Motion Control System
and
Operator Interface* (VC1)

User Manual

Revision 1.9

January 2006

PAN CONTROLS LIMITED

(*) Optional keypad and display

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1 DOCUMENT MANAGEMENT

1.1 Release

Issue	Date	Comments	Software
1.1	August, 1998	First release	V106.7
1.2	April, 1999		V107.3
1.3	February, 2000	Mk II keypad	V107.8
1.4	February, 2001	Rev F control board	V109.0
1.5	April, 2001	Mk III keypad	V109.1
1.6	June, 2001	Updated diagrams	V109.1
1.7	September, 2001	Option for new low end controller	V109.4
1.8	August, 2003	Improved display commands	V109.7
1.9	January, 2006	Corrected referencing commands	V109.7

1.2 Critical changes to software

The purpose of this section is to highlight changes to software revisions, where there could be compatibility problems with previous versions.

1.2.1 Version 107.6 (October 1999)

The SK command has had keys re-allocated to it. This means it is possible the a programme written for an earlier version of software will need to be changed. For example SKK5 now enables sequence 5 to be executed after pressing the right hand display key; previously it was after the escape key.

1.2.2 Version 107.8 (February 2000)

The RM (reference mode) command has been removed. The same functions are now carried out by the EI (Enable input) and MI (Mask input) commands, when the inputs referred to have been defined for reference activities.

1.2.3 Version 108.0 (March 2000)

The SU(Set Units) command has been removed. The variable system allows scaling to be performed more flexibly.

1.2.4 Version 109.7 (August 2003)

The EP, LP, XP, and PV profile commands have been removed. This is to make room for other more useful commands.

1.3 Key additions to software

The purpose of this section is to highlight additions to the language in software revisions.

1.3.1 Version 106.6
July 1998 - First variant of software with daughter board

1.3.2 Version 106.7
August 1998 - Added display/keypad features to controller
Added reset of parameters on fifth LED light after switch on
Allowed SP without interfering with DAC

1.3.3 Version 106.8
August 1998 - Added display pos snapshot and referencing

1.3.4 Version 106.9
October 1998 - Fixed bug with VT
Improved MD with no parameter
Allowed 256 numeric variables (%)
Added VO, UR, UM, UD, UO

1.3.5 Version 107.0
October 1998 - Added EE, HS. Fixed LL.

1.3.6 Version 107.1
October 1998 - Added selective SP(v).

1.3.7 Version 107.2
October 1998 - Fixed problem with numeric variables

1.3.8 Version 107.3
April 1999 - Fixed keypad scanning in rp loops
added reset and snapshots for b channel

1.3.9 Version 107.4
June 1999 - Set up for new keypad

1.3.10 Version 107.5
September 1999 - Corrected snapshot

1.3.11 Version 107.6
Added HR reset (watchdog)
- allowed all keys on Calman keypad
- enabled wired or mode for keypad outputs

1.3.12 Version 107.7
Jan 2000 - separated SPV ans SP functions

1.3.13 Version 107.8
Jan 2000 - added GL, EC, WX ,ZX & RX commands

1.3.14 Version 107.9
Feb 2000 - added NE & ZD commands

1.3.15 Version 108.0

Mar 2000 - Allowed rev f board with direct bus display
Fixed arrow key masking bug

1.3.16 Version 108.1

Apr 2000 - Allowed rev c daughter board
Allowed bounds counter for aux channel
Removed RM
n.b. Uses memory map which requires Config register to disable
EEPROM. Use DD command having entered priveleged mode using /*Pan*/
password. DP shows current state of CONFIG register ($0F factory setting - $0E after DD)
DC shows hex memory table, starting address from variable A
Allowed rev c daughter board

1.3.17 Version 109.0

Nov 2000 - Split with operator interface code

1.3.18 Version 109.1

Feb 2001 - Scan for Calman mk 2 keypad

1.3.19 Version 109.2

June 2001 - Fixed bug with OX command

1.3.20 Version 109.3

August 2001 - Allowed KPO... SAO... etc to variables

1.3.21 Version 109.4

V109.4 - September 2001 - Added VBC/S, IC, IS
modified to allow 14 inputs with Rev C daughter board

1.3.22 Version 109.5

March 2002 - Fixed bug relating to upper & lower limits
Fixed PO, and allowed use with variables

1.3.23 Version 109.6

October 2002 - Added CE and PL
Fixed bug with KS to allow KSn to reset within sequence

1.3.24 Version 109.7

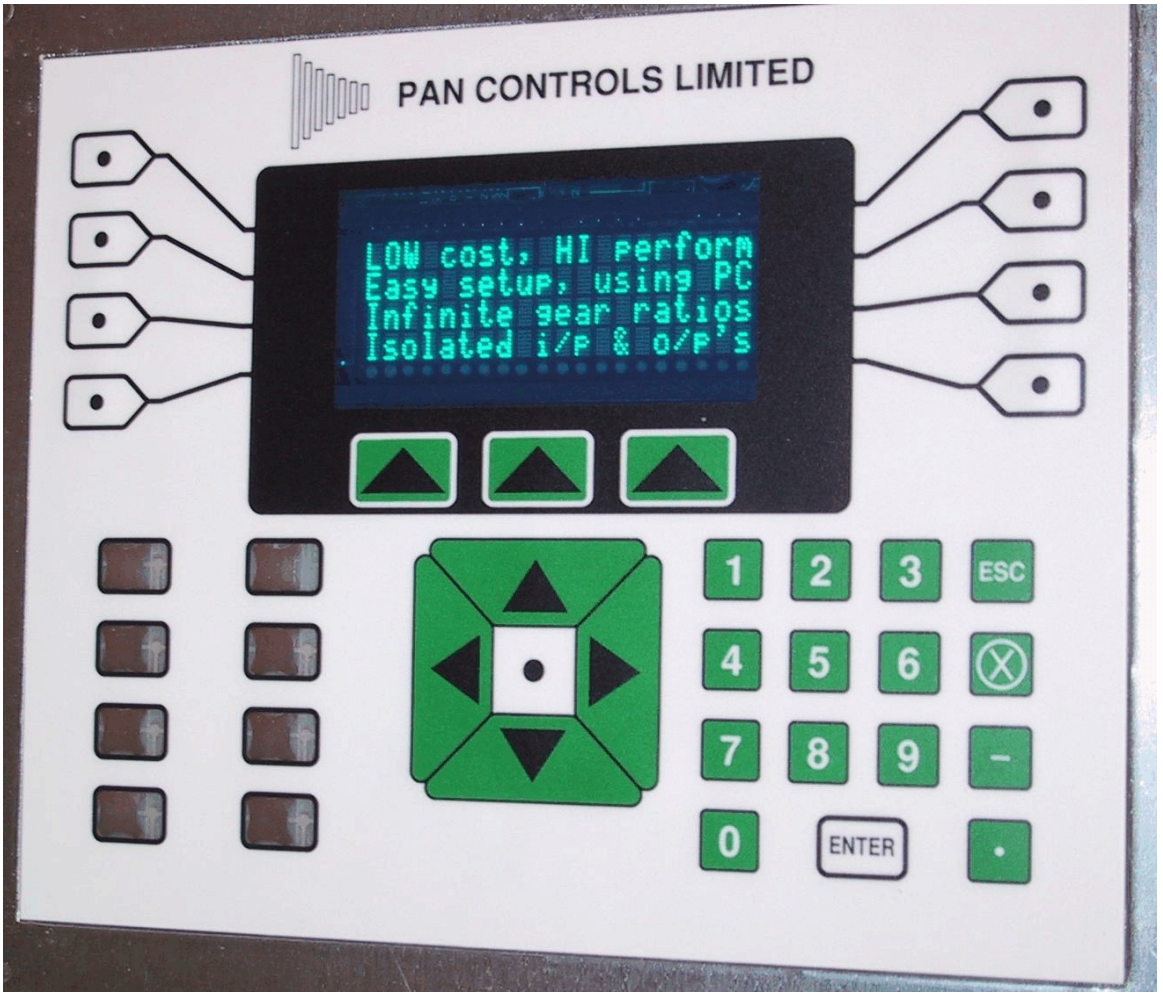
August 2003 - Added FN, ME, MV, and cursor control CR
Removed EP, LP, XP, & PV profile commands

2 INTRODUCTION

This document describes the Pan Controls motion control system.

The system controls a servo motor with position feedback. It monitors a second position channel, and provides a second auxiliary analogue output. The second position channel can be used as an input to the system. For example, the servo channel can follow the position encoder. The system may be set up with a Personal Computer, using software provided. Programmes can be developed on a personal computer, and downloaded to the controller. These can then be stored on the controller.

Digital control systems are not simple, but can be very useful when applied correctly. It is important to understand the basics of the operation of the system before it is installed on an expensive machine. The system is completely programmable in all aspects of its operation, and it is recommended that users carry out training to experiment to familiarise themselves with the facilities available. This is best done on an off-line test machine which is not directly linked into a production unit.



3 SYSTEM OVERVIEW

The control systems are based on a microprocessor running on Eurocard sized circuit boards, using established hardware and software technology. The system is designed to be able to provide an integrated solution to a wide range of motion control situations. There is an option for an integrated keypad an display.

3.1 Circuit boards

There are several different circuit boards which have been developed together with their associated software. These consist of:

3.1.1 Control board (PC3/120).

This is a microprocessor driven circuit board, based on a Motorola 68HC11 microprocessor. It communicates with a personal computer by an asynchronous serial port. Its functions include:

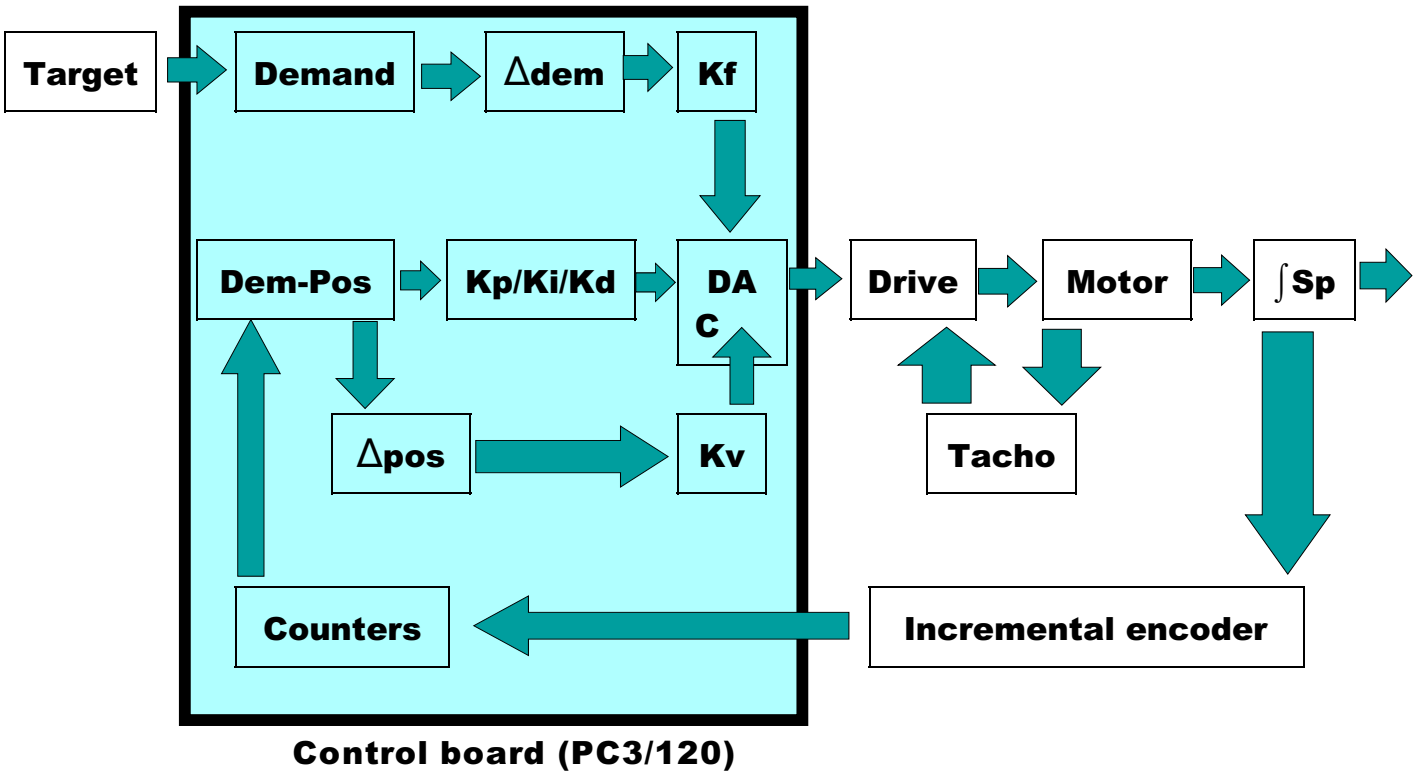
(i)Up to 2 channels D to A output (12 bits resolution). Bipolar -10/+10v output.
(ii)8 channels A to D input (8 bits resolution). These channels are not isolated, and must be in the range 0-5v.
(iii)2 channels Quadrature & ref input. RS-422 inputs (differential signals).
(iv)4 channels of general purpose parallel inputs (2 of which may be used for reference inputs). 5v un-isolated inputs.
(v)4 channels of general purpose parallel outputs. 5v un-isolated outputs.
(vi)2 asynchronous serial ports. One of these is also taken to an isolated RS-485/422 circuit for use on a proprietary bus, or general purpose RS-422.
(vii)Hardware watchdog.
(viii)Scanning keypad interface (8×8).
(ix)LCD/VFD character display interface.
(x)EEPROM facility for parameter storage.
(xi)Site for daughter board.

3.1.2 Control daughter board (PC3/121).

This is a daughter board, for use with the PC3/120 board. It communicates with the host control board by an asynchronous serial port. Its functions include:

(i)Up to 8 channels isolated parallel outputs.
(ii)Up to 16 channels isolated parallel inputs.
(iii)Up to 4 channels stepper control.
(iv)Hardware watchdog.
(v)Scanning keypad interface (8×8).

4 GENERAL DESCRIPTION - CONTROLLER



This section gives an overview of the operating principles and a brief description of the facilities of the digital motor control system.

The hardware resides on Eurocard circuit boards. The host processor, and the motion control interface for two axes are taken from an PC3/120 circuit board.

The control system works on the basis of continually sampling information and performing a control algorithm at a defined timer interval (known as the sampling time). This sampling time is set to be 1÷256th second. In other words, the time interval between updating calculations is about 3.9ms. The control software uses two key pieces of information to generate a positional error. These are the current demanded position, and the current measured position. The demanded position is calculated by the controller on the basis of a target positional move. For example, if the controller is asked to move a distance of 4000 encoder counts at a speed of 500 counts/sec and an acceleration of 2000 counts/sec², it can generate a velocity profile in terms of the desired position at every 1÷256th second. If the system is under control but not moving, there will still be a demand position, but it will not change.

This positional error information is used as the basis for a *PID* (proportional, integral, and derivative) calculation, whose output is fed to a Digital to Analogue Converter (DAC). The analogue voltage is sent to an analogue drive as a velocity command.

Most high performance drive systems will have an analogue velocity control loop built in. This takes the form of a Tacho-generator on the end of the motor shaft, which generates a voltage proportional to its velocity, and an associated gain potentiometer on the drive. This allows a stable, high gain system to be set-up.

There are two additional control terms built in to the software, which can be useful under particular circumstances. The first of these is a digital velocity feedback system. This is only really useful where no tacho feedback is available, and is bound to be of a lower performance that an analogue system due to the limitations of digital sampling. The second is called velocity feed-forward, and is proportional to the rate of change (derivative) of the internally generated demand position signal. This feature is particularly useful for helping a mechanical system to anticipate changes in velocity.

The system is intended for use with digital incremental position encoders which provide two signals in quadrature. The encoder interface multiplies the resolution of the encoder by four, such that each complete cycle of the encoder signals represents four counts.

The encoder signals are decoded and counted by hardware on the PC3/120 board. The software converts these to numbers which represent the measured position. This signal is then used to compare with the demanded position information, as described above.

The system is set up by high level commands from a serial link. Most commands are two letters, sometimes followed by a numerical parameter. These commands can be built up into programmes which can then be stored on non-volatile memory (EEPROM) on the system. The motors may be controlled using simple proportional control, where the demand signal depends on only the position error. The proportional gain constant is set by the user. It is also possible for the user to set gain constants for integral feedback, differential feedback, velocity feedback, and velocity feed-forward terms, providing very flexible control over the system transfer function.

When a move command is entered, the system moves the motor according to a trapezoidal velocity profile defined by the acceleration, velocity, and distance of the requested move. The system velocity and acceleration may be set by the user. The motor speed increases at the set acceleration until it reaches the set velocity. It continues at this velocity until it is near enough to the required position to begin decelerating. The system calculates the point at which it should start decelerating, to minimise any overshoot. The rate of deceleration at the end of the move is the same as the acceleration at the start. If the change in position is small, the motor may not reach the set velocity, and will follow a triangular profile instead.

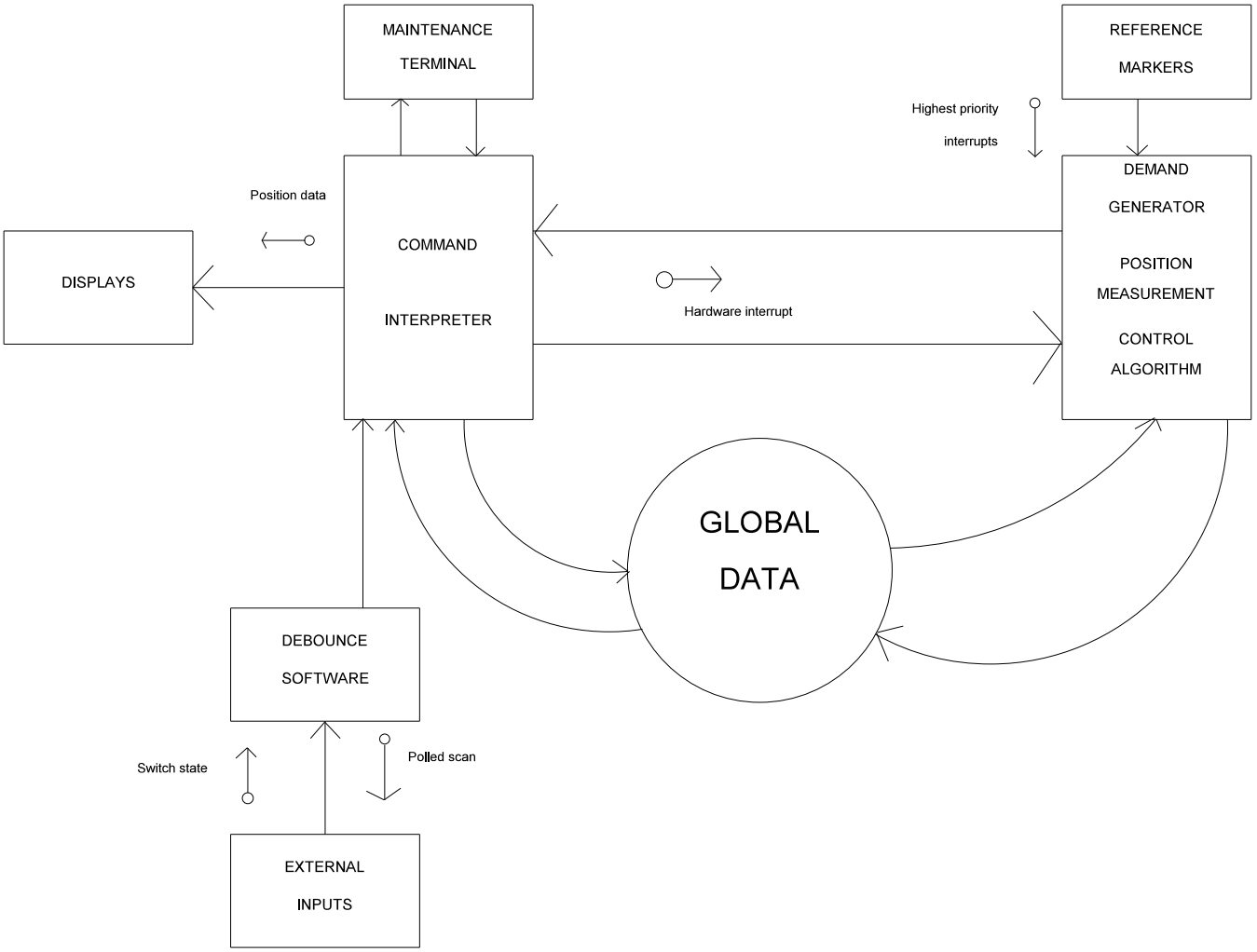
The motors may be controlled at a constant velocity instead of controlling the motor position. In velocity control mode, the system accelerates the motor until it reaches the specified system velocity, and then maintains that velocity. The motor may be stopped with the normal deceleration, or may be stopped abruptly in an emergency.

The system has up to 16 digital input and 8 output lines, which may be used in various ways. Inputs may be programmed to start either single commands such as a move or stop command, or to execute a string of commands or a stored sequence. Outputs may be set and cleared, and can be used to control external relays or valves, or just be used for status indication. They may also be used to allow the system to be controlled from an industrial programmable logic controller (PLC).

The facilities allow the user to define move profiles other than a trapezoidal or triangular profile, in order to follow a specific motion, or to mimic some mechanical system. Sequences of commands may also be defined by the user.

The use of variables allows a fixed programme to operate in a flexible manner.

5 GENERAL DESCRIPTION - SOFTWARE FUNCTIONALITY



Data flow diagram

The control software is highly deterministic, being interrupt driven by a hardware timer. The control algorithm is implemented every time this hardware timer generates an interrupt (every 1÷256 second). In addition, polling of the external inputs is carried out during the same servo loop closure process. Serial character receipt and transmission is also handled by the interrupt mechanism, and a special high priority interrupt is used for reference marker detection. This gives a response time of better than 15µs.

The command interpreter is executed in background mode, together with display routines.

The modular approach to the software means that system can be easily adapted to particular situations.

6 MODIFICATIONS TO THE USER PROGRAMME

The user programme consists of sequences of instructions which are stored in non-volatile memory on the Pan controller.

To make the management of the construction of the user programme simple, a system has been developed to allow the user to develop and modify a master copy of the user programme on a personal computer.

The sequence of programme development can be summarised as follows:

1 Develop programme on personal computer using any editor which will generate an ASCII file (i.e. no embedded control codes).
2 Download programme from personal computer to Pan controller (to the controller's RAM - volatile memory).
3 Save the programme from the controller's RAM to EEPROM (non-volatile memory).

This procedure means that a master copy of the programme is always maintained on a personal computer, and can be copied and maintained for archiving purposes.

A utility programme (called "PANTERM") is supplied to run on an MS-DOS based personal computer. This enables the personal computer to emulate a terminal, and to allow file transfer. The personal computer must have a serial port ("COM1", "COM2", "COM3", or "COM4").

It is suggested that a batch file be set up to enable the user to enter the programme by entering a single name (e.g. control). This will start the "PANTERM" programme, and prompt the user to press a key to start terminal emulation.

