6445 - MICRO SUPERVISOR

TECHNICAL MANUAL

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CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

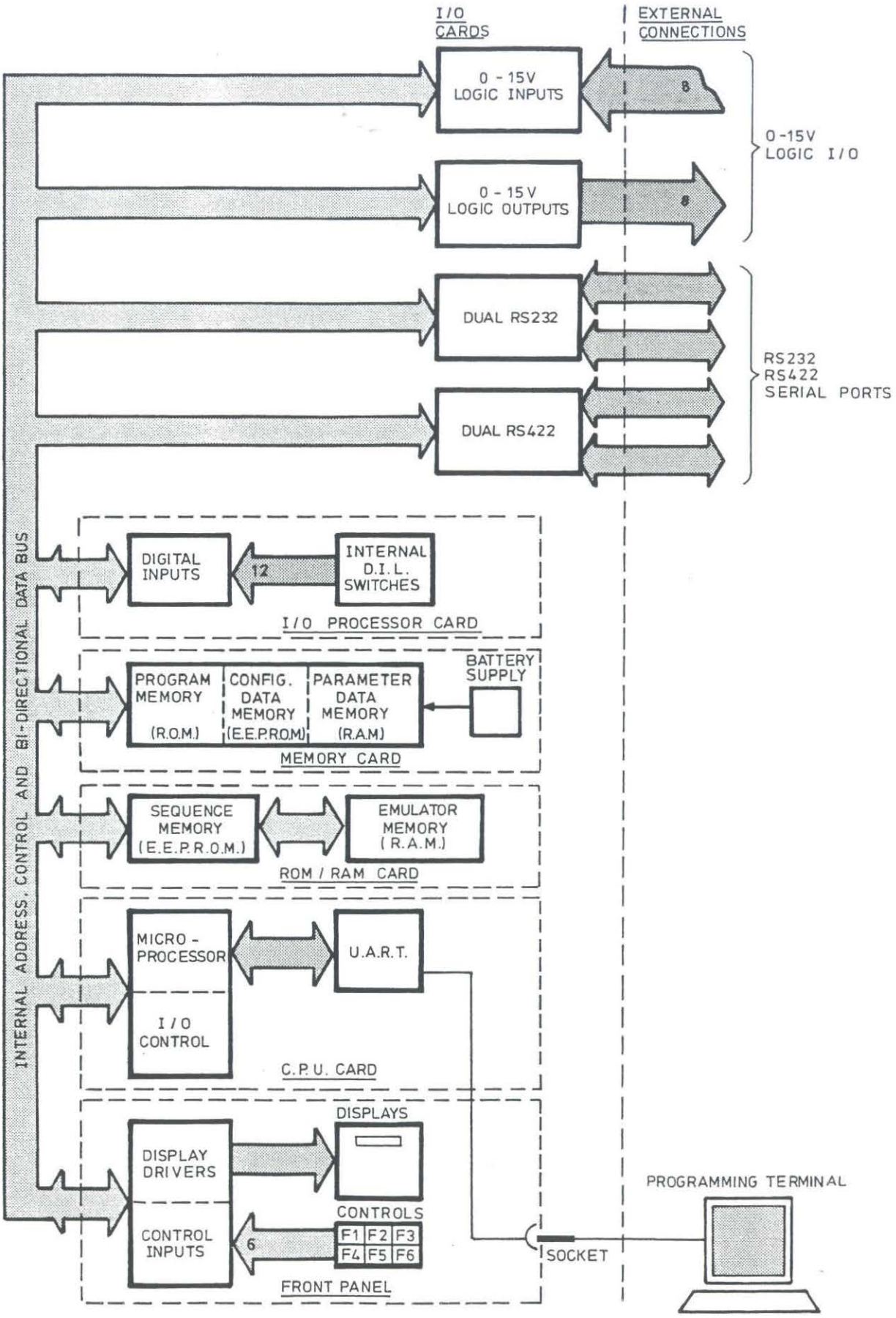


FIG 1.1 6445 MICROSUPERVISOR SCHEMATIC BLOCK DIAGRAM

SECTION 1 GENERAL DESCRIPTION

1.1 Introduction

The 6445 Micro Supervisor is a TCS System 6000 programmable instrument in the same family as the 6433 Programmable Signal Processor.

The hardware enhancements provide the following features:-

- RS422 serial interface to Micro-Vis/Maxi-Vis Supervisory Systems.
- RS422 serial interface for local instrument communications.
- RS232 serial interface via the instrument front panel for an external programming terminal.
- Two RS232 serial interfaces for use as alternate programming terminals, local peripherals, or other communicating devices (e.g. PLCs).

N.B. All serial interfaces are non-isolated.

- 8 non-isolated Digital Inputs.
- 8 non-isolated Digital Outputs.
- Programmable 8 character alpha-numeric display.
- 6 programmable function buttons.

The software enhancements extend the 6433 stack-oriented interpretive programming language "TCS Forth"* and provide

- Floating point arithmetic.
- 16 internal timers with 2ms resolution.
- Real-time clock and calendar.
- 128 internal variables.
- Pseudo channel and pseudo instrument capability.
- Addition of sub-routines for text and data strings.
- Built-in diagnostics and error reporting.

(*) FORTH is the registered trademark of Forth Inc.

The highly compact 'Reserve Polish' notational language allows the following operations to be programmed:-

a) Access to the logic states of any of the direct digital inputs. Combinational logic and sequence timing manipulations and routing results to digital outputs.

b) Access to any of the instrument parameters of the external instruments connected to the instrument bus. Arithmetic, sequencing and logic manipulations may be carried out with routing to any output or non-read-only parameter in the connected instrument data base.

c) The 6445 may perform combinations of (a) and (b) in the same way as the 6433.

d) Text strings may be created in the Forth program and presented to an external printer or VDU for specialist logging and display tasks.

As a continuous background task, the 6445 scans and reads all enquiry-polled parameters within the configured external instruments and the internally configured pseudo channels. This data may be used for internal calculations and is made available to the supervisory computer. In this way the 6445 appears transparent as far as the Maxi-Vis instrument data base is concerned.

It can be seen that the 6445 can be placed between the supervisory system and a group of TCS instruments to provide the following functions:-

- Softwired instrument configurations.
- Sophisticated control strategies.
- Sequencing and logic control for batch plant.
- Simple data logging systems.
- Computation of data from a number of loops.
- Local plant operator interface.
- Modem interface.

The 6445 Micro Supervisor is fully compatible both electrically and mechanically with the Turnbull Control Systems' System 6000 Range of Modular Process Control Equipment.

As a systems component, it plugs directly into the range of TCS rack and bin systems and integrates with the full capabilities of the range of process control monitoring and supervisory systems.

1.2 Features and General Description

The general features of the 6445 Micro Supervisor are as illustrated in Fig 1.1.

The hardware structure is such that each of the instrument functions, namely:-

Front Panel Displays and Operator Controls

Digital Input/Output Signals

Dual UART Interfaces - etc.

are implemented as separate hardware blocks. Each of these functional blocks communicates with the Central Processor Unit (CPU) which controls the overall operation of the instrument via the internal communication busses shown. The CPU itself contains the microprocessor which is the intelligent 'heart' of the device and it in turn has to communicate with 2 blocks of memory. The memory card stores the necessary set of instrument operating programs together with the polled parameters and pseudo channels ranging and status information. The PROM/RAM Emulator card holds the sequence of program steps entered by the programmer.

The front panel contains an 8 character alpha-numeric display and 6 operator pushbuttons that may be utilised within the instrument program.

The 8 character display is used by the background program to display error and diagnostic messages. If this display is used for other programmable functions, the Error/Diagnostic messages will automatically flash over the existing message.

The 6 function pushbuttons have no pre-defined function but may be used within the applications programme.

A socket is provided on the front panel to allow an external programming terminal to be connected which may be used to enter or edit the applications programme.

Two ports at the rear of the instrument may also be used for this purpose, or for remote peripherals, or other communicating devices.

Two further serial ports are provided for the local instrument bus and the supervisory computer.

An 8-way 0-15V Logic Input Card is fitted in Slot 1 and an 8-way 0-15V Logic Output Card is fitted in Slot 2.

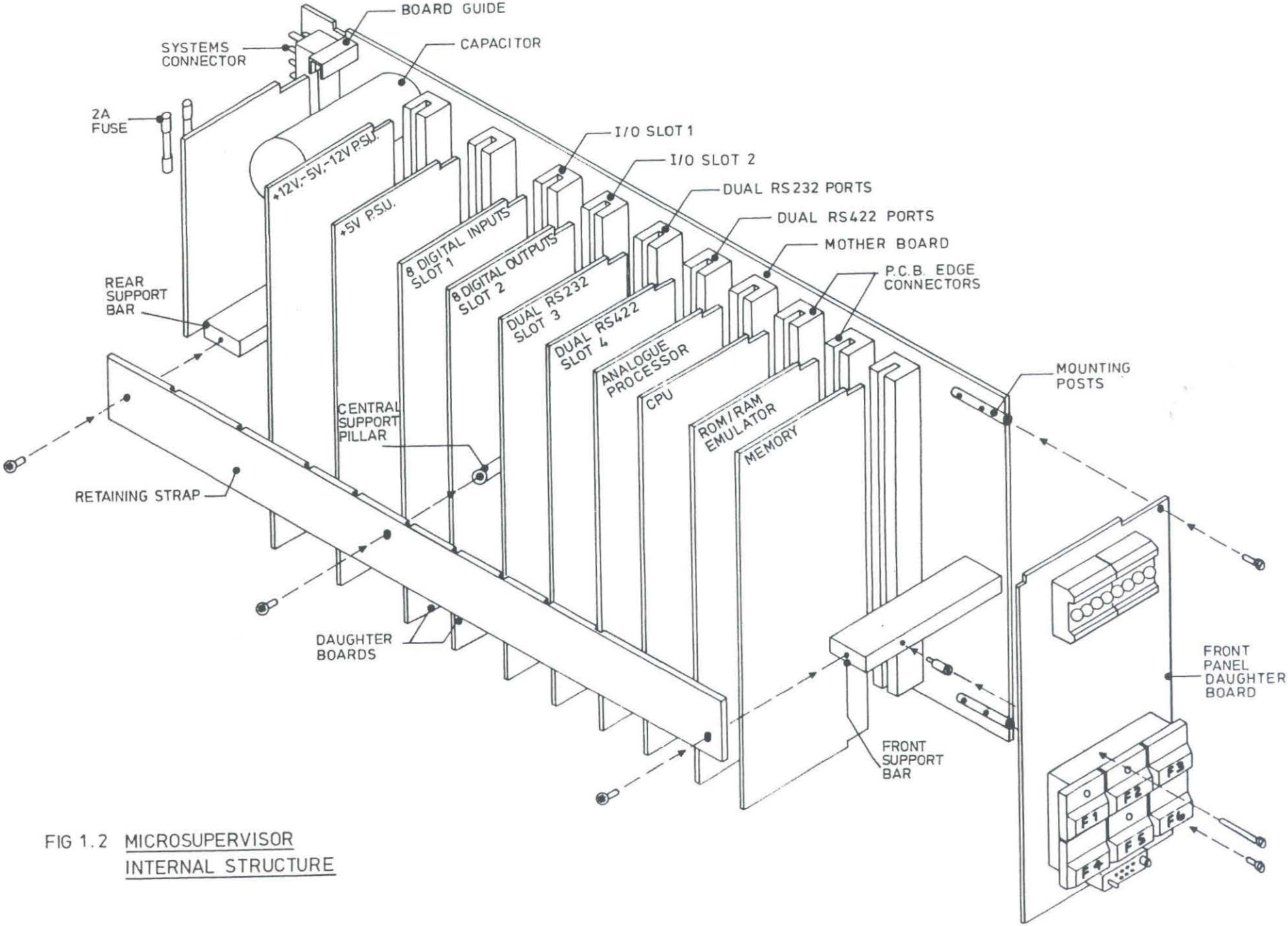


FIG 1.2 MICROSUPERVISOR INTERNAL STRUCTURE

1.3 Mechanical Structure

The Mechanical Structure of the 6445 Micro Supervisor is shown in Fig 1.2. Each of the functional blocks is implemented on a single printed-circuit board (pcb) which plugs into an interconnection or Mother-board via pcb edge connectors. The Front-Panel pcb is connected to the Mother-board via a 15-way single-in-line connector and is secured via three retaining screws and the front support bar. All the other daughter boards plug into 48-way pcb edge connectors except for a small fuse board at the rear of the module. The pcb carries the fuses and power supply protection circuitry and is connected direct to the Mother-board via soldered "F" pins and is restrained by board guides. The large reservoir smoothing capacitor, C1, is mounted directly on to the Mother-board.

The rear end of the Mother-board carries the 48-way male systems edge connector which plugs directly into the TCS racking connector system.

The connectors for the remaining daughter boards are provided with polarising clips to ensure that the boards are always inserted in the correct order. The daughter board connector characteristics are listed in Table 1.1. The I/O daughter boards are firmly held in the Mother-board edge connectors by means of a restraining strap. This strap has lateral grooves for positive mating with each daughter board and is provided with three fixing screws. These are connected to the front support bar, a central support pillar in between I/O slots 3 and 4, and the rear support bar next to the fuse board.

The complete set of daughter boards and the Mother-board slide into a 72mm sleeve assembly which is fitted with a front-panel fascia as illustrated in Fig 1.3. The fascia carries the cover for the programming terminal and the metal catch-handle for module withdrawl. A metal clip is mounted at the rear of the sleeve to lock the Mother-board assembly in position.

1.3.1 Rack, Bin and Panel-Mounting Instruments

The 6445 Micro Supervisor may be mounted in the standard TCS Rack, Bin and Panel-Mounting assemblies, i.e. 7000, 7600, 7900 and 7950.

The 6445 is a standard 72mm wide module and hence the standard 19" assembly will hold 6 units.

The rear connector pin charts are given in Appendices A, B and C.

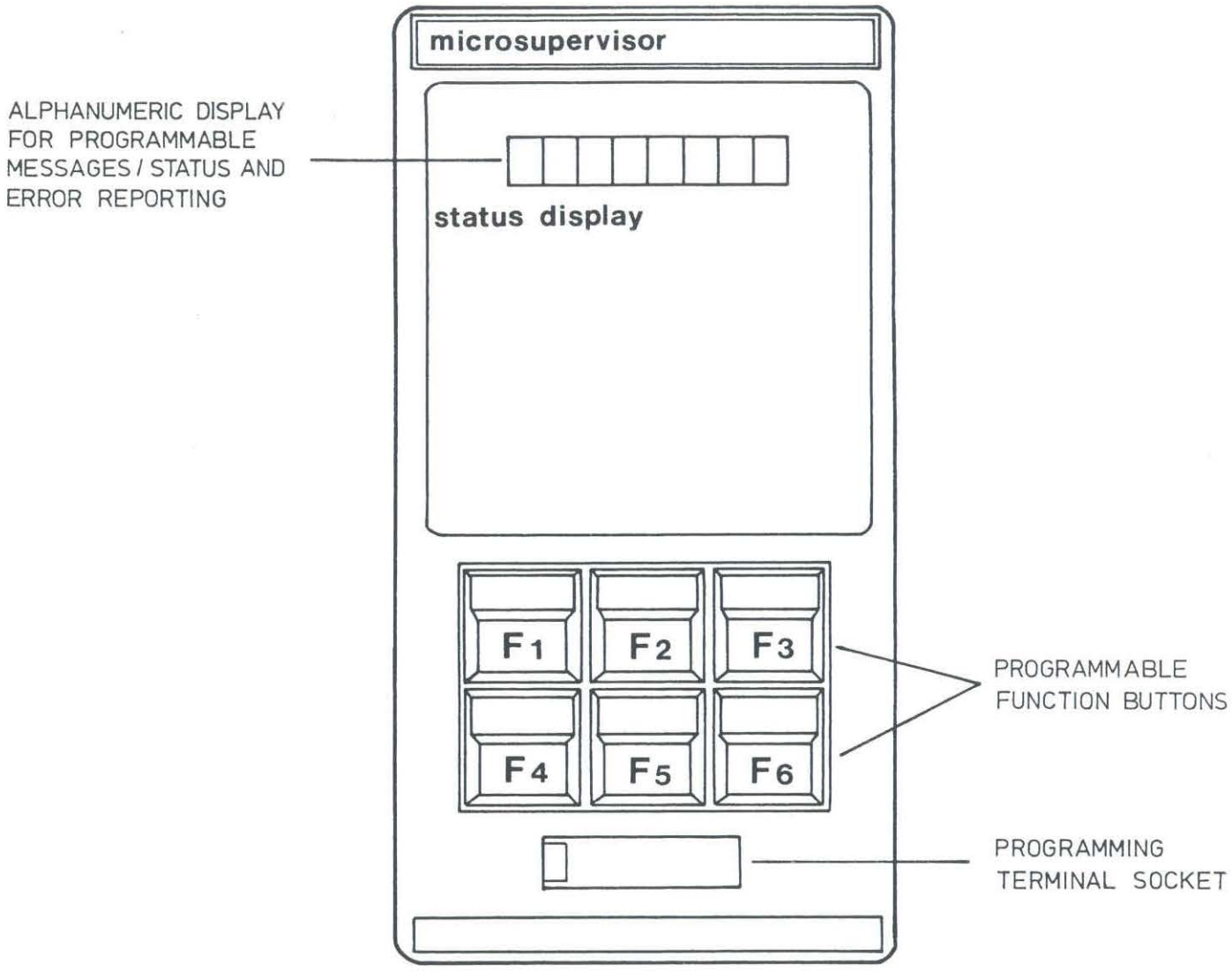


FIG 1 3 6445 MICROSUPERVISOR FASCIA DIAGRAM

CONNECTOR NUMBER	CONNECTOR TYPE	DAUGHTER BOARD FUNCTION	POLARISING KEY POSITION
1	Double-Sided	Memory Mk 6 (012)	40 - 41
2	Double-Sided	ROM/RAM Emulator (003)	40 - 41
3	Double-Sided	Central Processor Unit	39 - 40
4	Double-Sided	Analogue Processor (002)	19 - 20
5	Double-Sided	Dual UART Slot 4	3 - 4
6	Double-Sided	Dual UART Slot 3	3 - 4
7	Single-Sided	8-Way Digital Output Card Slot 2	27 - 28
8	Single-Sided	8-Way Digital Input Card Slot 1	27 - 28
9	Single-Sided	+5V Power Supply	25 - 26
10	Single-Sided	±12V, -5V Power Supply	14 - 15

TABLE 1.1 Daughter Board Edge Connector Characteristics

1.4 Daughter Board Functional Description

Each of the daughter boards are described in turn to indicate their function within the basic 6445 Micro Supervisor.

1.4.1 Front-Panel Daughter Board (Assembly: AC 069452)

The front-panel daughter board holds the display components together with the Operator Control pushbuttons. It comprises a row of 8, red, 17-segment alpha-numeric LED displays. Each of the 8 digits is capable of displaying a full 64 ASCII character set. It may be programmed to display any status message or parameter identity required by the operator, such as Parameter Tag, Operational State, Operator Instructions, etc. It will also display diagnostic messages as well as the programmed functions.

There are 6 function pushbuttons fitted. All the buttons are of the momentary action type.

The pushbuttons have no defined operation in the basic instrument, but may be set up to operate as required within the Applications Programme. The pushbuttons are labelled F1 to F6 inclusive.

The front-panel board contains all the drive electronics associated with these displays and pushbuttons and also carries the 7-pin socket into which the external programming terminal may be plugged.

1.4.2 Central Processor Daughter Board (Assembly: AC 075854)

The CPU daughter board contains the 16 bit microprocessor chip itself together with the associated support logic required for interrupt handling and for providing the necessary input/output decoding logic. A Universal Asynchronous Receiver Transmitter (UART) circuit and associated drivers are used to communicate with the external programming terminal via the front-panel socket.

The CPU card also contains a Watchdog timer circuit which monitors the microprocessor input/output functions. Upon detection of a failure, the instrument-healthy output goes low and the alpha-numeric readout displays the error message.

1.4.3 Memory Daughter Board (Assembly: AC 076042)

The Memory daughter board is used to store the actual 6445 operating programs in a Read-Only Memory (ROM) while the input/output channel parameters and other variables are stored in a non-volatile Randon-Access Memory (RAM).

