS1). The second exception flag byte (EXFLAGS2) specifies which kind of soft error has been detected.

If no SCB exists, or if an SCB exists but a Read command is active when an exceptional condition is detected, a unit check is generated rather than an exception indication. (There are two reasons for a non-existing SCB: either a channel program is running but no Control SCB or Autopoll command has been issued, or no channel program is active).

If a soft error is indicated in the exception flag bytes, the counter fields in the SCB have not been updated for the frame in which the error has been detected.

If several soft errors are detected during a channel program, only the first error is reported.

The soft error conditions are:

Second Exception Flag	Meaning	Link Direction at Time of Error	Synchron. Initiated	Link State after Error		Action
				Primary	Secondary	
'01'	An idle timeout, followed by 15 marks, is detected when an Autopoll command is active. Applicable to primary mode only.	inbound	no	outbound	-	• If primary, turn line to outbound. • Set Status Modifier (simulate unexpected reply). • Flush channel program.
'02'	Same as 01, but for Read PIU or Sense SCB. Applicable to primary mode only.	inbound	no	outbound	-	• If primary, turn line to outbound.
'04'	Nonproductive receive timeout when an Autopoll command was active.	inbound	no	outbound	inbound	• Same as '01'.
'05'	Same as '04', but with Read PIU or Sense SCB. Note that a nonproductive receive timeout is also reported in case of length count overflow for an I-frame received by Read PIU.	inbound	no	outbound	inbound	• Same as '02'.

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Second Exception Flag	Meaning	Link Direction at Time of Error	Synchron. Initiated	Link State after Error		Action
				Primary	Secondary	
'06'	NS out of sequence. In secondary mode, this error is set only after all I-frames in sequence (until a frame with a P/F bit equal to one is received) have been inspected for a matching NS count.	inbound	yes	outbound	outbound *	• Synchronize and flush.
'08'	An abort sequence, followed by 15 marks, or an invalid SDLC sequence is received.	inbound	no	outbound	inbound	• If an Autopoll command is active same as '01' otherwise same as '02'
'0B'	Address mismatch detected in primary station.	inbound	yes	outbound	-	• Synchronize and flush.
'0C'	Frame received too short, (less than 4 bytes). At the beginning of a data stream, short frames are considered to be noise and are neglected.	inbound	yes	outbound	outbound *	• Synchronize and flush. • If an Autopoll command is active, set Status Modifier before flushing because this error is considered an unexpected reply.
'0E'	FCS bad on Autopoll response.	inbound	yes	outbound	outbound *	• Same as '0C'.
'0F'	FCS bad (except for Autopoll response).	inbound	yes	outbound	outbound *	• Same as '0C'.
'11'	Overrun	inbound	yes	outbound	outbound*	• Synchronize and flush.
'12'	Not enough buffer space. 1. In a data spanning situation, no subsequent Read PIU is found in the channel program to accommodate the rest of the frame, or no buffer is provided at all, or 2. A frame with an I-field is received in response to a Sense SCB command.	inbound	yes	outbound	outbound*	• Store the total length of incompletely stored frame at the beginning of the first buffer area as usual. • Sychronize and flush.
'40'	Short Hold Mode Disconnect (X.21 Switched)	inbound	no	-	-	• Flush channel programm

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Second Exception Flag	Meaning	Link Direction at Time of Error	Synchron. Initiated	Link State after Error		Action
				Primary	Secondary	
'81'	Underrun	outbound	-	outbound	inbound	• Abort and flush. If secondary, turn line to inbound.
'82'	Frames acknowledged fewer than frames sent.	inbound	-	-	-	• No special action.

* This applies if synchronization acts normally, that is, if a P/F bit equal to one is received.

CCW Flags

Chaining Flags: Command chaining is executed according to standard channel practice.

Data chaining is performed as soon as the length count field is decremented to zero and the chain data flag (CCW bit 32) is found on. Read PIU and Write PIU commands cause an overrun if chain data is specified.

Channel Indirect Data Addressing (IDA) Flag: The IDA flag (CSW bit 37) is valid only in System /370 mode. The data address is exchanged if the IDA bit is found on when the CCW is fetched during Command initiation or Chaining of commands

The data address is also exchanged during data transfer operations when the CA detects a page boundary crossing, and the IDA flag is set in the current CCW. Bits 0-7 in the IDA word must contain all zeros, otherwise program check is set. The data address in the CCW must be on a fullword boundary, otherwise program check is set.

Program Controlled Interruption: A program controlled interruption is generated during command initiation or during chaining.

Suppress Length Indication Flag and Skip Flag: The suppress length indication flag (CCW bit 34) and the skip flag (CCW bit 35) are handled according to standard channel practice.

Termination of Operations

Termination at Initiation of Operation

When the CA detects an unusual condition during the initiation of an operation, the command is rejected. Condition code 1 is set, and the status portion of the CSW is stored. No interruption condition is generated.

When an unusual condition causes a command to be rejected during command chaining, an interruption is generated, and the chain of commands is broken.

Termination of Immediate Operations

If no command chain is specified with an immediate operation such as Control No-op, the channel end and device end condition is brought to the attention of the program by storing the CSW, and by setting the condition code to 1.

If command chaining is specified with an immediate operation such as Control No-op, condition code 0 is set when the immediate command is initiated. The subsequent CCWs are handled normally, and the channel end/device end condition for the last CCW generates an interruption.

Termination of Command Execution

At command termination, channel end and device end are set in the CSW, and an interruption request is generated.

Any unusual condition causes command chaining to be suppressed and a terminating condition to be generated. The unusual condition is set in the channel status or unit status portion of the CSW, together with channel end and device end. An interruption request is generated. A Test I/O or Clear I/O instruction clears both interruptions at the same time.

Termination by Halt I/O or Clear I/O Instruction

When a channel program is stopped by a Halt I/O or Clear I/O instruction, the corresponding line is disabled.

Ending Condition Classification

The following is a description of all possible ending conditions, classified by error severity. For a more detailed list of error conditions see "Sense Information" and "Soft Errors and Recovery" in this chapter.

Group	Ending Condition	Indications
1	Normal Ending.	CSW: CE, DE
2	Soft Error. This group covers retriable errors that occur during high level CCW operation. A bit is set in the SCB exception byte. Unit check is not presented.	CSW: CE, DE
3	Retriable Hard Error. This group covers retriable errors on low level CCWs. It is composed of nearly all unit checks with data check, overrun, lost data, and timeout, and has only a few exceptions. For example, unit checks with vertical redundancy check and data check in the SCB (hex 91 in sense byte 1) are not included in this group, nor are unit checks for lost data which refer to Dial.	CSW: CE, DE, UC
4	Intervention Required. This group covers non-retriable errors related to system parts external to the processor. It is composed of all unit checks with intervention required, plus (in case of an external modem) those unit checks with lost data which refer to Dial.	CSW: CE, DE, UC
5	Equipment Check. This group covers CA hardware (including integrated modems) or microcode errors. It is composed of all unit checks with equipment check, plus those units with lost data which refer to Dial.	CSW: CE, DE, UC or channel status
6	Program Error. This group covers channel programming errors. These situations should not occur.	CSW: CE, DE, UC or channel status

General Synchronization Rules

Independent of the semantics of each command, the CA has to maintain synchronization between line activities and the execution of the channel program.

Line Direction Transitions

After an Enable command, the line direction of a primary station is outbound, and that of the secondary station is inbound. The line goes from outbound to inbound in the following situations:

- A P/F bit is sent.
- In a secondary station, a fill character timeout occurs.
- In a secondary station, an abort sequence is sent because of underrun.

The line goes from inbound to outbound in the following situations:

- A P/F bit is received.
- In a primary station, nothing is received and either idle detection (15 marks received after idle timeout) or non-productive receive timeout occurs.
- In a primary station, an abort sequence is received.

Note: On a line set to outbound, continuous flags (hex '7E') are sent out between frames.

Channel Program Synchronization Rules

If no channel program is active, the line direction is outbound, except in the following cases, when it is inbound:

- A P/F bit is transmitted with the last line-affecting command of the preceding channel program. For a primary station, however, the line is turned back to outbound after idle timeout or non-productive receive timeout.
- For secondary stations only:
  - A fill character timeout occurs.
  - An abort sequence is sent out because of underrun.
  - A non-productive receive timeout occurs.
  - A frame with no matching address is received. Such a frame is ignored. A P/F bit causes no line turnaround.
  - Data is received when no channel program is active. The station remains at inbound even if the P/F bit is set. A unit check, with the lost data bit set, is not raised.

A channel program is never complete until the line status is as described in the preceding rules. Channel program termination is suspended if necessary. The only time when synchronization is not established is after the rejection of a command, at which time the line direction is undetermined until the next timeout establishes a unique situation. The same is true when a program check or protection check occurs. These checks, when detected, cause immediate program termination.

Description of Timeouts

Nonproductive Receive Timeout

Line Direction: **Inbound.**

Reason: In a primary station no leading flag is received after the line is turned to inbound. The line is not idling (otherwise, an idle timeout would have been detected), that is, only meaningless information has been received.

In a secondary station no leading flag is received after the line has been turned to inbound. The line is either receiving meaningless information or is idling (because no idle timeout is defined for the secondary station).

In a primary or secondary station at least one leading flag is received after the line has been turned to inbound, but no trailing flag is received.

In a primary or secondary station a Read PIU is active and the accumulated frame length of an I-frame exceeds 2^{16}.

Started: When turning the line to inbound.

After a valid frame has been received.

Actions: Generate a soft error or unit check.

For a primary station, turn the line to outbound.

If no channel program is active, keep the generated unit check.

If a channel program is active, raise a unit check and terminate the channel program.

Idle Detect Timeout

Line Direction: **Inbound.**

Reason: In primary stations only, no frame is received and the line is idle (no meaningless information). The idle timeout can have a time value of 0 if an abort sequence is received.

Started: When the line is turned to inbound.

Actions: If following this timeout 15 marks are not received, no action is needed (a non-productive receive timeout will come up later).

If no command is active, no action is needed. If a command is active (it can only be a read-type) and an SCB exists:

- Set the soft error indication into the SCB.
- Flush the channel program and terminate it (no synchronization).

If a command is active and no SCB exists:

- Generate a unit check.
- Raise the generated unit check and terminate the channel program (without flushing).

Turn the line to outbound.

Fill Character Timeout

Line Direction: **Outbound.**

Reason: A write-type command is outstanding; that is, too many continuous flags have been transmitted after line turn-around or after transmitting a frame with the P/F bit at zero. This is a programming error.

Started: Whenever the CA starts transmitting continuous flags, that is, after turning the line to outbound, and after transmitting a frame with the P/F bit at zero.

Actions: Generate a unit check and raise at the next opportunity (that is at the first CCW of the next channel program).

For a secondary station, turn the line to inbound.

Unit Check and Soft Error Handling

In addition to the synchronization of line activities with the channel program, there is also a rule governing the synchronization of error situations with the channel program and line activities.

The general rule is that if a unit check is generated, it is presented and the channel program is completed as soon as possible. This can be done if the following three conditions are fulfilled: a command is active, no previous sense information is pending, and the line direction is correct.

Under these conditions, the unit check is presented at the termination of the currently active command. Synchronization is performed before this termination if the line direction is inbound. If, however, no command is active, the unit check is presented when the next command is initiated. If this command is a Disable, the unit is reset.

If sense information relating to a previous unit check exists, the current unit check cannot be presented. It is, therefore, kept until the sense information is reset, for example, by a Read command. The unit check is then presented as described in the preceding paragraph.

As an exception, a unit check with command reject is always presented immediately, regardless of the line status.

In the case of a soft error, the channel program is not immediately terminated. It is flushed to allow for a concluding Sense SCB command. If the current transfer is inbound, the termination of the channel program is synchronized with the line activity. When a soft error occurs while a unit check is being presented, the soft error information will not have been read by the Sense SCB command which usually terminates a channel program. This information will still, however, be available as a result of the Sense SCB command, because the SCB is part of the sense information.

Chapter 6. X.21 Switched Facility

Introduction

A number of countries such as Germany, Japan and Nordic countries offer circuit-switched public data networks that follow recommendation X.21 of the International Telegraph and Telephone Consultative Committee (CCITT). This recommendation (in further text simply called X.21) defines a terminal-to-network interface that consists of seven signals which are not only used to send and receive data but to establish calls as well.

