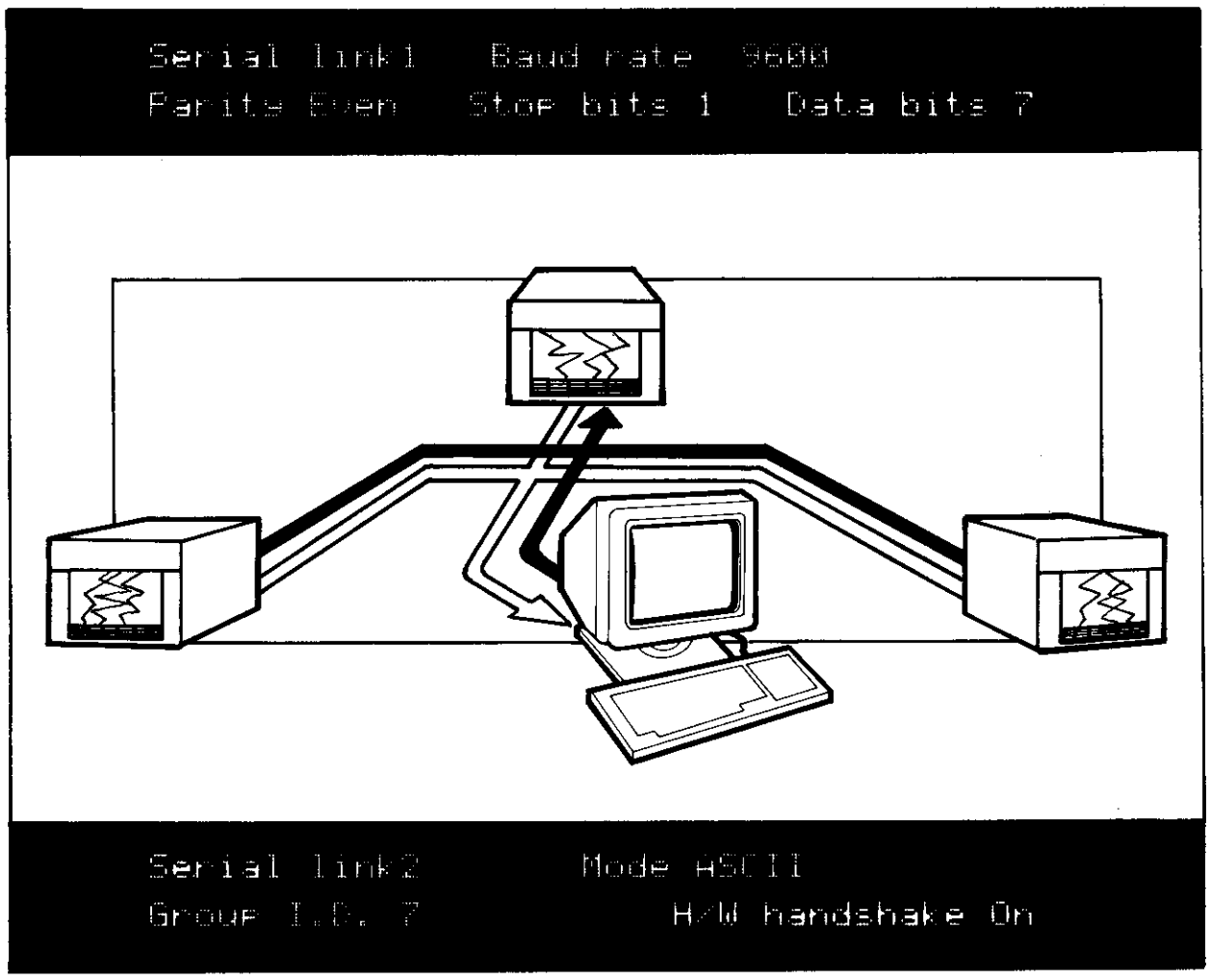
CHESSELL

Serial communications instruction manual
Model 4001

SERIAL COMMUNICATIONS INSTRUCTION MANUAL



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SERIAL COMMUNICATIONS INSTRUCTION MANUAL

1.0 INTRODUCTION

The purpose of this document is to describe the implementation of a communications link between a host (supervisory) computer, and one or more 4001 chart recorders.

It is intended that this document shall be used by those who require the mechanical, electrical, electronic and software information necessary to set up a serial data link.

It is assumed that the user is familiar with the installation and operation manual (part no. HA237229) supplied with the instrument.

This introductory section includes brief descriptions of the RS232 and RS422 standards. Section 2 contains mechanical and electrical installation procedures. Section 3 describes the communications protocols which are currently supported by 4001 recorders, including descriptions of the procedures for:—

a) Establishing a logical connection.

b) Message transfer.

c) Termination of a connection.

Additionally, details of parameter validation are given.

Section 4 gives details of the data formatting required to send and receive data to and from a 4001 recorder. Section 5 is a reference section, and section 6 gives a number of examples of how to read from and write to a 4001 recorder.

1.1. COMMUNICATIONS STANDARDS

1.1.1. INTRODUCTION

Two internationally agreed standards for electrical interconnection are supported, viz: RS232C and RS422. Full details of these standards are beyond the scope of this document, but may be found in the relevant specifications published by Electronic Industries Association, Washington D.C. Table 1.1.1 gives brief specification for the two standards. The following are brief outlines of the application of these standards to 4001 model recorders.

1.1.2. RS232C

The RS232 interface is used to wire the host computer to a single instrument, through a relatively short length of screened cable. The maximum usable distance varies according to a number of parameters including data transmission rate (baud rate), the electro-magnetic environment through which it passes, etc. Figure 1.1.2 shows a typical wiring diagram for an RS232 serial data link.

Hardware Handshake

Hardware handshake is a means whereby the host and recorder state whether or not they are available to receive data. To achieve this, four lines of the RS232 link are used:—

a) CTS (Clear to send.)	:	Host is ready to receive data.
b) RTS (Ready to send.)	:	4001 is ready to receive data.
c) DCD (Data carrier detect.)	:	Host device available.
D) DTR (Data terminal ready.)	:	4001 available.

The above lines are defined as being 'on' when high (positive) and 'off' when low (negative).

1.1.2 (Cont.)

DCD and DTR go high as soon as the relevant devices are initialised (unless the hardware handshake is set off at either device).

1. HANDSHAKE OFF. With handshake selected off (Serial Link 2 Page), RTS and DTR are set off. DCD and CTS signals from the host are ignored by the 4001.

2. HANDSHAKE ON. With handshake selected on, signal RTS is used to tell the host that the 4001 is ready to receive data. As soon as the recorder is initialised, DTR and RTS go high. (This allows the 4001 to receive an EOT even when it is transmitting). The 4001 then waits, if necessary, for the CTS line to go high, transmits its message and awaits further messages from the host.

NOTE.
If hardware handshake is selected on, but the data link is not wired for CTS, RTS, DCD, and DTR, the 4001 will still communicate as DCD and DTR, and CTS and RTS are internally connected at the 4001, through 8.2 k-ohm resistors (see figure 1.1.2).

1.1.3. RS422

Figure 1.1.3 is a typical wiring diagram for an RS422 serial data link. It should be noted that the host computer TxA and TxB are connected to the RxA and RxB connections respectively, of the 4001 communications module and vice-versa.

As indicated in the figure, the RS422 datalink allows a number of instruments to be wired in parallel to common receive and transmit buses. All the output drivers go into a high impedance state (essentially open-circuit) when not transmitting i.e. outputs are tri-stated.

SINGLE SERIAL LINK (RS232)

Transmission Standard	:	RS-232-C (bi-directional)
Protocol	1:	ANSI-X3.28-2.5-A4
	2:	ASCII version of Protocol 1.
Data Rates	:	110, 300, 600, 1200, 2400, 4800, 9600 baud.
Character Format	:	1 start; 7 or 8 data; 1 or 0 parity; 1 or 2 stop bits.
Parity	:	None, odd, even as selected.

MULTI DROP SERIAL LINK (RS422)

Transmission Standard	:	RS-422-A
Protocol	1:	ANSI-X3.28-2.5-A4
	2:	ASCII version of Protocol 1.
Data Rates	:	110, 300, 600, 1200, 2400, 4800, 9600 baud.
Character Format	:	1 start; 7 or 8 data; 1 or 0 parity; 1 or 2 stop bits.
Parity	:	None, odd, even as selected.
Line impedence	:	120 ohm twisted pair.
Line length (maximum)	:	4000 ft at 9600 baud
No. of instruments per line	:	8

TABLE 1.1.1. RS232 AND RS422 DATA LINK SPECIFICATIONS

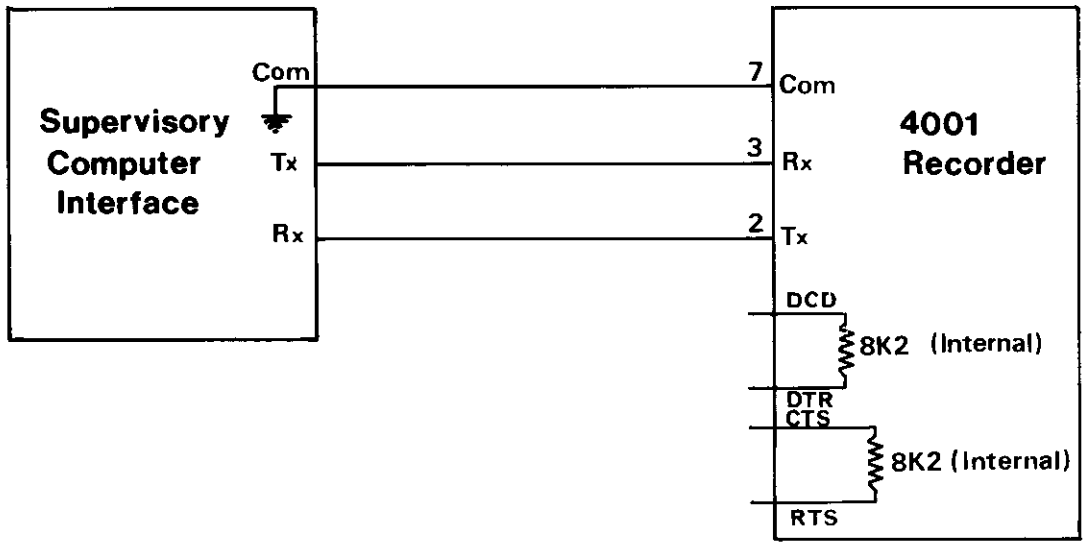


Figure 1.1.2 Typical RS232 Data Bus Connections

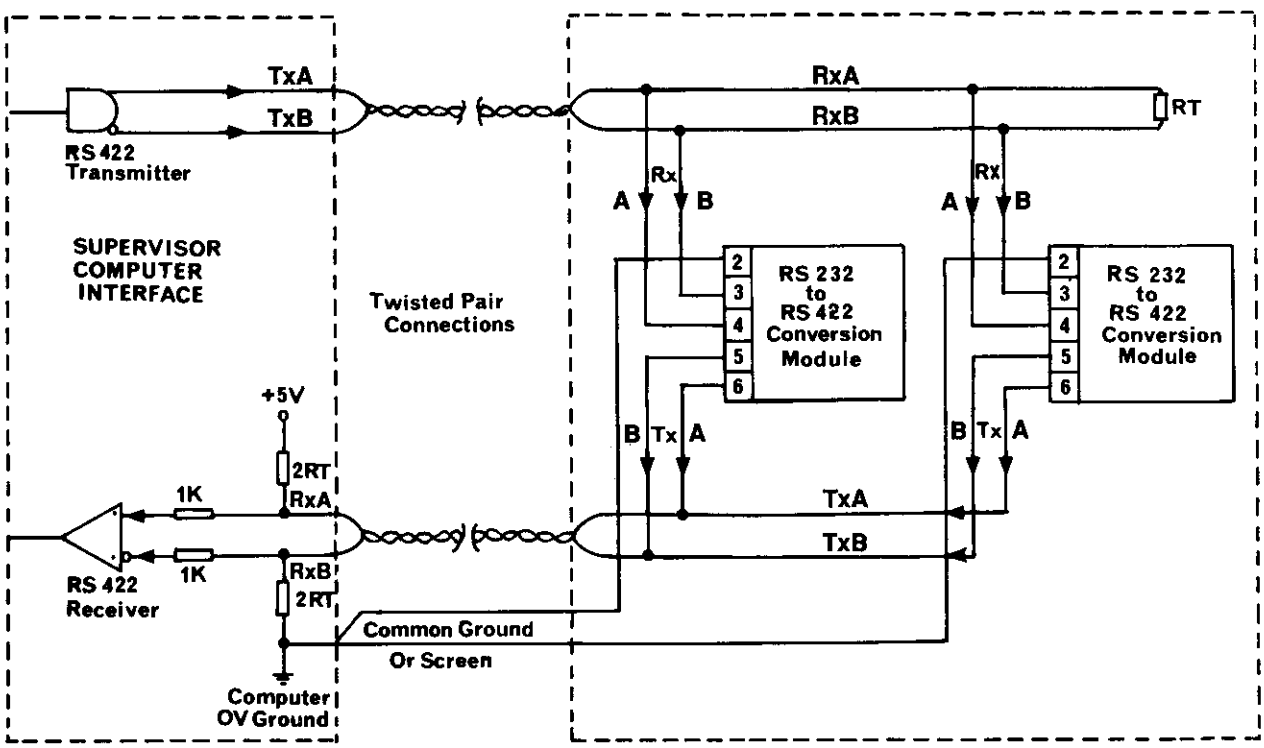


Figure 1.1.3 Typical RS422 Data Bus Connections

INSTALLATION

2.0. INTRODUCTION

CAUTION

Circuit cards within this instrument contain devices which are susceptible to damage from electro-static discharge. Ensure that a static-safe work area is available before removing any circuit card, and that all normal precautions against static damage are taken. (For details, refer to the maintenance manual.)

The conversion of a standard 4001 recorder to one which has a communications link requires the following items:—

1) EPROMS containing communications software.
2) For RS422, an RS232-to-RS422 communications conversion module, complete with a removable 6-way terminal block/connector.
3) Suitable cable or transmission line.

2.1. MECHANICAL INSTALLATION

2.1.1. RS232

The 4001 instrument is fitted with a 25-way D-type socket which accepts the standard RS232 cable termination. If required, the plug may be secured by two 4-40 NC screws.

2.1.2. RS422

To convert the standard RS232 interface into an RS422 interface, a conversion module (part number LA237582) is required (shown fitted in figure 2.1.2.). The module has a 25-way D-type plug at one end and this plug mates with the RS232 25-way socket fitted at the rear of the recorder. When inserted, the two screws 'A' are used to secure the module.

2.2. ELECTRONIC AND ELECTRICAL INSTALLATION

Open the door, pull the instrument forward and swing the access system open to reveal the control card (shown in figure 2.2.).

Taking precautions against electro-static damage, replace the EPROMS (IC32, IC33) with the communications versions. Ensure that the MSB and LSB EPROMS are correctly located as shown in figure 2.2. The MSB EPROM is marked RUXXXXXX, and the LSB EPROM is marked RLXXXXXX, where XXXXXX is a 6-figure part number.

Locate the switch SW1 and switch (left) to the communications position.

Close the access system, push the instrument back into its case, and close the door.