If the Pan controller is connected to the personal computer and switched on, then any keys which are pressed on the personal computer will be echoed back to the screen. If characters are not echoed, then there is something wrong with communications. The leads should be checked. Also, the "PANTERM" configuration can be modified by pressing <ALT> C. A sample screen might appear as follows:

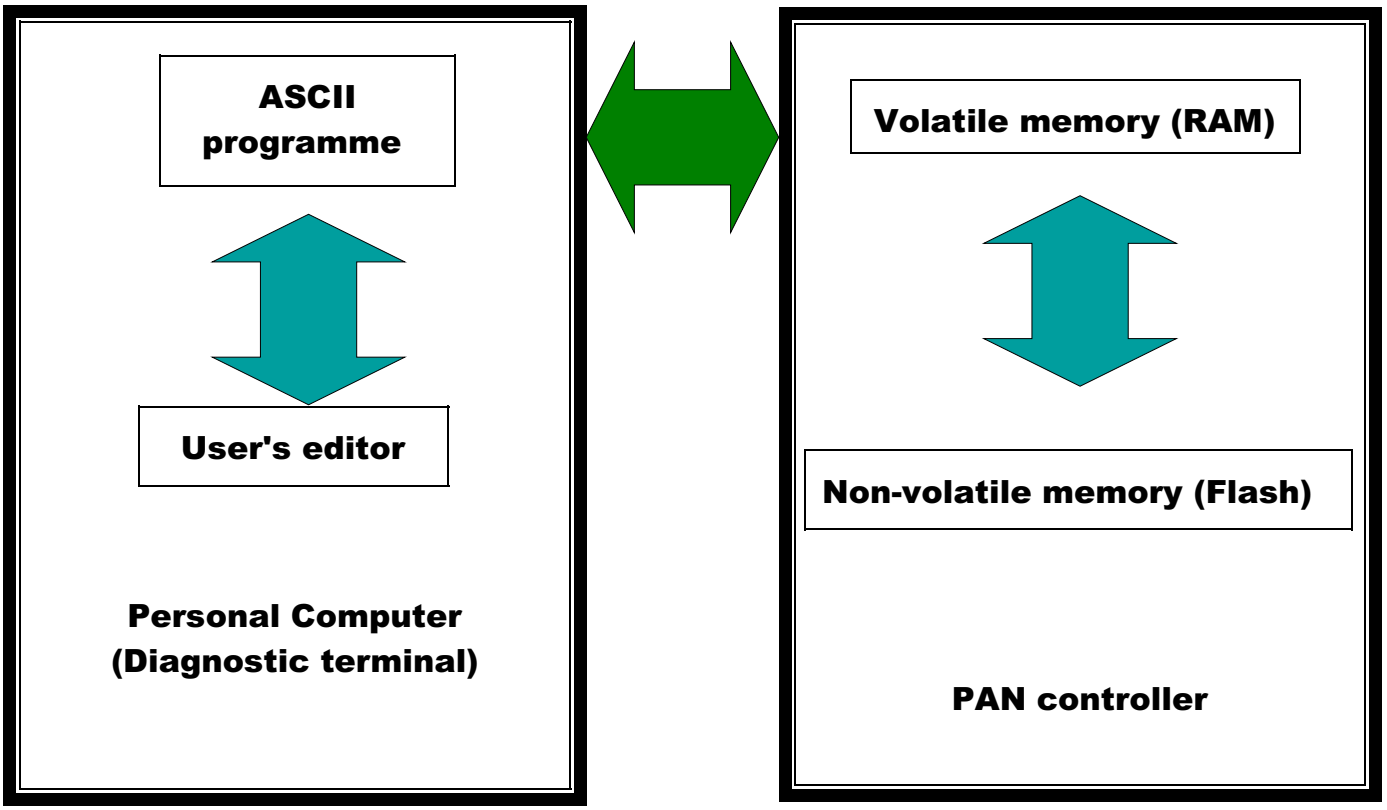
Configuration	
Communications Port (1 - 4):	1
Baud Rate:	9600
Serial mode; RS232, 422 or 485:	232
File loading delay (milliseconds):	0
File loading mode: Transparent or Check for acknowledge	C
Software or Hardware handshaking:	S
Colour or Mono display:	C
Parity: None or Even:	E
Editor name:	ed

In order to modify a source programme, it is necessary to access the editor by pressing <ALT> E. The user is then prompted to enter a file name (e.g. "ICI6.1"). The editor then enables the user to move around the programme, using the cursor keys and the <Page Down> & <Page Up> keys.

Modifications can be made until the user is satisfied. The user can then leave the editor by pressing <esc> followed by E (to Exit and save), followed again by <esc>.

In order to download a source programme from the personal computer to the Pan controller, it is first necessary to ensure that the controller is in the "privileged mode" (see command "PM"). It is suggested that the user resets

the controller to its default state by using the "RS" command, particularly when doing a final installation. This will enable a definite checksum to be established on a particular machine. This means that any subsequent changes (accidental or intentional) can be identified. If the file loading mode is set to C (checksum), The programme is downloaded by pressing <ALT> U. The user is then prompted to enter a file name (e.g. "ICI6.1"), and the programme will then be transferred. If the programme uses stored profiles, these will need to be downloaded in the same way (e.g. ICI6.PRF).



PANTERM programme maintenance environment

7 COMMAND DESCRIPTION

7.1 General

This section gives full details of all the system commands and syntax. Numeric parameters are denoted by "$_{nn}$". Parameters entered as a binary string ("0"s and "1"s) are denoted by "$_{bb}$". All commands are terminated by a carriage return (CR) or by a carriage return and line feed (LF). The system responses are all followed by (CR)(LF).

Numeric parameters are input and output in either decimal or hexadecimal. Commands are available to set the system to use one or the other. Decimal numbers are output by the system as signed seven digit numbers. Hexadecimal numbers are output in 24 bit two's complement format as six hex digits with no sign. Leading zeros are not suppressed in numeric outputs. Decimal numbers are entered as signed or unsigned (assumed positive) numbers. Hex numbers are entered as signed 23 bit or unsigned 24 bit two's complement numbers. Leading zeros may be omitted. Any number may be entered as a variable (a to z) by suffixing the command with a "V" followed by the variable. In addition, commands which output numeric data may be re-directed to a variable by suffixing the command with an "O" followed by the variable.

The normal character set consists of the letters A-Z and a-z, the numbers 0-9, "+", "-", and space. Multiple command sequences may be entered as one command line, with the individual commands separated by a delimiter character. Any "/" character may be used as a delimiter between commands. The maximum input line length is 255 characters. Backspace or delete may be used to remove characters from the current input line. Command extensions usually use a ":" character to separate parameters. Other non-printing characters are simply echoed, and have no effect.

The escape character (Hex 1B) will exit from any command which is producing a long list of many pages. The tilde (~) character (Hex 7E) will cause the system to halt any current activity and perform a soft reset.

For systems without a keypad and display, the commands which relate to this hardware will obviously not function.

The commands allow very flexible control of the system. They fall broadly into the following categories.

(a) Miscellaneous.
Commands to change between channels, and to handle the stored setup data.

(b) Mode commands.
These include commands to change between motor off and position control modes, and between privileged and normal modes.

(c) Move commands.
These include commands to move to absolute and relative positions, to find the zero reference position, to move at a constant velocity, and to stop the move either normally or abruptly.

(d) Set parameter commands.
These commands set up a wide range of system parameters, including the velocity and acceleration of the normal moves, and setting up the creep and deadband facilities.

(e) Sequence commands.
These include commands to enter, list, and execute complex command sequences.

(f) Profile commands.
These commands are used for the profile move facilities ("Software Cam"). Profiles can be executed simultaneously on channels 1 and 2.

(g) Wait commands.
These commands may be used in command sequences to wait until a condition is true before executing the next command in the sequence.

(h) Error trapping.
These commands set up the system error conditions.

(i) Gain commands.
These include commands to set up the constants used in the closed-loop control algorithm.

(j) Digital input and output commands.
These are commands to directly control the input and output lines.

(k) Reference commands.
These include commands to set up continuous position correction on the reference input signal.

(l) Configuration commands.
These commands allow the user to configure the digital input and output lines for various automatic functions.

(m) Display commands.
These include commands to display parameter values and status information via the serial port.

(n) Variable commands.
These commands allow the user to set up and read values by means of variables.

(o) Conditional commands.
These commands allow the system to test certain conditions, and to execute commands depending on whether or not those conditions are met.

The command reference section (7.2) gives the allowable range and any default value of all the system parameters, and in most cases gives an example of the use of the command. Any lengths or length related units are defined in terms of position encoder counts, multiplied by an optional user-defined scale factor. Note that the range and default values are given in encoder counts, and if a scale factor is used then the allowed range and default values change accordingly.

The current value of any parameter may be found by entering the command to set the parameter, without entering a new value. The system then shows the current value on the display, followed by a "?" prompt character. The user may then enter a new value, or just type return to keep the current value. The current definitions of all the input and output lines are listed with the LI command.

Many commands that affect the behaviour of the system are *restricted*, or *privileged*, and can be used only in privileged mode after entering a password. This allows the system to be configured as required by the Control Engineer or Systems Engineer, while preventing access to the more fundamental setup parameters by the machine operator. The system can be programmed to start up automatically, or to operate from external digital signals.

The complete system setup, including all parameter values, input and output line definitions, sequences and profiles, may be stored in non-volatile memory using the SP save parameters command. The setup data is

saved together with a checksum value. This is used when the system is initially powered up, to check the integrity of the stored data. If the data has changed at all, the checksum test fails, and the system gives an error message and resets the system to the manufactured default configuration.

7.2 Command Reference

7.2.1 Miscellaneous commands

VN(D) Display version number.

This command prints information about the version of software fitted to the system. It gives the version number of the firmware, its revision date, and some configuration information. If there is user programme information (entered using the EV command, page 15), it will also be displayed. The optional D parameter re-directs the version information to the display unit.

SP(V) Save parameters. (restricted)

This command saves all the programmable parameters in non-volatile memory. There may be a short delay while the save operation takes place. The saved parameters become the new defaults, used by the system on power-up. The SP command also saves any profiles sequences, and variables A-Z together with numeric non-volatile variables. At the end of the save operation, the system calculates a cyclic redundancy check byte (CRC) on the saved data, which is then saved in non-volatile memory as well. This allows the saved data to be verified at any time by comparing the stored CRC byte with a calculated one. If the saved data has changed at all, the stored CRC will not be the same as the calculated CRC. The optional V parameter allows only the numeric non-volatile memory to be saved. This can be useful when these variables are being used to save operator programmes, and need to be saved regularly. Since none of the other system parameters are being saved, this operation can be considerably faster than SP with no parameter. If the save operation fails for any reason, then an "F" error message is returned. In this case, please contact your sales office. This command is restricted, and is only available in privileged mode.

CS Checksum test.

This command is used to verify the data stored in the non-volatile memory. The system calculates a new CRC value for the stored data, and displays it. It then compares the new value with the CRC value that was stored with the data when it was saved. If the values are different, an "F" fail error message is displayed. If the CRC test fails, it indicates that the stored data has changed since it was saved. If this occurs, please contact your supplier.

RD Reload stored data. (restricted)

This command reloads all the parameters, input and output line definitions, sequences and profiles from the stored setup in the non-volatile memory. If the stored data checksum is not correct, then this command returns the 'F' failed error message, and the stored data values are not loaded.

RA Reverse analogue output sense

This command reverses the output sense of the main control DAC. The command actually toggles the sense of bit 4 of the control word.

RE(2/B) Reverse encoder input sense

This command reverses the input sense of either encoder. The command actually toggles the sense of bit 4 of the control word. The suffix 2 or B reverses the input sense of the auxiliary channel encoder.

RS(D) Reset to default setup. (restricted)

This command resets all the parameters, variables except numeric type, input and output line definitions, sequences and profiles to their default settings.

On power-up, the system recalculates the checksum on the saved data in the non-volatile memory. If the calculated checksum does not match the stored checksum, then the RS function is executed automatically to reset the system to its default state.

If the reset button is pressed during the fifth ON period of the flashing L.E.D. after power up, then the system will reset to its default values.

If the optional "D" parameter is used, the display unit is re-written.

HR_{nn} Set Hard Reset sequence or initiate Hard Reset.
Range : 0 to 255
Default : 0

This command locks the software watchdog in order to force a system reset (after about 2 seconds).

LA List all parameters.

This command lists all the parameters(with the exception of the HW hardware setup word and DW display word), input and output line definitions, sequences and profiles to the serial port in a suitable format for entering parameters etc. at a later date. If the system is connected to an MS-DOS based personal computer running the PANTERM programme, the parameters can be recorded on disk for backup purposes and loaded into another control system to duplicate parameter setting from one machine.

BH Breakdown of current Hardware.

This command displays the hardware which the software has recognised when the system has been switched on. This information is saved, together with the stored parameters. If the hardware found does not match the stored parameters, then the system will be reset, and a warning will be sent to the screen.

EV"ccc" Enter a user software revision no string.

This stores a character string (enclosed by double quotes, maximum 16 characters). This can be useful for identifying the current setup, using the VN command.

GW_{bbbb} Set global control word. (restricted)
Range : 0000 0000 to 1111 1111 (binary).
Default : 0000 0000

This command allows the user to write a value into the global system control word. Note that the leading zeros may be omitted. The global control word allows various components of the system to be enabled and disabled, as required. The global control word bit functions are described below.

		Bit set	Bit cleared
bit	0	Vacuum Fluorescent display brightness BR0 (see table below)	
	1	Vacuum Fluorescent display brightness BR1 (see table below)	
	2	Reserved for future expansion.	
	3	Reserved for future expansion.	
	4	Reserved for future expansion.	
	5	Unipolar velocity signal output (0-10v)	Bipolar velocity signal output (0-±10v)
	6	Reserved for future expansion.	
	7	Reserved for future expansion.	

Bit 1 (BR1)	Bit 0 (BR0)	Brightness
0	0	100%
0	1	75%
1	0	50%
1	1	25%

7.2.2 Mode commands

LM Link axis to second encoder

Links the motion of the controlled axis to the second encoder. The second encoder and the controlled axis will be linked by a ratio defined by the FD and FM parameters. If a velocity link is defined (using the LW parameter), the current axis will increase in velocity by the defined acceleration rate until it reaches the desired velocity (i.e. the velocity of the channel being followed, multiplied & divided by its FD and FM parameters). The derived velocity (which can be averaged using the VT parameter) from the channel which is being followed (the second encoder) will be used. The ST command will cause the motor to decelerate from its current velocity to a standstill, using a deceleration rate defined by the SA parameter.

FD_n Set link factor for division.
Range : 0 to 16
Default : 0

This command sets the division factor for linking one axis to another. The actual position data is divided by 2^n in conjunction with being multiplied by the FM parameter. The largest division factor is 256.

Example : FD 4
This sets the link division factor to $2^4 = 16$.

FM_n Set link factor for multiplication.
Range : 1 to 65535 or -32767 to 32767
Default : 256

This command sets the multiplication factor for linking one axis to another. The actual position data is multiplied by n÷256 in conjunction with being divided by two to the power of the FD parameter. The largest multiplication factor is 65535 (÷256). If bit 7 of LW is set, then negative multipliers are allowed.

Example : FM 9
This sets the link multiplication factor to 9.

Example : FM 5888/FD5
This sets the link multiplication factor to 5888, and the division factor to $2^5 = 32$. The resultant factor is therefore 5888÷256÷32 = 0·71875.

LW_{bbbb} Link motions control word. (restricted)
Range : 0000 0000 to 1111 1111 (binary).
Default : 0

This command allows the user to set various motion linking control options. Note that the leading zeros may be omitted. The link motions control word bit functions are described below.

		Bit set	Bit cleared
bit	0	Position link	Velocity link
	1	Reserved for future expansion.	
	2	Reserved for future expansion.	
	3	Reserved for future expansion.	
	4	Reserved for future expansion.	
	5	Reserved for future expansion.	
	6	Reserved for future expansion.	
	7	Reserved for future expansion.	
	8	Allow negative multiplier for FM	Positive multiplier only for FM

PC Enter position control mode.

This command puts the system back into the normal state with the motor position continuously controlled, after an MO command has been executed, or a position error abort has occurred. The prompt character ">" is returned in position control mode.

In position control mode, an onboard relay on the hardware is energised such that the motor command signal is available from the command signal output. The spare contacts of the relay are also switched over, for use as a drive enable signal if required.

MO Motor off.

Turns off the position control servo loop action. All other facilities still operate normally, including the input and output lines, and the encoder position is continuously monitored. When the system is returned to position control mode, the motor does not jump back to its last controlled position, but remains at its new position. The system returns a ":" character as a prompt when in the motor off state.

In the motor off state, the motor command signal output is switched directly to 0v by the onboard relay. The spare relay contacts are also switched to their normal unenergised state. It is recommended that this relay is used to disable the drive completely. If the drive is not disabled in the motor off state, then it is likely that the motor position will drift, due to some offset in the drive circuits, since the motor position is not controlled in this state.

The MO command may also be used as a third stop command, to put the motor directly to the motor off state from any other state, instead of using the ST stop or AB abort commands.

PM Enter privileged mode.

For most applications, it is only necessary to make full use of the command set when the system is first programmed, and not during normal operation. Many of the commands control the basic setup of the system, such as the gain commands used to tune the system. Unauthorised access to these commands could result in a severe loss of performance or even damage to the machine. For this reason, the command set is divided into **normal**, and **restricted** or **privileged** commands.

The normal commands are always available. These include the basic move commands, and many of the simple set parameter commands such as those used to set the velocity or acceleration for the system. Restricted commands are only available in what is termed **privileged mode**. Entry to privileged mode is only permitted with a password, which itself is programmable.

If restricted parameters must be changed during normal operation, the relevant commands may be executed from a stored sequence. This bypasses the privileged mode check at runtime, but still prevents unauthorised access to the system programming since the ES enter sequence command is also restricted.

The PM command is used to enter privileged mode and gain access to the complete command set. The system responds with "Enter password: " to prompt the user to enter the password. The password is **not** echoed as it is entered. If the password is correct, the system responds with an "OK" message, and goes into privileged mode. If the password is incorrect, the system sends an "E" error message and stays in normal mode.

Example :

System	User	Comments
>	PW<CR>	Set password command
Enter password:	(password)	The new password is echoed
>		

NM Enter normal mode.

This command is used to return to normal mode from privileged mode, if the user no longer needs access to the restricted commands. Note that the system powers up into normal mode.

PW Set password. (restricted)

This command allows the user to set the privileged mode password. The system replies "Enter password: ", and the user should then type in the new password. The new password is limited to a maximum of ten characters. It is saved in non-volatile memory with the other setup parameters when the SP command is executed. The PW command is itself restricted, and is only available in privileged mode.

Example :

System	User	Comments
>	PW<CR>	Privileged mode command
Enter password:	(password)	The password is not echoed
O.K.		Password accepted
>		

7.2.3 Move commands

AB(K) Abort, emergency stop.

The motor stops immediately, ignoring the system acceleration. This may be used instead of the ST command, where an abrupt stop is required. The AB command may also be used to break out of sequences. The optional K parameter enables a selective abort from any pending keypad operations (e.g. VK), whilst maintaining all other current system operations. Likewise AB without the K parameters maintains any current keypad operations, whilst stopping all motion operations.

ST_{nn} Stop.

The motor stops under controlled deceleration, set by the SZ command. The stop command may be used during a normal move or constant velocity move to decelerate the motor to a stop. The ST command may also be used to break out of sequences. The optional parameter allows the stop to finish at a defined absolute position.

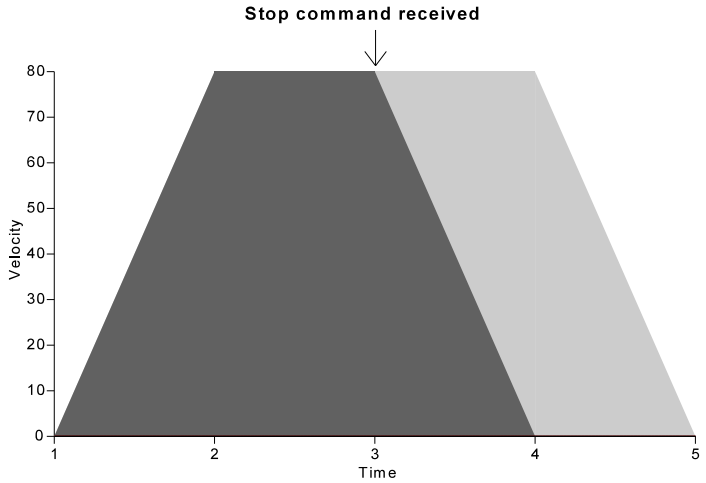


Figure 2 Move with normal stop

$MA\pm_{nn}$ Move to absolute position $\pm_{nn}$.
Range : ± 4 000 000 (4.0E6) encoder counts.

The motor moves to the absolute position given in the command. It follows a trapezoidal velocity profile (graph of velocity against time). The motor accelerates from rest at the system acceleration, set by the SA command, until it reaches the system velocity, set by the SV command. At the end of the move, the motor decelerates at the same rate to stop at the desired final position. The position is entered in user units, which are equal to encoder counts.

Example : MA +2000
The motor moves to absolute position 2000.

MR±$_{nn}$ Move ±$_{nn}$ units relative to current position.
Range : ± 8 000 000 (8.0E6) encoder counts.

The system performs a move similar to the absolute move above, but the move distance is defined relative to the current position. The move distance is entered in user units.

Example : MR -3000
The motor moves 3000 units from its current position in the negative direction.

VC± Move at constant velocity.

The system accelerates the motor at the system acceleration until it reaches the system velocity, in the specified direction. It then controls the motor at constant velocity, until asked to stop by the ST command. Velocity control mode can only be entered from position control mode, and not directly from the motor off state.

Example : SA 1000/ SV 2000/ VC+
This command sequence sets the acceleration to 1000 units per second squared, the velocity to 2000 units per second, and then accelerates to the set velocity in the positive direction.

IN± Initialise position.

The system performs the initialisation sequence to find a zero position reference signal. The system gives the "I" initialise prompt character while executing the initialisation sequence. The motor accelerates to the system velocity in the specified direction. When the system detects a reference input signal, it resets the position counters to zero immediately. The motor then decelerates to a stop and moves back to the new zero position.

NOTE: The IN command works independently of the settings of all the other reference commands. This is so that whatever the reference setup for normal running, the IN command always works normally. The exceptions to this are bit 3 of the RW reference options word, which disables the move back to the new zero point, and bit 4 of RW which defines whether any reference input is valid, or only a combination of them. The reference offset value is also effective during the initialisation sequence, such that the position at which the reference signal is detected is defined as the absolute position given by the value of RF, not necessarily zero. For more details read the reference command section (section 7.2.10, page 50) later in this manual.

If no reference input or marker input is defined, then the IN commands returns the E error message, and the initialisation sequence is not executed.

Example : RW0 / IN +
The motor moves in the positive direction until the reference input is seen. It then stops, and in this example it moves back in the negative direction to the reference position.

ID Initialise DAC offset.

Under normal conditions, there may be some constant offset in the demand signal analogue output amplifiers which causes the motor to settle at a position slightly different to the required position. The ID command sets the system up to allow for this (assumed constant) offset in all subsequent position control operations. It must be used every time the system is powered on, when the system is in position control mode, to set the actual position as close as possible to the required position. This can be done automatically by using the autostart sequence facility. This is particularly necessary when the final position window as set by the SW command is small, otherwise the output offset may be such that the motor normally settles at a position outside the final position window, and after a move remains in the move state without returning to the normal position control mode. The ID command is only effective in normal position control mode, with the motor actually controlling the position, and it has no effect if the motor is not driving the system. Note that friction in the mechanical system can also cause a position offset after a move command is executed.

If this command is used on a regular basis (e.g. whenever the system is switched on), it will have the effect of removing any drift in the analogue amplifier which may have arisen with time.

7.2.4 Set parameter commands

SW_{nn} Set Window. (restricted)
Range : 0 to 65535
Default : 10

This command sets a window around the required final position of a move. Its operation is such that the system finishes a move and returns the prompt character to the user only when the motor is within this window. Note that when using a narrow window, it is important that the DAC offset on the current channel has been initialised with the ID command. If not, the offset may be large enough to put the motor outside the window when it is stopped, and the system will stay in the move state without returning the normal prompt. If this occurs, the ST or AB commands may be used to get back to the normal state. Note that the window is specified in encoder counts. This command is restricted, and may only be used in privileged mode.

Example : SW 25
This command sets the window to 25 counts. Thus the system returns the normal prompt at the end of a move only when the motor is within 25 counts of the required position.

$SB(B)_{nn}$ Set position overflow bound. (restricted)
Range : 1 to 4 000 000 (4.0E6)
Default : 4 000 000

This command sets upper and lower bounds on the absolute position of the system. If the position of the motor exceeds the upper bound then the position bound value is subtracted from the current position. If the position goes below the lower bound, the bound value is added to the current position to keep the position within bounds. The suffix B sets the bounds for the auxiliary channel. Note that this does NOT limit the range of any move commands, but only changes the value of the final position for moves outside the position bounds. This is illustrated by the example below. There is also a 32-bit position overflow counter which is incremented when the position passes the upper bound, and is decremented when the position passes the lower bound. This effectively provides a 32-bit high order extension to the absolute position. The overflow count may be displayed by using the DC command, and may be reset to zero by the RC command.

The bound position defined by the SB command is also used as the expected reference position when the system is set up to continuously monitor the reference input. Refer to section 7.2.10 (page 50)for more details about the reference commands.

