TERMINAL SUBSYSTEMS

MODE 4 (200 UT) INTERFACE SPECIFICATIONS

The Terminal Systems Development Division will soon be releasing Mode 4 support through the 7077/791 local communications controller. With the introduction of Mode 4 support on the LCC, it is conceivable that the requirement may arise to interface non-CDC equipment which emulates the 200 user terminal into CDC higher-level processors. There exists the possibility that other vendors' terminals may not operate correctly in this environment even though no problems are encountered when using CDC 200 user-type terminals. This article is intended to help answer many of the questions that may arise, as well as to point out some of the peculiarities and potential problem areas when working with this protocol. Additionally, the PSD support function at TSDD will be available to provide consulting services to any vendor whose terminal is experiencing interface problems as mentioned previously.

A proper presentation of Mode 4 requires first of all, clarifying the differences between Mode 4, Mode 3, and Mode 2, as well as the various versions of Mode 4 protocol.

A protocol as related to data communications refers to a set of procedures for control of information as it flows over a data link to a station and eventually a specific device. The procedure defines the various data elements and message components and describes the ways they may be structured in the various message types. Within the constraints of a specific protocol is provided therefore, the framework within which products with similar features can co-exist on the same data communications link and maintain consistent operation. Although the terminals supported by a particular protocol may have a wide range of capabilities and features, it is possible for them to operate together, provided they retain compatibility of required system characteristics, examples being:

- Signaling rate
- Mode of transmission
- Communications network interface
- Unique device control codes
- Exact timing relations, if appropriate

Data communication protocols are structured to allow the use of defined elements within these characteristics and from this definition, derive their unique features and characteristics; hence, Mode 2, Mode 3, and Mode 4.

Mode 2 protocol will only support synchronous lines which are point-to-point, full-duplexed and non-switched. The transmission flow will be two-way simultaneous at line speeds from 2400 bits per second (bps) to 50K bps. Current products supporting this protocol include the 731-10, 732-10, and 733-10 batch terminals.

Mode 3 protocol supports asynchronous lines of speeds of 110-300 bps which are point-to-point, two-way alternate (half-duplexed) and may be either switched or non-switched. This protocol is intended to support Model 33/35 teletypes (ASR and KSR) and the CDC 713 CRT terminal.

Mode 4 protocol which consists of variants 4A, 4B, and 4C, supports two-way alternate synchronous lines with the following line characteristics:

1) Line speed of 600-9600 bps point-to-point, half-duplexed switched

2) Line speed of 1200 bps to 9600 bps point-to-point - 2-wire or 4-wire non-switched

3) Line speed of 1200 bps to 9600 bps multi-drop - 2-wire or 4-wire non-switched

The Mode 4A variant of Mode 4 protocol is the procedure for exchange of data between a CDC 200 user terminal and/or products emulating the 200 UT and a data source. The unique feature of this variant is the selection of peripherals with pre-defined codes in the message text. It is this variant which will be dealt with in this article.

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Mode 4B protocol exists to permit the exchange of data between a data source and CDC 216-type terminals. The distinguishing feature of this procedure is that devices have unique address.

Mode 4C protocol is primarily the attempt at an overall corporate standard for Mode 4. It defines areas previously undefined or defined differently for certain implementations. It also eliminates major conflicts with ANSI standards and has expanded capabilities to cover the foreseeable requirements for the future.

Current Control Data terminals employing Mode 4 protocols include:

TERMINAL	PROTOCOL
714 Multi-Station	Mode 4B/C
214-XX BCD	Mode 4A
200 UT BCD	Mode 4A
217-XX BCD	Mode 4A
711-10	Mode 4B
731-12 LSBT	Mode 4A
732-12 MSBT	Mode 4A
200 UT ASCII	Mode 4A
734-1	Mode 4A

With this background serving to clarify the significance of the term protocol and its employment by CDC, it is possible to investigate in more depth Mode 4A 200 UT protocol and to point out some of the more obvious occurrences that generate problems when utilizing this line communication procedure.

The 200 UT can receive six types of messages. It is capable of sending four types of messages, where we have ten unique message types. The 200 UT responds (sends) only after receiving a message, so the computer communicating with the 200 UT must initiate all transmission. One exception to this is when the POLL switch is in WAIT position. If in a POLL WAIT, an acknowledge is transmitted. If a READ RESPONSE becomes available at a later time, it is transmitted without waiting for a POLL. A CRT message will be transmitted when the operator sets the SEND key (a poll must previously have been received).