It is one of the attractive features of X.21 that the public data network is able to communicate detailed call-status information to the data terminal equipment (DTE). Call-progress signals such as 'number busy', 'access barred', 'number changed', etc., are passed from the network to the call-originating terminal to let it "know" why a particular call was not completed. Conversely, the data terminal equipment places calling information directly onto the same interface that is used for data transfer, thus eliminating the need for a separate calling unit.

The integrated communications adapter offers the X.21 interface for any of its SDLC-configured communication lines. The interface is ordered via feature code and consists physically of a driver card and a cable with a 15-pin connector (X.21-connector) attached. This connector plugs into the data transmission box (the data circuit terminating equipment - DCE -) of the public network.

X.21 General Function

The X.21 support uses the well-known Dial command to transfer user-supplied call selection data from main storage to the communication adapter where this data is translated into a call request signal and a number of International Alphabet Number 5 (IA5) characters to "make" an outgoing call.

The communications adapter then monitors the call progress via the new Listen command which is chained to the Dial command. The Listen command transfers the call progress signals from the data circuit terminating equipment (DCE), speak: from the public data network to main storage. Normal events, such as call-collision, are handled by the communication adapter without notifying the software (the calling terminal wins).

Two call-progress signals must be received in response to an outgoing call and this is checked for, otherwise unit check with detailed error information is given. Certain types of call progress reports lead to a retry and the number of retries as well as any pauses between them can be specified by the user (to achieve compliance with network rules). After call establishment, a fully transparent half duplex data path is provided between the end users to transfer data in any code.

The X.21 interface also handles incoming calls. The Enable command activates the line and the Listen command (which is chained to Enable) transfers the DCE-provided information to main storage when a call does actually come in (auto-answer effect). The DCE provides information identifying the caller in the IA5 code which is translated to EBCDIC by the communications adapter. Thus a fully transparent connection is established also for incoming calls.

All commands that follow the call establishment to perform the actual data transfer (Read, Write, Read PIU, Write PIU, etc.) are the same as those described in the preceding chapter (Chapter 5. Synchronous Data Link Control). The same applies to the technical details of data transfer (synchronization, link control, etc.).

The X.21 procedures deal only with call establishment, and this is described in more detail in the following paragraphs. These paragraphs mention the IA5 alphabet and certain states as reference but do not show all details. For full information about all aspects of X.21, see CCITT Yellow Book Volume VIII, Fascicle VIII. 2 Nov. 1980.

Functions Supported

Since X.21 is a recommendation which includes many possible functions, this paragraph describes which functions are supported by the communications adapter's X.21 interface. The following functions are supported:

Auto Answer. This is the ability to detect an incoming call from the network and to establish a connection.

Call Progress Signals. This is the ability to recognize call progress signals (which are two-digit numbers) and the ability to indicate an interim connection status or the unsuccessful outcome of a call.

Call Progress Blocks. This is the ability to receive a number of call progress signals separated by a comma.

Address Call. This is the ability to send the full or abbreviated number of the remote data terminal equipment. Presently, six or seven digit numbers are in use (more numbers being required for international calls).

Direct Call. This is the ability to "call" a specific data terminal equipment (previously determined) without using a number. Merely a call request is initiated and this leads to the pre-specified connection.

Closed User Group Facility. This is the ability to define a user group in such a way that any member can only communicate with any other member of the same group, but not outside this group.

Calls Barred. This is the ability to limit the use of numbers to a certain range, for example, to local calls only. The following can be specified:

- Full number selection barred.
- Outgoing calls barred.
- Outgoing international calls barred.
- Incoming calls barred.
- Incoming international calls barred.

The subscriber selects the various functions by specifying parameters in the supporting software (VTAM/VTAME).

X.21 Interface Phases

The actions on the X.21 switched interface can be divided into four phases: Quiescent, call-establishment, data transfer and clearing. On an X.21 leased

interface (see paragraph "X.21 Leased Facility" at the end of this chapter), there is only the quiescent phase and the data transfer phase. The various phases are distinguished by using a combination of interface signals (see Physical Interface).

The Quiescent Phase is a non-active phase during which the DCE and the DTE indicate a ready or a not ready state.

The Data Transfer Phase is the phase after successful call establishment in which a half-duplex and completely transparent transmission path is maintained between both end users. The communications adapter transfers EBCDIC code and uses SDLC as line control.

The Clearing Phase is the phase in which either the DTE or the DCE initiates a release of the connection and the interface returns to the quiescent state.

Physical Interface

The physical interface consists of the following seven signals which exist as wire pairs each (A and B) because the circuits are electrically balanced. The circuits are assigned to the following pins in the 15-pin plug:

Signal Name	**Pin Assignment**	
	A	**B**
Cable Shield	1	-
(T) Transmit	2	9
(C) Control	3	10
(R) Receive	4	11
(I) Indication	5	12
(S) Signal Element Timing	6	13
(B) Byte Timing (not used)	7	14
(G) Signal Ground	8	- (reserved)

The circuits have the following general functions:

Transmit. The transmit circuit transfers binary data from the terminal to the network (during the data transfer phase). During the call-establishment phase, binary call-control signals are sent to the network over this circuit.

Control. The control circuit is used together with 'transmit' to define the terminal's state to the network. For example, during the call-establishment phase, the "on" condition (binary 0) of the control circuit tells the network that the data on the transmit circuit is call selection information.

Receive. The receive circuit transfers binary data from the network to the terminal (during the data transfer phase). During the call-establishment phase, binary call progress signals from the network are received over this circuit.

Indication. The indication circuit is used together with 'receive' to inform the terminal via the "on" condition (binary 0) that the connection with the end user is established.

Signal Element Timing. The signals on this circuit originate at the network and provide bit timing to the terminal. The network supplies this timing at all times and in such a way that the binary condition is on and off for nominally equal periods of time. When the terminal presents a binary signal on circuits T and C, the transitions occur nominally when the signal on circuit S goes from off to on. When the network presents a signal on circuits R and I, the terminal recognizes the transitions nominally when circuit S goes from off to on condition.

Byte Timing. This circuit, while intended to provide 8-bit timing information, is not used by IBM equipment. Detailed information about the exact combination and timing of all signals can be found in CCITT Yellow Book, Volume VIII Fascicle VIII. 2 Nov.1980. The communications adapter follows the timing as described in this document.

Channel Command Words (CCWs)

The following channel command words are used by the supporting software to operate the X.21 switched facility:

Hex	Command Name
27	Enable
29	Dial
0A	Listen
23	Set Mode
2F	Disable
E4	Sense I/O
40	Sense

The commands are described in the following paragraphs because their function is specific for X.21 switched lines.

Enable (X'27')

The Enable command prepares a line equipped with X.21 switched interface to accept incoming calls. Once Enable is issued to an X.21 switched line, the command remains active and is completed only when a call arrives (or a Halt instruction terminates the command).

An incoming call is accepted when the public network (DCE) is ready, and the calling information arrives beginning with SYN, BEL, BEL. This is monitored by the communications adapter. An acceptable call is responded to with the raising of the control circuit to the DCE and then channel end and device end are presented for the Enable command. The Listen command should be chained to Enable to pick up the incoming data (see 'Listen').

Dial (X '29')

The Dial command transfers call selection data from the storage location defined by the data address to the communications adapter where this (EBCDIC) data is translated to International Alphabet Number 5 (IA5) characters and transmitted to the DCE. The call selection data must be prepared by the user in such a way that it consists of numeric characters 0...9 and valid delimiters (- + , . /). To specify a direct call, only the + character (X '4 E') need be transferred.

The communications adapter checks that the DCE is ready and if so, raises the call request (which is a binary 0 on both the transmit and control circuits). The adapter then waits for the 'proceed to select' response from the DCE and sends the call selection characters (if the response is given in time).

The call selection characters are translated into IA5 codes, as shown in the following table:

Translate Table

Graphic	EBCDIC	IA 5
+	X'4E'	2/11
,	X'6B'	2/12
-	X'60'	2/13
.	X'4B'	2/14
/	X'61'	2/15
0	X'F0'	3/0
1	X'F1'	3/1
2	X'F2'	3/2
3	X'F3'	3/3
4	X'F4'	3/4
5	X'F5'	3/5
6	X'F6'	3/6
7	X'F7'	3/7
8	X'F8'	3/8
9	X'F9'	3/9
SYN	X'32'	1/6

Figure 18 on page 155 in Appendix A shows the code table of the International Alphabet No. 5.

The SYN characters for maintaining synchronization are inserted by the communications adapter. Channel end and device end are presented for the Dial command when the call selection characters have been transmitted to the DCE (or the command is terminated by a Halt instruction). If a Halt or Clear instruction stops the Dial command, unit exception is additionally presented and the 'DTE clear request' is sent to the DCE. The line is then cleared and set to 'DTE controlled not ready' state.

Listen (X'0A')

The Listen command transfers incoming call progress signals (if any) from the line to the storage location defined by the data address. The command should be command-chained from a preceding Dial or Enable command to ensure pickup of call progress signals received from the DCE. The data arrives in IA5 coding, is translated by the communications adapter to EBCDIC, and then transferred to main storage where it is then available for evaluation. The following call progress signals (two-digit codes) may be received:

Code	Meaning	Recommended Action
01	Terminal called	Wait
02	Redirected call	"
03	Connect when free	"
20	No connection	Try again
21	Number busy	"
22	Selection signals procedure error	"
23	Selection signals transmission error	"
61	Network congestion	"
41	Access barred	Do not try again because success is not likely for some time
42	Changed number	"
43	Not obtainable	"
44	Out of order	"
45	Controlled not ready	"
46	Uncontrolled not ready	"
47	DCE power off	"
48	Invalid facility request	"
49	Network fault in local loop	"
51	Call information service	"
52	Incompatible user class of service	"
71	Long term network congestion	"
72	POA out of order	"
81	Registration/cancellation confirmed	No action
82	Redirection activated	No action
83	Redirection deactivated	No action

The communication adaption monitors the incoming progress signals (digits) to ensure that they are valid which means that a two-digit code followed by a control character (+ or ,) is received. Any DCE-provided information (for example, the called line identification) is likewise monitored for correct sequence which means that a leading control character * or / (hex '5C' or '61') must be followed by data and a trailing + or, (hex '4E' or '6B'). The incoming data is stripped of any SYN (X'32') or leading shift-in characters (X'0F' or IA5 0/15) such as used in Japan's DDX network, and the remaining data is stored in main storage.

The termination of the Listen command depends on the data that is being received, as follows:

If non-retry codes such as 22, 41...52, 71, 72, and 81...83 (or invalid codes) are received, the command terminates with unit check and sense code X'4034'.

If wait codes such as 01, 02, and 03 are received, a restart timer is started and up to three retries (maximum) are performed by the communications adapter.

If try-again codes such as 20, 21, 23, and 61 are received, the retry timeout (which can be set between 0 to 25.5 seconds) is started and the Listen command is terminated with unit check and sense code X'01F4' when the timeout has elapsed. The timeout ensures a delay before the operation is repeated (by software). Several countries permit a retry only after the following delays:

Germany and Austria. For sense code X'01F4' cases, try again after 5 seconds, but not more than 8 repetitions. After the 8th retry, wait 30 seconds then try again. For 4X and 5X codes (sense code X'4034'), call selection of another number is immediately possible; for 7X codes a retry is allowed after 30 seconds have passed.

Japan. For sense code X'01F4' cases, try again but not more than 3 repetitions. After the third retry, wait 30 seconds then try again. In sense code X'4034' cases (codes 4X, 5X, 7X,) wait 10 minutes, then try again.

Nordic Countries (using DATEX). There are no regulations to follow (but it is nevertheless advisable to put in some restriction to avoid overloading the data net).

Note: Successful completion of a call is indicated by the 'indication' circuit rather than by a call progress signal. The Listen command terminates with channel end and device end in this case.