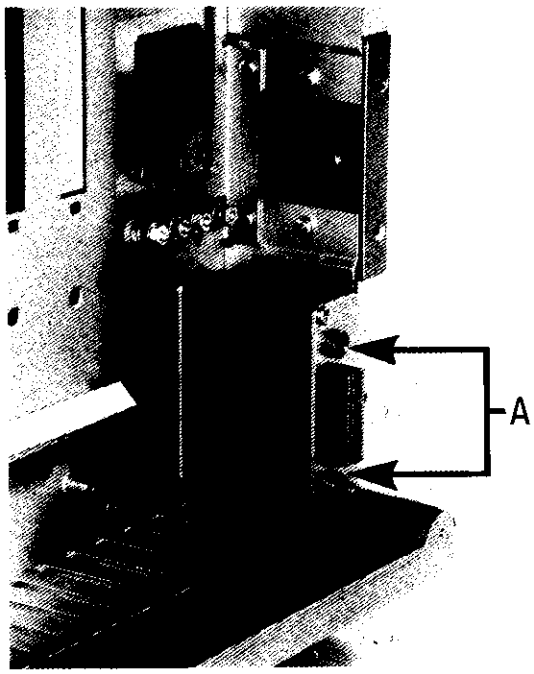


Figure 2.1.2 RS232 to RS422 Conversion Module

2.2.1. RS232

Insert the RS232 cable terminator (plug) into the 25-way communications socket. Figure 2.2.1. shows a pin allocation for the RS232 link.

2.2.2. RS422

Wire the 6-way terminal block provided to a suitable transmission cable. Figure 2.2.2. shows a pin allocation for the RS422 link.

When more than one instrument is being supervised by a computer , it is necessary to parallel the connections together. This may be done either at the computer or at the instrument end.

Biassing Resistors

As a result of the 4001's outputs being tri-state; when none of the instruments is transmitting, the Rx inputs to the computer interface see an open circuit. Such a state is not acceptable to the computer so bias resistors are connected as shown in figure 1.1.3. These resisitors have the effect of pulling the inputs to their idle states when no data is being transmitted or if the data link is broken for any reason. Suggested values are given in the "Terminating Resistor" section below. Pin 1 of the conversion module is a voltage source which may be used to bias the host's Rx-line. Pin 1 supplies 5 volts via a 4.7 k ohm resistor.

Terminating Resistor

An open ended transmission line produces unwanted reflections of any signals travelling along it. With long cable runs, these reflections may be interpreted as 'real' data resulting in data corruption. To resolve this problem, a "terminating" resistor is inserted across the transmission line. To maximise output power, this resistor should display the same impedance as the characteristic impedance of the transmission line (normally 120 ohms). If such a resistor is used, the line appears to be of infinite length, and so, produces no reflections. A resistor of this value will however reduce signal amplitude, so a compromise value is chosen. For a line impedance of 120 ohms, a 220 ohm resistor is suggested.

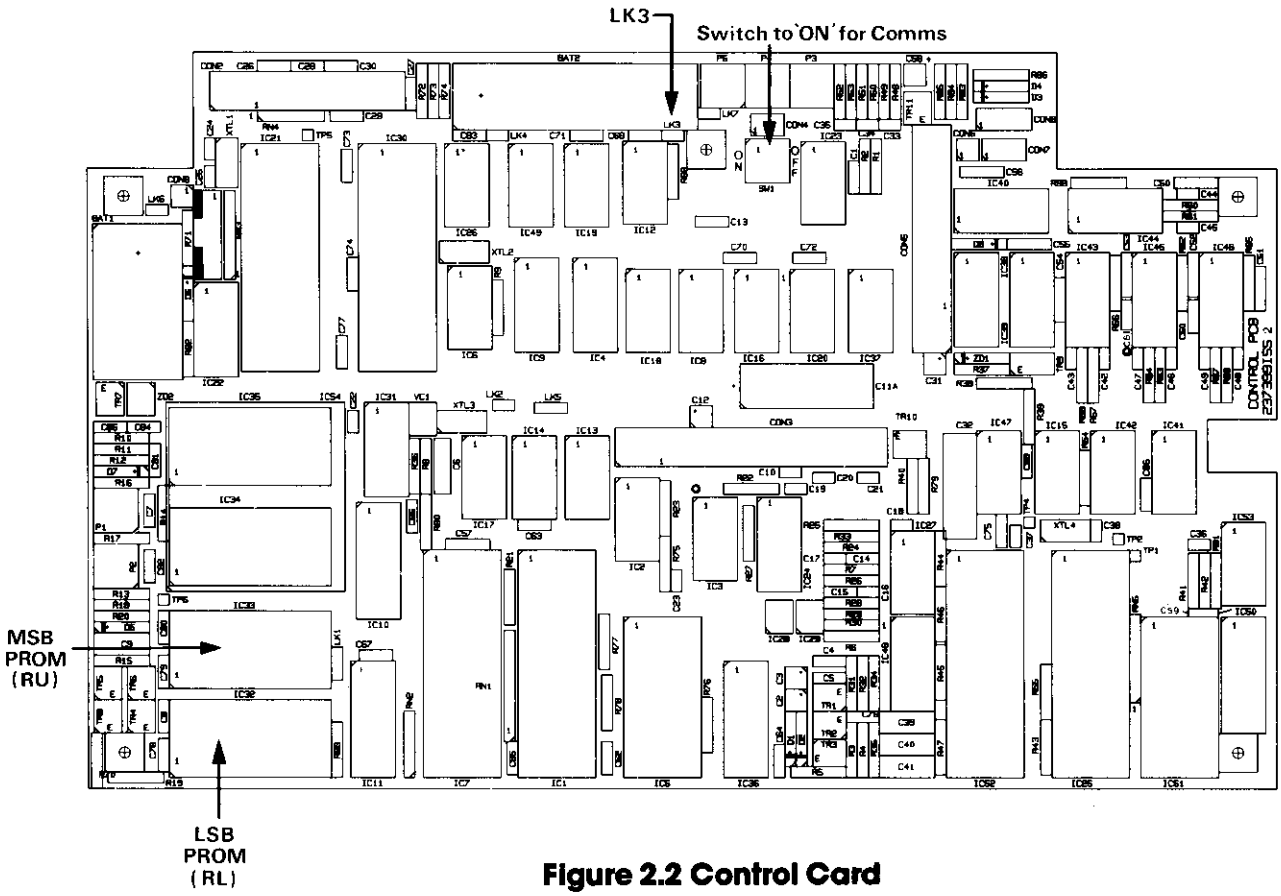
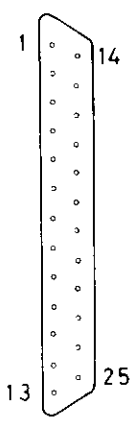


Figure 2.2 Control Card



TERM	ASSIGN
1	PROTECTIVE GROUND
2	Tx
3	Rx
4	RTS
5	CTS
7	SIGNAL GROUND
8	DCD
14	RESERVED OUTPUT
19	RESERVED OUTPUT
20	DTR

Figure 2.2.1 RS232C

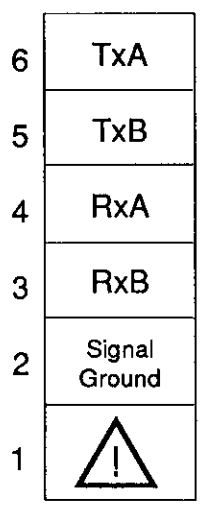


Figure 2.2.2 RS422

2.2.2 (Cont.)

The values of the bias resistors (see Biassing Resistor section above) should be approximately twice the value of the terminating resistor (ie, 430 or 470 ohms for 120 ohm lines). If, however, no terminating resistor is used the bias resistors should have a value approximately equal to 1000 times the magnitude of the biassing voltage (eg, for a biassing voltage of 5 volts, resistors of value 4.7 k-ohms or 5.1 k-ohms should be selected.)

2.2.3. EARTHING

To help reduce the effects of electrical noise, a common zero volt reference line is required between the host computer and any 4001 instrument with which it is communicating. If the local mains earths of the host and the instrument have a potential difference of less than 4 volts, the computer and instrument signal grounds may be connected to their local mains earths.

Alternatively, a common ground line may be run from each 4001 and the host computer.

2.3. PROGRAMMING THE 4001 FOR COMMUNICATIONS

The following parameters are available for update via the recorder's display and keyboard. Section 5 gives details of values available for each parameter.

a) Baud rate
b) Parity
c) Number of stop bits
d) Number of data bits
e) Protocol
f) Group Address
g) Hardware handshake on/off

Items a) to d) are set up using Serial Link 1 Page. Items e) to g) are set up using Serial Link 2 Page. Refer to Section 6 of the installation and operation manual (HA 237229).

To access Serial Link 1 Page, carry out the following procedure:

a) If the recorder is in RUN mode, press the Run/Prgm button and enter the Login number. Leading zeros may be omitted.

b) Press 'Channel', press '0', press 'ENTER'. (Channel 0 holds the instrument parameters).

c) Use the PAGE SCROLL (down arrow) key to scroll through the display pages until Serial Link 1 Page appears.

To access Serial Link 2 Page, scroll one further page.

To set a parameter, the flashing cursor is moved to that parameter using the left or right arrow key. Once the cursor is positioned, the FIELD SCROLL (up arrow) key is used to scroll the menu of values associated with the parameter. When all the updates have been made to a particular page, the new selections are written to the recorder's data base by means of the ENTER key.

Validation of the data's entry is given by the disappearance of the contrast-inverted 'E' from the instrument status field.

To return to run mode, the Run/Prgm key is pressed.

PROTOCOL

3.0. INTRODUCTION

A protocol defines the control codes, data sequencing and so on required for the successful use of a data link. The recorder supports two operator selectable protocols: ASCII and ANSI. With the exceptions noted below, the two are identical in operation. Table 3.0 is a brief specification for the ASCII and ANSI protocols.

Power	Supplied by the recorder
Baud rate	110, 300, 600, 1200, 2400, 4800, 9600.
Data format	1 Start bit; 7 or 8 data bits; Odd, even or no parity; 1 or 2 stop bits.
Protocol 1	With block check control, full ASCII character set with additional special characters. ANSI-X3.28-2.5-A4. Uses non-printing control codes.
Protocol 2	As for protocol 1, but uses printing characters (BS4505) instead of ASCII control codes. The block check control is ommitted. XON and XOFF are supported.
Connections:	
RS232:	Rx, Tx, RTS, DCD, DTR, 0V, Earth, by 25-way connector (Figure 2.2.1)
RS422:	RxA, RxB, TxA, TxB, 0V. and 5V. (via a 4.7 kΩ resistor) by plug-in module with 6-way terminal block/connector (Figure 2.2.2).

TABLE 3.0. PROTOCOL SPECIFICATION

NOTE.
As supplied, the instrument is set up to the following (default) status.

Baud rate	:	9600
Parity	:	None
Stop bits	:	One
Data bits	:	Eight
Mode	:	ANSI
Group Number	:	Zero (See section 3.2.1.)
Hardware Handshake	:	Off

3.1. ASCII PROTOCOL (PROTOCOL 2)

This protocol is intended for use with those personal computers, terminals etc. which are unable to transmit ASCII control codes (STX, EOT for example) and/or have no hardware handshake. The "non printing" control codes are replaced by 'printing' characters as shown in table 3.1. When this protocol is in use, the 4001 will respond to XON and XOFF characters generated by the host. It should be noted that after the transmission of an XOFF character, the instrument will not respond to any further inputs until it has received an XON.

No Block Check Control (BCC) byte (refer to section 3.3.2) is sent. This is because the value of BCC is unpredictable and might represent one of the control codes thus causing confusion to the host.

Apart from these differences, the description which follows for the ANSI protocol applies to the ASCII protocol.

DEFINITION	ANSI		ASCII	
	NON PRINTING CHARACTER		PRINTING CHARACTER	
	CODE	HEX	CHAR.	HEX
START OF TEXT	STX (Control B)	02	"	22
END OF TEXT	ETX (Control C)	03	#	23
END OF TRANSMISSION	EOT (Control D)	04	$	24
ENQUIRY	ENQ (Control E)	05	%	25
ACKNOWLEDGE	ACK (Control F)	06	&	26
NEGATIVE ACKNOWLEDGE	NAK (Control U)	15	(	28

TABLE 3.1. CONTROL CODE TO PRINTING CHARACTER CONVERSION

3.2. ANSI PROTOCOL (ANSI -X3.28-2.5-A4) (PROTOCOL 1)

In this mode, every control or data character is transmitted as an ASCII character, or an eight-bit special character. These characters are packaged with 'start', 'stop' and 'parity' bits to form a 10, 11 or 12 bit word, according to set-up. (Table 3.0 gives the format available.)

In order for the host to communicate with a recorder, 2 modes of operation are specified: POLLING and SELECTION.

POLLING — used to read data from the instrument into the computer.

SELECTION — used to write data from the computer into the instrument.

Each mode is implemented as three procedures:—

a) Establish connection
b) Message transfer
c) Terminate connection

Before describing these procedures in detail, it is necessary to explain the addressing method used to define a particular recording channel in a particular instrument.

3.2.1.GROUP ID (G)

This is an operator selectable address (from 0 to 7) set up by means of Serial Link 2 Page display (reference section 2.3.). This group identifier represents an instrument address.

3.2.2. Unit Address (U)

The protocol makes use of the concept of a 'logical unit' (LU). The logical connection to the instrument is made to a logical unit by transmitting address information before any commands or data are given. Each 4001 recorder is divided into 9 LUs (addesses 0 to 8). LU 0 gives access to instrument parameters. The remaining 8 LUs have the 30 recording channels of the 4001 allocated to them as shown in table 3.2.2.

The Group ID (G) and the Unit address (U) are sufficient to access one logical unit uniquely, and allow a logical connection to be established.

Once the connection is established, a further address is required in order to access a particular recording channel. This address is called the Channel Address (CA).

LOGICAL UNIT NO.	ANALOGUE INPUT CHAN.
1	1 TO 4
2	5 TO 8
3	9 TO 12
4	13 TO 16
5	17 TO 20
6	21 TO 24
7	25 TO 28
8	29 AND 30

NOTE. Logical unit 0 is used to access all instrument and alarm parameters.

TABLE 3.2.2. LOGICAL UNIT CHANNEL ALLOCATION

3.2.3. Channel Address (CA)

The channel address (0 to 3) identifies one of the recording channels within the logical unit specified by the Group ID and Unit address. Table 3.2.3. shows recording channel number in terms of unit address (U) and channel address (CA). For example, to communicate with recording channel 23, the unit address is 6 and the channel address is 2.