The following message types are received by the 200 UT:

> A. POLL
> B. ALERT
> C. WRITE
> D. RESET WRITE
> E. CLEAR WRITE
> F. DIAGNOSTIC WRITE

The following message types are transmitted by the 200 UT:

> A. ACKNOWLEDGE
> B. REJECT
> C. ERROR
> D. READ

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MODE 4 {200 UT} INTERFACE SPECIFICATIONS {cont'd}

The general format of messages is as follows {in octal}:

026	
026	-4 SYNC CODES
026	
026	
001	- SOH {Start of Header}
16X-17X	- Site Address
140, 141, 160 or 161	- Station Address and Sequence Bit
	- Control Code
	- Data {0-1040 words}
003	- ETX {End of Text}
XXX	- MPC {Message Parity Character}

All control information in the messages is always received with odd parity.

005	- POLL
007	- ALERT
* 021	- WRITE
* 014	- RESET WRITE
* 022	- CLEAR WRITE
006	- ACKNOWLEDGE
030	- REJECT
025	- ERROR
* 020	- DIAGNOSTIC WRITE
* 023	- READ

* The WRITE, RESET WRITE, CLEAR WRITE, DIAGNOSTIC WRITE and READ messages may contain data. The block of data is followed by an E1, E2, E3, or E4 {preceding the ETX}, specifying what is to be done with the data or from where to solicit the next block of data.

In the WRITE messages, E1, E2, E3, and E4 have the following meaning:

E1 - Display the message on the CRT

E2 - Print the message on the printer

E3 - Request card read data to be sent from the 200 UT

E4 - Start of text indicator when operating in LINE MODE ON DISPLAY

In the READ message, they have the following meaning:

E1 - This block contains operator-composed data {from CRT keyboard}.

E2 - /1/ If cards were being read {if last WRITE contains E3 requesting cards to be read}, E2 indicates 'all cards have been read, hopper is empty, card is jammed, or light-dark check error occurred'. It is treated generally as a card reader not ready condition.

/2/ If printing was being done {if last WRITE contained an E2 request}, E2 indicates the printer is not ready, and write message with print data must be re-sent.

E3 - /1/ If cards were being read, E3 indicates card reading can continue.

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MODE 4 (200 UT) INTERFACE SPECIFICATIONS (cont'd)

/2/ If printing was being done, E3 indicates printing can continue.

Note that E codes are, in fact, character pairs consisting of an ESCAPE CODE (ESC) and the function to be performed.

Description of Message Types Received by 200 UT

1. POLL - This is a fixed-length message which is sent to the 200 UT to determine its status and to receive data.

2. ALERT - This is a fixed-length message which is sent to the 200 UT to sound its audible alarm without destroying any CRT data being composed.

3. WRITE - This is a variable length message which is sent to the 200 UT and may or may not contain data. It is used to:

   a.   send display data to 200 UT

   b.   send print data to 200 UT

   c.   request card data from 200 UT

4. RESET WRITE and CLEAR WRITE - These act the same as WRITE, but are intended for CRT - keyboard communication, allowing the computer to control placement of output data onto the CRT screen.

5. DIAGNOSTIC WRITE - Used only for maintenance.

Description of Message Types Sent by 200 UT

1. ACKNOWLEDGE - This is a fixed-length message sent by the 200 UT to acknowledge successful receipt of an ALERT, WRITE, RESET WRITE or CLEAR WRITE, and in a special case, to a POLL (if POLL switch is in WAIT position and no data ready to send).

2. REJECT - This is a fixed length message sent by the 200 UT to indicate rejection of a previously received message in the following situation:

   a.   A POLL is received, but the SEND key has not been activated or an automatic read request has not been initiated (by a WRITE).

   b.   The display controller is busy at the time of receipt of the WRITE, RESET WRITE, or a CLEAR WRITE code.

3. ERROR - This is a fixed-length message sent by the 200 UT to indicate unsuccessful receipt of the last message from the computer. Errors include:

   a.   Illegal or unrecognized conditions detected after the correct site address.

   b.   Character and/or message parity error.

   c.   The modem carrier was removed before the ETX.

   d.   A WRITE message was received and did not end with an escape and an E1, E2, or E3.

