# Quin Systems Limited

# Programmable Transmission System

# MiniPTS 2+1 Reference Manual

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*(MAN525)*

## Copyright Notice



## Software Version

This manual reflects the following software version.

- MiniPTS 2+1 firmware version 1.7.3 or higher.

## Important Notice

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Suggestions for improvements in either the products or the documentation are welcome.

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# 1. Introduction

This document describes the MiniPTS 2+1, a member of the Quin Systems digital Programmable Transmission System (PTS) range. It also covers the MiniPTS 3, which is identical to the MiniPTS 2+1 in most respects. For simplicity, this manual refers to the MiniPTS 2+1 only.

The systems comprise both hardware and software to control a number of servo motors. They are controlled by sending commands via an RS-232 serial interface, either from a standard computer terminal, or from a host computer system. The software allows the user to fully control the servo system using simple high level commands.

**PLEASE READ THIS MANUAL THOROUGHLY !**

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 experiment to familiarize themselves with the facilities available. This is best done on a machine which is not required for production !

# 2. General Description

This section gives a brief description of the facilities of the MiniPTS 2+1. The MiniPTS 2+1 consists of the SRV-2 two/three axis controller module, which is a complete standalone system.

The system is controlled by high level commands, received directly from an RS-232 computer terminal or serial link. Most commands are two letters, sometimes followed by a numerical parameter. The command set allows full control over every aspect of the servo system. Once a system is programmed, its complete setup, including complete sequences of operations, may be saved in a nonvolatile memory. The system operation can be made fully automatic, so that the programming terminal can be removed once the setup is complete.

A motor 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 minimize 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 follows 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 is intended for use with digital incremental position encoders which provide two signals in quadrature. This allows the system to measure both the distance and direction of motion of the motor, thus providing the closed-loop feedback information for the controller. The encoder input interface circuit multiplies the resolution of the encoder by four, such that each complete cycle of the encoder signals represents four counts. The standard systems include full isolation of the encoder input signals, and are designed for use with encoders having differential line driver outputs. This is to get best performance and noise rejection in an industrial environment.

The MiniPTS 2+1 has sixteen digital input and eight digital 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 explicitly set and cleared, and can be used to control external relays or valves, or just for status indication. They may also be used to allow the system to be controlled from an industrial programmable logic controller (PLC). On the standard units, the digital inputs and outputs are fully isolated, and are compatible with 24V logic signals.

The demand signal outputs to the motor drives are analogue signals, ranging from –10V to +10V. These are compatible with most motor drive systems.

Comprehensive sequence commands allow complex operations to be completely specified. Sequences may include any valid commands or command strings. Sequences may include commands for single or multiple motors; where sequences include commands for more than one motor, operations on different motors may run in parallel or in sequence. Profile commands allow the user to define a custom velocity profile for any motor. This provides the facilities for non-trapezoidal move profiles, for example to minimize mechanical stress in the machine. Two motors may be linked together as if by a gearbox or similar linkage, but under software control. The relationship between the motor positions is completely user-defined.

All facilities may be applied to point-to-point positioning applications, or to continuous process machinery where the motors operate continuously in one direction. The systems may be used with a wide range of motors and drives, depending on the requirements of the application.

# 3. Commands

## 3.1 General Notes

The command reference section gives full details of all the system commands and syntax. Numeric parameters are denoted by “nn” or ‘n’. Parameters entered as a binary string (‘0’s and ‘1’s) are denoted by “bb”. All input commands or command strings are terminated by a carriage return <CR>. The system responses are all followed by <CR><LF>. Note that the system echoes <CR> as <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. 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 when entering values. Hexadecimal number entries must begin with a numeric character or a sign, not an alphabetic character, to distinguish them from normal commands.

Certain length related parameters can be entered as floating point numbers consisting of an optional sign, one or more leading digits, a decimal point, and one or more trailing digits. Floating point values are accurate to approximately seven digits which is sufficient for most applications. Floating point numbers are displayed to the precision defined by the FP command.

The normal character set consists of the letters “A-Z” and “a-z”, the numbers “0-9”, and the ‘+’, ‘–’, and space characters. Commands may be sent in either lower case or upper case. Lower case commands are echoed unchanged, but are converted to upper case before storing as command sequences or function input strings. Strings of multiple commands may be entered as one command line, with the individual commands separated by a ‘/’ delimiter character. The ‘/’(slash) character must be used as the command delimiter. The maximum input line length is 255 characters. The backspace character is used to remove characters from the current input line. Most other non-printing characters are echoed as a dot, and have no effect. The escape character may be used to stop a list command, or to exit from the list of commands given by the help command.

Any ‘+’ characters at the beginning of an input line are ignored. This is to prevent any errors when using a modem link to a remote system; the standard hangup character sequence is “+++”, and this would otherwise leave the system with two ‘+’ characters in the input buffer after the modem link is closed. Also note that if the command input buffer is busy, such as when querying a parameter and the ‘?’ prompt is displayed, then other communications such as Modbus will not proceed until the buffer is available.

The standard command set provides flexible and complete control of the system. The commands fall broadly into the following categories.

- Miscellaneous.
  Commands to change between channels, and to handle the stored setup data.

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

- Move commands.
  These are the basic commands for moving and stopping the motors, using the normal trapezoidal move profile.

- Set parameter commands.
  These commands set up a wide range of system parameters, including the velocity and acceleration of the normal moves.

- Sequence commands.
  These commands allow the user to enter, list, and execute complex command sequences.

- Profile commands.
  These commands are used for the profile move facilities (Software Cam).

- Map commands.
  These commands allow the user to enter, list, and execute channel-to-channel position mappings (Software Gearbox).

- Wait commands.
  These commands are used in command sequences to wait until a condition is true before executing the next command in the sequence.

- Error handling.
  These commands set up the system error monitoring functions.

- Gain commands.
  These commands set up the gain constants used in the closed-loop control algorithm.

- Reference commands.
  These commands set up the continuous position correction facilities for use with position reference input signals.

- Digital input and output commands.
  These commands directly control the digital input and output lines.

- Configuration commands.
  These commands configure the digital input and output lines for various automatic functions.

- Timer/counter functions
  These provide comprehensive facilities for setting up timers and counters using the digital input and output lines.

- Phase advance commands
  These commands control a speed-dependent phase advance mechanism for slave channels in mapping, and for position trigger outputs.

- Display commands.
  These commands output parameter values and status information via the serial port.

- Analogue control commands
  These commands are used to set up closed loop tension control, and to allow the motor torque to be controlled in various ways.

- Variables
  Variables and expressions can be used in place of constants for most command parameters to increase the flexibility of the system. They are of particular use in conjunction with the Operator's Panel.

- Edit mode
  Edit mode is an operating mode which allows the MiniPTS 2+1 to be set up for a new product without interference from any input functions or trigger variables.

The command reference section 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. This scale factor is set by the SU set units command. Note that the range and default values are given in encoder counts, and if a scale factor other than one 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 input and output lines are listed with the LI and LO commands.

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 programmed as required by the Control Engineer or Systems Engineer, while preventing access to the more fundamental setup parameters by the machine operator. When programming is complete, the programming terminal may be removed. 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 nonvolatile 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 factory default configuration.

## 3.2 Command Execution

Commands can be executed in a number of different ways. This section explains how the system deals with different methods of execution, and how to get the most out of your system. The main ways of executing commands are as follows.

- Command line.
  Commands can be entered singly or as a string at the RS-232 terminal and they are executed immediately when <CR> is typed.

- Sequences.
  Sequences containing one or more lines of commands can be defined using the ES command. The commands are executed by issuing the XS command. Sequences can themselves call other sequences.

- Input line function.
  The DI command can be used to define a command string to be executed when the input line is activated.

- Trigger variable.
  A trigger variable can be defined which causes a command string to be executed when the variable is updated.

The simplest way to execute a command is to type it on its own at the command line. A command entered in this way can be executed at any time, provided the current state of the motor allows it, and it is not a restricted command being entered in normal (unprivileged) mode. If the motor is in an inappropriate state, a context error message will be displayed in the form “cannot execute <cmd> while <state>”. For example, if a VC+ command is entered while the motor is executing a move command the following error message is displayed.

```
Cannot execute VC+ while moving
```

The second way to execute commands is to type a string of several commands at the command line. The advantage is that the system waits for one command to finish before executing the next thus ensuring that the motor is in the correct state to execute each command and avoiding the type of conflict that can occur with single commands. For example, the following command string will safely move to the initial position, run at constant velocity until the input line is activated and then stop.

```
MA1500/VC+/WI3-/ST
```

A sequence consists of one or more lines of commands which can be executed by issuing the appropriate XS command. Sequences and command strings on the MiniPTS 2+1 execute in parallel by sharing the available processor time. More explicit control over command execution in sequence or in parallel is controlled by the CH and CP commands, which are described later. An example of two sequences running in parallel is shown below. In this example sequence 2 executes while sequence 1 is asleep waiting for the MA command to complete.

```
1> ES1
S1: CH1/MA1500/VC+/WI3-/ST
S1:
1> ES2
S2: CH1/DP/DV
S2:
1> XS1
1M XS2
DP345
DV256
1M
```

Sequences are automatically split up into a number of sub-sequences which are executed on the individual channels. Before a sub-sequence can be executed it must be sent to the relevant channel. This is done explicitly by compiling the sequence using the CM command, or it can be done automatically on sequence execution.

Commands which have a variable or expression as a parameter are always sent to the channel as a command string since the parameter is evaluated at execution time and can not therefore be preloaded as a sub-sequence.

Note that the above rules only apply at the channel level and do not affect operation at host level. In other words, the fact that one channel is executing a sub-sequence does not restrict operations involving any other channels.

Input line functions are executed in the same way as command strings and are subject to the same rules. A command string triggered by a variable is executed in the same way as a normal command string or an input line function and is also subject to the same rules.

Command strings are split into sections, each of which can be executed either by a single channel or by the host processor. Sections which are to be executed at channel level are sent as command strings even if they consist of a single command. This is done to keep the proper synchronization between commands. An exception to this rule is a single channel level command which occurs at the end of the command line. In this case the command is sent as a single command and can be executed at any time provided the motor state allows it. For example the following command string is always accepted if it is executed from the command line, from an input line, or triggered by a variable.

```
CH1/SV$SPD
```

The speed at which commands are executed is influenced by whether they are executed at channel level or at host level. In general, channel level commands are executed rather more quickly than host level commands because there is less overhead involved. For example, an input line function which consists only of channel level commands can be dealt with at channel level and is therefore quick and repeatable. An input line function which involves host level commands requires communication between the channel and the host, and from the host back to the channel, before any commands are executed, and is therefore slower and less repeatable. Note that any command which involves the CH and CP channel change commands, or a variable or expression, has to be dealt with at host level.

To determine which commands are executed at channel level and which at host level, please refer to the command summary in section 7.1.

# 4. Command Reference

## 4.1 Miscellaneous Commands

**VN** **Print version number.**

This command prints information about the version of software fitted to the system. This version information should be noted for reference in any customer support questions.

**SP** **Save parameters (restricted).**

This command saves all the programmable parameters to nonvolatile memory. There may be a delay while the save operation takes place, depending on the amount of data to be saved. The saved parameters become the new defaults, used by the system on power-up. The SP command also saves any profiles and sequences. At the end of the save operation, the system calculates a checksum on the saved data by means of a cyclic redundancy check (CRC) algorithm. The checksum is then also saved in nonvolatile memory. This allows the saved data to be verified at any time by comparing the stored checksum with a newly calculated one. If the saved data has changed at all, the stored checksum will not be the same as the calculated checksum. If the save operation fails for any reason, then an error message such as “nvm write failed” is returned. In this case, please contact your sales office. The SP command is restricted, and is only available in privileged mode.

**CS** **Checksum test.**

This command is used to verify the data stored in the nonvolatile memory. The system calculates a new checksum value for the stored data, and displays it. It then compares the new value with the checksum value that was stored with the data when it was saved. If the values are different, a “checksum error” message is displayed. If it was not possible to calculate the checksum for the stored data, a “checksum failed” error message is displayed. If the checksum test fails, it indicates that the stored data has changed since it was saved. If this occurs, please contact your sales office.

**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 nonvolatile memory. It also resets all output lines to their power-up state. Undefined outputs are cleared low. If the stored data checksum is not correct, then this command returns the “stored data invalid” error message, and the stored parameter values are not loaded.

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

This command resets all the parameters, input and output line definitions, sequences and profiles to their default settings. It also resets all output lines to the default off state (cleared).

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

**LA** **List all parameters.**

This command lists all the parameters, input and output line definitions, sequences and profiles to the screen in a suitable format for entering the parameters etc. at a later date. If the system is connected to an IBM PC running the PTSTerm program, or any similar communications program that allows logging data to disk, the parameters can be recorded on disk for backup purposes and downloaded into the MiniPTS 2+1 at a later date if the parameter settings are lost for any reason.

The LA command may optionally be followed by a binary parameter to select which aspects of the current setup are to be listed. The bit functions with bit values in brackets are described below.

Bit 0 This bit controls whether sequences are listed (1) or not (0).

Bit 1 This bit controls whether input and output line definitions are listed (1) or not (0).

Bit 2 This bit controls whether trigger variables (defined using '>') are listed (1) or not (0).

Bit 3 This bit controls whether parameters are listed (1) or not (0).

Bit 4 This bit controls whether maps and profiles are listed (1) or not (0).

Bit 5 This bit controls whether signal sequences (defined using the SX command) are listed (1) or not (0).

The escape key may be used to stop the LA command early.

**RZnn** **Set parameter file size (restricted).**
**Range: 0 to size of nonvolatile memory fitted.**
**Default: 28000**

This command sets the size of the file in nonvolatile memory used for storing parameters with the SP command. In systems fitted with an Operator's Panel it may be necessary to reduce the size of the parameter file to allow space for storing the Panel configuration files in nonvolatile memory. To avoid losing parameters when the RZ command is used, follow the procedure shown in the example below.

**Example : `RZ20000`**
This sets the parameter file to 20000 bytes. Note that the stored parameters will be lost following an RZ command unless the procedure below is followed.

| System | User | Comments |
|---|---|---|
| `1>` | `RD` | Read stored parameters. |
| `123456` | | System displays checksum |
| `1>` | `RZ20000` | Set parameter file to 20000 bytes |
| `1>` | `SP` | Save parameters to new file |
| `654321` | | System displays new checksum |
| `1>` | | |

The command can also be issued without a parameter to find the current size of the parameter file.

**FM** **Display free memory.**

This command displays information about the memory space available for sequences, maps and profiles. It returns both the global free memory space on the host processor and the local free memory space on each axis. For more details refer to the full description of the FM command on page 50.

**SK** **Set software license key.**

The MiniPTS 2+1 supports a number of optional software packages, such as the Modbus interface or the Motion Generator option. These options are chargeable, and are controlled by a license key feature to prevent them being enabled in the field without authorization. Systems which are ordered with a particular feature will normally have the license key installed before delivery.

The SK command lists the serial number for the unit, and all currently enabled software options. It allows license key values to be entered, enabling or disabling these software options. The license key values are unique for each optional software package and for each unit, as they are calculated using the unit serial number. To upgrade a system and enable a new option, it is necessary to obtain a license key value from your sales office for the specific system.

To disable a previously enabled option, enter the option name and press Enter or CR when the system prompts for the version number.

The SK command is also used to enable or disable the software for the Operator's Panel and Mini Operator's Panel, as they use the same serial port as the various PLC interfaces. In this case the required software is enabled without a license key by entering a version number of zero.

**Example :**

| System | User |
|---|---|
| 1: | SK<CR> |
| Serial number: 001234 | |
| Feature Version Key | |
| modbus 1.1 0EE2 | |
| New feature ? | mapgen |
| Version ? | 1.1 |
| Key ? | F0E1 |
| OK | |
| 1: | |

## 4.2 Mode Commands

**PC** **Enter position control mode.**

This command puts the current motor channel back into the normal state with the motor position continuously controlled, after the MO motor off command has been executed or any motor error has occurred. The prompt character '>' is returned in position control mode. The demand position is initialized to the current measured position when the PC command is executed.

In position control mode, an onboard relay on the servo controller is energized 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.

The MiniPTS 2+1 is limited to having only two channels at one time controlling real motors. If the PC command is used to put a third channel into position control, the command gives the "command not available" error message, and the channel remains in the motor off state. The MiniPTS 3 allows all three motor channels to be controlled at the same time 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 ':' colon 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 unenergized state. It is recommended that this relay is used to disable the motor 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.

If the MO command is used as a motor off stop command when the system is executing a multi-channel sequence, it only puts the current channel into motor off and leaves the remainder of the multi-channel sequence running. If it is necessary to put all channels into motor off then the GF global motor off command should be used.

**PM** **Enter privileged mode.**

The full set of commands available on the MiniPTS 2+1 is very powerful and complete. However, in most applications, it is only necessary to make full use of the commands 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. Unauthorized 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 unauthorized access to the system programming since the ES enter sequence command is also restricted.

The PM command is used to enter privileged mode from normal 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 “O.K.” message, and goes into privileged mode. If the password is incorrect, the system prints the error message “password incorrect” and stays in normal mode.

**Example :**

| System | User | Comments |
|---|---|---|
| `>` | `PM<CR>` | Privileged mode command |
| `Enter password :` | | The password is not echoed |
| `O.K.` | | Password accepted |
| `>` | | |

If the password is defined as the default carriage return only, then the system powers up in privileged mode.

**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 in normal mode if a password (other than just a carriage return) has been defined and saved. If no password is defined, the system powers up in privileged 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 eight characters. The password is saved in nonvolatile 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> | Set password command |
| Enter password : | xxxxx | The new password is echoed |
| > | | |

If the password is defined as the default carriage return only, then the system powers up in privileged mode.

**VMn** **Set virtual motor mode (restricted).**
**Range : 0 to 1**

This command defines whether the axis is in normal or virtual motor mode. In virtual motor mode, the axis can operate without a motor or encoder connected, since the actual position is calculated internally from the demand position. If the value passed with the VM command is zero, the channel is set to normal mode. If the value passed is 1, the channel is set to virtual motor mode. The motor enable relay is held in the off state when in virtual mode, but all other commands operate normally, including the position reference and snapshot inputs.

Virtual motor mode may be particularly useful in the following circumstances.

- For testing commands and sequences before the controller is connected to the machine.
- For providing a dummy master axis in position mapping. For example, two axes could be made to trace a circular outline by providing a third master axis moving at constant velocity in virtual motor mode and mapping the two slave axes to the master with a sine and cosine map respectively.

**Safety Note :**
The control signal to the motor is switched to 0V and the enable relay is set to the motor off state when the axis is in virtual motor mode.

The MiniPTS 2+1 is limited to having only two channels at one time controlling real motors. If the VM command is used to take a third channel out of virtual mode in any state other than motor off, the command gives the “command not available” error message, and the channel remains in virtual mode. The MiniPTS 3 allows all three motor channels to be controlled at the same time if required.

## 4.3 Move Commands

**MA±nn** **Move to absolute position ± 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 divided by the user scale factor. The distance scale factor is set by the SU command, described in the set parameter commands section.

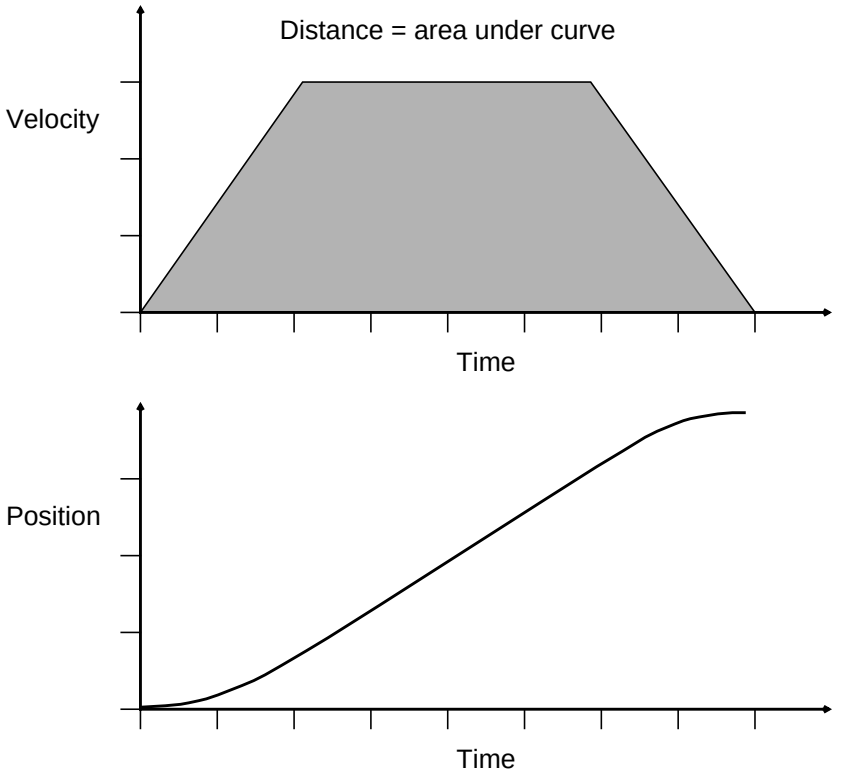



**Figure 1. Trapezoidal move profile.**

If the move distance is small, the velocity is high, or the acceleration is low, the motor may not reach the set velocity within the given move distance. In this case the motor follows a triangular velocity profile instead of a trapezoidal one.

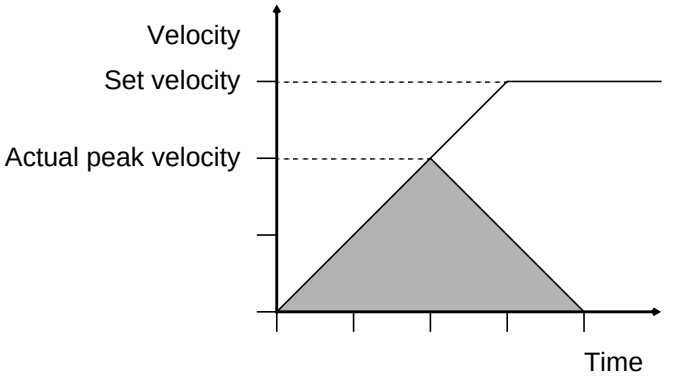



**Figure 2. Triangular move profile.**

When the system executes an absolute or relative move command, it gives the 'M' move prompt character. The move commands may only be used from the idle position control state. If the channel is not in position control mode when a move command is entered, the system returns the error message "cannot execute MA while ...". If no parameter is given, the system gives the error message "invalid command". If the position is outside the allowed range, it returns the error message "parameter out of range".

The target move position is also checked against the current values of the user-defined position limits, set by the LH and LL commands. If the move would take the motor outside the set position limits, then the "target position outside limits" error message is again returned, and the move is not executed. If the SB set bound value is less than the appropriate high or low limit, then the target position limit checking is disabled, as the absolute position value wraps around to zero at the bound position before reaching the limit position.

On cyclic machines it may be useful to constrain absolute moves such that the motor always moves in one direction, or always moves the shortest distance to the required absolute position. These options are controlled by the move direction constraint bits (bits 1–3) in the MW parameter.

**Example : `MA+2000`**

The motor moves to absolute position +2000 counts.

**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 demand position. The move distance is entered in user units.

The target move position is checked against the current values of the user-defined position limits, set by the LH and LL commands. If the move would take the motor outside the set position limits, then the "target position outside limits" error message is returned, and the move is not executed. If the SB set bound value is less than the appropriate high or low limit, then the target position limit checking is disabled, as the absolute position value wraps around to zero at the bound position before reaching the limit position.

The direction of a move relative is not constrained by the direction constraint bits in the MW parameter. The direction of the move is given by the sign of the move relative parameter.

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

**ST** **Stop.**

The motor stops under controlled deceleration, set by the DC command. The stop command may be used during any motion to decelerate the motor to a stop. When the motor is stopping, the system gives the ‘S’ stopping prompt character. The ST command may also be used to exit prematurely from any wait condition.

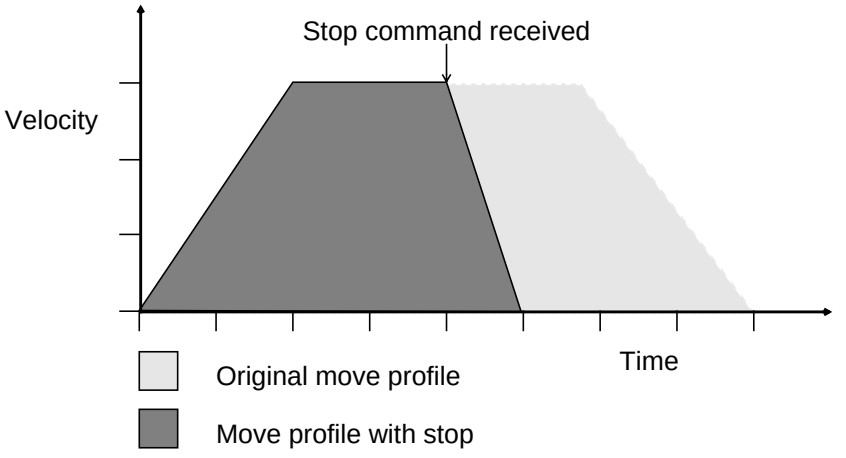



**Figure 3. Move with normal stop.**

The ST command does not break out of any local command sequences or repeat loops currently being executed. If it is required to stop command execution, the AX command must be used.

If the ST stop command is used to stop from mapping or executing a profile, then the deceleration starts at the current instantaneous speed.

## AB Abort, emergency stop.

The motor stops immediately, ignoring the system deceleration value set by the DC command. This may be used instead of the ST command, where an immediate stop is required. It can be used at any time to stop the motor immediately. The AB command is also used to exit prematurely from any wait condition.

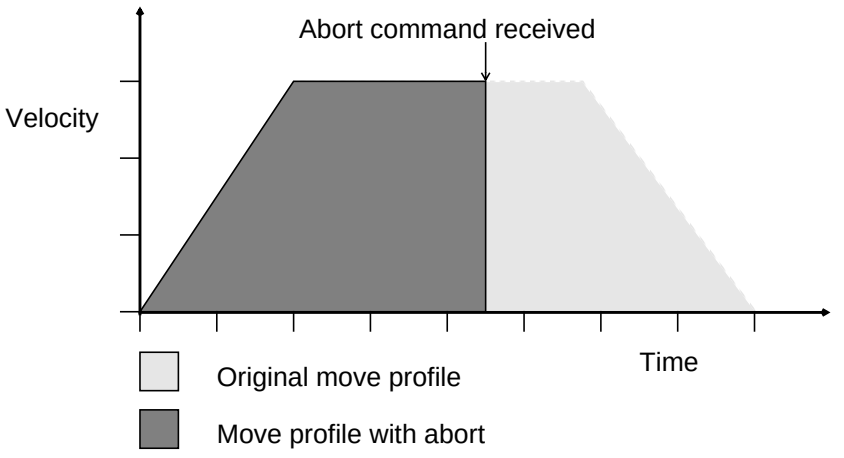



**Figure 4. Move with abort.**

The AB command does not break out of any local command sequences or repeat loops currently being executed. If it is required to abort command execution, the AX command must be used.

If the AB command is used when the system is executing a multi-channel sequence, it only aborts the current channel and leaves the remainder of the multi-channel sequence running. If it is necessary to abort all channels then the GA global abort command should be used.

**VC**[±] **Move at constant velocity.**

This command is used to move the motor at a constant velocity in the direction specified, without any target position. If the direction is not specified, the motor moves in the direction given by the DN command. The system accelerates the motor at the defined acceleration until it reaches the velocity set by the SV command. It then controls the motor at constant velocity, until it is told to stop. While in constant velocity mode, the system gives the 'V' velocity control prompt character.

Velocity control mode can only be entered from position control mode, and not directly from the motor off state. If the channel is not in the idle position control state, then the VC command returns an error message.

**Example : `SA1000/SV2000/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.

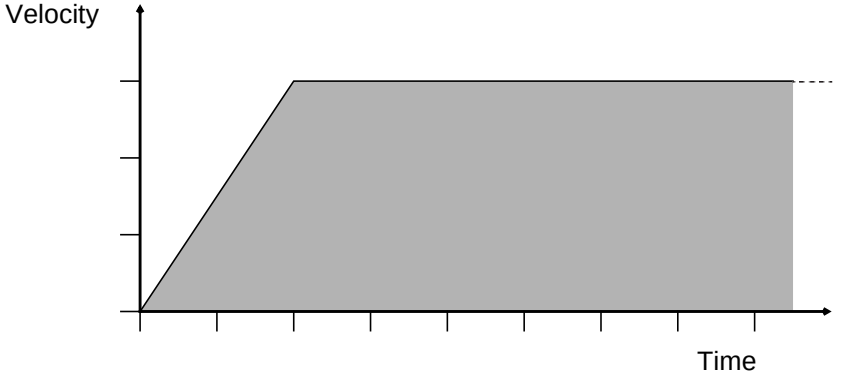



**Figure 5. Constant velocity move.**

**IN[±]** **Initialize position.**

The system performs the initialization sequence to find a zero position reference signal. The system gives the 'I' initialize prompt character while executing the initialization sequence. From the normal PC state, the motor accelerates to the system velocity in the direction specified. If no direction is specified, the motor moves in the direction given by the DN command. When the system detects any reference input signal, it decelerates to a stop and resets the position counters as required. The motor then (optionally) moves back to the new zero position.

This command may also be used in states other than PC. In this case the system simply waits for a reference signal and sets the zero position accordingly.

**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 after the reference input is detected, and bit 4 of RW which defines whether any reference input is valid, or only a combination of them. The RF reference offset value is also effective during the initialization 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 please refer to section 4.11 later in this manual.

If no reference input or marker input is defined, then the IN command returns the error message "no reference input defined", and the initialization sequence is not executed.

**Example : `IN+`**

The motor moves in the positive direction until a valid reference input is seen. It then stops, and moves to the newly defined zero position. In this example, the motor moves back to the position where the reference input signal was detected.