CA	LOGICAL UNIT ADDRESS (U)							
	1	2	3	4	5	6	7	8
0	1	5	9	13	17	21	25	29
1	2	6	10	14	18	22	26	30
2	3	7	11	15	19	23	27	
3	4	8	12	16	20	24	28	
	RECORDING CHANNEL NUMBER							

TABLE 3.2.3. RECORDING CHANNEL ADDRESSING (U AND CA)

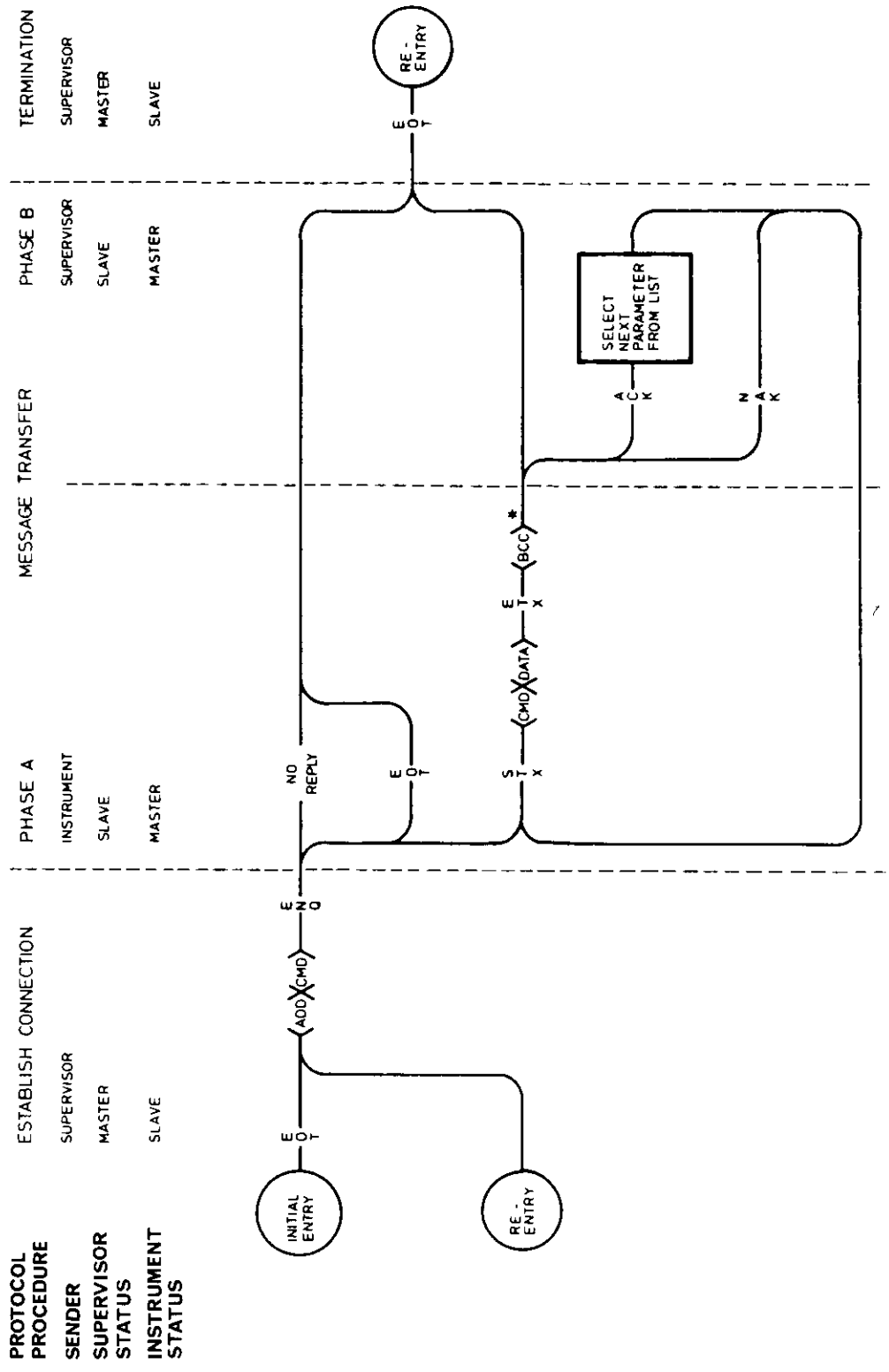


Figure 3.3 Polling Sequence for Reading Data from a Logical Unit

3.3. READING DATA FROM A LOGICAL UNIT (POLLING)

Data is requested by the supervisory computer using the polling sequence illustrated in figure 3.3. The figure shows the sequence divided into 3 procedures:—

a) Establish connection
b) Message transfer
c) Terminate connection

3.3.1. ESTABLISH CONNECTION PROCEDURE

Initially, the supervisory computer has master status, and begins the establish connection procedure by transmitting a polling message:—

EOT G G U U CA C1 C2 ENQ

This message identifies a logical unit using the group and unit numbers described in sections 3.2.1 and 3.2.2. of this document.

NOTE. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

EOT
The control character EOT resets the data link to all associated instruments. This causes each instrument to examine the next 4 characters to see if they address one of its logical units.

G
This is the group number described in section 3.2.1. The group number is transmitted twice for security.

U
This is the logical unit number described in section 3.2.2. The unit number is transmitted twice for security.

If the group and unit addresses are recognised, the logical link with the addressed logical unit is established, and the logical unit will then act upon the remainder of the message.

CA
This is the channel address used to identify a particular recording channel, as described in section 3.2.3.

C1, C2
These two alpha-numeric characters form a mnemonic which specifies the instrument, channel or alarm parameter whose value is to be read. (Refer to section 5). THESE TWO CHARACTERS MUST BE ENTERED AS UPPER CASE.

ENQ
The polling message is terminated by the ENQ control character.

Example:

If the host computer requires to know what is the measured value of channel 20 of instrument 3, the following polling message is sent:—

EOT 3 3 5 5 3 M V ENQ

NOTE. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

3.3.2. MESSAGE TRANSFER PROCEDURE

After the supervisory computer has transmitted the ENQ character, the protocol enters the Message Transfer procedure. Figure 3.3. shows that this procedure takes place in 2 phases:—

a) Phase A — Instrument is the sender
b) Phase B — computer is the sender

Phase A

1. POLLING COMPLETE RESPONSE. Once the instrument has recognised the logical unit address, the channel address and the parameter mnemonic, it assumes master status, and transmits the following message.

STX CA C1 C2 D1 ... DN ETX BCC

NOTE. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

STX prefixes the message being sent to the computer.

CA is the channel number discussed in section 3.2.3.

C1, C2 are the parameter's mnemonic (see section 5).

D1 to DN are the N data bytes in which the value of the parameter is held (see section 4).

ETX terminates the message so that the computer is made aware that the next character is the block check control (BCC).

BCC (not ASCII mode). This block check control byte is generated by exclusive OR'ing firstly CA and C1, and then the result of this with C2. The result of this XORed with D1 and so on up to and including ETX. The final result is the BCC, and it is used to check to see if any errors have occurred during the transmission of the message.

Example:

If the measured value of channel 20 of instrument 3 is 25% of the span, the message returned to the computer is as follows.

STX 3 MV>0FFF ETX BCC

NOTES.
1. 0000 = zero; 3FFF = Full scale;
2. >Advises that the data following is in Hex.
3. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

2. POLLING INCOMPLETE RESPONSE. If the instrument recognises the logical unit address, but connot recognise the parameter mnemonic, or the channel address is invalid etc, it terminates its master status by sending the message:—

STX CA C1 C2 EOT (See note 3. above)

3. NO RESPONSE. If the logical unit address is not recognised, or if there is some error in, for example, parity or baud rate setting, or if there is a fault in the data link or instrument hardware, etc, no response will be made to the host computer.

3.3.2 (Cont.)

Phase B

1. POLLING COMPLETE RESPONSE. Following a polling complete response, the protocol enters phase B, where the supervisory computer becomes the sender. The instrument waits for an acknowledgement (ACK or NAK) or an end of transmission (EOT), which terminates the logical connection.

If the supervisory computer responds with ACK, the next parameter in the parameter sequence (see section 3.5) is accessed, and its value is transmitted to the computer.

If the computer responds with NAK (negative acknowledge) the instrument re-transmits the value of the last parameter polled. The NAK response is made either if an error occurred in the last message, or if the computer wishes to monitor one particular channel continuously. If an error occurs, a read of the error parameter 'ER' returns a code showing the cause of the error. (see table 5.1.3).

2. POLLING INCOMPLETE RESPONSE. Following a polling incomplete response, the protocol enters phase B. In this case, the supervisor may not send and acknowledgement (ACK or NAK) but must re-start the polling sequence.

3. FOLLOWING NO RESPONSE. The supervisory computer should time out, retain master status, and enter the termination procedure.

3.3.3. TERMINATION PROCEDURE

The termination procedure is entered under the following circumstances:—

a) The supervisory computer wishes to stop polling a particular logical unit or parameter.
b) No response is received from a polled logical unit.
c) The polled logical unit responds with an EOT.

The computer assumes master status and transmits an EOT to re-set the data link. It then starts a new polling sequence, performs a selection sequence (described below) or idles until a further parameter is to be accessed.

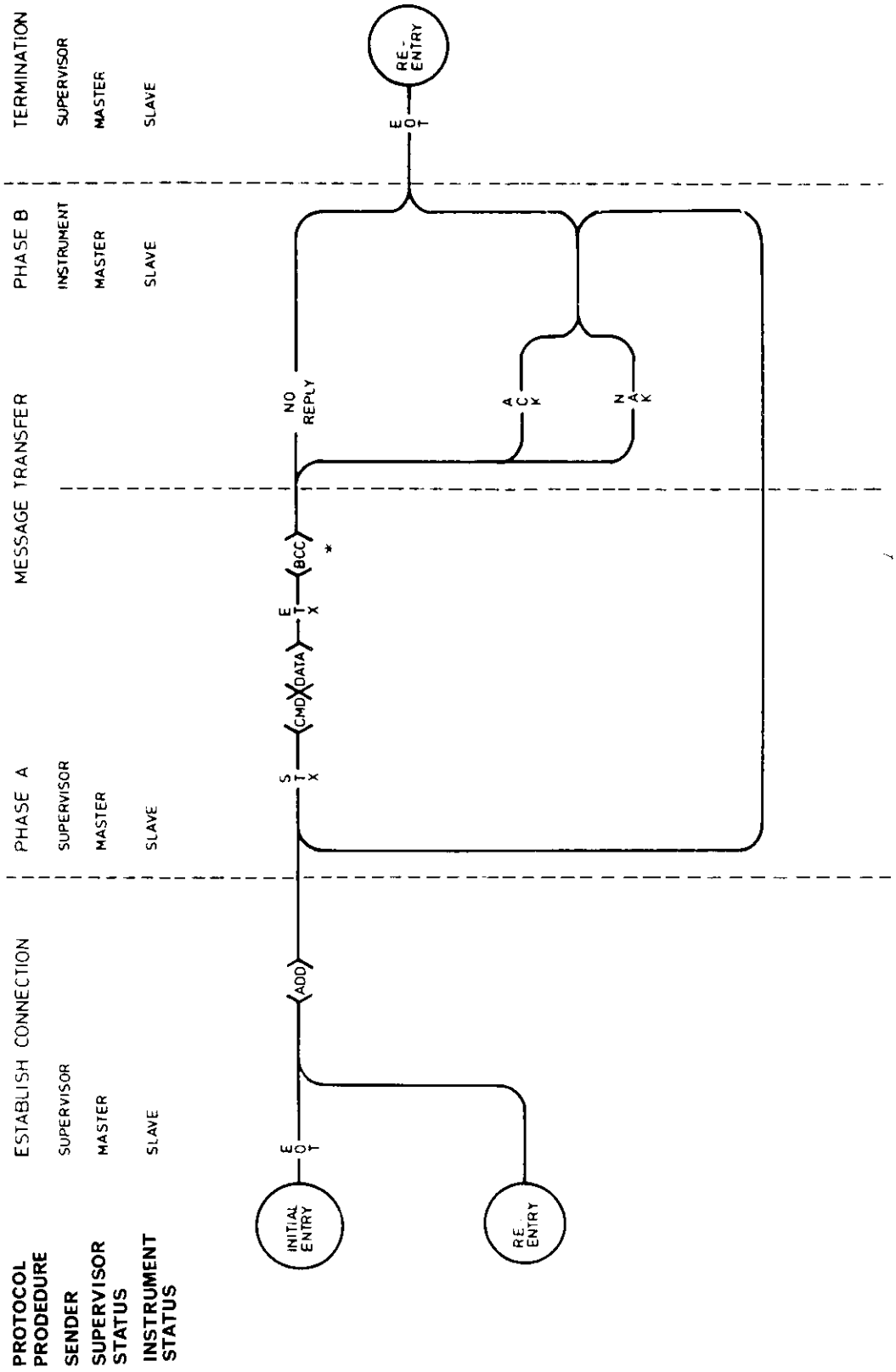


Figure 3.4 Selection Sequence for Writing Data to a Logical Unit

3.4. WRITING DATA TO A LOGICAL UNIT (Selection)

Data is written to a logical unit using the selection sequence shown in figure 3.4. The figure shows the sequence to be divided into 3 procedures:—

a) Establish connection
b) Message transfer
c) Terminate connection

3.4.1. ESTABLISH CONNECTION PROCEDURE

The supervisory computer retains master status throughout the selection sequence. The sequence is started by the transmission of the following:

EOT G G U U STX CA C1 C2 D1 ... DN ETX BCC

Each of these characters is defined in sections 3.2. and 3.3.

NOTE. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

Once the address (G G U U) has been recognised, the sequence enters the message transfer procedure.

3.4.2. MESSAGE TRANSFER PROCEDURE

Figure 3.4. shows that the procedure is split into two phases:—

a) Phase A — supervisor is the sender
b) Phase B — instrument is the sender

Phase A

After the establish connection procedure, this phase is entered directly, and the addressed logical unit reads the second part of the selection message:—

STX CA C1 C2 D1 ... DN ETX BCC

NOTE. The spaces between characters have been entered in this example only for the sake of clarity. Such spaces must not be entered when transmitting messages.

As soon as the addressed logical unit receives the message, it performs the following tasks:—

a) It calculates the BCC from CA to ETX inclusive, and verifies that it corresponds with the BCC sent from the computer. If no error is found,
b) It verifies that the channel number is valid for the logical unit addressed. If it is,
c) It verifies that the characters C1, C2 correspond to a valid parameter mnemonic. If so,
d) It verifies that D1 to DN contain valid data, If so,
e) It updates the selected parameter with the new value.

3.4.2 (Cont.)

Phase B

If the parameter is updated successfuly, the instrument responds with an acknowledge (ACK) indicating that the message was accepted as being correct, and that the selection has been performed.

At this stage, the host may re-enter the selection procedure at STX to access a further parameter in the same logical unit. If, however, an error was detected, a negative acknowledge (NAK) character is transmitted. Upon receipt of this, the supervisor computer may enter the termination procedure outlined below, or it may remain in the message transfer procedure and transmit the same, or a different message.

If the logical unit address is not recognised, or a wrong parity or baud rate setting is selected, or if the communications link has failed etc., then no-response is made by the instrument. The host computer should time-out and enter the termination procedure.

3.4.3. TERMINATION PROCEDURE

The termination procedure is entered under the following circumstances:—

a) The supervisory computer has completed the selection process for that particular logical unit.
b) No response is received to a selection message.

The computer transmits an EOT character and then either starts a new selection or polling sequence, or it enters an idle state until a further parameter is to be accessed.

3.5. PARAMETER SCROLLING

This facility allows the sequential reading of the values of a number of parameters without requiring a complete polling sequence each time. The parameters are scrollable in 3 groups:—

a) Block (channel) parameters
b) Alarm parameters
c) Instrument parameters.

3.5.1. BLOCK PARAMETERS

Block parameters are those associated with measured values (for a full list see table 5.4.3.). Each ACK received by the instrument causes CA to be incremented, and the value of the same parameter to be transmitted for the next channel. When CA reaches the maximum for the logical unit it resets to 0 and the process repeats itself until a NAK or EOT is received.

3.5.2. ALARM PARAMETERS

Each ACK received after the transmission of an alarm parameter causes the next alarm parameter for the channel to be accessed and transmitted. Once the final alarm parameter is reached, the instrument accesses the first alarm parameter, and the cycle continues until a NAK or EOT is received. Note that alarm parameters are accessible only through logical unit (U) 0.