4. READ - This is a variable-length message sent by the 200 UT in response to a POLL if read request is active. It may or may not contain data. The READ message may contain:

   a.   display data (entered via keyboard), or

   b.   card read data, and/or

   c.   status concerning printer or card reader.

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MODE 4 {200 UT} INTERFACE SPECIFICATIONS {cont'd}

The following table indicates the possible 200 UT responses to each computer original message:

Computer Sends	200 UT Sends
1. POLL	*ACK, REJECT, ERR, or READ
2. ALERT	ACK or ERR
3. WRITE, RESET WRITE, or CLEAR WRITE	ACK, REJECT, or ERR
4. DIAGNOSTIC WRITE	REJECT or READ

A null response can occur {timeout} which indicates that either the HLP request was not received by the terminal, or the terminal response was lost through transmission error.

* ACK sent in response to POLL only when POLL switch in WAIT position.

Message Sequence Bit

The 200 UT provides for the reception of a message sequence bit {0 or 1} in each write message which is merely echoed back in each response message. The computer may toggle this bit between 0 and 1 on each WRITE message it sends, allowing it to determine if a message was actually received properly by the 200 UT in certain error conditions which would otherwise be ambiguous - computer would not know whether to re-send a block of data at the risk of repeating a block or to not send, risking the dropping of a block {see later discussion of error recovery}.

Sequence Bit Rules

1. The 200 UT saves the sequence bit {0 or 1} from the WRITE, CLEAR WRITE, and RESET WRITE message if and only if its response to the write message is an 'ACK'.

2. The 200 UT includes the currently saved sequence bit {0 or 1} in all messages it sends back to the computer {READ, ACK, ERR, and REJ messages}.

The sequence bit is bit 2^4 in the station address byte.

To maintain consistent performance of devices using Mode 4A 200 UT protocol requires complete understanding of the operation of the terminal features as they relate to the communication procedures as well as proper handling of data formats and control methods. What follows are observations concerning those topics which are not explicitly understood and, therefore, exist as potential problem areas when programming or operating within the confines of this protocol.

Commencing with the input operations of the card reader, several observations may be made concerning card formats and processing. Major areas of concern include code sets, special end-of-record and end-of-file cards, card buffer lengths, and card-reader-not-ready conditions.

Code set is a very special problem for the programmer. Particular customers may use keypunches to punch their hollerith cards which do not necessarily comply to Control Data standard code set for terminals. To alleviate this problem, every character should first be printed on a sheet of paper. Perform this procedure by assigning a unique definition for punch configuration which will define each character. Because of additional variables on print drums, code set can be a serious problem when programming a terminal. Try to stay as close as possible to CDC standards when defining the code set for your terminal. Observation and conformity with the code set on the higher-level processor should also be considered when defining the code set.

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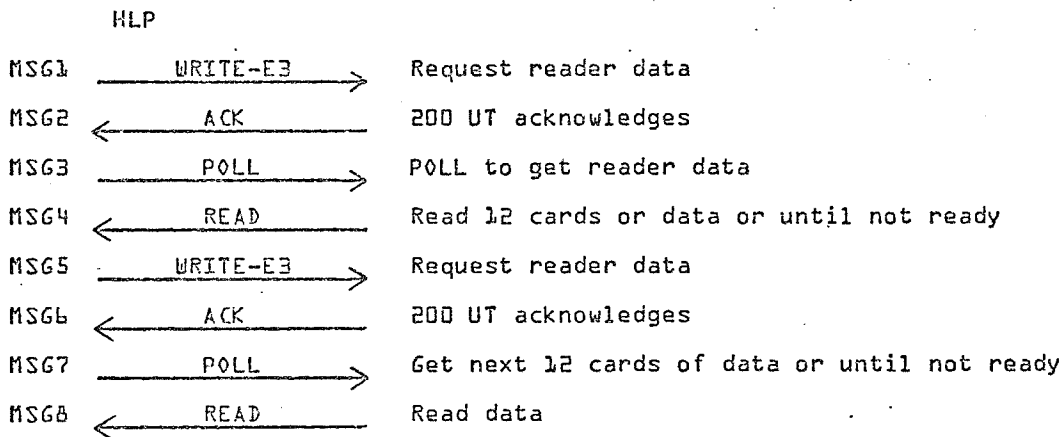MODE 4 (200 UT) INTERFACE SPECIFICATIONS (cont'd)

In addition to code set, card input can also create problems if job structures are not interpreted correctly. A case in point would be the processing of 7/8/9 end-of-record card and 6/7/8/9 end-of-file card by CDC CYBER or 6000 HLP software. .