To the Listen command, the following control characters are valid:

Graphic	EBCDIC	IA5
*	X'5C'	2/10
+	X'4E'	2/11
,	X'6B'	2/12
/	X'61'	2/15
Sift-In	X'0F'	0/15 (not stored in data area)

Set Mode (X'23')

The Set Mode command sets up the same parameters as previously described for SDLC lines (see Chapter 5) except that one additional parameter byte (byte 8) is required for an X.21 switched line. Byte 8 specifies the retry timeout in the range of 0 to 25.5 seconds. The time is coded in binary steps of 0.1 seconds each, as follows:

Hex	Meaning
X'00'	0.0 sec
X'01'	0.1 sec
X'02'	0.2 sec
etc.	etc.
X'0A'	1.0 sec
X'0B'	1.1 sec
etc.	etc.
X'FF'	25.5 sec

The default value in byte 8 is 6 seconds (X'3C') which is set at system reset time. The completion of the Listen command is delayed until the retry counter has reached zero.

Note: If "short hold mode" is used, four additional bytes are appended to byte 8 (see 'Short Hold Mode' for details).

Disable (X'2F')

The Disable command clears any calls or connections. When issued, the communications adapter transmits the 'DTE clear' request to the DCE and waits for the 'DCE clear' confirmation. Thereafter, the line is in the 'DTE controlled not ready' state (state 14), where no incoming calls are accepted.

Sense I/O (X'E4')

The Sense I/O command provides the same identification as previously described for SDLC lines in Chapter 5 except that bit 5 in byte 6 is set to 1 meaning "X.21 switched line".

Sense (X'40')

The Sense command transfers two bytes of error information from the communications adapter to the storage location defined by the data address if a unit check status has been presented. The first byte (sense byte 0) contains general error information and byte 1 contains specific codes. These codes are shown grouped per command so that the individual meaning for each command can be found quickly.

Sense Byte 0

Hex	Meaning
X'80'	Command Reject
X'40'	Intervention Required
X'20'	- not used -
X'10	- not used -
X'08'	Data Check
X'04'	- not used -
X'02'	Lost Data
X'01'	Timeout

Sense Information Coding Summary

This summary shows which detail codes are associated with which commands.

Command Reject (Bit 0).

8004 See Dial.

8005 See Enable and Dial.

8006 See Listen.

800B See Listen.

Intervention Required (Bit 1).

4020 See Listen.

4024 See Dial.

402A See Enable and Dial.

402C See Enable and Dial.

4033 See Enable and Dial.

4034 See Listen.

4035 See Enable, Disable, Dial and Listen.

Data Check (Bit 4).

0894 See Listen.

0897 See Listen.

0898 See Dial.

Lost Data (Bit 6)

02C0 See Listen.

02C1 See Listen.

02C7 See Listen.

Timeout (Bit 7)

01E7 See Dial and Listen.

01EC See Disable.

01F4 See Listen.

Sense Codes per Command

The following is a break-down of sense codes as they can appear for each command.

Enable

Sense	Description
8005	The addressed line is not in disabled state when the Dial or Enable command is initiated.
402A	DCE is not 'ready' (state 1) at Dial or Enable command initiation or execution. Line is cleared, set to 'DCE controlled not ready' state 14.
402C	Procedure error. Abnormal condition when waiting for 'proceed to select' or 'incoming call': 1. More than expected number of characters received. 2. Character other than 'BEL' or '+' received. 3. Invalid SDLC sequence received. Line is cleared, set to 'DTE controlled not ready' state 14.
4033	Connection cleared ('DCE clear') before completion. Line is set to 'DTE controlled not ready' State 14.
4035	Comparator error. Will be set if a difference between input and output of any line converter in the interface card is detected. Above indication can erroneously be forced if the cables (internal or external) are not correctly plugged so that the balanced receiver is floating. This could also be the case if the TEST key is pushed on the DCE. Line is cleared, set to 'DTE controlled not ready' state 14.

Dial

Sense	Description
8004	The line is not X.21 switched.
8005	The addressed line is not in disabled state when the Dial or Enable command is initiated.
4024	The loss of the external clock signal (DCE clock) is detected during the execution of a Write Type command. Line is cleared, set to 'DTE controlled not ready' state 14.
402A	DCE is not 'ready' (state 1) at Dial or Enable command initiation or execution. Line is cleared, set to 'DCE controlled not ready' state 14.
402C	Procedure error. Abnormal condition when waiting for 'proceed to select' or 'incoming call': 1. More than expected number of characters received. 2. Character other than 'BEL' or '+' received. 3. Invalid SDLC sequence received. Line is cleared, set to 'DTE controlled not ready' state 14.
0898	Format error. An invalid character was detected in the selection sequence. Line is cleared, set to 'DTE controlled not ready' state 14.
4033	Connection cleared ('DCE clear') before completion. Line is set to 'DTE controlled not ready' State 14.
01E7	'Proceed to select' (state 3) not received following 'call request' (state 2) or 'ready for data' (state 12) not received following 'DCE waiting' (state 6) or 'Call accepted' not properly terminated. Line is cleared, set to 'DTE controlled not ready' state 14.

Listen

Sense	Description
4035	Comparator error. Will be set if a difference between input and output of any line converter in the interface card is detected. Above indication can erroneously be forced if the cables (internal or external) are not correctly plugged so that the balanced receiver is floating. This could also be the case if the TEST key is pushed on the DCE. Line is cleared, set to 'DTE controlled not ready' state 14.
8006	The Listen command is not preceded by Enable or Dial.
800B	The Listen command is issued to a line that is already in data phase.
4020	Connection cleared ('DCE clear') before completion. Line is set to 'DTE controlled not ready' State 14.
4034	Non-retry type Call Progress Signal received: 22, 4X, 5X, 7X, 8X or unrecognizable. Line is cleared, set to 'DTE controlled not ready' state 14
0894	Unrecognizable DCE provided information (no '+' received) or invalid CPS received. Line is cleared, set to 'DTE controlled not ready' state 14.
0897	Format error. The call progress report received was not equal to two characters or did not end with IA5 "+" delimiter. Line is cleared, set to 'DTE controlled not ready' state 14.
01E7	'Proceed to select' (state 3) not received following 'call request' (state 2) or 'ready for data' (state 12) not received following 'DCE waiting' (state 6) or 'Call accepted' not properly terminated. Line is cleared, set to 'DTE controlled not ready' state 14.
01F4	Retry type Call Progress Signals received: 20, 21, 23 or 61. Line is cleared, set to 'DTE controlled not ready' state 14.
02C0	At least one full character has been received and lost because no Listen command was active. The line is disabled. Line is cleared, set to 'DTE controlled not ready' state 14.
02C1	The length count is decremented to zero without a trailing flag for read (including Listen) command being received. The command is terminated immediately. Line is cleared, set to 'DTE controlled not ready' state 14.
02C7	A 'halt I/O' instruction is issued while a read-type command (including Listen) is active. The command is terminated immediately. Line is cleared, set to 'DTE controlled not ready' state 14.
4035	Comparator error. Will be set if a difference between input and output of any line converter in the interface card is detected. Above indication can erroneously be forced if the cables (internal or

external) are not correctly plugged so that the balanced receiver is floating. This could also be the case if the TEST key is pushed on the DCE. Line is cleared, set to 'DTE controlled not ready' state 14.

Disable

Sense	Description
01EC	DCE did not signal clear confirmation (DCE ready) within 2 seconds. Line is cleared, set to 'DTE controlled not ready' state 14.
4035	Comparator error. Will be set if a difference between input and output of any line converter in the interface card is detected. Above indication can erroneously be forced if the cables (internal or external) are not correctly plugged so that the balanced receiver is floating. This could also be the case if the TEST key is pushed on the DCE. Line is cleared, set to 'DTE controlled not ready' state 14.

X.21 Short Hold Mode

To avoid paying for a line connection even though no useful data traffic goes on, the "short hold mode" is offered on X.21 switched lines. The short hold mode consists of a set of optional parameters that can be specified via the Set Mode command. When specified, the communication adapter monitors the line for actual data traffic as soon as the data transfer phase is established on the DTE/DCE interface. If nothing but non-productive polling goes on (during an Autopoll command), the communications adapter clears the connection after a given time interval and reports this clearing back to the software in form of a soft error (which preserves the session). Short hold mode is put into effect by additional parameters in the Set Mode command.

Set Mode Parameters for Short Hold Mode

When short hold mode is to be used, the Set Mode command must transfer four additional bytes to the communications adapter (these will be bytes 9...12) thus increasing the total count of this command to 13. The bytes represent a timer and a counter respectively, which must both run down to zero before the line can be cleared. The bytes represent the following:

Byte	Meaning
9	Initial free period timer (high)
10	Initial free period timer (low)
11	Nonproductive poll count (high)
12	Nonproductive poll count (low)

Initial Free Period Timer

This timer allows the user to take full advantage of any "initial free period" that may be offered by the network or to fully exploit the "first charge" period. The timer can be set between 0.1 second (minimum) and 3276. 7 seconds (maximum) in 0.1 sec. steps. The timer starts running at the instant when 'data phase' is established. The connection is definitely maintained as long as the timer is running. When the timer has elapsed, it depends on the non-productive poll count whether or not the connection is cleared (whichever goes to zero last initiates the clearing action).

Nonproductive Poll Count

This count allows the user to give the Autopoll command a chance to become successful within a given limit. The count specifies the number of contiguous non-productive polls that must be completed before the connection can be cleared.. The count may range from 1 (minimum) to 32767 (maximum). When the count is reduced to zero, the connection is cleared provided the initial free period has elapsed in the meantime. If the initial free period timer has not yet elapsed, the communications adapter waits until this timer has run down to zero before initiating the clearing action. However, the communications adapter does not actually disconnect as long as a link level response from the DCE is outstanding.

When the disconnection occurs, the remaining channel program is flushed up to the Sense-SCB command, and the SCB which is returned to VTAM will indicate

'soft error' (bit 0 in first exception byte is on) and error code X '40' in the second exception byte, indicating "short hold mode disconnect" (see 'Soft Errors and Recovery' in Chapter 5 'Synchronous Data Link Control').

Parameter Validity Checks

A Setmode command which supplies only nine parameter bytes (bytes 0 ... 8) is valid, but does not set short hold mode or change it. A Setmode command which specifies the initial free period counter (bytes 9 and 10) as "zero" resets short hold mode (if it was in effect). The non-productive poll count is then ignored and may be omitted.

However, if bytes 9 and 10 contain a non-zero value, bytes 11 and 12 must be supplied and must contain a non-zero value, too. If this rule is not observed, or if either counter contains a value in excess of 32767, Setmode is rejected with data check X'0899'. Short hold mode, when set, remains in effect until explicitly reset by command or by a program or clear reset.

X.21 Leased Facility

Several countries offer a circuit-leased public data network for data transmission following the X.21 Leased Recommendation of the CCITT.
An X.21 leased interface can be ordered for any SDLC-configured communication line of the CA. The X.21 leased interface consists only of a driver card and cable with a 15-pin (X.21) connector attached. No commands, procedures or changes are associated with the X.21 leased facility, in fact this facility has no impact on anything other than the physical interface (hardware). Therefore, all information published in Chapter 5 'Synchronous Data Link Control' applies without change to an X.21 leased facility.

Chapter 7. X.25 Packet-Switching Facility

Introduction

The International Telegraph and Telephone Consultative Committee at Geneva approved in 1976 the so-called X.25 Recommendation. This recommendation (subsequently called "X.25") specifies the interface between packet-mode data terminals and networks capable of transporting data packets (i.e. information of a specific format).

Since "terminals" may be products of differing sizes, purposes, and capabilities, they are summarily referred to as data terminal equipment (DTE). Networks capable of transporting data packets are called packet-switched data networks (PSDNs). These networks consist of switching nodes and high-speed transmission links between these nodes. Many countries offer such networks today or have PSDNs projected. To the using terminal, none of the internals of the PSDNs are visible. The network presents itself as the data-circuit terminating equipment (DCE). The X.25 recommendation defines the interface between DTE and DCE.

The integrated communications adapter of the 4361 processor supports X.25 on any of its synchronous communication lines (when so configured).

X.25 Interface

The X.25 interface defines three different levels; the physical, link, and packet level.

The physical level governs the mechanical, electrical and procedural characteristics required to maintain the physical circuit between DTE and DCE. One of the characteristics of X.25 is that virtual circuits are superimposed on the physical circuit, and these virtual circuits can be permanent or switched. Architecturally, up to 4095 virtual circuits can be multiplexed on a single physical (real) circuit. This also allows two-way simultaneous (duplex) data transmission. The communications adapter can provide the physical level on any of its lines.