3.5.3. INSTRUMENT PARAMETERS

Instrument parameters are scrolled in the same way as alarm parameters are. Table 5.4.2. gives the scrolling order. As the alarm parameters, the logical unit address must be 0 to gain access to these parameters.

3.6. PARAMETER VALIDATION

It should be noted that in addition to the group checks described below, the limits of individual parameters are checked on receipt. For example, Shunt Resistor value is checked to determine that it lies within the range 1 to 999.

With alarm and channel parameters, a number of checks are made to see if any non-allowable, or contradictory entries have been made. As alarm or channel parameters are received, they are stored in a buffer, until an enter alarm (EA) or enter channel (EC) is received. Upon receipt of EA or EC the checks detailed below are carried out.

3.6.1. ALARM BUFFER VALIDATION

Alarm variable updates are loaded into a buffer, until an EA is received. The checks listed below are then carried out, and if the update is valid, it is loaded into the recorder's data base, and an ACK is returned. If the update is not valid, the buffer content is discarded and a NAK is returned.

a) Unassigned alarms — no checks

b) Absolute alarms:
OL$\leqslant$ setpoint $\leqslant$ OH
Hysteresis (A1[10-14]) $\leqslant$ 9.5% span
Output address is valid.

c) Deviation alarms
OL $\leqslant$ set point — deviation
OH$\geqslant$ set point + deviation
Hysteresis (A1[10-14]) $\leqslant$ 9.5% span
Output address is valid

d) Rate-of-change alarms
OH-OL $\geqslant$ Amount of change
Period index (A2[11-13]) $\leqslant$ 6
Output address is valid.

3.6.2. CHANNEL BUFFER VALIDATION

Channel buffer validation is carried out in a similar way to alarm buffer validation, but with the checks listed below. ACK or NAK is returned according to whether the data is found to be valid or not.

a) OL < OH
B) IL < IH
c) IL > −2.48 Volts
d) IH < 10.24 Volts
e) FL < FH
f) Linearisation (function) units are valid. Thermo-couples and RTDs must be temperature units; other types must have their own units.
g) Input signal units are valid for log, square root, linear etc. functions (must be V, mV, or mA).
h) Linearisation limits are not exceeded (see channel function display description in the Installation and Operation manual HA237229.)
i) External cold-junction lies within the linearisation limits.
j) The selected linearisation table is present.
k) The selected special linearisation limits have been calculated.

DATA FORMATTING

4.0. INTRODUCTION

Data is transferred between host computer and logical unit as a stream of control and data bytes as discussed in section 3. This section describes how the data bytes (D1 to DN) are assembled.

4.1. DATA PACKING

Figure 4.1. shows the structure of typical data bytes. It should be noted that when non-standard characters are to be transmitted (ref. table 5.3), -eight data bytes are used instead of seven and if the number of data bits is set to seven, then the standard 7-bit ASCII code will result. Conversely, if eight bits are set, then an MSB of 0 needs to be added to the normal 7-bit ASCII character set.

In the non-transmitting state, the transmission line is held at logic 1 (MARK or OFF). As soon as the host computer or instrument is ready to transmit a character, it drives the line low to a logic 0 (SPACE or ON) state for one bit period. This is called the START bit and it is used to state that a stream of data is on its way so that the receiver can synchronise with the data stream. The binary code for the character being transmitted (see table 5.3.) is then sent starting with the least significant bit (bit 0). Following this are a parity bit, if used, and one or two stop bits which set the line high again.

It should be noted that the control characters (EOT for example) and BCC are transmitted in a similar way.

4.1.1. DATA FORMATS

Each accessible parameter has one of three data formats allocated to it. Only the specified format may be used for any particular parameter, and these formats must be established in the host's data base. The format for each parameter is given in tables 5.1.1. to 5.1.3. The three formats used, decimal, hex and character are as follows:—

Decimal Format

Parameters are transmitted as five data bytes, D1 to D5. One of these bytes must contain code for a decimal point (or a minus sign if the value is negative). The remaining data bytes contain code for the decimal value being read or written.

When writing to the 4001, the decimal point or minus sign may be positioned in any of D1 to D5, and leading and trailing zeros may be entered as desired. For example, .3000 is as acceptable as 000.3.

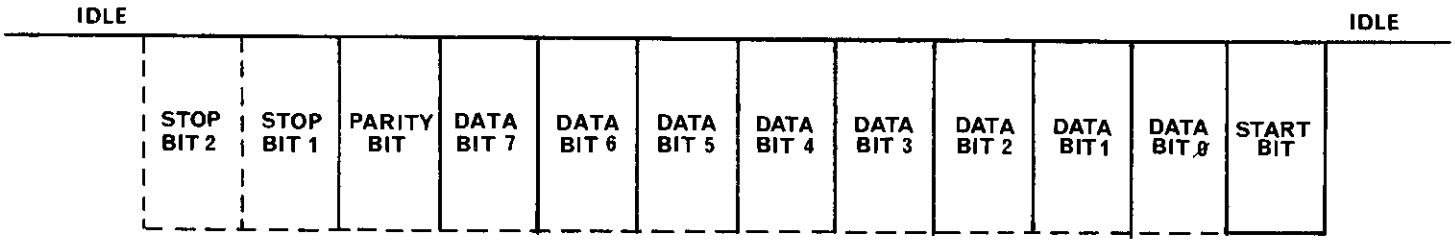
It should be noted that only 3 decimal places are made use of by the 4001, which rounds numbers with more than 3. This means that if a value of .3488 is written to a 4001, a value of 0.349 will be entered.

When reading from a 4001, leading zeros are not transmitted except for values of less than 1, when a zero is inserted as the first character.

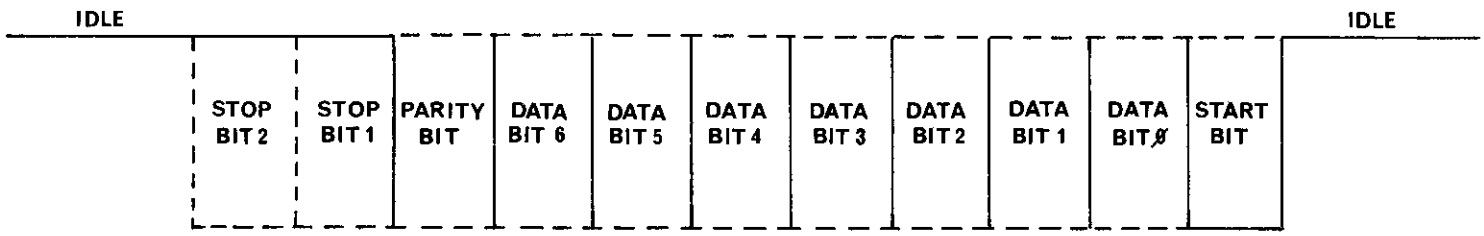
Example:

Disregarding start, stop and parity bits, the contents of the data bytes D1 to D5 are as follows for a value of −23.45.

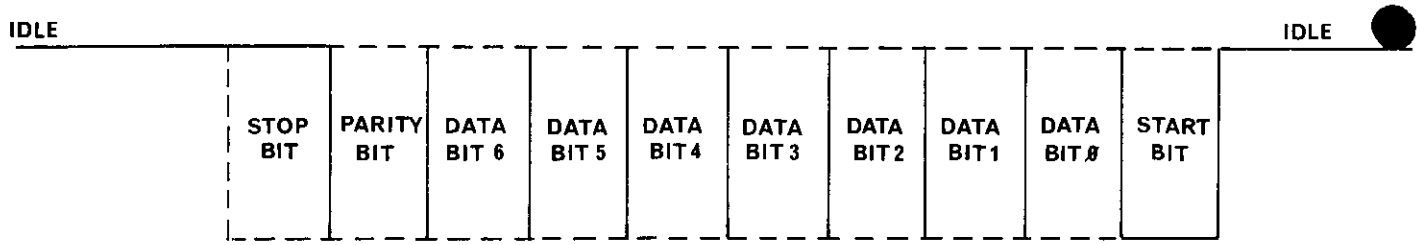
DATA BYTE	DATA CODE	DECIMAL VALUE
D1	011 0010	2
D2	011 0011	3
D3	010 1101	—
D4	011 0100	4
D5	011 0101	5



(a) 1 start, 8 data, 1 parity, 2 stop



(b) 1 start, 7 data, 1 parity, 2 stop



(c) 1 start, 7 data, 1 parity, 1 stop

Figure 4.1 Typical Data Byte Structures

DATA FORMATTING

4.0. INTRODUCTION

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Disregarding start, stop and parity bits, the contents of the data bytes D1 to D5 are as follows for a value of −23.45.

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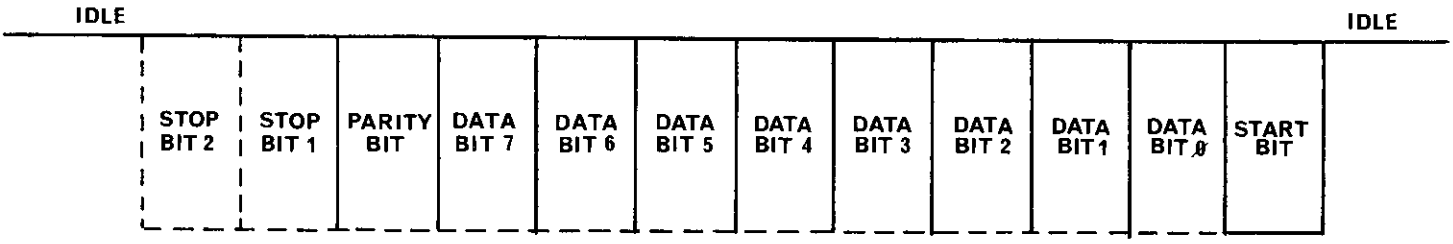
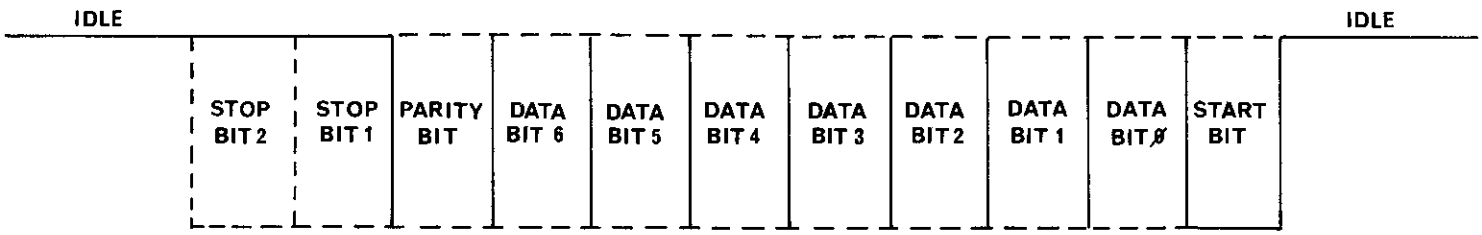
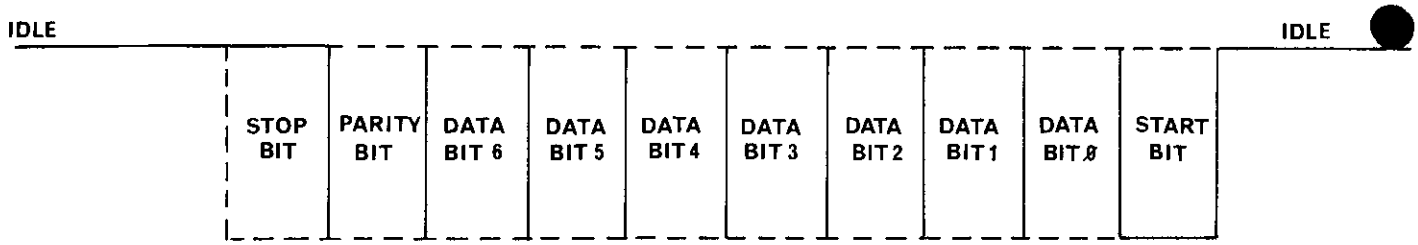
D1	011 0010	2
D2	011 0011	3
D3	010 1101	—
D4	011 0100	4
D5	011 0101	5



(a) 1 start, 8 data, 1 parity, 2 stop



(b) 1 start, 7 data, 1 parity, 2 stop



(c) 1 start, 7 data, 1 parity, 1 stop

Figure 4.1 Typical Data Byte Structures

4.1.4 (Cont).

Hexadecimal Format

Hex format parameters are held in the 4001 as 16-bit words. The data is packed into five data bytes as follows: D1 contains the code for ">". (This tells the host or recorder that what follows is in Hex format) D2 to D5 hold bits 15 to 12, 11 to 8, 7 to 4, and 3 to 0 respectively, of the 16-bit word.

As an example, table 5.1.2 shows that the total number of alarms which have been allocated, is held in bits 5 to 0 of NA. If, say, fifty-eight alarms have been allocated, then bits 5 to 0 will contain the binary code for fifty-eight (11 1010) and the 16-bit word will read: 0000 0000 0011 1010, in binary, or with each group of 4 bits encoded into Hex (table 5.2.1), 003A. Thus, D2 to D5 will contain the codes for 0, 0, 3 and A respectively viz:

DATA BYTE	DATA CODE	DECIMAL VALUE
D2	011 0000	0
D3	011 0000	0
D4	011 0011	3
D5	011 1010	A

Character Format

This format is used for transmitting strings of text words. Each data byte (D1 to DN; N max. is defined for each character format parameter in table 5.1.3) contains 7 or 8 bit code for any one of the characters listed in table 5.3.

4.2. DATA RATES

The following sample calculations are based on worst-case communications with no overheads due to re-transmissions, and with negligible overheads due to the host. Also assumed are a baud rate of 9600, and data bytes made up of 1 start, 7 data, 1 parity and 1 stop bit. This results in a time of 1.04mS being taken to transmit 1 byte of data.

NOTE: For recorders fitted with software version 4.6, the response times quoted in the following calculations should be increased by 30mS to 35mS.

4.2.1. ANSI PROTOCOL

a) Single parameter poll.
Establish connection..... 9 bytes = 9.36mS
Valid reply .....11 bytes = 11.44mS
Response time ..... = 5mS
Total time ..... = 25.8mS = 38 polls/sec.

b) Multiple parameter poll.
In this case, the total number of bytes required is (9 + 11)n bytes where n is the number of parameters being polled. For example, the number of bytes required to poll all 14 parameters of one channel is:

(11 + 9)14 = 280 bytes = 291.2 mS.

To this time, must be added 5 (14)mS for response times, giving a total time of 361.2mS = 2.7 channels per sec.

4.2.1 (Cont).

c) Single parameter selection.
Establish connection ..... 5 bytes (5.20mS)
Message transfer.....11 bytes (11.44mS) (command and data)
1 byte (1.04mS) (ACK)
Response time ..... (5.0mS)
Total time ..... 22.68mS = 44 selections/sec.

d) Multiple parameter selections.
For multiple parameter selections, the establish connection procedure is entered only once. Thus, for n parameters, the total number of bytes is 5 + 12n bytes. For all the 12 parameters which may be written to this gives a total of 149 bytes, which is equivalent to 155 mS. Added to this must be 5mS response time per parameter, (= 60mS for the 12 parameters), giving a total time of 215mS = 4.6 channels per second.

