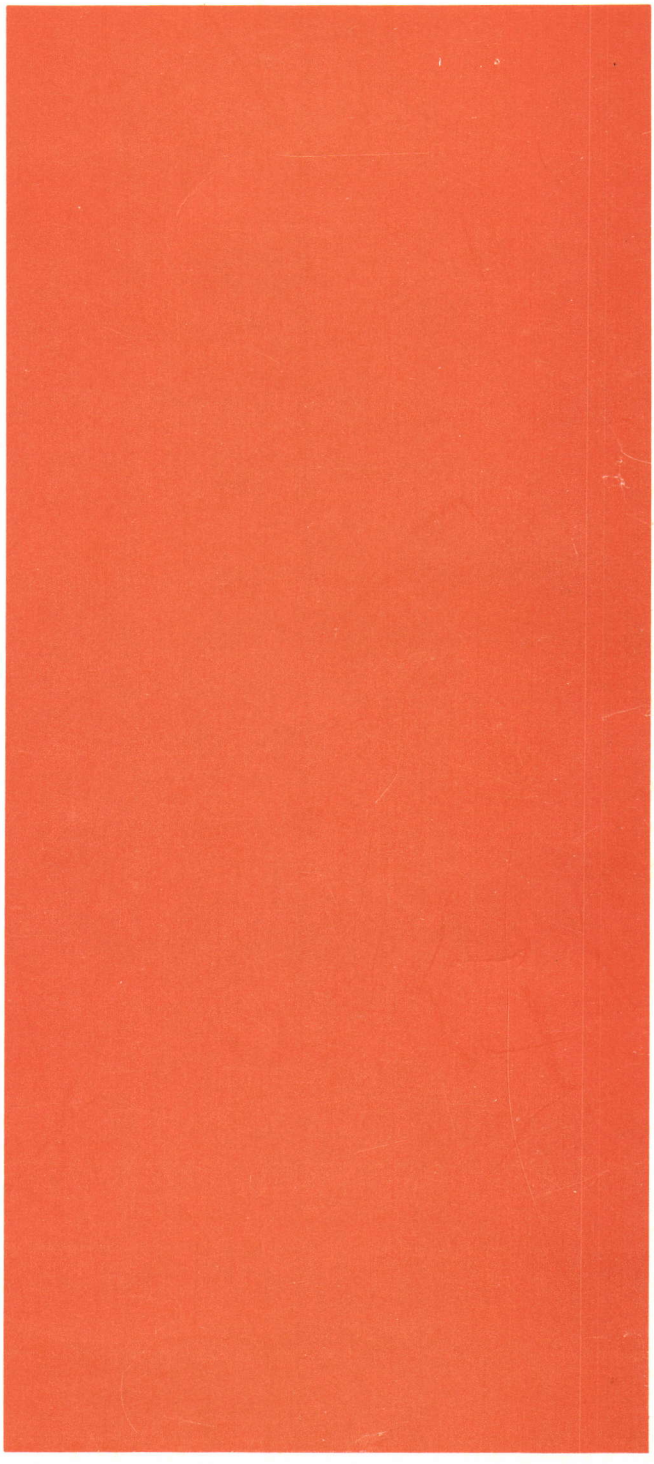
Honeywell

VUPAK 2
DDC SYSTEM

SERIES 16

SOFTWARE



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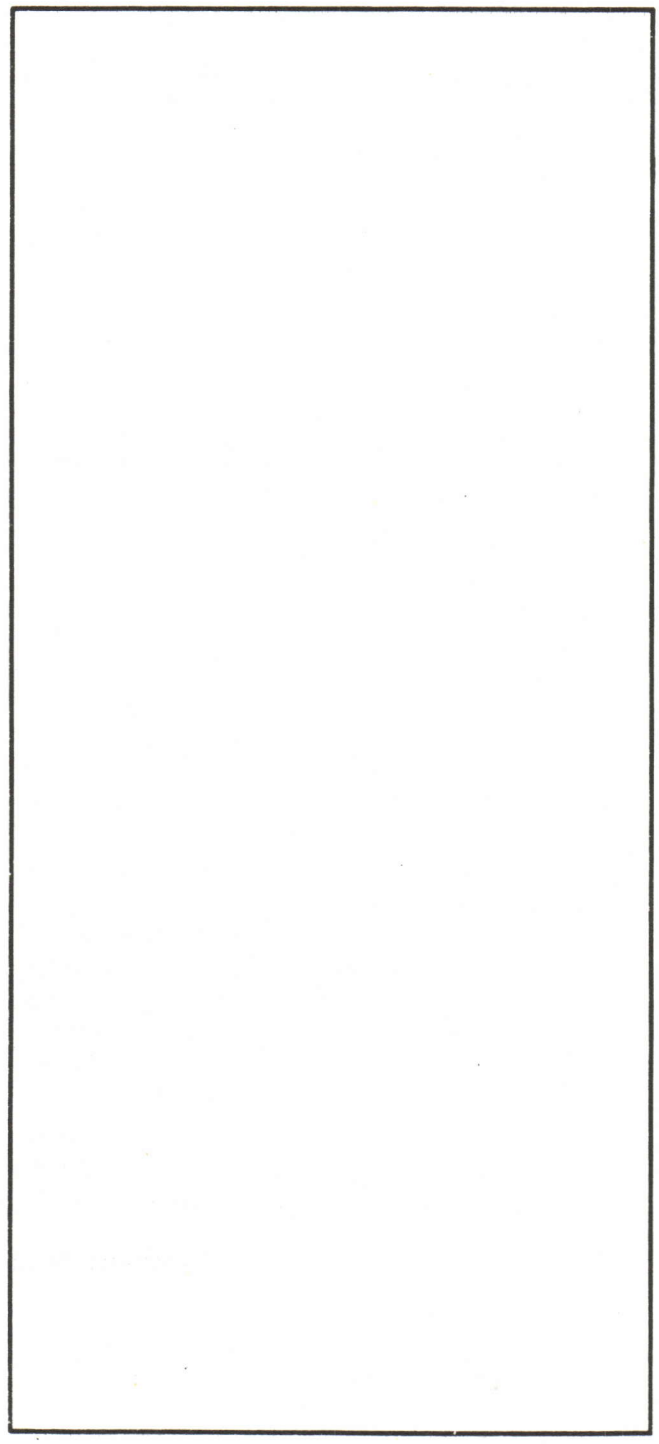