The actual physical element is a cable with a modem connector which represents the beginning of a point-to-point non-switched connection between DTE and DCE. The modem connector may be either a CCITT X.21 (15-pin) style or the X.21 bis (25-pin) style which is identical with the CCITT V.24 and EIA RS-232-C style connectors. A maximum data transmission rate of 9.600 bits per second is allowed per X.25 line and two addresses (subchannels) per line are required. As a load, each X.25 line counts twice its nominal speed.

The link level defines procedures that allow the establishment of a connection between one node (DTE) and another (DCE) and synchronization of the data transfer between them. Information transmitted between end users may traverse several data links and nodes. The link level procedures are provided entirely by micro code in the communications adapter. The procedures include tasks such as node initialization, data transmission and acknowledgement of transmitted blocks, signaling readiness to receive, and retransmission of lost frames. Actually the

HDLC 'Link Access Procedure Balanced' (LAPB) is used which does not distinguish between a primary and a secondary station but allows both sides to assume control on an alternating basis.

The packet-level defines formats and control procedures for logical channel allocation and routing, establishing and clearing calls, packet sizing/splitting, data transfer, flow control, and error recovery. The packets are the basic information units that are transmitted through the packet-networks, as if a physical point-to-point connection existed between the end users. The data packet handling is provided by software (VTAM) which uses specially designed channel command words (CCWs) which the communications adapter executes. In addition to data packets, various types of control packets can be sent between DTE and DCE (and vice-versa). The control packet traffic is also handled by software. Details about packet formats are described in the *"General Information Manual for attaching SNA Nodes to X.25 Networks"*, Form Number GA27-3345, and in *"VTAM X.25 Communication Adapter Support"*, Form-Number SC33-6171.

Subsequent paragraphs describe essentially how packets are transferred across the link and which channel programs and CCWs are used to accomplish this.

General Function of X.25 Support

Each X.25 line (or "port") is supported by two channel programs, the buffer pool program and the link control program. These software programs are control programs, not applications. The buffer pool program establishes data areas (buffers) in main storage for inbound and outbound data. The link control program tells the communication adapter which outbound buffers to use, when to use them, and in which sequence. The link control program also informs the software (packet handler) about buffers that have been filled with inbound data from the line and initiates their transfer to main storage.

The main storage areas for outbound data are created by Write-Packet CCWs (one area per CCW). The main storage areas for inbound data are created by Read-Packet CCWs (one area per CCW). The buffer pool program issues these CCWs always in pairs so that always an outbound area and an inbound area is created. Such an "area pair" is called a buffer, and up to 63 buffers can be created per X.25 line. The buffers are sequentially numbered 0, 1, 2, etc; as they are being created by the buffer pool program, as shown in Figure 7. This program is conceptually a continuously running program, and it is always started as the first one during line activation (prior to the link control program). When the buffer pool program has passed through its chain of CCWs once, it is considered to be running.

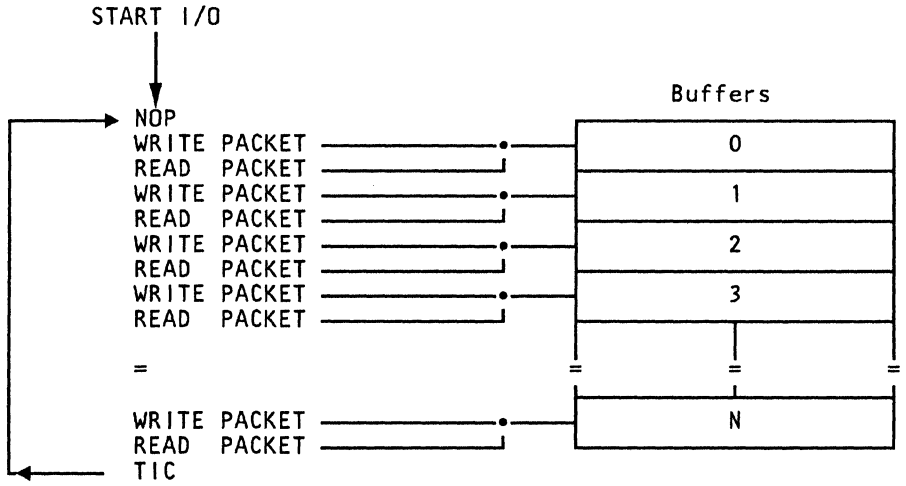

Figure 7. Buffer Pool Program

In this manner, space for inbound and outbound data is made available before any data can come in from the line. At any point in time, each buffer is either under control of the software or under control of the hardware (communication adapter) but never both. For this reason, the inbound and outbound areas of a buffer may be identical (although they need not be).

Initially, all buffers belong to the software. To provide for inbound traffic, the software passes a number of "free" buffers to the communications adapter via its link control program which is started after the buffer pool program. The link control program allocates these buffers by issuing a Control-Read CCW which identifies the individual buffers to be used for input and the total number of them. The communications adapter builds an internal "free" queue from this information.

Buffers for outbound traffic are filled by the application software (with I-frames) and are then passed on to the communications adapter via the link control program. This program issues a Control-Write CCW which identifies the individual buffers to be used for output. The communication adapter builds from this information an internal "transmit" queue.

With a "free" queue and a "transmit" queue established, actual data transfer can begin by activating the Read-Packet and Write-Packet CCWs in the sequence prescribed by the link control program. When buffers from the "transmit" queue have transmitted their contents and received an acknowledgement from the DCE, they are placed into the "free" queue (the same as those directly passed by the software for inbound traffic).

Buffers in the "free" queue are filled with inbound data from the line and are then placed into a "filled" queue. The filled buffers are detected by the link control program which checks periodically on the state of all buffers. Figure 8 shows the structure of the continuously running link control program.

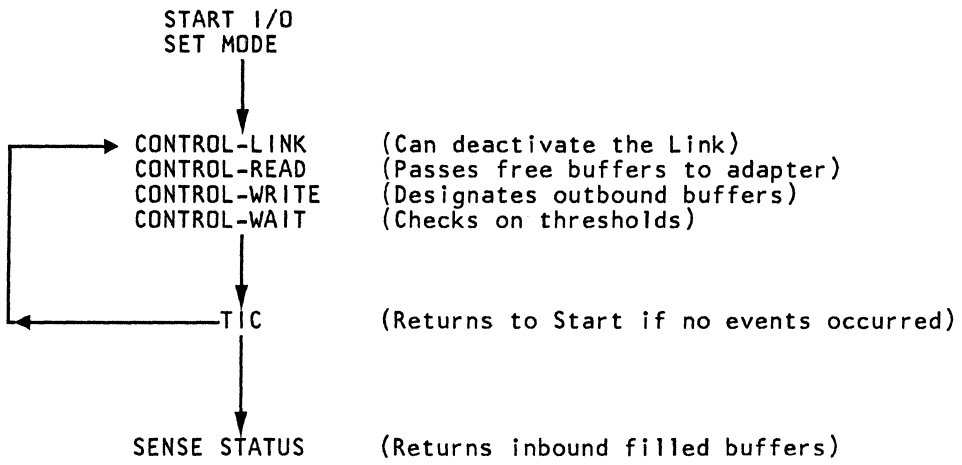

Figure 8. Link Control Program

The active part of the program begins with a Control-Link CCW which provides the means to stop operations when required. A Control-Read follows which passes free buffers to the hardware for inbound data, followed by a Control-Write which designates outbound buffers for transmission. Thereafter, a Control-Wait CCW is issued which checks on various previously established thresholds such as the maximum filled buffers threshold, maximum free buffers threshold, minimum free buffers, etc. If one of these thresholds is exceeded (or an error is detected), the link control program skips to the Sense-Status CCW, else it starts from the beginning.

The Sense-Status CCW passes all filled buffers to the software (thus freeing the filled queue) and reports the status of all buffers (how many buffers are filled, released, needed, accepted, etc). In this way, the link control program "drives" the data transfer operations across the DTE-DCE interface while the buffer control program keeps providing the required main storage space and performs the actual data transfer.

Control via Thresholds

From the preceding introduction it is obvious that the entire buffer pool is used by both the software and the hardware in common but a single buffer can belong to only one component at any one time.

To facilitate the passing of buffers back and forth between the two components a number of thresholds are established via a Set-Mode CCW. The thresholds allow the control mechanism to adapt itself to the traffic requirements. A few examples may show this.

Minimum Free Buffers. As the free buffers are being filled with I-frames coming from the line, the number of free buffers is reduced accordingly. When the minimum threshold is passed, this fact is recognized by the next Control-Wait command. Recognition of threshold transgression leads to the issuing of a Sense-Status CCW which returns the filled buffers to software and demands additional free buffers.

Maximum Free Buffers. As outbound buffers are being transmitted, they become free when the acknowledgement for the transmitted data is received. Eventually the maximum free buffers threshold is passed and this is noticed by the next Control-Wait CCW. This leads to the issuing of a Sense-Status CCW which returns the excess free buffers to software.

Maximum Filled Buffers. When the maximum filled buffers threshold is reached due to data coming in from the line, this fact is noticed by the next Control-Wait CCW which leads to the issuing of a Sense-Status CCW. This CCW returns the filled buffers to software. The effect is similar to exceeding the minimum free buffers threshold.

Inbound Traffic Timeout. When the first packet is received error-free, a timeout (in the range of 0.1 to 25.5 seconds) is started. If the filled buffers queue does not reach the maximum threshold during that time, the inbound traffic timer elapses and this condition is recognized by the next Control-Wait CCW. This leads to a Sense-Status CCW which returns whatever filled buffers exist at that time. This allows a timely return of inbound data even if no threshold is reached.

The following paragraphs explain format and usage of the various CCWs including thresholds, status reports, and error information in detail.

Channel Command Words for X.25 Support

The following channel command words are valid:

Hex	Command Name
X'03'	No Operation
X'05'	Write-Packet
X'06'	Read-Packet
X'08'	Transfer-in-Channel (TIC)
X'14'	Sense-Status
X'23'	Setmode
X'1F'	Control-Link
X'2B'	Control-Read
X'1B'	Control-Write
X'17'	Control-Wait
X'04'	Sense
X'E4'	Sense I/O

No Operation (X'03')

The No-operation (No-op) command performs no function at the communications adapter. However, it must have a valid data address and a valid count (a non-zero value) and it is executed as an immediate command which returns 'channel end' and 'device end' during initial selection. The command can be used to find out whether the addressed facility exists and is in an error-free state.

The No-op command starts the buffer pool program which goes through an initial sequence of Write/Read-Packet CCWs. When it returns to the No-op, the completion of this No-op is delayed until the link control program is started. In this way, the buffer pool program does not place any unproductive burden on the communications adapter even though it is continuously running by concept.

Write-Packet (X'05')

The Write-Packet command establishes an area in main storage which is intended to be filled with outbound data. The area begins at the location defined by the data address and extends for as many bytes as defined by the count.

The area (buffer) thus defined must not cross a page boundary. It is designated to hold the I-field of an HDLC I-frame. A new I-field must always start at the beginning of a buffer but it may span several buffers. If a buffer contains the beginning of an I-field or an entire I-field, the first two bytes represent a length count which defines the entire length of the I-field including the two count bytes (I-field length plus 2). For this reason, the Write-Packet CCW that starts a new I-field must have a count of at least 3. Only I-fields are placed into the buffer, the flag, address, control fields, etc, that belong to a HDLC-frame are generated by the communications adapter when the I-field is actually sent out.

When the buffer pool program is started for the first time, none of the Write-Packet CCWs transfer any data. They merely establish buffer numbers, and define location and size of these buffers. The actual data transfer occurs later when the link control program activates the individual commands.

The first Write-Packet CCW in the buffer pool program must be chained from a Control-Noop, all others that follow must be chained from Read-Packet CCWs. The CC and SLI flags must be on, all other flags must be off. If these conditions are not met, the buffer pool program is terminated at initial selection with 'command reject'.

Read-Packet (X'06')

The Read-Packet command provides a data area in main storage for inbound data. The data area begins at the location defined by the data address and extends from there (in ascending order of address) for as many bytes as specified by the count.