4.2.2. ASCII PROTOCOL

The calculations for ASCII are made in a similar way.

a) Parameter polling.
Establish connection ..... 9 bytes = 9.36mS
Valid reply .....10 bytes = 10.4mS
Response time ..... = 5mS.
Total time ..... = 24.76.

b) Parameter selection.
Establish connection ..... 5 bytes = 5.2mS.
Message transfer .....10n bytes (10.4(n)mS) (Command and data)
1n bytes (1.04(n)mS)(ACK)
Response times..... 5(n)mS.
Total time ..... =21.64(n)mS.

Where n is the number of parameters being written to.

REFERENCE SECTION

5.0. INTRODUCTION

This section consists of a number of data tables. These tables are intended as a quick reference guide to operators familiar with the protocol and data formatting sections of this document, and with the installation and operation manual HA237229.

5.1. ALPHA-NUMERIC LIST OF PARAMETER MNEMONICS

This table contains lists of the channel, alarm and instrument parameter mnemonics. The required data format, the permission (read only, read/write, etc.) with respect to the supervisory computer, bit allocation (where applicable) and definition are all given in this table. In addition to the above mnemonics, a number of others are given (command mnemonics). These do not access parameters directly, but cause the serial link to perform some action, such as "disable program mode".

Table 5.1.1. contains details of Alarm parameters and flags, as follows:

NAME	MNEMONIC (BITS)
ALARM ACKNOWLEDGE FLAG	A2 (9)
ALARM ACTIVE FLAG	A2 (8)
ALARM TYPE	A1 (8 TO 9)
AMOUNT OF DEVIATION (CHANGE)	A4 (0 TO 15)
AVERAGING PERIOD (ALARM TYPE 3)	A1 (10 TO 13)
CHART SPEED CHANGE FLAG	A2 (2)
CONDITIONAL PRINT FLAG	A2 (3)
DIGITAL VALUE FLAG	A2 (4)
HYSTERESIS (ALARM TYPES 1 AND 2)	A1 (10 TO 14)
LOG PRINT FLAG	A2 (6)
NEEDS ACKNOWLEDGE FLAG	A2 (10)
OUTPUT CHANNEL NUMBER	A1 (0 TO 4)
OUTPUT SLOT NUMBER	A1 (5 TO 7)
PERIOD INDEX	A2 (11 TO 13)
PRINT MESSAGE FLAG	A2 (5)
SENSE FLAG	A2 (1)
SET POINT	A3 (0 TO 15)
SKIP FLAG	A2 (0)

Table 5.1.2 contains details of channel parameters and flags, as follows:

NAME	MNEMONIC (BITS)
CHANNEL DESCRIPTOR	EU (13 TO 15)
CHANNEL DESCRIPTOR NUMBER	LN (0 TO 15)
CHANNEL STATUS	ST (0 TO 15)
CJC TEMPERATURE	CJ (0 TO 15)
CJC TYPE	CF (6 TO 7)
FUNCTION ENGINEERING UNITS	CF (12 TO 15)
FUNCTION HIGH VALUE	FH (0 TO 15)
FUNCTION LOW VALUE	FL (0 TO 15)
FUNCTION TYPE	CF (8 TO 11)
INPUT HIGH VALUE	IH (0 TO 15)
INPUT LOW VALUE	IL (0 TO 15)
INPUT SIGNAL ENGINEERING UNITS	EU (4 TO 7)
INTERPOLATION ENABLE FLAG	CF (3)
DESCRIPTOR LEGEND PRINT ENABLE FLAG	CF (1)
MEASURED VALUE	MV (0 TO 15)
NUMBER OF ALARMS	NA (0 TO 5)
PRINT ZONE	EU (0 TO 3)
SCALE HIGH VALUE	OH (0 TO 15)
SCALE LOW VALUE	OL (0 TO 15)
SCALE PRINT ENABLE FLAG	CF (0)
SCALE UNITS	EU (8 TO 12)
SHUNT VALUE	SH (0 TO 15)
TRACE SKIP FLAG	CF (2)

Table 5.1.3 contains details of instrument parameters and flags, as follows:

NAME	MNEMONIC (BITS)
BATCH NUMBER	BN
BUZZER FLAG	IF (0)
CHANNEL DESCRIPTORS	CD
CHANNEL ENGINEERING UNITS	CE
CHART SPEED UNITS FLAG	IF (2)
CURRENT CHART SPEED FLAG	IF (1)
DATE FORMAT FLAG	IF (3)
DAY OF MONTH	DY (0 TO 15)
HOURS	HR (0 TO 15)
INSTRUMENT ALARM FLAG	IS (0)
INSTRUMENT DESCRIPTOR	ID
INSTRUMENT IDENTIFIER	II (0 TO 15)
CUSTOMER LINEARISATION TABLES	L1, L2, L3
MINUTES	MI (0 TO 15)
MODE 2 LOG INTERVAL	M2 (0 TO 15)
MODE 3 LOG INTERVAL	M3 (0 TO 15)
MONTH	MO (0 TO 15)
PAPER DIVISIONS	PD (0 TO 15)
PRINT MODE	PM (0 TO 1)
SECONDS	SE (0 TO 15)
SERIAL LINK ERROR STATUS	ER (0 TO 15)
SLOT CONFIGURATION	SC (0 TO 63)
SPEED 1	CS (0 TO 7)
SPEED 2	CS (8 TO 15)
TEXT TO BE PRINTED	PT
VERSION NUMBER	VN
YEAR	YR (0 TO 15)

Table 5.1.4 contains details of command mnemonics as follows:

NAME	MNEMONIC
ALARMS ACKNOWLEDGE	AA
DISABLE PROGRAM MODE	DP
ENTER ALARM DATA	EA
ENTER CHANNEL DATA	EC
ENABLE PROGRAM MODE	EP
GET ALARM	GA
GET FREE ALARM	GF

5.2. DECIMAL-BINARY-HEX CONVERSION

This contains a conversion of decimal numbers 0 to 15 into binary and hex (table 5.2.1) and a table allowing decimal-hex and hex-decimal conversion between 0000 and 3FFF to be carried out (table 5.2.2).

5.3. CHARACTER SET

This table contains ASCII codes in binary, hex and decimal. Included are the full range of upper and lower case characters on a standard QWERTY keyboard, together with control code such as STX, ETX, EOT and so on. In addition, non-standard codes for the special 4001 display characters are given. Where 8 data bits are required, an additional 0 must be added (as the MSB) to those codes that are shown as being 7 bits long.

5.4. SCROLLING ORDER

This table contains scrolling orders for 1) alarm and 2) instrument mnemonics. Table 5.4.3 contains an alphabetic list of block (channel) mnemonics.

5.5. SERIAL LINK PARAMETERS

This table contains the serial link options available to the operator via serial link 1 page and serial link 2 page.

5.6. CROSS-REFERENCE PARAMETER LISTING

This table contains a list of section numbers which appear in the Installation and Operation Manual (HA 237229). The parameters details in these sections are listed, together with their associated mnemonics and the table in which the mnemonics appear (Table 5.1.1, 5.1.2, 5.1.3 or 5.1.4).

5.7. RECORDING CHANNEL ADDRESSING

This table consists of a list which allows the conversion of analogue channel recording numbers to their logical unit and channel addresses.

TABLE 5.1.1. ALARM PARAMETERS

1. Alarm parameters are accessible only with a logical unit address (U) of zero.
2. Before a new alarm can be set-up a "get free alarm" mnemonic (GF) must be transmitted. Refer to table 5.1.4. for GF definition.
3. After all the data for the alarm has been set-up, an "enter alarm" mnemonic must be transmitted to cause the data to be written into the recorder's data base.
4. When an EA is received, the checks listed below are carried out, and if the update is valid, the data is loaded into the recorder's data base and an ACK is returned. If the update is not valid, the buffer content is discarded and a NAK is returned.

ALARM BUFFER VALIDATION CHECKS

a) Unassigned alarms — no checks.

b) Absolute alarms:
OL $\leqslant$ setpoint $\leqslant$ OH
Hysteresis (A1[10—14]) $\leqslant$ 9.5% span
Output address is valid.

c) Deviation alarms
OL $\leqslant$ set point − deviation
OH $\geqslant$ set point + deviation
Hysteresis (A1[10—14]) $\leqslant$ 9.5% span
Output address is valid.

d) Rate-of-change alarms
OH − OL $\geqslant$ Amount of change
Period index (A2[11—13]) $\leqslant$ 6
Outpur address is valid.

5. In order to access current alarms, a 'get alarm' command (GA) must be transmitted in order to copy the relevant alarm's parameters into the alarm buffer. Refer to table 5.1.4 for GA definition. After any update to the alarm an EA must be transmitted to write the new data to the recorder's data base. An example is given in section 6.1.8.

TABLE 5.1.1. ALARM MNEMONICS

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
A1	HEX		ALARM PACKET 1.	
		0 TO 4	OUTPUT CHANNEL NO 0 = CHANNEL 1 1 = CHANNEL 2 2 = CHANNEL 3 3 = CHANNEL 4 4 = CHANNEL 5 5 = CHANNEL 6 6 = CHANNEL 7 7 = CHANNEL 8	R/W
		5 TO 7	OUTPUT SLOT NO 0 = OFF 1 = SLOT 2 2 = SLOT 3 3 = SLOT 4 4 = SLOT 5 5 = SLOT 6 6 = SLOT 7 7 = SLOT 8	R/W
		NOTE...SLOT 1 RESERVED FOR INPUTS		
		8 TO 9	ALARM TYPE: 0 = UNASSIGNED 1 = ABSOLUTE 2 = DEVIATION 3 = RATE-OF-CHANGE	R/W
		10 TO 14	HYSTERESIS FOR ALARM TYPES 1 AND 2. FIXED POINT, 0 TO 9.5% SPAN NOTE... BIT 14 IS A BINARY FRACTION (LOGIC 1 =0.5). BITS 10—13 ARE THE INTEGER PART OF THE HYSTERESIS VALUE.	R/W
		15	NOT USED (ALARM TYPES 1 OR 2)	
		OR		
		10 TO 13	AVERAGING PERIOD FOR ALARM TYPE 3 INTEGER 1 TO 9	R/W
		14 TO 15	NOT USED (ALARM TYPE 3)	

TABLE 5.1.1. ALARM MNEMONICS (CONT.)

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
A2	HEX		ALARM PACKET 2.	
		0	SKIP FLAG (1 = SKIP)	R/W
		1	SENSE FLAG: 1 = HIGH, 0 = LOW, FOR ABSOLUTE ALARMS IGNORED FOR DEVIATION ALARMS. 1 = RISE, 0 = FALL FOR RATE-OF-CHANGE ALARMS.	R/W
		2	CHART SPEED CHANGE FLAG (1 = ENABLED)	R/W
		3	CONDITIONAL PRINT FLAG (1 = ENABLED)	R/W
		4	PRINT DIGITAL VALUE FLAG (1 = ENABLED)	R/W
		5	PRINT MESSAGE FLAG (1 = ENABLED)	R/W
		6	LOG PRINT FLAG (1 = ENABLED)	R/W
		7	NOT USED	
		8	ALARM FLAG (1 = ALARM; 0 = NO ALARM)	READ ONLY
		9	ALARM ACKNOWLEDGE FLAG (1 = ACKNOWLEDGED)	
		10	NEEDS ACKNOWLEDGE FLAG (1 = NEEDS ACKNOWLEDGEMENT)	READ ONLY
		11 TO 13	RATE-OF-CHANGE ALARM PERIOD INDEX. 0 = 1 SEC. 4 = 10 MINS. 1 = 10 SECS. 5 = 30 MINS. 2 = 30 SECS. 6 = 1 HOUR. 3 = 1 MIN.	R/W
		14 TO 15	SPARE	
A3	HEX		ALARM PACKET 3. VALID ONLY FOR ABSOLUTE AND DEVIATION ALARMS.	
		0 TO 15	SET POINT (0 TO 3FFF) AS A PROPORTION OF FULL SCALE	R/W
A4	HEX		ALARM PACKET 4. VALID ONLY FOR DEVIATION AND RATE-OF-CHANGE ALARMS.	
		0 TO 15	AMOUNT OF DEVIATION (0 TO 3FFF)	R/W
		OR 0 TO 15	RATE-OF-CHANGE (0 TO 3FFF)	R/W
NOTE...BECAUSE THE SET POINT IS A PROPORTION OF FULL SCALE, ANY CHANGE IN SCALE WILL RESULT IN A CHANGE IN THE ABSOLUTE VALUE OF ANY SET POINTS, DEVIATIONS OR RATES-OF-CHANGE SET UP IN A3 AND A4 ABOVE.				

TABLE 5.1.2 CHANNEL MNEMONICS

NOTES...

1) Channel parameter updates are loaded into a buffer, until an EC is received. The checks listed below are then carried out, and if the update is valid, it is loaded into the recorder's data base, and an ACK is returned. If the update is not valid, the buffer content is discarded and a NAK is returned.

   a) OL < OH
   b) IL < IH
   c) IL > −2.48 Volts
   d) IH < 10.24 Volts
   e) FL < FH
   f) Linearisation (function) units are valid. Thermo-couples and RTDs must be temperature units; other types must have their own units.
   g) Input signal units are valid for log, square root, linear etc. functions. (Must be V, mV or mA.)
   h) Linearisation limits are not exceeded (see channel function display description in the Installation and Operation manual HA237229.)
   i) External cold-junction lies within the linearisation limits.
   j) The selected RAM linearisation table is present.
   k) The selected RAM linearisation limits have been calculated.

2) Four further checks are carried out as a background task. This means than an 'ACK' may be returned, as described above, even if one of these checks (listed below) fails, causing the channel not to measure. It is recommended therefore that a read of channel status (ST -ref. table 5.1.2) is made, 2 seconds (min.) after an EC has been written, to establish that all the checks have passed. The background checks are as follows:

   a) Input span > minimum analogue card span.
   b) Input span > minimum RTD card span.
   c) Maximum analogue card input range is not exceeded.
   d) Maximum RTD card input range is not exceeded.

3) Channel Descriptor (CD), Linearisation tables L1, L2, L3, and Scale units (CE) are held in a write protected area of RAM. In order to write to these parameters, it is necessary to fit link 3 on the control board. (LK3 on figure 2.2).

TABLE 5.1.2. CHANNEL MNEMONICS (CONT.)

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
CF	HEX		CHANNEL FLAGS	
		0	SCALE PRINT ENABLE FLAG (1 = ENABLED)	R/W
		1	LEGEND PRINT ENABLE FLAG (1 = ENABLED)	R/W
		2	TRACE SKIP FLAG (1 = SKIP)	R/W
		3	INTERPOLATION ENABLE FLAG (1 = ENABLE)	R/W
		4 TO 5	NOT USED	
		6 TO 7	COLD JUNCTION TYPE 0 = OFF 1 = INTERNAL 2 = EXTERNAL	R/W
		8 TO 11	LINEARISATION TYPE 0 = THERMOCOUPLE TYPE B 1 = THERMOCOUPLE TYPE E 2 = THERMOCOUPLE TYPE J 3 = THERMOCOUPLE TYPE K 4 = THERMOCOUPLE TYPE R 5 = THERMOCOUPLE TYPE S 6 = THERMOCOUPLE TYPE T 7 = 100 OHM PLATINUM RESISTANCE THERMOMETER 8 = SQUARE ROOT EXTRACTION 9 = LOG LAW A = LINEAR LAW B = EXTERNAL C = OFF D TO F = USER SPECIFIED TABLES	R/W
		12 TO 15	LINEARISATION TYPE ENGINEERING UNITS 0 = DEGREES CELSIUS (°C DISPLAYED) 1 = DEGREES FAHRENHEIT (°F DISPLAYED) 2 = KELVINS (K DISPLAYED) 3 = DEGREES RANKINE (R DISPLAYED) 4 TO 6 = USER SPECIFIED UNITS 7 = SQUARE ROOT, LOG, LINEAR, EXTERNAL OR OFF	R/W
CJ	HEX	0 TO 15	COLD JUNCTION TEMP CONTROL TEMPERATURE INTEGER 0 TO 999 (HEX 0000 TO 03E7)	R/W

TABLE 5.1.2. CHANNEL MNEMONICS (CONT.)