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September 1972

PREFACE

The Direct Digital Control (DDC) System Manual outlines the basic capabilities of the VUPAK 2 Industrial Process Control Package. Both the hardware and software aspects of the system are summarised, although emphasis is placed on the use of associated documentation where detailed information is required. Section 2 tabulates the VUPAK 2 manuals together with associated Series 16 Software Manuals; Hardware documents are listed separately. Special system restrictions and an overall specification follow, and the manual is concluded by a description of the system operation.

CONTENTS

Section		*Page*
1	INTRODUCTION	1 - 1
1.1	System Features	1 - 1
2	ASSOCIATED DOCUMENTATION	2 - 1
2.1	Hardware Documentation	2 - 1
2.2	Software Documentation	2 - 1
3	SIZE RESTRICTIONS ON VUPAK DDC SYSTEM	3 - 1
3.1	Low Level Inputs	3 - 1
3.2	Vutronik Stations	3 - 1
3.3	Operators Console and Message Systems	3 - 1
3.4	Analogue Inputs	3 - 1
3.5	Core	3 - 1
4	SYSTEM HARDWARE SPECIFICATIONS	4 - 1
4.1	Mandatory Hardware Requirements	4 - 1
4.2	Equipment Sizes	4 - 1
4.3	Cable Lengths	4 - 1
4.4	Physical Interface with Plant and Controllers	4 - 4
4.4.1	Analogue and Digital Inputs	4 - 4
4.4.2	Control Outputs	4 - 4
4.5	Power Supply Specification	4 - 4
4.5.1	Limits of Voltage (Nominal 115 Volts)	4 - 4
4.5.2	Frequency Limits (Nominal 50Hz)	4 - 5
4.5.3	Voltage Reductions and Breaks in Supply	4 - 5
4.5.4	Waveform	4 - 5
4.5.5	Noise and Transients	4 - 5
4.5.6	Power Consumption Figures	4 - 5
4.6	Earthing Specifications	4 - 5
4.7	Environmental Specification	4 - 6
4.7.1	Temperature and Humidity	4 - 6
4.7.2	Air Conditions	4 - 6
5	SOFTWARE	5 - 1
5.1	Software Modules	5 - 1
6	SYSTEM OPERATION	6 - 1
6.1	System Initialisation	6 - 1
6.2	Restarting the system	6 - 1
6.3	Resume of the Operators Console Facilities	6 - 1

Section *Page*

6.3.1 Action Sequences 6 - 2
6.3.2 Function of Point Records 6 - 3
6.4 Alarm and Operator Action Messages 6 - 5
6.5 System Configuration Records 6 - 6

ILLUSTRATIONS

Figure

4 - 1 Mandatory Hardware Requirements 4 - 2
4 - 2 Cable Lengths 4 - 3
5 - 1 Vupak DDC Program Structure 5 - 4

TABLES

Table

2 - 1 Associated Documentation - Hardware 2 - 2
2 - 2 Associated Documentation - Software 2 - 3
4 - 1 Dimensions 4 - 1
5 - 1 Software Modules 5 - 1
6 - 1 Action Sequences 6 - 2
6 - 2 Point Records 6 - 3
6 - 3 Alarm Message Abbreviations 6 - 5
6 - 4 Operator Action Messages 6 - 6

1 INTRODUCTION

This manual provides a description of the VUPAK DDC System and outlines the constituent basic components. It also provides pointers to associated documentation in which may be found a more detailed description of individual features.

1.1 System Features

The VUPAK DDC System is a complete hardware and software computer system providing for data acquisition and control.

Throughout the manual reference is made to DAS and DDC when referring to components of the total system, these terms are defined below;

(a) DAS (Data Acquisition System)

A capacity for the collection of plant data, linearising, filtering and generating alarms on the collected data with data logging periodically and on demand.

(b) DDC (Direct Digital Control)

A capacity for the implementation of control, notably 3 term, dead time, ratio or cascaded, with the calculated output sent direct to the final control device.

The system is designed to be very modular, both in hardware and software design, facilitating additions or changes in the system to suit specific requirements.

2 ASSOCIATED DOCUMENTATION

Documentation for the system is divided into two discrete sections:

(1) Hardware documentation.

(2) Software documentation.

2.1 Hardware Documentation

Table 2 - 1 provides the list of Technical Manuals associated with the hardware of a basic system.

2.2 Software Documentation

Table 2 - 2 provides the list of Technical Manuals associated with the software of a basic system.