The data area (buffer) thus defined must not cross a page boundary. It is designated to receive the I-field of an HDLC I-frame. A new I-field always starts at the beginning of a buffer and may span several buffers. The first two bytes in the starting buffer of an I-field represent the length count which specifies the entire length of the I-field including the two count bytes. For this reason, a Read-Packet CCW that contains the beginning of an I-field must have a count of at least 3.

When the buffer pool program is started for the first time, none of the Read-Packet CCWs actually pick up any data. The commands merely prepare the input space. The actual data transfer occurs later when the link control program activates the individual commands.

The Read-Packet CCW must be command-chained from a Write-Packet CCW, and it must have the CC and SLI flags on and all other flags off (otherwise command reject occurs).

Transfer-in-Channel (X'08')

The Transfer-in-Channel (TIC) command fetches a CCW from the location defined by the data address and presents this CCW as the next one to be

executed. In this way an absolute branch is achieved. The buffer pool and the link control programs use the TIC command to return to their starting points and thus keep continuously running.

Setmode (X'23')

The Setmode command is a prerequisite for starting the link control program. Setmode transfers 13 parameter bytes from the storage location defined by the data address to the communications adapter. The parameters control the operation of the addressed X.25 line until another Setmode command is given. The buffer pool program must be running and the CD flag must be off, otherwise the Setmode command is rejected. The parameters specify the following:

Byte 0: Response Timer (TP)

The value in byte 0 defines how long the communications adapter will wait for a response (from the DCE) to a command frame that was sent out. A value from 0.1 to 25.5 seconds can be set. The timer starts running each time when a Receive Ready (RR) or Receive Not Ready (RNR) with poll bit set to 1 (a definite poll) or a Set Asynchronous Balanced Mode (SABM) or a Disconnect (DISC) command is sent to the DCE. When the time expires before a response is received, the timer is restarted FP-times (see response time factor, below). At the end of these FP intervals, the command frame is sent again CP-times (see response timer count).

Byte 1: Response Time Factor (FP)

The contents of byte 1 specify how often the response timer (TP, above) must expire before the frame (for which a response is demanded) is sent again. A value from 1 to 255 may be set.

Byte 2: Response Timer Count (CP)

The contents of byte 2 specify how often the sending of the frame (for which a response is demanded) is repeated. A value from 1 to 255 may be set. If this count is exhausted, an error is reported (via the Sense-Status CCW) and the link is set to 'disconnected' state.

Byte 3: Inbound Traffic Timer

The value in byte 3 defines a time (in the range of 0.1 to 25.5 seconds) after which any buffers filled with inbound data are transferred to the software. The timer starts running when the first new frame is received error-free following a return of all previously filled buffers.

Byte 4: Wait For Data-Set-Ready Timer

The timer defines how long the communications adapter waits for the physical interface signal 'data set ready' (DSR) to return after it has dropped. The time may be set between 0.1 and 25.5 seconds. The timer starts running when DSR drops (after it was on). If the signal does not come back before the time expires, the link is set to 'inactive' and both channel programs are stopped with unit check indicated.

Byte 5: Retransmission Count

The value in byte 5 may range from 1 to 255 and defines how often one and the same frame is retransmitted to the DCE without being acknowledged. If the count is exhausted before an acknowledgement is received, an error is reported (via Sense-Status CCW) and the link is set to 'disconnected' state.

Bytes 6 and 7: Maximum I-Field Size

The value in bytes 6 and 7 defines the maximum size which the I-field of an HDLC I-frame may have to be accepted by the communications adapter. The size may range from 1 to 64-K (bytes). If a larger I-field is received, the frame is discarded, a 'frame reject' (FRMR) response followed by a 'disconnect' command is sent to the DCE and the error is reported (via Sense-Status CCW).

Byte 8: Window Size

The window size may range from 1 to 7 and specifies how many unacknowledged outbound frames may be outstanding at maximum. The communications adapter observes the window size and takes appropriate actions which ensure that the number of outstanding acknowledgements is kept below this threshold. If the threshold is reached, the adapter stops the transmission of outbound I-frames.

Byte 9: Filled Buffers Threshold

The value in byte 9 specifies how many buffers may be filled with inbound frames (I-fields) before they must be returned to software. When the threshold is reached, a Sense-Status CCW returns the filled buffers.

Byte 10: Maximum Free Buffer Threshold

Byte 10 specifies how many free buffers may accumulate before they must be returned to software. The threshold may range from 1 to the maximum number of buffers created by the buffer pool program. When the threshold is exceeded the communications adapter returns a number of buffers that is halfway between the minimum free buffer threshold (see next paragraph) and the total number of free buffers existing at that time.

Byte 11: Minimum Free Buffer Threshold

Byte 11 specifies how low the number of free buffers may fall before new buffers are demanded from the software (buffer pool program). The minimum threshold may range between 1 and a number that is somewhat less than the maximum free buffer threshold. When the minimum threshold is passed, the communications adapter demands a number of buffers that is halfway between the minimum and maximum free buffer thresholds.

Byte 12: Network Type

Byte 12 defines the packet-switched data network (PSDN) to which the X.25 line is connected, as follows:

Hex	Meaning
X'00'	Passive Networks (e.g. TRANSPAC of France)
X'C0'	Vendor CTNE Networks with the following nets : - Iberpac (Spain) - Arpac (Argentina)
X'80'	Vendor Nothern Telecom with the following nets : - Datex P (Germany) - Telepac (Switzerland) - Datapac (Canada) - Switchstream 1 (U.K.) - Isranet (Israel) - Telepac (Mexico)

For networks identified as X'80', the communications adapter waits for a response to DISC, DM or SABM until the response timeout expires. If it expires, a "no valid response" error is reported. The same applies to networks identified with X'C0' except that the adapter does not wait for a response to the DISC command.

The Setmode command is executed successfully only when the buffer pool program is already running and when no invalid parameters are detected, otherwise the command is rejected.

Control-Link (X'1F)

The Control-Link command provides the means to stop the continuously running link control program, or both the link control program and the buffer pool program, or to let them run unaffected. The data address points to a parameter byte which specifies the action as follows:

Hex	Meaning
X'00'	No effect (keep running)
X'40	Stop both programs
X'C0'	Stop both programs
X'80	Stop link control program only.

The stop action includes the issuing of the Sense-Status CCW which returns any buffers filled with inbound data and gives a detailed report on all buffers, errors, etc (see Sense-Status). When both programs are stopped, the link is placed in the 'inactive' state. When only the link control program is stopped, the link is placed in the 'disconnected' state. The programs can subsequently be activated again by a new Start I/O instruction.

The Control-Link command is executed successfully only when the link is in any state other than 'inactive' and when the buffer pool program is running, otherwise Control-Link is rejected. For additional details about the link states, see "State Diagram".

Control-Read (X'2B')

The Control-Read command specifies how many buffers in total and which ones are to be used to pickup inbound data. The data address in the CCW points to a storage location from where a number of parameter bytes are fetched and transferred to the communication adapter. The first parameter byte specifies the total number of buffers to be used and the subsequent bytes each specify a buffer number. The buffer numbers may be in any sequence (e.g. 5, 9, 2, 60, etc). The communications adapter will then activate the corresponding Read-Packet CCWs

which will perform the actual data transfer when the link is in the 'information transfer' state. Since the position of each Read-Packet CCW in the buffer pool program chain corresponds to the buffer number (the first one corresponds to buffer 0, the next one to buffer 1, etc), the buffer numbers are direct pointers to the Read-Packet CCWs and therefore the data transfer occurs in the prescribed sequence.

The Control-Read is executed successfully only when the buffer pool program is running and the link is in any state other than 'inactive'. In addition, the CD flag must be off, otherwise the command is rejected.

Control-Write (X'1B')

The Control-Write command specifies which data areas (buffers) are to transfer their contents over the line. The data address points to a storage location from where a number of parameter bytes are fetched and transferred to the communications adapter which uses them for control. The first parameter byte specifies the total number of buffers to be used and the subsequent bytes each specify a buffer number. These buffer numbers may be in any sequence, and the buffers will be transmitted in the sequence specified.

When the link is in the 'information transfer' state, the communication adapter starts the actual transmit operation by activating the Write-Packet CCWs that correspond to the buffer numbers designated by the Control-Write command.

The Control-Write command is executed successfully only when the buffer pool program is running and the command is chained from a preceding Control-Read CCW. In addition, the CD flag must be off.

Control-Wait (X'17')

The Control-Wait command checks on the various thresholds and link terminating states and provides a skip to the Sense-Status CCW if any condition is found. The skip is performed by terminating the Control-Wait command with the 'status modifier' set. This status modifier flag causes skipping over the adjacent CCW (if the command chaining flag is on) and the command thereafter is executed. This should be a Sense-Status CCW which returns all filled and free buffers.

If no threshold is passed and no terminating condition (such as a request for disconnection or link deactivation, or a protocol error) is found, a 100 to 200 millisecond timer is started. If that time expires and still no terminating condition or threshold passing event has occurred, the command terminates normal (channel end/device end) and thus leads to the TIC which returns to the beginning of the link control program (see Figure 8). Else, the skip to the Sense-Status CCW occurs.

The Control-Wait is executed successfully only when chained from a preceding Control-Write CCW provided the buffer pool program is running, else it is rejected.

Sense-Status (X'14')

The Sense-Status CCW returns all filled and free buffers to the software (by specifying their indices) and gives a detailed status report. The data address defines the location in storage where the information will be stored for evaluation by the software.

Three categories of information are provided in the following sequence: error information, buffer status, and counters (see Figure 9).

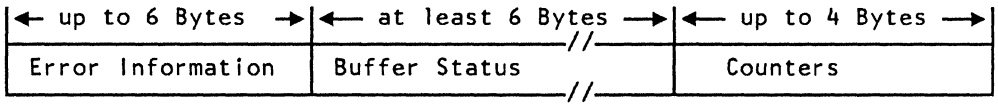

Figure 9. Sense-Status Data

Error Information

The error information shows the state of the link in six bytes (see Figure 10).

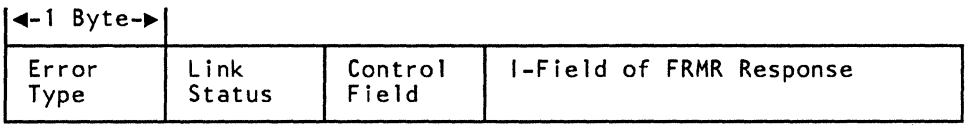

Figure 10. Error Information (in Sense-Status Data)

Error Type

The error type byte shows which type of error occurred in coded form. The table below lists the error codes and shows how the communications adapter reacts to them.

Code	Meaning	Effect
X'21'	**FRMR Received** A frame reject response was received.	The link state does not change. If a more severe error occurs while FRMR is waiting tc be reported, that error is reported. FRMR received causes the control field and the 3-byte I-field to be reported (as shown in Figure 10).
X'41'	**Wrong Command** Any command (other than SABM) received with poll bit set during link-setup.	The link is set to 'disconnected', the causing control field is reported, and all buffers are released to the free queue.

Code	Meaning	Effect
X'42'	**Response Missing** No valid response received to 'SABM, DISC, or RR/RNR' after sending command Cp-times.	The link is set to 'disconnected', no control field is stored and all buffers, except those in the filled queue, are released to the free queue.
X'43'	**Buffer Omitted** In transmit buffer spanning, a "spanned" outbound buffer was not passed via Control-Write.	-- Same as above. --
X'44'	**Wrong Length Sent** I-field length in first outbound buffer exceeds maximum or is less than 3.	-- Same as above. --
X'45'	**Wrong Frame Received** Any unnumbered frame except FRMR received during information transfer state.	Same as above, except that the control field is stored.
X'46'	**Invalid Frame Received** Any I- or S-frame has an invalid NR count, or an invalid control field, or a frame with too large an I-field was received, or an S- or U-frame had an I-field associated.	Same as above, but in addition the FRMR response is returned and the FRMR I-field is reported in the error information (as shown in Figure 10).
X'47'	**X-mit Count Exhausted** The retransmission count limit is reached.	The link is disconnected and all buffers except those in the filled queue are returned to the free queue.
X'81'	**FCS Check** Frame check sequence error detected.	The error is recovered by the communications adapter and reported only for statistical purposes, no control field or I-field is reported.
X'82'	**Abort Received**	-- Same as above. --
X'83'	**Overrun**	-- Same as above. --
X'84'	**Underrun**	-- Same as above. --

Code	Meaning	Effect
X'85'	**Reject Sent Out**	Same as above, except that the control field and I-field are stored.
X'86'	**Reject received**	-- Same as above. --
X'87'	**Retransmission initiated**	-- Same as above. --

Link Status

The link status byte shows whether the link is inactive, disconnected or in the information transfer state, as follows:

Link Code	Meaning
X'01'	Inactive
X'04'	Disconnected
X'10'	Information Transfer

Buffer Status

The buffer status is a field of at least five bytes length which may have a buffer specification list appended if filled and/or released buffers exist. The buffer status field is structured as shown in Figure 11.