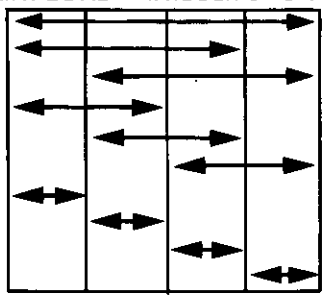
MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
EU	HEX		ENGINEERING UNITS AND CHANNEL DESCRIPTOR	
		0 TO 3	PRINT ZONE — INTEGER 0 TO 9  	R/W
		4 TO 7	INPUT SIGNAL UNITS 0 = C (CELSIUS) 4 = mV 1 = F (FAHRENHEIT) 5 = V 2 = K (KELVIN) 6 = mA 3 = R (RANKIN)	R/W
		8 TO 12	SCALE UNITS INTEGER 0 TO 12 (HEX 0 TO C). SELECTS 1 of 13 ENGINEERING UNIT STRINGS HELD IN RAM — REF CE (TABLE 5.1.3).	R/W
		13 TO 15	CHANNEL DESCRIPTOR — INTEGER 0 TO 7. SELECTS 1 OF 8 CHANNEL DESCRIPTOR STRINGS HELD IN RAM — REF CD (TABLE 5.1.3)	
FH	DECIMAL		FUNCTION TYPE-HIGH VALUE REAL	R/W
FL	DECIMAL		FUNCTION TYPE-LOW VALUE REAL	R/W
IH	DECIMAL		INPUT SIGNAL-HIGH VALUE REAL	R/W
IL	DECIMAL		INPUST SIGNAL-LOW VALUE REAL	R/W
LN	HEX	0 TO 15	CHANNEL DESCRIPTOR NUMBER INTEGER 0 TO 99 (HEX 0000 TO 0063) NUMBERS ABOVE 99 GIVE TWO SPACES	R/W

TABLE 5.1.2. CHANNEL MNEMONICS (CONT.)

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
MV	HEX	0 TO 15	MEASURED VALUE INTEGER F99A to 4665 (−10 TO 110% SPAN) 0000 = SCALE ZERO 3FFF = FULL SCALE A000 = INVALID DATA 9FFF = OVERRANGE DATA A001 = UNDERRANGE DATA	R/W
NOTE... MV MAY BE WRITTEN TO ONLY WHEN LINEARISATION (CF[8 TO 11]) IS SET TO EXT. (11) AND SLOT CONFIGURATION SC (TABLE 5.1.3) IS SET TO DC I/P (0), RT I/P (2), OR EX I/P (E)				
NA	HEX	0 TO 5 6 TO 15	NUMBER OF ALARMS NO. OF ALARMS CURRENTLY ASSIGNED INTEGER 0 TO 60 (HEX 0000 TO 003C) NOT USED (SPARE)	READ ONLY
OH	DECIMAL		SCALE-HIGH VALUE REAL	R/W
OL	DECIMAL		SCALE-LOW VALUE REAL	R/W
SH	HEX	0 TO 15	SHUNT VALUE SHUNT VALUE IN OHMS INTEGER 1 TO 999 (HEX 0001 TO 03E7)	R/W
ST	HEX	0 TO 15	CHANNEL STATUS INTEGER 0 TO 6: 0 = CHANNEL IS CONFIGURED AND IS MEASURING AN ANALOGUE INPUT. 1 = CHANNEL IS CONFIGURED AND IS MEASURING AN EXTERNAL INPUT. 2 = CHANNEL OFF 3 = INPUT SPAN IS LESS THAN THE MINIMUM ANALOGUE CARD SPAN. 4 = INPUT SPAN IS LESS THAN THE MINIMUM RTD CARD SPAN. 5 = MAXIMUM ANALOGUE CARD INPUT RANGE EXCEEDED. 6 = MAXIMUM RTD CARD INPUT RANGE EXCEEDED	READ ONLY

TABLE 5.1.3. INSTRUMENT MNEMONICS

NOTE 1. ACCESS TO INSTRUMENT PARAMETERS MAY BE GAINED ONLY THROUGH THE USE OF A UNIT ADDRESS (U) OF ZERO.
2. CHANNEL ADDRESS (CA) MUST BE PRESENT AND VALID (0 TO 9; A TO F) EVEN THOUGH IT IS NOT USED WHEN ACCESSING INSTRUMENT PARAMETERS.

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WTR HOST
BN	CHARACTER		BATCH NUMBER STRING STRING OF 1 TO 8 CHARACTERS	R/W
CD	CHARACTER		CHANNEL DESCRIPTORS 8 × CHARACTER STRINGS, END TO END	R/W
CE	CHARACTER		SCALE ENGINEERING UNITS STRINGS 13 × 5 CHARACTER STRINGS, END TO END	R/W
CS	HEX	0 TO 7 8 TO 15	CHART SPEED CHART SPEED 1; INTEGER 0 TO 9 CHART SPEED 2; INTEGER 0 TO 9 INTEGER mm/HR in/HR 0 OFF OFF 1 5 0.25 2 10 0.5 3 20 1 4 30 2 5 60 4 6 120 6 7 300 10 8 600 25 9 1200 50 NOTE... METRIC/IMPERIAL IS SELECTED USING IF(2) (SEE BELOW)	R/W R/W
DY	HEX	0 TO 15	DAY NUMBER INTEGER 1 TO 31 (HEX 0001 TO 001F)	R/W

TABLE 5.1.3. INSTRUMENT MNEMONICS (CONT.)

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
ER	HEX		COMMS ERROR STATUS CLEARED BY READING. ER HOLDS ONLY THE LAST COMMS. ERROR CODE.	
		0 TO 15	INTEGER 0 TO 36 (HEX 0 TO 24) (REMAINDER UNDEFINED) 00 = NO ERROR 01 = INVALID MNEMONIC 02 = CHECKSUM ERROR 03 = READ ATTEMPTED ON WRITE ONLY PARAMETER 04 = WRITE ATTEMPTED ON READ ONLY PARAMETER 05 = INVALID LOGICAL UNIT/CHANNEL ADDRESS COMBINATION 06 = NO FREE ALARMS AVAILABLE 07 = ATTEMPT TO ACCESS AN INVALID OR NON-EXISTENT ALARM 08 = INVALID ALARM NUMBER FOR THIS CHANNEL 09 = PRINTER BUFFER NOT EMPTY 0A = INVALID TIME PARAMETER 0B = INVALID INSTRUMENT DESCRIPTOR LENGTH 0C = INVALID BATCH NUMBER LENGTH 0D = INVALID CHANNEL PARAMETER 0E = INVALID CHANNEL DESCRIPTOR LENGTH 0F = INVALID SCALE UNITS LENGTH 10 = PROGRAM MODE ACTIVE. CANNOT DISABLE 11 = PRINT LINE TOO LONG 12 = INVALID COLOUR SELECT CODE 13 = LINEARISATION TABLE TOO LONG 14 = LINEARISATION TABLE TOO SHORT 15 = INVALID SLOT CONFIG. STRING LENGTH 16 = INVALID SLOT CONFIGURATION 17 = INVALID PRINT MODE 18 = INVALID PAPER DIVISIONS 19 = INVALID CHART SPEED PARAMETER 1A = INVALID LOG INTERVAL — MODE 3 1B = INVALID LOG INTERVAL — MODE 2 1C = PARITY ERROR 1D = RECEIVE OVERRUN ERROR 1E = FRAMING ERROR 1F = INVALID DATA FORMAT 20 = CHANNEL NUMBER OUT OF RANGE 21 = ALARM NUMBER OUT OF RANGE 22 = CHANNEL NOT CONFIGURED FOR EXTERNAL INPUT 23 = DATA BASE UPDATE PENDING 24 = PROTECTED AREA OF RAM IS NOT WRITE ENABLED	READ ONLY

TABLE 5.1.3. INSTRUMENT MNEMONICS (CONT.)

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
HR	HEX	0 TO 15	HOURS INTEGER 0 TO 23 (HEX 0000 TO 0017)	R/W
ID	CHARACTER		INSTRUMENT DESCRIPTOR 1 TO 24 CHARACTERS	R/W
IF	HEX		INSTRUMENT FLAGS	
		0	BUZZER (1 = ON)	R/W
		1	CURRENT CHART SPEED FLAG (REF CS) (1 = SPEED 2; 0 = SPEED 1)	R/W
		2	CHART SPEED UNITS FLAG (REF CS) (1 = in/h; 0 = mm/h)	R/W
		3	DATE FORMAT (1 = U.S; 0 = EU)	R/W
		4 TO 15	NOT USED (SPARE)	
II	HEX	0 TO 15	INSTRUMENT IDENTIFIER (ALWAYS GIVES INSTRUMENT MODEL NO.)	READ ONLY
IS	HEX		INSTRUMENT STATUS	
		0	INSTRUMENT ALARM FLAG (1 = ACTIVE)	READ ONLY
		1 TO 15	NOT USED (SPARE)	
L1 L2 L3	CHARACTER		LINEARISATION TABLES B-SPLINE NO OF KNOTS (1 WORD) HEADER (4 WORDS) 4 TO 40 KNOTS (2 WORDS EACH) 8-CHARACTER LEGEND 2-CHARACTER ENGINEERING UNITS (WORDS ARE 4 ASCII CHARACTERS)	R/W
NOTE... LINEARISATION TABLE MUST BE MONOTONIC				
MI	HEX	0 TO 15	MINUTES INTEGER 0 TO 59 (HEX 0000 TO 003B)	R/W
MO	HEX	0 TO 15	MONTH INTEGER 1 TO 12 (HEX 0000 TO 000C)	R/W
M2	HEX	0 TO 15	MODE 2 LOG INTERVAL INTEGER 0 TO 9999 (HEX 0000 TO 270F) INTERVAL IN MINUTES BETWEEN TIMED LOGS IN PRINT MODE 2 (TEXT). (0 = OFF)	R/W
M3	HEX	0 TO 15	MODE 3 LOG INTERVAL INTEGER 0 TO 59994 (HEX 0000 TO EA5A) WHEN POLLED (READ FROM), THE VALUE INDICATES THE INTERVAL IN 10s OF SECONDS BETWEEN TIMED LOGS IN PRINT MODE 3 (TABULAR). (0 = OFF). WHEN SELECTED (WRITTEN TO) IF THE VALUE IS LESS THAN 10 (IE, 0 TO 90 SECONDS); THE VALUE IS DISPLAYED IN SECONDS. FOR VALUES OF 10 OR MORE, THE VALUE IS TRUNCATED AND DISPLAYED AS MINUTES.	R/W
PD	HEX	0 TO 15	PAPER DIVISIONS NUMBER OF DIVISIONS ON PAPER INTEGER 1 TO 10 (HEX 0001 TO 000A)	R/W

TABLE 5.1.4. COMMAND MNEMONICS

MNEMONIC	FORMAT	BITS	DEFINITION	PERMISSION WRT HOST
AA			ALARM ACKNOWLEDGE. ALL CHANNEL ALARMS WHICH REQUIRE ACKNOWLEDGEMENT ARE ACKNOWLEDGED	WRITE ONLY
DP			DISABLE PROGRAM MODE. IF THE OPERATOR INTERFACE IS NOT IN PROGRAM MODE, THE LOGIN FACILITY IS DISABLED AND AN ACK IS RETURNED. IF THE OPERATOR INTERFACE IS IN PROGRAM MODE, NO ACTION IS TAKEN AND A NAK IS RETURNED	WRITE ONLY
EA			ENTER ALARM DATA. ON RECEIPT OF THIS MNEMONIC, THE ALARM BUFFER DATA IS CHECKED FOR VALIDITY. IF VALID, THE ALARM RECORD IS WRITTEN TO THE CHANNEL INDICATED IN THE GA/GF MNEMONIC, OR RETURNED TO THE POOL IF THE TYPE IS UNASSIGNED, AND AN ACK IS RETURNED. IF THE DATA IS INVALID, IT IS DISCARDED AND A NAK IS RETURNED.	WRITE ONLY
EC			ENTER CHANNEL DATA. ON RECEIPT OF THIS MNEMONIC, THE TEMPORARY DATA BUFFER IS CHECKED FOR VALIDITY. IF VALID, THE DATA IS WRITTEN TO THE DATA BASE, AND AN 'ACK' IS RETURNED. IF THE DATA IS NOT VALID, IT IS DISCARDED AND A 'NAK' IS RETURNED.	WRITE ONLY
EP			ENABLE PROGRAM MODE. ON RECEIPT OF THIS MNEMONIC, THE LOGIN FACILITY IS ENABLED, REGARDLESS OF ITS PREVIOUS STATE. ACK IS ALWAYS RETURNED.	WRITE ONLY
GA	HEX	 0 TO 5 6 TO 7 8 TO 12 13 TO 15	GET ALARM. IF THE INDICATED ALARM EXISTS, THE DATA RELATING TO IT IS EXTRACTED FROM THE INDICATED CHANNEL AND STORED IN AN ALARM BUFFER, WHERE IT MAY BE ACCESSED BY ALARM MNEMONICS A1 TO A4. ALARM NUMBER. INTEGER 1 TO 60 NOT USED (SPARE) CHANNEL NUMBER. INTEGER 1 TO 30 NOT USED (SPARE)	WRITE ONLY
GF	HEX	 0 TO 4 5 TO 15	GET FREE ALARM IF THERE IS A FREE ALARM IN THE POOL, IT IS EXTRACTED AND PLACED IN THE ALARM BUFFER FOR MODIFICATION AND RE-ASSIGNMENT TO THE INDICATED CHANNEL. AN 'ACK' IS RETURNED. IF THERE ARE NO FREE ALARMS, A 'NAK' IS RETURNED. CHANNEL NUMBER. INTEGER 0 TO 30 NOT USED (SPARE)	WRITE ONLY

DECIMAL	BINARY	HEX
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

TABLE 5.2.1. DECIMAL (0 TO 15) — BINARY-HEX CONVERSION

HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
0001	1	0010	16	0100	256	1000	4096
0002	2	0020	32	0200	512	2000	8192
0003	3	0030	48	0300	768	3000	12288
0004	4	0040	64	0400	1024	—	—
0005	5	0050	80	0500	1280	3FFF	16383
0006	6	0060	96	0600	1536	—	—
0007	7	0070	112	0700	1792	—	—
0008	8	0080	128	0800	2048	—	—
0009	9	0090	144	0900	2304	—	—
000A	10	00A0	160	0A00	2560	—	—
000B	11	00B0	176	0B00	2816	—	—
000C	12	00C0	192	0C00	3072	—	—
000D	13	00D0	208	0D00	3328	—	—
000E	14	00E0	224	0E00	3584	—	—
000F	15	00F0	240	0F00	3840	—	—

TABLE 5.2.2. HEX (000 TO 3FFF) — DECIMAL CONVERSION

Table 5.3

CHARACTER SET

	CHARACTER	CONTROL	BINARY CODE	HEX CODE	DECIMAL CODE
	NUL — Null		000 0000	00	0
	SOH — Start of Heading	A	000 0001	01	1
*	STX — Start of Text	B	000 0010	02	2
*	ETX — End of Text	C	000 0011	03	3
*	EOT — End of transmission	D	000 0100	04	4
*	ENQ — Enquiry	E	000 0101	05	5
*	ACK — Acknowledge	F	000 0110	06	6
	BEL — Bell	G	000 0111	07	7
	BS — Backspace	H	000 1000	08	8
	HT — Horizontal tabulation	I	000 1001	09	9
	LF — Line feed	J	000 1010	0A	10
	VT — Vertical tabulation	K	000 1011	0B	11
	FF — Form feed	L	000 1100	0C	12
	CR — Carriage return	M	000 1101	0D	13
	SO — Shift Out	N	000 1110	0E	14
	SI — Shift In	O	000 1111	0F	15
	DLE — Data link escape	P	001 0000	10	16
*	DC1 — Device control 1 (XON)	Q	001 0001	11	17
	DC2 — Device control 2	R	001 0010	12	18
*	DC3 — Device control 3 (XOFF)	S	001 0011	13	19
	DC4 — Device control 4 (stop)	T	001 0100	14	20
*	NAK — Negative acknowledge	U	001 0101	15	21
	SYN — Synchronous idle	V	001 0110	16	22
	ETB — End of Trans Block	W	001 0111	17	23
	CAN — Cancel	X	001 1000	18	24
	EM — End of Medium	Y	001 1001	19	25
	SUB — Substitue	Z	001 1010	1A	26
	ESC — Escape		001 1011	1B	27
	FS — File Separator		001 1100	1C	28
	GS — Group Separator		001 1101	1D	29
	RS — Record Separator		001 1110	1E	30
	US — Unit Separator		001 1111	1F	31

* Only those characters marked with a star are correctly interpreted by the 4001 recorder. Use of any of the other control codes may lead to an un-recoverable error.