Example : SB1000
This sets the position bounds to ±1000 counts. An application of this is where it is required to know the motor position to within one revolution of the motor only, but it is not necessary to distinguish between complete revolutions of the motor. If a move from zero to position 1200 is executed, the final position is 200. The motor has moved a total distance of 1200 counts as required, but the final position is the remainder when divided by the bound value. If a move from zero to -1200 is executed, the final position is -200. In this application, the position overflow counter represents the number of complete revolutions of the motor from the zero position to the current position, and the normal position value defines the position within one revolution.

SV_{nn} Set velocity (speed).
Range : Creep velocity (SS) to 800 000 (8.0E5)
Default : 1024

This command is used to set the system velocity, in user units per second. It may be used when the motor is stationary, or when moving at constant velocity after a VC command.

Example : SV 5000
This sets the system velocity to 5000 units per second.

SA_{nn} Set acceleration.
Range : 1 to 2 000 000 000 (2.0E9)
Default : 1024

This command sets the normal system acceleration to the specified value, in user units per second squared. Note that the acceleration is rounded to the nearest multiple of 256, giving a resolution of 256 counts.

Example : SA 10000
This sets the system acceleration to 10000 units per second squared.

SC_{nn} Set creep distance.
Range : 0 to 65535
Default : 0

The normal trapezoidal velocity profile for a position move can be modified to include a slow speed creep to the final required position. The creep distance is the distance from the final position over which the system moves at the slow creep speed, set by the SS command. This may be used to minimise overshoot at high speeds and accelerations.

Example : SC 200
This command sets the creep distance to 200 units. A position move command will now start to decelerate earlier than normal, such that the system reaches the slow creep speed at least 200 units before the final required position.

SS_{nn} Set slow creep speed.
Range : 1 to system velocity (SV)
Default : 32

This command allows the user to set the speed of the slow creep to the final position, if required. It is specified in the same units as the system velocity.

Example : SS 100
This sets the slow creep speed to 100 units per second.

SD_{nn} Set deadband.
Range : 0 to 65535
Default : 0

The system normally controls the position of the motor continuously, whether moving or stopped. This command allows the user to set up a deadband about the nominal position, within which the system will not control the position of the motor. This may be used, for example, to prevent hunting in systems with mechanical backlash. The deadband only becomes active after the system has reached the required position and the settling time, set by the SL command, has expired.

Example : SD 100
This sets the deadband to 100 units. The system will now only control the position of the motor if it moves more than 100 units away from the required position.

SL_{nn} Set settling time.
Range : 0 to 65535
Default : 256

This command sets the time that the system waits, after reaching its required position, before the deadband becomes active. It is specified in units of 1/256 seconds.

Example : SL 128
This sets the settling time to 128x1/256 = 0.5 seconds.

$ZC[_{nn}]$ Zero position counters or set position.

If a position value is given, the system sets the current demand position to the given (absolute) value. If no value is given, it sets the current demand position to be zero absolute position. The ZC command may be used at any time.

Example : MA-5000/ ZC
This moves the motor to position -5000, and sets the position counters to zero at that position.

Example : ZC8000
This defines the current demand position as position 1000

RC(2/B) Reset position overflow counter.

This command resets the position overflow counter to zero. The overflow is incremented when the position exceeds the upper bound, and is decremented when the position passes the lower bound. The suffix 2 or B resets the overflow counter for the auxiliary channel.

$TS_{hh:mm:ss}$ Time set.

This command allows the user to set the system time. It expects the time to be in the format $_{yy:hh:mm:ss}$.

$DB(K)_{nn}$ Set input debounce time. (restricted)
Range : 0 to 255
Default : 5

This command sets up a debounce time for all the digital inputs. It is specified in 1÷256 second (about 4ms) ticks. Before an input signal is recognised as valid, it must be stable for the number of samples given by the DB command. This facility may be used to reduce the effect of noise in a system by reducing the number of false triggers due to noise. The suffix K allows the keypad debounce time to be adjusted.

NOTE: The debounce value does not apply to reference inputs. These inputs are programmed so as to be detected immediately on a change of state, to get the most accurate position information possible.

Example : DB 2
This sets the debounce time to about 8 ms (2 samples).

7.2.5 Sequence commands

This section describes the sequence facilities. They provide comprehensive facilities for defining, reviewing and executing complex command sequences. Sequence definitions may be entered up to the memory capacity of the system. If the system runs out of memory, it returns an "N" no room error message.

ES_{nn} Enter sequence.
Range : 1 to 255

This command is used to enter sequences into the system. The system responds with a "S_{nn}:" prompt for the sequence entries. Each entry in the sequence is any valid command line. Command sequences on one command line are accepted as one sequence entry. Sequence entries may also include commands to execute other sequences and profiles. To end the sequence, make a blank entry by just entering a (CR), and the system then returns to normal operation. The sequence is accessed by means of the sequence number assigned by the user when it is entered.

Example :

System	User	Comments
>	ES 1 (CR)	Enter sequence 1
S1:	ID/ IN - (CR)	Initialise position
S1:	MA100/ WT256/ MA0/ WT256/ RP3 (CR)	Do this 3 times
S1:	MA 2000 (CR)	A single move
S1:	(CR)	End sequence
>		Normal prompt

LS_{nn} List sequence.
Range : 1 to 255

This command allows the user to examine a sequence that has previously been entered into the system. The sequence is listed on the display or terminal, one command entry per line. The sequence may be listed continuously, or the system can print one line at a time and wait for the user to press the (CR) key before printing the next line. This is useful when using the system with a membrane keyboard or a hand-held terminal which only has a small number of display lines. This list pause facility is controlled by one of the flag bits in the DW command.

Example : LS 1
This will list sequence 1 on the display or terminal. The output for the sequence given above would look like this.

```
>LS 1 (CR)                          User input to list  sequence.
S1: ID/IN-
S1: MA100/WT256/MA0/WT256/RP3
S1: MA2000
>
```


XS_{nn} Execute sequence.
Range : 1 to 255

This command tells the system to execute sequence number $_{nn}$. The normal status messages for each part of the sequence are printed on the display as they are executed. The sequence will abort automatically if any error condition occurs. A sequence may be aborted by using the AB command. The ST stop command may also be used to stop the currently executing move command.

Example : XS 3
The system executes stored sequence no. 3.

RP_{nn} Repeat.
Range : 1 to 255, or no value

This command tells the system to repeat the sequence of commands on the current command line, up to the RP command, $_{nn}$ times. If no repeat count is given, the system will repeat indefinitely.

Example : MA 2000, MA 0, RP5
This moves the motor to position 2000 and then back to position 0, repeated 5 times.

ER(F) End repeat.

This command allows the user to exit from a repeat loop cleanly, at the end of the current loop. This is in contrast to the stop and abort commands, which stop the system immediately, in the middle of whatever action is taking place. It may be used in repeat loops with a repeat count, or in endless repeat loops In either case, the loop terminates normally at the end of the command line.

When the ER command is executed, any commands following the original RP command are not executed. Commands following the ER command are executed when the repeat loop terminates. This allows a command line beginning with the ER command to override the current operation, and neatly replace it with a new operation at the end of the repeat loop.

The optional F parameter allows the termination of a for-next loop next time the loop is completed (See page 62).

HS_{nn} Display history of sequences executed.
Range : 1 to 255, or no value

Displays a list of the numbers of the most recent $_{nn}$ sequences executed in inverse chronological order. If no parameter is given, all of the last 256 most recently executed sequences are listed.

$SK(_{A-M})_{nn}$ Execute sequence on keypad entry event.
Range : 1 to 255, or no value

This command sets up the system to execute sequence number $_{nn}$ as soon as the enter key has been pressed on the keypad (after a VK command, page 75). This allows for the system to operate in an asynchronous manner. The optional prefix parameter (A-M) allows non-numeric keys to start events at any time. These keys can be selectively masked using the EK and MK commands (page 48).

Example : SK 56
The system executes stored sequence no. 56 after a variable has been entered using the VK command.

Parameter	Operator interface Mk2	Operator interface Mk1	16-key Keypad
A	F1	F1	A
B	F2	F2	B
C	F3	F3	C
D	F4	F4	D
E	F5	F5	E
F	F6		F
G	F7		
H	F8		
I	Left display		
J	Centre display		
K	Right display		
L	ESC	ESC	
M	Left arrow		
N	Right arrow		
O	Up arrow		
P	Down arrow		
Q	Secret key		
R	Dot key		
S	F9	(top left)	
T	F10	(second top left)	
U	F11	(third top left)	
V	F12	(fourth top left)	
W	F13	(top right)	
X	F14	(second top right)	
Y	F15	(third top right)	
Z	F16	(fourth top right)	

CE_{nn} Execute sequence continuously as timed event.
Range : 0 to 255

This command sets up the system to execute sequence number $_{nn}$ as soon as the time defined by the PL parameter has passed. This sequence will be repeated indefinitely at the defined time interval until CE0 or an AB command is entered. Note that the time interval relates to the start of the sequence, even if the sequence takes a significant time to execute.

Example : PL512/CE 12
The system executes stored sequence no. 12 after continuously every 2 seconds.

PL_{nn} Set parameter for looping continuous event
Range : 20 to 65535
Default : 256

This command sets the time parameter for the CE continuous sequence command. The units are system ticks (1÷256 second).

Example : PL128
This sets the delay between continuous sequence events to ½second.

EE_{nn} Execute sequence on error condition.
Range : 1 to 255, or no value

This command sets up the system to execute sequence number $_{nn}$ as soon as a system error state is encountered. This allows for system to interrogate the system error and display an appropriate message.

Example : EE 123
The system executes stored sequence no. 123 after an error state has been reached.

NE_{nn} Execute sequence after snapshot event
Range : 0 to 255

This command sets up the system to execute sequence number $_{nn}$ as soon as a snapshot event has taken place. This command needs to be reset after each operation.

Example : NE 55
The system executes stored sequence no. 55 after an a snapshot event has taken place.

MF Display free memory.

This command displays information about the memory space available for sequences and profiles. This command returns the amount of free space as a number of bytes. The maximum space available is about 12 kbytes.

It is possible under certain circumstances for the internal memory to become fragmented, when maps and profiles are being entered and deleted. This could give rise to the system reporting an "N" out of memory error message when the total amount of spare memory is larger than the data being entered. This occurs because the system allocates a contiguous block of memory for each map or profile. A simple solution to this problem is to save and restore the parameters using the SP and RD commands. This compacts the data and forces all the spare memory into one single block.

Example :

System	User	Comments
>	MF<CR>	Enter MF command
6538		System returns number of bytes free
>		

$AS(R)_{nn}$ Set autostart sequence.
Range : 0 to 255
Default : 0

This command is used to set up a command sequence to execute automatically when the system starts up, after all the saved setup parameters and configuration details are loaded from the non-volatile memory. If no sequence number is given, the system prints the current autostart sequence number. If the "R" option is entered, an auto-start sequence for startup after software watchdog reset can be entered. This could be the same as the AS auto-start sequence, but could be some alternative sequence to ensure a safe re-start.

To disable the autostart sequence facility, set it to zero. If the sequence specified in the AS command is not defined, then the system simply does nothing at start-up.

HR_{nn} Set Hard Reset sequence or initiate Hard Reset.
Range : 0 to 255
Default : 0

This command locks the software watchdog in order to force a system reset (after about 2 seconds).

XT Exit from current sequence.

This command tells the system to exit from the sequence which is currently running. If this is a sequence which has been called from another sequence, then the calling sequence will continue execution.

GL_n Go to line in sequence
Range : 1 to no of lines in current sequence

This command allows looping to a specified line number within a sequence. Note that it can only be executed from within a sequence.

Example:
A sequence might consist of the following:

CO3/MR5000
SO4/WT500/II5-/XT
GL1

This will continue looping to line 1 until input line 5 is negative, when the XT command will escape from the sequence.

7.2.6 Wait commands

The wait commands are most useful in command sequences. They allow the user to specify some condition that must be satisfied before the system will execute the following commands. The system returns a "W" status message to indicate that it is waiting. If the position specified in a wait for position command is outside the range of the previous move command, then the system gives an "O" error message to indicate that the position was out of range.

WT_{nn} Wait for time.
Range : 0 to 2,147,483,647

This command tells the system to wait for the given time, in units of 1÷256 seconds, before proceeding to the next command.

Example : MA 2000/ WT 512/ MA 0
This command sequence tells the system to move to position 2000, wait there for 2 seconds, and then move to position 0.

$WI_{nn}\pm$ Wait for input line $_{nn}$.
Range : 1 to 8×n (where n=No of control boards)

This command tells the system to wait until the specified input line goes to the specified state. Note that if the specified input line has been defined as some other function input, the system returns the "U" line already used error message.

Example : MA 5000/ WI 2 -/ MA 0
This sequence tells the system to move to position 5000 units, wait there until input line 2 goes to a logic low, and then move to position 0.

$WA\pm_{nn}$ Wait for absolute position.
Range : ± 4 000 000 (4.0E6) encoder counts.

This command tells the system to wait until it reaches the given absolute position before executing the next command. If the position specified in a wait for position command is outside the range of the previous move command, then the system gives an "O" error message to indicate that the position was out of range.

Example : SV 200/ MA 2000/ WA 1500/ SV 100
This sequence performs a move with a change of speed at a certain position. The velocity is initially set to 200 units per second. The motor begins a move to position 2000 at this velocity, and at position 1500 the velocity is changed to 100 units per second. The move is completed at the new velocity.

WR±$_{nn}$ Wait for relative position.
Range : ± 8 000 000 (8.0E6) encoder counts.

This command is similar to the WA command above. It tells the system to wait until it reaches the specified position, relative to the last position used in a command.

Example : VC+ /WR5000 /SV1000 /WR2000 /ST
The system starts moving at constant velocity. It moves at the previously specified system velocity until it reaches 5000 units from the start position. At this point, the velocity is changed to 1000 units per second. This velocity is held for the next 2000 units, and then the motor decelerates to a stop.

WF Wait for reference input.

This command sets the system into the wait state, until a reference input is seen. It may be useful in sequences, to allow the reference action to be changed after detecting the first reference since the system was started.

Example : RW 10100001 / WF / RW1 / SO3
This command string sets up the initial RW such that the reference input behaves as a fast ZC input. It then waits for the first reference input to be detected, and changes RW to the normal auto-correction setting. Finally an output line is set to indicate that the unit has initialised and is ready.

WB Wait for bound position.

This command tells the system to wait until the motor passes the next bound position (positive or negative) before continuing with the command string.

WC±$_{nn}$ Wait for bound overflow count.
Range : ± 2 000 000 000.

This command tells the system to wait until it the bound overflow counter increments (or decrements) by the specified count before continuing with the command string. It may be used, for example, to wait for a given number of machine cycles to complete before stopping.

WK($_{nn}$) Wait for keypad entry
Range : 1 to 64, A to Z, or no parameter

This command sets the system into the wait state, until an value has been entered using the VK command (page 75). An optional parameter can be entered, which corresponds to a code for the particular key (see appendix, page 115 and page 48). The system will then wait until the key referred to has been pressed.

WE End wait state.

This command ends the current wait state as if it had completed normally. This allows the user to escape from a wait state early but to continue with commands following the wait command.

Example :

System	User	Comments
1>	DI1-/WE	Escape from wait state on input line 1 going negative.
1>		

In this example, channel 1 moves to position 10000, waits 4 seconds and then moves back to zero. However if input line 1 goes negative during the wait state, the motor moves back to zero immediately.

7.2.7 Error trapping

SE_{nn} Set maximum position error. (restricted)
Range : 0 to 65535
Default : 800

This command sets a maximum position error which is continuously monitored by the system. If the position error at any time exceeds this value, the system gives a "G" error message, decelerates to a stop and enters the motor off state. The system must be returned to the position control mode before any further motion commands are accepted by the system. See section 7.2.2 (page 17) for details of the MO motor off and PC position control commands. The value is defined in user units.

Example : SE 500
This sets the maximum position error to 500 units.

TO_{nn} Timeout. (restricted)
Range : 1 to 65535
Default : 32

This command sets a timeout value, in units of 1÷256 seconds. When a move command is executed, if the motor does not move for a period that exceeds the timeout, then the system will print a "T" error message and go to the motor off state. The system must be returned to position control mode before any further move commands are accepted.

Example : TO 512
This sets the timeout to 2 seconds.

$LH\pm_{nn}$ Set high position limit. (restricted)
Range : ± 4 000 000 (4.0E6)
Default : + 4 000 000

This command sets up a user-defined limit position. If at any time the absolute position of the motor exceeds the high position limit, the system gives the "LH" error message and goes to the motor off state. This is similar to the action taken on detecting a limit switch input. The value is defined in user units.

$LL\pm_{nn}$ Set low position limit. (restricted)
Range : ± 4 000 000 (4.0E6)
Default : - 4 000 000

This command sets up a user-defined limit position. If at any time the absolute position of the motor is less than the low position limit, the system gives the "LL" error message and goes to the motor off state. This is similar to the action taken on detecting a limit switch input. The value is defined in user units.

Example : LH 10000/ LL 0
This sets the high position limit to 10000 units, and the low position limit to zero. If the motor position goes outside the range 0 to 10000 units, the system gives the appropriate error message and goes to the motor off state.

RT_{nn} Set reference timeout. (restricted)
Range : 0 to 255
Default : 0

This command sets up a timeout on the reference input. It is used when the system is set up for continuous monitoring of the reference input, to give a warning error message if the reference input is not detected. A counter is incremented each time the system passes a bound position, and cleared each time a valid reference input is detected. If the counter reaches the "RT" value, the system gives the "RT" error message. The reference timeout function may be disabled by setting it to zero if it is not required.

EW_{bb} Set local error options word. (restricted)
Range : 0000 0000 to 1111 1111 (binary)
Default : 0

This command allows the user to write a value into the error options word. Note that the leading zeros may be omitted. The error word allows various user and motor error options to be turned on or off. The error word bit functions are described below.

bit
0 When set to 1, the reference timeout error is treated as a motor error, and the system goes to the motor off state when a reference timeout occurs.
When set to 0, the reference timeout error is treated as a user error, and the system simply prints an error message.
1 When set to 1, the reference limit error is treated as a motor error, and the system goes to the motor off state when it occurs.
When set to 0, the reference limit error is treated as a user error, and the system simply prints an error message.
2 When set to 1, the reference correction overrun error is treated as a motor error, and the system goes to the motor off state when it occurs.
When set to 0, the reference correction overrun error is treated as a user error, and the system simply prints an error message.
3 Reserved for future expansion.
4 Reserved for future expansion.
5 Reserved for future expansion.
6 Reserved for future expansion.
7 Reserved for future expansion.

LE Display last error

This command redisplays the error message for the last error detected by the system. It is useful for finding an error message which has stopped the system when there is not normally a display connected to the machine, or to display the long error message for an error which has been reported with a short error message. This is done by setting bit 5 of DW before executing LE. This command can output to a variable which can use the information to intelligently trap errors within a sequence.

7.2.8 Gain commands

The motor control system operates by sampling the position of the motor at regular intervals, and calculating a motor demand signal according to some control algorithm. The algorithm used is of the following form.

$$V_{out}=KPe_i+KI\sum e_i+KD(e_i-e_{i-1})+KV(p_i-p_{i-1})+KF(d_i-d_{i-1})$$

where KP = proportional gain constant
KI = integral gain constant
KD = differential gain constant
KV = velocity feedback gain constant
KF = velocity feed-forward gain constant
e_i = position error (=demand position-measured position)
d_i = demand position
p_i = measured position

The dynamic behaviour of the system depends on these gain constants, and on the mechanical characteristics of the system being controlled. Tuning the control system to get the best performance on a particular mechanical setup requires setting up these gain constants. Some of the gain terms in the control algorithm may be disabled by setting appropriate bits in the control word. For more details see the CW command description below.

The actual scaling between position error and output voltage, for proportional gain only, is as follows:

$$V_{out}=Err\times\frac{KP}{256}\times\frac{10}{2048}$$

where KP is the proportional gain term, and Error is the position error, measured in encoder counts. The other control terms are similar.

The performance of the system may be monitored by means of the auxiliary analogue output channel. Commands are provided to output various signals on this channel for viewing on an oscilloscope or chart recorder. These are described at the end of this section. The scaling of the monitor output is similar to that of the main demand output, but uses the KM monitor output gain.

CW_{bbbb} Set control word. (restricted)
Range : 0000 0000 to 1111 1111 (binary).
Default : 0100 1011

This command allows the user to write a value into the system control word for the current motor channel. Note that the leading zeros may be omitted. The control word allows various components of the demand signal to be disabled if required, and allows the sense of the encoder input and of the command signal to be reversed. The control word bit functions are described below.

NOTE: The encoder and command signal sense should only be changed while the module is in the motor off state, as the system may be made completely unstable by reversing either of these. This facility is intended to be used only when initially connecting the module to the motor system, to avoid having to rewire the system if the encoder connections are reversed. It also allows the logical positive and negative directions to be reversed under software control, by toggling both the encoder and output reversal bits in the control word.

		Bit set	Bit cleared
bit	0	Enable integral control	Disable integral control
	1	Enable velocity feed-forward control	Disable velocity feed-forward control
	2	Enable differential control	Disable differential control
	3	Enable velocity feedback control	Disable velocity feedback control
	4	DAC output/stepper direction reversed	DAC output/stepper direction normal
	5	Encoder input reversed	Encoder input normal
	6	Power up in motor off state	Power up in position control mode
	7	Integral term active when static only	Integral term active continuously

The default control word value of 01001011 allows integral, velocity feedback, and velocity feed-forward control, and the channel powers up in the motor off state.

Example : CW 0000 0001
This enables proportional and integral control only.
(Proportional control is always enabled.)

KP_{nn} Set proportional gain constant. (restricted)
Range : 0 to 65535
Default : 256

This command sets the proportional gain of the system. The proportional gain acts on the measured position error, which is calculated as the difference between the current demand position and the position measured by the encoder. High gain gives the system a faster response and tighter position control, but if the gain is too high the system may oscillate. For best results, the proportional gain should be set as high as possible without inducing severe overshoot or oscillation.

KI_{nn} Set integral gain constant. (restricted)
Range : 0 to 65535
Default : 0

This command sets the gain for the integral term in the controller transfer function. When integral control is used, the system integrates the position error by adding the current error to a running total. Integral gain is useful to remove a constant position error, due to a steady load or friction, or in steady state velocity control, but also tends to make the system overshoot the target position at the end of a move because of the error accumulated during the move. This problem is known as "wind-up". The integral action may be set up to avoid this problem such that it is operative only when the system is static, by setting bit 7 of the control word to 1.

KD_{nn} Set differential gain constant. (restricted)
Range : 0 to 65535
Default : 0

This command sets the gain for the differential term in the controller transfer function. This term uses the differential of the position error (rate of change of error), which represents the velocity error of the system. This is useful where the position error is changing rapidly, for example if the required motion is a step change in position. In practice, if the system is anywhere near correct tuning, the position error is small and the rate of change of error is smaller still, so that the differential gain only has a limited effect on the system.

KV_{nn} Set velocity feedback gain constant. (restricted)
Range : 0 to 65535
Default : 0

This command sets the velocity feedback gain constant. The system uses the measured position to calculate the motor velocity, and this velocity, scaled by KV, is used in the controller transfer function. Note that differential control uses the rate of change of error, while velocity feedback uses the rate of change of position. Adding velocity feedback is similar to the effect of a tachogenerator connected externally to the motor drive, in that it adds damping to the system. This allows higher values of proportional gain to be used without giving excessive overshoot or oscillation, thus improving the speed of response of the system.

KF_{nn} Set velocity feed-forward gain constant. (restricted)
Range : 0 to 65535
Default : 0

This command allows the user to set the gain for the velocity feed-forward term in the controller transfer function. It uses the demand velocity as opposed to the measured velocity, and is particularly useful when following a set position or velocity profile. If a system is using proportional gain only, then there will be a steady position error when running at constant velocity, known as velocity lag. The feed-forward gain has the effect of reducing the velocity lag by adding a component dependent on the demand velocity into the demand signal output. The velocity lag error may be easily reduced to zero or even made negative, by increasing the value of the feed-forward gain. Alternatively, velocity lag may be reduced to zero by use of the integral gain, but this has other effects as well.

IT_n Set integration time constant. (restricted)
Range : 0 to 2
Default : 0

The position error is integrated with respect to time by adding the position error at each sample to a running total. This integral of error is then multiplied by the integral gain when required in the control algorithm. This command allows the time constant for the error integration to be set to three different values, as given in the table below. Note that the different time constants also give different scale factors on the integral gain; this means that the integral gain setting is only correct for one time constant setting.