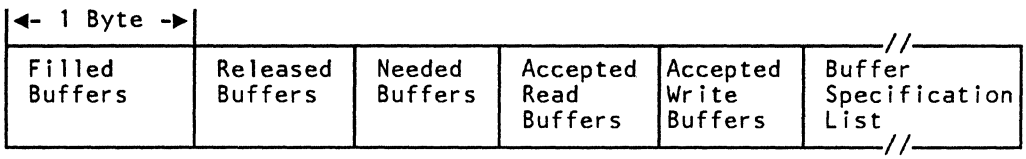

Figure 11. Buffer Status (in Sense-Status Data)

Filled Buffers. The filled buffers byte contains the total number of buffers that have been filled with I-fields from the line. The first bytes of the buffer specification list contain the indices to these buffers (the buffer numbers).

Released Buffers. This byte contains the total number of buffers that are released to the software because the maximum free buffer threshold is passed. The buffer specification list contains the indices to these buffers. The buffers are actually released by being reported via the Sense-Status CCW.

Needed Buffers. This byte shows the total number of buffers needed because the minimum free buffer threshold is surpassed (if that is the case).

Accepted Read Buffers. This byte shows how many read buffers have been enqueued by the communication adapter into the receive queue since the start of the link control program.

Accepted Write Buffers. This byte shows how many write buffers have been enqueued into the transmit queue of the communications adapter for transfer to the line. This number does not indicate that these buffers have already been sent out.

Buffer Specification List. This list consists of a number of bytes which contain buffer numbers. The size of this list depends on the existence of filled buffers, and/or released buffers (or both). If filled buffers exist, the list begins always with the filled buffers (one buffer number per byte) and continues thereafter with similar indices for released buffers (if they exist). If only released buffers exist, the list starts with the indices to those buffers, and the entire specification list is omitted if neither buffer category exists.

Counters

The buffer status is followed by a 4-byte counter field which is the last piece of information delivered by the Sense-Status CCW. Each byte comprises one counter, as follows:

Byte 0: Count of RRs sent out
Byte 1: Count of RRs received
Byte 2: Count of RNRs sent out
Byte 3: Count of RNRs received

Since the Sense-Status CCW delivers reports which differ in length depending on the actually available data, a sufficient length count should be chosen in the CCW with the SLI flag set. If the length count is so insufficient that, for example, the buffer specification list is cut short, the cut-off buffers are not released.

Sense (X'04')

The Sense CCW transfers two bytes of error information to the storage location defined by the data address if a unit check status exists. The first byte (byte 0) contains a general error indication, and the second byte (byte 1) gives a specific error report in coded form. The general indications in sense byte 0 are shown below.

Sense Byte 0	Meaning
X'80'	Command Reject
X'40'	Intervention Required
X'20'	Bus-Out Check (not used)
X'10'	Equipment Check
X'08'	Data Check
X'04'	Overrun (not used)
X'02'	- not used -
X'01'	- not used -

The codes in sense byte 1 are listed twice in the subsequent paragraphs for the reader's convenience:

They are listed separately for the buffer program and the link program. Each code is further listed under the applicable general error indication, for example, command reject. In this way it is easy to find which of several possible errors caused the command reject indication.

Buffer Pool Program Sense Codes

If Command Reject (X'80' in Sense Byte 0)

Sense Byte 1	Meaning
X'08'	More than 8 non-productive CCWs chained (see Note)
X'09'	Command invalid or out of sequence
X'12'	Read/Write packet area crosses page boundary
X'16'	Read/Write packet count less than 3
X'19'	Invalid flags in the CCW
X'1A'	Too many buffers (more than 63) specified
X'1B'	Ending TIC does not point to starting No-op command.

Note: Non-productive CCWs are No-op, Setmode, Sense, and Sense I/O

If Intervention Required (X'40' in Sense Byte 0)

Sense Byte 1	Meaning
X'33'	Link was deactivated by control-link CCW.
X'34'	Data Set Ready did not come up in time.
X'35'	Clear to Send was down for more than 10 seconds.
X'36'	Line clock was lost for more than 10 seconds.

Note: The above listed codes are logged in the unit check log area of the communications adapter (on the system diskette).

If Equipment Check (X'10' in Sense Byte 0)

Sense Byte 1	Meaning
X'60'	Unexpected trap occurred.
X'62'	Machine-check from CCA card.

Note: These codes are logged in the unit check log area of the communications adapter (on the diskette).

Link Control Program Sense Codes

If Command Reject (X'80' in Sense Byte 0)

Sense Byte 1	Meaning
X'08'	More than 8 non-productive CCWs chained (see Note)
X'09'	Command invalid or out of sequence
X'16'	CCW count less than minimum

If Data Check (X'08' in Sense Byte 0)

Sense Byte 1	Meaning
X'94'	Wrong Data in CCW.

If Intervention Required (X'40' in Sense Byte 0)

Sense Byte 1	Meaning
X'32'	Buffer Pool program has been terminated

Sense I/O (X'E4')

The Sense I/O CCW delivers seven identification bytes to the location defined by the data address. The bytes contain the following:

Byte	Contents
0	X'FF'
1	CPU-ID 1
2	CPU-ID 2
3	CPU-ID 3
4	X'CA' (Communication Adapter)
5	X'10' (X.25 Port)
6	X'00'

The CPU-ID bytes contain the model number of the host processor (for example 4361-05). The Sense I/O command, when issued by the buffer pool program is checked for compliance with the buffer pool program rules like any other CCW. The data area must not cross a page boundary, the PCI, CD, and IDA flags must be off, otherwise the command is rejected.

State Diagram

The following state diagram is provided for reference purposes only, and is useful only for skilled specialists. The diagram summarizes the link activities and defines how the communication adapter reacts to them, depending on the state in which it is at that time. The link activities are listed in the left-most column (top to bottom) and the adapter's reaction can be found at the intersection between the activity row and the state column. For example, when a frame reject (FRMR) is received while the link is in the information transfer state (state 4), the communications adapter prepares an error report of the "information only" type (rprt err).

The following diagram shows the adapter's behavior towards the link:

	Link setup State 2	Dis-connected State 3	Inform. transfer State 4	Disconn. requested State 5	Transient link setup State 6	Transient inform transfer State 7
init. by channel pg pass.ntwrk		xmit SABM →state 2	xmit I frame			xmit I frame
init. by channel pg act.ntwrk		→state 6	xmit I frame			xmit I frame
init. by tp timer	sabm(1)		rr/rnr p1	disc p=1		rr/rnr p1
Frames sent from network						
I P=1		xmit DM	rr/rnr f1	Xmit DM		rr/rnr f1 →state 4
I P=0			rr/rnr f0			rr/rnr f0 →state 4
FRMR			rprt err			
DISC	xmit dm rprt err. →state 3	xmit DM	xmit UA →state 3	xmit UA	xmit UA →state 2 (Note:)	xmit UA →state 3
DM f=1	rprt err. →state 3		→state 3	→state 3	→state 2	→state 3
DM F=0			→state 3		→state 2	→state 3

- continued on next page -

SABM	xmit UA →state 7	xmit DM	xmit UA xmit DISC →state 5	xmit DM →state 3	xmit UA →state 7	xmit UA
UA	→state 4		xmit DISC →state 5	→state 3		→state 4
REJ P=1		xmit DM	rprt err. send RR or RNR	xmit DM		rprt err. send RR, →state 4
RR/RNR P=1		xmit DM	rr/rnr f1	xmit DM		rr/rnr f1 →state 4
superv rsp superv p=0						→state 4
abort			rprt err.			rprt err.
FCS check			rprt err.			rprt err.
ns seq.err			rej1.time rprt err.			rej1.time rprt err. →state4
close link by microco and physic link inact	→state 1	→state 1	→state 1	→state 1	→state 1	→state 1
inv. frame			xmit frmr xmit disc →state 5			xmit frmr xmit disc →state 5

link inactive — enable modem interface → disconnected phase

state 1 — initiated by channel program — state 3

Note: In case of Spanish type networks the link state remains unchanged

I/O Instructions

Although the I/O instructions Start I/O, Test I/O, etc, are common knowledge, they are nevertheless listed in the following chapter because the condition codes which these instructions may elicit do have special meanings for the X.25 lines. In addition, the addressing of X.25 lines differs from the normally used scheme.

Addressing

The communications adapter belongs logically to the host processor's channel 0 and has an address range of X'30 to X'3F' assigned within that channel.

The ports which are configured as X.25 lines each have an address pair assigned beginning with 30/38 and continuing 31/39, 32/3A, and so forth up to 37/3F. An exception is the address pair 33/3B which cannot be used for X.25.

The low address of each pair belongs to the link control program, the high address belongs to the buffer pool program. Thus, a Start I/O instruction with address X'030' calls on the link control program for the first X.25 line. A Start I/O with address X'038' calls on the buffer pool program for that same line.

Start I/O and Start I/O Fast Release

Both instructions are executed alike by the communications adapter, that is, always as Start I/O. They start either the Buffer Pool or the Link Control program. The following condition codes may be expected:

Condition Code	Meaning
0	CCW can be initiated ok.
1	Command cannot be executed because, for example, beginning No-op does not specify command chaining, or an Inline Test is running, or an invalid command is issued (check CSW).
2	Addressed line is working or has an interruption condition pending.
3	Line address is invalid or addressed line is not installed.

Test I/O

The Test I/O instruction tests the state of the addressed subchannel. The following responses may be expected:

Condition Code	Meaning
0	Addressed line is available.
1	CSW stored, pending interruption condition is cleared.
2	Addressed line is working.
3	Line address invalid or line not installed.

Clear I/O

The Clear I/O instruction discontinues any ongoing operation and stores the status. Clear I/O should only be issued to the link control program. When Clear I/O is issued to the buffer pool program (high address of address pair), the X.25 port goes to inactive state and this causes a unit check in the link control program. The following condition codes may be expected from Clear I/O:

Condition Code	Meaning
0	Subchannel available.
1	CSW stored, pending interruption condition is cleared.
2	- not set -
3	Line address invalid or addressed line not installed.

Halt I/O and Halt Device

Both Halt instructions are executed alike. They terminate any ongoing operation and report the state of the addressed subchannel via condition code. The Halt instructions should be issued only to the link control program. When issued to the buffer pool program (high address of address pair), the X.25 port goes to 'inactive' state and this causes a unit check in the link control program. The following condition codes may be expected:

Condition Code	Meaning
0	Subchannel has interruption condition pending.
1	Current operation terminated
2	- not set -
3	Line address invalid or addressed line is not installed.

Chapter 8. Dynamic Trace Feature

The dynamic trace standard feature allows the CA to obtain trace data for a communication line using any line protocol. This trace data shows line information at the end of each CA trap, such as, the channel command active, the data byte received or transmitted and the error sense information.

The trace data is collected in an internal buffer which holds 2560 trace entries. The buffer wraps around when full. The trace data can be dynamically transferred to processor storage. When the dynamic trace is stopped, the last 2560 trace entries may be displayed on the operator's console by a maintenance selection option. The trace feature is supported by a trace program which runs under VSE/Advanced Functions as described in *VSE/Advanced Functions Serviceability Aids and Debugging Procedures*, SC33-6099.