The RAM chip is made non-volatile by means of a standby battery supply circuit which supplies power when the main supply has failed or undergoes a transient failure. A long-life Lithium primary cell is used for this purpose and it may be isolated from the circuit during long shelf storage periods, if required. An EEPROM is used to store configuration data.

1.4.4 ROM/RAM Emulator Daughter Board (Assembly: AC 075114)

The ROM/RAM Emulator Daughter Board contains 8K bytes of Random-Access Memory (RAM) which is used for storing the user defined sequence of program steps. Programs are always executed from RAM to allow on-line debugging and subsequent editing. Once the program has been checked out fully, the CPU can transfer data from the RAM area into a similar amount of Electrically Erasable PROM (EEPROM). Whenever the 6445 is subsequently powered up, or a sumcheck error is detected, the CPU automatically copies the program from EEPROM back into the RAM area to allow program execution. The CPU can also copy data from the EEPROM area back into the RAM under operator control to permit further editing and debugging cycles to be carried out.

Fig 2.1 shows that the ROM/RAM Emulator also carries a 4-way DIL switch and 4 red LED's along its top edge. With issue 1 software, only one of these switches is used, and this is S1 which serves as an EEPROM write inhibit switch.

1.4.5 Analogue Processor Board (Assembly: AC 069398)

The Analogue Processor Board provides a number of digital and analogue functions as follows:

a) Digital Functions

The board contains 12 internal switches which are used to set up the 6445 for certain communication channel characteristics. Certain CPU busses are also routed through to the selected Input/Output slots 1 to 4 as necessary by logic on this board.

b) Analogue Function

Circuitry is provided on the board which allows the CPU to measure the battery voltage under dynamic loading conditions.

1.4.6 Digital Input Daughter Board (Assembly: AC 069399)
I/O Slot 1

This board contains 8 non-isolated, non-latched, digital input circuits which can be instantaneously accessed by the CPU control and address busses. Each input is provided with a 15V CMOS buffer circuit fitted with a 100k pull-down resistor to 0V.

1.4.7 Digital Output Daughter Board (Assembly: AC 069401)
I/O Slot 2

This board contains 8 non-isolated digital latch circuits driven by the CPU control and address busses. The outputs of each latch are buffered by a 0-15V open- collector TTL gate fitted with a 2k2 pull-up resistor to the 15V supply.

1.4.8 Dual RS232 UART Daughter Board (Assembly: AC 075946)
I/O Slot 3

This board contains 2 non-isolated dual RS232 UART's driven by the CPU control and address busses. The ports are 2 wire RS232 (+12V) transmission standard. The maximum line length is 50ft at 9600 baud with selectable data rates from 110 to 9600 baud.

1.4.9 Dual RS422 UART Daughter Board (Assembly: AC 075946)
I/O Slot 4

This board contains 2 non-isolated dual RS422 UART's driven by the CPU control and address busses. The ports are 4 wire RS422 (0-5V) transmission standard with line impedance of 120-240 ohm twisted pair. The maximum line length is 4000ft and the baud rate is 9600 baud.

1.4.10 +5V Power Supply Daughter Board (Assembly: AC 066518)

This board basically consists of a switching regulator circuit which draws its power from a 20-39 volt smoothed unregulated input and can supply up to 2.5A before current limiting. The board also contains the necessary logic circuitry to detect Power On and the Power Failure conditions and alert the CPU accordingly.

1.4.11 +12V, -5V, -12V Power Supply Daughter Board
(Assembly: AC 066519)

This board also draws its power from the 20-30 volt supply input and uses a monolithic regulator to produce the +12V supply rail. A -16V supply is also generated on the board by means of an inverting regulator circuit and the -12V and -5V supply rails are derived from this with two further monolithic regulators. All 3 of these regulators incorporate current limit and thermal shutdown facilities.

1.4.12 Fuse Daughter Board (Assembly AC 076089)

This board is used to mount the main 2A supply fuse together with circuitry capable of blowing it in the event of any internal supply rail exceeding its voltage tolerance limit. In addition, the fuse board generates a regulated 15V supply for the Watchdog and other digital outputs, while a spare 2A fuse is also mounted on the board for convenience.

1.5 Technical Specification

1.5.1 Operator Display

Alpha-Numeric Readout : 8 character, red 17 segment display with full 64 ASCII character set capability

1.5.2 Operator Control

Function Selection : 6 momentary action, non-illuminated pushbuttons: F1 to F6 inclusive

1.5.3 Power Supplies

a) Input Voltage : (May be unsmoothed, full- wave rectified AC.)
: 20-30V DC recommended operating range
: 19-35V DC absolute maximum input limits

b) Input Current : 550mA

c) Input Fuse Rating : 2A

d) Internal Supply Rails :

Nominal Voltage	Voltage Tolerance	Current Limit
+12V	±0.5V	200mA
+ 5V	±0.25V	2.5A
- 5V	±0.2V	200mA
-12V	±0.5V	300mA

e) Power Failure Detect Threshold : When input voltage falls below 16.5 ± 2V

f) Memory Standby Battery Characteristics : Lithium type
: 3V nominal output at 160mAh
: 8-10 year shelf life typical
: 5 year life typical on continuous standby

g) Output Supply : 15V DC ± 0.5V at 200mA max.

1.5.4 Communications

a) No. of Communication Channels	:	5 serial ports
b) Type	:	Full duplex
c) Functions	:	(A) One dedicated data link via the front-panel used by the external programming terminal
	:	(B) Two dedicated data links via the rear connector for secondary programming terminal and printer
	:	(C) Two multi-drop data links via the rear connector used by a supervisory computer and instrument bus

(A) Front-Panel Terminal Link

a) Transmission Standard	:	Non-isolated 2 wire RS232/V24 (±12V)
b) Data Rate	:	Selectable from 110, 300, 600, 1200, 2400, 3600, 4800, or 9600 baud
c) Character Length	:	10 bits made up of:- 1 start + 7 data + 1 parity (even) + 1 stop

(B) Local Peripheral Link

a) Transmission Standard	:	Non-isolated 2 wire RS232/V24 (±12V)
b) Data Rate	:	Selectable from 110, 300, 600, 1200, 2400, 3600, 4800, or 9600 baud
c) Character Length	:	Selectable

(C) Multi-Drop Supervisory Link

a) Transmission Standard	:	Non-isolated 4 wire RS422 (0-5V)
b) Line Impedance	:	120-240 ohm twisted pair
c) Line Length	:	4000ft. max. (at 9600 baud)
d) No. of Instruments/ Line	:	16
e) Data Rate	:	9600 baud
f) Character Length	:	11 bits made up of:- 1 start + 8 data + 1 parity (even) + 1 stop

1.5.5 Physical Specification

a) Mechanical

(i)	Width	:	72mm
(ii)	Height	:	142mm
(iii)	Depth	:	300mm
(iv)	Weight	:	1.7kg.

b) Environmental

(i)	Operating Temperature	:	0 to +50 deg C
(ii)	Storage Temperature	:	-20 to +55 deg C
(iii)	Relative Humidity	:	5 to 90% non-condensing
(iv)	Ventilation	:	Rack or bin mounted instruments must have at least a 1U gap above and below the case for proper ventilation
		:	Sleeve mounted instruments should be mounted as specified in the 7900 Sleeve Data Sheet (see Appendix C)

1.6 Order Code

The 6445 has no physical options and is specified by the product name 6445.

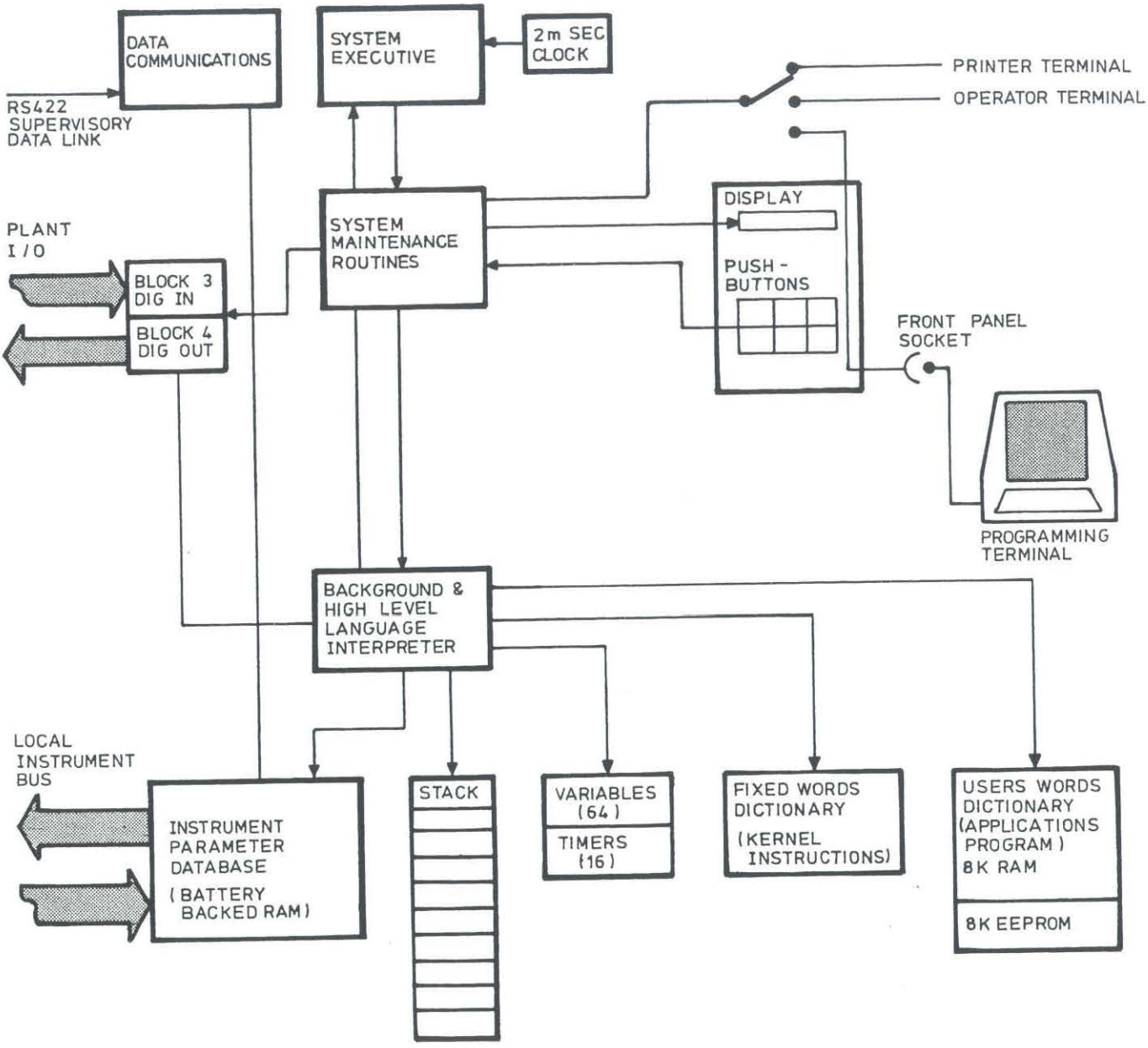


FIG 1.4 6445 MICROSUPERVISOR FUNCTIONAL OVERVIEW

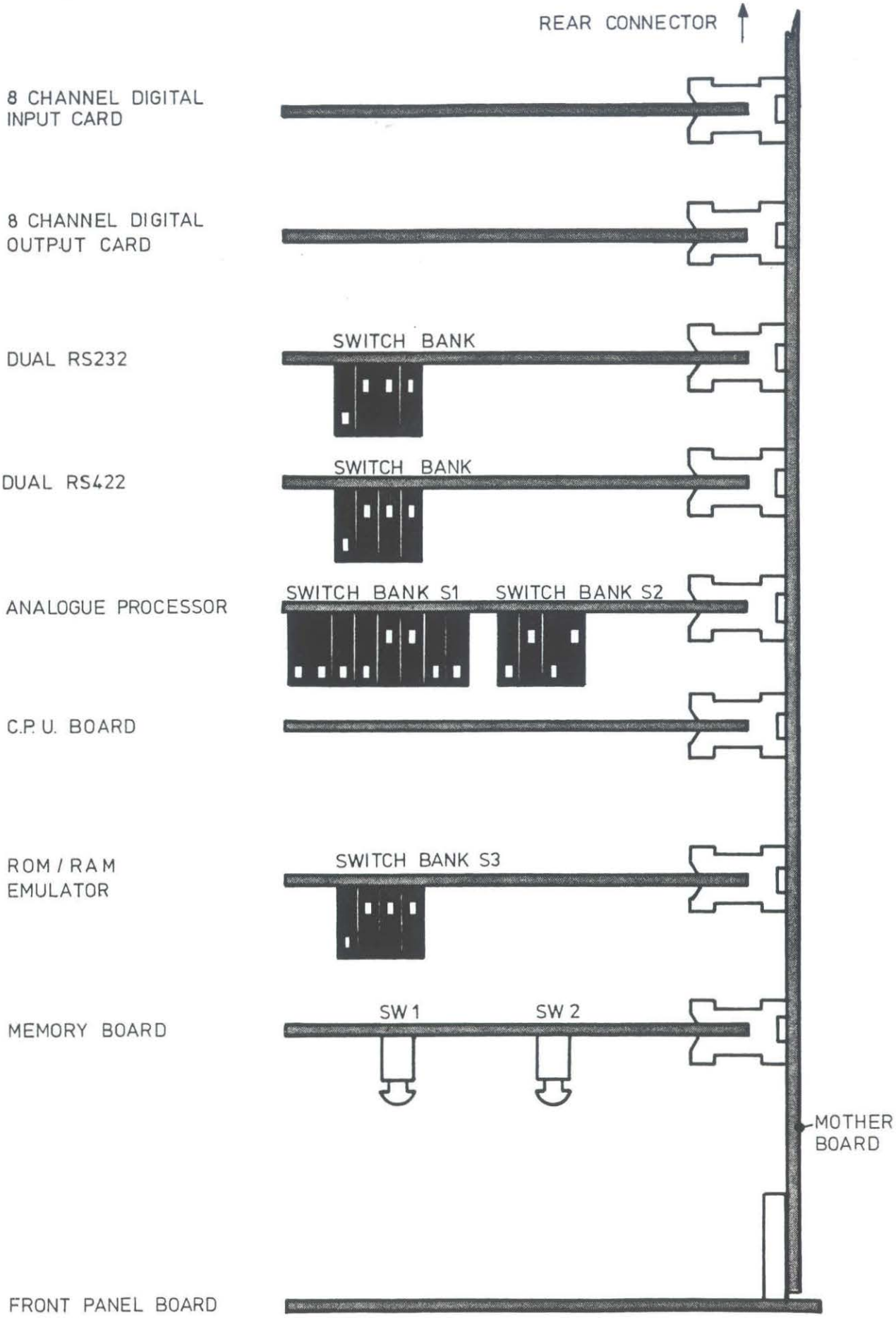


FIG 2.1 TOP VIEW OF MICROSUPERVISOR SHOWING INTERNAL SWITCH POSITIONS

SECTION 2 INSTALLATION

2.1 General Requirements

The sequence of events for installing a 6445 Micro Supervisor in a system should be as follows:

i) Rack or Bin Systems

a) Ensure that a 72mm slot, fitted with a 48-way connector and all the correct mounting hardware, is available in a TCS 7000 Rack or 7600 Bin.

b) Ensure that an appropriate 24V DC supply is available and has been wired to the slot in the manner outlined in the System 6000 Installation Guide, Section 5.

ii) Self-Powered Sleeves

a) Ensure that a 7900/7445 Self-Powered Sleeve is available.

b) Ensure that the 7900/7445 Self-Powered Sleeve has been correctly wired to either a 110/240V AC mains supply, or a 24V DC supply (see Appendix C).

iii) Before sliding the instrument into the rack, bin or 7900/7445 sleeve, check that all the internal switches have been set correctly as outlined in Section 2.3.

iv) Check that all the plant connections and other external inputs have been implemented correctly and that the signals are at the right levels as outlined in Section 2.4.

v) Power up the instrument in the manner outlined in Section 2.5.

vi) The 6445 may now be programmed for specific applications using the interpretive high level language as described in the Intelligent Instruments Programming Manual.

2.2 Power Supply Connections

For a description of power supply connections, including discussion of:

Basic Ground Connection

Connection of Separate 24V DC Supply

Common Parallel Supply Configuration

Combination Supply Configuration

External Ground Connections

refer to the System 6000 Installation Guide, Section 5.

Switch Bank	Switch Number	Switch Action		Switch Function
		On (DOWN)	Off (UP)	
S2 Right	1			Not used.
	2			Not used.
	3			Not used.
	4	Enable	Disable	Instrument Healthy Output Enable
S1 Left	1	See Table 2.2		Not used.
	2			Baud rate Select for front-panel RS232 port.
	3			
	4			
	5			Not used.
	6			Not used.
	7			Not used.
	8			Not used.

TABLE 2.1 Analogue I/O Processor Switch Functions

Switch Bank	Switch Number			Baud Rate	No. of Stop Bits
	2	3	4		
1	Off	Off	Off	110	2
	Off	Off	On	300	1
	Off	On	Off	600	1
	Off	On	On	1200	1
	On	Off	Off	2400	1
	On	Off	On	3600	1
	On	On	Off	4800	1
	On	On	On	9600	1

TABLE 2.2 Front Panel RS232 Port Baud Rate Selections

2.3 Internal Switch Settings

Fig 2.1 is a view of the 6445 Micro Supervisor looking down at the top of the sleeve and illustrates the relative position of the various daughter boards and their associated internal switches.

2.3.1 Memory Isolation Switch

This switch, SW1, is situated on the memory daughter board and its function is to isolate the CMOS memory from the standby battery supply. In normal operation, this switch should be ON (top pressed down) to ensure retention of data when external power is interrupted for any reason.

If the instrument is to be stored or left unpowered for any length of time without stored data in memory, then the switch should be OFF (top raised up) to prevent draining of the standby battery.

It should be noted that when the switch is set OFF that the stored data will be retained for 20 minutes minimum. After that time, data may be lost.

2.3.2 EEPROM Write Enable Switch

The communications configuration is stored in a 2K EEPROM on the memory daughter board. If it is desired to retain the present configuration, and prevent alteration to it, this switch should be OFF (top raised up).

2.3.3 Analogue I/O Processor Board Internal Status Switches

Fig 2.1 shows that the analogue input/output processor daughter board carries a 4-way and an 8-way DIL switch situated along the top edge. These two switch banks, S1 and S2, are used for setting up various functions of the 6445 Micro Supervisor. The functions assigned to the switches are listed in Table 2.1.

a) Switch Bank S1 Function

The only switches used are nos. 2, 3, and 4, which select the front panel RS232 port baud rate, as shown in Table 2.2.