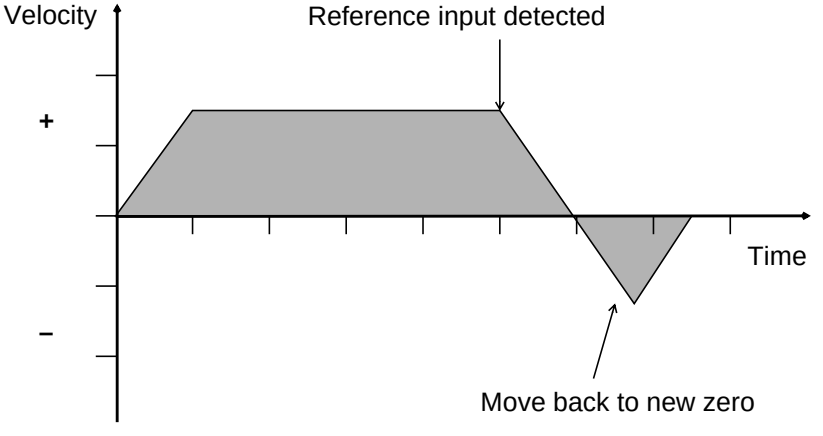



**Figure 6. Initialization to zero position.**

**IB[±]** **Initialize position and bounds.**

This command is similar to the IN command but also sets the position bounds in addition to finding the zero position. The system gives the 'I' initialize prompt character while executing the initialization sequence. From the normal PC state, the motor accelerates to the system velocity in the direction specified. If no direction is specified, the motor moves in the direction given by the DN command. When the system detects a reference input signal, it stores the position value immediately. The motor continues to move until a second reference input signal is detected and sets the position bounds to the distance moved since the first reference signal was received. The motor then decelerates to a stop, resets the position counters, and moves back to the new zero position.

This command may also be used in states other than PC when the system simply measures the distance between two successive reference signals and sets the zero position and bounds accordingly.

**NOTE :** The IB command works independently of the settings of all the other reference commands. This is so that whatever the reference setup for normal running, the IB 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 after the reference input is detected, and bit 4 of RW which defines whether any reference input is valid, or only a combination of them. The RF reference offset value is also effective during the initialization 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 please read the Reference Commands section later in this manual.

If no reference input or marker input is defined, then the IB command returns the error message "no reference input defined", and the initialization sequence is not executed.

**DN±** **Set motor direction.**
**Range : + or –**
**Default : +**

This command is used to set the default motor direction for the VC, IN and IB commands. If the command is issued without a sign the current default direction is displayed.

**Example : `DN-/VC`**
This sets the default direction to negative and starts the motor at constant velocity backwards. It is equivalent to issuing a VC- command.

**ID** **Initialize demand signal 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 correct 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 the position control mode, to set the actual position as close as possible to the required position. 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 at the end of a move command it returns the error message “failed to reach target position”. 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.

## 4.4 Set Parameters

**SVnn** **Set velocity (speed).**
**Range : 0 to 4 000 000 (4.0E6) counts per second**
**Default : 1024**

This command is used to set the system velocity, in user units per second. It may be used at any time, including when the motor is already moving. The diagram below shows a typical velocity profile where the velocity is increased part way through a normal move.

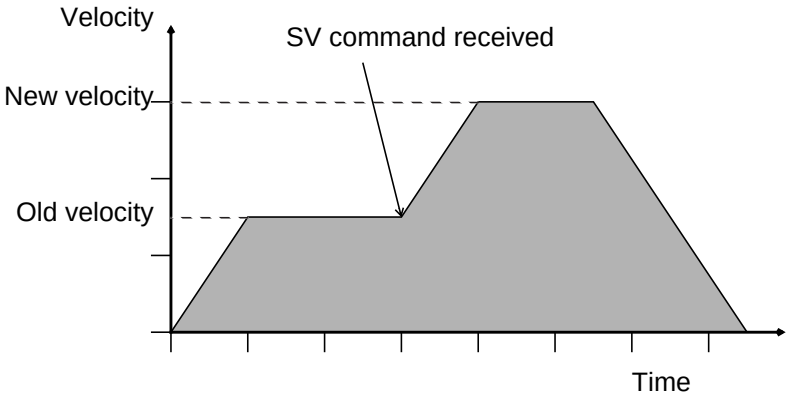



**Figure 7. Move with change of velocity.**

**Example : `SV5000`**
This sets the system velocity to 5000 counts per second.

**SAnn** **Set acceleration.**
**Range : 1 to 2 000 000 000 (2.0E9) counts per second squared**
**Default : 1024**

This command sets the normal system acceleration to the specified value, in user units per second squared. The acceleration value is used in the normal trapezoidal move functions for both the acceleration and deceleration ramps. It may be changed at any time. If a new acceleration value is given when the system is executing a move command, then the new value is accepted but is not used until the start of the next move. Note that the actual acceleration is rounded to the nearest multiple of 256 counts/second$^2$, and the minimum acceleration value is 256 counts/second$^2$.

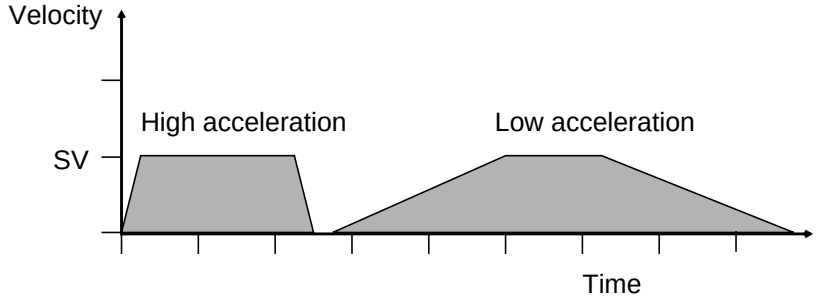



**Figure 8. Set acceleration.**

**Example : `SA10000`**

This sets the system acceleration to about 10000 counts/second$^2$. The actual acceleration value used in this case is 9984 counts/second$^2$ because of the rounding to the nearest multiple of 256.

**DCnn** **Set deceleration for ST command.**
**Range : 1 to 2 000 000 000 (2.0E9) counts per second squared**
**Default : 1024**

This command sets the deceleration to be used when stopping as a result of the ST command, and in normal initialization when the reference input is detected. The deceleration at the end of a normal move is set by the SA command. The command specifies the deceleration value in user units per second squared. Note that the actual deceleration is rounded to the nearest multiple of 256 counts/second$^2$, and the minimum value is 256 counts/second$^2$.

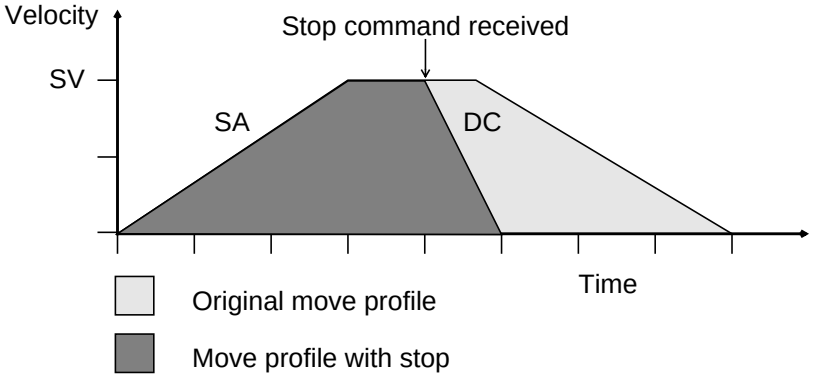



**Figure 9. Effect of DC command.**

The figure above shows the effect of setting the DC value higher than the SA value. This allows a gentle acceleration and deceleration for normal move profiles but gives a sharper deceleration if the move has to be terminated early by a ST command.

**SCnn** **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 speed, set by the SS command. This may be used to minimize overshoot at high speeds and accelerations.

This command is only effective during normal velocity mode when VJ is set to zero.

**Example : `SC200`**
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 speed at least 200 units before the final required position.

**SSnn** **Set slow speed.**
**Range : 0 to 4 000 000 (4.0E6) counts per second**
**Default : 32**

This command allows the user to set the speed of the slow creep to the final position, if required. The command also sets the slow speed to be used in slow velocity mode when VJ is set to 1. It is specified in the same units as the system velocity.

**Example : `SS100`**
This sets the slow speed to 100 counts per second.

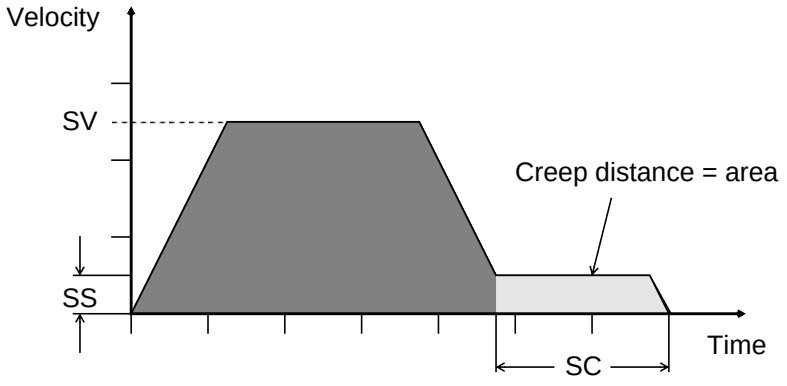



**Figure 10. Move with creep to final position.**

**VJn** **Set slow velocity mode.**
**Range : 0 to 1**
**Default : 0**

Setting VJ to 1 enables slow velocity mode. In this mode all moves are made at slow velocity as set by the SS command and the creep distance set by the SC command has no effect. Setting VJ to 0 puts the axis into normal velocity mode where moves are made at normal velocity as set by the SV command.

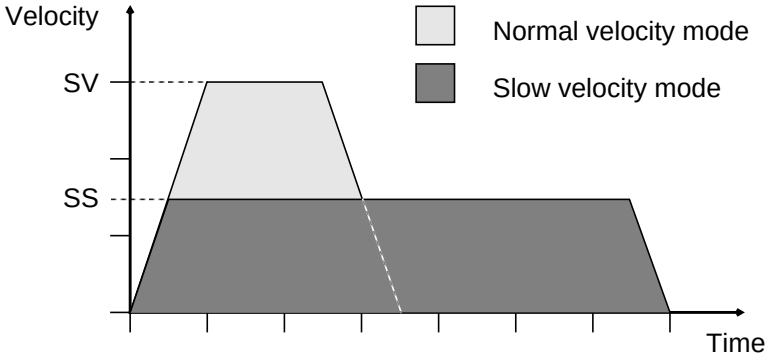



**Figure 11. Normal/slow velocity mode.**

**SWnn** **Set window (restricted).**
**Range : 0 to 65535 encoder counts**
**Default : 10**

This command sets a window or tolerance around the required final position of a move. The system defines the endpoint of a move as being when the demand position has reached the target position and the measured position is inside the window. It returns from the move state to the position control state only when the motor is within this window. Note that when using a narrow window, it is important that the demand signal offset has been initialized 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 return the error message “failed to reach target position”. Note that the window is specified in encoder counts, and is not scaled by the user scale factor. This command is restricted, and may only be used in privileged mode.

An output signal may be defined which indicates when the position error is outside the window given by SW. This is set up with the the OW command, described on page 135.

**Example : `SW25`**
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.

**SDnn** **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 does 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.

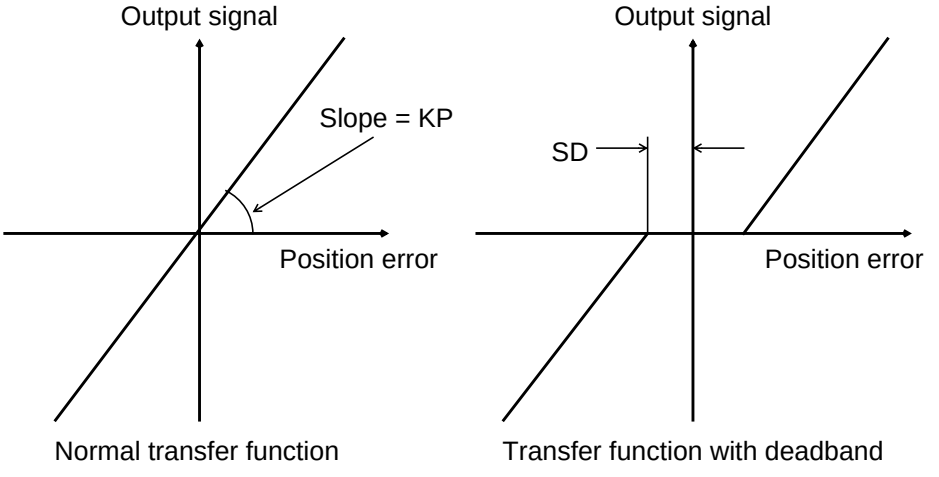



**Figure 12. Deadband.**

**NOTE :**
The deadband function is disabled on the current version of the MiniPTS 2+1 software.

**SLnn** **Set settling time.**
**Range : 0 to 255**
**Default : 255**

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 : SL128**
This sets the settling time to 128 × 1/256 = 0.5 seconds.

**BLnn** **Set backlash compensation distance.**
**Range : 0 to 65535**
**Default : 0**

This command sets up a backlash compensation facility. It applies only to the MA and MR point-to-point move commands. It defines an extra distance that the motor moves each time it reverses direction, thus taking up any slack or backlash between the motor and the final output. It is defined in encoder counts.

**Example : `BL20`**
This sets the backlash compensation distance to 20 counts. Each time the motor changes direction on successive move commands, the first move in the new direction is extended by 20 counts to take up the backlash.

**ISn** **Set increment select code (restricted).**
**Range : 0 to 8**
**Default : 0**

This command selects the parameter which is incremented by the IP command. Each channel has a separate IS value. The parameter selected is defined by the code as follows.

| Code | Parameter | Limits |
|---|---|---|
| 0 | None | |
| 1 | Current running speed | See below |
| 2 | Torque output (TQ) | ±2047 |
| | or Analogue control setpoint (AC) | ±2047 |
| 3 | Map base (MB) | ±4000000 |
| 4 | Map offset (MF) | ±4000000 |
| 5 | Reserved | |
| 6 | Set velocity (SV or SS) | See below |
| 7 | Scaled map multiplier (SM) | 0 to 65535 |
| 8 | Set bounds (SB) | 1 to 4000000 |

**IPnn** **Increment selected parameter.**
**Range : dependent on select code**

This command adds the value given to the parameter selected by IS. This allows a selected parameter, such as motor speed, to be increased or decreased in steps by repeating a single command. The increment value may be positive or negative and may be of any size. If the incremented value would exceed its allowed range, it is set to its maximum or minimum value as appropriate. When a parameter value is changed with the IP command, then the new value is retained until the unit is turned off, or the previously saved values are restored. The changed values are not automatically saved, but may be saved with the SP command if required.

The lower limit for incrementing the running speed (IS1) is zero. If the axis is running in normal velocity mode, at the speed set by the SV command, the upper limit is equal to twice SV. If the axis is running in slow velocity mode at the speed set by the SS command, the upper limit is equal to SV. The increment affects only the current running speed and not the SV or SS parameters, and is effective only until the motor stops. Subsequent moves start with the original speed of either SV or SS, as set by the VJ parameter.

Changes to the torque or tension control setpoint (IS2) affect the TQ or AC parameter value. If the new value is outside the allowed range, it is set to the maximum or minimum value as required.

Changes to map base (IS3) or offset (IS4) affect the MB/MF parameter values. If map base is changed, the change is subject to AV and the map base value wraps round at the master axis bound. If map offset is changed, the change is subject to AV and the map offset value wraps round at the slave axis bound.

The set velocity increment (IS6) is applied to the current set speed parameter, depending on the value of the VJ parameter. If the axis is in normal velocity mode (VJ0), then the speed increment is applied to the SV parameter, and the upper limit is the same as that for the SV command. If the axis is in slow velocity mode(VJ1), then the speed increment is applied to the SS parameter, and the upper limit is equal to SV. The lower limit for the set velocity in both cases is zero.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | SV1000 | Move velocity is 1000 |
| 1> | IS1 | Select running speed for increment |
| 1> | VC+ | Start motor running |
| 1V | IP100/DV | Increment running speed |
| 1 DV1100 | | Running speed is now 1100 |
| 1V | IP100/DV | Increment speed again |
| 1 DV1200 | | Speed is now 1200 |
| 1V | SV | Display set speed |
| 1 SV1000 | | Set speed has not changed |

**SUnn** **Set units (restricted).**
**Range : 1 to 65535**
**Default : 1**

This command sets the scale factor between encoder counts and user distance units, or the number of encoder counts that represent one user unit. It allows length related parameters to be entered in scaled units rather than in encoder counts. This command is restricted, and is only available in privileged mode.

The scale factor and all scalable parameters may be entered as floating-point numbers (i.e. containing a decimal point). This allows scaling to be used on systems where the scaling between encoder counts and distance units is not a simple integer. When floating-point numbers are used they are only accurate to approximately 7 digits so there may some loss of accuracy when large numbers are used. The FP command is used to set the precision for displaying floating-point numbers.

**Example : `SU5`**
This sets the user scale factor to 5, such that 1 length unit equals 5 encoder counts. For example, if 1 encoder count was equal to 2 microns, then a scale factor of 5 would allow parameters to be entered in units of 0.01 mm.

**FPnn** **Set floating point precision (restricted).**
**Range : 0 to 10**
**Default : 0**

The FP command is used to set the precision for display of floating point numbers. The parameter specifies the number of places after the decimal point. If FP is set to zero, only the integer part of the number is displayed. The FP command is **not** channel specific and only applies to scaled parameters.

**Example:**

| System | User | Comments |
|---|---|---|
| `1>` | `SU10/SV1000.4` | Set velocity to 1000.4 |
| `1>` | `FP2/SV` | Set precision to 2 |
| `SV1000.40` | | Velocity displayed to |
| `1>` | | 2 decimal places |

**MWbb** **Set move/map options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command allows the user to modify the operation of absolute moves as described previously. It also controls various aspects of the position mapping functions; these are described later in section 4.7. The value is entered as a binary number. Leading zeros may be omitted. The bit functions for MW relevant to the move absolute command are described here. These options are useful on cyclic machines, where a given absolute position repeats once every machine cycle, as defined by the SB value.

Bit 0 Used in mapping. Please refer to section 4.7, Map Commands.

Bit 1 When set to 0, the target position for an absolute move is taken from the command argument. The move distance may be larger than the set bound value SB if required.
When set to 1, the target position for an absolute move is set to the **nearest** correct cyclic position within SB. If MW bit 2 is set to 0, then the move distance is limited to ±SB/2. If MW bit 2 is set to 1, then the direction for absolute moves is set by MW bit 3, and the maximum move distance is SB, in the set direction only.

Bit 2 This bit is used if absolute moves must be constrained to only one direction.
When set to 0 it has no effect, and absolute moves may be in either direction, depending on the current position and the target position of the move.
When set to 1, absolute moves are always in one direction, as set by bit 3 of MW (see below).

Bit 3 This bit sets the direction for all absolute moves, if they are constrained by setting bit 2 of MW to 1.
When set to 0, absolute moves are in the positive direction.
When set to 1, absolute moves are in the negative direction.

Bit 4 Used in mapping.

Bit 5 Used in mapping.

Bit 6 Used in mapping.

Bit 7 Used in mapping.

**CWbb** **Set control word (restricted).**
**Range : 8 bit binary value.**
**Default : 0100 0000**

This command allows the user to write a value into the control word for the current channel. Note that leading zeros may be omitted. The control word allows the state in which the axis powers up to be defined, and allows the sense of the encoder input and of the command signal output 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 0 When set to 1, the auxiliary analogue output is used for torque control.
When set to 0, the main analogue output is used for torque control.

Bit 1 When set to 1, the sense of the auxiliary output used for torque limiting is reversed to provide a +10V output at zero torque demand.
When set to 0, the auxiliary output used for torque limit is normal providing a 0V output at zero torque demand.

Bit 2 Reserved.

Bit 3 This bit enables operation with a unipolar analogue output signal. The command signal is limited to the range 0–10V, and the direction is given by a digital output line, set by the DU command. This option is used with inverters or other similar drives which only accept speed input signals between 0 and 10V.

Bit 4 This bit defines the sense of the main analogue output for the motor command signal.
When set to 0, the command signal sense is normal; if the encoder is moved in the positive direction, a negative output voltage is produced at the command output.
When set to 1, the sense of the command signal output is reversed; if the encoder is moved in the positive direction, the command signal goes positive.

Bit 5 This bit defines the logical sense of the encoder input.
When set to 0, the encoder direction sense is normal; if encoder signal track A leads track B the motion is positive.
When set to 1, the encoder direction is reversed; if track A leads track B the motion is negative.

Bit 6 This bit defines the initial state of the system at power-up.
When set to 1, the axis powers up in the motor off state with the servo loop disabled. This is the default case for standard systems.
When set to 0, the axis powers up in position control mode with the servo loop active.

Bit 7 This bit modifies the integral control action to help avoid the problem of wind-up during a move.
When set to 0, the integral term is active continuously. This is the normal setting.
When set to 1, the operation of the integral action is modified such that the position error is only added to the current integral total when the motor is static, in the idle position control state. The integral value is maintained constant throughout any moves to sustain any offset correction accumulated while static.

The default control word value of 01000000 makes the channel power up in the motor off state.

**Example : `CW00000001`**

This sets up the axis to use the auxiliary analogue output for torque control and power up in position control mode.

**Example : `CW01110000`**

This reverses the sense of both the encoder feedback and the analogue output to the drive amplifier.

## 4.5 Sequence Commands

This section describes the sequence commands. 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 a “memory full” error message. Sequences of commands for multiple motors may be defined if required. Command execution on different channels may be explicitly specified to proceed in sequence or in parallel, with each channel working independently.

A sequence which consists only of commands for one motor is downloaded complete to the current motor channel when it is first called up, and is executed by the axis controller module itself. The sequence remains in the axis controller’s local memory for future use. This means that after the first time a sequence is used, it may be executed immediately on that channel without waiting for the sequence to be loaded from the host system every time.

A sequence which includes commands executed solely by the host system, or which includes commands for more than one motor channel and the appropriate channel change commands, is handled in a slightly different way. The sequence is first analysed by the host system, and split into its various components to be executed on each motor, and on the host. Any parts of the sequence that can be executed on a single channel are downloaded to that channel as a single-channel sequence. When the sequence is executed, the host system performs its required operations, and calls up the various sub-sequences on each of the motor channels. The local single-channel sequences are assigned sequence numbers by the host system automatically, and are not available to the user. If a system sequence is modified or deleted, the host system modifies or removes the appropriate local sequences as required. This mechanism for breaking the sequence down into its single-channel components and storing them in the channel controller’s local memory is analogous to caching mechanisms used in computers to improve the response speed of the system to commonly used commands. It provides fast execution of any sequence on the MiniPTS 2+1, by storing the single channel sequence components locally on each channel.

This sequence analysis and downloading is completely automatic and requires no interaction on the part of the user or programmer. A sequence is said to be **compiled** when it is analysed in this way and its components are downloaded to the appropriate channels. All sequences may be compiled by using the CM compile command with no parameter, or any specific sequence may be compiled separately. Alternatively, any sequence which has not previously been compiled is automatically compiled before it is executed when the XS command is given. Note that a sequence which contains no channel change commands can only be compiled when it is executed on the current channel, since there is no information in advance to tell the system where to send the sequence components.

Commands and sequences may execute in sequence or in parallel on different channels. The default case is for all commands to be executed in sequence, except where specified explicitly by the CP change channels in parallel command. All synchronization and correct sequencing of operations on different channels is now performed automatically. For example, consider a sequence which executes a move on channel 1, executes a move on channel 2, then returns to channel 1 to execute a profile.

```
S1: CH1/MA20000
S1: CH2/MA10000
S1: CH1/XP1
```

This sequence executes correctly when it is entered as shown here, since the system waits for each operation on a motor to complete before changing to another motor for the next operation. If it is possible to allow the two motors to operate at the same time, then the sequence may be modified as shown below.

```
S1: CP1/MA20000/XP1
S1: CP2/MA10000
```

In this case, the CP 2 command specifies that the change to channel 2 should proceed in parallel with the action on channel 1. Thus the move on channel 2 will execute at the same time as that on channel 1.

If some degree of synchronization is required between operations taking place in parallel, then this may be specified by defining the sequence as a set of parallel sequence components which themselves execute in sequence. An example is a set of point-to-point moves in two axes on an XY table. Each two axis move consists of two moves running in parallel on two motors, but both moves must be complete on both motors before the next action can take place. The next example shows this, and also demonstrates how sequences may be nested.

```
S1: CP1/MA20000/CP2/MA10000

S2: CP1/MA0/CP2/MA0

S3: XS1/SO3/XS2/CO3
```

If more general synchronization is required, there are commands available to manipulate signals between the motor channels and the host system. These may be used for synchronising operations on the host system and the channel controllers. They provide a signalling mechanism in both directions, both to and from the host system. These signal commands allow the user to explicitly specify that the system should wait for a previous operation to complete before proceeding to the next stage of the sequence. They also allow sequences to be started automatically on receipt of a specific signal from a channel.

**ESnn** **Enter sequence (restricted).**
**Range : 1 to 255**

The sequence commands allow the user easily to build up complex sequences of machine operations and store them in the MiniPTS 2+1. A stored sequence may be called up and executed with a single command.

The ES command is used to enter stored command sequences into the system. The system responds with a “Snn:” prompt for the sequence entries. Each entry in the sequence can be any valid command line. Command strings on one command line are accepted as one sequence entry. Sequence entries may also include commands to execute other sequences and profiles, to allow sequences to be nested. To end the sequence, make a blank entry by just typing a carriage return, 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.

The enter sequence command is restricted. This is because sequences may themselves contain restricted commands. When a sequence is executed, any restricted commands within the sequence execute normally, even if the system is not in privileged mode. This allows the user to set up predefined sequences including restricted commands, which can normally only be used in privileged mode.

A previously defined sequence may be changed simply by entering a new sequence definition with the same number. A sequence is deleted by re-defining it as an empty sequence with no commands.

**Example :** Entering a sequence

| System | User | Comments |
|---|---|---|
| > | ES1<CR> | Enter sequence 1 |
| S1: | ID/IN–<CR> | Initialize position |
| S1: | MA100/WT256/MA0/WT256/RP3<CR> | Repeat this 3 times |
| S1: | MA2000<CR> | A single move |
| S1: | <CR> | End sequence |
| > | | Normal prompt |

**Example :** Deleting a sequence

| System | User | Comments |
|---|---|---|
| > | ES1<CR> | Enter sequence 1 |
| S1: | <CR> | End sequence |
| > | | Normal prompt |

**LS[nn]** **List sequence.**
**Range : 1 to 255, or no parameter**

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. If no sequence number is given in the command, the system lists the numbers of all sequences which are currently defined.

The escape key may be used to stop the LS command early.

**Example : LS1**
This lists sequence 1 on the display or terminal. The output for the sequence given above would look like this.

| System | User | Comments |
|---|---|---|
| > | LS1<CR> | User input to list sequence. |
| S1: ID/IN– | | |
| S1: MA100/WT256/MA0/WT256/RP3 | | |
| S1: MA2000 | | |
| > | | |

**Example : LS**
This lists all sequences that are currently defined.

| System | User | Comments |
|---|---|---|
| > | LS<CR> | List all sequences. |
| S1 | | Sequence 1 is defined... |
| S4 | | ...and sequence 4... |
| S5 | | ...and sequence 5. |
| > | | |

**XSnn** **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 aborts automatically if any error occurs. A sequence may be aborted manually by using the AX command. A multi-channel sequence may be aborted by using the GX global abort execution command.

The XS command saves the current channel, and returns to this channel when the sequence is finished. This allows easier nesting of sequences.

**Example : XS3**
The system executes stored sequence no. 3.

**RPnn** **Repeat command line.**
**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 command line is repeated indefinitely. A repeat command with a specified repeat count of zero is ignored. If the repeat command is the first command in a command string, it has nothing to repeat and returns the “no commands before RP” error message. Only one repeat command is allowed on any command line. By using repeats within sequences, it is simple to set up a complete cycle of operations which can be started with one execute sequence command.

Note that the AX command may be used to break out of any repeat loop prematurely, and the ER end repeat command may be used to break out of the loop at the end of the current loop.

**Example : `MA2000/MA0/RP5`**
This moves the motor to position 2000 and then back to position 0, and repeats it five more times, giving a total of six operations.

**ER** **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 AX command, which stops command processing 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.

**AX** **Abort command execution.**

This command aborts execution of any command strings or sequences running on the current channel. It leaves the motor in its current state.

If the AX command is issued while the channel is in the mapping or constant velocity states, the motor is left in mapping or constant velocity as appropriate. If AX is issued while the channel is executing a move or waiting, the move or wait is finished normally but following commands are aborted.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | VC+ | Execute constant velocity move |
| 1V | DP/WT50/RP | Display position repeatedly |
| 1 DP1000 | | Position display |
| 1 DP1500 | | |
| 1 DP2000 | ... | |
| | | |
| 1V | AX | Terminates position display |
| 1V | | Channel is still moving |

**BK** **Break out of sequence.**

This command causes the system to break out of the current sequence and to continue executing commands in the calling sequence (if any). This is useful for terminating a sequence early depending on the state of an input line.

**Example :**

```
1> LS10
S10: CH1/II1+/BK
S10: CH1/IN+/SO3
1> XS10/MA1000
1>
```

In the above example, the initialization of channel 1 will only take place if input line 1 is negative. If output line 3 is fed back to input line 1, sequence 10 can be executed at any time but only causes initialization once after power-up.

**ASnn** **Set autostart sequence (restricted).**
**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 nonvolatile memory. If no sequence number is given, the system prints the current autostart sequence number.

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. The system also displays an “undefined sequence” error message.

**FM** **Display free memory.**

This command displays information about the memory space available for sequences, maps and profiles. It returns both the global free memory space and the local free memory space on each axis. The system keeps track of the amount of spare memory each time a map, profile or sequence is entered or deleted.

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 the “memory full” error message when the total amount of spare memory is larger than the data being entered. This occurs because the system tries to allocate a single 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 |
|---|---|---|

```
1:          FM
Spare non-volatile memory 23271 bytes
Spare working memory 77576 bytes
Largest free block 75176 bytes
1:
```

**CHn** **Change channel.**
**Range : 1 to 3**

This command allows the user to switch between motor channels. It may be used at any time.

If the CH command is used in a command string or sequence, then the system executes the commands given for each channel in strict sequence. The commands given for the second channel are not executed until the commands for the first channel have been completed.

**CPn** **Change channel in parallel.**
**Range : 1 to 3**

This command allows the user to switch between motor channels in a command string or sequence, and allow simultaneous command execution on more than one channel.