The dynamic trace feature has the following characteristics:

- One subchannel I/O address hex 03B is reserved exclusively for this feature.
- The use of the dynamic trace excludes the use of the other CA inline tests (ILTs) and the DASD adapter ILTs.
- Before the dynamic trace feature may be activated by a channel program the feature must have been invoked from the operator's console as one of the CA inline tests.
- The trace may be started for one line from the operator's console or by a channel program for the trace subchannel with a Set Trace Options command (hex 01).
- The trace data is collected in an internal buffer of 10k bytes which holds up to 2560 trace entries.
- The trace data may be dynamically transferred to the customer storage by a dynamic trace dump command (hex 42) or displayed on the operator's console after the trace has been stopped using the CA display trace data option.
- The trace may be stopped either from the operator console or by the Write Break (hex '0D') command or the Set Trace Options (hex 01) command. If the Dynamic Trace Dump command is being executed the operations may be stopped by issuing a Halt I/O, Halt Device, or Clear I/O instruction.

Trace Analysis

The trace analysis is described in *VSE Advanced Functions Serviceability Aids and Debugging Procedures*, SC33-6099.

Commands

Hex	Command Code CCW BITS 0	1	2	3	4	5	6	7	Command
01	0	0	0	0	0	0	0	1	Set Trace Options
02	0	0	0	0	0	0	1	0	** Dump Storage (not supported)
03	0	0	0	0	0	0	1	1	Control No-op
04	0	0	0	0	0	1	0	0	Sense
06	0	0	0	0	0	1	1	0	* Prepare (executed as No-op)
09	0	0	0	0	1	0	0	1	** Dump Trace Table (not supported)
0D	0	0	0	0	1	1	0	1	Write Break
27	0	0	1	0	0	1	1	1	* Enable (executed as No-op)
2F	0	0	1	0	1	1	1	1	* Disable (executed as No-op)
42	0	1	0	0	0	0	1	0	Dynamic Trace Dump
E4	1	1	1	0	0	1	0	0	Sense I/O

* Accepted for compatibility reasons.

** "Not supported" means that unit check, together with equipment check in sense byte 0, are set when the command is issued. The command reject bit is not set.

Set Trace Options

The Set Trace Options command is used to specify dynamic trace options.

The command will only be accepted if the dynamic trace has been invoked through CA inline test selection. Otherwise the command is terminated with unit check. Equipment check is indicated in sense byte 0.

Four bytes are read from the storage location specified in bits 8 to 31 of the CCW. If an invalid trace option is specified, the command ends with unit check and equipment check indicated.

Valid options in hexadecimal:

4010xx.. Start trace for line xx

4011xx.. Stop trace for line xx

Byte	Meaning
0	Must be always hex 40 (function byte)
1	Must be either hex 10 or hex 11 (trace option) The option byte is invalid if: The byte is hex 10 and the trace is already started for specified line.
2	Contains the address of the CA line to be traced. The specified address must belong to an installed CA line (maximum range hex 30 to hex 37).
3	Can be any value.

Sense

The Sense command causes one byte of sense information to be transferred to processor storage. Only command reject (bit 0) and equipment check (bit 1) are used.

The reasons for setting these sense bits are given in the description of the other trace channel commands.

Write Break

The Write Break command can be used instead of the Set Trace Options command to stop the dynamic trace. No data is transferred by this command. If the dynamic trace is not active the command is handled as No-op.

Dynamic Trace Dump

The Dynamic Trace Dump command transfers the trace data to processor storage in segments of four bytes.

The command is only accepted if:

1. The data address specified in bits 8 to 31 of the CCW starts on a fullword boundary and the length count is a multiple of four. Otherwise the command is terminated with unit check. Command reject indicated in sense byte 0.

2. The dynamic trace is invoked. Otherwise the command will be terminated with unit check. Equipment check is indicated in sense byte 0.

3. The dynamic trace is active for one CA line. Otherwise the command is terminated with unit exception indicated.

4. The data chaining flag in the CCW is off. Otherwise the command is terminated with unit check. Command reject is indicated in sense byte 0.

Trace entries, if available in the dynamic trace area, are transferred to storage until the length count is zero.

If the trace data runs out before the count is zero, the command remains active and resumes operation when the next trace entry is available.

If a trace area wrap-around occurs before the command is started or while the command is active (trace entries not transferred to storage or overwritten by new trace data), the current trace entry byte one is set to hex FF and all other trace entries are lost. The command resumes operation by transferring the trace entry from the last trace event.

The command may be stopped during execution by a Halt I/O, Halt Device, or Clear I/O instruction or by an operator command. In this case the command is terminated with channel end, device end, and unit exception indicated in the channel status word.

Sense I/O

The Sense I/O operation transfers seven bytes to processor storage as follows:

Byte	Meaning
0	Always hex 'FF'
1	CPU Identification 1 '43'
2	CPU Identification 2 '31'
3	CPU Identification 3 'XX', model number
4	Hex 'CA' for communications adapter
5	Hex '00' dynamic trace not invoked Hex '01' dynamic trace invoked
6	Always hex '00'

Appendix A. Code Tables

		Lower Case								Upper Case							
		Main Storage Byte Positions 0, 1, 2, 3, (S, B, A, 8)															
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
4, 5, 6, 7 (4, 2, 1, C)	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0		8	@		Ⓝ —			h		•	¢		Ⓝ —			H
0001	1	Space			y		q	&		Space			Y		Q	+	
0010	2	1			z		r	a		=			Z		R	A	
0011	3		9	/		j			i		(	?		J			I
0100	4	2					Minus Zero (MZ)	b		<						B	
0101	5		0	s		k			Plus Zero (PZ)		)	S		K			
0110	6		Ⓓ EOA #	t		l			Ⓨ		Ⓓ "EOA	T		L			Ⓨ ¬
0111	7	3			,		$	c					I		!	C	
1000	8	4			Bypass		Re-store	d		:			Bypass		Re-store	D	
1001	9		Punch On (PN)	u		m			Punch Off (PF)		Punch On (PN)	U		M			Punch Off (PF)
1010	A		Reader Stop (RS)	v		n			Horiz Tab		Reader Stop (RS)	V		N			Horiz Tab
1011	B	5			LF		CR / LF	e	·	%			LF		CR / LF	E	
1100	C		Up-shift	w		O			Down-shift		Up-shift	W		O			Down-shift
1101	D	6			Ⓑ EOB		Back-space	f	—				Ⓑ EOB		Back-space	F	
1110	E	7			Prefix		Idle	g		>			Prefix		Idle	G	
1111	F		Ⓒ EOT	x		p			Delete		Ⓒ EOT	X		P			Delete

0	1	2	3	4	5	6	7

Storage Byte

S	B	A	8	4	2	1	C

Terminal Code Structure

Start	B	A	8	4	2	1	C	Stop

Transmitted and Received Character

These codes perform no function in the 1050 Data Communication System but are valid data codes. They are not printable.

Duplicate Assignment

Figure 12. Code Structure for 1050 Data Communication System in IBM Terminal Control - Type 1 Operation

Notes:

1. Equivalent Functions: CR/LF=NL and LF=Index.

2. S-bit position (0=lower case, 1=upper case) inserted on receive or deleted on transmit operations.
   Insertion/deletion performed by hardware.

3. Start and stop bits are deleted at the CA during receive operations; added at the CA during transmit operations.

		Main Storage Byte Positions 0,1,2,3, (0, B, A, 8,)							
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111
4, 5, 6, 7 (4, 2, 1, C)	Hex	0	1	2	3	4	5	6	7
0000	0		8	Add		Ⓝ —			H
0001	1	Space			Y		Q	+	
0010	2	1			Z		R	A	
0011	3		9	/		J			I
0100	4	2					Mes-sage	B	
0101	5		0	S		K			Re-store
0110	6		Ⓓ EOA #	T		L			Ⓨ
0111	7	3					$	C	
1000	8	4					•	D	
1001	9			U		M			Sub-tract
1010	A			V		N			Tab
1011	B	5			LF		CR	E	
1100	C			W		O			
1101	D	6			Ⓑ EOB			F	
1110	E	7					Idle	G	
1111	F		Ⓒ EOT	X		P			Delete

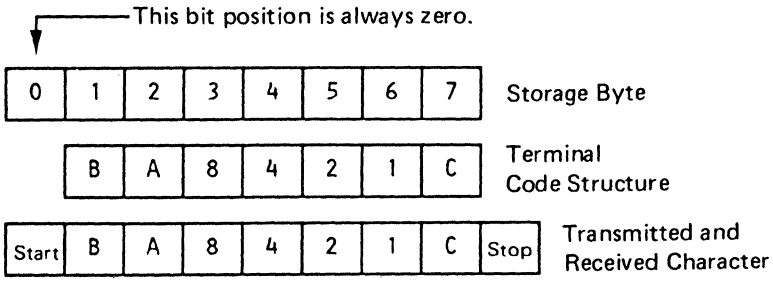

Figure 13. Code Structure for 1060 Data Communication System in IBM Terminal Control - Type 1 Operation

Note: Start and stop bits are deleted at the CA during receive operations; added at the CA during transmit operations.

		Lower Case								Upper Case							
		Main Storage Byte Positions 0, 1, 2, 3, (S, B, A, 8)															
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
4, 5, 6, 7 (4, 2, 1, C)	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0		8	@		¬ Ⓝ			h		•	¢		¬ Ⓝ			H
0001	1	Space			y		q	&		Space			Y		Q	+	
0010	2	1			z		r	a		=			Z		R	A	
0011	3		9	/		j			i		(	?		J			I
0100	4	2						b		< o						B	
0101	5		0	s		k					)	S		K			
0110	6		Ⓓ EOA #	t		l			Ⓨ •		¨ ± Ⓓ	T		L			¯ Ⓨ
0111	7	3			Ⓢ		$	c		;			¦ Ⓢ		!	C	
1000	8	4						d		:						D	
1001	9			u		m						U		M			
1010	A			v		n			Horiz Tab			V		N			Horiz Tab
1011	B	5			LF (Notes 3 & 5)		NL	e		%			LF (Notes 3 & 5)		NL	E	
1100	C		Up-shift	w		o			Down-shift		Up-shift	W		O			Down-shift
1101	D	6			Ⓑ EOB		Back-space	f		,			Ⓑ EOB		Back-space	F	
1110	E	7					IDLE	g		> "					IDLE	G	
1111	F		Ⓒ EOT	x		p					©	X		P			

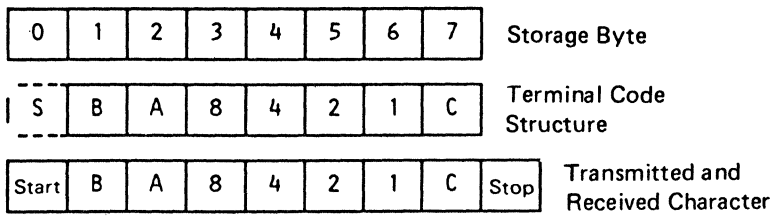

Figure 14. Code Structure for 2740 Communication Terminal or 2741 Communication Terminal in IBM Terminal Control - Type 1 Operations

Notes:

1. Start and stop bits are deleted at the CA during receive operations; added at the CA during transmit operations.

2. S-bit position (0 for lower case, 1 for upper case) is inserted during receive operations; deleted during transmit operations.

3. LF (line feed) performs indexing.

4. NL (new line) performs a carrier return and line feed.

5. The following characters (not used by 2740 or 2741 Communication Terminals) are provided for PTTC/BCD and PTTC/EBCDIC programming considerations with the 1050 Data Communication System:

   Punch ON (PN) 09 and 99
   Bypass (BY) 38 and B8
   Restore (RES) 58 and D8
   Punch OFF (PF) 79 and F9
   Delete (DEL) 7F and FF
   Prefix (PRE) 3E and BE.

6. In the 2741, the index key is replaced by an attention key: no indexing can be performed during transmission. Indexing is performed when the terminal receives an index character from the line.