Table 5.3 Character Set (cont.)

CHARACTER		BINARY CODE	HEX CODE	DECIMAL CODE
	– SPACE	010 0000	20	32
!	– exclamation mark	010 0001	21	33
"	– double quotation mark	010 0010	22	34
#	– hash (£ sign – ISO 7)	010 0011	23	35
$	– dollar sign (or £ sign)	010 0100	24	36
%	– percentage sign	010 0101	25	37
&	– ampersand	010 0110	26	38
'	– single quotation mark	010 0111	27	39
(	– left-hand bracket (round)	010 1000	28	40
)	– right-hand bracket (round)	010 1001	29	41
*	– asterisk	010 1010	2A	42
+	– plus	010 1011	2B	43
,	– comma	010 1100	2C	44
–	– minus	010 1101	2D	45
.	– period	010 1110	2E	46
/	– oblique	010 1111	2F	47
0		011 0000	30	48
1		011 0001	31	49
2		011 0010	32	50
3		011 0011	33	51
4	numerals	011 0100	34	52
5		011 0101	35	53
6		011 0110	36	54
7		011 0111	37	55
8		011 1000	38	56
9		011 1001	39	57
:	– colon	011 1010	3A	58
;	– semi-colon	011 1011	3B	59
<	– less than	011 1100	3C	60
=	– equals	011 1101	3D	61
>	– greater than	011 1110	3E	62
?	– question mark	011 1111	3F	63

Table 5.3 Character Set (cont.)

CHARACTER	BINARY CODE	HEX CODE	DECIMAL CODE
@ – "at" sign	100 0000	40	64
A	100 0001	41	65
B	100 0010	42	66
C	100 0011	43	67
D	100 0100	44	68
E	100 0101	45	69
F	100 0110	46	70
G	100 0111	47	71
H	100 1000	48	72
I	100 1001	49	73
J	100 1010	4A	74
K	100 1011	4B	75
L	100 1100	4C	76
M	100 1101	4D	77
N upper case letters	100 1110	4E	78
O	100 1111	4F	79
P	101 0000	50	80
Q	101 0001	51	81
R	101 0010	52	82
S	101 0011	53	83
T	101 0100	54	84
U	101 0101	55	85
V	101 0110	56	86
W	101 0111	57	87
X	101 1000	58	88
Y	101 1001	59	89
Z	101 1010	5A	90
[– LH Bracket (square)	101 1011	5B	91
/ – oblique	101 1100	5C	92
] – RH bracket (square)	101 1101	5D	93
^ – up arrow (common usage)	101 1110	5E	94
— – underline (← common usage)	101 1111	5F	95

Table 5.3 Character Set (cont.)

CHARACTER	BINARY CODE	HEX CODE	DECIMAL CODE
grave accent	110 0000	60	96
a	110 0001	61	97
b	110 0010	62	98
c	110 0011	63	99
d	110 0100	64	100
e	110 0101	65	101
f	110 0110	66	102
g	110 0111	67	103
h	110 1000	68	104
i	110 1001	69	105
j	110 1010	6A	106
k	110 1011	6B	107
l	110 1100	6C	108
m	110 1101	6D	109
n lower case letters	110 1110	6E	110
o	110 1111	6F	111
p	110 0000	70	112
q	111 0001	71	113
r	111 0010	72	114
s	111 0011	73	115
t	111 0100	74	116
u	111 0101	75	117
v	111 0110	76	118
w	111 0111	77	119
x	111 1000	78	120
y	111 1001	79	121
z	111 1010	7A	122
{ — LH bracket (curly)	111 1011	7B	123
| — vertical line	111 1100	7C	124
} — RH bracket (curly)	111 1101	7D	125
~ — tilde	111 1110	7E	126
DEL — Produces black square (■)	111 1111	7F	127
Å	1000 0000	80	128
Ä	1000 0001	81	129
Æ	1000 0010	82	130
ß	1000 0011	83	131
É	1000 0100	84	132
Ñ	1000 0101	85	133
Ö	1000 0110	86	134
Ø	1000 0111	87	135
ü	1000 1000	88	136
à	1000 1001	89	137
ä	1000 1010	8A	138
å	1000 1011	8B	139
à	1000 1100	8C	140
æ	1000 1101	8D	141
ë	1000 1110	8E	142
ê	1000 1111	8F	143

Table 5.3 Character Set (cont.)

CHARACTER	BINARY CODE	HEX CODE	DECIMAL CODE
é	1001 0000	90	144
è	1001 0001	91	145
ï	1001 0010	92	146
î	1001 0011	93	147
ì	1001 0100	94	148
ñ	1001 0101	95	149
ö	1001 0110	96	150
ϕ	1001 0111	97	151
ô	1001 1000	98	152
ò	1001 1001	99	153
œ	1001 1010	9A	154
ü	1001 1011	9B	155
û	1001 1100	9C	156
ù	1001 1101	9D	157
§	1001 1110	9E	158
ß	1001 1111	9F	159
ç c—cedilla	1010 0000	AO	160
¿	1010 0001	A1	161
¥	1010 0010	A2	162
₤	1010 0011	A3	163
€	1010 0100	A4	164
θ	1010 0101	A5	165
ϕ	1010 0110	A6	166
π	1010 0111	A7	167
μ	1010 1000	A8	168
Ω	1010 1001	A9	169
∫	1010 1010	AA	170
Σ	1010 1011	AB	171
≠	1010 1100	AC	172
≡	1010 1101	AD	173
≐	1010 1110	AE	174
⋯	1010 1111	AF	175
⁰ — Superscript	1011 0000	B0	176
¹ — Superscript	1011 0001	B1	177
² — Superscript	1011 0010	B2	178
³ — Superscript	1011 0011	B3	179
⁴ — Superscript	1011 0100	B4	180
⁵ — Superscript	1011 0101	B5	181
⁶ — Superscript	1011 0110	B6	182
⁷ — Superscript	1011 0111	B7	183
⁷ — Supercript	1011 1000	B8	184
⁸ — Superscript	1011 1001	B9	185
√	1011 1010	BA	186
±	1011 1011	BB	187
°	1011 1100	BC	188
× — multiply	1011 1101	BD	189
÷ — divide	1011 1110	BE	190
°	1011 1111	BF	191

Table 5.3 Character Set (cont.)

CHARACTER	BINARY CODE	HEX CODE	DECIMAL CODE
|←–	1100 0000	C0	192
⊢	1100 0001	C1	193
|	1100 0010	C2	194
£	1100 0011	C3	195
⩽	1100 0100	C4	196
⩾	1100 0101	C5	197
∨	1100 0110	C6	198
▲	1100 0111	C7	199
←	1100 1000	C8	200
→	1100 1001	C9	201
↓	1100 1010	CA	202
↑	1100 1011	CB	203
⪡	1100 1100	CC	204
⪢	1100 1101	CD	205
⩔	1100 1110	CE	206
⩓	1100 1111	CF	207
$_0$ – Subscript	1101 0000	D0	208
$_1$ – Subscript	1101 0001	D1	209
$_2$ – Susbcript	1101 0010	D2	210
$_3$ – Susbcript	1101 0011	D3	211
$_4$ – Subscript	1101 0100	D4	212
$_5$ – Subscript	1101 0101	D5	213
$_6$ – Subscript	1101 0110	D6	214
$_7$ – Subscript	1101 0111	D7	215
$_8$ – Subscript	1101 1000	D8	216
$_9$ – Subscript	1101 1001	D9	217
C contrast inverted C	1101 1010	DA	218
H contrast inverted H	1101 1011	DB	219
I contrast inverted I	1101 1100	DC	220
P contrast inverted P	1101 1101	DD	221
S contrast inverted S	1101 1110	DE	222
A contrast inverted A	1101 1111	DF	223
E contrast inverted E	1110 0000	EO	224
	1110 0001	E1	225
	1110 0010	E2	226

A1	ALARM PACKET 1
A2	ALARM PACKET 2
A3	ALARM PACKET 3
A4	ALARM PACKET 4

TABLE 5.4.1. ALARM MNEMONIC SCROLLING ORDER

SC	SLOT CONFIGURATION
IF	INSTRUMENT FLAGS
PM	PRINT MODE
PD	PAPER DIVISIONS
IS	INSTRUMENT STATUS
ER	SERIAL LINK ERROR STATUS
HR	HOURS
MI	MINUTES
SE	SECONDS
DY	DAY NUMBER
MO	MONTH
YR	YEAR
BN	BATCH NUMBER
CD	CHANNEL DESCRIPTOR*
CE	CHANNEL ENGINEERING UNITS*
II	INSTRUMENT IDENTIFIER
VN	SOFTWARE VERSION NUMBER
ID	INSTRUMENT DESCRIPTOR STRING
CS	CHART SPEED
M2	MODE 2 LOG INTERVAL
M3	MODE 3 LOG INTERVAL
L1	LINEARISATION TABLE 1*
L2	LINEARISATION TABLE 2*
L3	LINEARISATION TABLE 3*

TABLE 5.4.2. INSTRUMENT MNEMONIC SCROLLING ORDER

*THESE PARAMETERS RESIDE IN A WRITE PROTECTED AREA OF RAM. IN ORDER TO WRITE TO THESE PARAMETERS, LINK 3 MUST BE FITTED TO THE CONTROL BOARD — SEE FIGURE 2.2.

CF	CHANNEL FLAGS
CJ	COLD JUNCTION COMPENSATION
EU	CHANNEL ENGINEERING UNITS
FH	FUNCTION HIGH VALUE
FL	FUNCTION LOW VALUE
IH	INPUT SIGNAL HIGH VALUE
IL	INPUT SIGNAL LOW VALUE
LN	CHANNEL LEGEND NUMBER
MV	CHANNEL MEASURED VALUE
NA	NUMBER OF ALARMS
OH	SCALE HIGH VALUE
OL	SCALE LOW VALUE
SH	SHUNT VALUE IN OHMS
ST	CHANNEL STATUS

TABLE 5.4.3. BLOCK MNEMONICS

Baud Rate	: 110, 300, 600, 1200, 2400, 4800, 9600*
Parity Type	: NONE*, ODD, EVEN
Stop Bits	: ONE*, TWO
Data Bits	: 7, 8*
Protocol	: ASCII, ANSI*
Group Address	: 0*, 1, 2, 3, 4, 5, 6, 7
Handshake	: ON, OFF*

*REPRESENT THE SETTINGS WHEN THE INSTRUMENT IS DELIVERED, AND ARE DEFAULT SETTINGS IF THE RAM CHECK FAILS.

TABLE 5.5. SERIAL LINK PARAMETERS

TABLE 5.6.
4001 INSTALLATION AND OPERATION MANUAL CROSS-REFERENCE PARAMETER LISTING

SECTION	PARAMETER	MNEMONIC	TABLE
6.3	PROGRAM MODE DISABLE	DP	5.1.1
6.4	MEASURED VALUE	MV	5.1.2
	ENGINEERING UNITS	EU	5.1.2
6.5	HOURS	HR	5.1.3
	MINUTES	MI	5.1.3
	SECONDS	SE	5.1.3
	DAY	NOT ACCESIBLE VIA DATA LINK	
	DATE	DY	5.1.3
	MONTH	MO	5.1.3
	YEAR	YR	5.1.3
6.6	INSTRUMENT DESCRIPTOR	ID	5.1.3
	PRINT FORMAT MODE	PM	5.1.3
	BATCH NUMBER	BN	5.1.3
6.7	VERSION NUMBER	VN	5.1.3
	SCALE DIVISIONS	PD	5.1.3
	AUDIBLE ANNUNCIATOR	IF (0)	5.1.3
	DATE FORMAT	IF (3)	5.1.3
	CHART SPEED UNITS	IF (2)	5.1.3
6.8	I/O CARD TYPE	SC	5.1.3
6.13	CURRENT CHART SPEED	IF (1)	5.1.3
	CHART SPEED UNITS	IF (2)	5.1.3
	SPEED 1	CS (0 TO 7)	5.1.3
	SPEED 2	CS (8 TO 15)	5.1.3
6.14	TIME PERIOD	M2/M3	5.1.3
	TIME UNITS	M2/M3	5.1.3
	PRINT FORMAT MODE	PM	5.1.3
6.15	MEASURED VALUE	MV	5.1.2
	ENGINEERING UNITS	EU	5.1.2
	CHANNEL DESCRIPTOR	EU	5.1.2
	DESCRIPTOR NUMBER	LN	5.1.2
6.16	SCALE ZERO	OL	5.1.2
	SCALE SPAN	OH	5.1.2
	ENGINEERING UNITS	EU	5.1.2
	TRACE SKIP	CF (2)	5.1.2
6.17	LOW VALUE	IL	5.1.2
	HIGH VALUE	IH	5.1.2
	SIGNAL UNITS	EU (4 TO 7)	5.1.2
	SHUNT RESISTOR VALUE	SH	5.1.2
	COLD JUNCTION	CF (6 TO 7)	5.1.2
	CJ TEMPERATURE	CJ	5.1.2
	TEMPERATURE UNITS	NOT ACCESSIBLE VIA DATA LINK	