All other commands between the start of the sequence, each CP command, and the end of the sequence are treated as separate blocks of commands to be executed in sequence. The different command blocks, separated by the CP commands, are executed in parallel. The system returns an error message if a motor channel is referenced in more than one parallel block of commands.

Note that the parallel execution does not imply any synchronization between channels. If synchronization is required in the middle of a parallel operation, then the user may program this explicitly using the signal command facilities described later. Alternatively, the same result may be accomplished by splitting the sequence into smaller sequences, each of which is fully parallel, and nesting these sequences inside another sequence which executes them in order.

**Example : `CP1/MA1000/CP2/MA2000`**
This shows an example of parallel command execution on two channels. The move command on channel 2 executes at the same time as that on channel 1.

**CM[nn] Compile sequence(s).**

This command is used to download sequence definitions into their required channel controller modules. The system sequences are analysed and split into sections, each of which may be executed by only one channel. These single channel sub-sequences are then sent to the required channels and stored locally on each channel. This is the sequence caching facility described at the start of this section. When a new sequence is entered, it is normally not compiled until it is first executed. This introduces a slight delay when a sequence is first used, because it must be analysed and downloaded to the required channels before it can be executed.

The CM compile command allows any sequence to be downloaded to the appropriate channels, so that there is no delay on executing the sequence. If no sequence number is given, all sequences are compiled, provided they include the channel change commands to indicate on which channels they are used. If a sequence number is specified with the CM command, then only that sequence is compiled, together with any nested sequences that it calls. In this case a sequence with no channel change commands is compiled and sent to the current channel.

When a programmed MiniPTS 2+1 is powered up, sequences are not compiled automatically. Any sequences that should be downloaded before execution should be compiled with specific CM commands in an autostart sequence, set by the AS command.

Note that profiles and maps are now stored on the host system until required by a particular channel. Any profiles or maps which are referenced by a sequence on a specific channel are automatically downloaded to the appropriate channels as part of the sequence compilation, as well as the sequence components. If the required map or profile is not yet defined, then the system returns an error message and the compilation is not completed. In this case, the sequence may be compiled again when the map or profile has been defined, or it may simply be compiled automatically when the sequence is first executed.

**GS** **Global stop.**

This command sends a stop command ST to all channels of a multi-channel system.

**GA** **Global abort.**

This command sends an abort command AB to all channels of a multi-channel system.

**GF** **Global motor off.**

This command sends a motor off MO command to all channels of a multi-channel system.

**GX[nn]** **Global abort execution.**

This command sends an AX abort execution command to all channels, and also stops any processing of commands or sequences by the host. If the system is executing some operation and a command string beginning with GX is entered, then the current operation is stopped and any commands following the GX command are executed. This provides an override facility similar to that available with ER.

If a sequence number is specified in the GX command, then that particular sequence is aborted.

**USnn** **Send user signal to host.**
**Range : 1 to 127**

This command is used in command sequences to send a user-defined signal from an axis to the host system. The parameter gives the signal number sent to the host system. This is used, for example, to indicate to the host system that an operation is complete. The signal sets a **channel-specific** internal flag in the host system. This flag is tested by the HW host wait for signal command.

It is also possible to assign a sequence to execute automatically on receiving a specified user signal from a specific channel. This is done with the SX command, described on page 55. This is used, for example, to assign a multi-channel system sequence to execute when an input line is detected on a channel. The input line is programmed with the DI command to return a user signal to the host system, and the host system assigns a sequence to that signal on that channel.

**HWnn** **Host system wait for user signal.**
**Range : 1 to 127**

This command complements the US command above. It tells the host system to wait for a specified user signal **on the current channel** before continuing on to the next step in a system sequence. The system tests an internal flag, set by the specified signal, and continues with normal execution when the flag is set by the receipt of the signal. If the signal has been received before the HW command is executed, then the system continues immediately.

**ZSnn** **Initialize signal number nn.**
**Range : 1 to 127**

This command clears an internal flag for the specified signal on the current channel. It is used to initialize the flag before use with the HW command above, and to clear it after use.

**Example :**

```
S1: CH1/ZS1/MA1000/MA0/US1/HW1/ZS1
S1: CH2/XP5
```

This sequence shows the use of the signal commands. The system waits for user signal 1 to be received at the end of the first command line before proceeding to the next line. In this particular example, the signal commands are not required since the system forces sequential operation anyway, but they may be useful in other synchronization applications.

**SXn/n** **Set sequence to execute on a signal (restricted).**
**Range : signal number - 1 to 127**
**sequence number - 0 to 255**

This command sets up a given sequence to execute automatically on receiving the specified signal from the current motor channel. It requires two parameter values. The first parameter specified in the SX command is the signal number used, and the second parameter is the number of the sequence to be executed on receiving the specified signal from the current channel. This can be used in conjunction with the DI and US commands to provide global input function definitions on a multi-axis system. It is also used with the DX expanded input lines command to assign sequences to the expanded input codes. To disable the sequence for a given signal, assign sequence number zero to it.

If the SX command is given with no parameter, all SX definitions are listed.

Note that each channel has its own unique set of user signals. Signals on any channel are distinct from those on all other channels. This means that the SX definitions are also channel-specific.

**Example :**

| System | User | Comments |
|---|---|---|
| 2> | CH1 | Change to channel 1 |
| 1> | DI3-/US31 | Define input 3 to send signal 31 |
| 1> | SX31/12 | Assign sequence 12 to signal 31 |
| 1> | | |

This example shows how to set up input line 3 on channel 1 to execute sequence 12, by assigning the sequence to user signal 31, and defining input line 3 to send signal 31 when it goes to a logic low.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | SX | List current SX links to sequences |
| 1/1 | | Signal 1 starts sequence 1 |
| 2/5 | | Signal 2 starts sequence 5 |
| 31/12 | | Signal 31 starts sequence 12 |
| 1> | | |

This example shows how to list the current set of sequences attached to user signals.

**MUnn** **Mask user signal(s).**
**Range : 1 to 127**

This command is used to inhibit user-defined signals on the current channel. If a signal number is given, then the specified signal is masked. If no parameter is given, all user signals on the current channel are masked.

**EUnn** **Enable user signal(s).**
**Range : 1 to 127**

This command is used to enable user-defined signals on the current channel. If a signal number is given, then the specified signal is enabled. If no parameter is given, all user signals on the current channel are enabled.

**MEnn** **Set motor off error sequence (restricted).**
**Range : 0 to 255**
**Default : 0**

This command sets up a sequence to execute when any motor off error occurs on the current channel. If no sequence number is given, the system prints the current motor off error sequence number for the current channel. To disable the motor error sequence on this channel, set ME to zero. Note that the motor off error sequence may include commands for any channel(s).

**UEnn** **Set user error sequence (restricted).**
**Range : 0 to 255**
**Default : 0**

This command sets up a sequence to execute when any user error occurs on the current channel. If no sequence number is given, the system prints the current user error sequence number on this channel. To disable the user error sequence on the current channel, set UE to zero. Note that the user error sequence may include commands for any channel(s).

## 4.6 Profile Commands

This section describes the profile commands. They provide facilities for setting up motions with user-defined velocity profiles (the Software Cam). Profile definitions may be entered up to the memory capacity of the system. If the system runs out of memory, it returns a “memory full” error message.

The normal move commands allow the user to easily move the motor to any possible position. However, they use the trapezoidal velocity profile defined by the set velocity and acceleration parameters. In some applications, it may be desirable to use a different velocity profile such as a cosine or parabolic profile, in order to get best results from the motor or to limit the stresses in the mechanical system. It is also not clear from the normal move parameters exactly how long a given move command takes to complete, and it may be important in some machines to specify a motion that is known to take a specific time to execute. In either of these cases the profile move facilities are very useful.

The profile commands allow a velocity profile to be completely specified by the user as a table of positions. This gives the user complete flexibility over the motor velocity and acceleration. A typical application of this is where the profile is calculated to take into account higher order derivatives of position such as “jerk”, to give a particularly smooth motion. The profile table also defines exactly the time taken for the profiled move to execute, since this is equal to the number of entries in the table multiplied by the profile step time.

Data for the profiles is entered as absolute positions, or as relative position increments. In the absolute position format, each profile table entry represents the next motor position at that time step, relative to the start of the profile. In the relative position format, each table entry represents the change in position at each time step. The selection of either absolute or relative position format is controlled by bit 4 of DW, the display options word.

The profile step rate, or profile velocity, is itself programmable via the PV command. The profile velocity may be defined from 1 to 256 steps per second. At the slower step rates, intermediate position values between the positions given in the profile table are calculated by interpolating linearly between the table values. This maintains the smoothness of the speed control even at the slowest step rates.

The map step value, set by the MS command, is also used to set the profile table interpolation step size. If the map step value is greater than one, the EP command prompts the user for new position values at intervals of MS. The first entry in a profile table is at step MS. This allows the user to enter positions at longer time intervals, and the system interpolates linearly between them to generate the full resolution profile. The profile data is stored at the reduced resolution specified by MS, again saving memory space. When the profile data is displayed using the LP list profile command, it is listed at the value of MS at which the data was entered. When the profile is executed, the profile step rate is effectively PV/MS steps per second, with the motor moving at a constant velocity for the duration of each step.

Profiles may be generated automatically by the optional Motion Generator package, if enabled by the appropriate software key. To make best use of the available memory in the system without reporting unnecessary “memory full” errors, profiles with numbers above 200 are **not** saved to non-volatile memory with the SP command. These may be generated on demand and use working memory, rather than filling up the memory area allocated to the saved data.

**EPnn** **Enter profile nn (restricted).**
**Range : 1 to 255**

The EP command is used to enter move profile tables into the system. The system responds with a “Pnn:” prompt for the table entries. Each entry in the table is the (signed) distance between the new position and the start of the profile, that is, the required cumulative motor position relative to the start of the profile. To end the table, make a blank entry by typing just a carriage return, and the system then returns to normal operation.

**Example :** A very short profile!

| System | User | Comments |
|---|---|---|
| > | EP1 | Enter profile 1 |
| Absolute mode | | Position format |
| P1: | +10 | First position |
| P1: | +40 | |
| P1: | +100 | |
| P1: | +180 | |
| P1: | +270 | |
| P1: | +350 | |
| P1: | +410 | |
| P1: | +440 | |
| P1: | +450 | Final position |
| P1: | <CR> | End profile |
| > | | Normal prompt |

If bit 4 of DW is set, then the profile is entered as a table of (signed) relative position increments instead. The table values now represent the change in position at each time step, and thus the table may be viewed as a velocity profile.

**Example :** The same profile entered as relative position steps.

| System | User | Comments |
|---|---|---|
| > | EP1 | Enter profile 1 |
| Relative mode | | Position format |
| P1: | +10 | First relative move |
| P1: | +30 | |
| P1: | +60 | |
| P1: | +80 | |
| P1: | +90 | |
| P1: | +80 | |
| P1: | +60 | |
| P1: | +30 | |
| P1: | +10 | |
| P1: | <CR> | End profile |
| > | | Normal prompt |

**LP[nn]** **List profile nn.**
**Range : 1 to 255, or no parameter**

This command allows the user to examine a profile that has previously been entered into the system. The profile table is listed on the display or terminal, one table entry per line. The system prints the profile number, the step number, and then the position value for the entry. The total time taken for the profile to execute is given by the step time multiplied by the number of steps in the profile, which is equal to the step number of the last entry in the profile table.

If no profile number is given in the command, the system lists the numbers of all profiles which are currently defined.

If bit 4 of DW is set, the profile is listed as the relative position increment at each step, instead of as the cumulative position through the table at each step. At the end of the profile it then prints the total distance for the profile.

The escape key may be used to stop the LP command early.

**Example : `LP1`**
This lists profile 1 on the display or terminal. The output for the above example would look like this, in absolute position format.

| System | User | Comments |
|---|---|---|
| `>` | `LP1<CR>` | User input to list profile. |
| `Absolute mode` | | Position format |
| `P1 1: +10` | | |
| `P1 2: +40` | | |
| `P1 3: +100` | | |
| `P1 4: +180` | | |
| `P1 5: +270` | | |
| `P1 6: +350` | | |
| `P1 7: +410` | | |
| `P1 8: +440` | | |
| `P1 9: +450` | | |
| `>` | | |

The output for the same example would look like this in relative position format.

| System | User | Comments |
|---|---|---|
| > | LP1<CR> | List profile command. |
| Relative mode | | Position format |
| P1 1: +10 | | |
| P1 2: +30 | | |
| P1 3: +60 | | |
| P1 4: +80 | | |
| P1 5: +90 | | |
| P1 6: +80 | | |
| P1 7: +60 | | |
| P1 8: +30 | | |
| P1 9: +10 | | |
| Total distance = 450 | | |
| > | | |

**Example : LP**

This lists all currently defined profiles on the display or terminal.

| System | User | Comments |
|---|---|---|
| > | LP<CR> | List all profiles. |
| P1 | | Profile 1 is defined. |
| P3 | | Profile 3 is defined. |
| > | | |

**XPnn[–]** **Execute profile nn.**
**Range : 1 to 255**

This command tells the system to execute profile number nn. The ‘P’ profile prompt character is given while a profile is executed. The speed at which the system steps through the table (the profile velocity) is set by the PV command. Note that a profile is always executed **relative** to the current demand position. If the profile number is followed by a minus sign, the profile is executed in the reverse direction. A profile move may be aborted by using the AB, ST or MO commands. If the ST stop command is used, the motor decelerates to a stop from the current instantaneous speed at the deceleration rate set by the DC command.

**Example : XP1**
The motor executes the stored profile no. 1, at the speed set by the PV command.

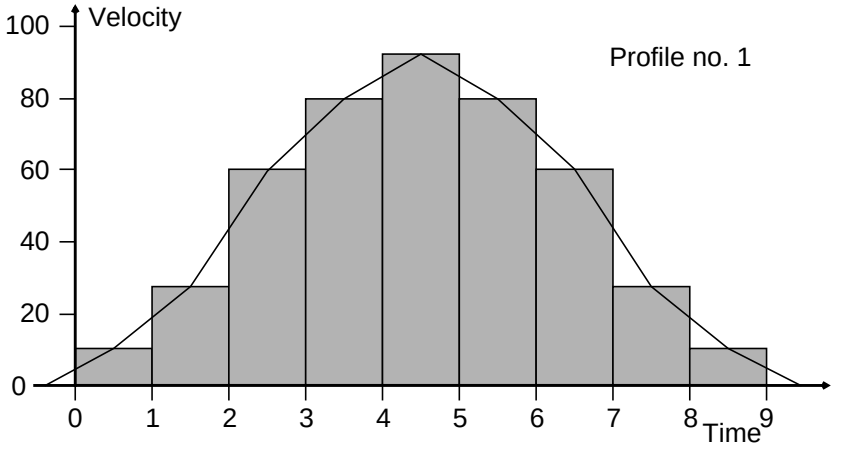



**Figure 13. Profiled move.**

**PVn** **Set profile velocity.**
**Range : 1 to 256**
**Default : 32**

This command sets the rate at which the channel steps through a profile table, known as the profile velocity. The step rate is defined in steps per second. The channel interpolates linearly between table points at the slower speeds in order to maintain smooth motion.

The profile velocity may be changed at any time, even while executing a profile.

**Example : `PV16`**
This sets the profile velocity, or step rate, to 16 steps per second.

**TPnn** **Transfer profile.**
**Range : 1 to 255**

This command tells the system to transfer the specified profile to the current motor channel.

The profile data is held internally as relative positions from the start of the profile.

**FM** **Display free memory.**

This command displays information about the memory space available for sequences, maps and profiles. It returns both the global free memory space on the host processor and the local free memory space on each axis controller. For more details refer to the full description of the FM command on page 50.

## 4.7 Map Commands

This section describes the commands to use the position mapping or “Software Gearbox” facilities.

The position mapping commands provide a mechanism for defining the required position of a slave motor with respect to a given master channel, for all possible positions of the master channel. The master channel may itself be controlling a motor, or it may simply be monitoring the position of, for example, a line shaft to which other motors must be synchronized. The mapping itself consists of a table of slave position values,. When the map is executed on the slave axis, its demand position is calculated by using the current master position as an index into the map table, and then using the value in the table as the slave demand position.

In a simple case, this allows a wide range of linear gear ratios to be defined between the master and slave axes. In more complex applications, it allows the system to mimic the action of nonlinear systems, where the position of the slave motor has some more complicated relationship to the master axis position. This can be used to replace eccentric gearbox mechanisms, crankshaft linkages, cam operated pushrods, or almost any mechanical linkage or transmission system with equal ease, simply by defining the required map table.

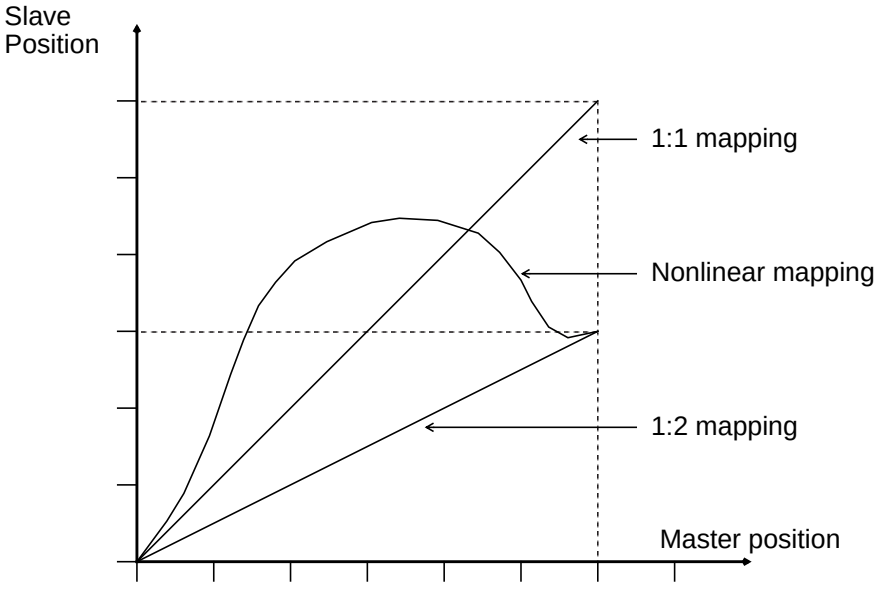



**Figure 14. Simple position maps.**

On a machine where both master and slave axes are only moving from point to point within a finite range of positions, for example on an XY table, the mapping simply needs to be defined over the range of master position actually used, and the mapping itself then defines the slave position range. This is the simplest application. In such a system, there is no need to set up the position bounds on either channel. They may be left at the default value, since the motor positions are constrained within fixed ranges and the motors cannot move continuously in one direction.

The diagram below shows a typical position mapping, where the slave channel is following some position profile relative to the master axis. This could be, for example, the path for a cutting tool on a machine where the master axis speed varies to maintain a constant linear tool speed across the material. This could not be easily achieved by other methods, which would rely on keeping the cutter motion synchronized in time with the master axis motion. This could only be set up for one specific master axis speed or profile, and would need to be reprogrammed to allow the machine to be run at a different speed. Using the position mapping mechanism, the master axis speed may be varied at any time, even during a cut, and the cutter stays on the correct path, as defined by the mapping.

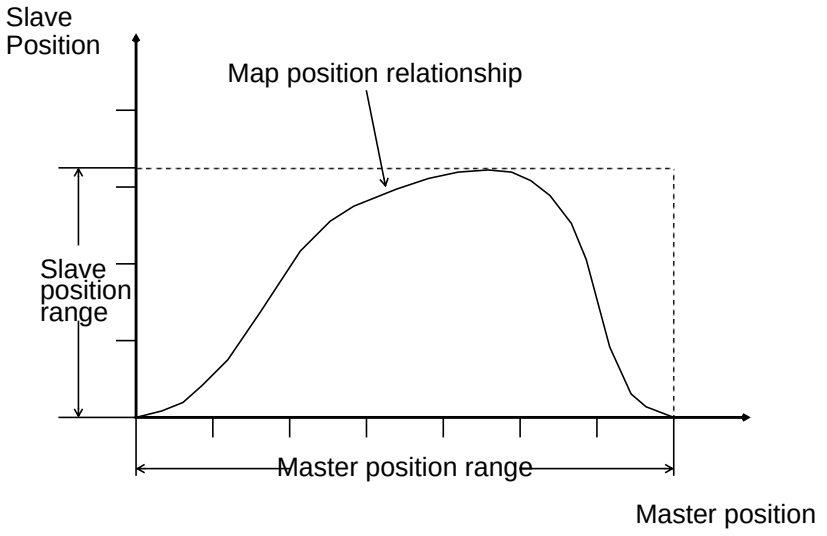



**Figure 15. Position mapping over a defined range.**

The example shown above could also apply to a machine where the master axis is a continuous rotary axis, such as a line shaft, with the slave axis profile repeating once for every cycle of the master axis. In this case the master bound position must be set to the master axis cycle length, and also copied to the slave axis with the MP map bound command.

On a machine where either or both axes are cyclic, the position bounds on each axis are set to the cycle length for that axis. The mapping must be defined such that the required slave axis position is continuous at the points where the master and slave axes pass their respective bound positions. If this is not done, the discontinuity in the mapping at the position bounds could give rise to very sudden changes in speed and position of the slave motor when the bound positions are reached.

If the slave position is not continuous across the map boundary, the difference between the required slave cycle length and the actual cycle length given by the mapped master position bound appears as a small shift of the slave axis relative to the master axis. This error accumulates over several cycles of the machine and behaves as an apparent drift of the slave axis. This type of problem is difficult to spot, but can be prevented by careful definition of the position map table.

The mapping should be defined over the master position range from zero to at least the master axis bound position. In addition, the master axis bound position value must be known by the slave axis, so that when the master axis position wraps around to zero at the bound position, the slave axis knows how to adjust its mapped demand position in order to maintain its speed across the master wraparound point. This is done automatically by the system when the ML map link command is used, but may be done manually if required by using the MP command.

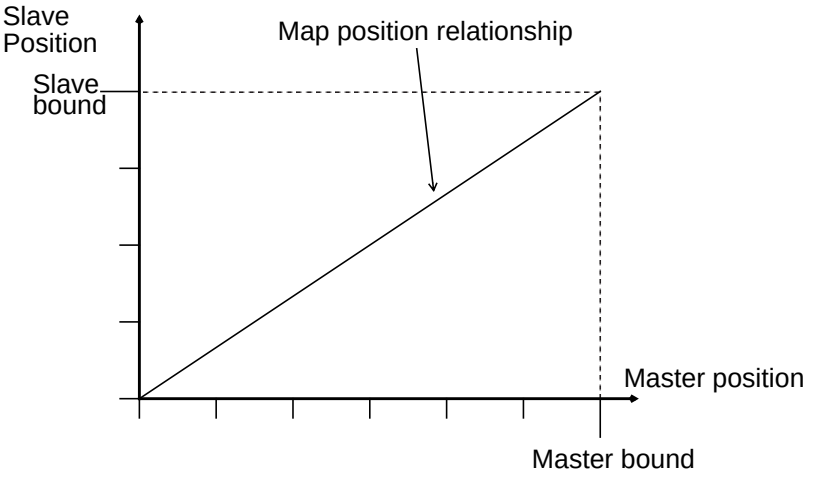



**Figure 16. Position map for a cyclic machine.**

The diagram above shows a system where the master and slave axes both complete one cycle in the same time, although they cover different distances, and the master and slave bound positions are coincident. It is not necessary for the master and slave bound positions to coincide, or for the slave axis bound position to repeat in the same interval as the master axis bound. In fact, in any linear ratio mapping other than the simple 1:1 case, the bound positions will not coincide and may not necessarily repeat at the same rate. This does not cause any problems in executing the map. It is also possible for the required slave position to go outside the slave bound value without any problems. In this case, the slave channel compensates automatically for its wraparound when it passes the bound position.

The position mapping between the master and slave channels may be modified by the map base and map offset commands. These appear to be similar, but have subtly different effects in practice. They shift the position map relationship along either the master position or the slave position axis. The map base value is subtracted from the master axis position before indexing into the map table. This has the effect of shifting the map curve to the right on the graph. The map offset value is added to the slave position value calculated in the mapping. This has the effect of moving the map curve up the graph. These two parameters allow any or all slave axes to shifted or rotated relative to the master axis, even while executing a mapping. An example of a similar situation is the ignition timing on a car engine; the timing adjustment involves rotating the distributor shaft relative to the crankshaft, so that the spark is generated earlier or later in the engine cycle.

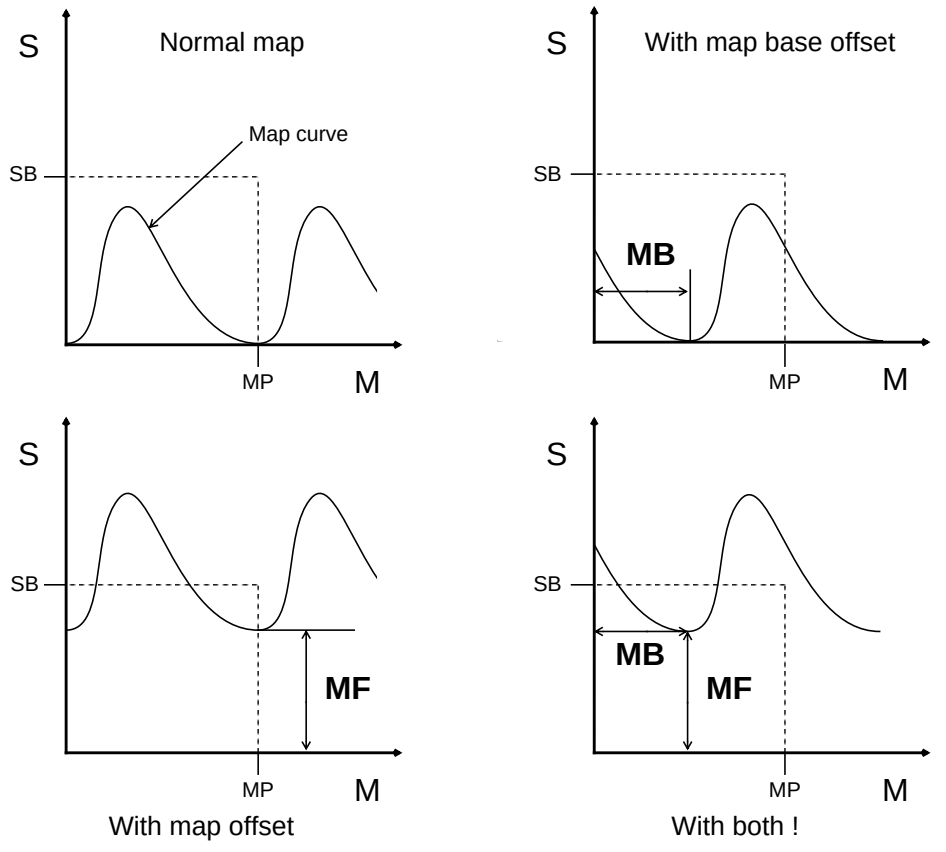



**Figure 17. Effects of map base and map offset.**

Data for the maps is entered as absolute slave axis positions, or as relative position offsets from the master axis position. In the absolute position format, each map table entry represents the required slave motor position at the given master axis position. In the relative position format, each table entry represents the difference between the slave axis position and the master axis position. The selection of either absolute or relative position format is controlled by bit 4 of DW, the display options word.

The map step value, set by the MS command, is used to set the map table interpolation step size. If the map step value is greater than one, the EM command prompts the user for new slave position values at master position intervals of MS. The first entry in a map table is at master position zero. This allows the user to enter positions at larger master position intervals, and the system interpolates linearly between them when the map is executed. The map data is stored at the reduced resolution specified by MS, again saving memory space. When the map data is displayed using the LM list map command, it is listed at the default value of MS on the current channel, and the (possibly different) value of MS at which the data was entered is shown before the list of data.

Maps may be generated automatically by the optional Motion Generator package, if enabled by the appropriate software key. To make best use of the available memory in the system without reporting unnecessary “memory full” errors, maps with numbers above 200 are **not** saved to non-volatile memory with the SP command. These may be generated on demand and use working memory, rather than filling up the memory area allocated to the saved data.

**EMnn** **Enter map nn (restricted).**
**Range : 1 to 255**

This command is used to enter position mapping tables into the system. The system gives a “Mnn xx:” prompt for each table entry, where “nn” is the map number, and “xx” is the entry number, corresponding to the master axis position for this entry. Each entry in the table is the (signed) absolute position on the slave axis at the current master channel position given by the table entry number. The master axis position is used as the index into the table to access a particular table entry. The value found at that table position is then the required slave axis position. To end the table, make a blank entry by entering just a <CR>, and the system then returns to normal operation. The mapping is accessed by means of the map number assigned by the user when it is entered.

Position map data may be entered up to the memory capacity of the system. If the system runs out of memory, it returns the “memory full” error message.

If bit 4 of DW is set to 1, then the map is entered as a table of offset values between the master axis and the slave axis positions. Each entry in the table is the (signed) difference between the master channel position and the required position of the slave channel. The master axis position is again used as the index into the table to access a particular table entry. The value found at that table position is the offset to be added to the master axis position to get the required slave axis position.

The map step value MS can be stored within the map table, ensuring that when the map is executed it always uses the intended value. To use this facility, the MS command is used as the first entry in the map table after the EM command, at the “Mnn 00:” prompt. This does not affect the default value of MS for the current channel, which is still used for listing the map with the LM command.

**NOTE :**

- The MiniPTS 2+1 system has 32k bytes of non-volatile memory for storage of all parameter values and map data etc. Care should be taken when using large map data tables that the stored data will fit within this limit.