Whenever an EOR or EOF card is detected by the card reader, this code must be expanded to look like an escape character and then the character for EOR or EOF. Always remember that one character in will result in two characters out. This may seem insignificant, but before this EOR or EOF card was read, all cards were kept on an even word boundary of 80 characters. Now this would result in 81 characters being generated and would cause possible confusion when examining data within memory. ·

Card buffer lengths can be problematic as a result of the fact that 200 UT protocol does not allow card compression going to the higher-level processor. This protocol also needs twelve cards in a block or a not-ready condition to force the cards to be sent to the higher-level processor. The requirements of the card reading function are:

   1)   Twelve cards are always read or X number of cards with a not-ready condition.

   2)   These cards are not sent to the HLP until the HLP writes an E3 to the card reader.

   3)   If the HLP writes an E3 and the card reader is not ready, the terminal will produce (in the data portion of the message) an escape with an E2 in the next message sent back to the HLP.

To help understand this procedure, observe the following diagram of the normal protocol procedure for reading cards.

                HLP

      MSG1 _____WRITE-E3_____>   Request reader data

      MSG2 <_____ACK_____   200 UT acknowledges

      MSG3 _____POLL_____>   POLL to get reader data

      MSG4 <_____READ_____   Read 12 cards or data or until not ready

      MSG5 ._____WRITE-E3_____>   Request reader data

      MSG6 <_____ACK_____   200 UT acknowledges

      MSG7 _____POLL_____>   Get next 12 cards of data or until not ready

      MSG8 <_____READ_____   Read data

The read response on the last message from the card reader could either be a 2-character read containing an ESCAPE and E2 or a data buffer containing from 1 to 12 cards with ESCAPE and E3. Other significant conditions to be aware of when doing card operation include:

   1)   If the HLP detects a job card error in the first 12 cards, the terminal will load 12 more cards, but the HLP will not write an E3 to the terminal. To empty the 12 cards loaded in the terminal requires a manual release condition for the terminal.

   2)   To use the card reading capability most efficiently should you load cards while transmitting cards to the HLP.

   3)   An illegal hollerith code should be masked or altered to reflect a legal character. A question mark (?) character is normally used.

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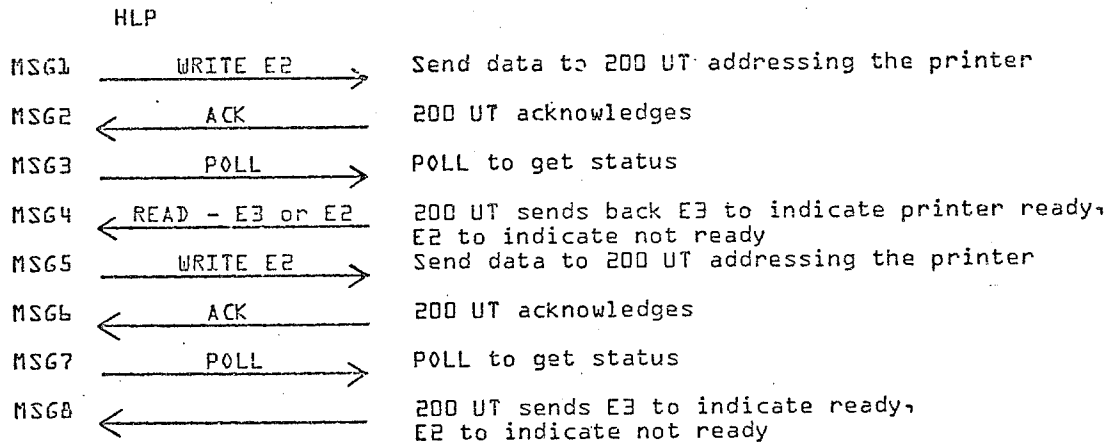
MODE 4 (200 UT) INTERFACE SPECIFICATIONS (cont'd)

4) Binary cards are not allowed to be transmitted on the standard 200 UT protocol.