Code	Time constant	Scale factor
0	1÷256	256
1	1	1
2	256	1÷256

The table indicates that with a short time constant, only small values of integral gain are usable without producing instability, because of the increased scale factor. Conversely, with a larger time constant, larger gain values may be used.

SF_n Set monitor output function. (restricted)
Range : 0 to 8
Default : 0

This command selects a particular control value to output on the auxiliary output channel. The possible monitor output functions and their associated gain terms are as follows:

Code	Function	Associated gain term
0	No output function	
1	Demand velocity	KF
2	Measured velocity	KV
3	Position error	KP
4	Integral of error	KI
5	Velocity error	KD
6	Absolute demand position	
7	Absolute measured position	
8	Global output value	AO

The monitor signal may be viewed with a storage oscilloscope, or recorded on a chart or UV recorder. This allows the servo control loop to be easily monitored as an aid to tuning a system. Code number 8 allows the user to set up an independently calculated value. This can then be sent out using the AO command.

AO_{nn} Set analogue output to global value.
Range (2) : ± 32767
Default : 0

This command selects a particular global value to output on the auxiliary output channel. The parameter defines the value of the output. Note that the D to A convertor has a resolution of 12 bits, and that actual values will be rounded to the nearest digit. The actual output voltage will depend on the KM and OM values.

A value of 32,768 is a special case, which will open the relay associated with this analogue output, setting the output to ground. Any other value will close the relay.

KM_{nn} Set monitor output gain. (restricted)
Range : 0 to 65535
Default : 0

This command sets the gain for the monitor output signal. The monitor output functions are scaled by the monitor gain, and not by the gains used in the control algorithm. The monitor output signals are also independent of the settings of the gain term enable bits in the control word.

$OM\pm_{nn}$ Set monitor output offset. (restricted)
Range : ± 32767
Default : 0

This command allows the auxiliary monitor output to be offset by a fixed voltage.

Example : SF2/ KM100/ OM25
This selects the measured velocity function to be output on the monitor line, sets a gain of 100 and an offset of 25

7.2.9 Digital inputs and outputs

The system has 12 inputs and 8 outputs. See the hardware connections for details of the pin numbers.

SO_{nn} Set output line $_{nn}$.
Range : 1 to 8

This command sets up the specified output line to a logic high. Note that the output state is maintained until superseded by another command for the same output line. If no output line number is set then all available output lines are set to a logic high.

Example : SO 1
This sets up line 1 to a logic high.

CO_{nn} Clear output line $_{nn}$.
Range : 1 to 8

This command clears the specified output line to a logic low. Note that the output state is maintained until superseded by another command for the same output line. If no output line number is set then all available output lines are set to a logic low.

Example : CO 7
This sets up line 7 to a logic low.

OC_{nn} Output code via expanded output group.
Range : 0 to maximum value possible on defined output group.

This command sets the expanded output line group (as defined by the OX command) to the given code data value. If the group was defined as active low, the data is inverted. It allows a number of output lines to be set or cleared at the same time, instead of using a string of separate SO and CO commands.

If this command is used when there is no output group defined, and "E" error message is returned. If the parameter value given cannot be represented as a binary number with the number of lines in the output group, then the "O" error message is returned.

Example : OC 5
This sets the output group lines to the binary value 0101 ($=5_{10}$).

RI_{nn} Read input line (s).
Range : 1 to 12

This command reads the current state of the specified input line, and prints it as a "0" or "1" on the display. A "0" represents a logic low, and a "1" represents a logic high. If no line number is given in the command, the system displays the current state of all available input lines.

Example : RI 3
This reads the state of input line 3, and prints it on the display.

System	User	Comments
>	RI3	Read a particular input
0		Input line 3 is low
>		Normal prompt

Example : RI
This reads the state of all 8 input lines, and displays them.

System	User	Comments
>	RI	Reads all inputs
1 0		Line 1 is low
2 1		Line 2 is high...
3 1		
4 0		
5 0		
6 0		
7 1		
8 0		
9 0		
10 0		
11 0		
12 1		
>		Normal prompt

RO_{nn} Read output line state(s).
Range : 1 to 8

This command reads the current state of the specified output line, reads its current state, and prints it as a "0" or "1" on the display. A "0" represents a logic low, and a "1" represents a logic high. If no line number is given in the command, the system displays the current state of all available output lines.

Example : RO 6
This reads the state of output line 6, and prints it on the display.

System	User	Comments
>	RO6	Read a particular output
0		Output line 6 is low
>		Normal prompt

Example : RO
This reads the state of all output lines, and displays them.

System	User	Comments
>	RI	Reads all outputs
1 1		Line 1 is high
2 0		Line 2 is low...
3 1		
4 0		
5 1		
6 1		
7 1		
8 0		
>		Normal prompt

$II_{nn}\pm$ If Input true do command line.
Range : 1 to 12

This command allows the programmer to specify that a command or command line is conditional on the current state of an input line. If the input line specified in the II command is in the specified state (the condition is true), then the remainder of the command line is executed. If the input line is not in the specified state, the remainder of the command line is skipped, and execution proceeds to the next line of input. This could either be the next line of a sequence, or new input commands.

This command can be used within sequences to construct multiple conditions, based on input line states.

Example : DP/II6-/MR20000/SO2
This displays the current position, and if input line no 6 is negative, the system moves 20000 counts, and sets output line 2. If input line 6 is positive, the current position is displayed, and the remainder of the line is ignored.

IO_{nn}± If Output true do command line.
Range : 1 to 8

This command allows the programmer to specify that a command or command line is conditional on the current state of an output line. If the output line specified in the IO command is in the specified state (the condition is true), then the remainder of the command line is executed. If the output line is not in the specified state, the remainder of the command line is skipped, and execution proceeds to the next line of input. This could either be the next line of a sequence, or new input commands.

This command can be used within sequences to construct multiple conditions, based on output line states.

Example : DP/IO3+/MR5000/CM6
This displays the current position, and if output line no 3 is positive, the system moves 5000 counts, and complements output line 6. If output line 3 is negative, the current position is displayed, and the remainder of the line is ignored.

MI_{nn} Mask function input.
Range : 1 to 12, or no parameter

This command is used to disable the action of defined function inputs or any expanded input group lines. It allows several input lines to selectively lock out defined actions, depending on the current function activated. For example, a machine start sequence assigned to a function input may disable itself once the machine has started, until the stop sequence assigned to another sequence re-enables it. This prevents any subsequent signal on the start input from generating unnecessary start sequence commands, which may not be allowed when the machine is running. Disabled inputs are enabled again by the EI command. If a line number is given as a parameter, then the specified line is disabled. If no line number is given, then all function inputs and/or expanded group inputs are disabled.

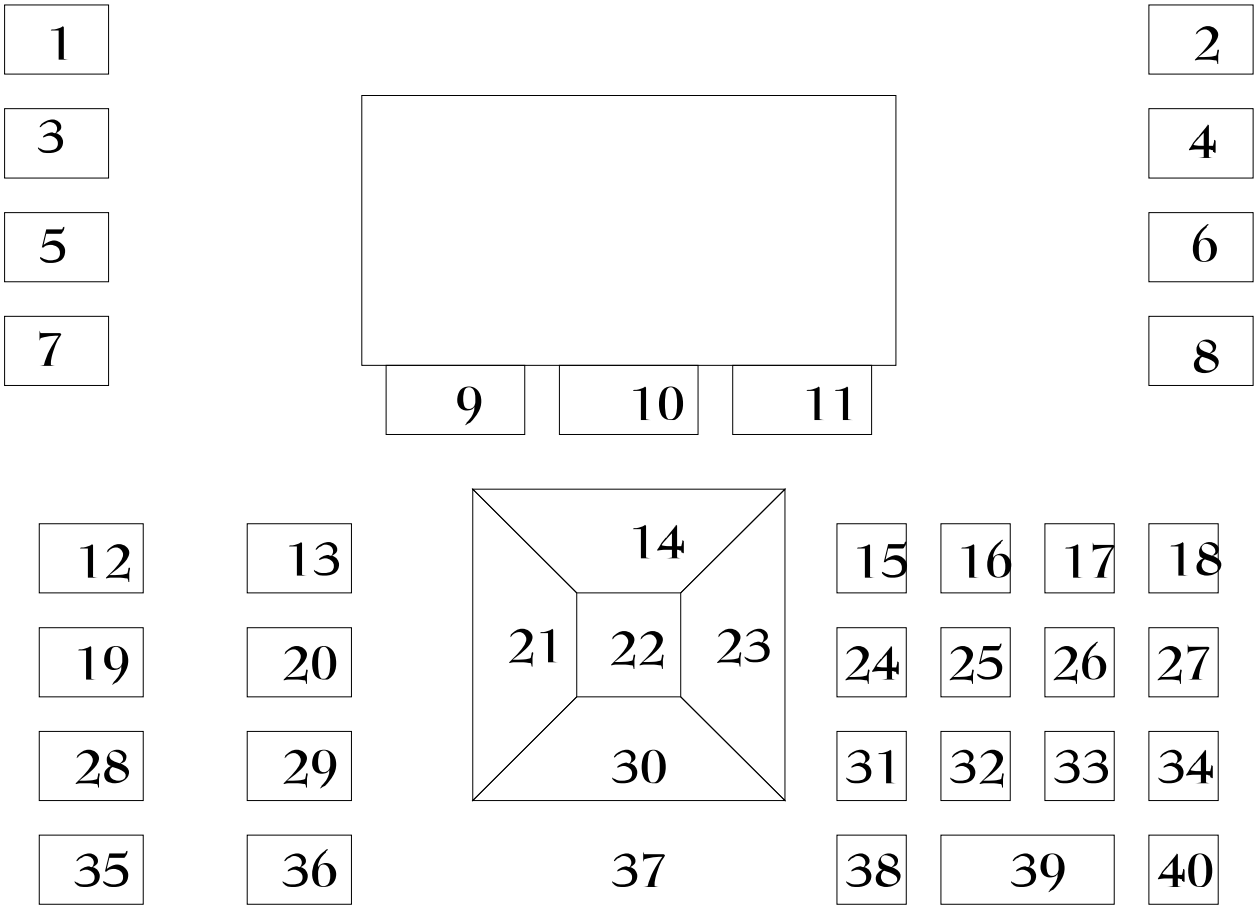
EI_{nn} Enable function input.
Range : 1 to 12, or no parameter

This command is used to enable the action of defined function inputs or any expanded input group lines, where they have been disabled by the MI command. If a line number is given as a parameter then the specified line is enabled. If no line number is given, then all function input and/or expanded group inputs are enabled.

NOTE: The disable/enable action applies **only** to inputs defined as function inputs with the DI command, or as expanded group inputs with the DX command. Input lines which are not currently defined for any particular function may be masked or enabled, but this has no effect unless the lines are subsequently defined as DI or DX inputs. It is not possible to disable other types of defined inputs with the MI command, or to inhibit the WI command.

MK_{nn} Mask keypad input.
Range : 1 to 64, A to Z, or no parameter

This command is used to disable the action of certain keys on the keypad. The parameter A to Z corresponds to the SK definitions, and is converted to the numeric keypad map. Note that not all the keys can be represented using the A to Z parameter. The numeric parameter corresponds to the following keys on the keypad:



If no parameter is entered, then all the above keys are disabled.

EK_{nn} Enable keypad input.
Range : 1 to 64, A to Z, or no parameter

This command is used to enable the action of certain keys on the keypad. It allows the keypad to start events, in conjunction with the SKn command (page 29) at any time. The parameter corresponds to the same keys as shown in the MK command above.

If no parameter is entered, then all the above keys are enabled.

$KS_n+!/_{nn}$ Set keypad sequence for arrow keys.
Range : 1 to 4, or no parameter, and sequence no 1 to 255

This command is used to enable the arrow keys to perform programmable jogs. The "+" option sets the operation when the key is pressed, and the "!" option sets the operation when it is released. The operations are defined in terms of sequences.

KS1 corresponds to the up arrow, KS2 down arrow, KS3 left arrow, and KS4 right arrow.

If no parameter is entered, then all the current settings are displayed.

7.2.10 Reference commands

This section describes the commands available to make use of the position reference facilities. In particular, these commands allow the user to set up a repetitive position reference marker and use it to automatically adjust the absolute position of the system. The position of the reference input is immediately stored when the reference input signal is detected. This position is compared with an expected reference position, either the current zero position or the nearest bound position. The difference is defined as the reference error, and the absolute position may be corrected by this amount if required. For more details on the SB set bound command, refer to section 7.2.4 (page 23).

RW_{bb} Set reference options word. (restricted)
Range : 0000 0000 to 1111 1111 (binary)
Default : 0001 0000

This command allows various reference functions to be enabled and disabled. The bit functions for the reference word are described below.

bit 0 When set to 1, enables the position correction on detecting a reference signal.
When set to 0, disables the position correction but still allows the measurement of reference error.

1 When set to 1, limits the position correction to a maximum value set by the SR command by setting RW bit 0 to a 1.
When set to 0, allows the full correction to be made regardless of the maximum value set by SR.

2 When set to 1, defers the position correction until the motor passes the adjustment set by the SJ command.
When set to 0, the correction takes place immediately the reference signal is detected.

3 When set to 1, inhibits the move back to the new zero position in the IN command sequence.
When set to 0, the IN command finishes with a move back to the new zero position defined by the just detected reference input.

4 When set to 1, the system always uses positive numbers when displaying its position. This means, that while the system is moving in the negative direction past the zero position, it will wrap to the current bounds value set using the SB command.
When set to 0, the system will display negative numbers as it passes the zero position moving in the negative direction. It will only wrap when it reaches either the positive or negative bounds value.

5 When set to 1, the system only corrects the displayed position value, not the motor position.
When set to 0, it corrects the motor position as well as the displayed position.

6 This bit defines the action taken if the reference error is greater than the maximum value set by the SR command and bit 1 of RW is set to enable this limit.
When set to 1, if the reference error is greater than the maximum value set by the SR command, the system corrects by this maximum value. The "RL" reference out of limits error is reported, and may set the channel to the motor off state if required.
When set to 0, a reference error greater than the maximum value is ignored completely and its value is discarded. This also inhibits the reference out of limits error message, and does not update the reference error displayed by the DF command.

7 When set to 1, the system always sets the position to zero on detecting a reference signal.
When set to 0, the system defines the reference position or ±SB, whichever is closest. This is the normal setting for use on a cyclic machine where, for example, SB is set to the repeat distance between encoder marker positions.

8 When set to 1, the system always uses positive numbers when displaying its position. This means, that while the system is moving in the negative direction past the zero position, it will wrap to the current bounds value set using the SB command.
When set to 0, the system will display negative numbers as it passes the zero position moving in the negative direction. It will only wrap when it reaches either the positive or negative bounds value.

Example : RW 11/ SR20
This enables the position correction on detection of a reference input, limits the allowed correction to a maximum of 20 encoder counts.

$SJ\pm_{nn}$ Set deferred adjustment position. (restricted)
Range : ± 4 000 000 (4.0E6)
Default : 0

This command allows the position correction on a reference input signal to be deferred until the motor passes a defined position. In some circumstances it may not be desirable to allow a sudden position correction to occur at the reference position, for example because of some mechanical interaction with other parts of a machine. In such a case, the SJ command defines a position which the motor must pass before the correction due to the reference signal takes place. This function is enabled by bit 2 of RW. If this bit is set to zero, the reference correction takes place immediately.

NOTE: If the SJ position is set to a value which is greater than the bound (set by SB), the reference correction will never take place.

SR_{nn} Set maximum reference correction. (restricted)
Range : 0 to 65535
Default : 65535

This command, when enabled by bit 1 of RW, limits the maximum allowed reference correction to the specified number of encoder counts. It may be used to eliminate false reference signals at positions far away from the expected reference position, or to allow the position reference facilities to be used even when the machine cycle length is not the same as the distance between reference marker signals.

When a reference signal is seen, the reference error is calculated as the difference between the zero position defined by the reference input, and the zero position or nearest bound position as measured by the normal system encoder counters. If enabled by bit 0 of RW and inside the limit defined by the SR command, the position is corrected by this reference error. If the reference error is greater than the maximum limit, the action taken depends on bit 6 of RW. If it is clear, then the position is not corrected, the out of limits error reference value is discarded, and the reference is ignored completely. If it is set, the position is corrected by an amount equal to the maximum correction limit.

If required, the system may be programmed to generate a motor error when the reference error is outside this limit. This facility is enabled by setting bit 1 of EW, the error options word. When this is set, a reference error greater than the reference set by SR gives a "RL" reference limit error message, and the channel goes to motor off. Note that the reference error and the out of limits error are only reported if RW bit 6 is set to 1 to enable correction by up to the defined limit. If RW bit 6 is set to 0, then reference errors outside this maximum limit are discarded and ignored completely, and no error is reported.

RF±$_{nn}$ Set reference offset. (restricted)
Range : ± 4 000 000 (4.0E6)
Default : 0

This command sets the offset for the reference position of the current motor channel. It defines the absolute position for the reference input signal.

Example : RF500
This sets the reference offset on channel 1 to 500 counts. This means that the position where the reference input signal is seen is defined as absolute position 500, and not zero.

RV$_{nn}$ Set reference correction velocity. (restricted)
Range : 0 to 8
Default : 0

This command sets the correction speed for any reference error. It is used to make large reference error corrections less harsh by spreading the correction over several time steps. If RV is set to zero, then the reference error correction is performed immediately in one step. If RV is not zero, then the position correction is limited to a set maximum speed, given by the sum of the reference velocity and the current (instantaneous) motor velocity. The reference correction velocity is a power of two fraction of the current motor speed, defined by the value of RV. This means that the reference correction speed scales automatically with the machine speed, such that the value of RV may be chosen for correct operation at full machine speed without causing unnecessary quick corrections at lower machine speeds.

At the maximum value of RV=8, the correction speed is equal to the current motor speed, and the correction is thus performed at twice the current motor speed. Each time RV is reduced by one, the correction speed is halved, down to the minimum value of RV=1, when the correction speed is 1÷256 times the current motor speed.

If the reference correction velocity is set too small, or the reference error is too large, then it is possible for the next reference signal to arrive before the correction for the previous reference is complete. This condition is called reference correction overrun, and is indicated by the "RO" error message. This error may be set to give either a user error or a motor error, by setting bit 2 of EW, the error word. If this error occurs, it indicates either that the machine is not performing correctly and is giving excessive reference errors, or that the value of RV is too small and should be increased.

RL_{nn} Set reference repeat length. (restricted)
Range : 0 to 4 000 000 (4.0E6)
Default : 0

This command sets the reference repeat length for the current motor channel. This is the position at which the system expects to see the reference position signal. If RL is set to zero, then trhe system uses the bound position, set by SB, as the expected reference position. If RL is set to some value greater than zero, then it is used as the expected reference position instead of the bound value. When a reference signal is detected, the position is compared with the nearest multiple of the reference repeat length, instead of to the nearest zero or bound position. This allows the expected reference position to be set independently of the bound position.

A typical example where this is useful is a leadscrew application, where the encoder is mounted on the motor and provides a marker signal every turn of the motor, while the bound value must be set for the total travel required by the motor. Using the RL command, the reference repeat length is set to the number of counts per turn of the motor, while the position bound is set as required by the linear motion. Each encoder marker signal then gives a useful reference error measurement which may be used for correction if required.

7.2.11 Configuration commands

$DR_n\pm$ Define reference input. (restricted)
Range : 1 to 4

This command defines the sense of the position reference input for the current motor channel. The system looks for the specified change in the reference input when the IN initialise position command is executed, and when the automatic reference facilities are enabled by the RW command. See the Reference Commands section (7.2.10, page 50) for more details on the reference facilities and commands. This command is restricted, and is only available in privileged mode.

Example : DR 2+
This specifies that the reference position is detected by a transition on input line no 1 for the current channel.

$DZ(B)_{nn}$ Define zero marker input on/off. (restricted)
Range : 0 to 1

This command defines whether the encoder zero marker input is on or off. The sense of the sense of this input is fixed and cannot be programmed. If the value passed with the DZ command is zero, the fast reference input is turned off. If the value is non-zero, the zero marker input is turned on. When the zero marker input is enabled, the system looks for a pulse on the zero marker input or a transition on any other reference inputs when the IN initialise position command is executed, and when the automatic reference functions are enabled by the RW command. For more details of the operation of the reference inputs, see the Reference Commands section (7.2.10, page 50). DZ operates on the primary channel and DZB is for the secondary position channel. This command is restricted, and is only available in privileged mode.

$EC_{nn}\pm$ Define external counter input. (restricted)
Range : 1 to 4

This command an input line to be an external counter, whose frequency must not be greater than 100Hz. The counter has a maximum value defined by the WX parameter. The counter subsequently wraps to zero. The counter can be read at any time by the use of the RX command. The external counter function uses the same mechanism as the reference input function to get an accurate count on an input signal. An EC input line may be returned to normal operation by entering this command without the sign. This command is restricted, and is only available in privileged mode.

Example : EC 1-
This specifies that the input line 1 is to be an external counter.

RX Read external counter input.

This command reads an external counter value.

WX_{nn} Wrap for external counter input.
Range : 1 to 2,147,483,647
Default : 2,147,483,647

This command sets the value at which an external counter wraps to zero.

$ZX[_{nn}]$ Zero external counter input or set counter input.
Range : 0 to 2,147,483,647

This command reads sets an external counter value to zero.

If a value is given, the system sets the current external counter to the given (absolute) value. If no value is given, it sets the external counter to be zero. The ZX command may be used at any time.

$DL_{nn}\pm$ Define limit switch input. (restricted)
Range : 1 to 12

This command defines the specified input line as a limit switch input for the current motor channel. The sign defines which logic state represents the out-of-limit condition. When the line goes to the specified state, the system stops the motor immediately, prints an "L_n" error message to indicate that a limit switch input was detected, and goes to the motor off state. Note that a line that has been defined as a limit switch input cannot be set or cleared. A line which has been defined as a limit switch input may be returned to normal operation by entering this command without the sign. This command is restricted, and is only available in privileged mode.

Example : DL 8 -
This defines input line 8 as an active low limit switch input. The system detects a limit switch when line 8 goes to a logic low.

Example : DL 4
This returns line 4, previously defined as a limit switch input, to normal operation.

$PS_n\pm$ Define position snapshot input. (restricted)
Range : 1 to 4

This command defines the specified input line as a position snapshot input for the system's current motor channel. The sign defines which logic transition is used to detect the snapshot position. The system monitors the snapshot input and stores the absolute position value at that time. The snapshot position data may be read at any time by using the DS command. The snapshot function uses the same mechanism as the reference input function to get an accurate measurement of position on an input signal. Note that because of this, only inputs 1 to 4 may be defined as a snapshot input. A position snapshot input line may be returned to normal operation by entering this command without the sign. A single input line can be defined as a position snapshot for both channels. Note that once a snapshot line has been triggered, it needs to be re-armed using the PS command. This is to remove the possibility of switch bounce causing mutliple triggering. This command is restricted, and is only available in privileged mode.

Example : PS 4 +
This defines that the snapshot position for motor channel 2 is detected on a low-to-high transition on input line 4.

DI_{nn}±/! Define input line function. (restricted)
Range : 1 to 12

This command defines a specified input line to have the given function. The sign specifies the active state of the input, such that the system executes the function when the input changes to the specified state. Alternatively the sign may be replaced by a "!" character. This indicates the action when a previously defined input line reverts to its normal state. The command function may be a single command, or may be a sequence of commands. The text of the command function is separated from the DI command by any delimiter character. The length of each definitions is limited to 80 characters. If there is not enough memory for the new line definition, the system will return an "N" no room error message. Note that a line that has been defined as a function input cannot be set or cleared. A function input line may be returned to normal operation by entering this command without the sign and the function text. This command is restricted, and is only available in privileged mode.

If a line is defined as an input, and is already in the true state when it is defined as a function input, the system does not act on the input until it has gone false and become true again. If an input is currently masked by the MI command when it is defined, it does not become active until it is enabled by the EI command.

Example : DI1+/ AB
This defines line 1 as a single command, such that when line 1 goes to a logic high, the system executes the AB command.

Example : DI2-/ ID/IN-/WT256/MR-5000/ZC
DI2!/ST
This defines line 2 as a command sequence, such that when it goes to a logic low, the system executes the given sequence. It initialises the DAC offset, initialises the position to the reference position, waits for 1 second, moves -5000 units, and zeros the position counters at this position. When the input line reverts to a logic high, the ST command is executed. If the system is still in motion, it will then stop.