**Example :**

This example shows the entry of a map in absolute position format. It sets up a mapping with the slave position equal to twice the master position; this gives the effect of a 2:1 gear ratio between the slave and master axes.

| System | User | Comments |
|---|---|---|
| 1> | EM1<CR> | Enter map 1 |
| Absolute mode | | Position format |
| M1 0: | 0 | First slave position |
| M1 1: | 2 | |
| M1 2: | 4 | |
| M1 3: | 6 | |
| M1 4: | 8 | |
| M1 5: | 10 | |
| M1 6: | 12 | |
| M1 7: | 14 | |
| M1 8: | 16 | |
| M1 9: | 18 | |
| M1 10: | 20 | |
| M1 11: | <CR> | End map |
| 1> | | Normal prompt |

The next example shows the same mapping entered in relative position format as a table of offsets, with the offset equal to the master position; this gives the same effect of a 2:1 gear ratio between the slave and master axes.

| System | User | Comments |
|---|---|---|
| 1> | EM1<CR> | Enter map 1 |
| Relative mode | | Position format |
| M1 0: | 0 | First offset value |
| M1 1: | 1 | |
| M1 2: | 2 | |
| M1 3: | 3 | |
| M1 4: | 4 | |
| M1 5: | 5 | |
| M1 6: | 6 | |
| M1 7: | 7 | |
| M1 8: | 8 | |
| M1 9: | 9 | |
| M1 10: | 10 | |
| M1 11: | <CR> | End map |
| 1> | | Normal prompt |

**LMnn** **List map nn.**
**Range : 1 to 255**

This command allows the user to examine map data previously entered into the system. The specified map is listed to the serial port, one map entry per line. Each entry is shown with its entry number, which represents the corresponding master axis position, followed by the slave position for that master position.

If bit 4 of DW is set to 1, the map is listed in relative position format as a table of position offsets between master and slave positions. The map entry value is the position offset added to the master axis position to generate the slave axis position.

The escape key may be used to stop the LM command early.

**Example : `LM1`**
This will list map 1 on the display or terminal. The output for the example above would look like this, in absolute position format.

```
1>              LM1<CR>     User input to list map 1.
Absolute mode               Position format
M1 0: 0
M1 1: 2
M1 2: 4
M1 3: 6
M1 4: 8
M1 5: 10
M1 6: 12
M1 7: 14
M1 8: 16
M1 9: 18
M1 10: 20
1>
```

This shows the same list map in relative position format.

```
1>              LM1<CR>     List map 1 command.
Relative mode               Position format
M1 0: 0
M1 1: 1
M1 2: 2
M1 3: 3
M1 4: 4
M1 5: 5
M1 6: 6
M1 7: 7
M1 8: 8
M1 9: 9
M1 10: 10
1>
```

**XMnn** **Execute map nn.**
**Range : 0 to 255**

This command puts the currently selected axis into the position mapping mode, where its demand position is calculated according to the specified mapping from another (master) channel's position. The master channel position is transferred to all slave channels; this is set up automatically when the slave channel is linked to the master channel with the ML map link command. While a channel is executing a position mapping, it gives the 'X' map mode prompt character. The stop or abort commands are used to exit from map mode.

**NOTE :** A map number of zero in the XM command is used for the special case of 1:1 mapping. If map zero is executed, the slave channel executes a 1:1 mapping, and it is not necessary to explicitly enter the 1:1 map data into the system.

When the slave axis executes a map, it has a choice of startup methods, as described here. If the master axis is stationary, then the slave axis can align itself with the required mapped position and then go into the mapped state (the alignment move). If the master axis is moving, then the slave axis can wait for the required mapped position to pass the current slave position, and then start following the mapping as it passes. This facility is called the Software Clutch, and is selected by bit 0 of MW, the map options word, which is described later. A third option is available, where the map offset value MF is adjusted automatically to maintain the position relationship between the master and slave axes; thus there is no alignment move and mapping starts immediately. This is selected by setting bits 0 and 2 of MW.

If the XM command is part of a string, the commands following XM are not executed until the slave axis has finished the alignment move or has synchronized with the master axis using the Software Clutch.

The action of the XM command is modified if tension control is on, as set by the AM1 command. When tension control is on, the map startup sequence is determined byAW bit 0. If AW bit 0 is set to 0, the slave axis goes immediately into mapping, using the software clutch, with the map ratio determined by the tension control loop. If AW bit 0 is set to 1, the slave axis moves at jog speed (set by SS) until the measured analogue input reaches the tension control setpoint, and then drops into mapping. This is intended to initialize tension control when the master axis is stationary. The direction of the slow speed initial move is set byAW bit 6.

If either of AW bits 4 and 5 are also set to 1, then the unit automatically initializes the map scale factor before executing the map under tension control. The system measures the distance moved by the master and/or slave axes between the two positions where the analogue input high and low limits are exceeded. The ratio of these two values gives a good estimate of the initial map ratio required by the tension control loop and is used at the start of synchronization. This allows the system to reach its correct steady state ratio much more quickly than if it starts from the default SM value, particularly if the system is not at its normal starting position.

An example where this is useful is a winding or unwinding application. In normal circumstances the system always starts with either a full or empty spool of material, and the initial scale factor is set in the SM parameter. Restarting the machine with the same spools uses the scale factor last calculated when the machine was stopped, and the tension loop restarts smoothly. However, if the machine may be started with spools that are partly filled to an unknown diameter, then the normal SM value is not at the correct value for running at the new spool diameter. The analogue range initialization function allows the required ratio with the actual spool diameters to be measured. The machine may be started with the new spool without any large transients while the tension control loop stabilizes from the initial default SM value to the new scale factor.

**MSnn** **Set interval between position map entries.**
**Range : 1 to 65535**
**Default : 1**

This command sets a map table step size for use when entering a simple mapping. If it is set to a value greater than 1, then when a map is entered, the user is required to only enter map data values at the given interval. The system interpolates between the values entered when the map is executed.

This function also reduces the size of memory required when saving the map table in nonvolatile memory.

Note that the interpolation step size set by the MS command also applies to profiles when entering them with the EP command or executing them with XP.

**Example :**
This example first sets a map step of 100, then sets up a mapping with the slave position equal to twice the master position as in the EM example. In this case the map table has been generated over a range of master axis positions from 0 to 1000 with only ten entries by the user. This map also only requires one hundredth of the storage space of the equivalent full resolution map table.

| System | User | Comments |
|---|---|---|
| 1> | MS100 | Set map step to 100 |
| 1> | EM1<CR> | Enter map 1 |
| Absolute mode | | Position format |
| M1 0: | 0 | First slave position |
| M1 100: | 200 | |
| M1 200: | 400 | |
| M1 300: | 600 | |
| M1 400: | 800 | |
| M1 500: | 1000 | |
| M1 600: | 1200 | |
| M1 700: | 1400 | |
| M1 800: | 1600 | |
| M1 900: | 1800 | |
| M1 1000: | 2000 | |
| M1 1100: | <CR> | End map |
| 1> | | Normal prompt |

**TMnn** **Transfer map.**
**Range : 1 to 255**

This command tells the system to transfer the specified map to the current motor channel.

**MLnn** **Map link slave axis to master axis nn.**
**Range : 1 to 3**

This command links the current channel to the specified master channel in preparation for execution of a position mapping. Note that a slave channel must be linked to some master channel before executing a map, or the slave channel gives the “not linked” error message.

If the ML command is given with no parameter, the system prints the channel number of the master axis for the current channel, if it is linked.

On the MiniPTS 2+1, a fifth logical channel is available in addition to the four real channels. This extra channel may be used as a virtual axis, for example in mapping or when using the Software Differential, or it may be used as an undriven encoder axis when the expansion board with the optional encoder interface is fitted.

**UL** **Unlink slave axis from master axis.**

This command is used to unlink a slave axis from its master axis after finishing a position mapping. Note that channels may be left linked to their master axis if required, while other commands are executed. It is only necessary to use the UL unlink command if the slave channel needs to be linked to a different master axis.

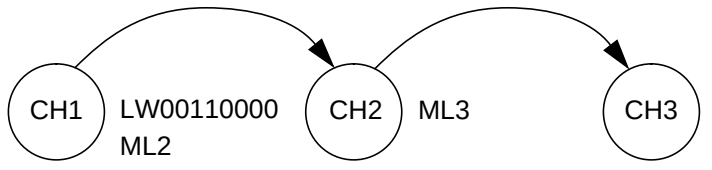
 

**LWbb** **Set link options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command allows the user to modify the operation of the map link function. It also enables the “Software Differential” function. The value is entered as a binary number, with each bit controlling a different aspect of the position mapping. Leading zeros may be omitted. The bit functions for the link options word are described below.

The Software Differential allows a slave motor to be synchronized so that it follows either the sum of or difference between the positions of two master axes. The slave axis must be linked to a master axis with the ML command, and this master axis must itself be linked to a second master axis. LW bits 4–6 control how the slave axis uses the position information from the two master axes.

Example setup for software differential




Slave axis First master axis Second master axis

Slave axis demand position = first master position – second master position

Note that the master channels may be in any state, provided the map links are set up as required. In particular, it is not necessary for the first master axis to execute a map in order to make use of the position data from the second master axis.

Bit 0 This bit controls whether the slave axis follows the master axis demand position or measured position. Normally the slave is set up to follow the master demand position, as this gives smoother motion on the slave axis. Sometimes it is more useful to set up the slave axis to follow the measured master position, particularly if the master axis has a large following error.
When set to 0, the slave axis is linked to the master axis demand position.
When set to 1, the slave axis is linked to the master axis measured position.

Bit 1 Reserved.

Bit 2 Reserved.

Bit 3 Reserved.

Bit 4 When this bit is set to 1, the Software Differential function is enabled. The master position data used by this channel is the sum or difference between the positions of two separate master channels.
When set to 0, the Software Differential function is disabled.

Bit 5 This bit determines whether the current channel uses the sum or difference between the two master channel positions when the Software Differential is enabled by setting LW bit 4.
When set to 1, the second master channel position is subtracted from the first master channel position.
When set to 0, the first and second master channel positions are added together.

Bit 6 When this bit is set to 1, the master position data is negated before being used by the current channel.
When set to 0, the master position data is used unchanged.

Bit 7 Reserved.

**MB±nn** **Set map base offset for master map positions.**
**Range : ± 4 000 000 (4.0E6)**
**Default : 0**

This command sets a map base value. This value is subtracted from the master axis position before using the position data on the slave axis. An alternative description is that it defines the base position of the mapped region on the master channel, such the slave channel is mapped onto the master channel position for the range (MB) to (MP+MB). Normally the mapping is defined over the range from zero to the master axis bound position MP. The MB parameter allows the slave channel to be advanced or retarded relative to the master axis.

**MF±nn** **Set slave map position offset.**
**Range : ± 4 000 000 (4.0E6)**
**Default : 0**

This command sets a map offset value. This value is added to the slave position obtained from the mapping. This allows the slave axis map profile to be rotated or shifted relative to the master axis.

Note that when speed mapping is enabled by setting MW bit 4, the MB and MF parameters have no effect on the initial relative positions of the master and slave axes. However, any changes in MB or MF while in speed mapping are applied to give the required change in position of the slave axis.

**SMn/n** **Scale mapping.**

**Range : multiplier : 0 to 65535**
**divisor : 1 to 65535**
**overall ratio : 0/255 to 255/1**
**Default : 1/1**

This command is used to set a scale factor for mapping. It is used on the slave channel, **not** on the master. The required absolute position on the slave channel, as defined by the mapping from the master position (or result of any software differential), is multiplied by the first parameter value and divided by the second value. This allows a wide range of scale factors to be realized, while keeping a simple integer ratio scale function. Note that changing the map scale factor while executing a map can give erratic results, because this may change the required slave axis demand position by a large amount. To avoid this problem AV can be used to smooth out the changes in SM.

The MB map base value scales in the same way, as it represents a shift on the master axis. The MF map offset value does not scale, as it represents a shift on the slave axis, measured in encoder counts.

**Example : `SM1096/361`**
This shows the map scale factor set to 1096 / 361. Thus the required slave position at any point is calculated by multiplying the result of the normal mapped position calculation (absolute slave demand position) by the factor 1096 / 361.

**BR** **Set map scale factor from bounds ratio.**

This command is used to automatically calculate the map scale factor (SM) on the slave axis from the ratio of the slave bounds to the master bounds. The scale factor calculated is equivalent to SB/MP. Because the scale factor depends on the value of MP, the BR command should only be executed after MP has been defined. This is normally done by executing the ML command. The correct sequence of operations is shown in the following example.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | SB4000 | Set master axis bounds |
| 1> | CH2 | Change to slave channel |
| 2> | SB5000 | Set slave bounds |
| 2> | ML1 | Link slave to master axis |
| 2> | BR | Calculate scale factor |
| 2> | XM0 | Execute map zero |

**AVn** **Set map base/offset/scale factor adjustment velocity**
**Range : 0 to 8**
**Default : 0**

This command sets the adjustment speed for any change in the map base, map offset or map scale factor values entered while the axis is executing a map. It is used to make large adjustments smoothly by spreading them over several time steps. If AV is set to zero, then any map base, offset or scale factor adjustment is performed immediately in one step.

If AV is not zero and the axis is executing a mapping, then the adjustment of **map base or offset** is limited to a set maximum speed, given by the sum of the adjustment velocity and the current (instantaneous) motor velocity. The adjustment velocity is a power of two fraction of the current motor speed, defined by the value of AV. This means that the adjustment speed scales automatically with the machine speed, such that the value of AV may be chosen for correct operation at full machine speed without causing unnecessarily quick adjustments at lower machine speeds.

At the maximum value of AV=8, the adjustment speed is equal to the current motor speed, and the adjustment is thus performed at twice the current motor speed. Each time the value of AV is reduced by one, the adjustment speed is halved, down to the minimum value of AV=1 when the adjustment speed is 1/128 times the current motor speed.

If AV is not zero and the axis is executing a mapping, then the change in **map scale factor** is applied at a rate defined by the value of AV. At the maximum value of AV=8, the adjustment is applied at a rate of ΔSM per 4ms tick. Each time the value of AV is reduced by one, the rate of adjustment is halved, down to the minimum value of AV=1 when the adjustment is applied at a rate of ΔSM/128 per 4ms tick.

If the module is not currently executing a map when a change is made to the map base, offset or scale factor, then the change takes place immediately. If the axis is in the middle of the alignment move at the start of execution of a map, then the adjustment is delayed until the alignment move is complete, so that there is no sudden change in required slave position when it reaches the end of the alignment move.

**MPnn** **Set master position bound, or map bound**
**Range : 1 to 4 000 000 (4.0E6)**
**Default : 4 000 000**

This command is used to pass the master channel position bound value to any slave channels.

**NOTE :** It is essential for the slave channel to have this information so that the mapping is continuous at the point where the master position wraps around to zero, that is, the master bound position. On a rotary system, where both the master and slave axis positions wrap around at their bound positions, it is very important to make sure that the distance between bounds on the master corresponds with the distance between bounds on the slave axis. If this is not correct, then the slave axis will appear to drift relative to the master axis position, because of the mismatch on the bounds values on the master and slave axes. This is quite difficult to spot, as similar symptoms arise if there are problems with the reference input setup.

The master bound is set up automatically by the ML map link function, when a slave channel is linked to a master channel.

**MWbb** **Set map/move options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command allows the user to modify the operation of absolute moves and position mapping in various ways. The value is entered as a binary number, with each bit controlling a different aspect of the position mapping. Leading zeros may be omitted. The bit functions for the map options word are described below.

Bit 0 This bit controls the behaviour of the system when a position mapping is executed.
When set to 0, the slave axis calculates its demand position as required by the mapping, and executes a normal trapezoidal move to align itself to that position before going into the mapped state.
When set to 1, the “Software Clutch” facility is enabled. This is used when it is required to lock a slave channel to a master axis which is already moving. In this case, the slave channel remains at its current position, until the calculated demand position from the mapping approaches the current slave position. The slave channel then ramps up to the required speed in such a way as to reach this speed at the correct mapped position. The time for this clutch acceleration ramp is defined by the CT clutch time command.
If bit 2 of MW is set as well as bit 0, then the XM command executes with an automatic offset adjustment. In this case, the map offset parameter MF is adjusted to maintain the current relative positions of the master and slave axes when the XM command is executed, and mapping starts immediately. No alignment move or clutch acceleration ramp is performed.

Bit 1 This bit is used when bit 0 of the map options word is zero, such that when a map is executed, it starts with an alignment move.
When set to 0, the target position for the alignment move is taken directly from the result of the mapping. The alignment move distance may be larger than the set bound value SB if required.
When set to 1, the target position for the alignment move is set to the **nearest** correct cyclic position within SB. If MW bit 2 is set to 0, then the move distance is limited to ±SB/2. If MW bit 2 is set to 1, then the direction for absolute moves is set by MW bit 3, and the maximum move distance is SB, in the set direction only.

Bit 2 If mapping starts with the alignment move, this bit specifies that it is constrained to move in only one direction.
When set to 0 it has no effect, and the map alignment move may be in either direction, depending on the current positions of both master and slave axes, and on the mapping.
When set to 1, the map alignment move is always in one direction, as set by bit 3 of the map options word (see below).
If bit 0 of MW is set as well as bit 2, it enables an automatic offset adjustment function. The MF value required to maintain the current position relationship between the master and slave axes is calculated at the start of the XM command, and there is no alignment move or clutch acceleration ramp.

Bit 3 This bit sets the direction of the map alignment move, if it is constrained by setting bit 2 of the map options word to 1.
When set to 0, the map alignment move is in the positive direction.
When set to 1, the map alignment move is in the negative direction.

Bit 4 This bit is used to execute a mapping as a speed mapping, where the slave speed is related to the master speed by the mapping, instead of relating the slave and master positions. This is useful in speed ratio control applications where the absolute position relationship between the master and slave channels is not important.
When set to 0, position mapping is executed.
When set to 1, speed mapping is executed.
If this bit is changed from a 1 to a 0 while mapping, the system changes from speed mapping to position mapping. The difference between the current demand position and that required by the position mapping is set into the MF parameter, and an MF increment is set up to return to the original MF value. This gives a smooth adjustment of the slave axis to the new mapped demand position, with the speed of the adjustment set by the AV parameter.

Bit 5 This bit enables the subtraction of the master axis position from the value found in the map table, and the map table value is used as an offset or correction to give the slave demand position. This option is provided mainly for compatibility with other systems.
When set to 1, the master position is subtracted from the map table value.
When set to 0, the master axis position is not subtracted from the map table value, as normal.

Bit 6 This bit controls an optional automatic setting of the bound value used on the slave axis while in mapping.
When set to 1, the value calculated on the slave axis as the mapped master position bound is copied temporarily to the slave axis position bound value **while in mapping**. This value is used for position wraparound, reference position comparisons, etc. in the same way as the normal position defined by the SB command. This facility is useful only when the slave axis cycle should correspond to the master axis cycle. It allows the system to automatically set up the slave axis bounds correctly for zero drift between axes, without any user interaction. It is particularly useful in conjunction with the SM map scaling function, when it is not always possible to define the mapping such that the mapped master bound corresponds to the physical slave axis cycle length. In this case, set this bit to automatically set the slave axis bounds to the mapped master axis bound, and use the auto-referencing facilities to correct the motor to the actual cycle length on each cycle.
When set to 0, the bound value as set by SB is used as normally while in mapping.

Bit 7 Reserved.

**CTn** **Set clutch time.**
**Range : 0 to 2560**
**Default : 0**

This command sets the acceleration ramp time for the "Software Clutch" facility. The software clutch is enabled by bit 0 of MW, the map options word. It allows a slave channel to be mapped onto a master axis that is already moving.

When the software clutch is enabled, a slave axis does not go immediately into the mapped state on performing an execute map command. Instead, it goes into a holding state and waits for the projected master position to pass the projected slave position at the end of the slave acceleration ramp, as given by the clutch ramp time factor. This clutch time defines the number of 1/256 second (about 4 ms) time steps, or ticks, taken for the slave axis to accelerate from rest to the required mapped speed.

While in the map hold state, the slave channel calculates the projected master axis position at the end of the slave acceleration ramp, and from this calculates the required slave axis position **and** speed at the end of the ramp. It then compares the start position of the ramp with the current slave axis position, and starts the acceleration ramp when this start position passes the current slave axis position. In this way the slave channel accelerates from rest to reach the required mapped speed **at the correct mapped position** in the number of time steps set by the CT command.

This provides a very powerful and accurate method of bringing slave axes into and out of mapping with a master axis that is running continuously, while preserving the position relationship between master and slave axes. This is unlike a mechanical clutch, where the positional accuracy is dependent on the response time of the clutch mechanism, and the accuracy of the start/stop control signal to the clutch actuator.

**Example : `CT128`**
This example shows the clutch time factor set to 128 time steps. Thus the slave axis will ramp up to the required mapped speed in 128 ticks (0.5s), at the correct mapped absolute position.

**BAnn** **Set map base advance.**
**Range : 0 to 65535**
**Default : 0**

The map base advance is a mechanism for shifting the mapped position of a slave axis, relative to the master axis, by some amount dependent on the current master axis speed. The base advance is applied to the slave axis in the same way as the fixed MB map base offset value, and thus is defined as a shift along the master axis proportional to master axis speed. This command sets the scale factor between the measured master axis speed and the actual map base advance. The scaling of the base advance is given by the expression

$$\text{Map base advance} = (\text{master speed} / 256) \times (\text{BA} / 256)$$

where the master speed is measured in encoder counts per second. For example, with a measured master axis speed of 10,000 counts per second, a value for BA of 200 gives a map base advance of 30 encoder counts.

**BTn** **Set master speed averaging time constant.**
**Range : 0 to 8**
**Default : 0**

Master speed averaging is useful in speed mapping, and with the map base advance facility. When the master axis is also controlled by the system, the demand speed for the master axis is available to the slave, giving very smooth operation. When the master is not controlled, but is just an encoder fitted to some other part of the machine, the master speed can only be calculated from successive encoder positions. These positions are measured at 4ms intervals, and so the measured master speed is only accurate to 256 counts per second. In some applications, this may cause slight variations in the speed of the slave axis.

The BT command sets up an averaging mechanism on the slave axis, such that the number of samples of master speed doubles for each increment in the value of BT. At BT=0, no averaging is done, and the immediate measured master speed is used for the base advance calculations. At BT=8, $2^8$=256 samples are averaged over a period of 1 second, to give a speed measurement accurate to 1 count per second. The system keeps a running average of the master speed which is updated at each 4ms sample, so that the latest average speed is always available. This averaged master speed is used by the slave axis in speed mapping, allowing smoother operation in such applications.

Note that whenever the averaging time is changed, the current average value is reset to zero and the running average is restarted.

**GM** **Get mapped master axis bound position.**

This command allows the user to find the slave position which corresponds to the master axis bound position when executing a position mapping. This value is calculated internally by the slave channel when a map is executed, by feeding zero and the master position bound value into the mapping algorithm. The value is used by the slave channel when the master axis position wraps around to zero at the master axis bound position to keep the slave demand position continuous at this point. It is not normally used in programming the system, as it is used locally within the slave axis. However, it is sometimes useful to confirm that the mapping is behaving as expected by checking this value.

Another use for it is when the master and slave axes should both complete one machine cycle in the same time, but the value for the bound position on the two axes is different. In this case, if the internal mapped master bound is not the same as the slave axis bound value, then the slave axis will appear to drift relative to the master axis as the machine runs. This is because the mismatch between the slave axis bound and its mapped copy of the master axis accumulates from cycle to cycle. In this case it is necessary to adjust the map table values at the master axis bound position to get the correct result.

On some systems this may not be possible because of interactions with the map scale factor or master axis division factor. In such cases, it is possible to use the value for the mapped master axis position bound together with auto-referencing on the slave axis to solve the problem. The value for the mapped master bound is read by using the GM command, and this value is sent as the bound value with the SB command. In this way, the master and slave bound values tie up exactly, and any mismatch between the slave bound value and the actual repeat length of the slave encoder is handled by the auto-referencing functions. If required, this may be performed automatically by setting bit 6 of MW, the map options word.

**NOTE :** The GM value is only valid when the master axis bound has been set up correctly by the ML map link command, or has been sent with the MP command, and the slave channel is executing a map.

**GW** **Get wraparound offset value.**

This command allows the user to read the internal wrap offset value on a slave axis in mapping. This may be used as another confirmation that the mapping is executing correctly.

When the master axis position wraps around at the bound position, the position value passed to the slave channel changes by the master bound value. In order to keep the required slave demand position continuous either side of the master bound, an offset equal to the mapped master bound is then added or subtracted to the slave demand position. This value is called the wraparound offset. When the slave channel then wraps around at its bound position, the slave bound value is subtracted or added to the wraparound offset as required, again to keep the slave demand position continuous either side of the slave bound position.

The GW command reads back the current value of this internal wraparound offset value. In the simple case where the master and slave bound values are the same, it should be zero, +SB or –SB. If it has any values other than these, or if it has an upward or downward trend, then it is likely that there are problems with the map setup.

**FM** **Display free memory.**

This command displays information about the memory space available for sequences, maps and profiles. It returns both the global free memory space on the host processor and the local free memory space on each axis controller. For more details refer to the full description of the FM command on page 50.

## 4.8 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 executes the commands following the wait command. The system returns a 'W' status message to indicate that it is waiting.

**WTnn** **Wait for time.**
**Range : 0 to 65535**

This command tells the system to wait for the given time, before proceeding to the next command. The wait time is specified in units of 1/256 second (about 4ms).

**Example : `MA2000/WT512/MA0`**
This command sequence tells the system to move to position 2000, wait there for 2 seconds, and then move to position 0.

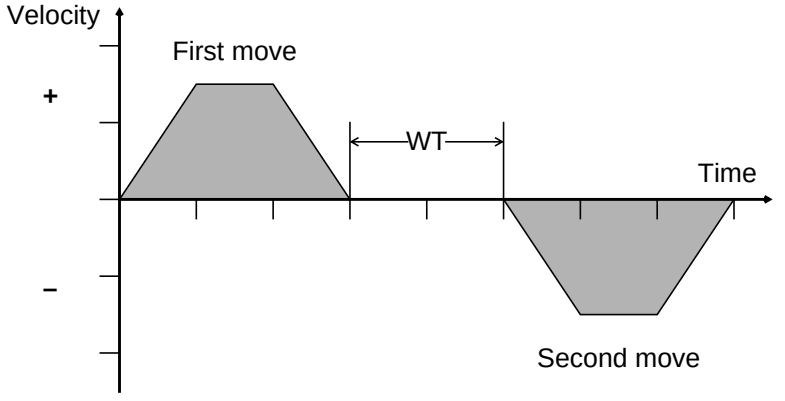



**Figure 18. Wait for time.**

**WI[g:]n±** **Wait for input line nn in group g.**
**Range : 1 to 8**

This command tells the system to wait until the specified input line goes to the specified state. If the input is already in that state then the WI command terminates immediately. An input line that is defined for some other function may be used in a WI command.

**Example : `MA5000/WI2-/MA0`**
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.

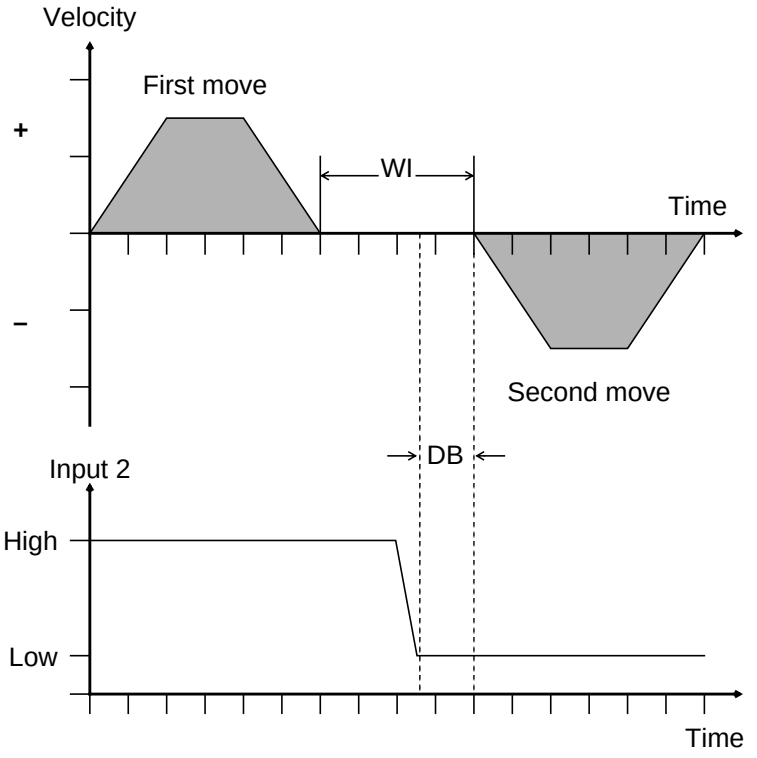



**Figure 19. Wait for input line.**

**WA±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 a "parameter out of range" error message to indicate that the position was out of range.

**Example : `SV200/MA2000/WA1500/SV100`**

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.

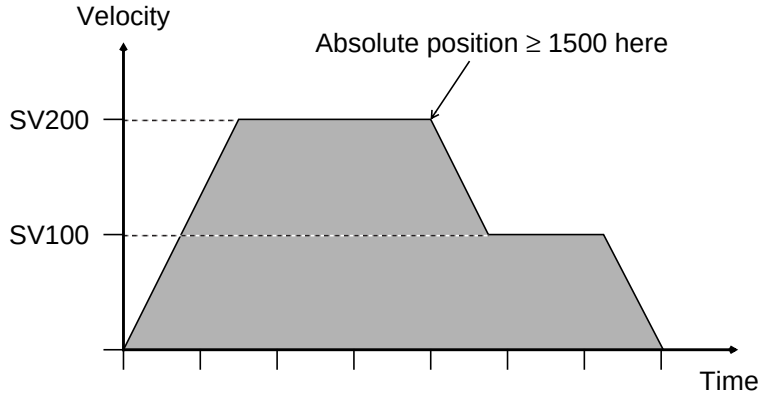



**Figure 20. Wait for absolute position.**

**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 some previous position.

The wait relative position counter is reset to zero on the following events. If a WR command is executed, it will terminate at the given distance relative to whichever of these events ocurred last.

| | |
|---|---|
| Entering position control mode | (PC) |
| Setting the current position | (ZC) |
| Start of a move | (MA, MR or VC) |
| Start of mapping | (XM) |
| Start of a profile | (XP) |
| End of wait for reference | (WF) |
| End of wait for bound | (WB) |
| End of wait for bounds count | (WC) |
| End of wait for position | (WA, WR) |
| End of other wait commands | (WT, WI) |

**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.

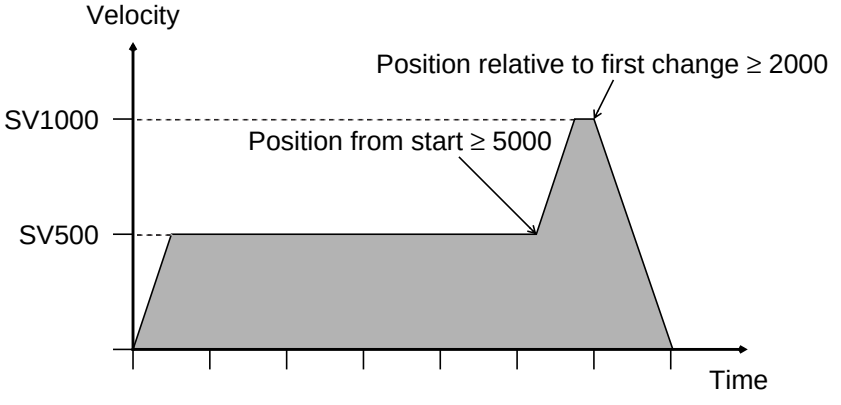



**Figure 21. Wait for relative position.**

**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.

If no reference input or marker input is defined, then the WF command returns the error message “no reference input defined”.