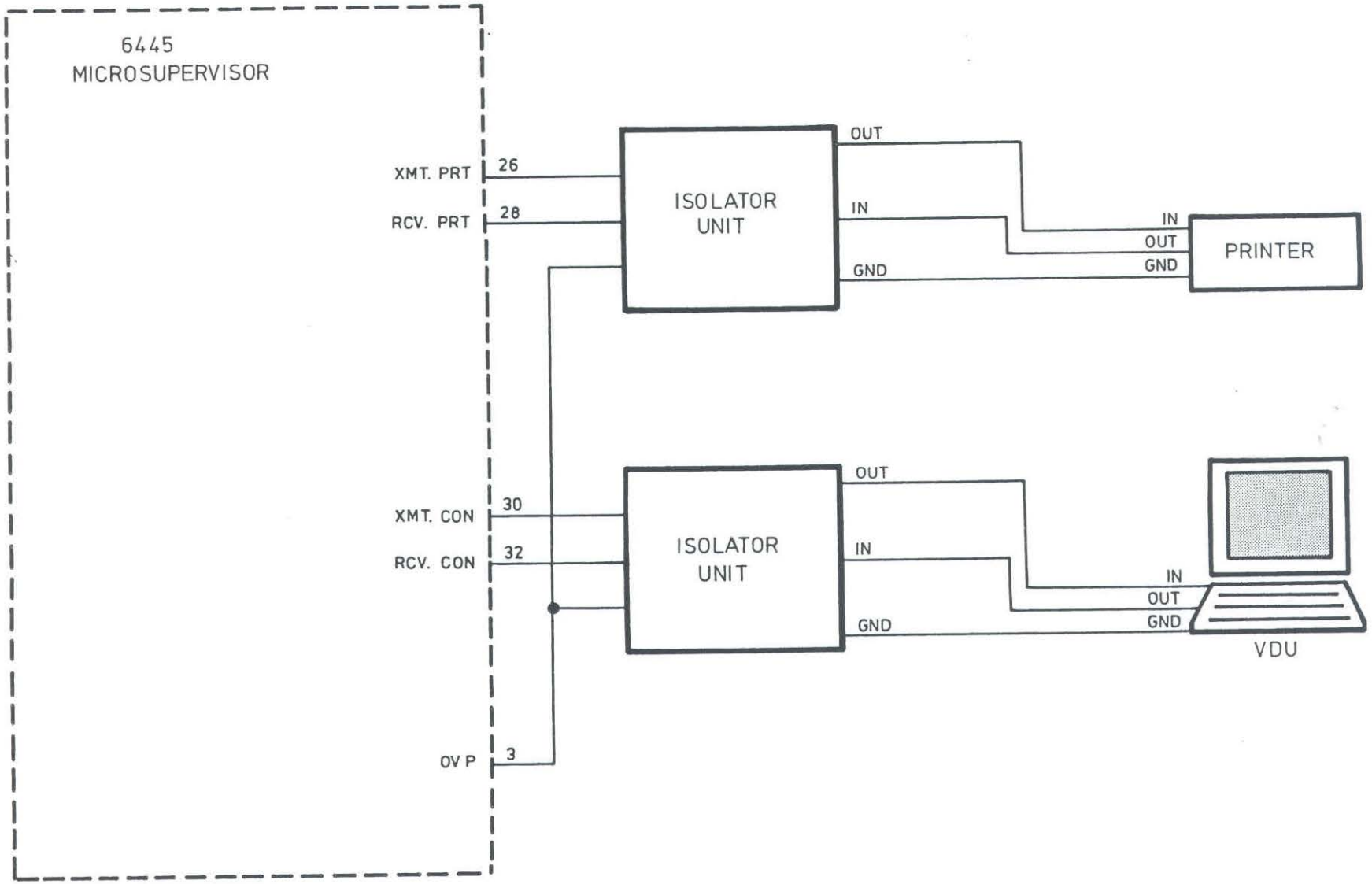


FIG 2.2 6445 MICROSUPERVISOR RS232 INTERCONNECTIONS

b) Switch Bank S2 Function

Only one of the four switches of switch bank S2 is used by Issue 1 software and this is allocated to the following function:-

a) Switch No. 4

This switch allocates digital output 8 as an 'Instrument Healthy' output. This output can be used to control a relay to allow the supervisory system to communicate with the instrument plant line by connecting the communication lines directly, bypassing the 6445 Micro Supervisor.

2.3.4 ROM/RAM Emulator Board Switches

It can be seen from Fig 2.1 that the ROM/RAM Emulator board has a third 4-way DIL switch bank, S3, available along its top edge. The 6445 issue 1 software currently allocates only one of these switches. The function of this switch is as follows:

a) Switch 1

This switch is used to control the write enable line to the 8K block of EEPROM situated on the ROM/RAM Emulator board as follows:

S3 no.1 OFF = Writing enabled.

S3 no.1 ON = Writing inhibited (read-only)

If S3 no.2 is ON and an attempt is made to copy from RAM into EEPROM using the "STORE" utility, an error is indicated.

2.3.5 UART Daughter Card Switches

Fig 2.1 shows that each UART daughter card has a 4-way DIL switch mounted on it. These switches are not used on the 6445.

Parameter		
Mode of Operation		Single Ended
Number of Drivers and Receivers allowed On Line		1 Driver 1 Receiver
Maximum Cable Length (m)		15
Maximum Data Rate (Bits/sec)		20k
Maximum Common Mode Voltage		±25V
Driver Output Signal		± 5V min ±15V max
Driver Load		3kOhm - 7kOhm
Driver Slew Rate		30V/ms max
Drive Output Resistance (high Z state)	Power On	NA
	Power Off	300 Ohm
Receiver Input Resistance		3kOhm - 7kOhm
Receiver Sensitivity		±3V

TABLE 2.3 RS232 Interface Characteristics

2.4 Plant and Other External Connections

Appendix A lists the function of the rear connector pins of the 6445 Micro Supervisor. For correct operation of the instrument in a system, it is necessary that external plant and equipment is connected up to it in the following manner.

2.4.1 Power Supplies

Power supply connections are fully dealt with in the System 6000 Installation Guide, Section 5.

2.4.2 Digital Inputs

A digital input board (type 16) is fitted in I/O slot 1. This provides 8 digital inputs which are only available to the FORTH program. The logic 1 input level is from 5-15V.

2.4.3 Digital Outputs

I/O slot 2 is fitted with an 8-way digital output board (type 24). Seven of these outputs are accessible only by the FORTH program. Channel 8 (pin 25) may be assigned as a "device operating" output. This goes high whenever the 6445 is communicating with the plant lines. It is intended to drive a relay which connects the supervisory bus directly to the plant line whenever the 6445 is not communicating with the plant line.

2.4.4 RS422 Serial Data Busses

For a full discussion of the RS422 Serial Data Busses, including discussion of:

Interface Connections

Cable Impedance and Termination

Interface Signal Polarity

refer to the System 6000 Installation Guide, Section 7.

2.4.5 RS232 Serial Data Lines

The serial data links between the 6445 Micro Supervisor and its local peripherals are implemented using EIA RS232 standard interface. Its characteristics are shown in Table 2.3.

The implementation of this interface is shown in Fig 2.2. The use of line isolators is strongly recommended as taking the 0V from a peripheral device to a system 0V can seriously affect system accuracy and safety due to ground loops, etc. The common 0V between 6445 and isolator, or between isolator and peripheral, can be conveniently provided by using the screen of a twin screened cable. As the line is short, no special termination procedures are required.

The normal condition for an output is the idle, i.e. not transmitting, state is to be a logical one, chosen to be nominally -12V. Logic zero is nominally +12V.

The only handshake protocol available on the 6445 Micro Supervisor RS232 ports is that commonly know as X-ON, X-OFF.

2.5 Instrument Power Up Sequence

There are two possibilities that can occur when the 6445 Micro Supervisor is connected to an external power supply.

2.5.1 Power Up From Unprogrammed State

When no program is stored in the EEPROM, then at power up the instrument will be in the HALTED state. The configuration will be random, or may contain no valid instruments. In the latter case, the diagnostic message NUL CFIG will be flashed on the status display.

2.5.2 Power Up From a Previously Programmed State

When the instrument at power up finds a program in EEPROM, the program is copied into RAM and begins execution.

2.6 6445 Hardware Diagnostic Facilities

The 6445 incorporates a number of diagnostic facilities for continuously montoring and checking status of the instrument hardware during operation. Each of these diagnostic facilities provides the following features:

i) Indications and identification of the fault in the front panel status display and a rear panel logic level.

ii) Well defined procedures for each fault type to maximise plant safety.

iii) Automatic re-start under certain transient fault conditions.

2.6.1 Watchdog Timer

The CPU card incorporates a Watchdog Timer circuit which has to be refreshed periodically by the CPU to maintain correct operation. If the CPU fails to refresh the Watchdog at the normal rate the following action occurs:

a) The WATCHDOG TIMER logic output on pin 9 of the rear connector is reset from 15V to 0V to indicate the fault condition and will stay low as long as the fault persists. The feature allows the pin 9 output to be used for external monitoring purposes.

b) All 8 digital outputs are reset to 0V to indicate the fault condition and will stay low as long as pin 9 is a 0V.

While the Watchdog is tripped out, a circuit applies restart signals every 10ms. There are three possible outcomes to a restart signal:

1) If the failure did not corrupt the stored program, or the configuration data in EEPROM, then the 6445 will restart as described in Section 2.5.2. The Watchdog output, pin 9, is set to 15V by the CPU about 30ms after restart occurs.

2) If failure corrupted the contents of EEPROM, the 6445 will restart as described in Section 2.5.1. The Watchdog output, pin 9, is set to 15V by the CPU about 30ms after restart occurs.

3) If the failure was due to a permanent hardware fault the CPU will not be able to refresh the Watchdog and the pin 9 logic output will remain at 0V.

INSTRUMENT FAULT	DIAGNOSTIC MESSAGE	ERROR RECOVERY
Watchdog failure	(Blank)	Replace instrument
Digital Input Card (I/O slot 1) faulty	CARD 1 ER	Replace Card 1
Digital Output Card (I/O slot 2) faulty	CARD 2 ER	Replace Card 2
Dual RS 232 UART Card (I/O slot 3) faulty	CARD 3 ER	Replace Card 3
Dual RS 422 UART Card (I/O slot 4) faulty	CARD 4 ER	Replace Card 4
Plant line configuration exceeds memory size	DB OVRFL	Edit configuration
Configuration EEPROM could not be written to	EEROM ER	Check write-protect jumper position
No user program running	*HALTED*	Run a program
Plant line configuration empty	NUL CFIG	Create a configuration
Run time error in user program	RT ERROR	Locate and correct the error
TEST word prompts	RCX ECHO	-
	WAIT KEY	-

TABLE 2.4 6445 Instrument Diagnostics

2.6.2 Instrument Diagnostic Messages

The 6445 Micro Supervisor monitors various functions within the instrument, apart from the Watchdog check, as described in Section 2.6.1. The additional diagnostic functions are listed in Table 2.4, with the diagnostic message that each one displays on the status display, e.g:

CARD3 ER

The 6445 hardware incorporates data I/O ports on the front-panel analogue I/O processor and the I/O daughter cards. A connection is made between input and output port to allow the CPU to check that each port is operating. Any board which fails this test, the appropriate diagnostic message is displayed. The diagnostic messages are described briefly below:

a) Front-Panel Hardware Fault

FP ERROR (Front Panel Hardware Error)

The CPU attempts to output this message when the front panel data ports are found to be faulty. All pushbuttons are disabled.

b) I/O Board 1,2,3,4 Hardware Fault

CARD1 ER (Card 1 Hardware Error)
CARD2 ER (Card 2 Hardware Error)
CARD3 ER (Card 3 Hardware Error)
CARD4 ER (Card 4 Hardware Error)

If a daughter card is faulty, the CPU displays the appropriate message on the status display.

c) Configuration EEPROM Error

EEROM ER

While attempting to write to the configuration EEPROM, an error was found, usually caused by the write protection being enabled.

d) User Program Run Time Error

RT ERROR

The FORTH interpreter has found an error at run time. The user must the error locate and correct the program.

e) No User Program Running

HALTED

The diagnostic message indicates that there is no user program executing, either because of a fault condition, or because the user is logged onto the instrument. This message can be removed by running a program.

f) Configuration Empty

NUL CFIG

There are no instruments, real or pseudo, in the instrument configuration.

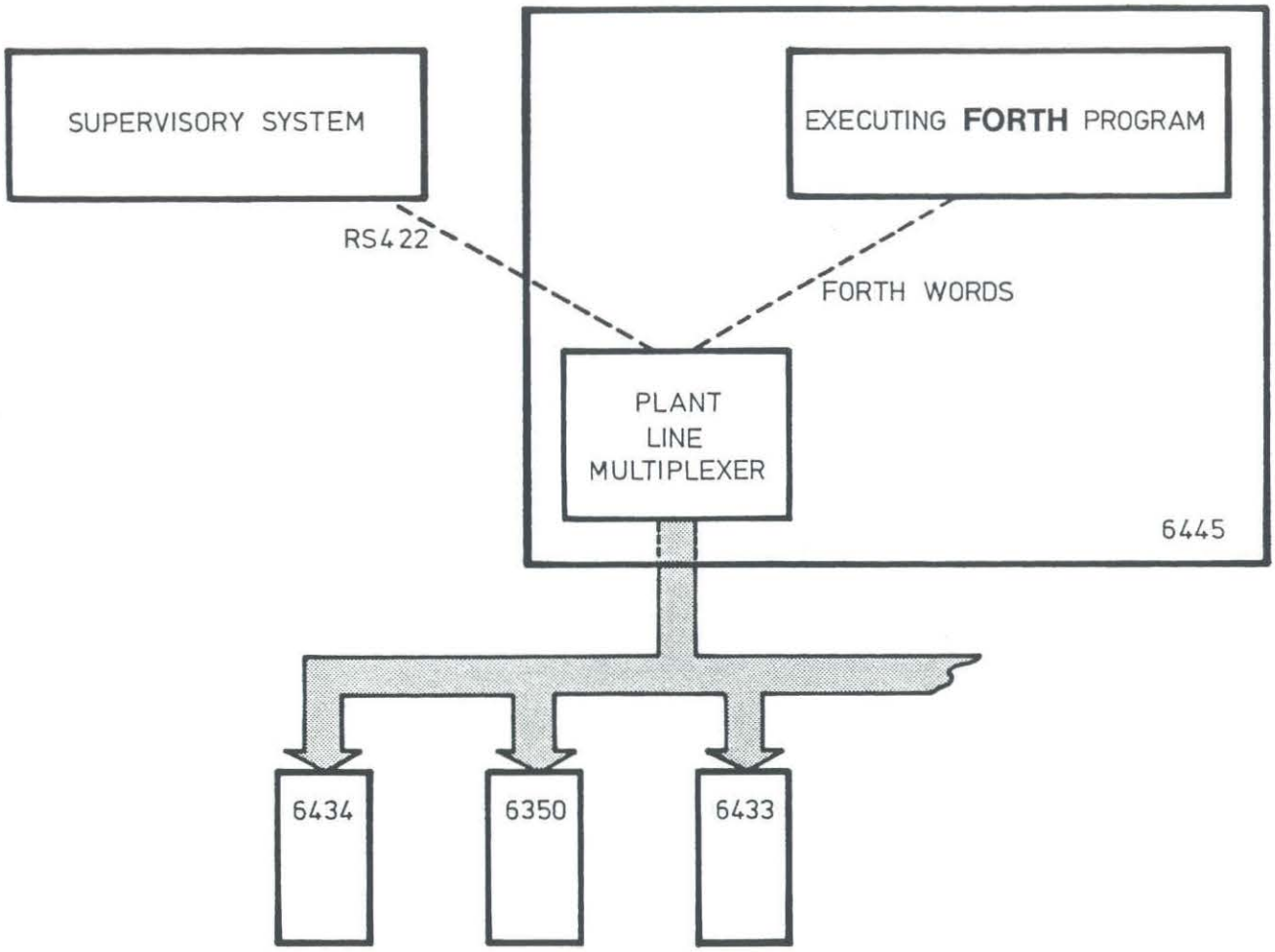


FIG 3.1 6445 MICROSUPERVISOR COMMUNICATIONS

SECTION 3 PLANT LINE COMMUNICATION

Overview

The 6445 allows a users FORTH program to access the data base of other System 6000 instruments. A supervisory system can also access these same instruments. Neither the 6445 Micro Supervisor, nor a supervisory system, need be aware of the others existence.

This situation is achieved by placing the instruments on an RS422 bus, called the Plant Line connected to the 6445. Operationally the 6445 communication can be represented by Fig 3.1.

Only those instruments on its own plant line can be accessed by the 6445 Micro Supervisor. Other instruments may be placed on the supervisory system RS422 bus (subject to bus loading). This group of instruments is accessible to the supervisory system, but not to the 6445 Micro Supervisor. Such a system would have the structure shown in Fig 3.2.

3.1 Communication Protocol

The 6445 supports an extended binary version of ANSI Standard X3.28 for its RS422 plant and supervisory lines. The extended binary protocol is described in Section 5 with reference to supervisory line communications. Because the 6445 introduces a delay in communications, it is not recommended practice to "cascade" 6445 Micro Supervisors.

An important feature of the binary protocol is enquiry polling. The 6445 Micro Supervisor cyclically enquiry polls all the instruments on its plant line which are known to it. This list of instruments is known as its plant line configuration. The 6445 then stores an image of all enquiry polled parameters of the plant line configuration, together with flags to indicate if the data has changed. Upon receiving an enquiry poll of an instrument in its plant line configuration, the 6445 Micro Supervisor interrogates its own flags and responds, if there is new data, by sending the data it previously gathered from the plant. The flags are reset by an acknowledgement from the supervisory system. It may be noted that enquiry polling the plant line by the 6445 and enquiry polls from the supervisory system are asynchronous. This leads to the data reported to the supervisory system being "old" by a certain amount.

This is discussed further in Section 3.4.

Other features of the binary protocol, single and multi parameter polls and selection, are handled by the 6445 effectively "relaying" the messages between the supervisory system and plant line. This leads to a delay in replying to a message, so necessitating the use of the SOH character. This is discussed in Section 5.3.1.

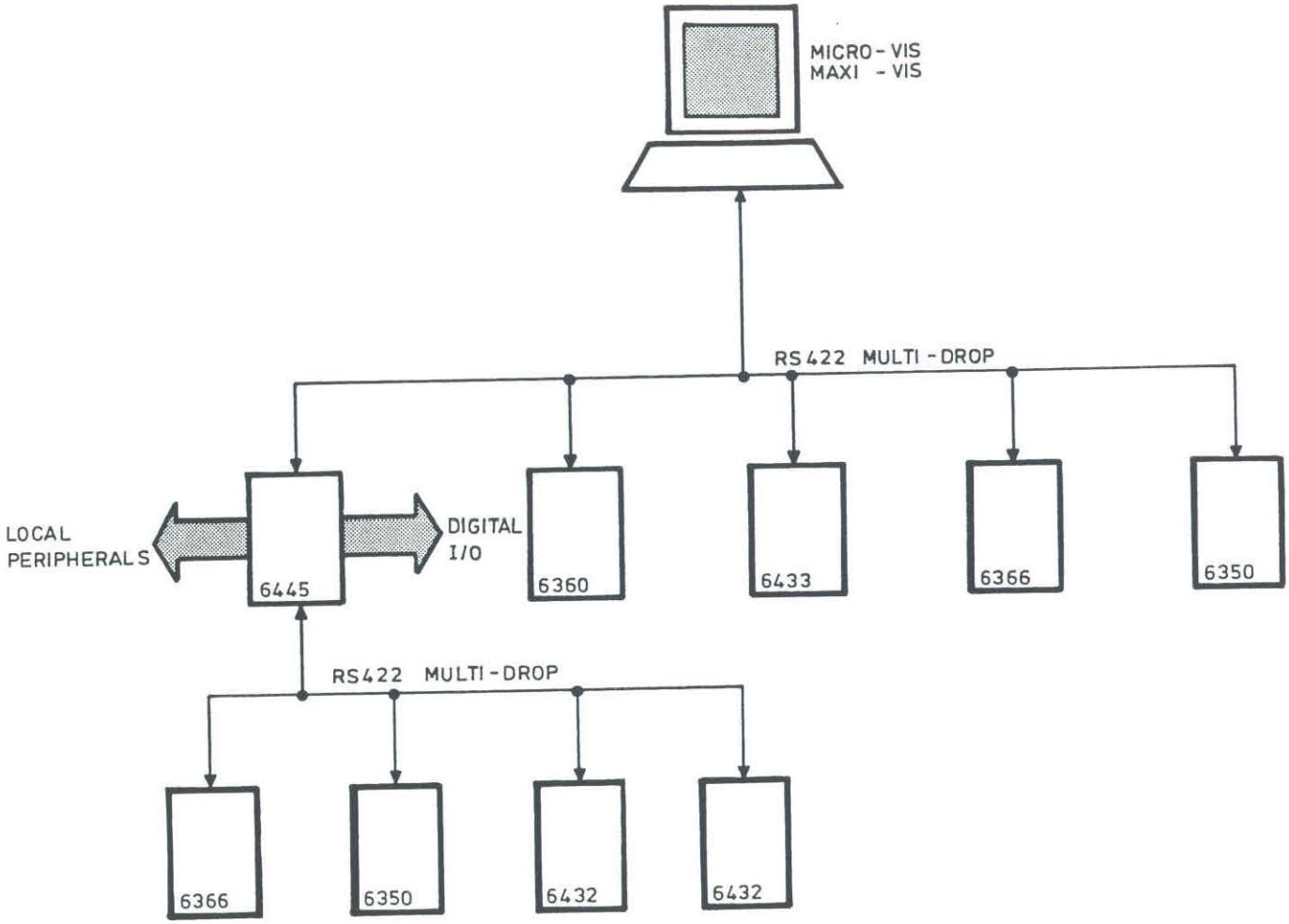


FIG 3.2 6445 MICROSUPERVISOR COMMUNICATIONS NETWORK

3.2 Supported Instrument Types and Memory Usage

In order to store an image of the enquiry polled parameters and their associated flags, a certain amount of memory must be allocated for each instrument in the plant line configuration. This is done by the 6445 automatically, but the available space is limited to 5376 bytes. Table 3.1 shows the list of System 6000 instruments supported by the 6445 Micro Supervisor, together with the memory used by each type. It should be noted that the 6850 Programmer is not supported by the 6445 Micro Supervisor.