TABLE 2 - 1
ASSOCIATED DOCUMENTATION – HARDWARE

HARDWARE							
CENTRAL PROCESSOR		REAL TIME CLOCK		PAPER TAPE READER		REAL TIME INTERFACE	
MODEL 316		316-1200	42401226100	PTR O & M	42401028001	RTI ADAPTER	41286101005
CP DESCRIPTION	42400343404	516-12	70130071657	PTR IPB	42401027001	DIGITAL I/O	41286101001
CP DESC & LOGIC	70130072174					ANALOGUE I/P	41286101003
CIRCUIT MODULES	70130072166					OPS CONSOLE	41286101092
INTERFACE	70130072167					COMP SIU	41286101086
INSTALLATION	70130072205					RTI CABINETS	41286101011
CONFIG RULES	70110011598					INST & MAINT.	41286101007
V & T ROUTINES	70130072189					VUTRONIK STATION	AS MODEL No
POWER SUPPLY	42401047001						
50 Hz MOD	70130072181						
MODEL 516							
INSTRUCTION VOL 1	70130071620						
INSTRUCTION VOL 2	70130071621						
INSTRUCTION VOL 3	70130071622						
INTERFACE	70130071624						
INSTALLATION	70130071625						
POWER SUPPLY	70130071933						
STANDARD SOFTWARE	42400343501						
COMMON							
OPS GUIDE	42400343402						

TABLE 2 - 2
ASSOCIATED DOCUMENTATION – SOFTWARE

SOFTWARE

LANGUAGES

FORTRAN IV	70130071364
FORTRAN TRANS	41286103126
FORTRAN MISC	41286103091
DAP 16 & MOD 2	41286384000
BASIC	41286103128

I/O

ASR 33/35	41286103089
HSR	41286103090

CP

PROG REF MAN	42400343401
PROG REF CARD	42400343405
DEBUG	41286452001

OP 16

USERS GUIDE	41286103020
UTILITIES	41286103055
ASR 33/35	41286103021
RTI LOG T/W	41286103043

VUPAK 2

OPS GUIDE	41286103173
APPLICATIONS	41286103174
SCAN ORG	41286103175
POINT RECORDS	41286103176
ACQ SUBSYSTEM	41286103177
UTILITIES & DRIVERS	41286103178
CONTROL & O/P	41286103179
MESSAGE SYSTEM	41286103180
OPS CONSOLE	41286103181
POINT REF & IDENT	41286103183
ACCEPTANCE SCH.	41286103184

3 SIZE RESTRICTIONS ON VUPAK DDC SYSTEM

The principal constraints on a standard VUPAK DDC System are introduced by timing. These constraints may be extended for special systems by hardware or software modifications.

3.1 Low Level Inputs

The low level inputs through the Real Time Interface (RTI) can be input at a maximum of 125 points per subsystem per second. Only one subsystem is supported.

3.2 Vutronik Stations

Each station requires 5ms to update and feed back. Stations are updated serially, therefore a maximum of 200 stations may be addressed in one second.

3.3 Operators Console and Message Systems

A 20% base load should be allowed in the software to ensure adequate operation of the Operators Console and Message Systems. Each DAS block, on one second scan, introduces approximately 0.12% software load, and control blocks, on one second scan, load the system by approximately 0.5% including station updating.

The load varies linearly with scan rate so that loops on ½ second scan provide twice the average loading of loops on 1 second scan. Similarly, loops on 8 second scan provide 1/8 of the average loading of loops on 1 second scan.

3.4 Analogue Inputs

A hardware maximum of 998 analogue inputs can be taken into the RTI, making due allowance for check signals on each page.

3.5 Core

The software at present supports a maximum of 16K core providing a maximum of approximately 5.5K of core for point records. At 8 words per DAS block and 17 words per full DDC block this provides for up to 680 DAS only points records or 320 full DDC blocks.

4 SYSTEM HARDWARE SPECIFICATIONS

4.1 Mandatory Hardware Requirements

Figure 4 - 1 shows the minimum computer hardware system required to run a VUPAK DDC system for up to 35 control stations. To this will be added analogue and digital input options as dictated by the plant signals on each system, and a suitable cabinet structure to contain the equipment.

4.2 Equipment Sizes

The details given in Table 4 - 1 are a guide to the size of the units comprising a VUPAK DDC system. Detailed sizes and an outline drawing of each unit and sub unit will be found in the manual particular to a unit.