**Example : `RW1/SR0/RM1/WF/SR100/SO3`**
This command string sets the SR value to zero initially, such that the first reference is detected without limiting the reference error. It then waits for the first reference input to be detected, and changes SR to give a maximum reference error of 100 counts. Finally an output line is set to indicate that the unit has seen one reference 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 the bound overflow counter has changed by the specified count value 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.

**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> | `MA10000/WT1024/MA0` | |

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 WT command is terminated early and the motor moves back to zero immediately.

## 4.9 Error Trapping

The system continuously monitors various aspects of its performance, in order to detect a range of error conditions. Some errors are critical, in that they prevent the system from controlling the motor correctly, or they indicate some external failure such as an encoder wiring fault. Others may be more or less important depending on the application.

Critical errors are called “motor off” errors. If such an error is detected, the axis shuts down to the motor off state, with the motor enable relay switched off. This is the safest course of action for the system to take when these error conditions occur. An error message is output on the main serial port, to indicate which error has been detected. An error code is also shown on the LED display. The motor error conditions are as follows.

- Motor position error.
- Motor timeout.
- Limit switch input detected.
- Motor position outside high or low position limit.
- Map position overflow.

The following error conditions may also be enabled as motor off errors, by setting bits in the error options word EW. When enabled, these also cause the axis to shut down to the motor off state. If not enabled as a motor off error, they are treated as user errors and just give an error message on the serial port. These optional motor off errors are as follows.

- Reference timeout.
- Reference outside limits.
- Reference correction overrun.
- Analogue input outside high or low limit.

**SEnn** **Set maximum position error (restricted).**
**Range : 1 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 “motor position error” message and enters the motor off state. The system must be returned to position control mode before any further motion commands are accepted by the system. See the mode commands section 4.2 for details of the MO motor off and PC position control commands. The value is defined in user units.

**Example : `SE500`**
This sets the maximum position error to 500 counts.

**TOnn** **Set timeout (restricted).**
**Range : 1 to 65535**
**Default : 32**

This command sets a timeout value, in units of 1/256 seconds. When the system expects the motor to move and the encoder position does not change for a period that exceeds the timeout, then the system prints a “motor timeout” error message and goes to the motor off state. The system must be returned to position control mode before any further move commands are accepted.

**Example : `TO512`**
This sets the timeout to 2 seconds.

**LHnn** **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 “high position limit exceeded” 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. If the SB set bound value is less than the high limit, then the high position limit checking is disabled, as the absolute position value wraps around to zero at the bound position before reaching the high limit position.

**LLnn** **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 “low position limit exceeded” 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. If the SB set bound value is less than the low limit, then the low position limit checking is disabled, as the absolute position value wraps around to zero at the bound position before reaching the low limit position.

**Example : `LH10000/LL0`**
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.

**RTnn** **Set reference timeout (restricted).**
**Range : 0 to 127**
**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 position half way between the expected reference positions, and cleared each time a valid reference input is detected. If the counter exceeds the RT value, the system gives the “reference timeout” error message. The reference timeout function is disabled by setting it to zero.

**MEnn** **Set motor off error sequence (restricted).**
**Range : 0 to 255**
**Default : 0**

This command sets up a sequence to execute when any motor off error occurs on the current channel. If no sequence number is given, the system prints the current motor off error sequence number for the current channel. To disable the motor error sequence on this channel, set ME to zero. Note that the motor off error sequence may include commands for any channel(s).

**UEnn** **Set user error sequence (restricted).**
**Range : 0 to 255**
**Default : 0**

This command sets up a sequence to execute when any user error occurs on the current channel. If no sequence number is given, the system prints the current user error sequence number on this channel. To disable the user error sequence on the current channel, set UE to zero. Note that the user error sequence may include commands for any channel(s).

**EWbb** **Set error options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command allows the user to write a value into the error options word for this channel. 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.

Bit 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.

Bit 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 overrun error is treated as a user error, and the system simply prints an error message.

Bit 3 When set to 1, the analogue input out of limits error is treated as a motor error, and the axis goes to the motor off state when it occurs.
When set to 0, the analogue input out of limits error is treated as a user error, and the system simply prints an error message.

Bit 4 When set to 1, reference timeout errors are suppressed, unless they are set as motor errors by EW bit 0.
When set to 0, reference timeout errors are displayed.

Bit 5 When set to 1, reference limit errors are suppressed, unless they are set as motor errors by EW bit 2.
When set to 0, reference limit errors are displayed.

Bit 6 When set to 1, reference correction overrun errors are suppressed, unless they are set as motor errors by EW bit 2.
When set to 0, reference correction overrun errors are displayed.

Bit 7 When set to 1, analogue input out of limits error messages that are not defined as motor errors are suppressed.
When set to 0, analogue input out of limits user errors are displayed.

**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.

## 4.10 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 best performance on a particular mechanical setup requires setting up these gain constants.

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

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

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 any axis may be monitored by using another channel's analogue output as a monitor output. 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.

**KPnn** **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.

**KInn** **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 a 1.

**KDnn** **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.

**KVnn** **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 into 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.

**KFnn** **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 the use of integral gain, but this has other effects as well.

**DK** **Display system constants.**

The system displays various parameter values, including the four main gain terms:

- Proportional gain constant KP
- Integral gain constant KI
- Velocity feedback gain constant KV
- Velocity feed-forward gain constant KF
- Scale units SU
- Velocity SV
- Acceleration SA
- Maximum position error SE

**ITn** **Set integration time constant (restricted).**
**Range : 0 to 2**
**Default : 1**

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.

**OLnn** **Set analogue output limit (restricted).**
**Range : 0 to 2047**
**Default : 2047**

This command is used to set an upper limit on the absolute value of the demand signal output to the motor. Once set the limit is active at all times.

**Example : `OL1024`**
The analogue output is limited between ±5V.

**SFn** **Set monitor output function (restricted).**
**Range : 0 to 16**
**Default : 0**

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

| Code | Function | Associated command |
|---|---|---|
| 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 | DD |
| 7 | Absolute measured position | DP |
| 8 | Tension or torque error | |
| 9 | Actual map scale factor | |
| 10 | Averaged measured speed | DV |
| 11 | Master speed | |
| 12 | Master averaged speed | |
| 13 | Tension control setpoint | AC |
| 14 | Reference error | DF |
| 15 | Snapshot position | DS |
| 16 | Demand velocity including any reference correction | |

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.

**KMnn** **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.

**OMnn** **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.

**AOn** **Set auxiliary output channel (restricted).**
**Range : 0 to 4**
**Default : 0**

This command allocates the monitor signal for the current channel to one of the four channel analogue outputs. The monitor function SF may be defined for the current channel at any time. The auxiliary output channel may be set for a particular analogue output only when its channel is in the motor off or virtual motor modes. If the channel is in any other state then the analogue output is not available for use as a monitor output. Conversely, if the analogue output has been allocated to a channel as a monitor signal, then this channel cannot be taken out of motor off or virtual mode.

To return an analogue output channel to normal operation, use AO0 on the channel where the auxiliary output is defined. Note that it is also possible to have the auxiliary output signal allocated to the current channel when it is in virtual mode; the signal does not have to be defined on a different channel's output. This may be useful in open-loop control applications.

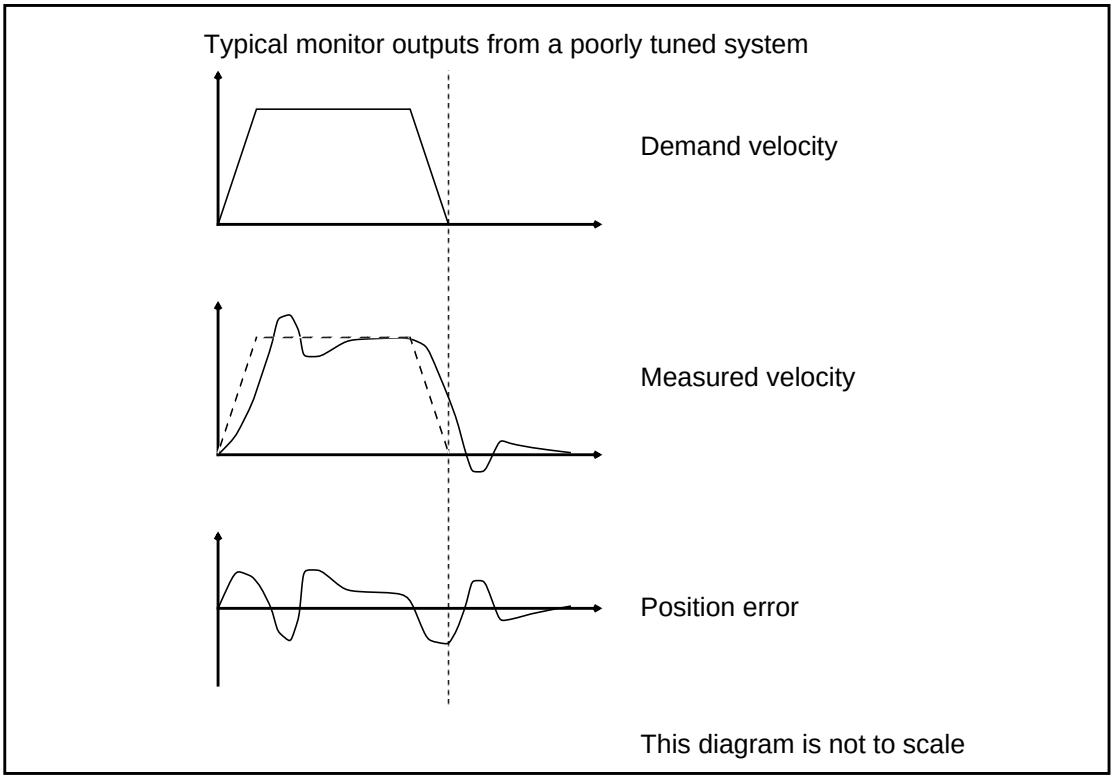



**Figure 22. Monitor output functions.**

## 4.11 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 signal, and to use it to automatically adjust the absolute position of the system. The position of the encoder 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.

The system supports two types of reference input signal. The encoder marker signal is connected via the Z and /Z inputs to a dedicated fast reference input, called the **zero marker** input, which responds to signals down to a minimum pulse width of 60ns. This is fast enough to deal with the single marker pulse from a high resolution encoder running at high speed. This input is configured with the DZ command. In addition to this, reference inputs may be programmed on inputs 1 to 4, using the DR command. These additional reference inputs are intended for use with other devices such as proximity switches or microswitches. Note that the fast reference or zero marker input is only used for the encoder marker signal, and cannot be programmed for any other uses, while inputs 1 to 4 may be programmed for any purpose.

Note that it is now possible to use referencing and snapshot functions on axes in virtual mode (VM1). They use interpolation to accurately calculate the position of the virtual axis at the point of the reference or snapshot input.

**ZC[nn]** **Zero position counters or set position.**
**Range : ± 4 000 000 (4.0E6) encoder counts, or no value**

If a position value is given, the system sets the current demand position to the given (absolute) value. If no value is given, the current demand position is set to zero. The bounds counter (BC) is set to zero in either case. If a position value larger than the set bounds value (SB) is given, then the ZC position value is divided by SB. The demand position is set to the remainder, and BC is set to the quotient.

The ZC command may be used at any time, although the accuracy of the set position clearly depends on the actual speed of the motor.

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

**Example : `ZC1000`**
This defines the current demand position as position 1000.

**SBnn** **Set position overflow bound (restricted).**
**Range : 1 to 4 000 000 (4.0E6) counts**
**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. 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 and reset to zero by the BC command.

The bound position defined by the SB command is normally used as the expected reference position when the system is set up to continuously monitor the reference inputs.

**Example : `SB1000`**
This sets the position bounds to ±1000 counts. A typical application of this is on a cyclic or rotary machine, 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 1500 is executed, the final displayed position value is 500. The motor has moved a total distance of 1500 counts as required, but the final position is the remainder when divided by the bound value. If a move from zero to position –1500 is executed, the final position value is –500. 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.

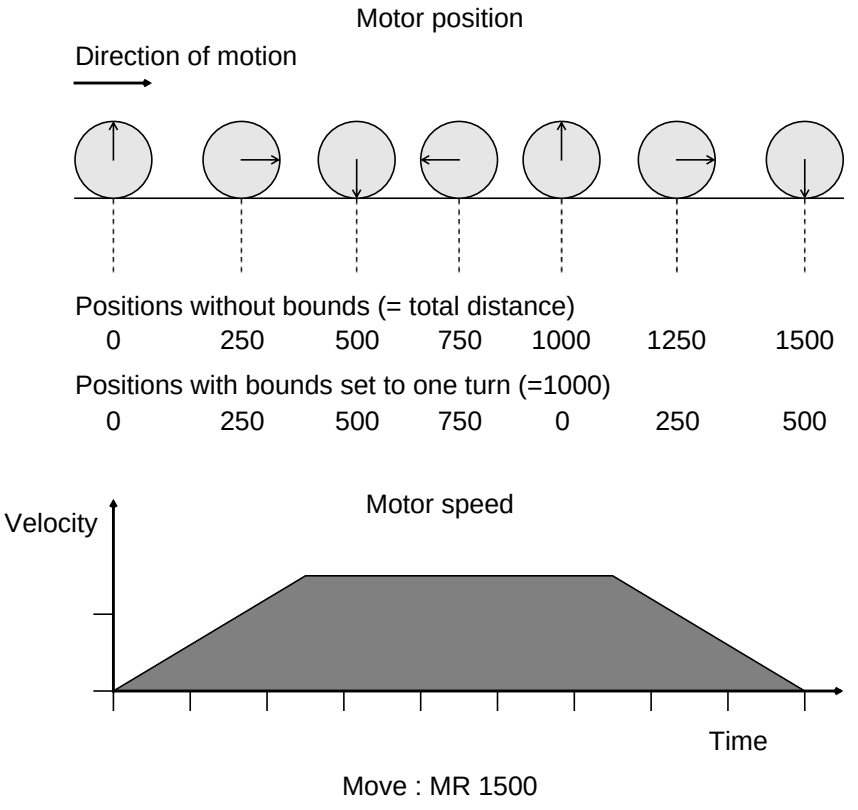



**Figure 23. Position bounds.**

**BCnn** **Set/display position overflow counter.**
**Range : ± 2147483647 (signed 32 bit)**

This command sets the position bound overflow counter to the specified value. The overflow counter is incremented when the position exceeds the upper bound, and is decremented when the position passes the lower bound. If no value is given, the current value of the bound overflow counter is displayed.

The BC value is also set when the ZC command is used. If no value is given with the ZC command, then BC is set to zero. If a position value is given, then it is divided by the set bounds value (SB) and BC is set to the result.

**DZn** **Define zero marker input on/off (restricted).**
**Range : 0 to 1**
**Default : 1**

This command defines whether the encoder zero marker input (the fast reference input) is on or off. 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 initialize position command is executed, and when the automatic reference functions are enabled by the RM and RW commands.

**DR[g:]n±** **Define reference input (restricted).**
**Range : 1 to 4**

This command defines the specified input line as a position reference input for the system. The sign defines which logic transition is used as the reference position. The system looks for the specified change in the reference input when the IN initialize position command is executed, and when the automatic reference functions are enabled by the RM and RW commands. Note that only inputs 1 to 4 may be defined as a reference input. This command is restricted, and is only available in privileged mode.

**RLnn** **Set reference repeat length (restricted).**
**Range : 0 to 4 000 000**
**Default : 0**

This command sets the reference repeat length. This is the position at which the channel expects to see the reference position signal. If RL is set to zero, then the 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. Note that if RW bit 7 is set to 1, then the RL value has no effect and the reference error is calculated relative to the zero 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 larger than 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 detected then gives a useful reference error measurement which may be used for correction if required.

**RMn** **Set continuous reference mode on/off.**
**Range : 0 to 1**
**Default : 0**

This command enables and disables the fast reference input (if defined by the DZ command), and any reference inputs defined by the DR command. If RM is set to 1, all reference inputs are enabled. If it is set to zero, all reference inputs are disabled.

With the reference inputs enabled, the system measures the reference position error by comparing the position on seeing the reference input signal with zero or the nearest bound position. The system can then correct its position according to the reference error, when enabled by bit 0 of the reference options word RW.

**RWbb** **Set reference options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

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, if the reference mode is enabled with the RM command.
When set to 0, disables the position correction but still allows the measurement of reference error.

Bit 1 This bit defines the action taken if the reference error is greater than the maximum value set by the SR command (when SR is not zero), provided that the FR parameter is zero. If FR is non-zero, then this bit has no effect.
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 value displayed by the DF command.
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 "reference out of limits" error is reported if LR is set to zero, and may set the channel to motor off if required.

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

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

Bit 4 When set to 0, any reference input is accepted as a valid zero position reference signal.
When set to 1, the system only accepts a valid reference on a combination of the defined reference inputs. The exact operation depends on the configuration of the fast reference or zero marker input. If the zero marker input is defined on with the DZ command, then any reference inputs defined on lines 1 to 4 are used to qualify the zero marker input. Thus a reference is only detected on the zero marker, and it is only accepted as a valid zero position signal if all other reference inputs are true at the same time. If the zero marker signal is defined off with the DZ command, then a valid reference is accepted when all reference inputs defined with the DR command are true, that is, the system performs a logical AND operation on the reference inputs to define a zero position signal.

Bit 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.
**NOTE:** This bit has no effect on a slave channel in the execute map state; a mapped slave axis will always correct the position of the motor for any reference error when the correction is enabled. This is because the mapping relates the absolute position on the master axis to a required absolute position on the slave axis.

Bit 6

Bit 7 When set to 1, the system calculates the reference error with respect to the current zero position, and the RL command has no effect.
When set to 0, the system calculates the smallest possible reference error with respect to the reference repeat length defined by the RL parameter. If RL is set to zero, then the bound value SB is used. 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.

**Example : `RW1/SR20/RM1`**

This enables the position correction on detection of a reference input, limits the allowed correction to a maximum of 20 encoder counts, and finally enables the reference inputs.

**Example : `RW10100001`**

This enables the reference input, and sets the system up to (a) only correct the displayed position, and (b) always set the position to zero on detecting a reference signal. In this setup the reference input has the same effect as a ZC command, but is effective on the fly at any time.

**SRnn** **Set maximum reference correction (restricted).**
**Range : 0 to 65535**
**Default : 0**

This command, when set to a non-zero value, 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 SR, then the action taken depends on bit 1 of RW and the FR parameter. If RW bit 1 is clear and FR is set to zero, then the position is not corrected, the out of limits reference error value is discarded, and the reference is ignored completely. If RW bit 1 is set, or FR is non-zero, the position is corrected by an amount equal to SR.

When the reference error is larger than SR, the LR parameter is zero, and correction up to the value of SR is enabled by RW bit 1 or FR non-zero, then a “reference out of limits” error message is given. If LR is non-zero, then this error is given for reference errors larger than LR. If required, the system may be programmed to generate a motor error when this error is detected. This facility depends on bit 1 of EW, the error options word. When EW bit 1 is set, a reference limit error sets the channel to motor off. Note that the reference error value and the out of limits error are only reported if the system has not already decided to ignore the reference error because it is outside the maximum limit.

**FRnn** **Set filter on reference error (restricted).**
**Range : 0 to 65535**
**Default : 0**

This command, when set to a non-zero value, defines a maximum value for the reference error in encoder counts. Any reference which gives a reference error value greater than FR is ignored completely. It is used to eliminate false reference signals at positions far away from the expected reference position. It is independent of the value of SR, which defines the maximum allowed reference correction.

**Example : `FR500`**
This sets the reference filter value to 500 counts. This means that any reference which gives a reference error greater than 500 counts is ignored.

**LRnn** **Set reference error limit (restricted).**
**Range : 0 to 65535**
**Default : 0**

This command, when set to a non-zero value, defines a limit value for the reference error in encoder counts. If a reference is detected and gives a reference error value greater than LR, then the "reference out of limits" error is reported. It is independent of the value of SR, which defines the maximum allowed reference correction, and of FR, the reference error filter value. When EW bit 1 is set, a reference limit error also sets the channel to motor off.

**Example : `LR800`**
This sets the reference filter value to 800 counts. This means that any reference which gives a reference error greater than 800 counts is reported as an error.

**RF±nn** **Set reference offset (restricted).**
**Range : ± 4 000 000**
**Default : 0**

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

**Example : `RF1000`**
This sets the reference offset to 1000 counts. This means that the position where the reference input signal is seen is defined as absolute position 1000, not zero.

**RVnn** **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 unnecessarily 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 1/128 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 “reference correction overrun” 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.

**RJ±nn** **Set deferred reference adjustment position (restricted).**
**Range : 0 to 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 RJ command defines a position which the motor must pass before the correction due to the reference signal is actioned. This function is enabled by bit 2 of RW. If this bit is set to zero, the reference correction takes place immediately.

This command may also be accessed with the SJ command, which is retained for compatibility with previous software versions.

**NOTE:** If the RJ position is set to a value which is greater than the bound (set by SB), or the reference repeat length if in use (set by RL), then the effective value used for RJ is the remainder when RJ is divided by SB (or RL). It is not possible to defer the correction until a position beyond the next reference position.

**RTnn** **Set reference timeout (restricted).**
**Range : 0 to 127**
**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 position half way between the expected reference positions, and cleared each time a valid reference input is detected. If the counter exceeds the RT value, the system gives the “reference timeout” error message. The reference timeout function is disabled by setting it to zero.

The RT reference timeout check is automatically disabled when an IB initialize bounds command is executed. This is to stop the system giving unnecessary reference timeout errors based on the previous set bound value, which may be smaller than the new bound length being measured.

**ZHnn** **Set reference input true high limit (restricted).**
**ZLnn** **Set reference input true low limit (restricted).**
**FHnn** **Set reference input false high limit (restricted).**
**FLnn** **Set reference input false low limit (restricted).**
**Range : 0 to 65535**
**Default : 0**

These four parameters define limits on the width of the reference input signal seen by the DR input. They allow the system to respond to a valid reference signal only if it matches the width limits given. The reference input is accepted as valid only if it is false for a distance which is between FL and FH, and it is then true for a distance between ZL and ZH. The input is therefore recognized as valid on the trailing edge of the reference signal, when it switches from true to false. However, the reference error for initialization and position correction purposes is calculated relative to the leading edge of the input signal, when it switches from false to true, as defined by the DR command. The distance limits are specified in encoder counts.

To disable any threshold test, set the limit value to zero. For example, to check that the reference input is false for at least 200 counts, with no maximum false distance, set FL to 200 and FH to 0. To disable reference width checking completely and return to normal operation, set all four values to zero.

Summary : reference input is accepted if
ZL <= distance with DR input true <= ZH
and FL <= distance with DR input false <= FH.

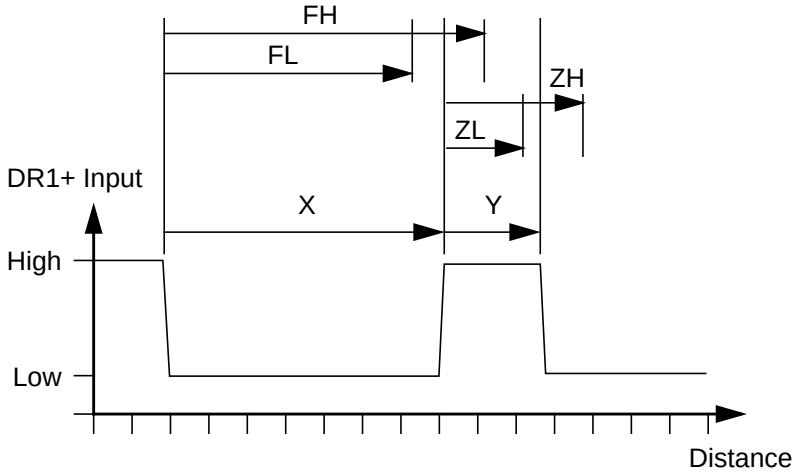



**Figure 24. Reference width checking with ZH, ZL, FH and FL.**

This feature is used to pick out a valid reference pattern from other signals that may be detected by the reference sensor. It is of particular use in printing and registration applications.

**RA[g:]n±** **Define reference accepted output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as a reference accepted output. The output gives a 4ms pulse when a reference input signal has been accepted as a valid reference. This may be used to indicate the presence of a good product, for example when using reference width checking. This command is restricted, and is only available in privileged mode.

**RHnn** **Set reference holdoff time (restricted).**
**Range : 0 to 127**
**Default : 0**

This command sets up a holdoff time on the reference input. When RH is set to a non-zero value, the reference holdoff function is enabled. When a reference input is detected, no further reference inputs are recognized until the holdoff time has elapsed. The reference holdoff function is disabled by setting RH to zero.

The reference holdoff function previously used the DB debounce time parameter, and was enabled by RW bit 6. The reference holdoff is now set by RH, independent of the DB parameter, and RW bit 6 is no longer used.

**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.

If no reference input or marker input is defined, then the WF command returns the error message “no reference input defined”.

**DF** **Display reference error.**

Displays measured absolute position error relative to the last valid reference input, in encoder counts.

## 4.12 Digital Inputs and Outputs.

The MiniPTS 2+1 has sixteen digital inputs and eight digital outputs. This section describes the commands available to read the inputs and control the outputs. They may be used immediately at the prompt, or in command strings and sequences.

The input and output lines on the MiniPTS 2+1 are divided into groups of eight lines, and all commands for the input and output lines take a group number prefix before the line number. This is to provide a more general input and output line numbering scheme for use with the SRVX expansion board. The standard MiniPTS 2+1 with sixteen inputs and eight outputs has two input groups and one output group. The expansion board increases this to forty input lines and sixteen output lines in total, divided into five input groups and two output groups.

The extended command syntax prefixes the line number with the group number, and uses a ‘:’ colon character to separate them. Commands which may be applied to all inputs or outputs on other units, such as RI or RO, are now applied to a group of inputs or outputs. Examples are shown below. If the group number is not specified in the command, then it is calculated from the line number to provide some backwards compatibility.

**Examples :**

| | |
|---|---|
| `SO1:2` | Set output 2 in group 1 (output 2). |
| `SO1:` | Set all unused outputs in group 1. |
| `CO2:5` | Clear output 5 in group 2 (output 13, on expansion board). |
| `RI1:1` | Read input 1, group 1 (input 1). |
| `RI2:1` | Read input 1, group 2 (input 9). |
| `RI1:0` | Read all inputs in group 1 (inputs 1–8). |
| `RI15` | Read input line 15 (input 7 in group 2). |
| `MI3:7` | Mask input line 7, group 3 (input 23, on expansion board). |
| `EI4:` | Enable all inputs in group 4 (inputs 25–32 on expansion board). |

| Group number | Input lines | Output lines |
|---|---|---|
| 1 | 1–8 | 1–8 |
| 2 | 9–16 | 9–16 * |
| 3 | 17–24 * | |
| 4 | 25–32 * | |
| 5 | 33–40 * | |

A ‘*’ indicates the signals on the expansion board. If this is fitted, then the system allows the use of these higher group numbers. If it is not fitted, then the higher group numbers give a “parameter out of range” error.

The MiniPTS 2+1 has a “virtual i/o” feature. This makes available one extra input group and output group which are not connected to any real signals. The current states of the virtual input lines are set by the virtual output lines, as if the outputs are connected to the inputs. This allows output functions such as the PO position trigger function to be attached to an input function such as DI without requiring any real inputs and outputs.

The virtual i/o groups are numbered one higher than the maximum real i/o groups. Thus input groups 1 and 2 are real inputs and use the sixteen 24V digital input signals, while input group 3 is a virtual input group. Output group 1 is real and controls the eight 24V digital outputs, and output group 2 is virtual. The virtual outputs in group 2 are connected logically to the virtual inputs in group 3. Setting output 2:1 high also sets input 3:1 high.

All input and output commands are available on the virtual inputs and outputs, with the exception of reference and snapshot functions. The virtual inputs are not subject to debounce. They may be used wth the timer/counter functions described later (in section 4.14 on page 140) to give very powerful combinations.

**SO[g:][n]** **Set output line n in group g.**
**Range : 1 to 8, or no parameter**

This command sets the specified output line to a logic high. The output state is maintained until superseded by another command for the same output line. If the specified output is programmed for some defined function, then the “line already defined” error is reported.

If no output line number is specified, then all available outputs are set. If a group number and colon are given with no line number, or the line number is zero, then all available outputs in that group are set. No error is reported if all outputs are in use.

**Example : `SO3`**
This sets output line 3 to a logic high.

**CO[g:][n]** **Clear output line n in group g.**
**Range : 1 to 8, or no parameter**

This command clears the specified output line to a logic low. The output state is maintained until superseded by another command for the same output line. If the specified output is programmed for some defined function, then the “line already defined” error is reported.

If no output line number is specified, then all available outputs are cleared. If a group number and colon are given with no line number, or the line number is zero, then all available outputs in that group are cleared. No error is reported if all outputs are in use.

**Example : `CO7`**
This clears line 7 to a logic low.

**RI[g:][n]** **Read input line(s) in group g.**
**Range : 1 to 8, or no parameter**

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 after the group number and colon, or the line number is zero, then the system prints the current state of all 8 input lines in the specified group and a letter to show whether each line is masked (M) or enabled (E). If no group number is given, the command defaults to group 1 (inputs 1–8).