As an example of maximum capacity, a 6445 could be configured for:

	128	6350 Process Controllers
or		
	91	6360 Bargraph Process Controllers
or		
	16	6433 Analogue 8-Channel Cards
or		
	128	6433 Digital 8-Channel Cards

With no other restrictions, the 6445 Micro Supervisor could support:

	128	Control Loops
or		
	128	Analogue Points
or		
	1024	Digital Points

3.3 Bus Loading

Up to 16 modules may be attached directly to the 6445 Micro Supervisor plant line. If a single 8245 Communication Buffer Unit is used to expand one line to four, up to 64 modules may be attached. The 8245 carries the additional benefit of opto-isolation.

INSTRUMENT TYPE	FUNCTIONAL DESCRIPTION	MEMORY USAGE
6350	Process Controller	42 bytes
6351	Incremental Controller	38 bytes
6352	Bushing/Averaging Controller	42 bytes
6353	Flow Controller	42 bytes
6355	Auto-tuning Controller	58 bytes
6356	Programmable Controller (2 loop)	58 bytes/loop
6358	8-Loop Controller	42 bytes/loop
6360	Process Controller (Bargraph)	58 bytes
6363	Flow Controller (Bargraph)	58 bytes
6365	Auto-tuning Controller (Bargraph)	58 bytes
6366	Programmable Controller (2 loop - Bargraph)	58 bytes/loop
6432/AI	8-Channel Analogue Input Board	322 bytes
6432/AO	8-Channel Analogue Output Board	322 bytes
6432/DI	8-Channel Digital Input Board	22 bytes
6432/DO	8-Channel Digital Output Board	22 bytes
6433/AI	8-Channel Real/Pseudo Analogue Input Board	322 bytes
6433/AO	8-Channel Real/Pseudo Analogue Output Board	322 bytes
6433/DI	8-Channel Real/Pseudo Digital Input Board	22 bytes
6433/DO	8-Channel Real/Pseudo Digital Output Board	22 bytes
6434	8-Channel Flow Totaliser	42 bytes/chan
6435	8-Channel Advanced Flow Totaliser	42 bytes/chan
6436	8-Channel Flow Monitor	42 bytes/chan
6437	8-Channel Flow Computer	42 bytes/chan

TABLE 3.1 List of Supported 6000 Instrument Types and Their Corresponding Memory Usage

(Note: Total Memory Available = 5376 bytes)

3.4 Scan Time

The scan time is a measure of the mean time taken to perform one update of the stored data in the 6445 database.

The scan rate is important as it directly affects:-

a) The size of control task which may be performed by the supervisory computers.

b) The age of the data presented to the supervisory computers.

For most practical purposes a maximum scan time (ST max) of approx. 500ms is appropriate such that the overall scan rates of the Micro-Vis/Maxi-Vis systems are not significantly affected.

The acceptable scan time is purely applications dependent.

The scan time is the sum of the time taken to enquiry poll each of the instruments configured in the 6445 database (the Instrument Scan Time - IST), plus the time taken to poll non-enquiry polled parameters or to update (select) parameters (the Computer Parameter Changes - CPC).

a) Instrument Scan Time (IST)

Table 3.2 gives an estimate of the best and worst practical instrument scan times for each of the supported System 6000 instruments. The best practical instrument scan time is where no enquiry polled parameters have changed and hence the instrument has nothing to report. The worst practical instrument scan time is where all the plant-variable (as opposed to operator variable) enquiry polled parameters have changed (e.g. on a 6350, that is the PV, SP and OP parameters). Table 3.2 also lists the absolute worst case instrument scan times, where all enquiry polled parameters have changed (e.g. at power-up), however, this is an abnormal condition and hence only the practical worst case instrument scan time is used in determining the maximum overall scan time (ST max).

b) Computer Parameter Changes (CPC)

When the supervisory computer either performs a selection (update) of a parameter, or polls a non-enquiry polled parameter, it is necessary for the 6445 to select/poll the instrument directly, rather than simply access its own database. The time taken to do this is known as the Computer Parameter Change period (CPC), and is typically 100ms.

Instrument Type	Best Case	Best Case Conditions	Worst Case	Worst Practical Case Conditions
6350,52,53,55, 56,58,60,63, 65, & 66	6.5ms	No Changes	24ms	3 Parameter Changes/ Poll (PV, OP and SP)
6351	6.5ms	No Changes	19.5ms	2 Parameter Changes/ Poll (PV and SP)
6434,35 (8 Channel)	52ms	No Changes	156ms	2 Parameter Changes/ Channel/Poll
6432,33 Analogue Card (8 Channel)	6.5ms	No Changes	47ms	1 Parameter Change/ Channel/Poll
6432,33 Digital Card (8 Channel)	6.5ms	No Changes	15ms	1 Parameter Change/ Channel/Poll

N.B. The absolute worst case scan time/instrument is on power-up or at a complete database change:

6350/60	-	50msecs
6358/6434	-	360msecs/8 Channels
6432/6433 Analogue Card	-	320msecs/8 Channels
6432/6433 Digital Card	-	22msecs/8 Channels

TABLE 3.2 6445 Instrument Scan Times

c) Overall Scan Time (ST)

The overall scan time (ST) is the sum of all the instrument scan times (IST's), plus all the Computer Parameter Change periods (CPC) which occur whilst all the instruments are scanned.

$$\Sigma ST = \Sigma IST + CPC \quad (i)$$

The sum of all the IST's is easily derived by adding the IST for each instrument configured in the 6445 database.

The sum of all the CPC's is not so readily determined, as the number of CPC's during the overall scan time depends on the overall scan time itself.

Given that the number of selections/polls per second is known, then the number per scan time is given by:

$$\text{Selection/Polls Per Scan Time} = ST \times [\text{Selection/Polls Per Second}]$$

Hence the sum of all CPC's:

$$\Sigma CPC = CPC \times ST \times [\text{Selection/Polls Per Second}]$$

Substituting the above in equation (i):

$$ST = \Sigma IST + CPC \times ST \times [\text{Selection/Polls Per Second}]$$

Solving for ST:

$$ST = \frac{\Sigma IST}{1 - CPC \times [\text{Selections/Polls Per Second}]}$$

Where all times are in seconds.

Example

Applications with 16 x 6350 Controllers with one computer change per second:

Best Case:

$$ST\ min = \frac{16 \times 0.0065}{1 - 0.1 \times 1}$$

$$= 115.55ms$$

Worst Case:

$$ST\ max = \frac{16 \times 0.024}{1 - 0.1 \times 1}$$

$$= 427ms$$

3.5 Creating The Plant Line Configuration

The list of instruments on the plant line is created either automatically, or by the user in a question and answer session. In order to do this, the user must first connect a terminal to the front panel port, or to the console line. The user must then log-on as described in the Intelligent Instrument Programming Guide, Section 4.

Three FORTH utility words are provided to enable the configuration to be created. These words are:

?CFIG - Display Plant Line Configuration

ACFIG - Automatic Configuration

MCFIG - Manual Configuration

3.5.1 ?CFIG (No Stack Usage)

The plant line configuration is displayed on the users terminal by this word. For each instrument, the Instrument Number (INO), instrument type (and extension where appropriate), and its status (real or pseudo) is displayed.

3.5.2 ACFIG (No Stack Usage)

This word warns the user that all pseudo channels will be deleted, and gives a chance to abort. If the user types a Y in order to continue, the 6445 Micro Supervisor deletes its present plant line configuration. It then polls all 128 possible INO, and includes in the plant line configuration all instruments which reply (with extension where appropriate) as real. Upon completion, it displays the plant line configuration in the manner of ?CFIG.

3.5.3 MCFIG (No Stack Usage)

MCFIG allows the user to delete the existing plant line configuration and create a new one; or the edit on existing configuration by adding, deleting, or replacing, instruments. It is the only way to create pseudo- instruments.

Calling MCFIG starts a question and answer session. The first question is:

New Configuration (Y/N)

Type Y to delete the existing configuration, or N to start an edit. Neither response is echoed.

The next question is:

```
Enter  INO   (0 to 127)  =
```

Type the Instrument Number of the module you wish to add to the configuration. If the configuration already includes an instrument at this INO, MCFIG will respond by displaying that instrument in the manner of ?CFIG and a further question:

```
INO  =  n Real      nnnn
Do You Wish to Overwrite   (Y/N)
```

Type Y to replace the instrument at this INO with another, or N to leave it as it is and skip the instrument entry question.

If the INO was not already in the configuration and when overwriting an existing instrument these questions are asked:

```
Enter TYPE e.g. 6350 =
```

Entering zero here will delete the instrument at this INO.

```
Enter TYPE EXTENSION (AI, AO, DI, DO)
```

This question is only asked for 6432 or 6433 module types.

```
Is is a Pseudo Instrument   (Y/N)
```

If a pseudo instrument is specified by typing Y, then for all instruments, except 6432 and 6433, the decimal point must be specified for all scaled parameters:

```
Decimal Point Position =
```

A value from 0 to 4 may be entered.

The question:

```
End Configuration   (Y/N)
```

is asked next. Type Y to store the new configuration and return to the FORTH prompt. Type N to start a new cycle of questions beginning at:

```
Enter  INO   (0 to 127)  =
```

Figure 3.1 shows typical sessions using MCFIG.

```
MCFIG

New Configuration (Y/N) [Y]
Enter   INO   (0 to 127)=0
Enter TYPE. e.g. 6350= 6350
Is it a Pseudo Instrument (Y/N) [N]
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=1
Enter TYPE. e.g. 6350= 6351
Is it a Pseudo Instrument (Y/N) [Y]
Decimal point position=3
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=2
Enter TYPE. e.g. 6350= 6352
Is it a Pseudo Instrument (Y/N) [N]
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=3
Enter TYPE. e.g. 6350= 6353
Is it a Pseudo Instrument (Y/N) [Y]
Decimal point position=0
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=4
Enter TYPE. e.g. 6350= 6432
Enter TYPE EXTENSION (AI,AO,DI,DO)=AI
Is it a Pseudo Instrument (Y/N) [Y]
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=5
Enter TYPE. e.g. 6350= 6432
Enter TYPE EXTENSION (AI,AO,DI,DO)=AO
Is it a Pseudo Instrument (Y/N) [N]
End Configuration (Y/N) [N]
Enter   INO   (0 to 127)=0
INO=0   Real    6350
Do you wish to Overwrite (Y/N) [Y]
Enter TYPE. e.g. 6350= 6355
Is it a Pseudo Instrument (Y/N) [N]
End Configuration (Y/N) [Y]

INO=0  Real    6355       INO=1  Pseudo  6351/DP=3 INO=2  Real  6352
INO=3  Pseudo  6353/DP=0  INO=4  Pseudo  6432/AI   INO=5  Real  6432/AO

*Free 7268*
```

FIG 3.3 MCFIG Example

_____ - Typed by User
[ ] - Typed by User not echoed, rest output by 6445

SECTION 4 PROGRAMMING FEATURES

The 6445 Micro Supervisor may be programmed in a version of TCS FORTH. The Intelligent Instrument Programming Manual describes fully the TCS FORTH implementation. Many hardware features are unique to the 6445 and new FORTH words have been added to make these available to the user program. New software features have also necessitated new FORTH words. Table 4.1 lists the new words, a brief description, and the section where they are discussed in more detail.

4.1 Installing and Running a User Program

At power-up, the 6445 Micro Supervisor copies the program EEPROM into RAM and searches for a user word called BGRND. When found, it is installed and begins execution. If not found, the message '*HALTED*' appears in the status display and no further action takes place. When a user logs off, the action is similar except that the program currently in RAM is used, and not copied from EEPROM.

The user word BGRND would normally contain a BEGIN - REPEAT loop so that the word will execute continuously.

4.1.1 Software Reset Facility

The word ABORT halts execution of the FORTH word in progress, searches for BGRND and, if found, begins execution. It is equivalent to the user typing ESC, followed by BGRND, followed by a carriage return.

ABORT provides a convenient method of exception handling, for instance if a sequence breaks down.

4.2 Hardware Features

New hardware features include the provision of three RS232 serial data ports and plant line communication. The use of local digital inputs and outputs, and front-panel access is new to this instrument.

4.2.1 RS232 Serial Data Ports

The front-panel port has a fixed data format, and its baud rate is set by DIL switches. The rear panel ports are set up by the user when logged-on at the front-panel port. Words SETUP and ?SETUP are provided for this purpose.

The FORTH program can re-direct terminal input and output dynamically between these three ports. In addition, terminal output may be directed to the status display. The word LINE selects the port for terminal input and output.

Three new words are provided to assist in producing reports, logs, operator displays, etc. These are LFMT., RFMT. and " (double quote).

Word	Description	Stack Usage	Section
?CFIG	Display Plant Line Configuration	(No Stack Usage)	3.5.1
ACFIG	Automatic Plant Line Configuration	(No Stack Usage)	3.5.2
MCFIG	Manual Plant Line Configuration	(No Stack Usage)	3.5.3
ABORT	Software Reset	(No Stack Usage	4.1.1
?SETUP	Display Pointer and Console Lines Set-Up	(No Stack Usage)	4.2.1a
SETUP	Change Pointer/Console Line Set-Up	(No Stack Usage)	4.2.1a
LINE	Direct Terminal I/O	(n .....)	4.2.1b
EMIT	Emit Character to Line	(n .....)	4.2.1c
KEY	Get Character from Line	(..... n)	4.2.1d
?LBUF	Get Number of Free Characters in Transmit Buffer of a Line	(..... n 1) (.....0)	4.2.1e 4.2.1e
GETEXT	Read Instrument Parameter	(n1n2..... n3)	4.2.2a
?GETEXT	Enquiry Poll Instrument Parameter	(n1n2..... 0) (n1n2..... n3 1) (n1n2.... n4 0 1)	4.2.2a 4.2.2a 4.2.2a
SETEXT	Write Instrument Parameter	(n1n2n3..... n4)	4.2.2a
GETRAW	Read Raw Instrument Parameter	(n1n2 ..... n3) (n1n2 ..... n4 0)	4.2.2b 4.2.2b
SETRAW	Write Raw Instrument Parameter	(n1n2n3 .....n4)	4.2.2b
GEXTOT	Read Flow Total	(n1 ..... n2n3 0) (n1 ..... n4)	4.2.2c 4.2.2c
SEXTOT	Write Flow Total	(n1n2n3 .....n4)	4.2.2c
TOTAL+	Add Flow Total	(n1n2n3n4...n5n6)	4.2.2d
TOTAL-	Subtract Flow Total	(n1n2n3n4...n5n6)	4.2.2d
GETDI	Get Digital Input	(n ..... f)	4.2.3a
GETDS	Get Digital Input Status	(.....n)	4.2.3b
SETDO	Set Digital Output	(f n .....)	4.2.4a
SETDS	Set Digital Output Status	(n .....)	4.2.4b
TAG.	Write Number to Status Display	(n .....)	4.2.5a
?F	Get Function Button Status	(n ..... f)	4.2.5b
LFMT.	Format and Left Justify Number for Output	(n1n2 .....)	4.3.1a
RFMT.	Format and Right Justify Number for Output	(n1n2 .....)	4.3.1a
"	Put String Pointer Onto Stack	(..... n)	4.3.1b
GETDATE	Put Date Information Onto Stack	(.....Y M D)	4.3.2a
SETDATE	Read Date Information From Stack	(D M Y .....)	4.3.2a
GETCLK	Put Time Information Onto Stack	(..... S M H)	4.3.2a
SETCLK	Read Time Information From Stack	(H M S .....)	4.3.2a
CLK.	Format Time Information for Terminal Output	(No Stack Usage)	4.3.2b
DATE.	Format Date Information for Terminal Output	(No Stack Usage)	4.3.2b
KEYCLK	Get Time Information from Terminal Input	(No Stack Usage)	4.3.2c

/Continued ...

TABLE 4.1 FORTH Words Associated with 6445 Micro Supervisor

/Continued ...

Word	Description	Stack Usage	Section
KEYDATE	Get Date Information from Terminal Input	(No Stack Usage	4.3.2c
ADJCLK	Regulate Clock	(n .....)	4.3.2d
SHFMSK	Shift & Mask Data	(n1n2n3 ..... n4)	4.3.3
CRCPOLY	Set CRC Polynomial & Date Length	(n1n2 ..... n3)	4.3.4a
CRCINIT	Initialise CRC Register	(n .....)	4.3.4b
CRCEXEC	Execute CRC Calculation	(n .....)	4.3.4c
CRCREAD	Read CRC Register	(..... n1n2)	4.3.4d

TABLE 4.1 FORTH Words Associated with 6445 Micro Supervisor

```
?SETUP

Line 3
Baud rate 9600
Stop bits 1
Parity Even
Character length 7
X-ON/X-OFF Enabled
Log-On Enabled

Line 4
Baud rate 9600
Stop bits 1
Parity Even
Character length 7
X-ON/X-OFF Enabled
Log-On Enabled

*Free 7268*
```

FIG 4.1 ?SETUP Example

a) ?SETUP and SETUP

?SETUP (No Stack Usage).

The current set up of both Line 3 and Line 4 is displayed on the users terminal by this word.

SETUP (No Stack Usage).

The set up of either port may be changed with this word. The user is prompted at each option and its operation is self-explanatory. Fig. 4.1 shows a typical display from ?SETUP.

In addition to being able to set up the communications link (speed, character length, parity, number of stop bits and X-ON/X-OFF protocol), it is also possible to enable logging on. When enabled, typing Control-P at a terminal connected to one of these lines enables access to FORTH in the same manner as through the front panel console port.

NOTE: In earlier versions of the 6445, Line 3 was known as the Console Port, and Line 4 as the Printer Port.

b) LINE

Line (n.....)

The parameter n taken from the stack directs terminal input and output to different devices as follows:

n	Device
3	Line 3
4	Line 4
5	Front-Panel Port
6	Tag Display*

* N.B. No input available from the Tag Display

Other values of n are illegal.

However, whenever a user logs-on, either at the front-panel, or at a log-on enabled Line 3 or Line 4, or types an ESC to halt execution while logged on, terminal input and output is returned to the users port.

c) EMIT

The TCS Programmable Instrument Programming Manual describes EMIT as follows for instruments which employ 7-bit ASCII characters:

> "In some cases it is useful to be able to transmit special control characters to the terminal. The EMIT operator takes a value in the range 0 to 127 off the top of the stack and transmits it to the terminal, eg to send one character to the terminal to ring the bell type:
>
> 7 EMIT Return
>
> If the value is in the range 128 to 255 it is transmitted as 3 ASCII characters:
>
> ESC C1 C2
>
> where ESC is the normal Escape character (Decimal 27), and C1 and C2 are the characters of low and high significance in the hexadecimal representation of the number.
>
> eg 128.10 = 80.16 is emitted as ESC 0 8
> 254.10 = FE.16 is emitted as ESC E F"

The 6445 is able to use either 7-bit or 8-bit ASCII characters on Lines 3 and 4. Where 7-bit characters are used, the above definition applies. Where 8-bit characters are used, however, values in the range 128 to 255 are transmitted directly as single characters.

d) KEY

The KEY word is implemented in a slightly different manner in the 6445 to other instruments.