Example : DI 3
This returns line 3, previously defined as a function input, to normal operation.

$DX_{nn}±$ Define expanded input line. (restricted)
Range : 0 to 7

This command sets up a group of input lines as an expanded input command facility. It operates in a similar way to the DI function input lines, but allows a larger range of different functions to be programmed into the system. When the DX function is used, input line 8 is used as a strobe or trigger input. The sense of the strobe input is given by the sign after the parameter. Lines 8 downwards are used for the expanded input function. To reset the expanded input group use the command "DX0".

On detecting the strobe input, the remaining input lines from line 7 (most significant bit) down to the line number specified in the DX command are read as a binary code. This value is used as the number of a sequence, which is executed immediately if it is defined. This allows a maximum of 127 possible different operations to be controlled by lines 1 to 7 on a single controller. If the strobe input is active low, as defined by the sign in the command, then the data lines are also inverted when deriving the number of the sequence to be executed. This keep the strobe input and data inputs consistent.

The MI mask input command may be used to disable any of the expanded input lines. If the strobe input is masked, no DX functions are executed until it is enabled by the EI command. If any DX data input lines are disabled, those input bits are masked out when deriving the DX number for the signal or sequence.

Example : DX 4-
This sets up an active low expanded input group on lines 4 upwards, as above. When a strobe signal is detected on line 8, the unit looks for a sequence number derived from the other input lines in the group, and if it is defined, then it is executed. Thus if the input lines 7-4 are in the binary pattern 0111 when the strobe input is seen, then sequence 7 is executed ($0111_2=7_{10}$).

Line	State	Bit Value	Decimal Value
8	High->low		
7	High	0	0
6	Low	1	4
5	Low	1	2
4	Low	1	1
3			Total 7
2			
1			

DB_{nn} Set input debounce time. (restricted)
Range : 0 to 255
Default : 5

This command sets up a debounce time for all the digital inputs. It is specified in 1÷256 second (about 4ms) ticks. Before an input signal is recognised as valid, it must be stable for the number of samples given by the DB command. This facility may be used to reduce the effect of noise in a system by reducing the number of false triggers due to noise.

NOTE: The debounce value does not apply to reference inputs. These inputs are programmed so as to be detected immediately on a change of state, to get the most accurate position information possible.

Example : DB 2
This sets the debounce time to about 8 ms (2 samples).

$DE_n\pm$ Define error output line. (restricted)
Range : 1 to 8

This command defines the specified output line as an error output. The line is set to the specified state when the system detects any motor off error condition, and is cleared to the opposite state when the axis is returned to the position control state with the PC command. Error conditions which are signalled in this way are as follows.

(a) Exceeding maximum position error.
(b) Exceeding maximum timeout.
(c) Detection of a limit switch input.
(d) Motor position outside position limits.

Any optional errors enabled by setting bits in the error word EW also cause the error output signal to switch. More details of the error conditions and commands to set them up are given in section 7.2.7 (page 36). This command is restricted, and is only available in privileged mode.

Example : DE 4+
This sets up an active high error output signal on output line 4. When an error condition is detected, output line 4 is set to a logic high.

PO_n± Define position trigger output. (restricted)
Range : 1 to 8

This command defines the specified output line as a position trigger output. The PO command **must** be followed by two position values. These define the range of positions, within which the output line goes to the state specified by the sign in the command. A line which has been defined as a position trigger output may be returned to normal operation by entering this command without the sign. This command is restricted and may only be used in privileged mode.

Example : PO5-: 1000: 2000
This example sets up an output as a position trigger, such that it goes low between positions 1000 and 2000.

Variables can be used to define position trigger points.

Example: IV%34:245/IV%43:900
PO2+:v%34::v%43:

The position range for the PO outputs is cyclic and repeats at the bound position defined by the SB command. To illustrate this, consider the above example again. Suppose that the bound position is set to 2000. In this case, the active position range for the position trigger output repeats at positions 3000 to 4000 (one cycle later), at 5000 to 6000 (two cycles later), and so on. It also repeats in the negative direction, at -1000 to 0, at -3000 to -2000, etc.

OX_n± Define expanded output line group. (restricted)
Range : 0 to 8

This command sets up a group of outputs that may be set to a binary code with a single OC command, instead of using a string of individual SO and CO commands. It reserves from line number 1 up to the line number given for the expanded output group, and the sign determines whether or not the output data should be inverted.

To reset the expanded output definition, use "OX0". If any of the outputs required for the expanded output group function are already defined as some other function the "U" error message is returned. This command is restricted and may only be used in privileged mode.

Example : OX3+
This example defines output lines 1-3 as an active high expanded output group. This allows output codes from 0 to 8 to be put on these lines with the OC command.

LI List I/O line definitions.

This command lists the current definitions of the I/O lines on the display. Lines defined as function inputs are shown as "$_{nn}$: ± I (function)", and lines defined as limit switch inputs are shown as "$_{nn}$: ± L", where $_{nn}$ is the I/O line number. Lines not defined as either function or limit switch inputs are left blank. The I/O line definitions are listed on the display or terminal, one per display line. They may be listed continuously, or the system can print one line at a time and wait for the user to press a key before printing the next line. This is useful when using the system with the membrane terminal, which only has a two line display. This list pause facility is controlled by one of the flag bits in the DW command.

Example : LI
This will list the I/O line definitions on the display or terminal. The display for some of the above definitions would look like this.

```
>LI (CR)                    User input to list  sequence
Inputs:
1: + AB                             Function input definition
2: - IN-/WT256/ID/MR-5000/ZC
3:                                  Normal I/O lines, undefined
4:
5:
6:
7: - L                      Active low limit switch inputs
8: - L
9:
10:
11:
12:
Outputs:
1:
2:
3:
4:
5:
6:
7:
8:
>
```


7.2.12 Loop commands

$FN_{v1n1:n2:n3}$ For variable $_{v1}$ = $_{n1}$ to $_{n2}$ step $_{n3}$ do command line.
Variable range : a to z or A to Z
$_{n1}$ & $_{n2}$ range : -2,147,483,647 to +2,147,483,647
$_{n3}$ range : 1 to +127

This command allows the programmer to use a variable (lower case letter type) to control a loop within a line of a sequence. More complex operation may be performed by calling sequences from the line. It allows numeric variables to be indexed from the loop variable (if a lower case variable is used). The step parameter, $_{n3}$, is optional, and when entered, its sign must be positive. This command can be nested, but note that if the same variable is used for different interacting FN loops, there is scope to get into indefinite loops. The constants $_{n1}$, $_{n2}$, and $_{n3}$ can be replaced by variables. A for next loop can be terminated by the ERF command (see page 28).

Example:

```
1>FNa2:4/OVa                          User input to start loop
+0000000002
+0000000003
+0000000004
1>

1>IVb8/IVc2/IVd2/FNab:c:d/OVa         User input to start loop using variables
+0000000008
+0000000006
+0000000004
+0000000002
1>

1>IV%20:10/IV%22:4/iv%24:2
1>FNc%20::%22::%24:/ovc               User input to start loop using numeric variables
+0000000010
+0000000008
+0000000006
+0000000004
1>

1>IV%20:10/IV%22:4/iv%24:2            User input to start loop using numeric variables
1>FNc%20::%22::%24:/vmc%22:d/ovc/iv%c:vd/ov%c:        Note the use of the loop variable for
                                                      indexing
+0000000010
+0000000040                           Value of variable %10
+0000000008
+0000000032                           Value of variable %8
+0000000006
+0000000024                           Value of variable %6
+0000000004
+0000000016                           Value of variable %4
1>
```

GL_n Go to line in sequence
Range : 1 to no of lines in current sequence

This command allows looping to a specified line number within a sequence. Note that it can only be executed from within a sequence.

Example:
A sequence might consist of the following:

CO3/MR5000
SO4/WT500/II5-/XT
GL1

This will continue looping to line 1 until input line 5 is negative, when the XT command will escape from the sequence.

7.2.13 Conditional commands

$II_{nn}\pm$ If Input true do command line.
Range : 1 to 12

This command allows the programmer to specify that a command or command line is conditional on the current state of an input line. If the input line specified in the II command is in the specified state (the condition is true), then the remainder of the command line is executed. If the input line is not in the specified state, the remainder of the command line is skipped, and execution proceeds to the next line of input. This could either be the next line of a sequence, or new input commands.

This command can be used within sequences to construct multiple conditions, based on input line states.

Example : DP/II6-/MR20000/SO2
This displays the current position, and if input line no 6 is negative, the system moves 20000 counts, and sets output line 2. If input line 6 is positive, the current position is displayed, and the remainder of the line is ignored.

$IO_{nn}\pm$ If Output true do command line.
Range : 1 to 8

This command allows the programmer to specify that a command or command line is conditional on the current state of an output line. If the output line specified in the IO command is in the specified state (the condition is true), then the remainder of the command line is executed. If the output line is not in the specified state, the remainder of the command line is skipped, and execution proceeds to the next line of input. This could either be the next line of a sequence, or new input commands.

This command can be used within sequences to construct multiple conditions, based on output line states.

Example : DP/IO3+/MR5000/CM6
This displays the current position, and if output line no 3 is positive, the system moves 5000 counts, and complements output line 6. If output line 3 is negative, the current position is displayed, and the remainder of the line is ignored.

IE_{v1v2} If $_{v1}$ is equal to $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is equal to variable $_{v2}$.

Example : IE NA/MR 5000/CO3
If variable "N" is 16 and variable "A" is 16, then the system executes a move of 5000 counts, and then clears output line 3.

IF_{v1v2} If $_{v1}$ is not equal to $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is not equal to variable $_{v2}$.

Example : IF tO/MA 0
If variable "t" is 516 and variable "O" is 516, then the system moves to an absolute position of 0 counts.

IG_{v1v2} If $_{v1}$ is greater than $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is greater than variable $_{v2}$.

Example : IG VW/IVV0
If variable "W" is 12 and variable "V" is 13, then 0 is allocated to variable V.

GT_{v1} If variable $_{v1}$ is greater than the time counter, then do the rest of the command line.

This command executes the remainder of the current command line, if the time counter is greater than variable $_{v1}$.

Example : GT X/SO12
If variable "X" is 544 and the time counter is 300, the output line 12 is set.

$IC_{n1:v1}$ If bit $_{n1}$ of variable $_{v2}$ is clear, then do the rest of the command line.

This command executes the remainder of the current command line, if bit number $_{n1}$ in variable $_{v1}$ is clear. This command can be used in conjunction with the VBC or VBS bit manipulation command to control flow through a programme.

Example : IC 3:b/MR -25000/SO5
If bit 3 in variable "b" is clear, then the system executes a move of -25000 counts, and then sets output line 5.

$IS_{n1:v1}$ If bit $_{n1}$ of variable $_{v2}$ is set, then do the rest of the command line.

This command executes the remainder of the current command line, if bit number $_{n1}$ in variable $_{v1}$ is set. This command can be used in conjunction with the VBC or VBS bit manipulation command to control flow through a programme.

Example : IS 17:%35/MR-25000/SO5
If bit 17 in variable "%35" is clear, then the system executes a move of -25000 counts, and then sets output line 5.

7.2.14 Display commands

DP(2) Display actual position.

Displays current position, in encoder counts. The optional parameter (2) enables the command to display the position of the second encoder.

DD Display demand position.

Displays current demand position, in encoder counts.

DV Display velocity.

Displays the current measured velocity of the system, in encoder counts per second. Note that the velocity is normally calculated as the difference between two successive position samples, and is therefore a multiple of 256 counts per second. If speed averaging is enabled by the VT command, then the displayed velocity is the average measured velocity, and has a correspondingly higher resolution.

VT_n Set velocity averaging time constant
Range : 0 to 8
Default : 0

The VT command sets up an averaging mechanism, such that the number of speed samples doubles for each increment of the value of VT. When VT is zero, no averaging takes place. When VT is 8, 2^8 (256) samples are averaged over a period of a second, to give a speed measurement accurate to 1 count per second. The system keeps a running average of the speed which is updated at each 4ms sample, so that the latest average speed is always available.

Note that whenever the averaging time is changed, the current average value is reset to zero and the running average is restarted. The averaged speed value is returned by the DV display velocity command.

DC(2/B) Display position bound overflow count.

Displays the current value of the position bound overflow count. Each time the motor passes the bound in the positive direction, this counter is incremented. When the motor passes the negative bound in the negative direction, the counter is decremented. The suffix 2 or B resets the overflow counter for the auxiliary channel. For more information see the SB command in section 7.2.4 (page 23).

DF(2/B) Display reference position error.

This command displays the last measured absolute position error relative to the reference input for this channel, in encoder counts. The suffix 2 or B allows a mechanism for interrogating whether the auxiliary channel has been initialised. If it has been initialised, it returns 1, and if not it returns 0. For more details on the reference commands see section 7.2.10, and the DR and DZ commands in section 7.2.11 (page 55).

DS1/2 Display snapshot position data.

This command displays the absolute position for the main or background channel (designated by 1 or 2) measured when a snapshot input signal was detected. For more details see the PS command in section 7.2.11 (page 55).

DT Display time.

Displays current time, in dd:mm:yy:hh:mm:ss format.

EO Echo mode off.

This command stops characters from being echoed back to the display terminal. It is subtly different from using bits 13 & 15 of the display word which will only allow requested data to be send to the display terminal.

EM Echo mode on.

This command enables characters to be echoed back to the display terminal (the default state). It reverses the effect of the EO command described above.

DK Display system constants.

The system displays various parameter values, in the following order:
- Proportional gain constant
- Integral gain constant
- Velocity feedback gain constant
- Velocity feed-forward gain constant
- Scale factor for length related units
- Velocity
- Acceleration (to nearest multiple of 256)
- Maximum position error

DM Continuous display mode.

Turns on a continuous display of demand position, measured position, position error, and time.

DO Display mode off.

Turns off the DM continuous display. This is the default state.

CD_{nn} Character delay, terminal.
Range : 0 to 255
Default : 0

This command sets the delay between characters sent to the serial terminal port, in units of 1/256 seconds. It allows the system to be used with terminals that do not support XON/XOFF protocols.

DN Use decimal numbers for input and output.

This is the default state. This command is restricted, and is only available in privileged mode.

HN Use hexadecimal numbers for input and output.

This command is restricted, and is only available in privileged mode.

DW_{bbbb} Display options word. (restricted)
Range : 0000 0000 0000 0000 to 1111 1111 1111 1111 (binary).
Default : 0000 0000 0010 0010

This command allows the user to set various display configuration options. Note that the leading zeros may be omitted. The display option word bit functions are described below.

		Bit set	Bit cleared
bit	0	Reserved for future expansion	
	1	PANTERM terminal	Standard terminal
	2	List pause on	List pause off
	3	Pads lines to 16 chars	Prints <CR><LF> after each line
	4	Reserved for future expansion	
	5	Verbose error messages	One or two char error messages
	6	Hexadecimal input & output	Decimal input & output
	7	Reserved for future expansion	
	8	Reserved for future expansion	
	9	Conditional tests in wait state.	Conditional tests - immediate execution.
	10	Reserved for future expansion	
	11	Reserved for future expansion	
	12	Reserved for future expansion	
	13	Always output required data	Normal operation
	14	Reserved for future expansion	
	15	No characters sent to terminal.	Characters sent to terminal.

The default value of 100010 is for a PANTERM 80 column terminal, and uses decimal input and output. It produces verbose error messages. This command is restricted, and is only available in privileged mode.

Note that bit 13 should be used in conjunction with bit 15 in order to have an effect. The result of combining bits 13 & 15 is to only transmit data of requested items (e.g. DP, OV, etc). This can be useful when the system is being controlled on the terminal port from a PLC. It is subtly different from using the EO (echo off command), since the echo off command sends prompts, error messages, etc.

Example : DW 101
This sets the display options for use with a 40 column display terminal, and turns the list pause on. The list pause is used when listing sequences and profile tables on a display with a small number of display lines.

HE Print help display.

This command prints a complete list of all commands on the system, in alphabetical order, a screenful at a time. It pauses between each page until a character is received. Help on a single command is displayed if the command mnemonic followed by "?" is entered.

Example:

System	User	Comments
>	DP?<CR>	Request help on DP
DP Return current position		Single line help

LE Display last error

This command redisplays the error message for the last error detected by the system. It is useful for finding an error message which has stopped the system when there is not normally a display connected to the machine, or to display the long error message for an error which has been reported with a short error message. This is done by setting bit 5 of DW before executing LE

MD(I)$_{n(:c)v1}$"ccc"'ddd' Send a character string to the LCD/VFD display.

This sends a character string (enclosed by double quotes) to the line number $_n$ of the LCD/VFD display, starting at character number $_c$ (optional). Variables $_{v1}$ can also be displayed before or within text. If single quotes are used instead of double quotes then the characters are converted as shown in the table below. Any number of variables can be used in this way. Either or both the character string and the variable can be entered. If the command is entered with no parameter, the display is cleared. If the command is entered with a line number, and no other parameter, the line referred to is cleared. If the command is entered with a line number, character number, and no other parameter, the line referred to is cleared starting from the character number entered.

The optional I parameter allows the real time display of the states of inputs and outputs. This uses the bottom 2 lines of the display.

The table below shows the displayed symbols when the matching characters are enclosed in single quotes ('). Where a ✖ is indicated, the character is illegal.

sp	!	"	#	$	%	&	'	(	)	*	+	,	_	.	/
sp		┌	┘	\	•		✖								
0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
										°c	°f				
@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Ä	À		á	å											
P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
Æ	æ	£	Pt										↩		
`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
α	ä	β		µ											
p	q	r	s	t	u	v	w	x	y	z	{	|	}	~	
→	"	θ	∞	Ω	ü	Σ	π	▯	←				÷	✖	✖

ME(R,E)$_{n1}$:$_{n2}$:$_{n3}$:$_{n4}$:$_{v1}$ Sends a variable to the LCD/VFD display.

This sends a variable $_{v1}$ to line number $_{n2}$ of the LCD/VFD display, starting at character number $_{n3}$. The first parameter $_{n1}$ allows a number (1 to 8) of variable "sites" to be set up for editing. When the MEE command is executed, the flashing cursor starts, and the up and down arrow keys can be used to index through any ME variables displayed on the screen. The parameter $_{n4}$ specifies the maximum number of characters allowable for a field entry. When the enter key is pressed, any of the 8 variable sites which have been set up will be read from the screen to their respective variables, and the cursor will go off. The SK command or WK13 (wait for enter key) can be used to trigger another event after the screen has been read.

The optional R suffix allows all the variable sites to be read without the enter key being pressed. It also resets the variable site pointers. This reset operation can be performed by using ME followed by <CR> only.

CRn(:c) Switch on/off cursor on the LCD/VFD display.

This controls the cursor, by switching it on line number $_n$ of the LCD/VFD display, at character number $_c$ (optional). The cursor can be switched off by entering CR with no parameter.

7.2.15 Variable commands

The system allows the use of integer variables. This enables fixed programmes to be modified merely by changing one or two key parameters. This can be particularly useful for controlling machine tools. The variables are 32 bits long and are signed. There are 308 of them; 26 of them are designated by the letters A-Z(case sensitive), and are saved in non-volatile memory with the SP command. Another 26 are volatile, and are designated by the lower case letters a-z(case sensitive). The remaining 256 are non-volatile and are designated by a % character followed by a number from 0 to 255, followed by a : full colon if the variable name is not the end of the variable command.

There are two extensions to inputting and outputting data:

1 V for inputting a parameter from a variable
2 O for outputting a parameter to a variable

Example: MRVC
This moves relative an amount defined in variable C.

Example: TOOa
Put the current value of Timeout into volatile variable a.

$IV_{v1}\pm_{nn}$ Input a variable (A to z).
Range : -2,147,483,647 to +2,147,483,647

Allows a variable $_{v1}$ to be set up.

Example : IVC 12000
This sets up variable "C" to a value of 12,000.

Example: IVa 24
IV %a:345
This sets up variable "a" to a value of 24, and then variable %24 to a value of 345.

$OV(_{"s"})_{v1}$ Output a variable.

Prints a value for variable $_{v1}$.

Example : OV%36
This displays the value of variable "%36" on the display terminal. The optional string can be placed between inverted commas before the variable name. This is useful for de-bugging a system, and allows a meaningful display to be set up on the terminal.

$VBC/S_{n1}:_{v1}$ Set or Clear a bit in a variable.

This commands allows individual bits within a variable to be set or cleared. This command can be useful for directing the flow of instructions in conjunction with the condition bit test commands IC and IS.

Example : VBS13:F
Set bit 13 of variable F.

$IC_{n1:v1}$ If bit $_{n1}$ of variable $_{v2}$ is clear, then do the rest of the command line.

This command executes the remainder of the current command line, if bit number $_{n1}$ in variable $_{v1}$ is clear. This command can be used in conjunction with the VBC or VBS bit manipulation command to control flow through a programme.

Example : IC 3:b/MR -25000/SO5
If bit 3 in variable "b" is clear, then the system executes a move of -25000 counts, and then sets output line 5.

$IS_{n1:v1}$ If bit $_{n1}$ of variable $_{v2}$ is set, then do the rest of the command line.

This command executes the remainder of the current command line, if bit number $_{n1}$ in variable $_{v1}$ is set. This command can be used in conjunction with the VBC or VBS bit manipulation command to control flow through a programme.

Example : IS 17:%35/MR-25000/SO5
If bit 17 in variable "%35" is clear, then the system executes a move of -25000 counts, and then sets output line 5.

$VD_{v1v2v3v4}$ Divide a variable ($_{v1}$ ÷ $_{v2}$ -> $_{v3}$).

This commands divides $_{v1}$ by $_{v2}$, and assigns the quotient to $_{v3}$. The remainder is assigned to $_{v4}$.

Example : VD AXu:Z
If variable "A" is 15 and variable "X" is 3, then variable "u" will be assigned the value 3, and Z will be assigned the value 0.

VM_{v1v2v3} Multiply a variable ($_{v1}$ × $_{v2}$ -> $_{v3}$).

This commands multiplies $_{v1}$ by $_{v2}$, and assigns the result to $_{v3}$.

Example : VM GIB
If variable "G" is 5 and variable "I" is 3, then variable "B" will be assigned the value 15.

VA_{v1v2v3} Add a variable ($_{v1}$ + $_{v2}$ -> $_{v3}$).

This commands adds $_{v1}$ to $_{v2}$, and assigns the result to $_{v3}$.

Example : VA XTO
If variable "X" is 16 and variable "T" is 5, then variable "O" will be assigned the value 21.

VS_{v1v2v3} Subtract a variable ($_{v1}$ - $_{v2}$ -> $_{v3}$).

This command subtracts $_{v2}$ from $_{v1}$, and assigns the result to $_{v3}$.

Example : VS HBZ
If variable "H" is 27 and variable "B" is 8, then variable "Z" will be assigned the value 19.

AV_{v1v2} Absolute value of variable (ABS($_{v1}$) -> $_{v2}$).

This command takes the absolute value of variable $_{v1}$ and assigns the result to $_{v2}$.

Example : AV Be
If variable "B" is -357, then variable "e" will be assigned the value 357.

Example : AV ZJ
If variable "Z" is 24, then variable "J" will be assigned the value 24.

IE_{v1v2} If $_{v1}$ is equal to $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is equal to variable $_{v2}$.

Example : IE NA/MR 5000/CO3
If variable "N" is 16 and variable "A" is 16, then the system executes a move of 5000 counts, and then clears output line 3.

IF_{v1v2} If $_{v1}$ is not equal to $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is not equal to variable $_{v2}$.

Example : IF tO/MA 0
If variable "t" is 516 and variable "O" is 516, then the system moves to an absolute position of 0 counts.

IG_{v1v2} If $_{v1}$ is greater than $_{v2}$, then do the rest of the command line.

This command executes the remainder of the current command line, if variable $_{v1}$ is greater than variable $_{v2}$.

Example : IG VW/IVV0
If variable "W" is 12 and variable "V" is 13, then 0 is allocated to variable V.

VP_n Sets decimal Point position for Variable display.
Range : 0 to 9
Default : 0

This command sets up the system to allow variables to have a decimal point displayed. The actual number will have to be scaled using the multiply and divide commands, and the decimal point is merely placed by the defined number of digits from the least significant. This arrangement ensures maximum flexibility combined with a minimum load on the microprocessor.