**Example : `RI1:2`**
This reads the state of input line 2, and prints it on the display.

| System | User | Comments |
|---|---|---|
| `>` | `RI1:2` | Read a particular input |
| `0` | | Input line 2 is low |
| `>` | | Normal prompt |

**Example : `RI`**
This reads the states of all inputs in group 1, and prints them, together with their mask/enable status.

| System | User | Comments |
|---|---|---|
| `>` | `RI` | Read all inputs in group 1 |
| `1 2 3 4 5 6 7 8` | | Line numbers |
| `0 1 1 0 0 1 0 0` | | Lines 2, 3, 6 are high |
| `E E M E M E E E` | | Lines 3 & 5 are masked |
| `>` | | Normal prompt |

**RO[g:][n]** **Read output line state(s) in group g.**
**Range : 1 to 8, or no parameter**

This command reads the current state of the specified output 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 after the group number and colon, or the line number is zero, then the system prints the current state of all 8 output lines in the specified group. If no group number is given, the command defaults to group 1 (outputs 1–8).

**Example : `RO1:`**
This reads the states of all outputs in group 1, and prints them.

| System | User | Comments |
|---|---|---|
| `>` | `RO1:` | Read all outputs in group 1 |
| `1 2 3 4 5 6 7 8` | | Line numbers |
| `0 1 1 0 0 0 1 0` | | Lines 2, 3, 7 are high |
| `>` | | Normal prompt |

**OC[g:]nn** **Output code via expanded outputs.**
**Range : 0 to maximum value possible on expanded outputs.**

This command sets the expanded output lines for the current channel (defined with the OX command) to the given code data value. 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 the expanded outputs were defined as active low, the data is inverted.

If this command is used when there are no expanded outputs defined, the "no output group defined" error message is returned. If the parameter value given cannot be represented as a binary number with the number of lines defined as expanded outputs, then the "parameter out of range" error message is returned.

**Example : OC5**
This sets the expanded output lines to the binary value 0101 ($=5_{10}$).

**II[g:]n±** **If input 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 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, either the next line of a sequence, or new input commands.

The II command may be followed by the EL command. If the input line is true the system executes the commands following II up to the EL command or end of line, whichever comes first. If the input line is false the system executes the commands following EL up to the end of line. The EL command must appear on the same line as the II command, except in a sequence, where it may also be the first command on the line following II.

**Example : `II2:2-/MR-1000`**
This example shows a conditional relative move. If input line 2 in group 2 is low, then the motor moves relative –1000 counts.

**IO[g:]n±** **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, either the next line of a sequence, or new input commands.

**Example : `IO1:3+/XS25`**
This example shows a conditional sequence. If output line 3 is high, then the system executes sequence 25.

**MI[g:][n]** **Mask function input.**
**Range : 1 to 8, or no parameter**

This command is used to mask the action of defined function inputs or any expanded input lines. It allows several input lines to selectively mask out defined actions, depending on the current function activated. For example, a machine start sequence assigned to a function input may mask itself once the machine has started, until the stop sequence assigned to another input 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.

Masked inputs are enabled again by the EI command. If a DI input line changes state while it is masked, then the function assigned to the change of state executes when the line is enabled. If the line changes state twice and returns to the same state as when it was masked, then nothing executes when it is enabled again.

If a line number is given as a parameter, then the specified line is masked. If a group number followed by a colon is given with no line number, or the line number is zero, then all function inputs and/or expanded inputs in the specified group are masked. If no line number or group number is given, then all function and expanded inputs in all groups are masked.

**BI[g:][n]** **Inhibit function input.**
**Range : 1 to 8, or no parameter**

This command is used to disable the action of defined function inputs or any expanded input lines. It is similar to the MI mask input function, but with the difference that **all** input state changes are ignored on inhibited inputs. Inhibited inputs are enabled again by the EI command.

If a line number is given as a parameter, then the specified line is inhibited. If a group number followed by a colon is given with no line number, or the line number is zero, then all function inputs and/or expanded inputs in the specified group are inhibited. If no line number or group number is given, then all function and expanded inputs in all groups are inhibited.

**EI[g:][n]** **Enable function input.**
**Range : 1 to 8, or no parameter**

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

If a DI input line changes state while it is masked, then the function assigned to the change of state executes when the line is enabled. If the line changes state twice while it is masked and returns to its original state, then nothing executes when it is enabled. If an input is inhibited with the BI command, then all changes of state are ignored while the input line is inhibited.

**NOTE:** The MI and EI commands may be used on any input lines. The mask/inhibit/enable action applies **only** to inputs defined as function inputs with the DI command, or as expanded inputs with the DX command. It is not possible to mask or inhibit other types of defined inputs with the MI or BI command, or to mask or inhibit the WI command.

**WI[g:]n±** **Wait for input line nn.**
**Range : 1 to 8**

This command tells the system to wait until the specified input line goes to the specified state. An input line that is defined for some other function may be used in a WI command.

## 4.13 Configuration Commands

The input and output lines on the MiniPTS 2+1 are divided into groups of eight lines, and all input and output configuration commands take a group number prefix before the line number. The standard MiniPTS 2+1 with sixteen inputs and eight outputs has two input groups and one output group.

The extended command syntax prefixes the line number with the group number, and uses a ':' colon character to separate them. Commands which may be applied to all inputs or outputs on other units, such as LI, are now applied to a specified group of inputs or outputs. Examples are shown below. If the group number is not specified in the command, then it is calculated from the line number to provide some backwards compatibility.

**Examples :**

| | |
|---|---|
| `DL7+` | Define limit switch on input 7 in group 1. |
| `DI3:5+` | Define function on input 5 in group 3. |
| `DE2:1-` | Define error signal on output 1, group 2. |
| `MG2:0011` | Define mask group for input group 2. |
| `LI2` | List input definitions for group 2 (inputs 9–16). |
| `LO1` | List output definitions for group 1 (outputs 1–8). |

| Group number | Input lines | Output lines |
|---|---|---|
| 1 | 1–8 | 1–8 |
| 2 | 9–16 | |

Note that it is now possible to use referencing and snapshot functions on axes in virtual mode (VM1). They use interpolation to accurately calculate the position of the virtual axis at the point of the reference or snapshot input.

The MiniPTS 2+1 has a "virtual i/o" feature. This makes available one extra input group and output group which are not connected to any real signals. The current states of the virtual input lines are set by the virtual output lines, as if the outputs are connected to the inputs. This allows output functions such as the PO position trigger function to be attached to an input function such as DI without requiring any real inputs and outputs.

The virtual i/o groups are numbered one higher than the maximum real i/o groups. Thus input groups 1 and 2 are real inputs and use the sixteen 24V digital input signals, while input group 3 is a virtual input group. Output group 1 is real and controls the eight 24V digital outputs, and output group 2 is virtual. The virtual outputs in group 2 are connected logically to the virtual inputs in group 3. Setting output 2:1 high also sets input 3:1 high.

All input and output commands are available on the virtual inputs and outputs, with the exception of reference and snapshot functions. The virtual inputs are not subject to debounce. They may be used wth the timer/counter functions described later (in section 4.14 on page 140) to give very powerful combinations.

**DZn** **Define zero marker input on/off (restricted).**
**Range : 0 to 1**
**Default : 1**

This command defines whether the encoder zero marker input (the fast reference input) is on or off. 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 initialize position command is executed, and when the automatic reference functions are enabled by the RM and RW commands. For more details of the operation of the reference inputs, please refer to section 4.11, Reference Commands, on page 106.

**DR[g:]n±** **Define reference input (restricted).**
**Range : 1 to 4**

This command defines the specified input line as a position reference input for the system. The sign defines which logic transition is used as the reference position. The system looks for the specified change in the reference input when the IN initialize position command is executed, and when the automatic reference functions are enabled by the RM and RW commands. See section 4.11, Reference Commands, on page 106 for more details on the reference facilities and commands. Note that only inputs 1 to 4 in group 1 may be defined as reference inputs. This command is restricted, and is only available in privileged mode.

**Example : `DR1-`**
This specifies that the reference position is detected on a high-to-low transition on input line 1.

**DL[g:]n±** **Define limit switch input (restricted).**
**Range : 1 to 8**

This command defines the specified input line as a limit switch input. 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 a “limit switch detected” error message, and goes to the motor off state. 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 : `DL3:7-`**
This defines input line 7 in group 3 as an active low limit switch input. The system detects a limit switch when line 7 goes to a logic low.

**Example : `DL5`**
This returns line 5 in group 1, previously defined as a limit switch input, to normal operation.

**PS[g:]n±** **Define position snapshot input (restricted).**
**Range : 1 to 4**

This command defines the specified input line as a position snapshot input for the system. 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 in group 1 may be defined as snapshot inputs. A position snapshot 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 : `PS4+`**
This specifies that the snapshot position is detected on a low-to-high transition on input line 4.

**DI[g:]n±/... Define function input (restricted).**
**Range : 1 to 8**

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. 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.

It is possible to define a different function on each state of the input line. For example, by connecting the input line to a push button and defining a move function on the high state and a stop function on the low state, the axis can be made to move when the button is pressed and to stop when the button is released.

If there is not enough memory for the new line definition, the system returns the “memory full” error message. A function input line may be returned to normal operation by entering this command without the sign and the function text. To delete a function defined on one state of the line but leave the other function intact, enter the command with a sign but without the function text. In this case the DI command must appear at the end of a line. This command is restricted, and is only available in privileged mode.

If an input line 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 : `DI2:2+/AB`**
This defines input line 2 in group 2 as a single command, such that when line 2 goes to a logic high, the system executes the AB command.

**Example : `DI2:2–/IN–/WT256/MR–5000/ZC`**
This defines input line 2 in group 2 as a command string, such that when it goes to a logic low, the system executes the given string of commands. It initializes the motor to the reference position, waits for 1 second, moves –5000 units, and zeros the position counters at this position.

**Example : `DI2:2–`**
This removes the function defined on input line 2 group 2 going low. Any command defined on this input line going high is unchanged.

**DX[g:]n±** **Define expanded input lines (restricted).**
**Range : 0 to 7**

This command sets up a block 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 in the specified group is used as a strobe or trigger input. The sense of the strobe input is given by the sign after the parameter. Input group 1 may not be used for the expanded input function to avoid clashes with any requirement for position reference inputs, which are only available on inputs 1-4. On other input groups, lines n up to 8 are used for the expanded inputs, where n is the line number given in the DX command. To reset the expanded input definition, use “DX g:0” or “DX g:n” without the sign.

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. On the MiniPTS 2+1, it is used as a signal number, and the specified user signal is sent to the host system immediately. The host system can then take appropriate action as required. Typically, a number of sequences are assigned to execute on the appropriate range of user signals. This allows a maximum of 127 possible different operations to be controlled by the 8 input lines allowed for the DX function. If the strobe input is active low, as specified by the sign in the command, then the data lines are also inverted when deriving the number of the signal to be sent to the host system. This keeps the strobe input and the data inputs consistent.

Only one set of DX inputs is allowed on any one channel or input line group. Since the user signals are channel specific, this prevents any ambiguity in identifying the source of the user signal when the DX strobe input is triggered.

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 : `DX2:3-`**

This sets up an active low expanded input group on lines 3 upwards in input group 2. When a strobe signal is detected on line 8, a user signal whose number is derived from the other input lines in the group is sent from the channel to the host system. In the example below, if user signal 5 is received then sequence 10 is executed.

| System | User | Comments |
|---|---|---|
| 1> | DX2:3- | Define expanded inputs on lines 3 upwards in input group 2 |
| 1> | SX5/10 | Code 5 triggers sequence 10 |
| 1> | SX4/2 | Code 4 triggers sequence 2 |
| 1> | | |

**MG[g:]bb Define input mask group (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command specifies a set of input lines, such that if one line in the set goes active, all the input lines in the set are immediately masked to prevent them acting. The lines remain masked until they are explicitly enabled. The set of lines is specified by a binary parameter where a bit set to 1 includes the corresponding input line in the group. Bit 0 of the parameter corresponds to input line 1 in the specified group.

The input mask group should only include inputs defined as function inputs with the DI command or as expanded group inputs with the DX command. The MG command has no effect on other types of input line.

The MG command applies to the specified input group only. It is not possible to specify automatic masking of inputs in a different input group. If no group number is given, the command defaults to group 1. If only the group number is given, the current MG parameter value for the specified group is displayed.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | DI1:1-/ST/EI2 | Execute stop on input line 1 |
| 1> | DI1:2-/VC+/EI1 | Execute move on input line 2 |
| 1> | MG1:00000011 | Place input lines 1 & 2 in mask group |

In the above example, the input line mask group is defined to include input lines 1 and 2. When input line 1 goes low, inputs 1 and 2 are both masked, the axis stops and then input 2 is enabled. When input line 2 goes low, inputs 1 and 2 are both masked, the motor starts, and input 1 is enabled. This makes sure that only one of the start or stop functions is enabled at one time, and that when one function is triggered, it is masked and the other function is enabled.

**BG[g:]bb Define input inhibit group (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command specifies a set of input lines, such that if one line in the set goes active, all the input lines in the set are immediately inhibited to prevent them acting. The lines remain inhibited until they are explicitly enabled. This is similar to the action of the MG parameter, but note that the inputs are inhibited instead of masked. Refer to the description of the MI, BI and EI commands for more details.

**DE[g:]n±** **Define error output (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.

More details of the error conditions and commands to set them up are given in section 4.9. This command is restricted, and is only available in privileged mode.

**Example : `DE1:6+`**
This sets up an active high error output signal on output line 6 in group 1. When an error condition is detected, the error output is set to a logic high.

**PO[g:]n±** **Define position trigger output (restricted).**
**Range : line number 1 to 8**
**positions ±4 000 000**

This command defines the specified output line as a position trigger output. If the PO command is given with a sign, it **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.

The position range for the PO position trigger outputs may be subject to a phase advance proportional to average measured speed. This is set by the PA phase advance parameter. If the PA value is non-zero, then the position trigger outputs occur at an earlier position than that defined. The amount of position shift is given by the value of PA and the average measured speed. Refer to section 4.15 for more details. Note that for correct operation, speed averaging with the VT command may also be required.

**Example : `PO1:5–/1000/2000`**
This example defines output line 5 in group 1 as a position trigger output, such that it goes low between positions 1000 and 2000.

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 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[g:]n±** **Define expanded output lines (restricted).**
**Range : 0 to 8**

This command sets up a block of output lines 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 outputs, and the sign determines whether or not the output data should be inverted. Note that the defined OX output lines are assigned to the current channel, and OC commands for these outputs must be executed on this channel.

If any of the outputs required for the expanded output function are already defined as some other function, the error message “line already defined” is returned. To reset the expanded output definition, use “OXg:0”.

**Example : `OX1:3+`**
This example defines output lines 1-3 in group 1 as active high expanded outputs. This allows output codes from 0 to 7 to be put on these three output lines with the OC command.

**BO[g:]n±** **Define bound overflow output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as a position bound overflow output. Each time the system passes the position bound set by the SB command, a logic high or low pulse is output on the specified output line. The sense of the pulse is defined by the sign given in the command. The output pulse lasts for a minimum of 4ms. A line which has been defined as a bound overflow 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 : `BO2:7+`**
This example defines output line 7 in group 2 as a position bound overflow output signal. Each time the system passes the position bound, a logic high pulse is output on line 7.

**RR[g:]n±** **Define reference reject output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as a reference reject signal output. The RR output is set true if any reference error occurs, and is cleared when a valid reference signal is detected. The sense of the output is defined by the sign given in the command. The output state is held until the next valid reference is detected. A line which has been defined as a reference reject 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.

A typical application of the RR command is for a simple product reject facility. If the reference input is triggered by the leading edge of a product on a conveyor belt, detected by a photocell or proximity switch, then the RR output together with the SR command indicates when a product is out of position by more than the SR value. This signal may then be used to trigger a product reject actuator if required.

**Example : RR5+**
This example defines output line 5 in group 1 as a reference reject output signal. If any reference error occurs, then output line 5 is set high. It stays high until the next valid reference is detected, when it is reset low.

**RA[g:]n±** **Define reference accepted output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as a reference accepted output. The output gives a 4ms pulse when a reference input signal has been accepted as a valid reference. This may be used to indicate the presence of a good product, for example when using reference width checking. This command is restricted, and is only available in privileged mode.

**OW[g:]n±** **Define outside window output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as a signal that indicates when the motor position error is larger than the SW set window value. This may be useful as a continuous “in position” signal, or as a position error signal at a lower priority than the normal motor position error threshold set by SE. This command is restricted, and is only available in privileged mode.

**AE[g:]n±** **Define analogue limit error output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as an analogue input out of limits error signal. The line is set to the specified state when the analogue input value is outside the high and low limits set by the AH and AL commands, and cleared again when the analogue input returns inside these limits.

**DU[g:]n±** **Define unipolar direction control output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as the direction output signal for use with the unipolar analogue output option, enabled by CW bit 3. The sense of the direction output is set in the DU command, but is reversed if CW bit 4 is set. The direction output will stay in any one state for a given minimum time, in order to comply with the requirements of most common inverter drives. This time is set by the UT command below.

**UTnn** **Set unipolar direction output delay time (restricted).**
**Range : 0 to 255**
**Default : 0**

This command sets up a delay time for the unipolar direction output signal. It is specified in units of 1/256 second (about 4ms). Most inverter drives specify that their direction control inputs must be held in one state for a certain minimum time before reversing again. The UT parameter should be set to give a delay time slightly longer than that required by the drive.

**DBnn** **Set input debounce time (restricted).**
**Range : 0 to 255**
**Default : 1**

This command sets up a debounce time for all the digital inputs. It is specified in units of 1/256 second (about 4ms). Before an input signal is recognized 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 or position snapshot 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 : DB2**
This sets the debounce time to about 8 ms (2 samples).

**LI[g]** **List input line definitions.**

This command lists the current definitions of the input lines for the specified group on the display. The list shows the inputline number, followed by a sign (+ or –) and a letter representing its function. Lines not defined are left blank. Function inputs also have their command string listed. The definitions are listed on the display or terminal, one per display line.

**LO[g]** **List output line definitions.**

This command lists the current definitions of the output lines for the specified group on the display. The list shows the output line number, followed by a sign (+ or –) and a letter representing its function. Lines not defined are left blank. The definitions are listed on the display or terminal, one per display line.

**Examples :**

| System | User | Comments |
|---|---|---|
| 1> | LI1<CR> | User command to list inputs |
| Inputs : | | |
| 1:1 – DR1 | | Reference input (ch.1) |
| 1:2 + DI3 AB | | Function input definition (ch.3) |
| 1:3 – DI1 IN–/WT256/ID/MR–5000/ZC | | |
| 1:4 + PS2 | | Snapshot input (ch.2) |
| 1:5 | | Normal input lines, undefined |
| 1:6 | | |
| 1:7 – DL1,2 | | Active low limit switch input |
| 1:8 | | Undefined |
| 1> | | |
| | | |
| 1> | LO<CR> | User command to list outputs |
| Outputs : | | |
| 1:1 + OX3 | | Expanded output group (ch. 3) |
| 1:2 + OX3 | | |
| 1:3 + OX3 | | |
| 1:4 – RR1 | | Reference reject output (ch. 1) |
| 1:5 – PO2 >1000 <2000 | | Position trigger output (ch. 2) |
| 1:6 + DE1 | | Error output (ch. 1) |
| 1:7 + BO4 | | Bound overflow output (ch. 4) |
| 1:8 – AE2 | | Analogue error output (ch. 2) |
| 1> | | |

**FSnn** **Select feedback encoder type (restricted).**
**Range : 0 to 8**
**Default : 0**

This command sets up different encoder feedback options for the current channel. The encoder feedback type may be set differently on each channel if required. The different feedback options are listed in the table below.

| FS | Option |
|---|---|
| 0 | Quadrature ×4 |
| 1 | Quadrature ×2 |
| 2 | Quadrature ×1 |
| 3 | Up/down count |
| 4 | Count and direction |
| 5 | SSI, relative position, binary |
| 6 | SSI, relative position, gray code |
| 7 | SSI, absolute position, binary |
| 8 | SSI, absolute position, gray code |

**Table 1: Encoder feedback options**

Note that the SSI encoder options require some jumper links to be fitted on the SRV-4 controller module. Please refer to Appendix A. on page 197 for more details. Also note that the NB command defines the number of data bits used with an SSI encoder.

**NBnn** **Set number of bits for SSI encoder (restricted).**
**Range : 12 to 24**
**Default : 24**

This command sets the number of data bits used when the channel is configured for use with an SSI encoder. It allows several different types of SSI encoder to be used in different applications, from single turn 12 bit to multiturn 24 bit models. The number of data bits may be set differently on each channel if required.

**CF** **Configure serial port options**

The MiniPTS 2+1 sets up its serial port options under software control rather than with jumper links. This is so that customers do not need to take the unit apart to change the serial port configuration for different software options such as Operator’s Panel or Modbus.

The CF command lists the current serial port configuration, and then prompts for a port to be changed. Port A supports both RS-232 and RS-485 operation, and also supports either hardware or software handshake in RS-232 mode. Port B supports RS-232 and RS-485 modes, but its handshake and tristate control options are determined by which particular software option is using port B, as set by the SK command.

```
1: cf
Port  Type   Handshake
 A    RS232     S/W
 B    RS485     N/A
Port ?
1:
```

## 4.14 Timer/Counter Functions

There are several commands available to support timer/counter functions on the digital output lines. This section describes these features briefly. The TC function may be combined with other output functions, for example to provide a defined pulse width for signalling to a PLC, or it may be used with the SO and CO commands.

It is also possible to use the timer/counter functions with external input signals. Commands are available to define a clock or trigger input, a gate input, and a reset input for any timer/counter output line.

**TC[g:]n± Define timer/counter output (restricted)**
**Range : line number 1 to 8**
**count 0 to 65535**
**mode 0 to 5**

This command defines the specified output line as a timer/counter output. If the TC command is given with the following sign, to define a new timer/counter output, then it should be followed by two parameters. The first parameter is the count value for the timer/counter, and the second value is the timer/counter mode.

The timer/counter mode values are as follows.

| Mode | Operation |
|---|---|
| 0 | One-shot up counter |
| 1 | Cyclic up counter |
| 2 | One-shot down counter |
| 3 | Cyclic down counter |
| 4 | One-shot timer |
| 5 | Cyclic timer |

**Table 2: Timer/counter modes**

The output line is initially set true (as defined by the sense in the TC command) when the timer/counter is first triggered, and it is reset false when the timer/counter reaches its final value, set by the count parameter.

In counter mode, the counter is incremented or decremented when either the SO command is given for the output, or any other defined output function on the same output goes true. If it is an up counter, its initial value is zero, and its final value is given by the count parameter. If it is a down counter, its initial value is the count parameter, and its final value is zero. On the first count, the output line is set true, and the counter is started and set to its initial value. When the count is incremented or decremented to its final value, the output line is reset false, and the counter is stopped and reset to its initial value. The counter may be stopped and reset at any time by using the CO command.

In timer mode, the timer is triggered in the same way as in counter mode, but once triggered it counts once per tick until the final count is reached. The output line is set true when the timer is triggered, and is reset false when the timer reaches the final count.

In one-shot modes, the timer/counter behaves as described above. In cyclic modes, it operates in a slightly different way. When the timer/counter reaches its final count, the output line is toggled to its opposite state, the counter/timer is reset to its initial value and continues to run. The output line changes state each time the counter/timer reaches its final count.

**Examples :**

`TC1:3+/20/1`

This defines a cyclic up counter, which toggles output 1:3 every twenty clocks. `SO1:3` increments the counter by 1. `CO1:3` stops the counter and resets it to zero.

```
RA1:4+
TC1:4+/5/4
```

These commands define a reference accepted output, and add a one-shot pulse timer to it. The timer is triggered by the RA output going true, and then holds the output true for 5 ticks (about 20ms). Thus it stretches the normal RA output time of 4ms to something a bit longer, to make it easier for it to be seen by a PLC.

LO lists these output definitions as follows.

```
Outputs
1:1
1:2
1:3 + TC Count=00020 Mode=1
1:4 + RA1 -> TC Count=00005 Mode=4
1:5
1:6
1:7
1:8
1>
```

**LC[g:]l** **List counter value**
**Range : 1 to 8**

The LC command lists the current count or time value of a timer/counter. This may be particularly useful in applications using a counter to count some external event or signal.

Note that it is not possible at the moment to assign the result of the LC command into a variable.

**TK[g:]n±/g/l** **Define timer/counter clock input**
**TG[g:]n±/g/l** **Define timer/counter gate input**
**TZ[g:]n±/g/l** **Define timer/counter reset input**
**Range : 1 to 8**

The TK command defines a clock/trigger input line for a timer/counter output. The TG command defines a gate input, and the TZ command defines a reset input. Note that all three of these commands require the input group and line number on which they are defined, and the output group and line number of the timer/counter to which they are assigned.

When a clock input changes from false to true, it increments or decrements a counter, or it triggers a timer, in the same way as the SO command on the timer/counter output. When a reset input is true, the timer/counter is stopped and is reset to its initial value, in the same way as the CO command on the timer/counter output. If a gate input is defined, it allows its timer/counter to run normally when it is true, and holds it at its current value when it is false.

**Example :**

```
TK1:2+/1/3
```

This defines a clock signal on input 1:2, assigned to a timer/counter on output 1:3. LI lists this as follows.

```
Inputs
1:1
1:2 + TK -> TC1:3
1:3
...
```

## 4.15 Phase Advance

**PAnn** **Set phase advance scale factor.**
**Range : 0 to 65535**
**Default : 0**

The phase advance feature is a mechanism for shifting all position trigger output signals programmed on the current axis by some amount dependent on the instantaneous measured speed. The phase advance is defined as a shift proportional to the current speed of the motor. This command sets the scale factor between the measured speed and the actual phase advance. The scaling of the phase advance is given by the expression

$$\text{Phase advance} = (\text{speed} / 256) \times (\text{PA} / 256) \text{ counts}$$

where the axis speed is measured in encoder counts per second. For example, with a measured speed of 20,000 counts per second, a value for PA of 500 gives a phase advance of 153 encoder counts.

**VTn** **Set velocity averaging time constant.**
**Range : 0 to 8**
**Default : 0**

When using the phase advance facility, the measured axis speed is used to calculate the required amount of phase advance. The measured speed is calculated from successive encoder positions at 4ms intervals, and so the measured speed is only accurate to 256 encoder counts per second. When used with the phase advance, any variation in the measured speed causes a varying phase advance term, giving erratic operation of any phase advanced output signals. In this case speed averaging is required to maintain correct operation.

The VT command sets up an averaging mechanism on the axis, such that the number of samples of speed doubles for each increment in the value of VT. At VT=0, no averaging is done, and the immediate measured speed is used for the phase advance calculations. At VT=8, $2^8$=256 samples are averaged over a period of 1 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.

**BAnn** **Set map base advance.**
**Range : 0 to 65535**
**Default : 0**

The map base advance is a mechanism for shifting the mapped position of a slave axis, relative to the master axis, by some amount dependent on the current master axis speed. The base advance is applied to the slave axis in the same way as the fixed MB map base offset value, and thus is defined as a shift along the master axis proportional to master axis speed. This command sets the scale factor between the measured master axis speed and the actual map base advance. The scaling of the base advance is given by the expression

$$\text{Map base advance} = (\text{master speed} / 256) \times (\text{BA} / 256)$$

where the master speed is measured in encoder counts per second. For example, with a measured master axis speed of 10,000 counts per second, a value for BA of 200 gives a map base advance of 30 encoder counts.

**BTn** **Set base advance time constant.**
**Range : 0 to 8**
**Default : 0**

When using the map base advance facility, the master axis speed is used to calculate the required amount of advance. When the master axis is also controlled by the system, the demand speed for the master axis is available to the slave, giving very smooth operation. When the master is not controlled, but is just an encoder fitted to some other part of the machine, the master speed can only be calculated from successive encoder positions. These positions are measured at 4ms intervals, and so the measured master speed is only accurate to 256 counts per second. When used with the map base advance, any variation in the master speed causes a varying base advance term. In this case master speed averaging is required to maintain smooth operation of the slave axis.

The BT command sets up an averaging mechanism on the slave axis, such that the number of samples of master speed doubles for each increment in the value of BT. At BT=0, no averaging is done, and the immediate measured master speed is used for the base advance calculations. At BT=8, $2^8$=256 samples are averaged over a period of 1 second, to give a speed measurement accurate to 1 count per second. The system keeps a running average of the master 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. When a slave axis is mapped to a master axis using speed mapping instead of position mapping , the slave axis uses the averaged master speed as its input.

## 4.16 Display Commands

**DP** **Display actual position.**

Displays current actual position, in encoder counts divided by the user scale factor.

**DD** **Display demand position.**

Displays current demand position, in encoder counts divided by the user scale factor.

**DV** **Display velocity.**

Displays the current measured velocity of the system, in encoder counts per second divided by the user scale factor. 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 value is the average measured velocity, and has a correspondingly higher resolution.

**DF** **Display reference error.**

Displays measured absolute position error relative to the last valid reference input, in encoder counts. For more details see the reference commands in section 4.11, and the DR and DZ configuration commands in section 4.13.

**DS** **Display snapshot position data.**

Displays the last absolute position measured when a snapshot input signal was detected. For more details see the PS configuration command in section 4.13.

**DA** **Display analogue input.**

Displays the current analogue input signal voltage as a number in the range ±2047, corresponding to ±10V. Thee DA command displays the analogue input signal value for the current channel.

**DT** **Display time.**

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

**TS** **Time set.**

This command allows the user to set the system time. The command must be entered without a time parameter. The system displays the current time and prompts for a new time, which should be entered in the format hh[:mm[:ss]].

**DM[nn]** **Continuous display mode.**
**Range : 1 to 65535, or no parameter**

If no parameter value is given, this comand turns on a continuous display of demand position, measured position, position error, and time. The data is displayed for the current selected channel. If a reference input is detected while the DM display is enabled, then the reference error or snapshot position value is displayed to the right of the continuous data.

If a parameter value is given, the system prints that number of lines of the position data, recorded at the full speed system sample time.

**DO** **Display mode off.**

Turns off the DM continuous display. This is the default state. This command may also be used to turn off the trace mode display.

**TR[nn]** **Enable trace mode.**
**Range : 0 to 65535, or no parameter**

This command controls a continuous trace display. It allows various data values to be displayed via the serial port, similar to the DM command, but it allows data from more than one channel to be simultaneously displayed, and it supports a wider range of data values.

The data values to be traced are specified by the TW and TI commands. The TW command is local to each channel, and enables or disables channel-specific data values such as position or speed. The TI command is global, and enables or disables tracing on input and output line states.

If a parameter value is given, the system prints that number of data samples, recorded at the full speed system sample time. If no parameter value is given, then single data samples are printed continuously, one line at a time, together with a timestamp value measured in system ticks.