TABLE 4 - 1
DIMENSIONS

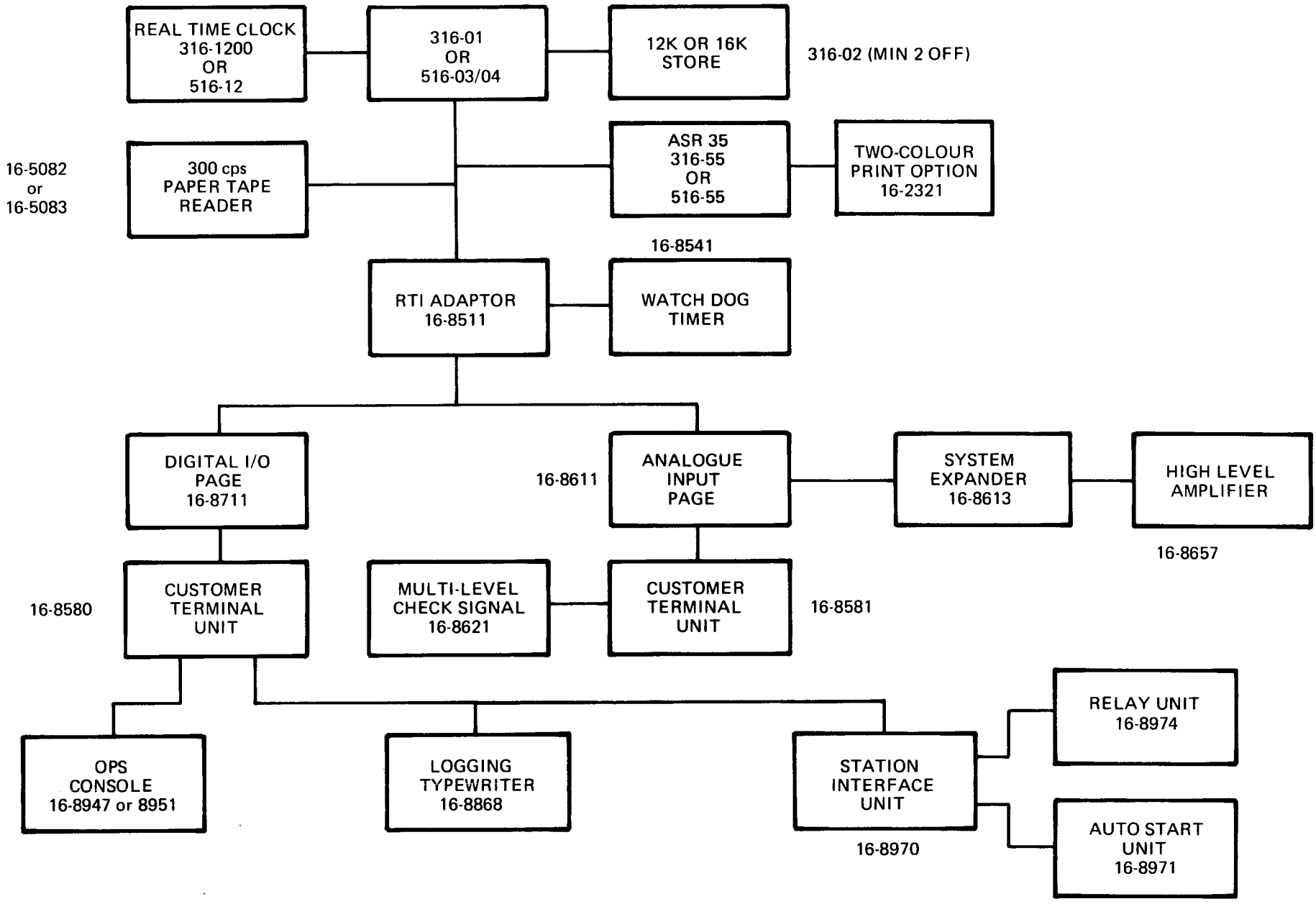
Unit	Height	Width	Depth
RTI Cabinet	1.8m	690 mm	710 mm
Station Interface Unit	260 mm	Contained in a standard 19in rack	
Operators Console ASR 35 IBM Selectric Typewriter Paper Tape Reader	340 mm 980 mm 250 mm 150 mm	540 mm 1.02 m 570 mm 360 mm	600 mm 610 mm 400 mm 330 mm
Model 316 (minimum configuration)	360 mm	Contained in a standard 19in rack	
Model 516 (minimum configuration)	810 mm	Contained in a 24 in rack	

4.3 Cable Lengths

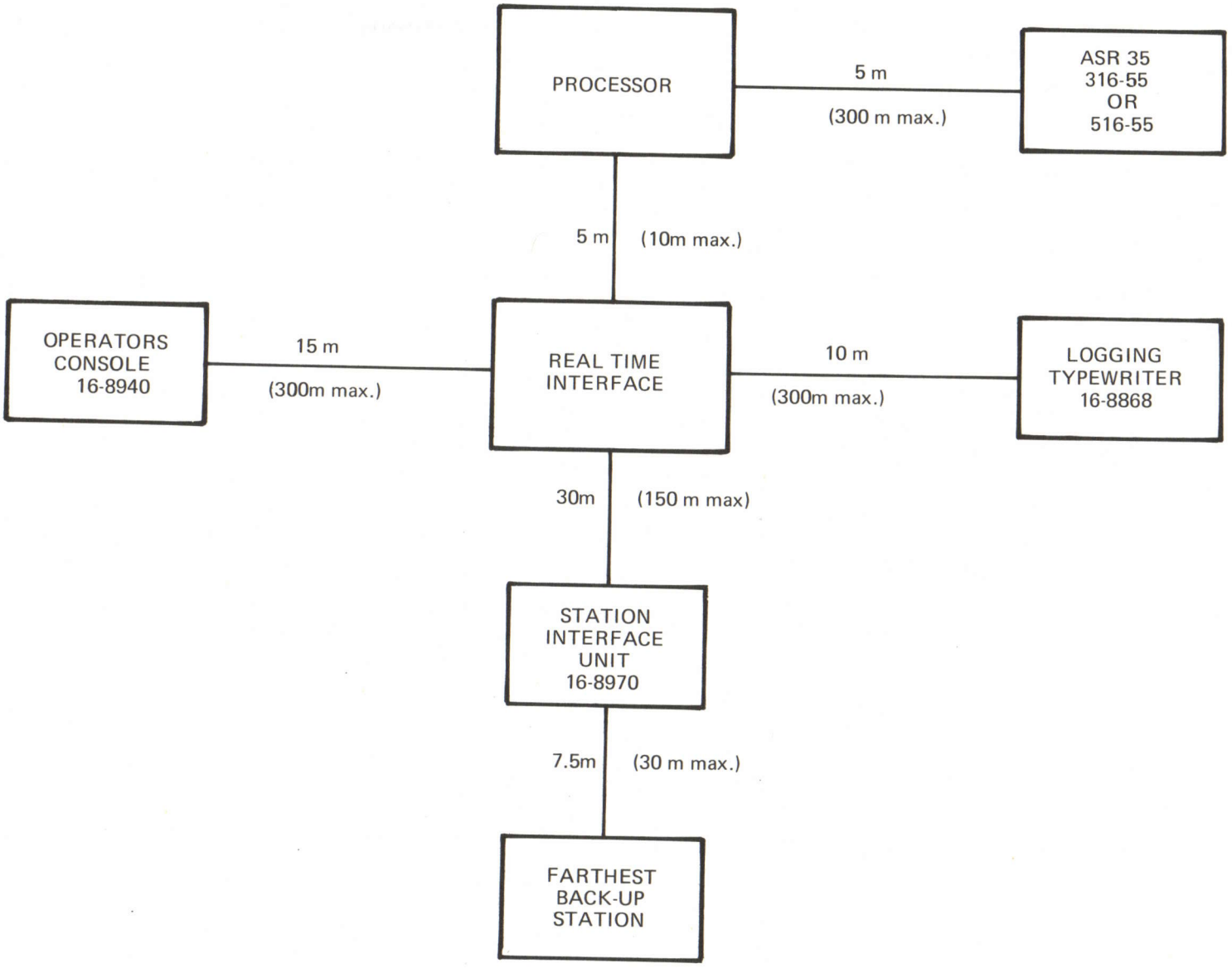
Figure 4 - 2 show a schematic cable layout on which is indicated the minimum and maximum cable lengths.