TABLE 5.6. (CONT.)
4001 INSTALLATION AND OPERATION MANUAL CROSS-REFERENCE PARAMETER LISTING

SECTION	PARAMETER	MNEMONIC	TABLE
6.18	LINEARISING TABLE	CF (8 TO 11)	5.1.2
	ZERO	FL	5.1.2
	SPAN	FH	5.1.2
	LINEARISING UNITS	CF (12 TO 15)	5.1.2
6.19	SCALE ENABLE	CF (0)	5.1.2
	DESCRIPTOR ENABLE	CF (1)	5.1.2
6.20	RECORDING ZONE	EU (0 TO 3)	5.1.2
	INTERPOLATION ENABLE	CF (3)	5.1.2
6.21	LOW POINT	NOT ACCESSIBLE VIA DATA LINK	
	HIGH POINT	NOT ACCESSIBLE VIA DATA LINK	
6.22	ALARM NUMBER	NOT ACCESSIBLE VIA DATA LINK	
	ALARM TYPE	A1 (8 TO 9)	5.1.1
6.23	THRESHOLD	A3	5.1.1
	ENGINEERING UNITS	EU	5.1.2
	ALARM HYSTERESIS	A1 (10 TO 14)	5.1.1
	SENSE	A2 (1)	5.1.1
	ALARM SKIP	A2 (0)	5.1.1
6.24	REFERENCE VALUE	A3	5.1.1
	DEVIATION VALUE	A4	5.1.1
	ENGINEERING UNITS	EU	5.1.3
	ALARM HYSTERESIS	A1 (10 TO 14)	5.1.1
	ALARM SKIP	A2 (0)	5.1.1
6.25	MEASURING UNITS	A4	5.1.1
	ENGINEERING UNITS	EU	5.1.2
	TIME PERIOD	A2 (11 TO 13)	5.1.1
	DIRECTION	A2 (1)	5.1.1
	ALARM SKIP	A2 (0)	5.1.1
	AVERAGING PERIOD	A1 (10 TO 13)	5.1.1
6.26	CHART SPEED	A2 (2)	5.1.1
	LOG ON ALARM	A2 (6)	5.1.1
	OUTPUT SLOT ADDRESS	A1 (5 TO 7)	5.1.1
	OUTPUT DEVICE ADDRESS	A1 (0 TO 4)	5.1.1
	PRINT MESSAGE	A2 (5)	5.1.1
	PRINT DIGITAL VALUE	A2 (4)	5.1.1
	CONDITIONAL PRINT	A2 (3)	5.1.1

TABLE 5.7. RECORDING CHANNEL ADDRESSING

CHAN	U	CA
1	1	0
2	1	1
3	1	2
4	1	3
5	2	0
6	2	1
7	2	2
8	2	3
9	3	0
10	3	1
11	3	2
12	3	3
13	4	0
14	4	1
15	4	2
16	4	3
17	5	0
18	5	1
19	5	2
20	5	3
21	6	0
22	6	1
23	6	2
24	6	3
25	7	0
26	7	1
27	7	2
28	7	3
29	8	0
30	8	1

EXAMPLES

6.1. EXAMPLES OF POLLING AND SELECTION

Where necessary, reference should be made to section 4 (data formatting) and tables 5.1.1 to 5.1.4 (parameter mnemonic definitions) when reading through these examples. It should be noted that the spaces between characters in the following examples have been inserted only for clarity.

6.1.1. TO READ A MEASURED VALUE

The following transfer of messages takes place when the host computer wishes to determine the measured value of channel 17 of instrument 6.

Host: EOT 66550 MV ENQ (ANSI)
$ 66550 MV % (ASCII)
4001: STX 0 MV >0FFF ETX BCC (ANSI)
" 0 MV >0FFF # (ASCII)

(Measured value is 0FFF (25% of fullscale) — ref table 5.1.2)

6.1.2. TO WRITE A VALUE TO A CHANNEL

The following transfer of messages takes place when the host computer wishes to write a value to channel 10 of instrument 2.

Host: EOT 2233 STX 1 MV >1FFF ETX BCC (ANSI)
$ 2233 " 1 MV >1FFF # (ASCII)
4001: either – ACK (&) — Channel is configured for external input.
or – NAK (( ) — Channel is not configured for external input.

6.1.3. CONTINUOUS POLLING OF A CHANNEL

The following transfer of messages takes place when the host computer wishes to poll channel 14 of instrument 0, continuously:—

Host: EOT 00441MV ENQ
4001: STX 1MV>0123 ETX BCC
Host: NAK
4001: STX 1MV>0140 ETX BCC
Host: NAK
4001: STX 1MV>0154 ETX BCC
etc.
Host: EOT

6.1.4. SCROLLING INSTRUMENT PARAMETERS

The following transfer of messages takes place when the host computer wishes to read the time and date currently in use in instrument 0. The following should be noted:

1. LU0 is used to access instrument parameters.
2. All values of date and time values are transmitted in Hex.
3. MI, SE, DY, MO, YR, follow HR in the instrument parameter scrolling order — see table 5.4.2.

Host:	EOT 00000HR ENQ	
4001:	STX 0HR>0009 EXT BCC	
Host:	ACK	
4001:	STX 0MI>0018 ETX BCC	(Decimal value = 24)
Host:	ACK	
4001:	STX 0SE>000A ETX BCC	(Decimal value = 10)
Host:	ACK	
4001:	STX 0DY>0002 ETX BCC	
Host:	ACK	
4001:	STX 0MO>0009 ETX BCC	
Host:	ACK	
4001:	STX 0YR>0055 ETX BCC	(Decimal value = 85)
Host:	EOT	

Giving the result: 9:24:10 2nd Sept 1985.

6.1.5. SELECTION RE-ENTRY

The following transfer of messages takes place, when the host computer wishes to re-set the date and time running in instrument 0. The example demonstrates that it is possible to make a number of entries to a 4001 instrument without having to establish a connection each time:

Host:	EOT 0000 STX 0HR>000A ETX BCC	(Decimal value = 10)
4001:	ACK	
Host:	STX 0M1>001E ETX BCC	(Decimal value = 30)
4001:	ACK	
Host:	STX 0DY>0002 ETX BCC	
4001:	ACK	
Host:	STX0MO>0009 ETX BCC	
4001:	ACK	
Host:	STX 0YR>0055 ETX BCC	Decimal value = 85)
4001:	ACK	
Host:	EOT	

This sets the following date and time into the instrument:—
10:30 2nd Sept 1985.

6.1.6. TO MODIFY SCALE LIMITS

The following transfer of messages takes place when the host computer wishes to re-set the scale limits of channel 27 of instrument 0 to −10 to 100:

Host:	EOT 0077 STX 2OL10—00 ETX BCC
4001:	ACK
Host:	STX 2OH100.0 ETX BCC
4001:	ACK
Host:	EOT 0000 STX 0EC ETX BCC
4001:	ACK

6.1.7. TO ASSIGN AN ALARM TO A CHANNEL

The following transfer of messages takes place when the host computer wishes to set up an alarm on channel 7 of instrument 0:

Host:	EOT 0000 STX 0GF>0007 ETX BCC	(Get a free alarm from the pool and assign it to channel 7.)
4001:	ACK	
Host:	STX 0A1>1D00 ETX BCC	(Set alarm for: no output, absolute, 3.5% hystersis.)
4001:	ACK	
Host:	STX 0A2>0034 ETX BCC	(Set: alarm on, low sense, change chart speed, print digital value, print message.)
4001:	ACK	
Host:	STX 0A3>2FFF ETX BCC	(Set point value = 75% of scale.)
4001:	ACK	
Host:	STX 0EA ETX BCC	
4001:	ACK	

The alarm is now assigned to the channel, and is included in the checking sequence.

6.1.8. TO MODIFY AN ALARM

The following transfer of messages takes place when the host computer wishes to re-set the alarm 1 set point of channel 7 to 25% of full scale:

Host:	EOT 0000 STX 0GA>0701 ETX BCC	(Extract alarm 1 from channel 7, and place it in the alarm buffer.)
4001:	ACK	
Host:	STX 0A3>0FFF STX BCC	(Re-set set point to 25% of full scale.)
4001:	ACK	
Host:	STX 0EA STX BCC	
4001:	ACK	

Alarm 1 on channel 7 is now modified, and the alarm checking continues with the new set point.

6.1.9. TO WRITE A TEXT STRING FOR PRINTING

The following message is sent by the host to print: "4001 "in red, "Serial " in orange and "Link" in green.

Host: EOT7700STX0*PT!14001 !2Serial !3LinkETXBCC Note: EOT, STX ETX, BCC are control characters
The 4001 will respond with either

ACK (Buffer is empty' the line will be queued for printing.)
or: NAK (Buffer is not empty; the line has been discarded.)

*When writing to any LU 0 parameter, the value of this CA parameter is ignored by the 4001, although it must be present. The value may be any valid Hex character (0 to 9, capital A to F).

Time to Print.

In print mode 3, any text queued in the buffer will be printed 'immediately'.

In print modes 1 or 2, however, the text to be entered will be queued (behind any scale, time, alarm etc. data) until a spare text line becomes available. Text lines are available every 3mm of chart and it is recommended that a calculation of time-before-print is made, using the currently selected chart speed, before the PT facility is made use of.

For a complete description of the available print modes, refer to the Installation and Operating instruction manual supplied with the instrument.

ADDENDUM

(Modifications for Software version 4.8)

1.0. INTRODUCTION

For recorders fitted with software version 4.8, a number of additions to or expansions of the previous version (described in the main body of this document) have been made. (The software version fitted, may be determined from the Instrument 2 page display.)

1.1. PARAMETER CHANGES

1.1.1. ALARM PARAMETERS (TABLE 5.1.1)

No changes

1.1.2. CHANNEL PARAMETERS

a) CHANNEL STATUS (ST—SECTION 5; PAGE 10)

5 additional codes have been incorporated, as follows:—

BIT	DEFINITION
7	Reserved
8	Reserved
9	Channel under range
A	Channel over range
B	Channel invalid

b) PROCESS VARIABLE (PV — NEW MNEMONIC)

Format : Decimal.
Permission : Read/Write
Description : Measured value, scaled in the current engineering units, instead of in hex (i.e. MV).
Poll values : −9999. = value is under range or invalid.
+9999. = value is over range.
Select values : Values sent to the recorder which are outside the current range by more than 10%, are represented as being under or over range, as applicable.

c) SPAN ADJUST (SA — NEW MNEMONIC)

Format : Hex
Permission : Read/Write
Description : Allows reading or writing of high adjust point, as described in the channel adjustment page display in section 6 of the Installation and Operation manual. See also Zero Adjust below.

d) ZERO ADJUST (ZA — NEW MNEMONIC)

Format : Hex
Permission : Read/Write
Description : Allows reading or writing of low adjust point, as described in the channel adjustment page display in section 6 of the Installation and Operation manual. See also Span Adjust above.

1.1.3. INSTRUMENT PARAMETERS

a) COMMUNICATIONS ERROR STATUS (ER — SECTION 5; PAGE 12)

Additional error codes. (Codes 0 to 40 (Hex 0 to 28) now used.)

ERROR CODE (HEX)	DEFINITION
25	PRINTER OFF LINE
26	PRINTER ON LINE
27	PRINTER BUSY
28	NO LOG IN MODE 1

b) INSTRUMENT FLAGS (IF — SECTION 5; PAGE 13)

Additional bit

BIT	DEFINITION
4	INTERNAL COLD JUNCTION TEMPERATURE UNITS 0 = Degrees C; 1 = DEGREES F

Allows the internal cold junction temperature (J1 to J5 below) to be read in degrees C or in degrees F as required.

c) INSTRUMENT STATUS (IS — SECTION 5; PAGE 13)

Additional bits

BIT	DEFINITION
1	Printer on/off line (1 = off line; 0 = on line)
2	Printer busy (1 = busy; 0 = not busy)

d) INTERNAL COLD JUNCTION TEMPERATURE (J1 TO J5 — NEW MNEMONICS)

Format : Decimal
Permission : Read only
Description : J 1 to J5 are the internal cold junction temperatures of I/O boards 1 to 5 respectively, assuming these boards to be DC input boards. The value is returned in degrees centigrade, or degrees Fahrenheit, according to IF bit 4 (see above). Should the temperature be invalid for any slot (e.g. dc input board not fitted in that slot), the value 999.9 is returned.

1.1.3. (Cont.)

e) YEAR (YR — SECTION 5; PAGE 14)

Change in range.

Format : Hex.
Permission : Read/Write.
Description : Bits 0 to 15 — Offset from the year 1900. Range 0 to 150 (Hex 0000 to 0096) allows any year between 1900 and 2050 to be read or written.
Change : Range was 0 to 99 (Hex 0000 to 0063) allowing the use of years 1900 to 1999 only.

1.1.4. COMMAND MNEMONICS (TABLE 5.1.4)

a) PRINTER ON LINE (CG — NEW MNEMONIC)

Upon receipt of this command, this printing function is switched on-line (provided that the printer is currently off-line and not busy), and an ACK returned. If the printer is busy or already on-line, a NAK is returned.

b) CHART HALT (CH — NEW MNEMONIC)

Upon receipt of this command, the chart is stopped (provided that the printer is off-line, and not busy) and and ACK is returned. Otherwise a NAK is returned. Used in conjuction with chart wind (CW) and chart re-wind (CR).

c) PRINTER OFF LINE (CO — NEW MNEMONIC)

Upon receipt of this command, the printing function is switched off-line (provided that the printer is currently on-line and not busy), and an ACK returned. If the printer is busy or already off-line, a NAK is returned.

d) CHART REWIND (CR — NEW MNEMONIC)

Upon receipt of this command, a single step increase in chart speed is made in the chart rewind direction (provided that the printer is off-line, and not busy), and an ACK is returned. The chart control accepts up to 25 such increases. More than 25 steps may be entered (and ACKS returned), but no further increase in chart speed will result. It should be noted that this command is effective whilst the chart is in either the re-wind or fast-forward mode.

e) CHART WIND (CW — NEW MNEMONIC)

Upon receipt of this command, a single step increase in chart speed is made in the chart fast-foward direction (provided that the printer is off-line, and not busy), and an ACK is returned. The chart control accepts up to 25 such increases; more than 25 steps may be entered (and ACKs returned), but no further increase in chart speed will result. It should be noted tnat this command is effective whilst the chart is in either the re-wind or fast-forward mode.

f) DATA DUMP (DD — NEW MNEMONIC)

Upon receipt of this command, one of the following takes place:

1) Printer off-line and not busy: A configuration dump is initiated, and an ACK is returned
2) Printer on-line, not busy, and print mode 2 or 3 is selected: A remote log is initiated (copies 'PRINT DATA' pushbutton's function) and an ACK is returned.
3) In any other case, a NAK is returned.

1.2. SCROLLING ORDER (TABLE 5.4.2. — SECTION 5 PAGE 23).

Additional instrument parameters J1 to J5 are added to the end of the scrolling order.

1.3. FURTHER CHANGES

1.3.1. INVERTED SCALES CAPABILITY

Recorders with software version 4.8, may use inverted scales. For example, an input range of 0 to 1 Volt, may be scaled as 100 to 0 rather than the more usual 0 to 100.

This has two effects on the serial communications link, as follows:

a) CHANNEL BUFFER VALIDATION (SECTION 3; PAGE 11 AND SECTION 5; PAGE 7)

OL < OH should now read OL < > OH (i.e. OL is not equal to OH).

b) SETTING ALARM SET POINTS AND SENSES.

It should be noted that the alarm sense (i.e. rising or falling) is related to the input signal, but the alarm set points are related to the scale.