The trace mode display is turned off by either TR0 or DO.

**TWbb** **Set trace options word.**
**Range : 16 bit binary value**

This command enables and disables tracing for various channel data values. When tracing is enabled with the TR command, the data values set by the TW channel options and the TI input/output trace options are displayed via the serial port. Each trace display field is labelled with a prefix letter and a channel number. The TW bit functions and prefix letters are listed below:

| Bit | Data value | Prefix letter |
|---|---|---|
| 0 | Demand position | D |
| 1 | Measured position | P |
| 2 | Position error | E |
| 3 | Demand velocity | V |
| 4 | Measured velocity | W |
| 5 | Average measured velocity | X |
| 6 | Reference error | R |
| 7 | Snapshot position | S |
| 8 | Change in demand | U |
| 9 | Change in position | C |
| 10 | Analogue input value | A |
| 11 | Analogue loop error | L |
| 12 | Actual map scale factor (%) | F |
| 13 | Master axis position | |
| 14 | Master axis velocity | |

**TIbb** **Set input/output trace options.**
**Range : 16 bit binary value**

This command enables and disables tracing for input and output line states. When tracing is enabled with the TR command, the data values set by the TW channel options and the TI input/output trace options are displayed via the serial port. Each input/output trace display field is labelled with a prefix letter and a group number. The TI bit functions and prefix letters are shown below:

| Bit | Data value | Prefix |
|---|---|---|
| 0 | Input group 1 | I1 |
| 1 | Input group 2 | I2 |
| 2 | Input group 3 | I3 |
| 8 | Output group 1 | O1 |
| 9 | Output group 2 | O2 |

**TF** **Turn off all trace options.**

This command turns off all trace data options on all channels by resetting the TW and TI parameters to zero. It simply provides an easy way to reset all trace options without having to change to each channel individually.

**DK** **Display system constants.**

The system displays various parameter values, in the following order:

- Proportional gain constant KP
- Integral gain constant KI
- Velocity feedback gain constant KV
- Velocity feed-forward gain constant KF
- Scale factor for length related units SU
- Velocity SV
- Acceleration (to nearest multiple of 256) SA
- Maximum position error SE

**CDnn** **Character delay.**
**Range : 0 to 255**
**Default : 0**

This command sets the delay between characters sent to the serial port, in units of 1/256 seconds. It allows the system to be used with terminals that do not support the xon/xoff handshake protocol, by simply inserting a time delay between each character sent from the MiniPTS 2+1.

**DWbb** **Display options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

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

Bit 0 When set to 0, the system does not restrict the length of any output display lines.
When set to 1, the system restricts output to 40 columns with the DK and DM commands.

Bit 1 Reserved.

Bit 2 Reserved.

Bit 3 Reserved.

Bit 4 When set to 0, maps and profiles are entered and listed in absolute position format.
When set to 1, maps and profiles are entered and listed in relative position format.

Bit 5 When set to 0, the normal one or two character error messages are returned by the system.
When set to 1, the system returns longer error messages. This is the default setting.

Bit 6 When set to 0, the system expects input values in decimal.
When set to 1, it expects input values in hexadecimal.
Note that this does not affect parameter values that are entered as binary numbers.

Bit 7 When set to 0, the system prints output values in decimal.
When set to 1, it prints output values in hexadecimal.
Note that this does not affect values that are printed as binary numbers.

The default value of zero is for a standard 80 column terminal, and uses decimal input and output. This command is restricted, and is only available in privileged mode.

**HE** **Print help display.**

This command prints a complete list of all commands available on the system, in alphabetical order, a screenful at a time. It pauses between each page until a character is entered. The escape key may be used to exit from the help command early. Help on a single command is displayed if the command mnemonic followed by '?' is entered. Single command help for commands such as SF or RW prints a list of the options for the command.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | DP?<CR> | Request help on DP command |

```
Display measured position
1>
```

**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.

**SYnn** **Enable system/channel prompts (restricted).**
**Range : 0 to 1**
**Default : 1**

This command is used to enable and disable prompt and status messages. SY1 enables prompts, and SY0 disables them. Display values such as DP and error messages are always sent to the serial port, even when prompts are disabled. The prompt is always given for the current focus channel, which is set by entering a single CH command at the terminal. Note that CH and CP commands in command strings and sequences do not change the terminal focus channel.

## 4.17 Analogue Control

This section describes facilities for performing analogue loop control, for either tension control or torque control applications. Closed loop tension control is performed by calculating the required speed ratio between a master and slave axis in mapping, with feedback on the analogue input. Closed loop torque control is performed by modifying the analogue torque output signal to achieve the setpoint on the analogue input. Open loop torque control allows the system to simply output the torque setpoint value as an analogue signal. The torque setpoint may be set manually, or may be derived from a position dependent map data table.

The tension control loop operates by sampling the analogue input value at regular intervals, and calculating a required speed ratio between master and slave axes according to some control algorithm. The algorithm used is of the following form.

$$\text{Ratio} = SM \times [1 + (AP e_i + AI \sum e_i + AD(e_i - e_{i-1}))]$$

where SM = default ratio
AP = proportional gain constant
AI = integral gain constant
AD = differential gain constant
$e_i$ = tension error (= tension setpoint – measured tension)

The MiniPTS 2+1 provides some facilities for controlling motor torque, and it is possible to switch from position control to torque control while the motor is mapping. Normally the torque control signal appears at the main analogue output as a voltage in the range ±10V, in which case the motor servo drive must be configured to convert the input voltage to a torque demand. If this is not possible the axis can be switched to use the auxiliary analogue output to limit the torque and the main analogue output to control the motor direction. In this case the auxiliary output voltage is in the range 0 – 10V and the main output is set positive or negative depending on the required motor direction. The level of the main output voltage is determined by the value of the SS command. The axis is instructed to use the auxiliary output by setting bit 0 in the control word CW.

When the main analogue output is used, the output voltage also includes the offset due to the ID command. The sense of the auxiliary output can be reversed by setting bit 1 in the control word CW. In this case the output voltage is +10V for zero demand and reduces towards 0V as the demand is increased.

The analogue output voltage from either the main or auxiliary output in open loop torque control mode is calculated from the torque setpoint as follows.

$$V_{out} = \left(\left(\text{Setpoint} \times \frac{KM}{256}\right) + OM\right) \times \frac{10}{2048}$$

The torque demand is either the value given with the TQ command for static torque control, or the value read from the map data table when executing a position-dependent torque control map.

In closed loop torque control mode, the system operates by sampling the analogue input value at regular intervals, and calculating a required analogue output signal according to the PID torque control algorithm. The algorithm used is of the following form.

$$V_{out} = \frac{1}{256} \times \left[ AP e_i + AI \sum e_i + AD(e_i - e_{i-1}) \right] \times \frac{10}{2048}$$

where AP = proportional gain constant
AI = integral gain constant
AD = differential gain constant
$e_i$ = torque error (= torque setpoint – measured torque)

In closed loop analogue control, 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 best performance on a particular mechanical setup requires setting up these gain constants.

The performance of the analogue control loop may be monitored by means of the analogue output monitor functions. Commands are provided to output various signals, including the analogue loop error and the current ratio, on the monitor output for viewing on an oscilloscope or chart recorder. These are described in section 4.10.

The action of the XM command is modified if tension control is on, as set by the AM1 command. When tension control is on, the map startup sequence is determined by AW bit 0. If AW bit 0 is set to 0, the slave axis goes immediately into mapping, using the software clutch, with the map ratio determined by the tension control loop. If AW bit 0 is set to 1, the slave axis moves at jog speed (set by SS) until the measured analogue input reaches the tension control setpoint, and then drops into mapping. This is intended to initialize tension control when the master axis is stopped. The direction of the slow speed initial move is set by AW bit 6.

If either of AW bits 4 and 5 are also set to 1, then the unit automatically initializes the map scale factor before executing the map under tension control. The system measures the distance moved by the master and/or slave axes between the two positions where the analogue input high and low limits are exceeded, and stores these in the AR parameters. The ratio of these two values gives a good estimate of the initial map ratio required by the tension control loop and is used at the start of synchronization. This allows the system to reach its correct steady state ratio much more quickly than if it starts from the default SM value, particularly if the system is not at its normal starting position.

An example where this is useful is a winding or unwinding application. In normal circumstances the system always starts with either a full or empty spool of material, and the initial scale factor is set in the SM parameter. Restarting the machine with the same spools uses the scale factor last calculated when the machine was stopped, and the tension loop restarts smoothly. However, if the machine may be started with spools that are partly filled to an unknown diameter, then the normal SM value is not at the correct value for running at the new spool diameter. The analogue range initialization function allows the required ratio with the actual spool diameters to be measured. The machine may be started with the new spool without any large transients while the tension control loop stabilizes from the initial default SM value to the new scale factor.

**AMn** **Set analogue control mode.**
**Range : 0 to 2**
**Default : 0**

This command selects the analogue closed loop control mode. AM1 enables tension control, AM2 enables torque control, and AM0 disables the analogue control functions. The analogue control loop may be enabled and disabled at any time. The AM value is not saved.

AM1 sets bits 0, 1 and 4 of MW to a 1. This forces the use of the software clutch and speed mapping, as required for tension control.

**APnn** **Set analogue control proportional gain (restricted).**
**Range : 0 to 65535**
**Default : 4096**

This command sets the proportional gain for the analogue control loop. The proportional gain acts on the measured analogue error, which is calculated as the difference between the required setpoint and the value measured by the analogue input. High gain gives the system a faster response and tighter 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.

**AInn** **Set analogue control integral gain (restricted).**
**Range : 0 to 65535**
**Default : 0**

This command sets the gain for the integral term in the analogue control loop. When integral control is used, the system integrates the analogue error by adding the current error to a running total. Integral gain is useful to allow for long term changes in ratio, as required for tension control in winding/unwinding applications.

**ADnn** **Set analogue control differential gain (restricted).**
**Range : 0 to 65535**
**Default : 0**

This command sets the gain for the differential term in the analogue control loop. This term uses the differential of the analogue error (rate of change of error), which represents the velocity error of the system. This is useful where the analogue error is changing rapidly, and provides damping in the analogue control loop.

**ACnn** **Set analogue control setpoint.**
**Range : ±2047**
**Default : 0**

This command sets the setpoint for the analogue control loop. The loop error is calculated by subtracting the measured analogue input value from the setpoint. It may be incremented and decremented by the IP command when IS is set to 2.

**TQnn** **Set manual torque control setpoint.**
**Range : ±2047**
**Default : 0**

This command is used to set the torque control setpoint. In open loop torque control, it sets the analogue output to the given demand value. The output voltage is related to the demand as shown in the equation on page 151. In closed loop torque control, the torque error is calculated by subtracting the measured torque (the analogue input value) from the torque setpoint. This error value is then used in the PID loop equation shown on page 152 to calculate the required analogue output signal.

When the TQ command is first executed, the axis controller enters torque control mode and the prompt changes to 'T'. It is only possible to enter torque control mode from position control mode. Once the axis is in torque control mode, the torque control setpoint can be changed by issuing further TQ commands, or it may be incremented and decremented by the IP command when IS is set to 2. To exit from torque control mode the ST, AB or MO commands can be used.

If the motor moves away from the demand position in the direction of the torque setpoint, then the torque is reduced as the position error increases. The available torque signal is maintained at the set value if the position error is less than SW, and then is reduced linearly as the error exceeds SW, reaching zero when the position error reaches SE.

**OLnn** **Set analogue output limit (restricted).**
**Range : 0 to 2047**
**Default : 2047**

This command is used to set an upper limit on the absolute value of the main analogue output. Once set the limit is active at all times and is not specific to the analogue control mode.

**Example : `OL1024`**
The analogue output is limited between ±5V.

**AWbb** **Set analogue control options word (restricted).**
**Range : 8 bit binary value.**
**Default : 0**

This command allows the user to modify the operation of the analogue control loop in various ways. The value is entered as a binary number, with each bit controlling a different aspect of the function. Leading zeros may be omitted. The bit functions for the analogue control options word are described below.

Bit 0 This bit controls the behaviour of the system when mapping is started with the XM command and tension control is enabled by setting AM1.
When set to 0, the slave axis goes immediately into mapping, using the software clutch, with the map ratio determined by the tension control loop.
When set to 1, the slave axis moves at jog speed (set by SS) until the measured analogue input reaches the tension control setpoint, and then drops into mapping. This is intended to initialize tension control when the master axis is stopped.
This bit set to 1 also enables the functions of AW bits 4, 5 and 6.

Bit 1 Reserved.

Bit 2 This bit controls the analogue control integral term. It allows the analogue control integral term to be turned off if required, for example if the controlled motor is disabled. This prevents the system from integrating up any static analogue error and giving a large transient when the motor starts again.
When set to 0, the analogue control integral term is disabled.
When set to 1, the analogue control integral term is enabled.

Bit 3 This bit sets the initial ratio when the slave axis is mapped to the master axis and tension control is enabled. It also allows the current ratio to be reset to the default value, as set by the SM command, at any time.
When set to 0, the initial ratio is the SM value.
When set to 1, the ratio value used previously is kept. Normally this is the last value calculated by the tension control loop before the slave axis was stopped.
When changed from a 1 to a 0, the current ratio is reset to the default value.

Bit 4 This bit controls the automatic measurement of the distance between the high and low analogue limits (the analogue range distance) on the slave axis when the XM command is executed. Refer to the AR and XR commands for more details.
When set to 1, the slave axis analogue range initialization is enabled.
When set to 0, the slave axis analogue range initialization is disabled.

Bit 5 This bit controls the automatic measurement of the distance between the high and low analogue limits (the analogue range distance) on the master axis when the XM command is executed. Refer to the AR and XR commands for more details.
When set to 1, the master axis analogue range initialization is enabled.
When set to 0, the master axis analogue range initialization is disabled.

Bit 6 This bit sets the direction of the tension takeup move when the slave axis is started with tension control enabled, and AW bit 0 set to 1.
When set to 0, the direction of the takeup move is the same as the sign of the initial tension error.
When set to 1, the direction of the takeup move is the opposite of the sign of the initial tension error.

Bit 7 This bit determines the sense of the analogue control loop.
When set to 0, an increase in the analogue error gives an increase in the output value.
When set to 1, an increase in the analogue error gives a decrease in the output value.

**ARnn** **Define analogue range distance (restricted).**
**Range : 0 to 65535**
**Default : 256**

This command defines or displays the distance between the analogue input high and low limits on the current channel, called the analogue range distance. It may be used to set this value for a master axis that is not driven by the unit, or to display the value measured by the XR initialization function.

**CR** **Calculate initial ratio from analogue range distances.**

CR calculates the ratio between the two AR values on the master and slave axes, and uses the result as the map scale factor. The ratio is calculated from the two AR values as AR(slave)/AR(master), in much the same way as the BR command does for the bounds values.

**XR** **Execute analogue range distance initialization.**

XR executes the analogue range initialization function manually on the current axis, and stores the measured value in AR.

The analogue range initialization function does the following:
The motor moves in one direction, chosen so as to move initially towards the setpoint, until one analogue input limit is crossed, stores the current position and stops. It then reverses and moves until the other analogue limit is crossed, stores this second position, and saves the difference between the two positions as the AR value.

It is important that the set bound values (SB) on the master and slave axes are larger than the AR distances to be measured by this function. If not, and the position value wraps around during the XR initialization, then the difference between the high and low limit positions does not represent the distance moved between the limits, and the result stored in the AR value is wrong. This is not usually a problem since in tension control applications the axes are synchronized using speed mapping, the bounds positions are not required for position synchronization or referencing and are set to their default maximum value.

If the current channel has tension control enabled by setting AM to 1, then the system assumes that this is a slave axis, and the XR command uses the analogue input and limit values for the current axis. If the current channel does not have tension control enabled, then the system assumes that this is a master axis. It finds the first slave axis linked to this axis with tension control enabled, and uses the analogue input and limit values for this axis. If no suitable slave axis is found linked to the current axis, with tension control enabled, then the analogue input and limits for the current channel are used.

Setting AW bits 4 and/or 5 on the tension controlled slave axis enables automatic measurement of the analogue range distance on the slaveand/ or master channels respectively at the start of mapping. If this is enabled on either axis, then the measured AR value(s) are used to calculate the initial map scale factor as AR(slave)/AR(master), as in the CR command.

**XTn/x/y** **Execute torque control over defined position range (restricted).**
**Range : map number 0 to 255**
**positions ±4 000 000**

This command is used to define a range of master axis positions in which the slave axis executes torque control mode, using the map specified by the parameter. It is used on the slave channel, not on the master. When the parameter is non-zero the command **must** be followed by two position values with the second value greater than the first. During mapping while the master axis is within the range defined by the positions the slave axis switches to torque control mode and the values in the map table specified by XT are interpreted as torque demand values. When the master axis is outside the specified position range the slave axis switches back to position control mode and uses the normal map table.

The torque control range can be turned off by entering the XT command with a map number of 0. In this case the position values are not required.

**Example : `CH2/ML1/XT11/1000/2000/XM10`**
This command links channel 2 to channel 1 for mapping, specifies a mapped torque control range and executes map 10. When the master axis, channel 1, is in the position range 1000 to 2000, channel 2 switches to torque control mode and uses map 11 as a torque map. When the master axis is outside the position range 1000 to 2000, the slave axis switches back to position control mode and executes map 10. Note that map 11, used as the torque map, only requires entries covering a range of master positions from 0 to 1000. The lower position value given in the XT command sets the lowest master position for the torque map. The values in the torque map are used as the torque setpoint in the same way as the TQ command.

**CWbb** **Set control word (restricted).**
**Range : 8 bit binary value.**
**Default : 0100 0000**

This command allows the user to write a value into the control word for the current channel. Note that the leading zeros may be omitted. The control word allows the analogue outputs to be configured as required for torque control applications. 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 0 When set to 1, the auxiliary analogue output is used for torque control. When set to 0, the main analogue output is used for torque control.

Bit 1 When set to 1, the sense of the auxiliary output used for torque limiting is reversed to provide a +10V output at zero torque demand. When set to 0, the auxiliary output used for torque limit is normal providing a 0V output at zero torque demand.

Bit 2 Reserved.

Bit 3 This bit enables operation with a unipolar analogue output signal. The command signal is limited to the range 0–10V, and the direction is given by a digital output line, set by the DU command. This option is used with inverters or other similar drives which only accept speed input signals between 0 and 10V.

Bit 4 This bit defines the sense of the main analogue output for the motor command signal. It also reverses the sense of the torque control output. When set to 0, the command signal sense is normal; if the encoder is moved in the positive direction, a negative output voltage is produced at the command output.
When set to 1, the sense of the command signal output is reversed; if the encoder is moved in the positive direction, the command signal goes positive.

Bit 5 This bit defines the logical sense of the encoder input.
When set to 0, the encoder direction sense is normal; if encoder signal track A leads track B the motion is positive.
When set to 1, the encoder direction is reversed; if track A leads track B the motion is negative.

Bit 6 This bit defines the initial state of the system at power-up.
When set to 1, the axis powers up in the motor off state with the servo loop disabled. This is the default case for standard systems.
When set to 0, the axis powers up in position control mode with the servo loop active.

Bit 7 Used in position control.

The default control word value of 01000000 makes the channel power up in the motor off state.

**Example : `CW00000001`**

This sets up the axis to use the auxiliary analogue output for torque control and power up in position control mode.

**Example : `CW01110001`**

This reverses the sense of both the encoder feedback and the analogue output to the drive amplifier.

**AHnn** **Set analogue input high limit.**
**Range : ±2047**
**Default : +2047**

This command sets the high limit for the analogue input. If the analogue input value exceeds this value, then the “analogue input high limit exceeded” error message is displayed. If bit 3 of the error options word EW is set to 1, then this is a motor error, and the axis shuts down to the motor off state.

**ALnn** **Set analogue input low limit.**
**Range : ±2047**
**Default : –2047**

This command sets the low limit for the analogue input. If the analogue input value goes below this value, then the “analogue input low limit exceeded” error message is displayed. If bit 3 of the error options word EW is set to 1, then this is a motor error, and the axis shuts down to the motor off state.

**AE[g:]n±** **Define analogue limit error output (restricted).**
**Range : 1 to 8**

This command defines the specified output line as an analogue input out of limits error signal. The line is set to the specified state when the analogue input valie is outside the high and low limits set by the AH and AL commands, and cleared again when the analogue input returns inside these limits. This gives an external indication that the MiniPTS 2+1 is maintaining the analogue input within the desired limits.

**DA** **Display analogue input value.**

Displays the current value of the analogue input signal on the current channel as a number in the range ±2047.

## 4.18 Variables and the Database

The variable database is a centralized facility which is accessible to all tasks in the system and holds a set of integer variables. Because variables are generally accessible, it is possible for the user to change a variable using the Operator's Panel and for the variable to be used subsequently to set a motor parameter in the MiniPTS 2+1. Similarly a variable can be set to some motor parameter, such as the position, which can then be displayed on the Operator's Panel. A variable can also be set up to trigger execution of a command string on the MiniPTS 2+1. This means that a button on the Operator's Panel can be set to update a variable which in turn triggers an action on the MiniPTS 2+1.

A variable is referred to by a short name which is assigned by the user but must keep to the following rules.

- A variable name consists of up to 3 characters which must be numbers '0-9' or letters 'A-Z' or 'a-z'.
- The name must not include punctuation characters such as '_' (underscore), '.' (dot) or any spaces.
- Upper and lower case letters are equivalent. For example 'POS' and 'pos' refer to the same variable.
- In MiniPTS 2+1 commands a variable is prefixed by '$' (dollar) to distinguish it from normal command mnemonics.

A variable can be set to a constant value using '=' (equals). For example the following command sets the variable $SPD to a value of 5000.

```
1> $SPD=5000
```

A variable can be used in place of a numeric parameter in most commands. For example the following command sets the velocity to the value of the variable $SPD which is currently 5000. If the variable has not been assigned a value, then the "undefined variable" error message is displayed.

```
1> SV$SPD
```

Conversely it is possible to query a parameter and place the result in a variable. The following example updates variable $SPD with the current velocity value.

```
1> $SPD=SV
```

A variable can be defined as a trigger variable so that when it is updated a string of commands is executed. The following example defines $SPD as a trigger variable which causes the velocity to be set to the value of $SPD each time the variable is updated.

```
1> $SPD>CH1/SV$SPD
```

Variables can be used in arithmetic expressions involving the standard operators +, -, *, /, %. The % remainder or modulo operator gives the remainder when the left operand is divided by the right. An expression must be enclosed in brackets and it may also be necessary to use further levels of brackets inside the expression to ensure that sub-expressions are evaluated correctly. In any expression the number of left brackets must always equal the number of right brackets. An expression can be used as a command parameter anywhere that a simple variable can be used. The following example does an initialization move based on the product length ($LEN) and batch size (20) but allowing for bounds wraparound ($BND).

```
1> CH1/MA(($LEN*20)%$BND)
```

If the product size is 600 counts and the bounds are 5000 counts the above command would result in a move to 2000. Note the extra pair of brackets to ensure that multiplication takes place before the modulo operation.

Variables should not be used in place of parameters which include a '+' or '–' sign. In particular, setting variable $A to 4 and typing DR$A– is not the same as typing DR4– and will merely give a syntax error. In commands which take more than one parameter a variable can be used in place of either or both parameters. The following example sets map scaling to 75/100.

```
1> $PC=75
1> SM$PC/100
```

Because variables are integers, division normally gives an integer result and any remainder is lost. However, where an expression includes a floating point constant number, the result is calculated to floating point accuracy. For example if $A has a value of 5, the first example below moves to a position of 2 units whereas the second moves to a position of 2.5 units.

```
1> MA($A/2)
1> MA($A/2.0)
```

Variables can also be used in logical expressions. These are used with the IF command to allow conditional execution of commands. A logical expression compares two values using the ==, !=, <, >, <=, >= operators to give a result of TRUE or FALSE. It can be combined with other expressions using the && and || operators to give compound expressions. An expression must be enclosed in brackets and it may also be necessary to use further levels of brackets inside the expression to ensure that sub-expressions are evaluated correctly. Ambiguous expressions in sequences may be resolved by the system; listing a sequence will show the result with brackets inserted as necessary.

The following table shows the valid arithmetic and logical operators, in order of precedence. Operators of equal precedence are are shown between double lines.

| Symbol | Operation | Example |
|---|---|---|
| – | Negate | (–5) = –5 |
| * | Multiply | (5*2) = 10 |
| / | Divide | (5/2) = 2 |
| % | Remainder | (5%2) = 1 |
| + | Plus | (5+2) = 7 |
| – | Minus | (5–2) = 3 |
| < | Less than | (5<6) = FALSE |
| > | Greater than | (5>5) = FALSE |
| <= | Less or equal | (5<=6) = TRUE |
| >= | Greater or equal | (5>=5) = TRUE |
| == | Equal to | (5==2) = FALSE |
| != | Not equal to | (5!=4) = TRUE |
| && | Logical AND | (5==4) && (5>4) = FALSE |
| \|\| | Logical OR | (5==4) \|\| (5>4) = TRUE |

**Table 3: Arithmetic and logical operators**

Because variables and expressions are evaluated at execution time, commands using them run somewhat slower than commands using only constant parameters.

**$var=nn** **Variable assignment.**

The equals sign '=' assigns the value or expression on its right to the variable on its left. Assignment can be used to initialize a variable or to set a variable to a new value based on the value of some other variable. If '=' is followed by a command mnemonic which can be queried, the result of the query is assigned to the variable.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | $SPD=5000 | Set variable $SPD to 5000 |
| 1> | $POS=DP | Set $POS to current position |

**WV$var** **Wait for write to variable.**

This command tells the system to wait until a value is written to the specified variable before continuing with the command string or sequence.

**$var>cmds** **Define trigger variable (restricted).**

The right arrow '>' defines the variable on its left as a trigger variable such that each time the variable is updated (it need not change value) the commands between '>' and the end of line are executed. It is important to make sure that the triggered commands do not cause the trigger variable to be updated otherwise the system will enter an endless loop when the trigger variable is first updated.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | $SPD>CH1/SV$SPD<CR> | |

In the example above, the variable $SPD is defined as a trigger variable so that each time it is updated, the velocity on channel 1 is set to the value of variable $SPD.

To remove the trigger variable definition the variable and '>' should be entered at the end of line with no following commands.

**VX** **List trigger variables.**

This command displays a list of all the trigger variables along with their associated command strings, one per line. Trigger variables are defined using '>' (right arrow). For each trigger variable the display shows the trigger variable, '>', its command string, and its mask/enable state.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | VX<CR> | List all trigger variables |
| $SPD>CH1/SV$SPD | | System lists $SPD and $TR |
| $TR>CH2/$POS=DD | | |
| 1> | | |

**MV[$var]** **Mask trigger variables.**

This command inhibits a specified trigger variable, or all trigger variables if no variable name is given. The VX command shows the current mask/enable state of all trigger variables.

**EV[$var] Enable trigger variables.**

This command enables a specified trigger variable, or all trigger variables if no variable name is given. The VX command shows the current mask/enable state of all trigger variables.

**LV$var List variable value.**

This command lists the value of the specified variable. The display shows the variable name, '=' and the value. If LV is entered without a variable name, the system lists all the currently defined variables in alphabetical order with their values.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | LV$SPD | List value of $SPD |
| $SPD=5000 | | Current value is 5000 |
| 1> | LV | List all variables |
| $ABC=1 | | Variables are listed in order |
| $SPD=5000 | | |
| $TR=0 | | |
| 1> | | |

**LXexpr List expression.**

This command displays the value of an expression or variable and is mainly useful for verifying that an expression is evaluated as expected during application development. The display echoes the LX command mnemonic followed by the numeric value of the expression.

**Example :**

| System | User | Comments |
|---|---|---|
| 1> | $SPD=5000 | Set $SPD to 5000 |
| 1> | LX($SPD+1000/100) | |
| LX5010 | | System displays result. |
| 1> | | |

In the example above, the LX command displays a result of 5010 rather than 60 because the division operator has higher precedence and is applied before the plus operator.

**VE$var** **Set error variable (restricted).**

This command defines the error variable for the current channel. The error variable is set to the error code each time an error occurs on its channel. Each channel has an error variable although it may be the same variable as for another channel. The error variable may be used to trigger a string of commands by defining it as a trigger variable. This allows some form of recovery action to be taken when an error occurs. Alternatively the error variable may be used to display a message on the Operator's Panel by specifying it as the associated variable to a message list. The error codes are listed in section 5.4.

**VS$var** **Set status variable (restricted).**

This command defines the status variable for the current channel. The status variable is set to the status code each time the status changes on its channel. Each channel has an status variable although it may be the same variable as for another channel. The status variable may be used to trigger a string of commands by defining it as a trigger variable. This allows some form of action to be taken when status changes. Alternatively the status variable may be used to display a message on the Operator's Panel by specifying it as the associated variable to a message list. The status codes are listed in section 5.3.

**IFexpr** **Execute commands if expression is true.**

The IF command causes the commands following it to be executed only if the expression is true (i.e. non-zero). This command affects all commands following it up to the end of line or the next EL command, whichever comes first. The expression following the IF command may consist of a simple variable, a comparison or a combination of expressions. A comparison uses the operators ==, !=, <, >, <=, >=. Expressions can be combined using the operators &&, ||.

**Example: `IF($X<10)/$X=($X+1)/SV($X*1000)/WT256/RP`**
This command line repeatedly increments $X, sets a new speed and waits 1 second until $X becomes equal to 10.

**Example: `IF(($X>=10)&&($X<=20))/SV($X*1000)`**
This example shows a more complex expression in the IF command.

**EL** **Else – execute commands if condition is false.**

The EL command causes the commands following it to be executed if the preceding IF or II command evaluated to false, or zero. The EL command must either appear on the same line as the associated IF or II command, or as the first command on the following line. If the EL command appears in any other position, all commands following it up to the end of line are simply ignored.

**Example: `II1-/MA1000/EL/MA5000`**
This command line executes a move to 1000 if input line 1 is negative or a move to 5000 otherwise.

**Example: `IF($S&&($A>=100))/XS$A/EL/XS99`**
This command line executes a sequence ($A) only if $S is non-zero and $A is greater than or equal to 100. Otherwise the default sequence 99 is executed.

**YA–YJ** **Free parameters.**

There are ten unused parameters on each channel, acessed by the commands YA, YB...YJ. They are saved to non-volatile memory by the SP command along with all other parameters. They may be used to save preset values for variables required by the application program.