MV_{v1v2v3} Move a block of numeric variables.

This commands moves a block of $_{v1}$ % type variables from address $_{v2}$ to $_{v3}$.

Example : iva20/ivb150/ivc220/MVabc
Move a block of 20 variables from %150 to %220.

$VK_{n:v1}$ Set a variable from the keypad.

This command waits for an input from the keypad. It displays the current value of the variable $_{v1}$ on the left hand side of line number $_{n}$ of the LCD/VFD display, and echoes the keys entered on the right hand side. Only decimal numbers are allowed. The Enter key causes the number entered to be assigned to the variable $_{v1}$. "<-" will perform a destructive backspace, and "ESC" will cancel the current entry. If the command is entered with no variable, any pending keypad input is cancelled.

$VO_{n1:n2:n3:n4}$ Sends a variable continuously to display.

This command sets up the system to allow display a system variable continuously, at a rate determined by the UR command. The suffix $_{n2}$ defines the line number on the display, $_{n3}$ defines the field width, and $_{n4}$ defines the starting character number within line $_{n2.}$ This will carry on updating the display until VO is executed without a parameter. $_{n1}$ has a limited number of values. If set to 1, the measured position will be displayed. If 2, the demand position will be shown.

CP_{n} Sets decimal Point position for Continuous variable display.
Range : 0 to 9
Default : 0

This command sets up the system to allow continuous display to put in a decimal point. The actual number will have to be scaled using the multiply and divide commands, and the decimal point is merely placed by the defined number of digits from the least significant. This arrangement ensures maximum flexibility combined with a minimum load on the microprocessor.

UR_{n} Set update rate (ticks) for continuous variable display.
Range : 0 to 255
Default : 1

This the update rate, in system ticks, for the VO command. This is the rate at which the VO display is updated. e.g. If a value if 2 is set, the display will be updated every 2 ticks.

UD_{n} Set continuous display parameter for division.
Range : 0 to 16
Default : 0

This command sets the division factor for the VO continuous display parameter. The actual data is offset by the UO parameter and divided by 2^{n} in conjunction with being multiplied by the UM parameter. The largest division factor is 256.

Example : UD 2
This sets the VO parameter division factor to $2^{2} = 4$.

UM_n Set continuous display factor for multiplication.
Range : 1 to 65535
Default : 256

This command sets the multiplication factor for the VO continuous display parameter. The actual data is offset by the UO parameter and multiplied by n÷256 in conjunction with being divided by two to the power of the FD parameter. The largest multiplication factor is 65535 (÷256).

Example : UM 512
This sets the VO parameter multiplication factor to 512 (÷256) = 2.

UO_n Set continuous display offset parameter.
Range : -32767 to 32767
Default : 0

This command sets an offset for the VO continuous display parameter. The actual data is offset by the UO parameter in conjunction with being multiplied by the UM parameter and divided by two to the power of the FD parameter. The largest division factor is 256.

Example : UO -3400
This offsets the VO parameter by a value of -3400.

7.3 Status and Error Messages

7.3.1 Status messages

This section gives the system status responses in various circumstances.

>	Normal prompt character in position control mode. The system is ready for the next command.
:	Prompt character in motor off state.
?	Prompt character for new parameter value.
I	Initialising to reference position.
M	Moving to new position.
P	Profile move. The system is executing a stored profile.
S	Stopping under normal deceleration.
V	Velocity control mode. The system is executing a constant velocity move.
W	Waiting. The system is waiting for some condition before continuing.

7.3.2 Error messages

This section gives the various error messages produced by the system.

B Binary number required.
The system received a non-binary character when it expected a binary number as input.

D Decimal number required.
The system received a non-decimal character when it expected a decimal number as input.

E Error in command.
The system received a command which was not recognised, not allowed at this time, or had an invalid parameter.

F Failed parameter save or checksum test.
The parameters and data saved in non-volatile memory have not verified correctly. Please contact your sales office.

G The previous move command was aborted when the instantaneous position error was greater than the maximum allowed position error set by the SE command.

H Hexadecimal number required.
The system received a non-hexadecimal character when it expected a hexadecimal number as input.

L Limit switch detected or position limit exceeded.

N No room.
The space available for input function strings, sequences or profiles is full.

O Out of range.
The value entered was outside the allowed range for the command.

R Restricted command.
This command is available only in privileged mode.

T Timeout.
The last move command was aborted when the system detected a timeout error.

U Line already in use.
It is not possible to set or clear an output line that has been defined as an error output, or to redefine an input line that is already defined as a reference, limit switch or function input.

8 INTERFACING

8.1 Notes on installation

The system relies on the position information from the incremental encoders, and any noise on the encoder signals can give rise to errors in the absolute position. Care must be taken in installation of the control module and the encoders to minimise any noise on the encoder signal lines. The encoder interfaces on the PC3/120 board have differential input stages for use with encoders with complementary outputs, providing high rejection of common-mode noise. In addition, spurious signals on one encoder track produce both an up and a down count, and thus cancel out. However, in particularly electrically noisy environments it is still possible to get position counting errors. The system will be set up so that its position is continuously adjusted for any errors by using a repetitive reference signal to correct them. Without such facilities, such errors would otherwise be accumulated over long periods of continuous operation, unless the system was stopped at regular intervals to re-initialise the absolute position.

The digital input and output lines are designed to be used with 24 volt logic levels. These lines are optically isolated from the microprocessor based circuits. This provides protection and allows higher voltage signals to be used for greater noise immunity.

8.2 Safety

The Pan control system provides many safety facilities, and it is recommended that these are used in addition to external safety systems such as hard-wired limit switches. Pan Controls can accept no responsibility for problems due to incorrect use of the safety features provided.

The safety features of the system are provided for very good reasons! It is important to understand the operation of all these facilities, as it is possible to do vast amounts of damage to both machinery and people with high performance motors and drives. It is not sufficient to decide that these facilities are not relevant to a particular application; they are provided to monitor the correct operation of the whole system, and if the system gives an error then it is telling you something important. The relevant commands are listed here.

SE	Set maximum position error
TO	Set timeout
LH, LL	Set position limits
DL	Define limit switch inputs

Please read thoroughly the descriptions of these commands at least, if no others.

8.3 Indicator L.E.D.'s

The control boards have two indicator L.E.D.'s to indicate various system functions. These can be viewed by looking through the window between the 2 position encoder/amplifier connectors.

(i) The left hand indicator is used to show whether the system is functioning correctly. For correct operation this flashes on and off equally once per second. If there is a hardware fault, or if the saved parameters do not match the hardware found, this L.E.D. will flash on and off, with a different time period for on and off. If a terminal is connected to the RS-232 port, it will be possible to identify what the problem is.

(ii) The right hand indicator shows the state of the on-board watchdog timer, which is in turn connected to the on-board relays. When the watchdog is activated, the L.E.D. is off.

8.4 Position Encoders

The system is designed for use with digital incremental position encoders. These encoders provide two signals in quadrature (one is phase shifted by 90° relative to the other). The system can monitor these signals and determine both the direction and distance of any movement. The direction is defined by which signal leads the other. The normal definition for both channels is such that the track A encoder input leads the track B input for movement in the positive direction.

The system generates four counts for each complete cycle of the input signals, such that an encoder with 1,000 counts per revolution is seen as generating 4,000 counts per revolution. The maximum count rate is 10^6 counts per second (1 MHz), giving a maximum encoder cycle rate of 250 kHz. On a 1000 line encoder, this is equivalent to a maximum speed of 250 revolutions per second, or 15,000 r.p.m.

The encoder inputs have differential input circuits for use with encoders with complementary output signals. The encoder signals are complementary signals with line driver outputs, which gives good noise rejection.

8.5 Demand outputs

The demand outputs to the high power drives are analogue signals with a range of ±10V, at 12 bits resolution. These outputs are switched directly to 0V in the motor off state. The motor drives should be connected such that a positive demand output signal causes the motor to move in the positive direction.

8.6 Relay Contacts

The relays which switch the demand outputs to 0V in the motor off state have a spare set of changeover contacts. These may be used to derive inhibit signals to the motor drives in the motor off state, or for example to switch a joystick onto a drive input to allow manual control of the motor.

8.7 Digital Input/Output Lines

The control system has fourteen isolated input and eight isolated output lines. Inputs may be programmed as a signal to execute a user-defined command sequence, or as limit switch inputs. Outputs may be controlled directly from command sequences if required. In addition, there is a dedicated error output line which may be programmed to give an indication of any serious system error condition. All the input lines indicate high if left unconnected.

8.8 Operation of Limit Switches

The limit switch inputs are programmable by means of the DL command. This allows the user to select any of the inputs as limit switch inputs, and to define the active state of each input. The inputs will float to a logic high if left unconnected.

If a limit switch is operated, the system will stop the motor immediately and go into the "motor off" state. The system displays an "L_{nn}" error message to indicate that a limit switch has been detected. All limit switches should be wired such that operation of any switch gives an error signal to the system.

8.9 Reference inputs

The reference inputs are used during the IN initialisation sequence to define the zero reference position for each motor. They may also be used to continuously update the system absolute position from the external zero reference if required. They are connected to marker signals from the position encoders. The reference inputs have differential input circuits similar to the encoder inputs.

The IN initialisation sequence is as follows.

1 Accelerate to the system velocity in specified direction.
2 When the reference switch is detected, zero the absolute position counters and decelerate the motor to stop.
3 Move to the new zero position (if allowed by RW options).

The sense of the reference input for the current channel is programmed by using the DR command.

8.10 Serial Communications

8.10.1 Diagnostic terminal

The serial link to the diagnostic terminal uses RS-232 signal levels. The serial word format used is 8 data bits, 1 stop bit, and even parity. The baud rate is fixed at 9600 baud.

The serial interface is buffered in software and echoes back the characters as they are received. It uses XON/XOFF software handshake, where it sends XOFF to signal that its input buffer is becoming full, and sends XON when it is ready for more characters. Note that if the XOFF is ignored, the buffer may overflow and characters will be lost. The system also responds to XON/XOFF to control its output.

The characters normally used for the XON/XOFF protocol are DC1 ($11 hex, cntl-Q) for XON, and DC3 ($13 hex, cntl-S) for XOFF.

9 ELECTRICAL CHARACTERISTICS

AC supply voltage :

Minimum	85 Volts
Maximum	264 Volts

AC supply frequency :

Minimum	47 Hz
Maximum	63 Hz

DC logic voltage :

Minimum	19 Volts
Maximum	29 Volts

Serial link (diagnostic terminal):

Signal levels	RS-232
Baud rate	9600
Data format	8 data bits, 1 stop bit, even parity

Encoder inputs :

Input impedance	6kΩ
Input signal levels	+5V
Input cycle rate	250 kHz max

Track A input leads track B input for positive movement

Command signal output :

Isolated output range	±10V
Resolution	12 bits

Digital Inputs (isolated):

Input signal levels	+24V (set by resistor network)
Input current	10 ma typical at selected input voltage

Digital Outputs (isolated NPN Darlington outputs):

Load current	100ma maximum

Relay contacts :

Rated load	1A 60V d.c. 0.3A 110V a.c. (resistive)
	0.5A 60V d.c. 0.2A 110V a.c. (inductive)
Carry current 2A	
Switch voltage max	60V d.c. 125V a.c.
Switch current max	2A d.c. 1A a.c. (resistive)
	1A d.c. 0.5A a.c. (inductive)
Switch power max	60W 60VA (resistive)
	30W 30VA (inductive)
Inductive load power factor	0.4 max
Contact resistance	50 mΩ max

10 SUMMARY

10.1 Commands

Note that some commands are restricted. These commands can be used only in privileged mode.

Miscellaneous commands

BH	Breakdown of current Hardware.	
CS	CheckSum test	
EV"ccc"	Enter a user software revision no string.	
GW_{bbbb}	Set global control word.	(restricted)
LA	List all parameters.	
RA	Reverse analogue output sense	
RD	Read data from nonvolatile memory	(restricted)
RE(2/B)	Reverse encoder input sense	
RS	ReSet complete setup to defaults	(restricted)
SP	Save Parameters	(restricted)
VN	display Version Number and revision date	

Mode commands

EO	Echo mode off.	
EM	Echo mode on.	
FD_n	Set link factor for division.	
FM_n	Set link factor for multiplication	
LM	Link motion to second encoder.	
LW_{bb}	Link motions control word.	(restricted)
MO	set to Motor Off	
NM	set to Normal Mode	
PC	set to Position Control mode	
PM	set to Privileged Mode	
PW	set PassWord	(restricted)

Move commands

AB	ABort, emergency stop	
ID	Initialise Demand signal offset	
IN±	INitialise to reference position	
$MA±_{nn}$	Move to Absolute position	(scaled)
$MR±_{nn}$	Move Relative to current position	(scaled)
ST	STop with normal deceleration	
VC±	set to Velocity Control mode	
VX	Move (multi-axis) at constant velocity.	

Set parameter commands

DB_{nn}	set input DeBounce time	(restricted)
RC	Reset bound overflow Count	
SA_{nn}	Set Acceleration	(scaled)
SB_{nn}	Set position Bounds	(restricted)(scaled)
SC_{nn}	Set Creep distance(scaled)	
SD_{nn}	Set Deadband	(scaled)
SL_{nn}	Set settLing time	
SS_{nn}	Set Slow creep speed	(scaled)
SV_{nn}	Set Velocity	(scaled)
SW_{nn}	Set Window on final position	(restricted)
$TS_{hh:mm:ss}$	Time Set	
$ZC[_{nn}]$	Zero position Counters or set position	(scaled)

Sequence commands

AS_{nn}	set AutoStart sequence	(restricted)
EE_{nn}	Execute sequence on error condition.	
ER	End Repeat	
ES_{nn}	Enter Sequence	(restricted)
GL_{n}	Go to line in sequence	
HR_{nn}	Set Hard Reset sequence or initiate Hard Reset.	(restricted)
HS_{nn}	Display history of sequences executed.	
$LS[_{nn}]$	List Sequence	(restricted)
MF	display Free Memory	
NE_{nn}	Execute sequence after snapshot event	
$RP[_{nn}]$	RePeat command line	
$SK(_{A-F})_{nn}$	Execute sequence on keypad entry event.	
XS_{nn}	eXecute Sequence	
XT	Exit from current sequence.	

Wait commands

$WA\pm_{nn}$	Wait for Absolute position	(scaled)
WB	Wait for Bound position	
$WC\pm_{nn}$	Wait for bound overflow counter	
WE	Wait End	
WF	Wait for reFerence signal	
$WI_{n}\pm$	Wait for Input	
$WK(_{nn})$	Wait for keypad entry	
WN	Wait for network acknowledge response	
$WR\pm_{nn}$	Wait for Relative position	(scaled)

Error handling

EW_{bb}	set Error options Word	(restricted)
LE	display Last Error	
$LH\pm_{nn}$	set High position Limit	(restricted)(scaled)
$LL\pm_{nn}$	set Low position Limit	(restricted)(scaled)
RT_{nn}	set Reference Timeout	(restricted)
SE_{nn}	Set maximum position Error	(restricted)(scaled)
TO_{nn}	set TimeOut	(restricted)

Gain commands

$AO_n:_{xx}$	Set analogue output to global value.	
CW_{bb}	set control word	(restricted)
IT_n	set Integration Time constant	(restricted)
KD_{nn}	set differential gain constant	(restricted)
KF_{nn}	set velocity feed-forward gain constant (restricted)	
KI_{nn}	set integral gain constant	(restricted)
KP_{nn}	set proportional gain constant	(restricted)
KV_{nn}	set velocity feedback gain constant	(restricted)
KM_{nn}	set Monitor output gain constant	(restricted)
LV_{nn}	Set lower stepper resonance velocity bound.	(restricted)
OM_{nn}	set Offset on Monitor output	(restricted)
SF_n	Set monitor Function	(restricted)

Reference commands

RW_{bb}	set Reference options Word	(restricted)
SR_{nn}	Set maximum Reference correction	(restricted)
$SJ\pm_{nn}$	Set deferred adJustment position	(restricted)(scaled)
RV_{nn}	set Reference correction Velocity	(restricted)
RL_{nn}	Set Reference repeat Length	(restricted)
$RF\pm_{nn}$	Set Reference oFfset	(restricted)

Input/output commands

$CO[_{nn}]$	Clear Output line(s)
$EI[_{nn}]$	Enable Input(s)
EK_{nn}	Enable keypad input.
$II_{nn}\pm$	If Input true, do command line
$IO_{nn}\pm$	If Output true do command line.
$MI[_{nn}]$	Mask Input(s)
MK_{nn}	Mask keypad input.
OC_{nn}	Output Code value
$RI[_{nn}]$	Read Input line(s)
$RO[_{nn}]$	Read Output line state(s)
$SO[_{nn}]$	Set Output line(s)
$WK(_{nn})$	Wait for keypad entry

Configuration commands

$BO_n±$	define Bound Overflow Output	(restricted)
DB_{nn}	set input DeBounce time	(restricted)
DE±	Define Error output sense	(restricted)
$DI±_{nn}$	Define function Input	(restricted)
$DL±_{nn}$	Define Limit switch input	(restricted)
DR±	Define Reference input sense	(restricted)
$DX_n±$	Define eXpanded input group	(restricted)
$DZ_n±$	Define zero marker input on/off. (restricted)	
$EC_{nn}±$	Define external counter input	(restricted)
LI	List I/O line definitions	
$OX_n±$	define eXpanded Output group	(restricted)
$PO_n±$	define Position trigger Output	(restricted)(scaled)
$PS_n±$	Define position snapshot input. (restricted)	
RX	Read external counter input.	
WX_{nn}	Wrap for external counter input	
$ZX[_{nn}]$	Zero external counter input or set counter input.	

Display commands

CD_{nn}	set Character Delay	
CN_n	Stop continuous display of position data to serial port number $_n$.	
CP_n	Sets decimal Point position for Continuous variable display	
CRn(:c)	Switch on/off cursor on the LCD/VFD display.	
DC	Display bound overflow Count	
DD	Display Demand position	(scaled)
DF	Display reFerence error	
DK	Display system constants	
DM	set continuous Display Mode on	
DN	use Decimal Numbers	(restricted)
DO	Display mode Off	
DP	Display current Position	(scaled)
DS	Display snapshot position data.	
DV	Display current Velocity	(scaled)
DT	Display time	
DW_{bb}	set Display Word	(restricted)
EO	Echo mode off.	
EM	Echo mode on.	
HE	print HElp display	
HN	use Hexadecimal Numbers	(restricted)
LE	Display Last Error	
MD_{v1}"ccc"	Send a character string to the LCD/VFD display.	
$ME(R,E)_{n1}:_{n2}:_{n3}:_{n4}:_{v1}:_{v2}:_{v3}$	Sends a variable to the LCD/VFD display.	
VT_n	Set velocity averaging time constant	

Loop commands

$FN_{v1n1n2n3}$	For variable $_{v1}$ = $_{n1}$ to $_{n2}$ step $_{n3}$ do command line.
GL_n	Go to line in sequence

Conditional commands

$IC_{n1:v1}$	If bit $_{n1}$ of variable $_{v2}$ is clear, then do the rest of the command line.
IF_{v1v2}	If $_{v1}$ is not equal to $_{v2}$, then do the rest of the command line.
$II_{nn}\pm$	If Input line true, do command line
$IO_{nn}\pm$	If Output true do command line.
IE_{v1v2}	If variable v1=v2, do command line
IG_{v1v2}	If variable v1>v2, do command line
$IS_{n1:v1}$	If bit $_{n1}$ of variable $_{v2}$ is set, then do the rest of the command line.
XE_{v1}	If variable $_{v1}$ is equal to the external counter, then do the rest of the command line.
XG_{v1}	If variable $_{v1}$ is greater than the external counter, then do the rest of the command line.

Variable commands

AV_{v1v2}	Absolute value of variable (ABS($_{v1}$) -> $_{v2}$).
CP_{n}	Sets decimal Point position for Continuous variable display
$IC_{n1:v1}$	If bit $_{n1}$ of variable $_{v2}$ is clear, then do the rest of the command line.
IE_{v1v2}	If variable v1=v2, do command line
IF_{v1v2}	If $_{v1}$ is not equal to $_{v2}$, then do the rest of the command line.
IG_{v1v2}	If variable v1>v2, do command line
$IS_{n1:v1}$	If bit $_{n1}$ of variable $_{v2}$ is set, then do the rest of the command line
$IV_{v1}\pm_{nn}$	Input a Variable
MV_{v1v2v3}	Move a block of numeric variables
OV_{v1}	Output a Variable
UD_{n}	Set continuous display parameter for division.
UM_{n}	Set continuous display factor for multiplication.
UO_{n}	Set continuous display offset parameter.
UR_{n}	Set update rate (ticks) for continuous variable display.
VA_{v1v2v3}	Add variables v1 + v2 ▸ v3
$VBC/S_{n1}:_{v1}$	Set or Clear a bit in a variable
VM_{v1v2v3}	Multiply variables v1 × v2 ▸ v3
VS_{v1v2v3}	Subtract variables v1 - v2 ▸ v3
$VD_{v1v2v3v4}$	Divide a variable ($_{v1}$ ÷ $_{v2}$ -> $_{v3}$).
VK_{v1}	Set a variable from the keypad.
VO_{n1}	Sends a variable continuously to display.
VP_{n}	Sets decimal Point position for Variable display.

10.2 Status Messages

>	normal prompt character
:	motor off prompt character
?	parameter value prompt character
C	executing slow Creep
I	Initialising to reference position
M	Moving to new position
P	executing a Profile
S	Stopping under normal deceleration
V	Velocity control mode
W	Waiting

10.3 Error Messages

B	Binary number required
D	Decimal number required
E	Error - unrecognised or invalid command
F	Failed parameter save or checksum test
G	position error Greater than maximum
H	Hexadecimal number required
L	Limit switch detected or position limit exceeded
N	No room in memory
O	parameter Out of range
R	Restricted command
T	Timeout abort
U	line in Use

11 PANTERM communications programme for personal computer

11.1 Introduction

The program can be run on an IBM Personal Computer or compatible MS-DOS computer (PC) to make that PC act as a terminal to a PAN digital control system. Please note that this programme operates best outside of a Windows shell. This is because the interrupt response time of a Personal Computer is degraded by the time-slicing requirements of a multi-tasking operating system. If the Personal Computer being used is running Windows 95, it is recommended to use the option *Restart the computer in MS-DOS mode.* Once installed and running, most commands entered on the PC are transmitted directly to the control system and any responses from the control system are displayed on the PC. In addition, some special commands are provided which are not transmitted to the control system but are handled locally by the PC. These commands allow text files to be edited locally on the PC and then transmitted to the control system. This allows complex command strings for the control system to be created and amended using the PC and then transmitted to the control system together.

11.2 Setting up the serial link

Some PAN control systems have more than one serial port. The port marked Terminal should be used. Most PCs have up to four serial ports referred to as COM1, COM2, COM3 & COM4. PANterm assumes that COM1 will be used but this can be changed. RS-232 levels should be used and it is assumed that the PC has a 9 way or 25 way D connector plug. If the PC has a different connector type then the PC and control system should be linked with a four wire lead having the following connections. The connections between a PC and the Control Board are as follows:

Connections for cable for IBM compatible Personal Computer:

9-pin plug(Controller)		25-pin socket(PC)	9-pin socket (PC)	
2	->	3	2	RX
3	<-	2	3	TX
5	<->	7	5	GND

RS-232 serial connections

PAN value control system's terminal ports are configured to run at 9600 baud and to use software handshaking by default. PANterm defaults to the same settings but can be changed by means of the configuration menu.

11.3 Using PANTERM as a simple terminal

PANterm is started from the MS-DOS command prompt (A> or C>) by typing:

PANTERM

There are no command line options. The PC will then display its copyright message for a few seconds, before going into terminal mode. When you receive your copy of PANterm it should already be configured to work with your control system. Typing RETURN at this point should produce a control system prompt on the screen:-

1:

If this does not happen, you will need to configure PANterm to work with your control system which is explained in the Configuration section below.

At this stage, control system commands such as CH1, PC, MR1000 etc can be typed and will be transmitted directly to the control system. The responses from the control system such as 1:, 1> and 2M will be displayed on the PC. Your PC is now working as a terminal on the control system.

To leave the PANterm terminal program and return to MS-DOS type Alt-X (Exit).

11.4 Preparing system command files

PANterm has been designed not just to send single commands to a control system, but also for the preparation and issuing of files of command to the systems. PANterm can also be used to receive a set of commands which actually exists on a control system, and place these commands in a file. You are then able to edit this file as required, and issue the new commands to the control system in a similar way.