		Main Storage Byte Positions 0, 1, 2, 3 (1, 2, 3, 4)															
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
4, 5, 6, 7 (5, 6, 7, 8)	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	BS	EOT	FF	STX	LF	ACK	SO	SOH	HT	ENQ/wru	CR	ETX	VT	BEL	SI
0001	1	NUL	BS	EOT	FF	STX	LF	ACK	SO	SOH	HT	ENQ/wru	CR	ETX	VT	BEL	SI
0010	2	@	H	D	L	B	J	F	N	A	I	E	M	C	K	G	O
0011	3	@	H	D	L	B	J	F	N	A	I	E	M	C	K	G	O
0100	4	SP	(	$	'	"	*	&	.	!	)	%	–	#	+	,	/
0101	5	SP	(	$	'	"	*	&	.	!	)	%	–	#	+	,	/
0110	6	`	h	d	l	b	j	f	n	a	i	e	m	c	k	g	o
0111	7	`	h	d	l	b	j	f	n	a	i	e	m	c	k	g	o
1000	8	DLE	CAN	DC4	FS	DC2	SUB	SYN	RS	DC1/xon	EM	NAK	GS	DC3/xoff	ESC	ETB	US
1001	9	DLE	CAN	DC4	FS	DC2	SUB	SYN	RS	DC1/xon	EM	NAK	GS	DC3/xoff	ESC	ETB	US
1010	A	P	X	T	\	R	Z	V	↑	Q	Y	U	]	S	[	W	←
1011	B	P	X	T	\	R	Z	V	↑	Q	Y	U	]	S	[	W	←
1100	C	0	8	4	<	2	:	6	>	1	9	5	=	3	;	7	?
1101	D	0	8	4	<	2	:	6	>	1	9	5	=	3	;	7	?
1110	E	p	x	t	|	r	z	v	~	q	y	u	}	s	{	w	Delete
1111	F	p	x	t	|	r	z	v	~	q	y	u	}	s	{/PAD	w	Delete

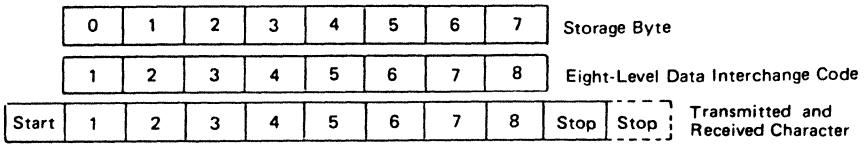

Figure 15. Eight Level TWX Code for Standard Keyboard Arrangement in US Telegraph Terminal Control - Type 2 Operations

Notes:

1. When two codes are shown for a single character, the shaded indication denotes the bit configuration due to the parity bit being held in Mark Hold state. The companion bit configuration has even parity.
2. Start/Stop bits are deleted at the CA during receive operations, added at the CA during transmit operations.

		Main Storage Byte Positions 0, 1, 2, 3 (0, 1, 2, 3)															
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
4, 5, 6, 7 (4, 5, 6, 7)	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	DLE	DS		SP	&	–									0
0001	1	SOH	DC1	SOS				/		a	j			A	J		1
0010	2	STX	DC2	FS	SYN					b	k	s		B	K	S	2
0011	3	ETX	DC3							c	l	t		C	L	T	3
0100	4	PF	RES	BYP	PN					d	m	u		D	M	U	4
0101	5	HT	NL	LF	RS					e	n	v		E	N	V	5
0110	6	LC	BS	EOB / ETB	UC					f	o	w		F	O	W	6
0111	7	DEL	IL	PRE / ESC	EOT					g	p	x		G	P	X	7
1000	8		CAN							h	q	y		H	Q	Y	8
1001	9		EM							i	r	z		I	R	Z	9
1010	A	SMM	CC	SM		¢	!		:								
1011	B	VT				.	$	.	=								
1100	C	FF	IFS		DC4	<	*	%	@								
1101	D	CR	IGS	ENQ	NAK	(	)	_	'								
1110	E	SO	IRS	ACK		+	;	>	=								
1111	F	SI	IUS / ITB	BEL	SUB	|	¬	?	"								

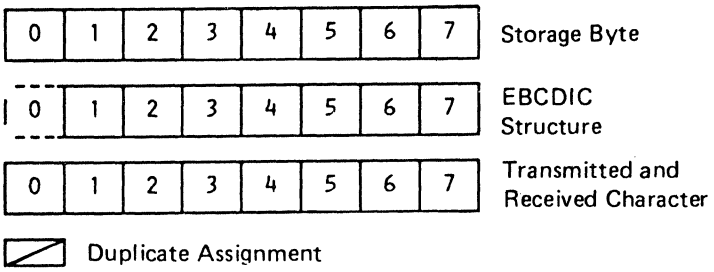

Figure 16. EBCDIC, as Used for Binary Synchronous Communication Control

Notes:

1. During receive operations in non-text mode, the DLE character, followed by any of the bit configurations in columns 6 or 7, will cause the command to be ended. However, only those bit configurations indicated by | | | are valid.

2. The following DLE sequences are defined:
   70 = ACK0
   61 = ACK1
   6B = WACK
   7C = RVI

		Main Storage Byte Positions 0, 1, 2, 3 (0, 7, 6, 5)															
Byte Positions		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
4, 5, 6, 7 (4, 3, 2, 1)	Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	0	NUL	DLE	SP	0	@	P	\	p								
0001	1	SOH	DC1	!	1	A	Q	a	q								
0010	2	STX	DC2	"	2	B	R	b	r								
0011	3	ETX	DC3	#	3	C	S	c	s								
0100	4	EOT	DC4	$	4	D	T	d	t								
0101	5	ENQ	NAK	%	5	E	U	e	u								
0110	6	ACK	SYN	&	6	F	V	f	v								
0111	7	BEL	ETB	'	7	G	W	g	w								
1000	8	BS	CAN	(	8	H	X	h	x								
1001	9	HT	EM	)	9	I	Y	i	y								
1010	A	LF	SUB	*	:	J	Z	j	z								
1011	B	VT	ESC	+	;	K	[	k	{								
1100	C	FF	FS	,	<	L	\	l	¦								
1101	D	CR	GS	-	=	M	]	m	}								
1110	E	SO	RS	.	>	N	^	n	~								
1111	F	SI	US / ITB	/	?	O	–	o	DEL								

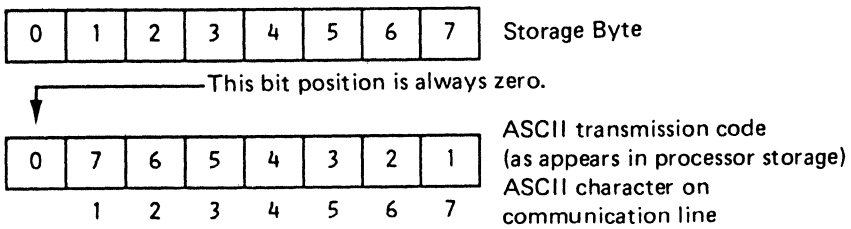

Figure 17. ASCII, as Used for Binary Synchronous Communication Control

Notes:

1. During receive operations in non-text mode, the DLE character, followed by any character appearing in column 3, causes the command to be ended.

2. The folowing DLE sequences are defined:
   30 = ACK0
   31 = ACK1
   3B = WACK
   36 = RVI

International Alphabet No. 5

International Reference Version

b7	0	0	0	0	1	1	1	1
b6	0	0	1	1	0	0	1	1
b5	0	1	0	1	0	1	0	1

Second Digit ↓ — First Digit →

bbbb 4321	0	1	2	3	4	5	6	7
0000	0	NUL	TC7 (DLE)	SP	0	@	P	`	p
0001	1	TC1 (SOH)	DC1	!	1	A	Q	a	q
0010	2	TC2 (STX)	DC2	"	2	B	R	b	r
0011	3	TC3 (ETX)	DC3	#	3	C	S	c	s
0100	4	TC4 (EOT)	DC4	¤	4	D	T	d	t
0101	5	TC5 (ENQ)	TC8 (NAK)	%	5	E	U	e	u
0110	6	TC6 (ACK)	TC9 (SYN)	&	6	F	V	f	v
0111	7	BEL	TC10 (ETB)	'	7	G	W	g	w
1000	8	FE0 (BS)	CAN	(	8	H	X	h	x
1001	9	FE1 (HT)	EM	)	9	I	Y	i	y
1010	10	FE2 (LF)	SUB	*	:	J	Z	j	z
1011	11	FE3 (VT)	ESC	+	;	K	[	k	{
1100	12	FE4 (FF)	IS4 (FS)	,	<	L	\	l	|
1000	13	FE5 (CR)	IS3 (GS)	-	=	M	]	m	}
1110	14	SO	IS2 (RS)	.	>	N	^	n	~
1111	15	SI	IS1 (US)	/	?	O	_	o	DEL

Usage Example: A = 4/1 BEL = 0/7

Figure 18. International Alphabet No. 5, used in X.21 Switched Facility

Glossary

This glossary contains technical terms associated with the subject of this publication. A wider and more general range of terms is contained in *IBM Data Processing Glossary*, GC20-1699.

IBM is grateful to the American National Standards Institute (ANSI) for permission to reprint its definitions from the American National Standard Vocabulary for Information Processing (Copyright © 1970 by American National Standard Institute, Incorporated), which was prepared by Subcommittee X3.5 on Terminology and Glossary of American National Standards Committee X3.

ABM. Asynchronous balanced mode

ACF. Advance communications function

ACK. Positive acknowledgement

ACU. Automatic call unit

ADM. Asynchronous disconnect mode

ARM. Asynchronous response mode

ASCII. American National Standard Code for Information Interchange

BCC. Block check character

BCD. Binary coded decimal

bps. Bits per second

CC. Condition code

CCITT. International Telephone and Telegraph Consultative Committee

CCW. Channel command word

CE. Channel end

CMDR. Command reject

contact polling. In the normal response mode of synchronous data link control, a method of setting up a secondary station for data transfer. The primary station sends a set normal response mode frame to the secondary station.

CRC. Cyclic redundancy check

CRQ. Call request

CSW. Channel status word

data polling. In the data transfer state of stations under synchronous data link control (secondary station in normal response mode), polling by means of receive-ready and receive-not-ready commands and responses. Stations poll each other for data, and respond to polling frames when no information frames are available for transmission.

data spanning. A method of handling frames (both inbound and outbound) that do not fit into a single buffer. Such frames are allowed to "span" several buffers. This means that several Read PIU and Write PIU commands are used for one frame.

data terminal equipment (DTE).
1. * A data source, a data sink, or both.
2. (SC1) The functional unit of a data station that serves as a data source or a data sink and provides for the data communication control function to be performed in accordance with a link protocol.

DE. Device end

DLE. Data link escape

DLO. Data line occupied

DM. Disconnected mode

DSC. Distant station connected

DTE. Data terminal equipment

DTR. Data terminal ready

EBCDIC. Extended binary-coded decimal interchange code

EIA. Electronic Industries Association

EIB. Error index byte

ENQ. Inquiry

EON. End of number

EOT. End of transmission

ERP. Error recovery procedure

ETB. End of transmission block

FCS. Frame check sequence

flushing. Executing all commands except for their line-affecting parts, that is:

- Performing chaining
- Testing the validity of the command code and format (raising unit check and discontinuing flushing if any error is present) but not testing the data address and whether the data buffer is fixed.
- Setting the status modifier (for Autopoll command).

I. Information

ID. Identifier

ISO. International Organization for Standardization

ITB. Intermediate text block

kbps. Kilobytes per second

LRC. Longitudinal redundancy check

nodem. (MOdulator-DEModulator.) A device that modulates and demodulates signals transmitted over communication facilities.

multipoint network. A line or circuit that interconnects several stations in a data communications system.

NAK. Negative acknowledgement

Nr. Number received

NRM. Normal response mode

Ns. Number sent

NSA. Non-sequenced acknowledge

NSP. Non-sequenced poll

PABX. Private automatic branch exchange

PCI. Program controlled interruption

P/F. Poll/Final

PIU. Path information unit

PTTC. Paper tape transmission code

RNR. Receive not ready

RR. Receive ready

RTS. Request to send

RVI. Reverse interruption

SCB. Station control block

SEP. Separator

SNRM. Set normal response mode

SOH. Start of heading

SP. Space

STX. Start of text

SYN. Synchronization

TIC. Transfer in channel

transparent mode. A mode of binary synchronous text transmission in which data, including normally restricted data link control characters, are transmitted only as specific bit patterns. Control characters that are intended to be effective are preceded by a DLE character. Contrast with nontransparent mode.

tributary station. In a centralized multipoint data communications system, this is a station, other than the control station, that can communicate only with the control station when polled or selected by the control stations.

TWX. Teletypewriter Exchange Service

UA. Unsequenced acknowledgement

UC. Unit check

UCW. Unit control word

VRC. Vertical redundancy check

VTAME. Virtual telecommunications access method entry

WACK. Wait before transmit

XID. Exchange station identification

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