Maximum cable lengths are quoted for the unit controllers and these lengths may be increased by the use of special controllers.

Example: The distance between the RTI and the computer may be increased to 200 metres by using an isolation/line driver unit.



MANDATORY HARDWARE REQUIREMENTS FIGURE 4 - 1



CABLE LENGTHS

FIGURE 4 - 2

4.4 Physical Interface with Plant and Controllers

4.4.1 Analogue and Digital Inputs

All analogue inputs to the computer system will be terminated on the RTI Analogue Customer Connection Terminals which may or may not include signal conditioning cards. The terminals are 6 - 32 screws with binding heads on 7/16in centres to accept up to 1.588mm single core wire or up to 50/0.25mm flexible wire.

All digital inputs or outputs will be terminated on the RTI Digital Customer Connection Terminals which have similar terminations to the Analogue terminals.

Plant cables may enter the RTI through gland plates in the top and bottom of the cabinets. Cable trunking is provided to route the cables neatly. Gland plates are supplied blank.

4.4.2 Control Outputs

Cables from the SIU carry Update Data and Address Data for the stations. These cables are provided with plugs for connection at the SIU but are left without plugs or tags at the station end, with each core flagged to denote its signal function.

The installer must provide terminations for this cable in the form most acceptable to his installation, and run the signals from these terminations to the control stations along other cables. Note that the 30 metre length restriction from SIU to stations will include all such installation cables and due consideration for this should be made in the siting of the SIU.

The SIU cables provided include a twisted pair for the multiplexed feedback of station status but do *not* include cable for feedback of updated output values. A screened twisted pair should be provided by the installer to feedback all multiplexed output values to the multiplexed feedback location in the RTI Master Analogue Page. Two extra pairs of cores should be provided for each station requiring dedicated feedback, and the analogue and digital feedbacks should be run in separate cables.

The RTI Installation and Maintenance Manual provides a useful description of System Signal Wiring Practice for RTI (see subsection 2.5 of that manual).

4.5 Power Supply Specification

The specification of power supply requirements given here assumes that only the equipments listed in the minimum configuration are used. A check should be made of any additional units ordered on a system to ensure that the power supply requirements are within these minimum configuration requirements.

4.5.1 Limits of Voltage (Nominal 115 Volts)

Lower	103 volts rms
Upper	126 volts rms

Note that all equipment should be specified to operate on 115 volts (nominal) to satisfy these requirements. Check that all units comply with this.

4.5.2 Frequency Limits (Nominal 50Hz)

Lower	49 Hz
Upper	52 Hz

4.5.3 Voltage Reductions and Breaks in Supply

The supply voltage must not fall below the lower limit (103 V rms) for one half cycle, or longer (ie 10ms).

4.5.4 Waveform

The waveform must be sinusoidal with less than 5% total harmonic distortion including less than 3% third harmonic distortion.

4.5.5 Noise and Transients

Voltage transients must not exceed 600 volts peak, positive or negative, and must not have a duration of more than 100 μs. No more than 5 such voltage spikes should be present during one half cycle of the supply.

Because of the high gain circuits used in parts of the system, noise generated in the primary power supply should be reduced as much as practicable. The installation of a double wound, double screened isolating transformer in the power supply is strongly recommended for reduction of spurious noise inputs. If the power supply tends to have dips, breaks or spikes, then a static no-break inverter power supply unit should be used to drive the computer system.

4.5.6 Power Consumption Figures

Unit	Approximate power requirements
Model 316 (Min)	500 VA
Model 516 (Min)	1000 VA
ASR 35	400 VA
Paper Tape Reader	250 VA
Operators Console	250 VA
SIU	100 VA
RTI (Min)	1000 VA

Power consumption for larger-than-minimum computers and RTI Configurations should be calculated using data provided in the appropriate manuals.

4.6 Earthing Specifications

The RTI is designed to incorporate a system star earth point. The instrumentation earthing system should be designed to use this earthing system, which is fully described in the RTI Installation and Maintenance Manual.

Note particularly that the system ground must be kept seperate from all other grounds at the installation, such as metal walls, piping or 'mains' earths, and a separate ground electrode installed for the VUPAK system, including the instrumentation.

Detailed attention to the design and implemation of a good earthing system will always repay the installer in problem-free commissioning.

4.7 Environmental Specification

All the equipment scheduled as part of the minimum hardware configuration will operate in the environmental limits specified below. The customer should check whether any additional equipment used necessitates a closer control of the environment.

4.7.1 Temperature and Humidity

0^{o} to $40^{o}C$ for 10% to 80% relative humidity.

4.7.2 Air Conditions

The component parts have been designed to give a great deal of protection from rust, corrosion and shock. However in any environment where corrosive dust particles or gases such as SO_2 or H_2S are present, the provision of dust and corrosive gas filters for computer room air supplies will greatly improve the system reliability and life expectancy. Full air conditioning contributes greatly to operator comfort and reduces fatigue. It should be seriously considered in all control situations where plant conditions are adverse.