You may edit a file of commands with any text editor. PANterm also allows you to set up a specific editor for use with the program, and this is explained in the configuration section. Note that your editor must be able to prepare a file which contains pure ASCII test, without hidden control codes. Most editors will do this in "non document" or "ASCII" mode. The resulting file should contain a list of control system commands in exactly the same format as you would type them in direct terminal mode. The file could look like this:

```
# move forward and back
CH1
PC
SA500
SV1000
MR5000
SV200
MR-5000
# move complete
```

Note that comment lines can be put in the file by starting the line with a "#" (pound or hash) symbol. In due course we will see what happens to these comment lines.

When the above example is sent to a control system it would cause the system to execute the move forward and back immediately. This assumes that the control system is ready to move and the velocity and accelerations are sensible. If an error occurs, perhaps because the motor cannot achieve this acceleration, then the system will respond in the normal way with an error message. If the move fails early on then all the subsequent move commands will generate errors and a whole batch of error messages may be received by the PC. Error messages can be recorded to a file disk (using the Alt-R PANTERM command). In addition the last error on the control system can be interrogated using the LE last error command.

If you do not want the sequence of commands to be executed immediately but to be stored on the control system for future use we could edit the file to look like:-

```
# enter sequence to move forward and back
ES1
CH1
PC
SA500
SV1000
MR5000
SV200
MR-5000

# end of sequence
# now define input line 1
DI1-/XS1
```

When this is sent to the control system, the sequence will be stored and input line 1 will be set up so that when it is activated (perhaps by an operator pushing a button) then the sequence will be executed. Note that the file contains a blank line at the end of the sequence. This tells the control system that the end of the sequence has been reached. This blank line must also be included when entering profiles and maps. Note that this command file could be written on fewer lines by putting several commands on one line with a delimiter between them:-

```
# enter sequence to move forward and back
ES1
CH1/PC/SA500/SV1000/MR5000
SV20/MR-50000

# end of sequence
# now define input line 1
DI1-/XS1
```

Putting several commands on one line has no effect on the way the control system will respond. The only exception to this rule is the repeat (RP) command. This is used as the last command on a line and causes all the previous commands on that one line to be repeated, in order, the specified number of times.

Spreadsheet programs can also be used instead of editors to prepare control system command files. Any spreadsheet which allows the user to output columns to a disk file in an ASCII format can be used. The following example shows how a spreadsheet might be set up to create a move profile:-

	A	B	C	D	E
1	JOLT FREE PROFILE CALCULATION				EP1
2				1	0
3	Parameters:-			2	1
4				3	3
5	Move distance	500	Counts	4	8
6	Move time	30	Ticks	5	14
7				6	24
8	w = 2*3.14159/B6 =	.2094393		7	38
9				8	54
10	Formula used in cells E2 to E31:-			9	74
11				10	98
12	Profile = B5/B6*(Dn-SIN(B8*Dn)/B8)			11	124
13				12	153
14	(where n is the row number)			13	184
15				14	217
16				15	250
	~~		~~~	~~~	
28				27	497
29				28	499
30				29	500
31				30	500
32					

If the spreadsheet is used to print column E to a disk file then that disk file would be a suitable control system command file. Note that the printout should include row 32 containing a blank entry. Note also that column E should be formatted so that the numbers in it are integers.

It will be obvious to any computer programmer that programming languages such as "Basic", "C" and "Fortran" can also be used to produce control system command files. By using such a language or a spreadsheet it is possible to produce complicated profiles and maps and load them into a control system far more easily than can be done by hand. Also, this approach is far quicker when it comes to making amendments. For instance, in the above example a second profile move, numbered 2, of 600 counts could be created by amending just two cells - E1 and B5.

11.5 Loading command files

Once you have prepared a control system command file and set up PANterm in its terminal mode, you are ready to transmit command files to the control system. This is called loading. To do this type UP (to put the controller in Upload mode) followed by Alt-L (Load). You will then be asked the name of the file that you wish to load. Type its name and press return. PANterm will now start sending the file to the control system. The characters that you will see on your screen are all echoed back from the control system, so that you know they have been received correctly. The exception to this rule is the comment; comments are not sent, but printed directly to the screen, in reverse colours.

When your command file has been loaded, the programme will revert to the terminal mode. Also, pressing any key while loading will cause the load to be paused; a second keypress will continue the load.

PANterm incorporates a delay mechanism so that you can check the response of the control system to your command file. You can type Alt-S (Slow) or Alt-F (Fast) to slow down or speed up the loading. A very slow speed combined with pausing can be useful for spotting errors.

While in terminal mode, you may want to record what some of the commands and definitions currently on the control system are. You can start this recording by typing Alt-R. You will be prompted to enter a name for the recording file. Both the commands that you type, and the control system's response will be recorded. You can stop the record at any time by pressing Alt-R again.

While loading a command file, you may wish to abort the load and return to the terminal mode. Press Alt-T (terminal) if you wish to do this. Pressing Control-C, which stops many programs, will not affect PANterm - this gets sent straight to the control system.

You might have aborted because you spotted an error in your command file. If so you will want to edit your file. PANterm allows you to type Alt-E which will start up your editor without leaving PANterm, provided that PANterm has been told which editor to use in the configuration section. You may use your editor as normal. On exiting your editor you will return immediately to PANterm in its terminal mode. By leaving PANterm in your PC's memory in this way, restarting PANterm is considerably speeded up.

11.6 Loading system programme files

The controller system programme can be changed by using the UP command from the boot programme. A system programme in Motorola S-record format must have bee prepared in advance, and this can be uploaded using the Alt-U option. Otherwise this option is similar in operation to the Alt-L load file option.

11.7 Configuring PANTERM

PANterm will generally be configured when you receive it. This facility allows you to set up differences required for your system once, and then to use that version in future without further difficulty.

To reconfigure PANterm, type Alt-C when you are in terminal mode. A new window will appear, with the header 'Configuration'. Each entry, together with its default value, is explained below.

Communications Port

Normally, PCs have up to 4 serial ports, one of which will be used to talk to the control system. PANterm is set up to use Port 1 by default. Some PCs have more than four ports; because this is not standard, and methods of implementation between different computers vary, it has not been possible to write PANterm to use other ports.

Baud Rate

This item indicated the speed at which PANterm will attempt to talk to the control system. This is normally set at 9600 baud, because this is the default speed at which the control system will communicate. You may want to change this value if you are talking to a different device (other than a control system).

Serial mode; RS232, 422 or 485

PANterm is designed to operate in conjunction with the standard 16450 or 16550 UART device. This option allows the use of an RS-422 or RS-485 converter (as manufactured by KK systems) to be connected to the standard RS-232 serial port of a personal computer. The hardware handshake mode (see below) can only be selected if the RS-232 option is selected, since the RS-422 and RS-485 adaptors do not have hardware handshake facilities. The RS-485 option uses the RTS line to control the direction of data flow.

File Loading delay

The rate of loading a file to the control system will be controlled by this value, which is in milliseconds. You may also speed up file loading by pressing Alt-F, which has the effect of halving the delay time on each press, or pressing Alt-S, which has the reverse effect. When you start to download a new file, the initial delay time will revert to this value. The default value is 0 milliseconds.

File loading mode; Transparent or Check for acknowledge

This determines how PANterm communicates with the control system. Under transparent mode, PANterm will load files (using Alt-L) exactly as they are entered on the keyboard. Under check for acknowledge mode, PANterm always waits for acknowledge after each <CR> character, and before starting to transmit the next line. It also performs a checksum check on the complete file at the end of transmission. If this fails, the personal computer displays the failure, and waits until the operator presses a key before continuing.

Software or Hardware Handshaking

If set to software handshaking, PANTERM will use the *XON* and *XOFF* characters for flow control. If set to hardware handshaking, PANTERM will use to dedicated hardware lines, *CTS* and *RTS* for flow control. Hardware handshaking is only allowed when the RS-232 serial mode has been selected.

Colour or Mono display

You should set this to colour if you have a colour screen, for better presentation. The default is mono.

Even parity or none

This should normally be set to Even. This performs parity checking on incoming data and generates a parity bit for outgoing data.

Editor name

This item is used to set the editor that you wish to use to edit the control system command files. By default, it is set to 'ed'.

11.8 Automatic baud rate configuration

PANterm has the facility to set its baud rate automatically to that of the controller to which it is connected. Having established the baud rate of the controller, PANterm sets the baud rate of the PC to match, and updates the PANterm configuration file accordingly. This feature is invoked by typing Alt-B.

11.9 PANTERM command summary

Alt-B (Baud rate set) Sets PANTERM to the baud rate of the controller automatically.

Alt-C (Configure) Allows configuration PANTERM.

Alt-D (Dos) Starts an MS-DOS shell.

Alt-E (Editor) Temporarily leaves terminal mode and loads your editor for editing control system command files.

Alt-F (Faster) Increases the speed at which command files are sent to the control system.

Alt-H (Help) Display a list of possible commands and other help information on screen.

Alt-L (Load) Starts loading of a control system command file. When your file has been loaded, the program will revert to the terminal mode.

Alt-R (Record) Allows recording of control system commands to a file. You will continue to record all commands until you repeat the Alt-R command.

Alt-S (Slower) Slows the speed at which command files are sent to the control system.

Alt-T (Terminate) Terminates loading of a control system command file and returns to terminal mode.

Alt-U (Upload) Starts loading of a control system S-record file. This is used for changing the system low level programme, and can only be used from the boot controller programme using the UP command. When the file has been loaded, the program will revert to the terminal mode.

Alt-X (eXit) Exits the PANterm terminal program and returns to MS-DOS.

12 CONNECTORS

12.1 Connector 1. 15-way D connector (3 row), for position encoder, reference i/p, analogue o/p.

1 Encoder track A
2 Encoder track $\overline{A}$
3 Encoder track B
4 Encoder track $\overline{B}$
5 Encoder track Z
6 No connection
7 No connection
8 Encoder power supply 0v
9 Encoder power supply +ve
10 Encoder track $\overline{Z}$
11 Velocity signal (DAC port B)
12 No connection
13 Velocity 0v (analogue ground)
14 Relay Common
15 Relay normally open or normally closed (jumper selectable)

12.2 Connector 2. 15-way D connector (3 row), for position encoder, reference i/p, analogue o/p.

1 Aux encoder track A
2 Aux encoder track $\overline{A}$
3 Aux encoder track B
4 Aux encoder track $\overline{B}$
5 Aux encoder track Z
6 No connection
7 No connection
8 Aux encoder power supply 0v
9 Aux encoder power supply +ve
10 Aux encoder track $\overline{Z}$
11 Aux velocity signal (DAC port B)
12 No connection
13 Aux velocity 0v (analogue ground)
14 Aux Relay Common
15 Aux Relay normally open or normally closed (jumper selectable)

12.3 Connector 3. 15-way D socket. Isolated inputs.

Input 1	1
Input 2	9
Input 3	2
Input 4	10
Input 5	3
Input 6	11
Input 7	4
Input 8	12
Input 9	5
Input 10	13
Input 11	6
Input 12	14
Input common (0v)	8

12.4 Connector 4. 9-way D plug. Isolated outputs.

Output 1	9
Output 2	4
Output 3	8
Output 4	3
Output 5	7
Output 6	2
Output 7	6
Output 8	1
Output common (24v DC)	5

12.5 Connector 5. 9-way D socket. RS-232 terminal connection.

1	Tx (data from controller)
2	Rx (data to controller)
3	No connection
4	No connection
5	Ground
6	No connection
7	No connection
8	No connection
9	No connection

12.6 Connector 6. Optional 17-way Klippon connector. Isolated inputs.

1	Input common (0v)	
2	Input 1	Labelled 1
3	Input 2	Labelled 2
4	Input 3	Labelled 3
5	Input 4	Labelled 4
6	Input 5	Labelled 5
7	Input 6	Labelled 6
8	Input 7	Labelled 7
9	Input 8	Labelled 8
10	Input 9	Labelled 9
11	Input 10	Labelled 10
12	Input 11	Labelled 11
13	Input 12	Labelled 12
14	Input 13	Labelled 13
15	Input 14	Labelled 14
16	Input 15	Labelled 15
17	Input 16	Labelled 16

12.7 Connector 7. Optional 9-way Klippon connector. Isolated outputs.

1	Output common (24v DC)	
2	Output 1	Labelled 1
3	Output 2	Labelled 2
4	Output 3	Labelled 3
5	Output 4	Labelled 4
6	Output 5	Labelled 5
7	Output 6	Labelled 6
8	Output 7	Labelled 7
9	Output 8	Labelled 8