The word KEY examines the input buffer to see if any keys have been pressed, and returns immediately to the program with the result on the stack. The effect on the stack is shown below:

Stack before	Stack after	Stack before	Stack after
Top- 5	Top- 0	Top- 5	Top- 1
-	5	-	65
		-	5
Example where no key was typed		Example where letter A was typed	

The use of a flag allows NUL characters (Decimal 0) to be received on Lines 3 and 4.

e) ?LBUF

The FORTH word, ?LBUF, will return on the stack number of free characters in the output buffer of the current line.

```
?LBUF(..... n)
```

The current line will have to be set before calling this word by using LINE. ?LBUF of the alphanumeric display will always return 8.

4.2.2 Plant Line Communication

The users FORTH program may read from any parameter available on binary communication from instruments in the plant line configuration. Any instrument parameter which is not read-only, may be written to. Pseudo instruments are handled in the same way, except only enquiry polled parameters, plus II (and S1, S2, S3 and S4 in the 6432/6433) are available. Only the enquiry polled parameters are read/write.

a) Standard Plant Line Communication

The three FORTH words, GETEXT, ?GETEXT and SETEXT, handle standard input and output to and from the plant line.

GETEXT

```
(n1 n2 ..... n3)
(n1 n2 ..... n4 0)
```

n1 is the Instrument Number (INO) of the instrument being polled. n2 is the Parameter Number (PNO) of the required data. After execution n3 is a completion code. There are five possible values. n4 (if top entry 0) is the data. The completion codes are shown in Table 4.2.

?GETEXT

```
(n1 n2 ..... 0)
(n1 n2 ..... n3 1)
(n1 n2 ..... n4 0 1)
```

The enquiry poll facility is made available to the user's program by ?GETEXT. n1 is the Instrument Number, and n2 the Parameter Number of the data being enquiry polled. Three replies are possible:

A zero at the top of the stack means that:

i) The parameter is enquiry polled.
and
ii) The data has not changed since the last ?GETEXT to this parameter.

A one at the top of the stack indicates that:

i) The parameter is not enquiry polled.
or
ii) The data has changed since the latest ?GETEXT.

The next stack entry, or entries, are the same as if a GETEXT had been executed.

SETEXT

```
(n1 n2 n3 ..... n4)
```

n1 is the data to be sent; n2 is the INO of the parameter; and n3 is the PNO of the target instrument. n4 represents a completion code of the transaction, explained in Table 4.3.

b) Raw Data Plant Line Communication

The FORTH words GETRAW and SETRAW work in a similar manner to GETEXT and SETEXT. They differ in that the decimal point position is always treated as being zero.

GETRAW

```
   (n1 n2 ..... n3)
or (n1 n2 ..... n4 0)
```

GETRAW is used in an identical manner to GETEXT, i.e. calling sequences and return codes are the same. The value returned, however, is always an integer, in the range -9999 to +9999. GETRAW may only be used with pseudo instruments, attempted use with real instruments returns error code 4.

SETRAW

(n1 n2 n3 ..... n4)

SETRAW is used in an identical manner to SETEXT, except that the data provided (n1) must be an integer in the range -9999 to +9999. If a non-integer is used, the data to the right of the decimal point will be discarded. The decimal point value actually used will be that applicable to the parameter, either as defined when the pseudo instrument was set up, or in the case of the 6432 and 6433 as defined in the ST parameter. SETRAW may only be used with pseudo instruments, attempted use with real instruments returns error code 3.

c) Flow Totaliser Communication

The FORTH words GEXTOT and SEXTOT are used to simplify the interface to flow totalisers (6434, 6435, 6436, and 6437), where two four-digit integers are required to provide the eight significant digits of a flow total.

GEXTOT

(n1 ..... n2 n3 0)
(n1 ..... n4)

n1 is the instrument number. If the top of stack value after execution is 0, the next two entries are the flow total (the most significant half of the flow total is at the top of the stack), otherwise the top of stack entry is an error flag, n4, with the same meaning as error codes for GETEXT.

If instrument number n1 is not a flow totaliser, GEXTOT return error code 5.

n	Meaning
-1	Time-Out (No Reply)
0	Successful Completion
1	INO not in Plant Line Configuration
2	Parameter Number Error (Pseudo Instruments Only)
3	Parameter Not Initialised (Pseudo Instruments Only)
4	Illegal Reply, e.g. Illegal Parameter Number (Real Instruments Only)
5	Not a Flow Totaliser (GEXTOT only)

TABLE 4.2 GETEXT, GEXTOT and GETRAW Completion Codes

n	Meaning
-1	Time-Out (No Reply)
0	Successful Completion
1	INO not in Plant Line Configuration
2	Parameter Number Error (Pseudo Instruments Only)
3	Illegal Reply, e.g. Read-Only Parameter (Real Instruments Only)
4	Illegal Reply, e.g. Read-Only Parameter (Pseudo Instruments Only)
5	Not a Flow Totaliser (SEXTOT only)

TABLE 4.3 SETEXT, SEXTOT, and SETRAW Completion Codes

SEXTOT

(n1 n2 n3 ..... n4)

n1 and n2 are the flow total, least significant half being put to the stack first. n3 is the instrument number. The word returns a flag, n4, with the same meaning as error codes for SETEXT. If instrument number n3 is not a flow totaliser, SEXTOT returns error code 5.

d) Flow Totaliser Handling

In order to further simplify the interface to flow totalisers, the FORTH words TOTAL+ and TOTAL- are provided. Whilst these words do not directly interface to the plant line, they are intimately linked to GEXTOT and SEXTOT and so are presented with them.

TOTAL+

(n1 n2 n3 n4 ..... n5 n6)

The integer pair n1 and n2 and the integer pair n3 and n4 are both 8-digit flow total values. Each is placed onto the stack, most-significant half first. TOTAL+ returns the sum of these as an 8-digit number represented as two integers with the most significant half on the top of the stack.

TOTAL-

(n1 n2 n3 n4 ..... n5 n6)

TOTAL- is similar to TOTAL+ except that the 8-digit value represented by n3 and n4 is subtracted from the 8-digit value represented by n1 and n2, the 8-digit result being returned in n5 and n6.

4.2.3 Local Digital Inputs

Digital inputs to the 6445 Micro Supervisor are not periodically scanned and then stored; when a FORTH word requests a digital input the data port is accessed at the time. No parameters are associated with the 6445 and so digital inputs are only available directly to the user's FORTH program.

a) Bit-Wise Digital Input

```
GETDI (n ..... f)
```

n specifies the digital input to be scanned; inputs are numbered 1 to 8. After execution the top stack entry is a flag, 0 or 1, reflecting the state of the particular input.

b) Byte-Wise Digital Input

```
GETDS ( ..... n )
```

Here all 8 digital inputs are read into the top 8 bits of a 16 bit word put onto the top of the stack.

4.2.4 Local Digital Outputs

In a similar manner to digital inputs, digital outputs are set when a FORTH word executes. The outputs cannot be read back once set; and only the user's FORTH program may set and reset the outputs. Digital output 8 may be allocated to the system and is then not available for use.

a) Bit-Wise Digital Output

```
SETDO (n1 n2 .....)
```

Here, n2 specifies which output is to be accessed and n1 specifies the value (0) or (not 0) to be written. Outputs are numbered 1 to 8.

b) Byte-Wise Digital Output

```
SETDS (n .....)
```

The top 8 bits of the 16 bit word at the top of the stack are written to digital outputs 1 to 8. The lower 8 bits act as individual bit masks for corresponding bits in the upper byte.

4.2.5 Front-Panel Access

The only front-panel operator interfaces are the status display and the six function switches.

a) Status Display

TAG.(n .....)

The word TAG. provides the means to write the number at the top of the stack to the Status Display. The number always starts at the left of the display and overwrites only that number of characters it needs to.

b) Function Switches

?F (n ..... f)

A function button is scanned individually by this word. n defines which button and takes value 1 to 6, corresponding to the markings on the switches. After execution, the top stack entry is 1 if the switch was pressed and zero otherwise.

4.3 Software Features

New software facilities available to the user's FORTH program are concerned with improved terminal output and a real time clock and calendar.

4.3.1 Terminal Output

New words LFMT. and RFMT. are provided to assist tabulation of numeric data for terminal (or printer) output. Strings may be created by use of " (double quote).

a) LFTM. and RFMT.

```
LFMT. (n1  n2  ......)
RFMT. (n1  n2  ......)
```

In order to produce readable data, some form of tabulation is necessary. LFMT. takes the data n1 and sends it to the current terminal line output at the left of an 8-character field with a decimal point position given by n2. The display then appears as given in the Table below. RFMT. has the same function, except that it is at the right of an 8-character field.

n	Display	
	LFMT.	RFMT.
0	+nnnn	+nnnn
1	+nnn.n	+nnn.n
2	+nn.nn	+nn.nn
3	+n.nnn	+n.nnn
4	+0.nnnn	+0.nnnn

Other values of n are illegal.

A plus (+) sign is shown above; negative numbers will, of course, be preceded by a minus (-) sign. Note the inclusion of a leading zero for a decimal point position of 4.

b) " (Double Quote)

This word adds string handling to TCS FORTH. It is available only in compiling mode where is has the form:

```
"  STRING TERMINATED BY "
```

The effect when executed is to leave on the stack a pointer to the string following. The words . (dot), (hash), (dollar), TAG., then recognise this pointer and instead of outputting a number, output the string instead.

4.3.2 Real Time Clock and Calendar

The real time clock and calendar has the following features:

i) Calendar adjusts automatically for leap years until 2000 A.D.

ii) Clock operates on 24-hour clock in hours, minutes, seconds.

iii) All data available for arithmetic and other operations.

iv) Quartz crystal stability.

v) Regulation possible to optimise accuracy.

vi) Time "frozen" at power-down; hence at power-up the time and date displayed will be that when power was lost.

New FORTH words are provided to enable use of the clock and calendar facilities.

a) Manipulation of Time/Date Information

```
GETDATE (......Y M D)
SETDATE (D M Y .....)
```

GETDATE copies from the date information to the stack the day of the month, the month as a number from 1 to 12, and the year, in the range from 0 to 99 as a year of a century.

SETDATE removes from the stack the same data and overwrites the current date information.

```
GETCLK (.....S M H)
SETCLK (H M S.....)
```

In a similar fashion to GETDATE, SETDATE, GETCLK and SETCLK copies data onto the stack, and removes from the stack data and overwrites current time information.

b) Time/Date Terminal Line Output

```
CLK.  (No Stack Usage)
DATE. (No Stack Usage)
```

These words send date/time information to the current terminal line output as 8-character strings, with leading zeros if appropriate. The output of CLK. is:

```
hh:mm:ss      hours : minutes : seconds
```

whereas DATE. outputs:

```
dd-mm-yy      day - month - year
```

c) Time/Date Terminal Line Input

KEYCLK (No Stack Usage)
KEYDATE (No Stack Usage)

To facilitate setting of the internal date and time data, these two words take input, from the current terminal line, in exactly the same form as CLK. and DATE. output. The separators (colon for KEYCLK and dash for KEYDATE) are output to the terminal to prompt for the next field. Entry is completed by the last character; no carriage return is required.

d) Clock Regulation

ADJCLK (n .....)

The adjustment of the clock is carried out in units of seconds per day. For example, if the clock gains 5 seconds per day, a value of n of -5 will compensate. Similarly, if losing 10 seconds a day, n of +10 will correct the clock.

4.3.3 Shift & Mask Data

The FORTH word 'SHFMSK' is provided as a convenient method of processing bit significant data.

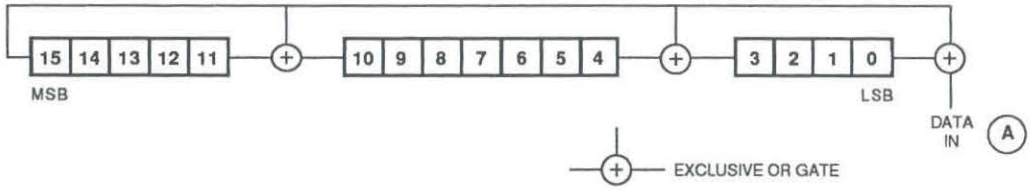
(n1 n2 n3 ..... n4)

This word takes the data, n1, as a 16-bit value, shifts it n2 bits (to the left if positive and the right if negative), and then performs a 16-bit AND of the result with n3. The result of this calculation is returned as n4.

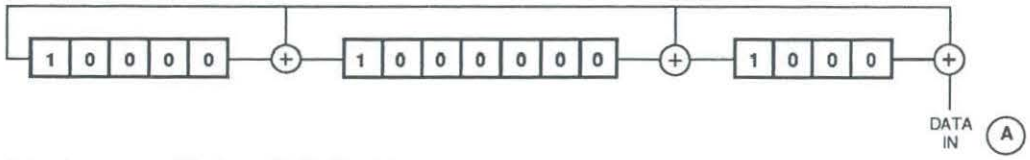
4.3.4 CRC Calculation

The two rear connected RS232 ports are capable of being configured to communicate with a range of devices. In order to ease the task of interfacing to protocols that implement CRC data verification, four FORTH words are provided for CRC processing. A brief description of CRCs is given below prior to describing these words.

The following block diagram shows a typical CRC arrangement. Each bit of transmitted data is applied in turn to point A (note the least significant bit will be transmitted first), and the register shifted one bit to the right. The second diagram shows the effect of shifting a single 'one' bit onto a register previously set to all zeroes.



CRC Register using Shift Registers and Exclusive-OR Gates



Injecting a "1" Bit into CRC Register

FIG 4.2 Typical CRC Arrangement

This combined operation could be interpreted as two separate operations: first a one bit rotate to the right, and secondly (and only if the XOR'd data bit was 'one') an exclusive 'or' of a polynomial value with the register. In this example the polynomial value would be 8408 hex.

The above process is repeated for each bit of each character of the message. Once the CRC is complete, it is transmitted as two additional characters at the end of the message. Hence CRC is always two character lengths.

The FORTH words to implement this are as follows:

a) CRCPOLY (n1 n2 .....n3)

Where n1 is the polynomial value, and n2 is the number of bits in the data character - maximum 8 (CRC length is therefore 2 x n2). This word initialises the operating conditions, the values of n1 and n2 staying unchanged until CRCPOLY is called again. n3 = 1 if n1 or n2 is invalid, otherwise n3 = 0.

b) CRCINIT (n .....)

Where n is a value to which the CRC register is initialised. Commonly this would be zero.

c) CRCEXEC (n ..... n)

Where n is a data character currently being transmitted to line. CRCEXEC will truncate n to the specified number of bits and will then shift and 'exclusive-or' the correct number of bits of n with the CRC register. n is returned on the stack unaltered, ready for transmission to line using the EMIT word, or for further processing upon character receipt.

d) CRCREAD (..... n1 n2)

Where n1 and n2 are the CRC register value, already split into two data words of the correct bit length, ready to be transmitted. The least significant word of the CRC register appears at the top of the stack as this is the part which requires transmission first.

SECTION 5 COMPUTER SUPERVISION OF 6445 MICRO SUPERVISOR

The 6445 Micro Supervisor has more communication facilities than most System 6000 instruments. It has three RS232 ports for interaction with a FORTH program; in addition it has two RS422 ports for communication to a supervisory system and to a line of TCS System 6000 instruments. There is a full duplex UART for each port.

The 6445 may be bussed with other System 6000 instruments on an RS422 line from a supervisory computer. The supervisory computer can then access all the instruments on the line, plus all the real and pseudo instruments configured within the 6445.

5.1 Serial Data Base Hardware Installation

A full definition of the RS422 transmission standards are given in Section 7 of the System 6000 Installation Guide, together with a discussion of:

a) Interface connections.
b) Cable impedance and termination.
c) Interface signal polarity.

5.2 Serial Data Transmission

Section 4 of the System 6000 Communications Handbook contains a discussion of:

a) RS422 characteristics and technical specification.
b) Serial data transmission.
c) Binary synchronous communication data link control.
d) Instrument number addressing.

5.3 Communication Protocols

All data transfers between the 6445 and supervisory computer, and between the 6445 and instrument on its plant line, via the RS422 data links are carried out using an ANSI standard communications protocol called BI SYNC (Binary Synchronous), known as X3.28. This instrument supports an extended version of the binary mode of communications at 9600 baud only.

The binary protocol is discussed in Section 6 of the System 6000 Communications Handbook. The extensions to the protocol are two extra control characters:

SOH

and

CAN

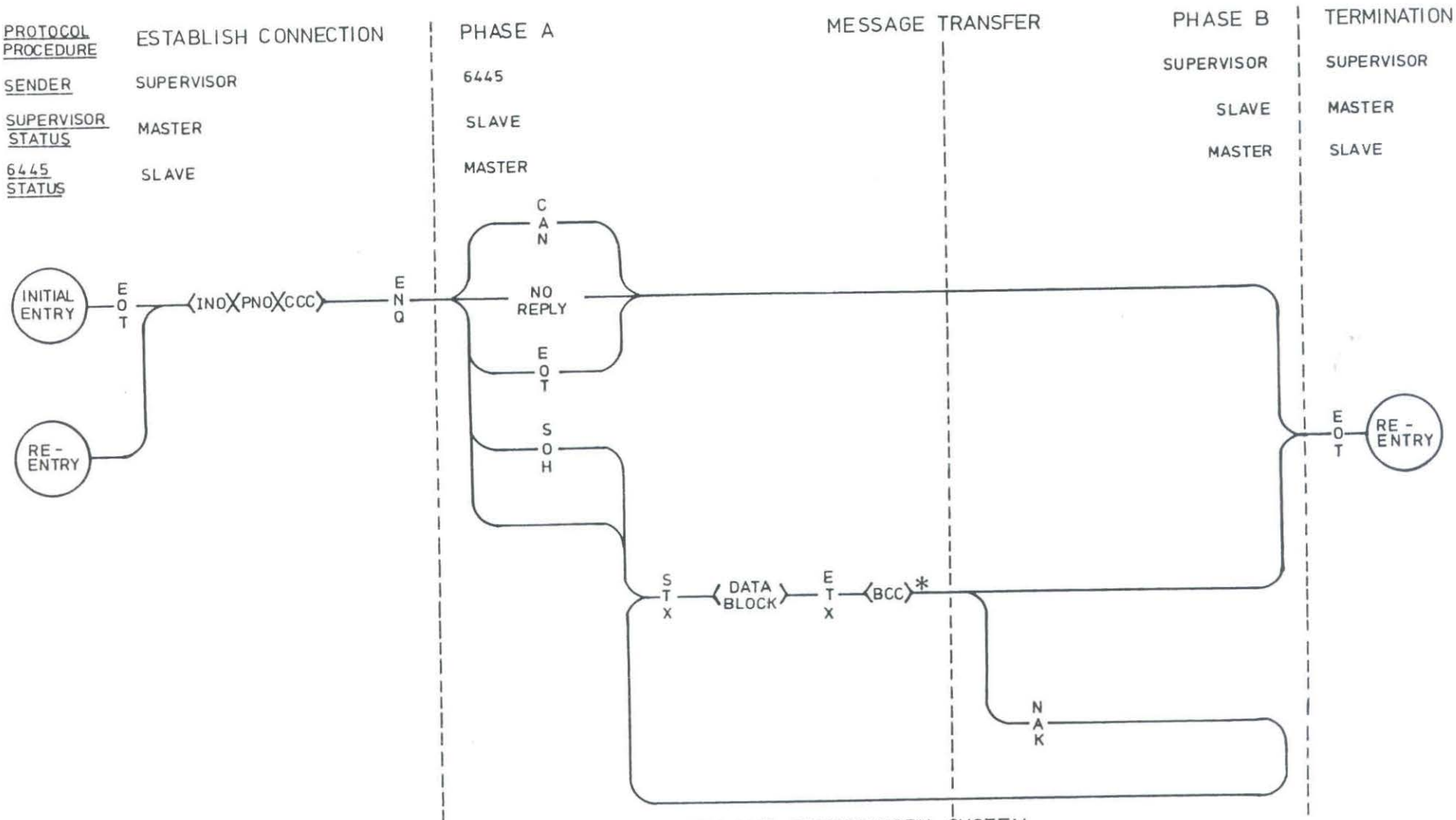


FIG 5.1 SINGLE PARAMETER POLLING SEQUENCE 6445 BETWEEN AND SUPERVISORY SYSTEM

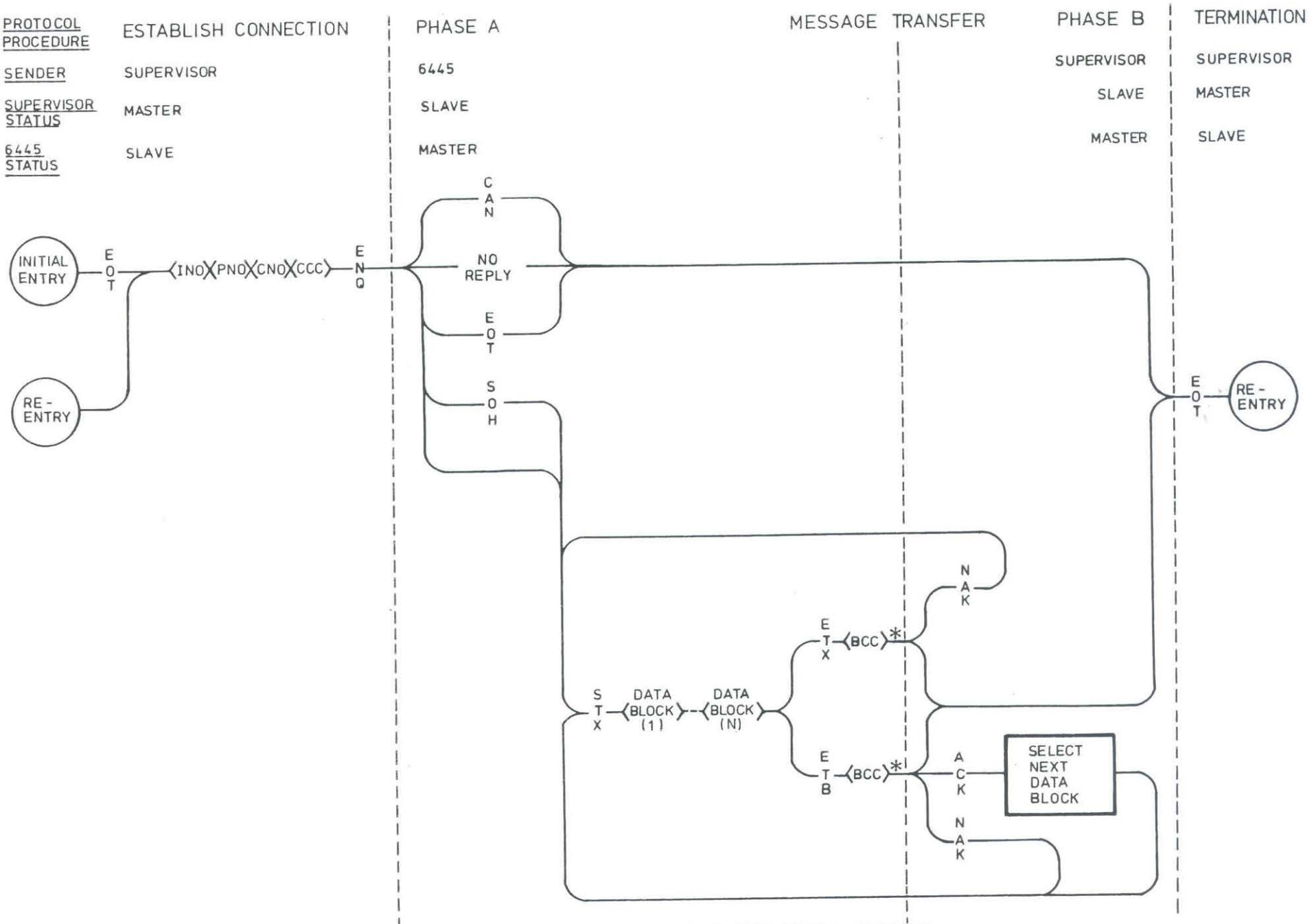


FIG 5.2 MULTI-PARAMETER POLLING SEQUENCE BETWEEN 6445 AND SUPERVISORY SYSTEM

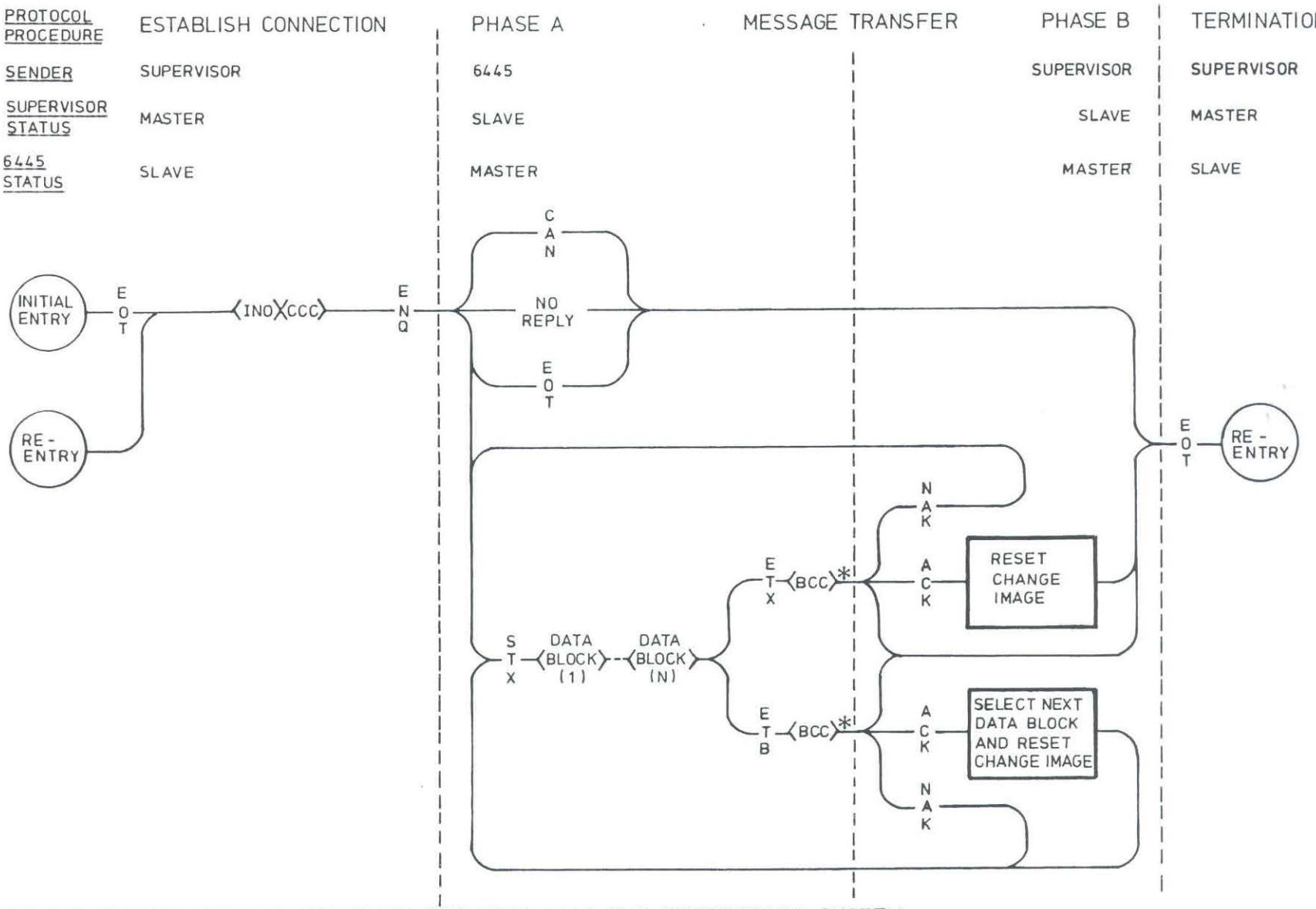


FIG 5.3 ENQUIRY POLLING SEQUENCE BETWEEN 6445 AND SUPERVISORY SYSTEM

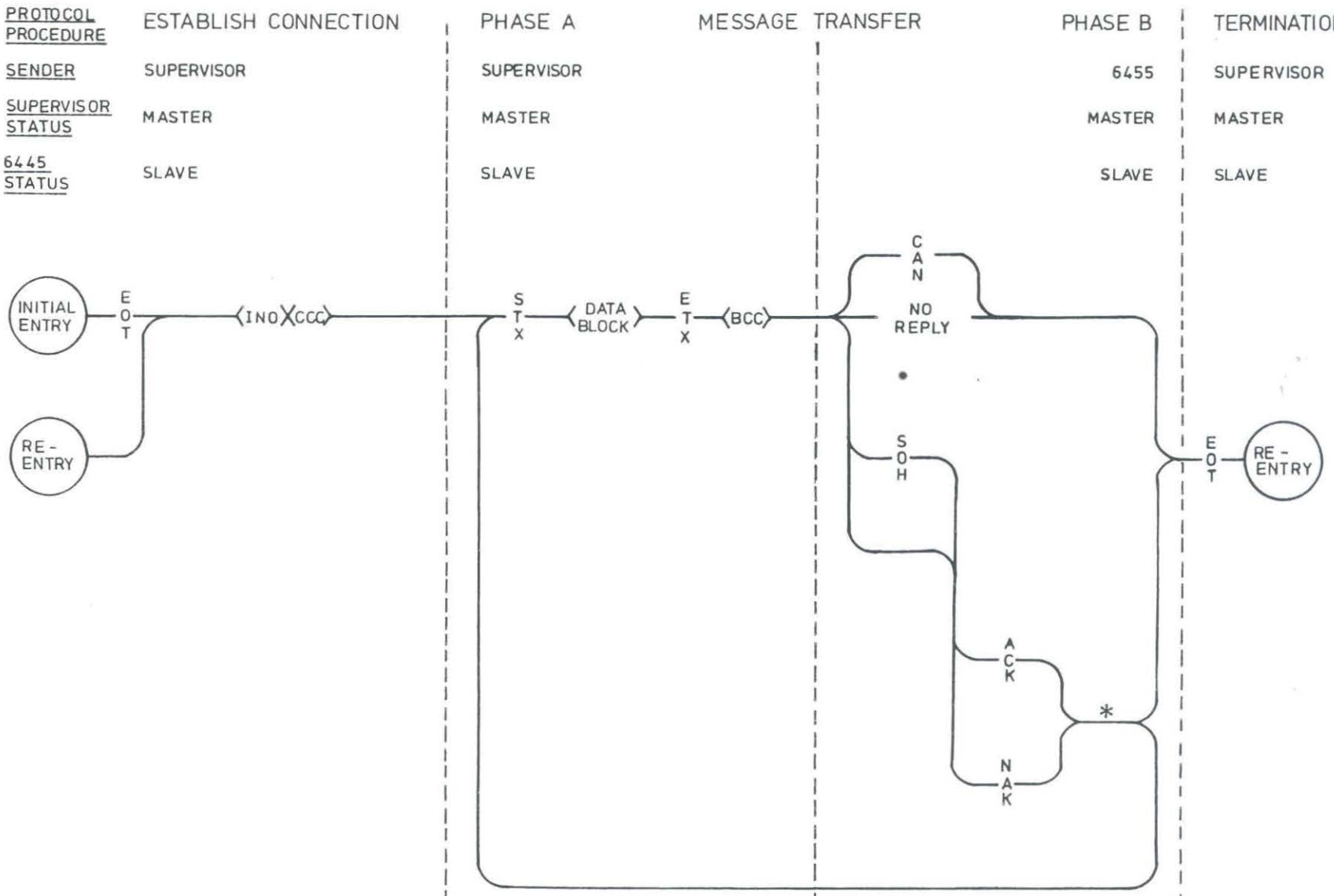


FIG 5.4 SELECTION SEQUENCE BETWEEN 6445 AND SUPERVISORY SYSTEM

5.3.1 SOH Control Character

This character may be sent by an instrument in response to a valid:

Single Parameter Poll
Multi Parameter Poll
or a Selection

It is never sent in response to an enquiry poll. The meaning of this control character is "Extend communication timeout to 250ms". This is to allow the 6445 to carry out a transaction with an instrument in its plant line configuration.

5.3.2 CAN Control Character

This character may be sent by the Micro Supervisor in response to any valid transaction. It has the meaning "The instrument at this Instrument Number is not currently replying".

5.3.3 Extended Binary Protocol Sequences

Fig. 5.1, 5.2, 5.3 and 5.4 show the revised sequences for the four types of extended binary protocol sequence.

5.4 Pseudo Instruments

Interaction between the 6445 FORTH program and a supervisory system can be provided by pseudo instruments. A pseudo instrument appears to both a supervisory system and a 6445 FORTH program as the enquiry polled parameters of a corresponding real instrument type, plus II. The issue digit (digit D) of II is returned as zero to indicate a pseudo. Any 6432 or 6433 pseudos will also be provided with whichever of the S1, S2, S3 or S4 parameters is appropriate to the configured instrument number. The appropriate parameter number can be derived from the following:

PNO = [(INO.AND.3)x2]+1

Only the board type (digits C and D) will be used (digits A and B set to zero).

Enquiry polled parameters are read/write from both the supervisory system and the FORTH program. Non enquiry polled parameters will be read-only. Parameter format, that is the decimal point position, is fixed for all instruments except 6432 and 6433 when the instrument was configured. For 6432 and 6433 signal processor modules, the decimal point is part of an enquiry polled parameter and hence may be changed by FORTH or supervisory system programs. Parameter ranges are either implied, as OP of a pseudo controller, or taken from range parameters, such as 1H, 1L or HR, LR. Hexadecimal parameters are always format zero. 'Ranged' parameters, such as PV, are limited to the range 1H,1L or HR,LR.

Enquiry polled parameters are accessible in the same way as real instrument parameters, including being flagged for enquiry polling as data changes, single or multi parameter polling.

Non enquiry polled parameters are only available to single parameter polls down the RS422 comms. Via FORTH they will be available to GETEXT as normal. Attempting to access these parameters with SETEXT will generate error code 4, (Illegal Reply - Pseudo Instruments. Tables 5.1 to 5.15 show the parameters associated with each pseudo instrument type.

	0	1	2	3	4	5	6	7
0			1H	1L	HA	LA	MN	SP
8	PV	OP						

TABLE 5.1 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6350

	0	1	2	3	4	5	6	7
0			1H	1L	HA	LA	MN	SP
8	PV							

TABLE 5.2 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6351

	0	1	2	3	4	5	6	7
0			1H	1L	HA	LA	MN	SP
8	CV	OP						

TABLE 5.3 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6352

	0	1	2	3	4	5	6	7
0			SH	SL	HA	LA	MN	SP
8	PV	OP						

TABLE 5.4 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6353

	0	1	2	3	4	5	6	7
0			1H	1L	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.5 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6355

	0	1	2	3	4	5	6	7
0			PH	PL	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.6 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6356

	0	1	2	3	4	5	6	7
0			1H	1L	DA		MN	SP
8	PV	OP						

TABLE 5.7 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6358

	0	1	2	3	4	5	6	7
0			1H	1L	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.8 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES: 6360

	0	1	2	3	4	5	6	7
0			SH	SL	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.9 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6363

	0	1	2	3	4	5	6	7
0			1H	1L	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.10 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES:6365

	0	1	2	3	4	5	6	7
0			PH	PL	HD	LD	MN	SP
8	PV	OP	HA	LA				

TABLE 5.11 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6366

	0	1	2	3	4	5	6	7
0								
8								
16	ST	HR	LR	HA	LA	PV	AR	
24	ST	HR	LR	HA	LA	PV	AR	
32	ST	HR	LR	HA	LA	PV	AR	
40	ST	HR	LR	HA	LA	PV	AR	
48	ST	HR	LR	HA	LA	PV	AR	
56	ST	HR	LR	HA	LA	PV	AR	
64	ST	HR	LR	HA	LA	PV	AR	
72	ST	HR	LR	HA	LA	PV	AR	

TABLE 5.12 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES: 6432/AI
6433/AI

	0	1	2	3	4	5	6	7
0								
8								
16	ST	HR	LR	OP	HO	LO		
24	ST	HR	LR	OP	HO	LO		
32	ST	HR	LR	OP	HO	LO		
40	ST	HR	LR	OP	HO	LO		
48	ST	HR	LR	OP	HO	LO		
56	ST	HR	LR	OP	HO	LO		
64	ST	HR	LR	OP	HO	LO		
72	ST	HR	LR	OP	HO	LO		

TABLE 5.13 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES: 6432/AO
6433/AO

	0	1	2	3	4	5	6	7
0								
8								
16	ST	AM	DS					

TABLE 5.14 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES: 6432/DI
6432/DO
6433/DI
6433/DO

	0	1	2	3	4	5	6	7
0								
8								
16					ST	HR	LR	HA
24	LA	FL	1F	2F				

TABLE 5.15 PARAMETER TABLE FOR
PSEUDO INSTRUMENT TYPES : 6434
6435
6436
6437

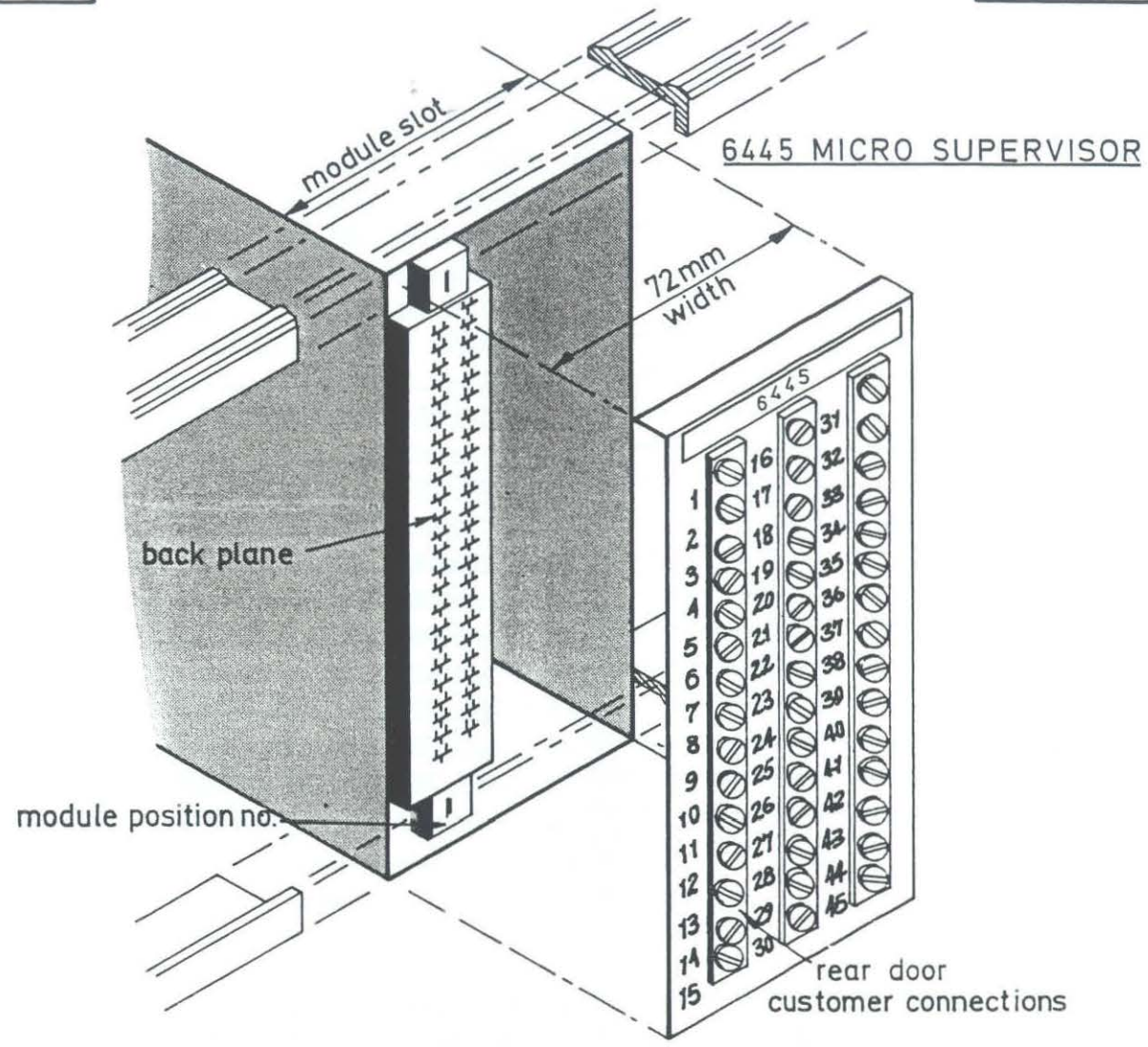
APPENDIX A

PIN NUMBER	PIN CONNECTIONS		
1			
2	OVR	OV REFERENCE	
3	OVR	OV POWER	POWER SUPPLIES
4			
5			
6			
7			
8	DC.SUPP.IN	DC SUPPLY (20-30V) INPUT	
9	W.DOG.OUT(1)	WATCHDOG TIMER OUTPUT	
10	DIG1.IN	DIGITAL INPUTS, I/O BLOCK 1	0-15V DIGITAL INPUTS
11	DIG2.IN		
12	DIG3.IN		
13	DIG4.IN		
14	DIG5.IN		
15	DIG6.IN		
16	DIG7.IN		
17	DIG8.IN		
18	DIG1.OUT	DIGITAL OUTPUTS, I/O BLOCK 2	0-15V DIGITAL OUTPUTS
19	DIG2.OUT		
20	DIG3.OUT		
21	DIG4.OUT		
22	DIG5.OUT		
23	DIG6.OUT		
24	DIG7.OUT		
25	DIG8.OUT	INSTRUMENT HEALTHY	
26	XMT.PRT	RS232 PRINTER LINE	RS232 PORTS
27			
28	RCV.PRT		
29			
30	XMT.CON	RS232 CONSOLE LINE	
31			
32	RCV.CON		
33			
34	P.XMT (-)	TRANSMIT OUTPUTS	RS422 PLANT SERIAL DATA BUS
35	P.XMT (+)		
36	P.RCV (-)	RECEIVE INPUTS	
37	P.RCV (+)		
38			
39			
40			
41			
42			
43			
44			
45	XMT.OUT (-)	TRANSMIT OUTPUTS	RS422 SUPERVISORY DATA BUS
46	XMT.OUT (+)		
47	RCV.IN (-)	RECEIVE INPUTS	
48	RCV.IN (+)		