5 SOFTWARE

5.1 Software Modules

A list of software modules used in VUPAK 2 is shown in Table 5 - 1 below. Reference should also be made to the Glossaries contained in each of the VUPAK 2 documents.

The VUAPK DDC program structure is shown in Figure 5 - 1.

TABLE 5 - 1
SOFTWARE MODULES

Module	Description
AA	Analogue Input Driver
AC	Organisation of the overall acquisition and control functions in the system
AD	Asynchronous and Operators Console Keyboard Driver
ADC TABLES	Table of analogue hardware configuration used
ADRRTN	Sets up station address lines
ANALIP	Organises the input of analogue data
AP	Action Printout
ASRDRV	ASR Output Driver
ASYNCH TABLES	Tables allowing the configuration of precise actions on change of various statii: The tables are ADDB, RBUF, COLR, POLR, RTNS, NOIP.
AT	Alarm Typeout
ALMRTN	Alarm routine
BCDB	Re entrant BCD To Binary routine
BDQR	First -in first-out block data queueing routine
BINBCD	Re-entrant binary to BCD Routine
BL	Software base load calculations
CA	Asynchronous status servicing program (AASP)
CP	Maintain date on calendar
CNTROL	Control organisation program
CONTAB	Table of control algorithms
CRAT	Ratio algorithm
DASPRO	Processing sequence for input data
DEDTAB	Table of output dead band values
DATABL, IWTABL, DEDDAD	Station address tables
DERVIP	Organises the derivation of data
DIFTAB	Table of alarm differentials

Continued...

TABLE 5 - 1

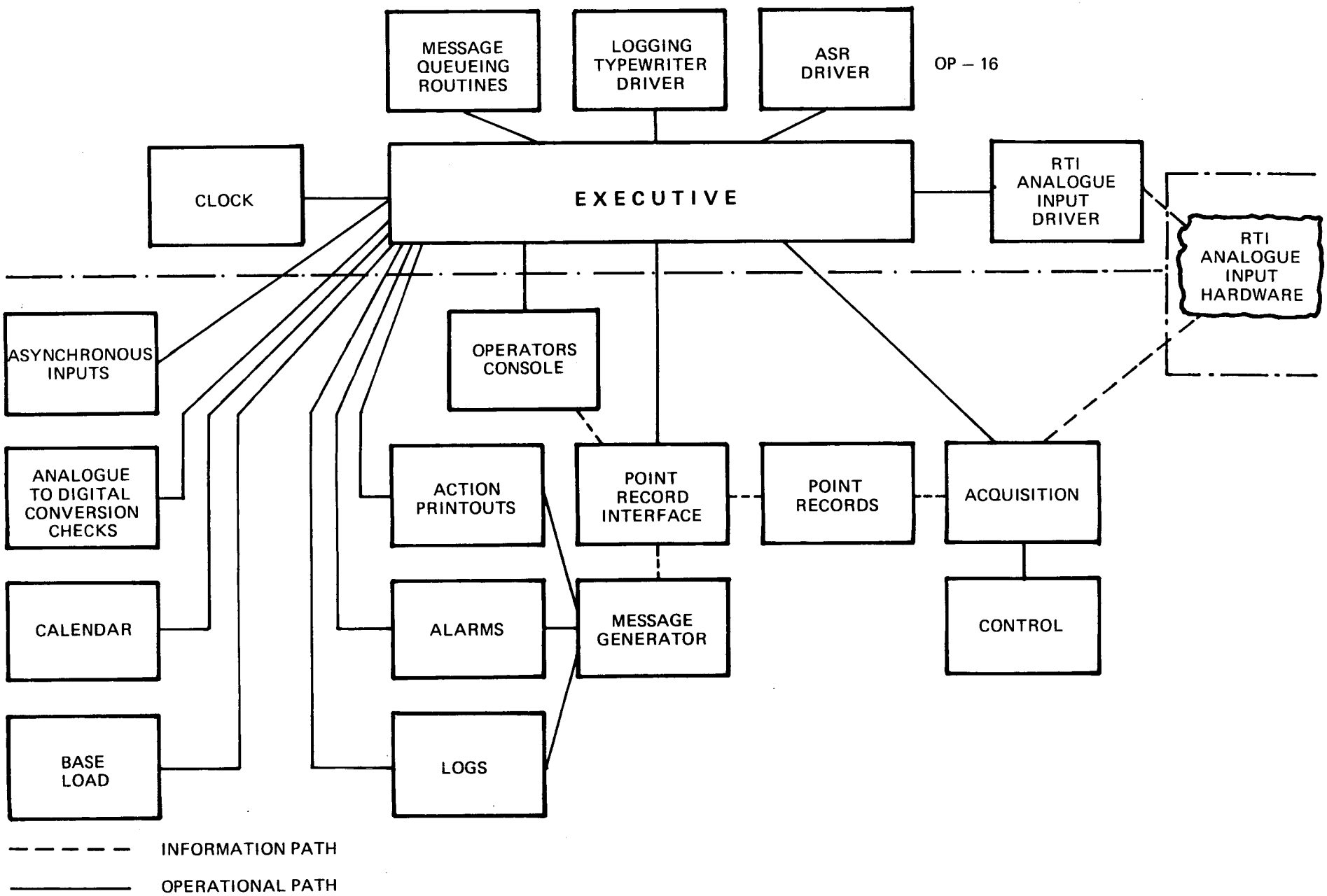
SOFTWARE MODULES (Contd.)