13 APPENDIX

13.1 Sample programme listing

```
# Dew24
GW11


# Comments
# 1: Slower backlash correction
# 2: Need up to 4 chain size/number of cuts.
# 3: Absolute programme needs to wait for footswitch after each move
# 4: Manual/auto switch - display F4 only in manual + parameters
#      Only allow arrow keys in manual mode with F5 pressed (-> manual set
#                          screen)
# 5: Beam raised input from relay contacts
#      a)Wire through amplifier enable circuit
#      b)Logical input to controller (-> no forward move with beam down)
#
# Inputs
# 1    Foot switch
# 2    Limit Switch
# 3    Finished cycle
# 4    Start programme
# 5    Manual/auto switch (=1 on manual)
# 6    Beam raised relay (=1 when raised)

#Variable list

#a     Used for sub-chain counter
#b     Used to define next programme if zero entry
#c     Used to define next programme after VK
#d     Used to define next sequence after kpad entry
#e     Used to define sequence after invalid keypad entry
#f     Used to set a default if memory at zero
#g     Indicates part no when entering chains
#h     Higher limit for keypad entry
#i     Set to 1 after initialisation
#j     Indicates which part of cycle =9 on foot switch exit
#k
#l     Lower limit for keypad entry
#m
#n
#o     Used for chain moves
#p
#q
#r
#s     Index var for cutting (relative move for chain)
#t     Used for displaying parameters in display mode
#u     Used as pointer for parameter after keypad entry
#v     Indicates which part of cycle
#w     Indicates whether chain or absolute
#x     Used as temporary parameter store while entering params
#y     Used for comparisons and repetitive asignments
#z     Used for comparisons and repetitive asignments
#A
#B
#C     No of cuts (absolute)
#D     Offset (x 10mm)
#E     Saw thickness (x 10mm)
#F     Multiplication factor - no of encoder counts per mm
#G     Division factor - to increase resolution on F
#H     Absolute machine limit (higher)
```



```
#I    First cut overshoot (to eliminate backlash)
#J
#K
#L    Absolute machine limit (lower)
#M
#N
#O
#P
#Q
#R
#V
#S
#T
#U    Velocity (fast)
#V
#W    Velocity (slow)
#X
#Y
#Z
# Numeric variables
#
#1    Absolute start position
#2    Relative cut position
#3    No of cuts
iv%241:1     # Default programme no
iv%242:35    # Saw thickness x 10mm
iv%243:102   # Unload position
iv%244:890   # Offset x 10mm
#IVP1        # Default programme no
#IVH102            # Unload position
#IVD900            # Offset x 10mm
#IVE30             # Saw thickness x 10mm
# Sequence numbering
#
# 40-49            Programme entry
# 160-169    Parameter entry


# Chain defined by negative start position
# w=2 when chain ; =1 for absolute moves
#
# Data format for programmes (groups of 10)
#     Chain type               Abs pos type
# 1)  -Start position                Start position
# 2)  No of additional cut (1)       2nd abs position
# 3)  Increment for additional cut (1)3rd abs position
# 4)  No of additional cut (2)       4th abs position
# 5)  Increment for additional cut (2)5th abs position
# Scaling factor  is 1870000/2963
#  = 952.6235354 counts/mm
# Offset = 90mm (the amount which is added to the zero position)
# n.b. The bigger the offset value, the smaller the cuts will be
#
#
EV "Dewar saw 2.4"
IVF60980           # Multiplication factor
IVG64        # Division factor
IVL40        # Low machine pos limit
IVH2050            # High machine pos limit
IVI5         # 5mm overshoot before first
IVV52000/CW1011011/KP150/SA100000/SVVV/SW50

IVW8/VDVWWz  # Set slow speed velocity
SE3000
SW50
UD13  # Set display division factor
ivz2097152 # 256 x 65536/8
```



```
vmzGz
vdzFzo
ivo10/vmozz
UMVz
CP1   # 1 decimal point
UR50  # Update rate for continuous display


AS255

ES255
SKA150       # Execute sequence 150 after F1 key
MK
EK1   # Only enable F1
SKB40 # Execute sequence 40 after F2 key
SKC21 # Execute sequence 21 after F3 key
SKD161       # Execute sequence 161 after F4 key
SKE71 # Execute sequence 71 after F5 key
DI1-/XS217   # Foot switch
DR2-         # Reference limit
DI3-/XS220   # Cycle complete
DI4-/XS230   # Start programme
DI5+/MK/EK1/XS150 # Manual
DI5!/MK/EK1/XS150 # Auto
wt500
xs97
md2" Press green button"
md3" to initialise the"
md4"    saw position"
EI5/EI4
SK99

ES40
ivu241       # Variable pointer
ive41  # Sequence no for entry
xs94   # Start keypad entry

ES41
XS97
MD2"Programme mode"
md3"Programme no (1-20):"
ivc95/ivd42/ivl1/ivh20
vk4:y
SK99

ES42
av%241:p/ivz1/vspzu/ivz10/vmzuu       # Use u to index into correct variable
av%u:w       # Set up w to define if Chain (=2) or Abs (=1)
ive43  # Sequence no for entry
ivf2   # Default value if cleared
xs94   # Start keypad entry

ES43
XS97
MD2"Programme ":p
md3"Abs(1) or Chain(2):"
ivc95/ivd44/ivl1/ivh2
vk4:y

ES44
xs92
ivz1/vazuu   # Variable pointer
ive45        # Sequence no for entry
ivf200       # Default value if cleared
xs94   # Start keypad entry

ES45
```



```
XS97
MD2"Programme ":p
md3"Absolute start posn:"
ivb0/ivc93/ivd46/ivl1/avHh
vk4:y
SK99

ES46
vs%u:Lm/ivz10/vmzmm            # Available mmx10 for chain moves
ivz1/vazuu   # Variable pointer
iezw/ive47         # Sequence no for entry
ivz2/iezw/ivg1/ive60     # Sequence no for entry
ivf0   # Default value if cleared
xs94   # Start keypad entry

ES47
XS97
MD2"Programme ":p
md3"Abs posn No 2"
ivb5/ivc93/ivd48/ivl0/avHh
vk4:y
SK99

ES48
ivz1/vazuu   # Variable pointer
ive49        # Sequence no for entry
xs94   # Start keypad entry

ES49
XS97
MD2"Programme ":p
md3"Abs posn No 3"
ivc93/ivd50/ivl0/avHh
vk4:y
SK99

ES50
ivz1/vazuu   # Variable pointer
ive51        # Sequence no for entry
xs94   # Start keypad entry

ES51
XS97
MD2"Programme ":p
md3"Abs posn No 4"
ivc93/ivd52/ivl0/avHh
vk4:y
SK99

ES52
ivz1/vazuu   # Variable pointer
ive53        # Sequence no for entry
ivf200       # Default value if cleared
xs94   # Start keypad entry

ES53
XS97
MD2"Programme ":p
md3"Abs posn No 5"
ivc93/ivd5/ivl0/avHh
vk4:y
SK99

ES60
XS97
MD2"Prog ":p" part "g
md3"No of chain cuts:"
```



```
ivb5/ivc93/ivd61/ivl0/ivh50
vk4:y
SK99

ES61
ivz1/vazuu   # Variable pointer
ive62        # Sequence no for entry
ivf10  # Default value if cleared
xs94   # Start keypad entry

ES62
XS97
MD2"Prog ":p" part "g
md3"Chain move:"
ivb0/ivc93/ivd63/ivl10/ivh2000
vk4:y
SK99

ES63
av%u:x/ivz10/vmxzx/vaxEx/ivz1/vsuzu/av%u:z        # Var E is saw thickness
vmzxx/vsmxm        # Update m - needs to be positive
ivz2/vazuu/ivz1/vazgg    # Variable pointer
ivz4/iggz/XS5/xt # If entered all chain cuts, then skip
ive60        # Sequence no for entry
ivf0   # Default value if cleared
xs94   # Start keypad entry

ES211 # Clear current programme
ivx1
vauxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0
varxr/iv%r:0

ES102
XS97
MD2"Prog "p" part "g
md3"No of chain cuts:"
ivx0/vax%r:x             # Set up x to be previous value
ivc3/ivl0/ivh50    # Min number = 0, max = 10
vk4:%r

ES3
ivz0/iez%r/XS5/XT  # Skip if = 0
IG%r:h/XS202/WT800/vaxz%r/XS102/XT
IGl%r/XS202/WT800/vaxz%r/XS102/XT
ivz1/vazrr/XS103

ES103
XS97
MD2"Prog "p" part "g
md3"Chain move:"
ivx0/vax%r:x       # Set up x to be previous value
ivc4/ivl10/ivh2000       # Min number = 0, max = 900
vk4:%r

ES4
ivz0
IG%r:h/XS202/WT800/vaxz%r/XS103/XT
IGl%r/XS202/WT800/vaxz%r/XS103/XT
igrp/XS5/xt # If entered all chain cuts, then skip
ivz1/vazrr/vazoo/xs102   # Else repeat
```



```
ES5
XS98
ivb0/IVc250
av%241:p/ivz1/vspzu/ivz10/vmzuu # Use u to index
ivz0/igzm/xs6/xt
MD2"Programme entered"
MD3" ...."
WT20/SPV
MD3:6" and saved"

es6
xs7/md2/MD2"       ERROR"
ivz-1/vmz%u:%u     # Indicates illegal programme

es7
md3/md3" Illegal programme"

ES161
ivu242       # Variable pointer
ive162  # Sequence no for entry
xs94  # Start keypad entry

ES91
vm%242:Fx/vdxGxz    # Set up x to be saw thickness
ivz10/vdxzxz             # Set up x to be encoder counts

ES92
ifyw/xs211 # Clear programme if previously changed type
avyw         # Set up w to define if Chain (=2) or Abs (=1)

ES94  # Set up for keypad entry
XS96  # Enable numeric keys
av%u:x       # Set up x to be previous value
ivz0/iffz/iezx/avfx      # If 0, then set default to f
avxy  # Set up to display current value
VK
XSve

es93  # If stopped programme early because of 0 entry, clear rest of prog
ivz0/ifzy/xs95/xt  # Exit if not zero
ivz10/vmzpx        # Use x to index into correct variable
ivz0/avz%u/ivz1/vazuu/igxu/rp
xs95

ES95
ivz0/ifbz/iezy/XSvb/XT   # Skip if = 0
IGyh/XS202/WT800/avxy/XSve/XT         # If out of bounds,
IGly/XS202/WT800/avxy/XSve/XT         # ... return to previous sequence with error
avy%u/XSvd  # Else carry on

ES162
XS97
MD2"Parameter mode"
md3"Saw width x 10mm:"
ivc95/ivd163/ivl20/ivh50
vk4:y
SK99

ES163
ivu243       # Variable pointer
ive164  # Sequence no for entry
xs94  # Start keypad entry

ES164
XS97
MD2"Parameter mode"
md3"Unload move, mm:"
```



```
ivc95/ivd165/ivl100/ivh800
vk4:y
SK99

ES165
ivu244       # Variable pointer
ive166  # Sequence no for entry
xs94  # Start keypad entry
av%244:%245 # Save old value temporarily

ES166
MD
MD1"Parameter mode"
md2"Start Point x 10mm:"
md3"Sht/short-reduce/Par"
ivc95/ivd167/ivl400/ivh1000
vk4:y
SK99

ES167
XS97
MD2"Parameters entered"
MD3" ...."
IVc250
WT20/SPv
MD3:6" and saved"
mo
ddox # Get current position
vs%244:%245:y      # Subtract old reading from new one
ivo0/ieoy/xt       # If the same then exit
vmyFz/vdzGzo
ivo10
vdzozo/vazxz
zcvz    # Zero to offset

ES19
XS96  # Enable numeric keys
VK
XS97
MD2
md3"Move position:"
avQx  # Set up x to be previous value
ivl0/valDl  # Min start position is offset
ivl40/ivc18/avHh
vk4:Q

ES17
xs98
MD2"Moving to "Q
md3
vmQFo/vdoGoz    # Get start position in encoder counts
vmIFq/vdqGqz/vaqoo     # Calculate backlash eliminate move
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
pc/mavo/wt100
md2
md2"Removing backlash"
vsoqo
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
svvW  # Set slow speed
pc/mavo
SVVV
mo
md2
md2"Moved to "Q
```



```
ES18
ivz0
IGQh/XS202/WT800/vaxzQ/XS19/XT
IGlQ/XS202/WT800/vaxzQ/XS19/XT
xs97
md2" Press green button"
md3"to move to position:"
md4"  ":Q
DI4-/XS17    # Start move
ei4

md1"1234567890abcdefghij"


ES21
II5+/ivq0/XS19 # Manual mode
II5-/XS30 # Auto mode

ES30
ivu241       # Variable pointer
ive31  # Sequence no for entry
xs94   # Start keypad entry

ES31
XS97
MD2"Run mode"
md3"Programme no (1-20):"
ivc95/ivd32/ivl1/ivh20
vk4:y
SK99

ES32
av%241:p/ivz1/vspzu/ivz10/vmzuu       # Use u to index into correct variable
av%u:w       # Set up w to define if Chain (=2) or Abs (=1)
ivz0/igz%u/xs7/xt  # Illegal programme
ivz1/vazuu # Set pointer correctly for programme
ivf2   # Default value if cleared
ivz2/iezw/ei4/ivg1/ei1/mi3/av%u:t/xs23            # Chain programme
ivz1/iezw/ei4/ei1/mi3/xs33/ei1/mi3    # Abs programme
ivz0/iezw/xs77     # No programme

ES28
mi/ei1/ei5 # Mask inputs
XS33   # Display absolute programme

es33
md1
MD1"Programme (Abs) "p
av%u:t/ivC1                    # Get absolute value into t
MD2"Start pos "t
ivz1/vazuu/av%u:t/vazuu/av%u:v
ivy0/ieyt/xt       # Exit if zero
md3/vaCzC/md3"P 2 "t
ivy0/ieyv/xt       # Exit if zero
vaCzC/md3:11"P 3 "v
vazuu/av%u:t/vazuu/av%u:v
ivy0/ieyt/xt       # Exit if zero
md4/vaCzC/md4"P 4 "t
ivy0/ieyv/xt       # Exit if zero
vaCzC/md4:11"P 5 "v
ei1/mi3 # Enable inputs

ES23
MD
MD1"Prog(Chain) "p" prt "g
MD2"Start pos ":t
ivz1/vazuu/av%u:t
```



```
ivz0/iezt/xt
md3"No of chain cuts ":t
ivz1/vazuu/av%u:t
ivz0/ifzt/md4"Chain distance "t

ES75
mi/ei1/ei5 # Mask inputs
XS23  # Display chain programme

ES76
ivz2/ifzw/xt       # If not chain, then exit
av%241:p/ivz1/vspzu/ivz10/vmzuu      # Use u to index into correct variable
ei4/av%u:w
ivz1/vazuu  # Increment pointer to first entry
av%u:t                   # Get absolute value into t (start pos)
ivz2/vmzgz/vazuu/ivz2/vsuzu    # Increment to correct part
xs75        # Chain programme

ES77
XS97
MD2"Programme  "p
MD3"No programme entered"

ES79
MD
av%241:p/ivz1/vspzu/ivz10/vmzuu      # Use u to index into correct variable
ei4/av%u:w
ivz1/vazuu  # Increment pointer to first entry
xs72        # Enable arrow keys
ivz2/iezw/ivg1/av%u:t/xs75           # Chain programme
ivz1/iezw/xs28/ei1/mi3   # Abs programme
ivz0/iezw/xs77     # No programme

ES71
II5+/XS73 # Manual mode
II5-/XS79 # Auto mode

ES73
VK
XS98
ivv0/ivc22/ivl1/ivh20
MD2"Manual mode"
md3"Arrow keys enabled"
XS72

ES72  # Enable arrow keys
mk/ek1/ek3/ek7/ek8/ek9

ES96  # Enable number & enter keys
MK/EK1/EK12/EK13/EK14/EK17/EK18/EK19/EK22/EK23/EK24/EK25/EK28/EK30

ES97
MD
MD1"PAN CONTROLS LIMITED"


ES98
MD
MD1"PAN CONTROLS LIMITED"
XS249 # Set up continuous position display

ES99
IVz250
IFcz/XSVc    # Execute sequence, defined by variable c

ES150
ivb0/mi4/XS97
```



```
II5+/XS151 # Manual mode
II5-/XS152

ES151
mk/ek1/ek6/ek16
mi3
DI4-/XS17    # Start move
MD3"F3: Manual move     "
MD4"F5: Enable arrow keys"

ES152
mk/ek1/ek2/ek6/ek11/ek16
DI4-/XS210   # Start programme
MI4
MD
MD1"F2: Change programme"
MD2"F3: Start programme"
MD3"F4: Change parameter"
MD4"F5: Display prog"


ES202
MD2"       ERROR        Value out of bounds "
MD4
MD4"Max: ":h:" Min: ":l

ES203
XS98
MD2"       ERROR        No programme "P

es204
XS98
MD2"       ERROR"
MD3"  Start hydraulics"

ES210
II3+/XS204/XT      # If not at start of cycle, then send message & exit
PC
ei3          # Enable complete signal
XS212/XS213        # If at home position, then position wood
ivv0

ES194
MD2
md2"    Cutting"
md3
md3"Cut no "b " of "c

ES195
MD2
md2"  Aborted cut cycle"
md3
md3"  Need to re-start"

ES216
MO/CO1/WT80/SO1    # Start cut

ES217
ii5+/xs216/xt      # Set start cut output line (manual mode)
II6-/ivj9/XS195/XS216/xt       # If in auto and beam down, then exit programme
pc/mavo/wt100/ivz9/ifzj/xs194        # Else display "cutting"
xs216 # Set start cut output line

ES209 # Use to add all cuts
avru/ivx0
ivz2/vauzu/vac%u:c/ivz1/vazxx/ivz3/igzx/rp
```



```
ES212
ivb1/ivz1/vs%241:zp/ivz10/vmzpp      # Use p to index into correct variable
av%p:w                   # Set up w to be type of programme
ivz1/vazpp/vazpr   # Use r to index into change
vazrs              # Use s to index into no of cuts
ivz0/av%p:x  # Set up x to be absolute start position
iezx/xs203/xt      # If no programme entered, then exit
avru/vmxFx/vdxGoz    # Get start position in encoder counts
ivz2/iezw/ivc1/vac%r:c/avca/xs209/avru      # Get no of cuts in c, if chain
ivz1/iezw/avCc     # Get no of cuts in c, if absolute
xs214        # Move to start position

es213
XS98
md2"   Load position    "
md3"Cut no "b " of "c
wt50
MO

es230
II3+/XS204/XT      # If not at start of cycle, then send message & exit
mi4
xs98
md2"   Initialising"
md3
md4
dz0/rm1/pc/in-
wt50/id
wt50/vm%244:Fz/vdzGzo
ivo10
vdzozo
zcvz    # Zero to offset
ivi1  # Set flag to indicate initialised
mo
DI4-/XS210   # Set green button to start programme
ei4/mk/EK1/XS150 # Set up display

es214
xs98
md2"Moving to start"
md3"Cut no "b " of "c
vmIFq/vdqGqz/vaqoo     # Calculate backlash eliminate move
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
pc/mavo/wt100
md2"Removing backlash   "
vsoqo
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
svvW  # Set slow speed
mavo
SVVV/ivj2
ivz1/iewz/vazpr/av%r:t # Get next position in %r (absolute move)

es215
ivz2/iezw/ieba/ivz2/vauzu/vaszs/vaa%u:a # If at end of chain group, increment
ivz1/vazbb   # Increment cut counter
xs98
md2"Moving to next cut"
md3"Cut no "b " of "c
ivz2/iezw/xs218/xt # Chain move
ivz1/XS221/iezw/xs219 # Absolute move

es218
av%s:x       # Set up x to be change
md1
md1"Next cut = "x" mm"
```



```
vmxFx/vdxGxz    # Get change in encoder counts
vsoxo  # Subtract from current abs move
xs91    # Set up x to be saw thickness
vsoxo        # Subtract saw thickness
ivj1  # Set up absolute position in encoder counts
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
pc/mavo/wt100
xs217 # Start saw

es219
vm%r:Fo/vdoGot  # Get abs position in o (mm)
ivz1/vazrr/av%r:t # Get next position in %r (absolute move)
md2"Moving to:          "
md3"Cut no "b " of "c
vmIFq/vdqGqz/vaqoo     # Calculate backlash eliminate move
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
pc/mavo/wt100
md2"Removing backlash   "
vsoqo
xs85         # Check that position is legal
ivz1/iexz/xs86/xt  # If out of bounds, do not move
svvW  # Set slow speed
mavo/wt500
SVVV/ivj2/mo
md2"  Push foot switch  "
md3"   to continue      "

es220
xs98/ivv0
md2"Cut complete"
ivz9/iejz/mi/ei1/ei4/ei5/xt # If foot switch pressed in middle, then exit
iecb/xs222/ivj0/xt       # Cycle complete
igcb/xs215   # Do incremental moves until complete

es221 # Move to unload position
xs98
md2"Moving to unload pos"
md3
vm%243:Fo/vdoGoz    # Calculate unload pos
ivx0/vsxoo   # Change sign
xs89         # Check that position is legal
pc/ivz1/iexz/vmLFo/vdoGoz/mavo/xt # If out of bounds, move as far as poss
mrvo/wt75

es89  # Check to see if move is legal
ddoz/vazoz   # Convert to abs position
xs88

ES85
AVoz  # Get abs move into z
xs88

ES88
IVx0
vmHFy/vdyGyx    # Get upper limit in encoder counts
ivx0/IGzy/xs87/xt  # Set flag in x if outside a limit
vmLFy/vdyGyx    # Get lower limit in encoder counts
ivx0/IGyz/xs87/xt  # Set flag in x if outside a limit

ES87
ivx1

ES86
XS97
MD2"      ERROR"
```



```
MD3" Move out of bounds"
WT300

ES222 # Cycle complete
xs98/mo/md2"Cycle complete"
XS221 # Move to unload position
PC/xs212/xs213     # Move back to start position

ES239 # Set to motor off & reset velocity & re-enable arrow keys
MO
XS72/SVVV

ES240
XS249 # Set up continuous position display
mk/EK1
SVVV
PC
VC+

ES241
XS242
mk/EK1
PC/SVVW/VC-

ES242
ST

ES243
XS249 # Set up continuous position display
mk/EK1
SVVV
PC
VC-

ES246
mk/EK1/ivw8/vdWwwz
PC/SVVw/VC-

ES247
XS242
XS239 # Set to motor off & reset velocity & re-enable arrow keys

es248
MD4"Pos (mm): "
VO1:4:12     # Continuous variable display

ES249
MD4
ivz1/ieiz/xs248
ivz0/ieiz/MD4"Press green button"

ES254
XS97
LEoo
MD2"  ERROR "o

ES170
ivz1/ig%241:z/ivz1/vs%241:z%241       # Up arrow
XS79

ES172
ivz20/igz%241/ivz1/vaz%241:%241       # Down arrow
XS79

ES174
ivz1/iggz/vsgzg    # Left arrow
XS76
```



```
ES176
ivz4/igzg/ivz1/vagzg     # Right arrow
XS76

ES180
II5+/XS246 # Manual mode
II5-/XS170 # Auto mode

ES181
II5+/XS247 # Manual mode

ES182
II5+/XS241 # Manual mode
II5-/XS172 # Auto mode

ES183
II5+/XS247 # Manual mode

ES184
II5+/XS240 # Manual mode
II5-/XS174 # Auto mode

ES185
II5+/XS247 # Manual mode

ES186
II5+/XS243 # Manual mode
II5-/XS176 # Auto mode

ES187
II5+/XS247 # Manual mode

KS1+/180
KS1!/181
KS2+/182
KS2!/183
KS3+/184
KS3!/185
KS4+/186
KS4!/187
#End
```


13.2 Operator interface keypad codes

Backspace	08
Enter	13
ESC	27
*	42
+	43
,	44
-	45
/	47
0	48
1	49
2	50
3	51
4	52
5	53
6	54
7	55
8	56
9	57
Left arrow	60
Right arrow	62
Up arrow	94
Down arrow	95
Secret key	126
F1	177
F2	178
F3	179
F4	180
F5	181
F6	182
F7	183
F8	184
Left display	193
Centre display	194
Right display	195

13.3 Error codes

0 None

General errors 1-7
1 Unknown command
2 Invalid command entry
3 Command not allowed at this time
4 Cannot change parameter at this time
5 Parameter out-of-range
6 Restricted command
7 Restricted parameter

Reference errors
11 No reference input defined

Memory errors
12 No more room in memory for sequences/profiles
13 No more room for DI strings
14 Stack overflow

Nvm and checksum errors
15 Nvm write timed out
16 Nvm verify failed
17 Data overflowed save space
18 Calculated checksum differs from saved
19 Cannot calculate checksum

Move errors
20 Move target outside limits
21 Failed to reach final position window
22 Moving away from specified wait position (WR)

Sequence/profile errors
23 Undefined sequence
24 Undefined profile
25 Profile step data too large
26 Cannot enter a sequence while running any sequence
27 Cannot enter profile while it is in use
28 Cannot execute command unless in sequence
29 Cannot goto sequence line no

I/O line errors
30 Line in use (busy)
31 Line not yet defined
32 Input line too noisy (II)
33 2nd posn must be > 1st (PO)
34 No output group defined (OC)
35 Not an output (DSC-2 RO)
36 Cannot use this input while initialising (DSC-2)

Numeric errors
37 Binary no. expected
38 Decimal no. expected
39 Hex no. expected
40 Numeric overflow

Other errors

41 Password incorrect
42 No commands before ...
43 No commands after ...
44 Only 1 repeat per line
45 Cannot execute string while busy
46 Command decode error
47 Variable name out of range
48 Time out for auxiliary serial port
49 Already doing VK

Motor off errors

107 Limit switch errors from 1 to here
108 Reference timeout error
109 Reference error outside limits
110 Reference error correction overrun
111 Position error
112 Timeout error
113 High position limit error
114 Low position limit error

Motor off errors unique to multi-axis version

115 Map update timeout error
116 Map position overflow (out of range)
115 Bounds limit error

13.4 ASCII Table

(American Standard Code for Information Interchange)

ASCII	EQUIVALENT FORMS			
Char.	Binary	Oct	Hex	Dec
NUL	00000000	000	00	0
SOH	00000001	001	01	1
STX	00000010	002	02	2
ETX	00000011	003	03	3
EOT	00000100	004	04	4
ENQ	00000101	005	05	5
ACK	00000110	006	06	6
BEL	00000111	007	07	7
BS	00001000	010	08	8
HT	00001001	011	09	9
LF	00001010	012	0A	10
VT	00001011	013	0B	11
FF	00001100	014	0C	12
CR	00001101	015	0D	13
SO	00001110	016	0E	14
SI	00001111	017	0F	15
DLE	00010000	020	10	16
DC1	00010001	021	11	17
DC2	00010010	022	12	18
DC3	00010011	023	13	19
DC4	00010100	024	14	20
NAK	00010101	025	15	21
SYN	00010110	026	16	22
ETB	00010111	027	17	23
CAN	00011000	030	18	24
EM	00011001	031	19	25
SUB	00011010	032	1A	26
ESC	00011011	033	1B	27
FS	00011100	034	1C	28
GS	00011101	035	1D	29
RS	00011110	036	1E	30
US	00011111	037	1F	31

ASCII	EQUIVALENT FORMS			
Char.	Binary	Oct	Hex	Dec
space	00100000	040	20	32
!	00100001	041	21	33
"	00100010	042	22	34
#	00100011	043	23	35
$	00100100	044	24	36
%	00100101	045	25	37
&	00100110	046	26	38
'	00100111	047	27	39
(	00101000	050	28	40
)	00101001	051	29	41
*	00101010	052	2A	42
+	00101011	053	2B	43
,	00101100	054	2C	44
-	00101101	055	2D	45
.	00101110	056	2E	46
/	00101111	057	2F	47
0	00110000	060	30	48
1	00110001	061	31	49
2	00110010	062	32	50
3	00110011	063	33	51
4	00110100	064	34	52
5	00110101	065	35	53
6	00110110	066	36	54
7	00110111	067	37	55
8	00111000	070	38	56
9	00111001	071	39	57
:	00111010	072	3A	58
;	00111011	073	3B	59
<	00111100	074	3C	60
=	00111101	075	3D	61
>	00111110	076	3E	62
?	00111111	077	3F	63

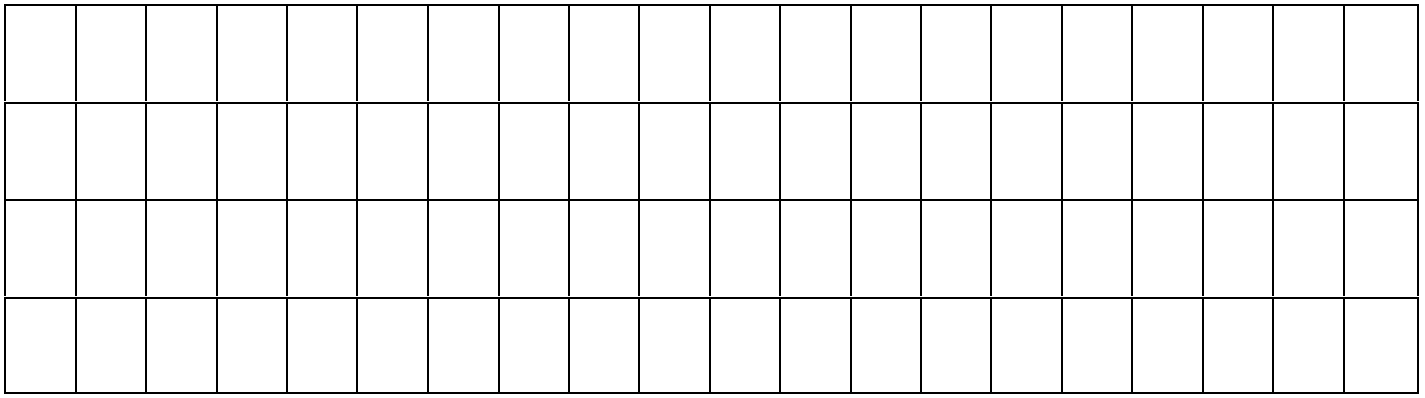
ASCII	EQUIVALENT FORMS			
Char.	Binary	Oct	Hex	Dec
@	01000000	100	40	64
A	01000001	101	41	65
B	01000010	102	42	66
C	01000011	103	43	67
D	01000100	104	44	68
E	01000101	105	45	69
F	01000110	106	46	70
G	01000111	107	47	71
H	01001000	110	48	72
I	01001001	111	49	73
J	01001010	112	4A	74
K	01001011	113	4B	75
L	01001100	114	4C	76
M	01001101	115	4D	77
N	01001110	116	4E	78
O	01001111	117	4F	79
P	01010000	120	50	80
Q	01010001	121	51	81
R	01010010	122	52	82
S	01010011	123	53	83
T	01010100	124	54	84
U	01010101	125	55	85
V	01010110	126	56	86
W	01010111	127	57	87
X	01011000	130	58	88
Y	01011001	131	59	89
Z	01011010	132	5A	90
[	01011011	133	5B	91
\	01011100	134	5C	92
]	01011101	135	5D	93
^	01011110	136	5E	94
_	01011111	137	5F	95

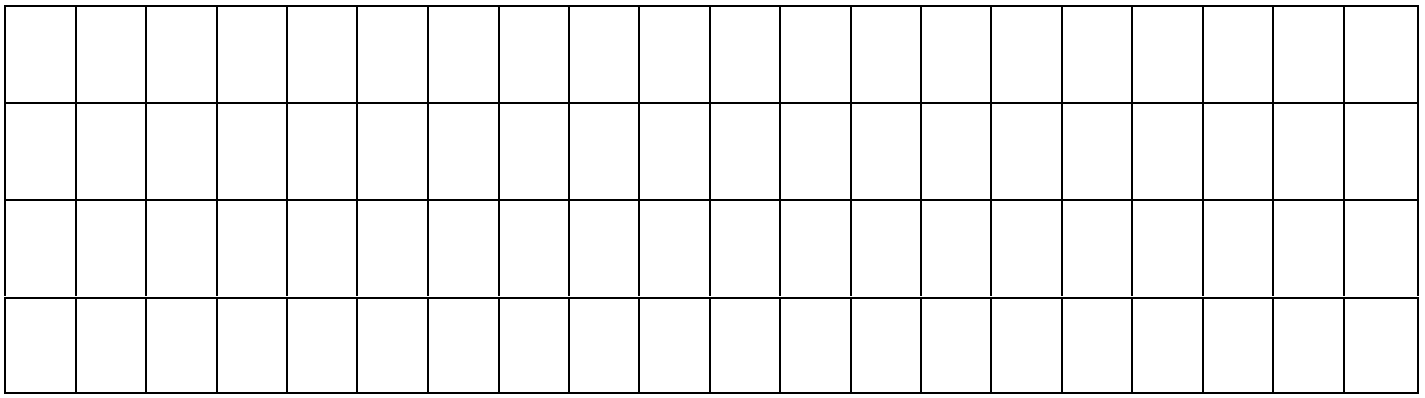
ASCII	EQUIVALENT FORMS			
Char.	Binary	Oct	Hex	Dec
`	01100000	140	60	96
a	01100001	141	61	97
b	01100010	142	62	98
c	01100011	143	63	99
d	01100100	144	64	100
e	01100101	145	65	101
f	01100110	146	66	102
g	01100111	147	67	103
h	01101000	150	68	104
i	01101001	151	69	105
j	01101010	152	6A	106
k	01101011	153	6B	107
l	01101100	154	6C	108
m	01101101	155	6D	109
n	01101110	156	6E	110
o	01101111	157	6F	111
p	01110000	160	70	112
q	01110001	161	71	113
r	01110010	162	72	114
s	01110011	163	73	115
t	01110100	164	74	116
u	01110101	165	75	117
v	01110110	166	76	118
w	01110111	167	77	119
x	01111000	170	78	120
y	01111001	171	79	121
z	01111010	172	7A	122
{	01111011	173	7B	123
|	01111100	174	7C	124
}	01111101	175	7D	125
~	01111110	176	7E	126
DEL	01111111	177	7F	127

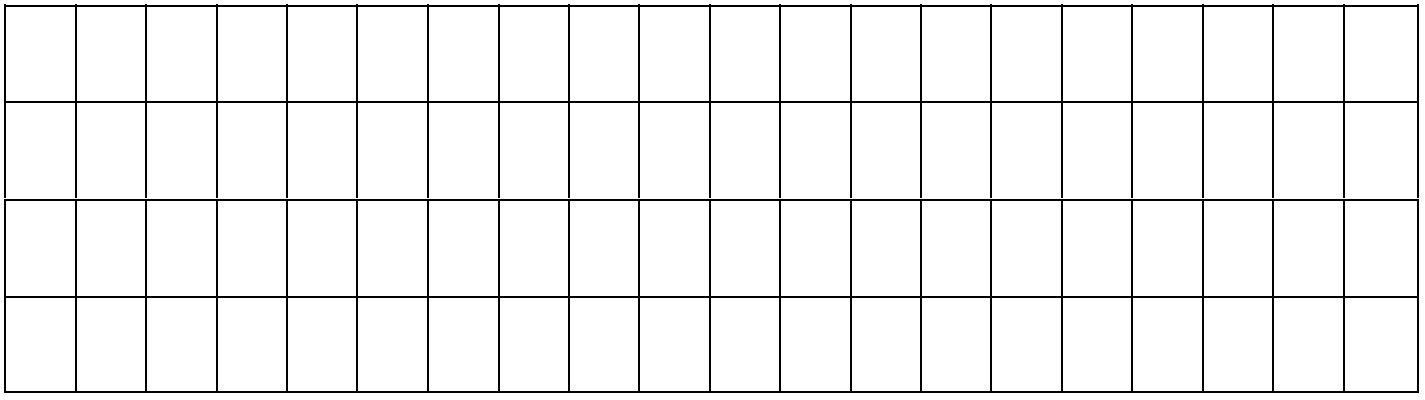
13.5 Operator interface template

The following template can be copied and used as a template for creating new screens.

DISPLAY TEMPLATE







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