	MICRO SUPERVISOR																	
	6445																	
PIN NO	FUNCT	FROM	TO	FUNCT	FROM	TO	FUNCT	FROM	TO	FUNCT	FROM	TO	FUNCT	FROM	TO	FUNCT	FROM	TO
1																		
2																		
3	0V P																	
4																		
5																		
6																		
7	+15V OUT																	
8	D.C.SUP IN																	
9	W.DOG OUT(1)																	
10	DIG 1 IN																	
11	DIG 2 IN																	
12	DIG 3 IN																	
13	DIG 4 IN																	
14	DIG 5 IN																	
15	DIG 6 IN																	
16	DIG 7 IN																	
17	DIG 8 IN																	
18	DIG 1 OUT																	
19	DIG 2 OUT																	
20	DIG 3 OUT																	
21	DIG 4 OUT																	
22	DIG 5 OUT																	
23	DIG 6 OUT																	
24	DIG 7 OUT																	
25	INST HLT H(1)																	
26	XMT PRT																	
27																		
28	RCV PRT																	
29																		
30	XMT CON																	
31																		
32	RCV CON																	
33																		
34	P.XMT (–)																	
35	P.XMT (+)																	
36	P.RCV (–)																	
37	P.RCV (+)																	
38																		
39																		
40																		
41																		
42																		
43																		
44																		
45	XMT OUT (–)																	
46	XMT OUT (+)																	
47	RCV IN (–)																	
48	RCV IN (+)																	

loop identifier

rack & module no.



The B6445 termination assembly consists of a 48-pin back plane connector with a wire loom linking the module connections on the back plane to three rows of 15 customer terminals.

The assembly is used to mount 6445 Micro Supervisors into 7600 bin units and can only be ordered as part of a 7600 bin system.

Detailed technical and mechanical specifications can be found in the following documents :-

7600 Sales Literature
6445 Product Specification
6445 Technical Manual

Iss 1; May 86 Part no: HA 076864 U007

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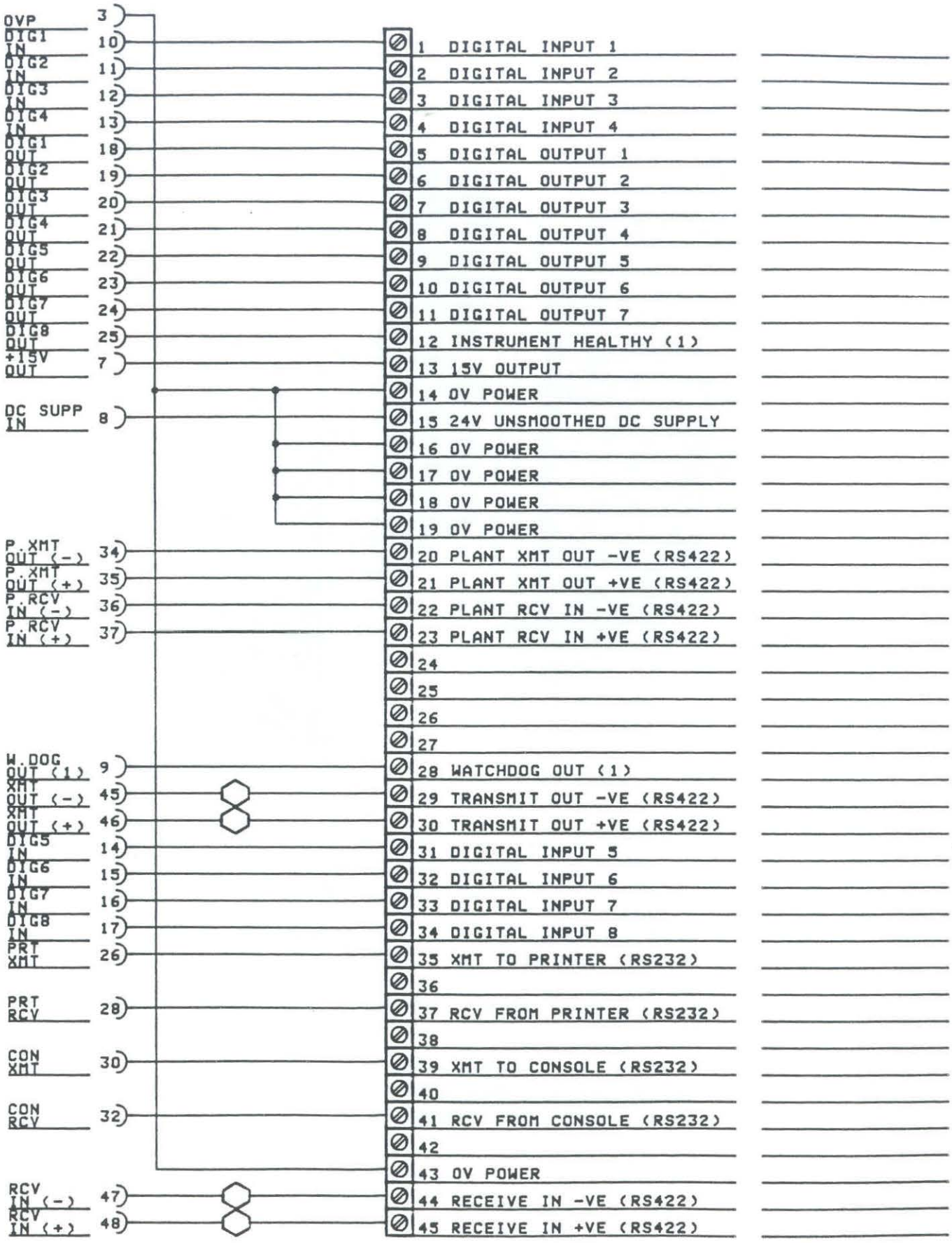
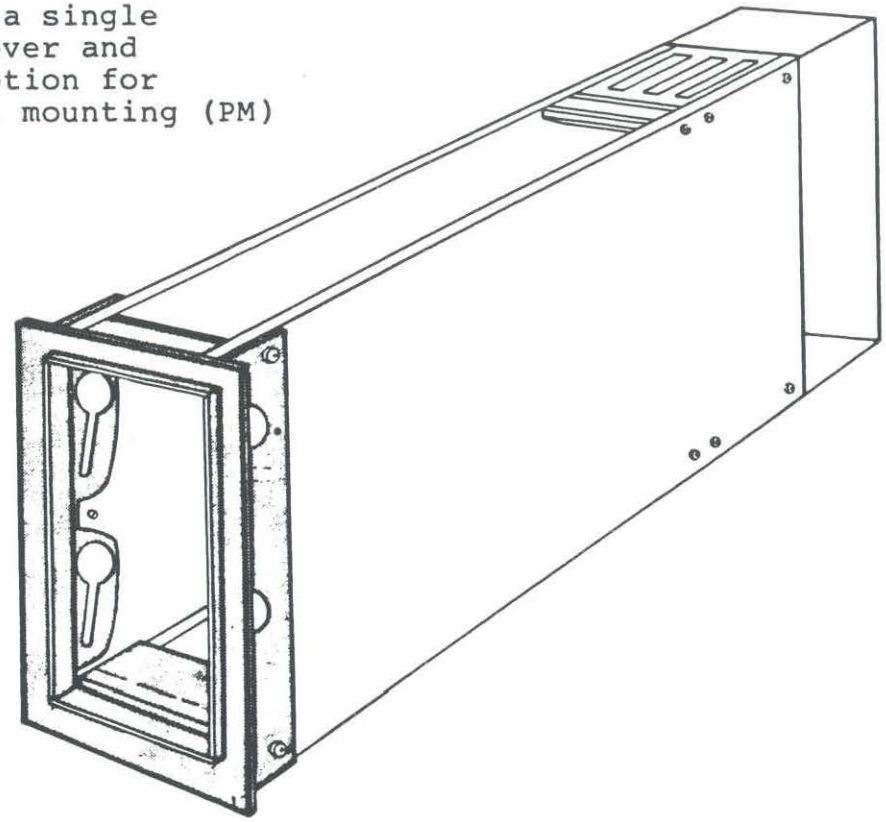
Broadwater Trading Estate Worthing Sussex BN14 8NW
Telephone Worthing (0903) 205277
Telex 87437



⬡ THESE LINES MAY BE BUSED TO OTHER MODULES IN THE BIN

SINGLE OR MULTI-WAY SLEEVE ASSEMBLY FOR MICROPROCESSOR BASED INSTRUMENTATION

NOTE
Drawing shows a single sleeve with cover and gland plate option for standard panel mounting (PM)

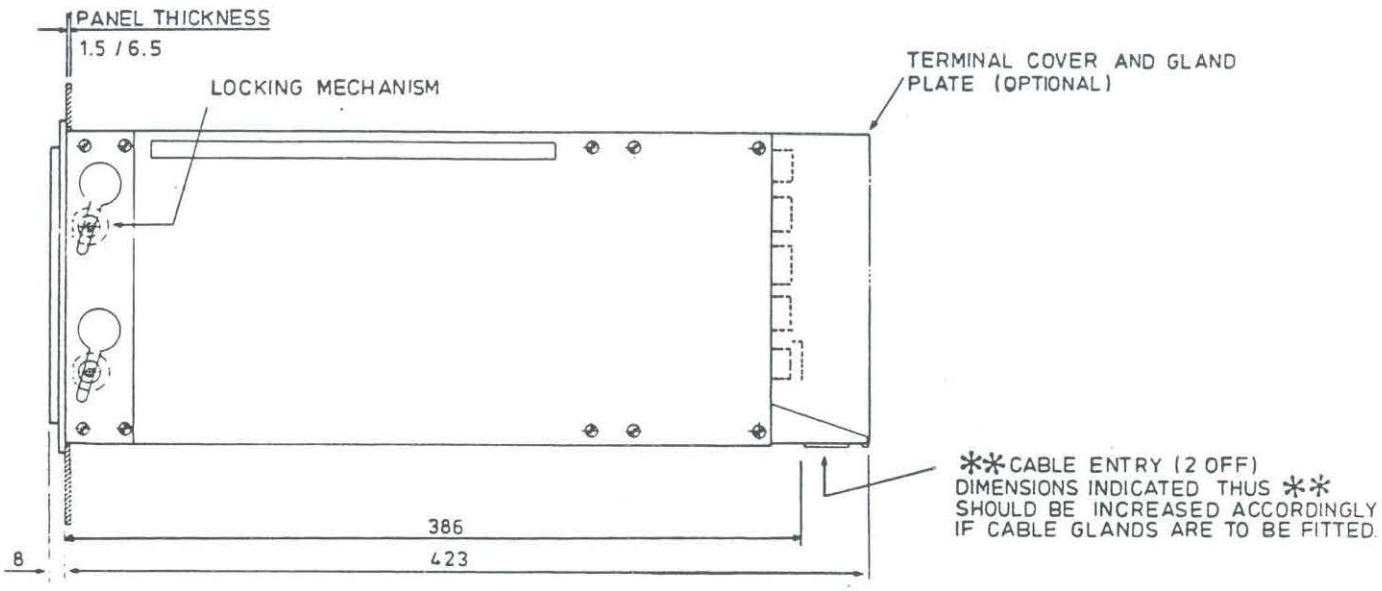


* Single, 3-way or 6-way panel mounting versions
* 6-way 19" rack mounting version
* all module connections available via screw terminals
* each module individually powered from 24V d.c. or mains

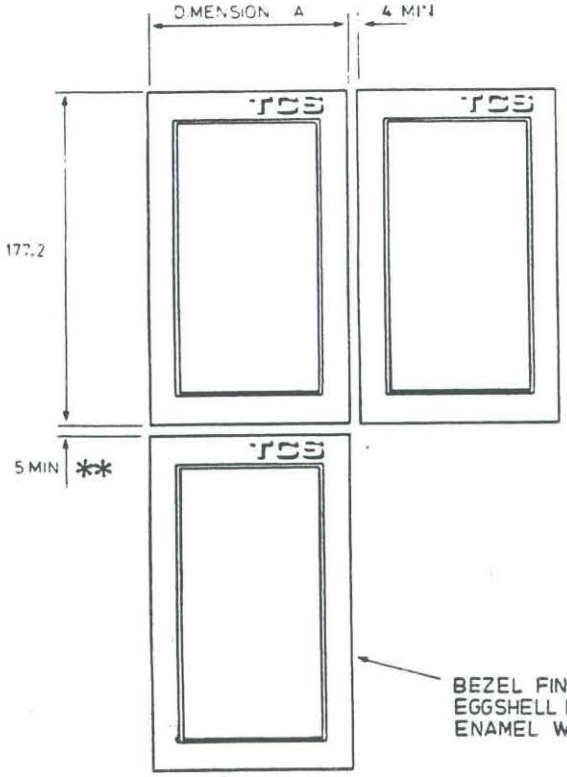
The 7900 assembly enables from 1 to 6 modules from the TCS System 6000 range of microprocessor based instruments to be panel or rack mounted in sleeves. Any combination of modules can be specified including Controllers, Signal Processors, and Flow Totalisers. Each instrument within the 7900 unit is individually powered via its own rear termination assembly, which also gives access to all the module connections.

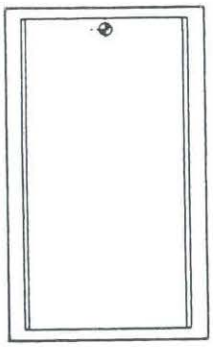
TECHNICAL SPECIFICATION

1) Installation Details for Panel Mounting Sleeves



SIDE VIEW





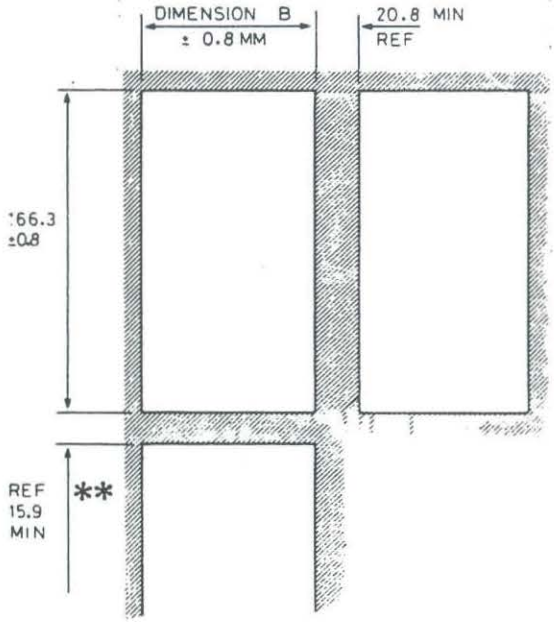
REAR VIEW

DIMENSION A	SLEEVE WIDTH
105	1-WAY
249	3-WAY
465	6-WAY

FRONT VIEW SHOWING OTHER POSSIBLE ADJACENT SLEEVES

2) Mounting Instructions

The dimensions of the various 7900 assemblies can be ascertained from the side and front view diagrams which also show the closest positioning of adjacent units. The diagram below gives the panel cut-out dimensions corresponding with the closest unit positioning.



DIMENSION B	SLEEVE WIDTH
88.2	1-WAY
232.2	3-WAY
448.2	6-WAY

PANEL CUT-OUT DETAILS

To position a 7900 assembly in a panel and subsequently mount a microprocessor based instrument within it, the following installation procedure is carried out:-

(i) Press an empty 7900 sleeve assembly firmly into the panel cut-out.

(ii) On the 1-way sleeves, insert the 2 locking mechanisms into the lower keyhole slots on either side and push them down as far as possible. On 3 and 6 way sleeves, fit locking mechanisms in all four positions.

(iii) Tighten the socket screw inside each locking mechanism in a clockwise direction using the 2.5 A/F Hex Key provided.

(iv) For the TPM option fit the locating spigot on the DIN clip into the slot on the side plates, with the face pressed against the rear of the panel then tighten the screw until the assembly is secure.

(v) Slide the instrument, with its own 72mm module sleeve firmly into the recess using the catch-handle to lock it into position.

(vi) The optional rear-terminal cover may be removed to allow wiring access for power-supply and plant connections which may be brought in via the 2 cable entry glands provided. Rear supporting is recommended especially on mains powered versions.

DESCRIPTION	ORDER CODE
Single or Multi-way Sleeve Assembly	7900
Sleeve Width	
a) Single Sleeve	1-WAY PM
or b) 3-Way Sleeve Panel Mounting	3-WAY PM
or c) 6-Way Sleeve Panel Mounting	6-WAY PM
or d) 6-Way Sleeve Rack Mounting	6-WAY 19" RM
or e) 1-Way Sleeve Thick Panel Mounting	1-WAY TPM
or f) 3-Way Sleeve Thick Panel Mounting	3-WAY TPM
or g) 6-Way Sleeve Thick Panel Mounting	6-WAY TPM
Supply Voltage	
a) 24V DC	24V
or b) 110V AC	110V
or c) 240V AC	240V
N.B. Multi-Way assemblies all have the same supply voltage	
Rear door cover and gland plate option for the rear termination assemblies	CGP

DESCRIPTION	ORDER CODE
Rear Termination Assemblies Specify which instrument is to fit into each sleeve position starting from the left-hand end (front view). Select from the following:-	
a) 6350, 6351, 6352, 6353, 6355, 6356 - single loop Controllers	7350, 7351, 7352, 7353, 7355, 7356
or b) 6358 - 8-loop Controller	7358
or c) 6360, 6363, 6365, 6366 - Bargraph Controllers	7360, 7363, 7365, 7366
or d) 6432, 6433 - Signal Processors	7432, 7433
or e) 6434, 6435, 6436, 6437 - Flow Totalisers	7434, 7435, 7436, 7437
or f) 6255, 6445 - Communications units	7255, 7445
or g) 6850 - Setpoint Programmer	7850
or h) Blank slot	BLANK
Current Inputs For the following modules the option of 1-5V or 4-20mA is provided. (All channels to be the same) a) 7350, 7351, 7352, 7353, 7355, 7356 b) 7360, 7363, 7365, 7366 c) 7850	
1-5V (Standard)	--
4-20mA (Option)	BR
N.B. Every slot must be specified in order:- /slot 6 /slot 5 /...../slot 2 /slot 1 / where slot 1 is in the most right-hand position viewed from the front. These options form the second line of the Ordering Code.	