Module	Description
DIGO	Digital output
DIGTIP	Organises the input or pre-digital data such as counter inputs
EPMOD	Error print module for RTX-16
ESTT	Special routine to establish which scan a point record is using
EXEC A	RTX-16 Executive
FBUP	Update point record with feedback
FEEDBK	Feedback from Stations
FIFO	First-in first-out single parameter queueing routine
FLTTAB	Table of filtering constants
FLTRTN	Digital filtering routine
INLRTN	Applies a maximum limit to the incremental output change.
LIMTAB	Table of incremental limits
LINRTN	Linearisation routine
LINTAB	Table of linearisation constants
LOGDRV	Logging typewriter driver
LP	Log program
MDRQ	Multi-device request queueing routine
MENT	Message generator
MESSAGE TABLES	List of engineering units and alphabetic identities stored in ASCII for use in RANGE
MULT/DIV	Re-entrant multiply and divide routines
OC	Operators Console program
OD	Output to Operators Console Display
OPACTS	Operators Console action sequences
OPCON TABLES	Tables linking functions with switches and displays on Operators Console
OPINT	Operating system initialisation routine
OORRTN	Routine to check for ADC overload
OUTSUP	Control output Supervisor
PI	Point record Interface Program
PRI SPECIALS	Special routines for entry/collection of data in point records

Continued....

TABLE 5 - 1
SOFTWARE MODULES (Contd.)

Module	Description
PRI TABLES	Data tables defining storage location and size of parameters passed by Point Record Interface Program
PTID	Special console routines for 'Point Identity' 'Configure' and 'Interrogate' functions
RANG	Tables to define ranges required in engineering units after conversion by the RANGE routine
RANGE	Convert data to ASCII format
RENT	Set up and enter any re-entrant routine
SBRLST	List of special input derivation routines
SCAINT	Scan initialisation and organisation program
START	Initialisation routines for VUPAK programs
SO	Station output driver
STNOPR	Output to station and trigger timing chain
STSW	Status switching for stations (four routines called: CCACT, CLACT, LCACT & LLACT)
3 TERM	Three term algorithm (including dead time)
VALPRG	Determines whether calling program is allowed to change a parameter
VERAMP	Analogue to digital converter check
XCOM	RTX-16 Configuration module for VUPAK



VUPAK DDC PROGRAM STRUCTURE

FIGURE 5 - 1

6 SYSTEM OPERATION

6.1 System Initialisation

There are two types of 'initialisation' used in VUPAK. The term initialisation is used for the initial configuration of a standard system tape to suit the customers requirements before any point records are configured. Subsequent starts on fully or partly configured tapes use a re-initialisation sequence which is automatic.

The initialisation program on an unconfigured system tape occupies an area of core above the VUPAK system programs and is overwritten by the point record and derived input data block areas after initialisation.

This enables the use of a comprehensive conversational configuration sequence, as described the VUAPK 2 Operators Guide and the VUPAK 2 Utilities and Drivers PRM, without any on-line core overhead. After initialisation, a configured system tape should be generated using PALAP. (see CP Operators Guide).

6.2 Restarting the system

The following procedure should be carried out to restart a system:

(1) Load the configured 'System and Point Record' tape.

NOTES:

(a) If the computer has been stopped by a power failure or by turning the RUN switch to SI mode and no other programs have been fed into the computer, step (1) above may not be necessary.

(b) If two separate tapes are punched, one for the programs and one for the point records, care must be taken to ensure that the values in the program table SCNSRT correspond to the point record tape exactly.

(2) Master clear the computer and start the program at P register = '1000.

(3) Type '$' on the computer I/O typewriter.

(4) From the console, put the system back on-line. Note that the exact procedure for putting the system back on-line will vary from plant to plant. It is *Vital* that plant engineers establish a procedure for this operation and ensure that all operators are throughly familiar with that procedure.

6.3 Resume of the Operators Console Facilities

The VUPAK 2 Operators Guide and VUPAK 2 Operators Console PRM provides a full description of the facilities provided; but for quick reference a table of functions which can be performed from the console is given here.

All functions which are shown as enterable from the console may be configured to be non-enterable when the Inhibit keyswitch is set, with the limitation that indirectly accessible functions must all be locked out together under the INTERROGATE KEY and not locked out individually.

6.3.1 Action Sequences

A summary of action sequences is detailed in Table 6 - 1 below:

TABLE 6 - 1
ACTION SEQUENCES

Function	Description	Tick if entry inhibited in standard system when keyswitch set
Real Time	Display and entry of the time of day	✓
Raise	When a setpoint or output value is being displayed it will be raised or lowered at 1% per second for as long as the appropriate key is depressed. When an octal location is displayed the operator may step up or down in core one location each time a key is pressed.	
Lower		
Demand Program 1	Loop summary printed on logging typewriter	
Demand Program 2	Operators console lamp and switch test	
Demand Program 3	Octal entry facility	✓
Demand Program 4	Reinitialise ADC checks	
Device	Turn on and off the alarm typewriter (device 1) and logging typewriter (device 2)	✓
Log Interval	Interval in minutes between cyclic logs. Log interval zero prevents any cyclic logs occuring.	✓
Demand Log	Request a log in addition to normal cyclic logs	
Interrogate	(a) If no point identity is being displayed a point identity may now be called up on the display	
	(b) If a point identity is displayed all the functions of that point identity can be inspected in sequence. All enterable functions may be changed when they are displayed.	✓
Configure	Configure a new loop on line. Each parameter will be requested in turn on the console display until a 'CONFIG, COMPLTE' message is displayed to denote that the loop is configured	
Point Identity	Enables an existing point identity to be displayed on the console.	