5) A card buffer is not released until the HLP writes an E1, E2, E3, or E4 to the terminal.

The code set is also one of the major features to be aware of when performing printer output with 200 UT protocol. Code set and compression of blanks and zeros are the primary areas of caution when printing.

Compression of blanks and zeros are sent from the HLP to the terminal. The terminal must look at these characters which are always preceded by an ESCAPE and decompress them.

The compression codes for INT BCD, EXT BCD, and ASCII transmission are similar but not identical. For a complete table of the differences, please refer to the reference manuals for 200 UT devices.

The print drum on your specific printer could present a problem if the characters do not match the customer's requirements. The printer message is sent down from the HLP as a normal data message ending with an ESCAPE and E2. Any errors encountered during the transmission of the print message will cause the data not to be printed. The normal print message ending with ESCAPE and E2 will be answered with either an acknowledge or error. If the message is error-free, it is answered with an ACK, if not an ERR. After the print message is sent, the HLP will POLL the terminal to determine if the printer was ready or not ready. An example of the printer flow is:

HLP

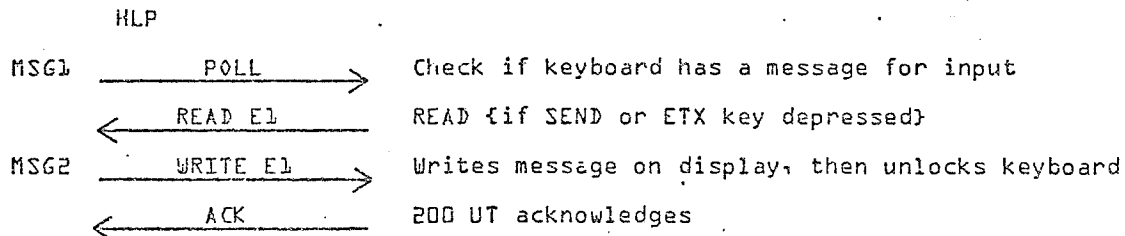| MSG1	WRITE E2 ⟶	Send data to 200 UT addressing the printer
MSG2	⟵ ACK	200 UT acknowledges
MSG3	POLL ⟶	POLL to get status
MSG4	⟵ READ - E3 or E2	200 UT sends back E3 to indicate printer ready, E2 to indicate not ready
MSG5	WRITE E2 ⟶	Send data to 200 UT addressing the printer
MSG6	⟵ ACK	200 UT acknowledges
MSG7	POLL ⟶	POLL to get status
MSG8	⟵	200 UT sends E3 to indicate ready, E2 to indicate not ready

The keyboard and display are generally quite basic and cause few problems for the programmer in relation to protocol procedures. The one detail that is worth pointing out is the LINE MODE feature. The LINE MODE feature is the capability to protect previously entered or response data from being altered. Generally, the display/keyboard will be either 50 characters X 20 lines or 80 characters X 13 lines. When using LINE MODE, you must have a special symbol to denote the beginning of the input field on a display. If the hardware allows more than 80 characters on a line, you could place the special symbol on the beginning or end of the line. If the hardware only gives the ability of 80 characters per line, you must trail the special symbol one line behind and wipe out the character previously displayed in that position. Another restriction to observe when using LINE MODE occurs when attempting to re-send a full screen of data. If the data does not begin at the top of the screen, you will lose one character. This is a very rare occurrence, but worth making note of.

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MODE 4 (200 UT) INTERFACE SPECIFICATIONS (cont'd)

When sending data from the keyboard to the HLP, compression is not used. When receiving data from the HLP, again no compression will be present. The normal keyboard flow is:

```
              HLP

MSG1  _____POLL_____>    Check if keyboard has a message for input

        <_____READ E1_____   READ (if SEND or ETX key depressed)

MSG2  _____WRITE E1_____>    Writes message on display, then unlocks keyboard

        <_____ACK_____    200 UT acknowledges
```

In examining the message sequences for the devices comprising a 200 UT-type device, it should be noted that error recovery occurs in one of two ways. If the input message has received the site address and the message is in error beyond this character, the terminal will answer back with an ERROR message. If the terminal finds an error with the site or before the terminal re-syncs and does not answer the message, thus allowing the host processor to time out and re-try the message. When data is being transferred to and from the terminal, the error process is checked with the station address. The way the terminal treats a station address is if the message is a write answered with an acknowledge, you reply with the same station address as was sent in the write. All other messages are answered with the previous station address. See the previous discussion on Bit Sequencing for further clarification of this method.