ORDER CODE EXAMPLES

a) A 6350 Process Controller in a single sleeve with 4-20mA current input on all three channels:-
7900/1-WAY PM/240V/CGP/7350/BR

b) A 3-way panel mounting assembly with two Controllers and a Programmer:-
7900/3-WAY PM/240V/CGP/7350/7350/BR/7850

c) A 6-way 19" rack mounting assembly:-
7900/6-WAY 19" RM/240V/7350/7350/7350/7350/BR/7432/7850/BR

d) A 1-way thick-panel mounting sleeve:-
7900/1-WAY TPM/24V/CGP/7432

TECHNICAL SPECIFICATION

a) Length : 423mm with CGP option
: 386mm without CGP option

b) Width
(i) 1-Way PM or TPM : 105mm
(ii) 3-Way PM or TPM : 249mm
(iii) 6-Way PM or TPM : 465mm
(iv) 6-Way 19" RM : 482.6mm (19")

c) Height (all versions) : 177.2mm (7")

d) Panel cut-out dimensions
(i) 1-Way : 88.2 x 166.3 + 0.8mm
(ii) 3-Way : 232.2 x 166.3 + 0.8mm
(iii) 6-Way : 448.2 x 166.3 + 0.8mm

e) Panel thickness
(i) PM version : 1.5 to 6.5mm
(ii) TPM version : 6.5 to 24mm

f) Permissible mounting angle : Panel may slope from vertical by -45 to +90 degrees

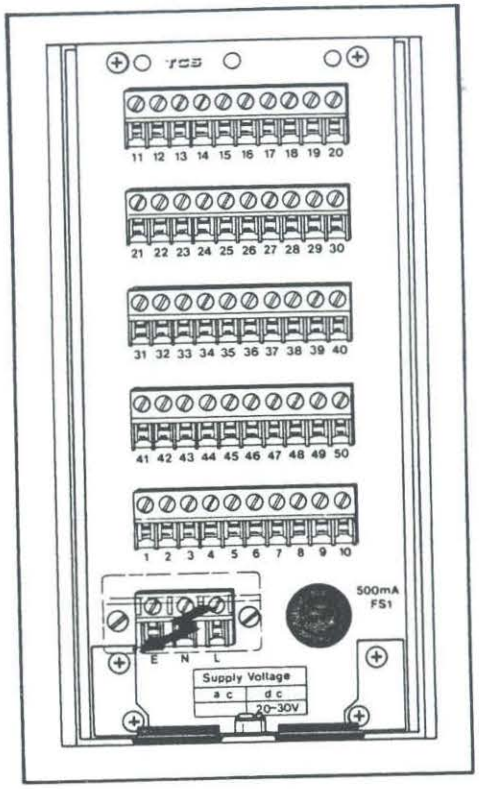
g) Customer cable size : 0.5 to 1.5mm

h) Bezel finish : Eggshell black stove enamel with silver trim

i) Weight

	DC VERSION	MAINS VERSION
(i) 1-Way PM or TPM :	3.6Kg	4.3Kg
(ii) 3-Way PM or TPM :	8.4Kg	10.5Kg
(iii) 6-Way PM or TPM or RM :	15.6Kg	19.8Kg

MICRO SUPERVISOR REAR TERMINATION ASSEMBLY



* Panel Mounting
* Modular Construction
* All Module Connections Available Via Screw Terminals
* 24V DC and Mains Powered
* Input/Output terminals ergonomically arranged in blocks of 8

REAR VIEW WITH TERMINAL COVERS REMOVED
DRAWING SHOWS 1WAY/MAINS POWERED VERSION

The 7445 Rear Termination assembly enables 6445 Micro Supervisor to be fitted into 7900 single or multi-way sleeves. Each 7445 assembly allows an associated 6445 module to function as a stand-alone instrument and enables it to be fitted into conventional panel cut-outs.

The Block Diagram shows that the 7445 contains a mains transformer and bridge rectifier assembly. A 0.5A screw-in type fuse is provided and 110V or 240V AC operation is selected internally. The mains input terminals have a separate 3-way connector block (51-53), while a further terminal (2) may be used for a 24V DC input or back-up supply, if required.

The input/output connections are arranged in 4 rows of 10 terminals for Block 1, Channels 1-8 (11-18), Block 2 (21-28), Block 3 (31-38) and Block 4 (41-48). Each row also has a 0V ref. terminal (19,29,39,49), and a 0V power terminal (20,30,40,50), to facilitate plant wiring.

The inter-connections between the 7445 screw terminals and the 6445 module pins are given in the cross-reference table which lists all those connections not shown in the Block Diagram.

SLEEVE TERMINAL NUMBER	MODULE PIN NUMBER	FUNCTION		OPTION (S3)
1	3	0V.PWR	POWER	
2		DC.SUPP.IN	SUPPLIES	
3	7	+15V.OUT		
4	5			
5	43			
6	9	W.DOG.OUT(1)	RS422	
7	45	XMT.OUT(-)	SUPERVISORY	
8	46	XMT.OUT(+)	DATA SERIAL	
9	47	RCV.IN(-)	BUS	
10	48	RCV.IN(+)		
11	10	DIG1.IN		
12	11	DIG2.IN		
13	12	DIG3.IN	DIGITAL	
14	13	DIG4.IN	INPUTS	
15	14	DIG5.IN	BLOCK 1	
16	15	DIG6.IN		
17	16	DIG7.IN		
18	17	DIG8.IN		
19	2	OV.REF		
20	3	OV.POW		
21	18	DIG1.OUT		
22	19	DIG2.OUT		
23	20	DIG3.OUT	DIGITAL	
24	21	DIG4.OUT	OUTPUTS	
25	22	DIG5.OUT	BLOCK 2	
26	23	DIG6.OUT		
27	24	DIG7.OUT		
28	25	DIG8.OUT		
29	2	OV.REF		
30	3	OV.POW		
31	26	XMT.PRT	RS232	
32	27		PRINTER	
33	28	RCV.PRT	LINE	
34	29			
35	30	XMT.CON	RS232	
36	31		CONSOLE	
37	32	RCV.CON	LINE	
38	33			
39	2	OV.REF		
40	3	OV.PWR		
41	34	P.XMT(-)	RS422 PLANT	
42	35	P.XMT(+)	SERIAL DATA	
43	36	P.RCV(-)	BUS	
44	37	P.RCV(+)		
45	38			
46	39			
47	40			
48	41			
49	2	OV.REF		
50	3	OV.PWR		
51		EARTH	A.C.	
52		NEUTRAL	MAINS	
53		LINE		

TECHNICAL SPECIFICATION

(A) Electrical

The 6445 Micro Supervisor which is plugged into the 7445 sleeve, is fitted with two blocks of digital I/O, three RS232 ports and two RS422 ports.

(a) Digital Inputs

Number of Inputs	: 8 non-latched, non-isolated inputs
Input Signal Levels	: Logic Zero = 0V
	Logic One = 5-15V

(b) Digital Outputs

Number of Outputs	: 8 latched, non-isolated outputs
Output Signal Levels	: Logic Zero = 0v
	Logic One = 15V

(c) RS232C Ports

Number of Ports	: 3 non-isolated, full duplex ports
Output Signal Levels (Nominal)	: Logic Zero = 12V
	Logic One =-12V

(d) RS422 Ports

Number of Ports	: 2 non-isolated, half duplex ports
Output Signal Levels	: $\pm$5V differential signals
Input Signal Levels	: $\pm$2V minimum differential signal

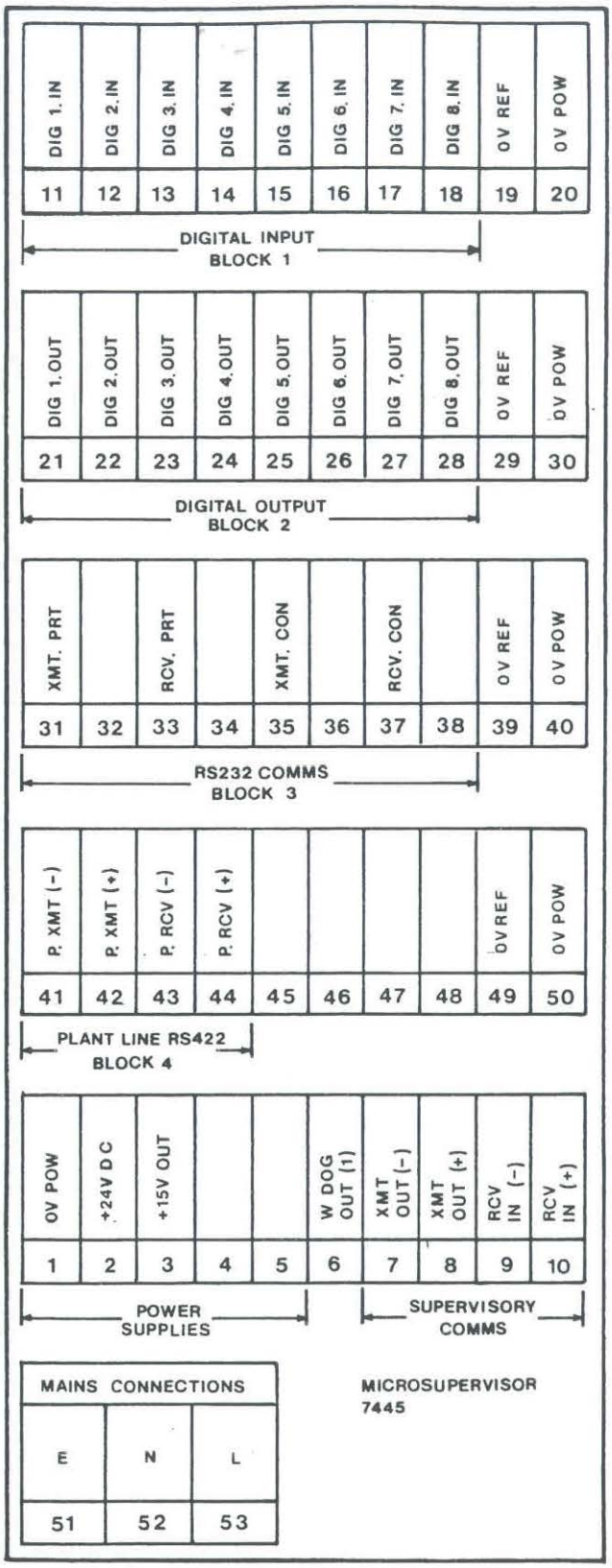
(B) Power Supplies

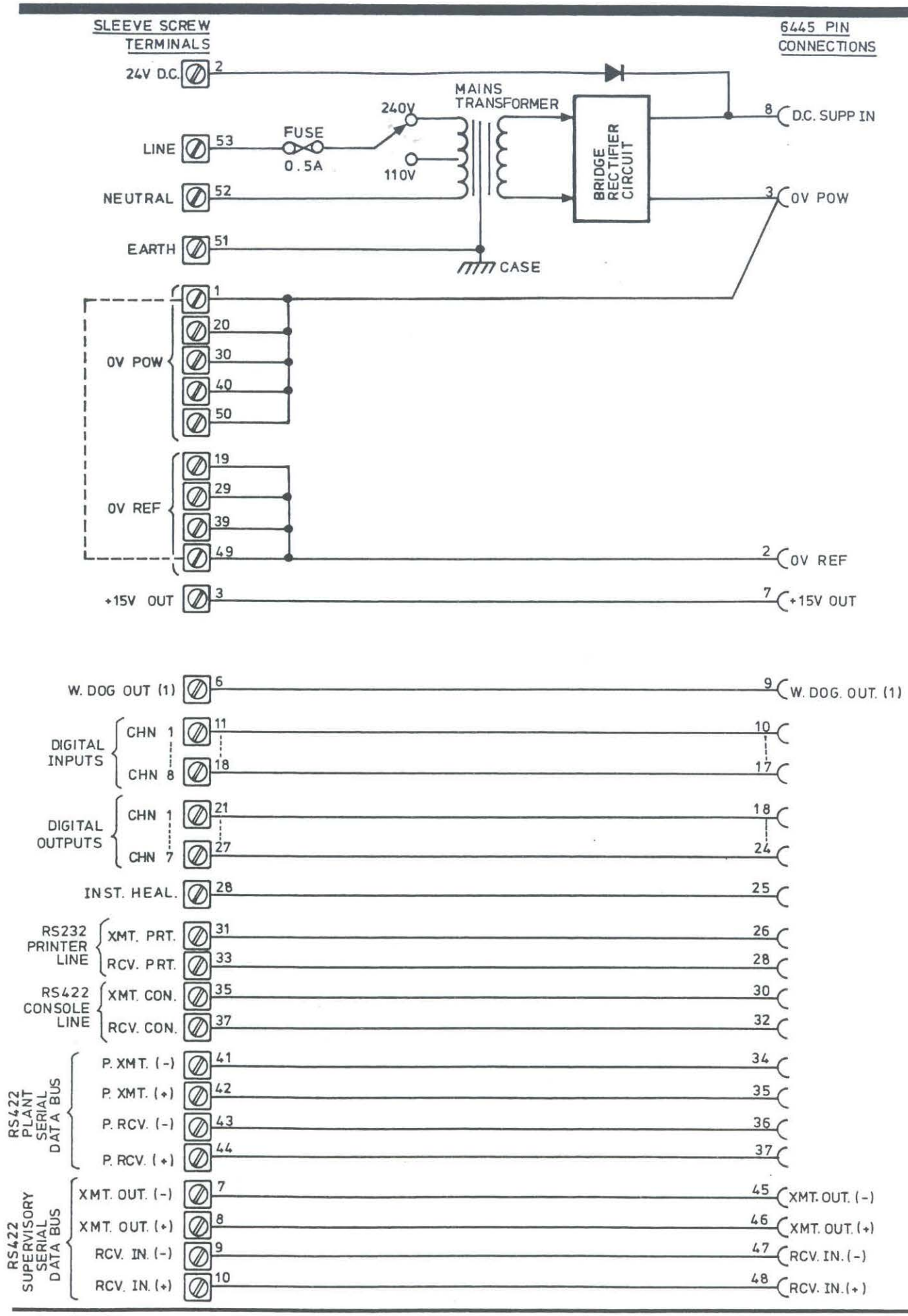
(a) Supply Inputs

Mains Version	: 110V AC at 220mA rms 240V AC at 100mA rms
24V DC Version	: 23-30V DC at 650mA
Back-Up Supply Input	: 20-30V DC on mains versions only

(b) Supply Outputs : 15V DC $\pm$ 0.5V at 100mA max.

(c) Fuse Rating : Separate 0.5A screw-in type fuse provided with mains versions only


DIG 1.IN
DIG 2.IN
DIG 3.IN
DIG 4.IN
DIG 5.IN
DIG 6.IN
DIG 7.IN
DIG 8.IN
0V REF
0V POW
11 12 13 14 15 16 17 18 19 20
DIGITAL INPUT BLOCK 1
DIG 1.OUT
DIG 2.OUT
DIG 3.OUT
DIG 4.OUT
DIG 5.OUT
DIG 6.OUT
DIG 7.OUT
DIG 8.OUT
0V REF
0V POW
21 22 23 24 25 26 27 28 29 30
DIGITAL OUTPUT BLOCK 2
XMT. PRT
RCV. PRT
XMT. CON
RCV. CON
0V REF
0V POW
31 32 33 34 35 36 37 38 39 40
RS232 COMMS BLOCK 3
P. XMT (-)
P. XMT (+)
P. RCV (-)
P. RCV (+)
0V REF
0V POW
41 42 43 44 45 46 47 48 49 50
PLANT LINE RS422 BLOCK 4
0V POW
+24V D C
+15V OUT
W DOG OUT (1)
XMT OUT (-)
XMT OUT (+)
RCV IN (-)
RCV IN (+)
1 2 3 4 5 6 7 8 9 10
POWER SUPPLIES
SUPERVISORY COMMS
MAINS CONNECTIONS
E N L
51 52 53
MICROSUPERVISOR 7445


SLEEVE SCREW TERMINALS
6445 PIN CONNECTIONS
24V D.C.
2
MAINS TRANSFORMER
240V
110V
LINE
53
FUSE
0.5A
NEUTRAL
52
EARTH
51
CASE
BRIDGE RECTIFIER CIRCUIT
8
D.C. SUPP IN
3
0V POW
0V POW
1
20
30
40
50
0V REF
19
29
39
49
2
0V REF
+15V OUT
3
7
+15V OUT
W. DOG OUT (1)
6
9
W. DOG. OUT. (1)
DIGITAL INPUTS
CHN 1
CHN 8
11
18
10
17
DIGITAL OUTPUTS
CHN 1
CHN 7
21
27
18
24
INST. HEAL.
28
25
RS232 PRINTER LINE
XMT. PRT.
RCV. PRT.
31
33
26
28
RS422 CONSOLE LINE
XMT. CON.
RCV. CON.
35
37
30
32
RS422 PLANT SERIAL DATA BUS
P. XMT. (-)
P. XMT. (+)
P. RCV. (-)
P. RCV. (+)
41
42
43
44
34
35
36
37
RS422 SUPERVISORY SERIAL DATA BUS
XMT. OUT. (-)
XMT. OUT. (+)
RCV. IN. (-)
RCV. IN. (+)
7
8
9
10
45
46
47
48
XMT. OUT. (-)
XMT. OUT. (+)
RCV. IN. (-)
RCV. IN. (+)

APPENDIX E SOFTWARE REVISION HISTORY

This Table details the modifications of the 6445 Micro Supervisor software:

SOFTWARE ISS.	SOFTWARE REL.	DATE	MEMORY BOARD	PROMS TYPE	PROMS NO.	REMARKS
1	1	31/10/86	Mk 6 (012)	27128	2	Initial Release
2	1	13/08/87	Mk 6 (012)	27128	2	Many new FORTH features; ?LBUF, TOTAL+, TOTAL-, GEXTOT, SEXTOT, GETRAW, SETRAW, SHFMSK, CRCPOLY, CRCINIT, CRCEXEC, CRCREAD words added. SETUP, ?SETUP, EMIT modified pseudo-instruments to include II & S1 to S4 parameters. RS 232 ports parsing modified. 64 extra variables added. Ctrl-X no longer overwrites RAM from EEPROM.
2	1.1	25/02/88	Mk 6 (012)	27128	2	Problems cured with the following:- a) Nulls in terminal I/O b) Pseudo analogue O/P c) Pseudo flow totals
2	2	01/12/87	Mk 6 (022)	27C 256	1	As issue 2/1.1 but 32k x 8 bit PROM fitted (option 022)

MANUAL ISS.	MANUAL REV.	DATE	PAGE	AMENDMENT
1	A	08/86		Initial Release
2	A	08/87		Printed and bound in standard TCS Technical Manual format, updated for issue 2/1 software.
			i to vii	Page numbers added.
				Section 4 expanded to include new FORTH words.
			5.6	Sections 5.3.1 to 5.3.3 added.
			5.7	Section 5.4 added.
2	B	03/88	iv	4.3.3 changed from 'Mark' to 'Mask'.
			vi	Fig. 4.2 added.
			4.5	'nul' changed to 'NUL' (Decimal 0) at foot of page.
			4.9	Table 4.3, n=3 and 4 'Write-only' changed to 'Read-only' parameter.
			4.16	Diagram added in middle of page.
			E.1	Software review history updated to include issue 2/2 software.
2	C	03/89	ii	2.6.2 changed from p2.11 to 2.12.
			vii	Table 2.4 added at p2.11.
			2.11	New Table 2.4 inserted.
			2.12	Changed from p2.11.
			3.4	5120 bytes changed to 5376 bytes.
			3.5	2 bytes added to each figure for memory usage, 5120 changed to 5376 bytes.

ISS.	DATE	ISS.	DATE	TECHNICAL MANUAL AMENDMENT RECORD SHEET		
1	13/11/86			DRAWN : MEE	MANUAL TITLE : Micro-Supervisor	
2	29/03/88					
3	01/03/89			CHECKED :		
				APPROVED :	PRODUCT CODE : 6445	
				TURNBULL CONTROL SYSTEMS LIMITED	DRAWING NO. ZZ 076864C	SHT 1 OF 1 SHTS