6.3.2 Function of Point Records

Point Record functions are summarised in Table 6 - 2 below:

TABLE 6 - 2
POINT RECORDS

Function	Description	Tick if entry inhibited in standard system when keyswitch set
Algorithm Index * ‡	Type of algorithm (max. 16 types)	
Point Identity*	Two Alpha, three numeric character name for a loop	
Input Mode Specification * ‡	Defines type of data input; high or low level analogue, digital or internally derived.	
Multiplexer address ‡	Defines the input address to be used by the RTI for analogue or digital inputs	✓
Subroutine index *‡	Defines which derivation subroutine to use for derived inputs	✓
Subroutine parameter	Different subroutines require different types and quantities of data. A numeric identifier is required for each parameter before it is displayed.	✓
Digital Filtering Constant ‡	Index to filtering parameters	✓
Isothermal block number ‡	Defines which RTI isothermal block is used for each thermocouple input to provide automatic cold junction compensation	✓
Linearisation Routine ‡	Index to appropriate linearisation table	✓
Engineering Format Spec ‡	Index to range of engineering values to be displayed and printed	✓
High Limit	Process variable alarm limits	
Low Limit		
Alarm differential	Index to alarm typeout 'deadband'	
Logging status ‡	Each point may be ON or OFF log	✓
Control related loop ID	Identity of the loop providing the set point or bias to loops with algorithm index 3, 5 or 7	✓
Set point	Set point for 3 term calculations	

TABLE 6 - 2
POINT RECORDS (Contd.)

Function	Description	Tick if entry inhibited in standard system when keyswitch set
Proportional Factor	Three term parameters	✓
Integral Factor		✓
Derivative Factor		✓
Proportion Factor	Ratio parameters	✓
Ratio bias		✓
Direct/reverse action ‡	Whether to increase or decrease an output to increase a measured value.	✓
Dead time gain	Dead time compensation parameters	✓
Process dead time		✓
Dominant lag		✓
Output limits index ‡	Index to Maximum output increment	✓
Dead band ‡	Index to Minimum output increment	✓
Output address	Number of output station	✓
Scanning interval	Index to scan rate, ½ second to 32 seconds, but BEWARE; scanning interval zero will delete the block.	✓
Supervisory status	On control loops if the supervisory status is ON, all operator update of the loop is prohibited	✓
Computer status	State of a control loop is either computer auto ON computer auto OFF (= computer manual).	
Station status +	The station status is displayed as ON (= computer) or OFF (= local)	
Output value +	The output value feedback from the control station is displayed and updated each second	
Process variable +	The input to the loop is displayed and updated each second	

NOTES:

* Enterable only during configuration of a loop

\+ For display only cannot be entered from the console

‡ Accessible indirectly only (via INTERROGATE key)

6.4 Alarm and Operator Action Messages

The messages typed out on the system ASR fall into one of two categories.

(1) Alarm messages.

(2) Operator action messages.

The two message systems use the same typewriter but otherwise are independent, so that saturation of the Operator Action printout will not cause any alarm messages to be lost.

Every message is started with a printout of the time, followed, where appropriate, by the point identity of the loop to which the message applies. The messages are typed in abbreviated form to save time and core. The abbreviations used are self-explantory, but to avoid any possible confusion the abbreviations used and their full meanings are given in Table 6 - 3 and 6 - 4. Note that in all cases, red print-out denotes the alarm condition and black print-out denotes a return to the safe condition for Table 6 - 3.

TABLE 6 - 3
ALARM MESSAGE ABBREVIATIONS

Abbreviation	Meaning
HI	Process variable has exceeded the high limit.
LO	Process variable is below the low limit.
OK	Process variable is within the high and low limit.
IP	In attempting to linearise the process variable a number outside the range 0 to 1 has been generated.
IP: ADC OVERLOAD	Too high an input voltage has been fed into the RTI for the voltage range selected, causing the analogue to digital converter to generate an invalid code. Control will continue using the last valid PV read for the loop.
OP	The output station was not correctly addressed at the last attempt.
AD	An error has been detected in the analogue input system. All acquisition on erroneous amplifiers will cease immediately.
CA	Change of state of a digital input
AT	Alarm table saturated

TABLE 6 - 4
OPERATOR ACTION MESSAGES

Abbreviation	Meaning
ALG INDX	Algorithm index
PT IDENT	Point identity
IP SPEC	Input mode specification
MXOR ADD	Multiplexer address
SUBR NO	Subroutine number or index
SUBR PAR	Subroutine parameter
DIG FILT	Index to digital filtering constant
ISO BLK	Isothermal block number
LIN INDX	Linearisation routine index
ENG SPEC	Engineering units specification
HI LIMIT	High Limit
LO LIMIT	Low Limit
ALM INDX	Alarm differential index
LOG STUS	Logging status
CRL ID	Control related loop identity
SET PT	Set Point
PROP GN	Proportional factor
RATIO BS	Ratio bias
INT GN	Integral factor
DERIV GN	Derivative factor
DIR/REV	Direct/reverse action
DT GAIN	Dead time gain
PRCES DT	Process dead time
DOM LAG	Dominant lag
OP LIMS	Output limits index.
DED BND	Dead band index
SCN INDX	Scanning period index
SPER STS	Supervisory status
OP VALUE	Output value
PV	Process variable
AP	Action printout buffer saturated

6.5 System Configuration Records

The VUPAK 2 Point Reference and Identification manual provided with each system should be used to maintain an up-to-date detailed record of the configuration of the users system.

The manual provides configuration charts for each of the seven standard algorithms enabling simultaneous recording and configuration of the control system by the operator. The operator action printouts will provide a useful hard copy of all system changes for updating the configuration details at regular intervals.

The Point Reference and Identification Manual also provides blanks of each of the system data tables to provide, firstly, a help in designing and implementing the control system and, secondly, a permanent record of the meaning of each of the system indices.