The following examples demonstrate how this procedure operates for various error conditions on write operations. If a write message is received incorrectly by the terminal, the data source retransmits.

	Transmitted Message	Station Address	Response Message	Station Address
Message 1	Write	161	Acknowledge	161
Message 2	Write	141	Acknowledge	141
Message 3	Write	161	Acknowledge	161
Message 4	Write	141	Error	161
Message 5	Write	141	Acknowledge	141

If the data source fails to receive a response correctly, another message (station poll or alert) may be transmitted in an effort to determine the status of the preceding write message. This new message may use either of the station addresses. If the original write message is received correctly, the response to the second transmission supplies the original station address. In the following example, the acknowledge message response to the write message marked with the * is assumed to have been destroyed by a line error.

	Transmitted Address	Station Address	Response Message	Station Address
Message 1	Write	161	Acknowledge	161
Message 2	Write	141	Acknowledge	141
Message 3	Write	161	Acknowledge*	161
Message 4	Poll	141 or 161	Reject	160
Message 5	Write	141	Acknowledge	141

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MODE 4 (200 UT) INTERFACE SPECIFICATIONS (cont'd)

Assuming the line error destroys the error response (*), the data source transmits a poll message to determine status. An alternate address in the reject message response informs the data source of the error condition in the previous write. Retransmission is then the normal procedure.

	Transmitted Message	Station Address	Response Message	Station Address
Message 1	Write	161	Acknowledge	161
Message 2	Write	141	Acknowledge	141
Message 3	Write	161	Error *	141
Message 4	Poll	141 or 161	Reject	140
Message 5	Write	161	Acknowledge	161

The preceding information has been intended to offer some insight into potential areas for problems when doing card input, printer output or keyboard input/output. In support of these functions, the following general comments concern additional cautions to be observed when programming or operating a terminal using Mode 4A 200 UT protocol.

- The manual release feature will free the terminal up and do error recovery restart. The restart is accomplished by clearing all internal pointers in the terminal and re-syncing the communications line.

- Depressing the interrupt key stops all reading and printing from the host processor, and permits a message to be entered from the CRT. This tells the reader not to send any more card buffers and to hold back the reply of printer ready or not ready to the host processor. An exception to this occurs, however, if the card or printer response ends with an E2 code. In this instance, intervention is overridden.

- A sync code should never be inserted between the end of text (ETX) and message parity character (MPC). The host processor must regard the byte following the ETX as the MPC. Note that the MPC could have the same bit pattern as the sync.

- Any sync code that appears after the start of header (SOH) and before the message parity character (MPC) should be discarded.

- When the card reader is sending a 12-block sequence of cards to the host processor, the reader should be reading the next 12 cards to refill the buffer.

- When reading cards, the host processor will always write an E3 to the terminal. The terminal, if it is not ready with card input, should respond with a read containing an E2. A poll-reject sequence should be avoided or the not-ready condition will never be output as an error message.

- During a POLL operation, there could be data after the control code (E codes) and before the end of text (ETX). An error should not be output in this case.

- A print line can be longer than 136 characters; if so, truncation is performed.

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MODE 4 {200 UT} INTERFACE SPECIFICATIONS {cont'd}

- When operating with certain modems {e.g., CDC 358 transceivers}, be very careful when turning the line around. If in the software, a request to send is dropped too soon after you have put the last character on the line, you may clear the line before the character has been received on the other end of the transmission line.

- Timing considerations should be known and adjusted to. Some modems for terminals capable of simulating the 200 UT require, for instance, the output of a pad of characters behind the message parity character {MPC} to insure reception of the MPC at the remote end.

In conclusion, this article has attempted to introduce the idea of protocol, define its application to CDC products, and present the flow of Mode 4A protocol while covering some of the major problem areas to be observed when implementing the procedure. Protocol is the major consideration in communication and as such, a confusing subject to many who are required to work with it. In future issues of the PSI Excerpts, information such as that contained in this article will be presented on related subjects, such as Mode 4C and IBM 2780 protocols, devices that utilize these procedures, and special considerations when implementing and utilizing these methods.