Some software options may use some of the YA–YJ commands to set extra parameters. For example, the Modbus interface option uses the YJ parameter on channel 1 for the unit number or node number.

**OP** **Configure Operator's Panel (restricted).**

This command allows the user to access the Operator's Panel configuration menus. When OP is entered, the system displays a banner giving information about the command. The user then presses <CR> to access the configuration menus. To exit from configuration, return to the main menu and select option 0 or press <CR> to finish configuration. Then press '~' (tilde) to return to the normal MiniPTS 2+1 prompt.

**Safety Note.**

While the Operator's Panel is being configured, normal motor control commands cannot be processed. For this reason it is strongly recommended that any motors attached to the MiniPTS 2+1 are set to a safe state such as motor off before entering the OP command.

Please refer to the Operator's Panel Reference Manual for full details on setting up the Quin Programmable Operator's Panel.

## 4.19 Edit Mode

Edit mode is an operating mode for the MiniPTS 2+1 which allows commands to be entered at the command line prompt without being executed immediately. Instead the commands are buffered internally and only executed when the GO command is issued to return the MiniPTS 2+1 to normal Run mode. The main use of Edit mode is for entering commands from a remote computer, such as the AFE IC2X system. Because there are no delays in executing the commands, communications with the remote computer are more reliable.

An important advantage of Edit mode is that the commands are executed in strict order. Normally lines of commands entered at the prompt are executed in parallel so that the user always has control of the machine and is able to change parameters or abort execution while the machine is running. In Edit mode each command line is executed only when the previous line has finished.

When Edit mode is entered the sequence of events is as follows.

- The system executes the GS (Global Stop) function to terminate any command strings and/or sequences currently executing.
- While the system is in Edit mode all input functions and trigger variables are ignored so that no commands can be executed.
- The user (or remote computer) enters the setup commands which are buffered for later execution.
- Sequences, maps and profiles can be entered as normal.
- When all the required commands have been entered, the user enters the GO command to return to normal Run mode and trigger execution of the buffered commands.

The commands used to switch into Edit mode and back to Run mode are described below.

**ED** **Enter Edit mode (restricted).**

This command is used to enter Edit mode. In this mode all command execution is inhibited and commands entered at the prompt are buffered for later execution when the system returns to Run mode. When the ED command is entered at the terminal, the command line prompt changes to ED: as a reminder that the mode has changed.

**GO** **Return to Run mode (restricted).**

This command is used to return to normal Run mode from Edit mode. The GO command enables normal command execution and triggers execution of the commands buffered in Edit mode. Because of the way the command is implemented, it completes immediately and returns the normal system prompt.

**Example:**

The following example shows the use of Edit mode to buffer an IN command followed by DP. In addition, it shows a sequence being entered in Edit mode. Note that the RS command is entered before going into Edit mode to avoid deleting sequence 10 when we return to Run mode. The IN and DP commands are executed in strict order on exit from Edit mode.

| System | User | Comments |
|---|---|---|
| 1> | RS | Reset the system |
| 1> | ED | Enter Edit mode |
| ED: | ES10 | Enter sequence 10 |
| S10: | CH1/MA1000 | |
| S10: | CH2/SO3 | |
| S10: | | Finish sequence 10 |
| ED: | CH1/IN+ | Initialization commands |
| ED: | CH1/DP | |
| ED: | GO | Return to Run mode |
| 1I | | Executing buffered commands |
| 1S | | |
| 1> | | Initialization finished |
| 1 DP2 | | Executing DP command |
| 1> | LS | List sequences |
| 10 | | Sequence 10 is defined |
| 1> | | |

# 5. Status and Error Messages

## 5.1 Status Messages

This section gives the system status messages in various circumstances.

> Normal prompt
> This is the prompt character in position control mode. The system is ready for the next command.

: Motor off prompt.
This is the prompt character in the motor off state.

? New value prompt.
This character is used to prompt for a new parameter value.

I Initialising.
The system is executing the IN initialize command.

M Moving.
The system is executing a normal trapezoidal move.

P Profile move.
The system is executing a stored profile move.

S Stopping
The system is executing a normal controlled stop.

T Torque control mode.
The axis is operating in torque control mode.

V Velocity control mode.
The system is executing a constant velocity move.

W Waiting.
The system is waiting for some condition before continuing.

X Executing a position mapping.
This channel is linked to another master axis and is executing a position mapping. The ‘X’ prompt is used to indicate that the channel is cross-linked to another channel, since the ‘M’ prompt is used for normal moves.

## 5.2 Error Messages

This section describes the various error messages produced by the system. The short error message is given first, followed by the corresponding long error message and a description of the error condition. The system defaults to using long error messages, as set by DW bit 5.

AH Analogue input high limit exceeded.
The high limit set on the analogue input has been exceeded.

AL Analogue input low limit exceeded.
The low limit set on the analogue input has been exceeded.

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

CT Clutch timeout.
The software clutch was unable to start the mapping because the current slave position is outside the range of positions onto which the master position is mapped.

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

DF Command decoding failed.
This is an internal system error message. It indicates that there was some problem in decoding the command. It should not arise in a normally working system, but is reported for fault finding and debugging.

E Unknown command <cmd> – type HE for help.
The system received a command which was not recognized.

E Invalid command entry <cmd>.
A command was given with an invalid parameter.

E Cannot execute <cmd> while <state>.
The command given cannot be executed while the system is in its current state.

E Cannot change <cmd> while <state>.
The parameter given cannot be changed while the system is in its current state.

E <cmd>: Command not available.
This command is not available with the current configuration, or in the current state.

E Cannot execute <cmd> while monitor function defined.
It is not possible to use this channel while a monitor function on another channel is assigned to this channel’s analogue output.

E Monitor function not available while output in use.
The monitor function (SF) cannot be defined while the auxiliary output is being used for torque control etc., or the auxiliary output cannot be assigned to the specified channel's analogue output.

E <cmd>: No reference input defined.
The command cannot be executed because there is no reference input defined.

E Cannot compile sequence while executing any sequence.
A sequence cannot be compiled because a sequence is already being executed on the indicated channel. This error message normally occurs when a sequence is executed without being previously compiled.

E Cannot transfer map while it is executing.
A map cannot be transferred to a channel which is already executing the map.

E Cannot transfer profile while it is in use.
A profile cannot be transferred to a channel which is already executing the profile.

E <cmd>: No output group defined.
The command given can only be used when there are expanded output lines defined.

E No commands after <cmd>.
This command can not be used at the end of a command line.

E No commands before <cmd>.
This command can not be used at the beginning of a command line.

E MLn: Already linked to channel m.
A slave channel cannot be linked to more than one master channel.

E MLn: Invalid link command completes a chain.
Channels cannot be linked in a closed chain.

E TS: Error setting time.
The parameter entry for the TS command was not correct, or a system error occurred on attempting to set the new time.

E <cmd>: Sequence stack overflow.
A sequence or set of nested sequences must not call themselves; this would cause indefinite recursion.

E Only one repeat allowed in any command line.
Only one repeat command may be given on one command line.

E Command <cmd> not available.
The command given is not available on this version of the system.

E <cmd>: Not a DI input
Cannot list the input function for a line which is not a DI input.

E EL command without matching IF or II
EL command is only valid following IF or II

F Nvm write failed.
The parameters and data could not be saved to nonvolatile memory successfully.

F Nvm verify failed.
The parameters and data saved to nonvolatile memory have not verified correctly.

F Saved data overflows nvm space.
The save parameters command has more data to save than will fit into the available nonvolatile memory space.

F Checksum error.
The calculated checksum value does not match the checksum saved with the data.

F Stored data invalid.
The stored data is invalid.

F Can’t access stored data: error n.
The system cannot access parameters stored in nonvolatile memory. The error number is an internal system error code.

F Error sending command.
An error occurred while sending the stored setup parameters to the motor channel.

FA Sequence/profile data pointer error
An internal error has occurred on the axis controller module.

FA <cmd>: String pointer error
An internal error has occurred on the axis controller module.

G Motor position error.
The system measured an instantaneous position error greater than the maximum allowed position error set by the SE command.

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

Ln Limit switch detected.
A limit switch input has been detected.

LH High position limit exceeded.
The motor position moved above the maximum value set by the LH command

LL Low position limit exceeded.
The motor position moved below the minimum value set by the LL command.

MO Map position overflow.
Either the demand position calculated for the slave channel by the mapping, or the mapped master axis bound calculated at the start of mapping, was outside the maximum range for absolute positions.

N <cmd>: Memory full.
There is no more room in memory for maps, profiles or sequences.

N <cmd>: Working memory full.
There is no more room in working memory for temporary storage for the given command.

NI <cmd>: Input line too noisy.
An input line remained unstable for at least two debounce times and the II command could not make any decision.

O <cmd>: Parameter out of range.
The value entered was outside the allowed range for this command.

O <cmd>: Target position outside limits.
The target position specified in a move command is outside the low or high position limits.

O <cmd>: Moving away from wait position.
The motor is moving away from the position specified in a wait for position command.

O <cmd>: Undefined map.
The specified map is not defined.

O <cmd>: Undefined profile.
The specified profile is not defined.

O <cmd>: Undefined sequence.
The specified sequence is not defined.

O <cmd>: Second position below first.
The two positions for this command must be in order, with the second position higher than the first.

O MLn: Invalid master channel.
A slave channel cannot be linked to itself, or to a channel not fitted to the system.

R Restricted command <cmd>.
This command may only be used in privileged mode.

R Restricted parameter <cmd>.
This parameter may only be changed in privileged mode.

RL Reference error outside limits.
The latest reference error measured was outside the limit set by the SR or LR command.

RO Reference correction overrun.
The previous reference correction was not complete when the next reference input signal was detected.

RT Reference timeout.
The system has completed several reference length cycles without detecting any reference signals.

SY This message indicates that some internal system error has occurred. These should not arise in a normally working system, but are reported for fault finding and debugging. If the long error messages are enabled, then more detail about the error condition is given.

T Motor timeout.
The system has detected a timeout error. The encoder has not moved at all for the timeout period, although the system expected it to move.

T Failed to reach target position.
The motor did not reach the move target position to within the position window before the timeout expired.

U <cmd>: Line already defined.
It is not possible to manually set or clear an output line that has been defined for some output function, or to redefine an input or output line that is already defined for a different function.

VA Undefined variable <var>.
An attempt has been made to reference a variable before it has been defined. A variable is defined by setting its value either using the MiniPTS 2+1 or the Operator's Panel.

VA Error accessing variable <var>.
The specified variable could not be accessed. This message normally indicates that the database is overloaded. The situation may be improved by reducing the access to variables to a minimum.

VA Error setting variable <var>.
The specified variable could not be set. This message normally indicates that the database is overloaded. The situation may be improved by reducing the access to variables to a minimum.

VA Attempt to divide by zero variable <var>.
An attempt has been made to divide by a variable which has a value of zero. This is not allowed as it would give an invalid result.

WF Watchdog test failed
The watchdog test has failed.

WT Watchdog timeout.
The watchdog timeout period has expired.

## 5.3 Status Codes

This section gives the numeric values for the status codes which are placed in the status variable defined by the VS command. The status code may be a combination of the values shown here. For example, if the channel is in the velocity control state and is waiting for an input line, then the status code value is 256 + 2 = 258.

| | |
|---|---|
| 0 | Idle mode (PC) |
| 1 | Waiting for time (WT) |
| 2 | Waiting for input line (WI) |
| 3 | Waiting for absolute position (WA) |
| 4 | Waiting for relative position (WR) |
| 5 | Waiting for reference input (WF) |
| 6 | Waiting for bounds wraparound (WB) |
| 7 | Waiting for bounds counter value (WC) |
| 256 | Constant velocity mode (VC) |
| 512 | Moving (MA, MR) |
| 1024 | Executing a profile (XP) |
| 2048 | Executing a position mapping (XM) |
| 4096 | Stopping (from ST) |
| 8192 | Initialising (IN, IB) |
| 16384 | Torque control mode (TQ) |
| 32768 | Motor off (MO) |

## 5.4 Error Codes

This section gives the numeric values for the error codes which are placed in the error variable defined by the VE command.

| | | |
|---|---|---|
| 1 | 0x01 | Error setting sleep time |
| 2 | 0x02 | Error setting timeout for channel signals |
| 3 | 0x03 | No data ready |
| 4 | 0x04 | Error testing for data ready |
| 5 | 0x05 | Not ready to receive data |
| 6 | 0x06 | Error testing ready-for-data |
| 7 | 0x07 | Error setting up signals |
| 8 | 0x08 | Error setting up event n |
| 9 | 0x09 | Cannot access channel 1 |
| 10 | 0x0A | Error closing path to motor n |
| 11 | 0x0B | MLn: Already linked to channel n |
| 12 | 0x0C | MLn: Link would complete a closed loop |
| 13 | 0x0D | MLn: Cannot link channel to itself |
| 14 | 0x0E | MLn: Invalid master channel |
| 15 | 0x0F | Not linked to a master channel |
| 16 | 0x10 | TS: Error setting time |
| 17 | 0x11 | Cannot access stored data |
| 18 | 0x12 | Stored data invalid |
| 19 | 0x13 | Saved data overflows nvm space |
| 20 | 0x14 | Error sending command |
| 21 | 0x15 | Nvm write failed |
| 22 | 0x16 | Checksum error |
| 23 | 0x17 | Error setting up display buffer |
| 24 | 0x18 | Error fetching display sample count |
| 25 | 0x19 | Previous signal to channel still pending |
| 26 | 0x1A | Map slave channel address table is full |
| 27 | 0x1B | Slave channel address not found in table |
| 28 | 0x1C | Device not ready |

| | | |
|---|---|---|
| 29 | 0x1D | Error: n |
| 30 | 0x1E | Error reading error status |
| 31 | 0x1F | Restricted command <cmd> |
| 32 | 0x20 | Restricted parameter <cmd> |
| 33 | 0x21 | Error reading status |
| 34 | 0x22 | Invalid channel change |
| 35 | 0x23 | Cannot change to CHn twice in same sequence |
| 36 | 0x24 | More than 1023 channel level sequences |
| 37 | 0x25 | Error sending output to terminal |
| 38 | 0x26 | Expression too deeply nested |
| 39 | 0x27 | Error accessing variable <var> |
| 40 | 0x28 | Error setting variable <var> |
| 41 | 0x29 | Undefined variable <var> |
| 42 | 0x2A | Error notifying variable <var> |
| 43 | 0x2B | Attempt to divide by zero variable <var> |
| 44 | 0x2C | <cmd>: Working memory full |
| 45 | 0x2D | <cmd>: Too many threads in use |
| 46 | 0x2E | Interpolation speed too high for command <cmd> |
| 47 | 0x2F | Interpolation radius too small for command <cmd> |
| 48 | 0x30 | Timeout starting interpolation command |
| 49 | 0x31 | Channel signal lost |
| 50 | 0x32 | EL command without matching IF or II |
| 51 | 0x33 | Unknown command <cmd> - type HE for help |
| 52 | 0x34 | Invalid command entry <cmd> |
| 53 | 0x35 | Cannot execute <cmd> while <state> |
| 54 | 0x36 | Cannot change <cmd> while <state> |
| 55 | 0x37 | <cmd>: Parameter out of range |
| 56 | 0x38 | Reference timeout |
| 57 | 0x39 | Reference error outside limits |
| 58 | 0x3A | Reference correction overrun |
| 59 | 0x3B | <cmd>: Reference inputs disabled or not defined |
| 60 | 0x3C | <cmd>: Memory full |

| | | |
|---|---|---|
| 61 | 0x3D | <cmd>: Thread stack overflow |
| 62 | 0x3E | <cmd>: String memory full |
| 63 | 0x3F | Failed to reach target position |
| 64 | 0x40 | <cmd>: Target position outside limits |
| 65 | 0x41 | <cmd>: Moving away from wait position |
| 66 | 0x42 | <cmd>: Undefined sequence |
| 67 | 0x43 | <cmd>: Undefined profile |
| 68 | 0x44 | Profile step data too large |
| 69 | 0x45 | Cannot enter or execute sequence while it is in use |
| 70 | 0x46 | Cannot transfer profile while it is in use |
| 71 | 0x47 | Table data pointer error |
| 72 | 0x48 | <cmd>: Line already defined |
| 73 | 0x49 | <cmd>: Input line too noisy |
| 74 | 0x4A | <cmd>: Second position below first |
| 75 | 0x4B | <cmd>: No output group defined |
| 76 | 0x4C | <cmd>: Not a DI input |
| 77 | 0x4D | <cmd>: String pointer error |
| 78 | 0x4E | No commands before <cmd> |
| 79 | 0x4F | No commands after <cmd> |
| 80 | 0x50 | Only one repeat allowed in any command line |
| 81 | 0x51 | Cannot execute command string while busy |
| 82 | 0x52 | Cannot execute command string on DIn while busy |
| 83 | 0x53 | <cmd>: Command decoding failed |
| 84 | 0x54 | <cmd>: Undefined map |
| 85 | 0x55 | Map data value too large |
| 86 | 0x56 | Cannot transfer map while it is executing |
| 87 | 0x57 | Clutch timeout |
| 88 | 0x58 | Host input buffer overflow |
| 89 | 0x59 | Command <cmd> not available |
| 90 | 0x5A | Command <cmd> not available on this channel |
| 91 | 0x5B | Watchdog test failed |
| 92 | 0x5C | User error code n |

| | | |
|---|---|---|
| 93 | 0x5D | Limit switch detected |
| 94 | 0x5E | Motor position error |
| 95 | 0x5F | Motor timeout |
| 96 | 0x60 | High position limit exceeded |
| 97 | 0x61 | Low position limit exceeded |
| 98 | 0x62 | Map position update timeout |
| 99 | 0x63 | Map position overflow |
| 100 | 0x64 | Encoder counter read error |
| 101 | 0x65 | SSI encoder too noisy |
| 102 | 0x66 | Demand position error |
| 103 | 0x67 | Clock tick during servo loop |
| 104 | 0x68 | Missed servo loop execution |
| 105 | 0x69 | Motor off error n |
| 106 | 0x6A | Watchdog timeout |
| 107 | 0x6B | Loss of signal |
| 108 | 0x6C | Tracking error |
| 109 | 0x6D | Analogue input high limit exceeded |
| 110 | 0x6E | Analogue input low limit exceeded |
| 111 | 0x6F | Cannot execute <cmd> while monitor function defined |
| 112 | 0x70 | <cmd>: Monitor function not available while output in use |
| 113 | 0x71 | <cmd>: Analogue setpoint outside limits |
| 114 | 0x72 | Cannot execute <cmd> during analogue range initialization |
| 115 | 0x73 | More than 1023 channel level strings |
| 116 | 0x74 | Only one pending ER allowed at a time |
| 117 | 0x75 | Command interpreter error - <cmd> |
| 118 | 0x76 | Stack overflow |
| 119 | 0x77 | <cmd>: Input line function still active |
| 120 | 0x78 | <cmd>: Trigger variable function still active |

# 6. Interfacing

## 6.1 Notes on Installation

The MiniPTS 2+1 system is a sophisticated computer system, and care should be taken in all installations to protect the unit from high voltages and to minimize electrical noise on signal and power supply lines. **Quin Systems can accept no responsibility for problems arising from poor installation.** Please refer to the PTS Installation Manual for more information.

A digital servo controller relies on the position information from its incremental encoder, and any noise on the encoder signals can give rise to errors in the absolute position. Care must be taken in installation of the MiniPTS 2+1 unit and the encoders to minimize any noise on the encoder signal lines. The standard systems have full optical isolation on all the encoder signals, and require encoders with complementary line driver outputs. The encoder input interface has a differential input stage for use with such encoders, 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. Noise is reduced by using encoders with line driver outputs. Where the environment is electrically noisy, or where the system will be used continuously and reliability is important, it is possible to set up the system such 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 reinitialize the absolute position.

The digital input and output lines are also fully isolated from the machine or plant, both for protection and to allow 24V signals to be used. This provides greater noise immunity and allows direct interfacing to industrial control equipment such as a programmable logic controller (PLC). Isolation is also available as an option on the analogue output signals if required.

## 6.2 Safety

The MiniPTS 2+1 system provides many safety facilities, and it is recommended that these are used in addition to external safety systems such as hardwired limit switches. **Quin Systems 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 | Set high position limit |
| LL | Set low position limit |
| DL | Define limit switch inputs |

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

## 6.3 Position Encoder

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 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 1000 counts per revolution is seen as generating 4000 counts per revolution. The maximum input frequency of the encoder signals is 1.2 MHz with the normal ×4 multiplication in the encoder counter, giving a maximum count rate of 4.8 MHz. On a 2500 line encoder giving 10000 counts per turn, this is equivalent to a maximum speed of 480 revolutions per second, or 28800 r.p.m.The encoder input signals are all fully isolated. The standard systems are designed for use with encoders with complementary line driver outputs, to get maximum noise immunity. The position encoder feedback is fundamental to the correct operation of the system, and so all precautions against noise are justified. The input configuration is for 5V encoders.

The SRV-2 servo controller module in the MiniPTS 2+1 supports other types of position feedback device if required, including SSI absolute encoders.

## 6.4 Demand Output

The demand output signal to the high power motor drive is an analogue signal with a range of ±10V, at 12 bits resolution. This output is switched directly to 0V in the motor off state by a reed relay on each axis. The motor drive is normally connected such that a positive demand output signal causes the motor to move in the positive direction.

## 6.5 Relay Contacts

The axis controller uses a reed relay to switch the demand output signal to 0V in the motor off state. The relay has a spare set of changeover contacts which are uncommitted and available for external use. These may be used to derive an inhibit/enable signal to the motor drive, or for example to switch a joystick onto the drive input to allow manual control of the motor.

## 6.6 Digital Inputs and Outputs

The system has 16 digital inputs and 8 outputs. The inputs and outputs may be programmed for a wide range of predefined functions, or they may be controlled explicitly if required. All the digital inputs and outputs are optically isolated, providing protection for the control system and 24V interfacing capability.

## 6.7 Analogue Input

The SRV-2 controller used in the MiniPTS 2+1 has three analogue inputs. The signal inputs are multiplexed, and the multiplexer output is buffered with a differential amplifier. The analogue inputs have a range of ±10V. The analogue signal levels are converted to digital values at 12 bits resolution. The DA command displays the analogue input signal value for the current channel.

## 6.8 Operation of Limit Switches

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

If a limit switch is operated, the system stops the motor immediately and goes into the “motor off” state. The system displays the “limit switch detected” error message. All limit switches should be wired such that operation of any switch gives an error signal to the system. The system may be programmed to execute an error sequence automatically on any motor off error condition, including detection of a limit switch, by using the ME command.

## 6.9 Reference Inputs

A reference input is required on each motor channel during the IN initialization sequence to define the zero reference position for the motor. Reference inputs may also be used to continuously update the absolute position of the motor from the external zero reference if required. They may be connected to a marker signal from the position encoder, or to a microswitch that senses the position of the motor. The initialization sequence is as follows.

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

Reference inputs are programmable on inputs 1-4 (not 5-7) by using the DR command. A dedicated encoder marker input is also available, enabled by the DZ command. See section 4.11 for more details on the full range of reference facilities.

## 6.10 Serial Communications

The serial link uses RS-232 signal levels as standard, but may be configured for RS-485 if required. The serial word format used is 8 data bits, 1 stop bit, and no 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. The MiniPTS 2+1 uses xon/xoff software handshake by default on the programming terminal port, but it also supports hardware handshake using RTS and CTS signals. The serial ports are set up by the CF command (configure serial port options), described earlier on page 138.

# 7. Summary

## 7.1 Commands

Note that some commands are restricted. These commands can be used only in privileged mode. Commands which are executed at host level are followed by (host). Commands which are affected by scaling are followed by (scaled).

**Miscellaneous commands**

| | | |
|---|---|---|
| VN | display Version Number and revision date | (host) |
| SP | Save Parameters to nonvolatile memory | (restricted)(host) |
| CS | CheckSum test | (host) |
| RD | Read Data from nonvolatile memory | (restricted) |
| RS | ReSet complete setup to defaults | (restricted)(host) |
| LA | List All parameters | (host) |
| RZ | ResiZe parameter file | (restricted)(host) |
| FM | display Free Memory | (host) |
| SK | set Software license Key | (restricted)(host) |

**Mode commands**

| | | |
|---|---|---|
| MO | set to Motor Off | |
| PC | set to Position Control mode | |
| NM | set to Normal Mode | (host) |
| PM | set to Privileged Mode | (host) |
| PW | set PassWord | (restricted)(host) |
| VMn | set Virtual Motor mode | (restricted) |

**Move commands**

| | | |
|---|---|---|
| MA±nn | Move to Absolute position | (scaled) |
| MR±nn | Move Relative to current position | (scaled) |
| ST | STop with normal deceleration | |
| AB | ABort, emergency stop | |
| VC[±] | set to Velocity Control mode | |
| IN[±] | INitialize to reference position | |
| IB[±] | Initialize position and Bounds | |
| DN± | set default motor DirectioN | |
| ID | Initialize Demand signal offset | |

**Set parameter commands**

| | | |
|---|---|---|
| SVnn | Set Velocity | (scaled) |
| SAnn | Set Acceleration | (scaled) |
| DCnn | set DeCeleration for stop command | (scaled) |
| SCnn | Set Creep distance | (scaled) |
| SSnn | Set Slow jog/creep speed | (scaled) |
| VJn | set Velocity mode to Jog or normal | |
| SWnn | Set Window on final position | (restricted) |
| BLnn | set BackLash compensation distance | (scaled) |
| ISn | set Increment Select code | (restricted) |
| IPnn | Increment selected Parameter | |
| SUnn | Set Units | (restricted)(host) |
| FPnn | Set Floating point Precision | (restricted)(host) |
| MWbb | set Move/map options Word | (restricted) |
| CWbb | set Control Word | (restricted) |

**Sequence commands**

| | | |
|---|---|---|
| ESnn | Enter Sequence | (restricted)(host) |
| LS[nn] | List Sequence | (host) |
| XSnn | eXecute Sequence | (host) |
| RP[nn] | RePeat command line | |
| ER | End Repeat | |
| AX | Abort command eXecution | |
| BK | BreaK out of sequence | (host) |
| ASnn | set AutoStart sequence | (restricted)(host) |
| FM | display Free Memory | (host) |

**Multi-channel commands**

| | | |
|---|---|---|
| CHn | CHange channel | (host) |
| CPn | Change channel in Parallel | (host) |
| CM[nn] | CoMpile sequence(s) | (host) |
| GS | Global Stop | (host) |
| GA | Global Abort | (host) |
| GF | Global motor oFf | (host) |
| GX[nn] | Global abort eXecution | (host) |
| USnn | send User Signal | |
| HWnn | Host system Wait for user signal | (host) |
| ZSnn | Zero user Signal | (host) |
| SXn/n | set Sequence to eXecute on signal | (restricted)(host) |
| MUnn | Mask User signal | (restricted)(host) |
| EUnn | Enable User signal | (restricted)(host) |
| MEnn | set Motor Error sequence | (restricted)(host) |
| UEnn | set User Error sequence | (restricted)(host) |

**Profile commands**

| | | |
|---|---|---|
| EPnn | Enter Profile | (restricted)(host) |
| LP[nn] | List Profile | (host) |
| XPnn[–] | eXecute Profile | |
| PVn | set Profile Velocity | |
| TPnn | Transfer Profile | (host) |
| FM | display Free Memory | (host) |

**Map commands**

| | | |
|---|---|---|
| EMnn | Enter Map | (restricted)(host) |
| LM[nn] | List Map | (host) |
| XMnn | eXecute Map | |
| MSnn | set Map Step | (host) |
| TMnn | Transfer Map | (host) |
| MLnn | Map Link to master channel | |
| UL | UnLink from master channel | |
| LWbb | set Link options Word | (restricted) |
| MTnn | set Map update Timeout | (restricted) |
| MB±nn | set Map Base offset | |
| MF±nn | set Map oFfset | |
| SMnn/nn | Scale Map | |
| AVn | set map base/offset/scale Adjustment Velocity | |
| MPnn | set Master Position bound | (restricted) |
| BR | Set map scale factor from Bounds Ratio | |
| MWbb | set Map/move options Word | (restricted) |
| CTn | set software Clutch Time | |
| BAnn | set map Base Advance | |
| BTn | set map Base advance master speed averaging Time | |
| GM | Get Mapped master bound position | |
| GW | Get Wraparound offset value | |
| FM | display Free Memory | (host) |

**Wait commands**

| | | |
|---|---|---|
| WTnn | Wait for Time | |
| WI[g:]n± | Wait for Input line | |
| WA±nn | Wait for Absolute position | (scaled) |
| WR±nn | Wait for Relative position | (scaled) |
| WF | Wait for reFerence signal | |
| WB | Wait for Bound position | |
| WC±nn | Wait for bound overflow Count | |
| WE | Wait End | |

**Error handling**

| | | |
|---|---|---|
| SEnn | Set maximum position Error | (restricted)(scaled) |
| TOnn | set TimeOut | (restricted) |
| LH±nn | set High position Limit | (restricted)(scaled) |
| LL±nn | set Low position Limit | (restricted)(scaled) |
| RTnn | set Reference Timeout | (restricted) |
| MTnn | set Map update Timeout | (restricted) |
| MEnn | set Motor Error sequence | (restricted)(host) |
| UEnn | set User Error sequence | (restricted)(host) |
| EWbb | set Error options Word | (restricted) |
| LE | display Last Error | (host) |

**Gain commands**

| | | |
|---|---|---|
| KPnn | set Proportional gain constant | (restricted) |
| KInn | set Integral gain constant | (restricted) |
| KDnn | set Differential gain constant | (restricted) |
| KVnn | set Velocity feedback gain constant | (restricted) |
| KFnn | set velocity feed-Forward gain constant | (restricted) |
| DK | Display system constants | (host) |
| ITn | set Integration Time constant | (restricted) |
| OLnn | set analogue Output Limit | (restricted) |
| SFn | Set monitor Function | (restricted) |
| KMnn | set Monitor output gain constant | (restricted) |
| OMnn | set Offset on Monitor output | (restricted) |
| AOn | set Auxiliary Output channel | (restricted) |

**Reference commands**

| | | |
|---|---|---|
| ZC[nn] | Zero position Counters or set position | (scaled) |
| SBnn | Set Bound position | (restricted)(scaled) |
| BCnn | set Bounds Counter | |
| DZn | Define Zero marker input | (restricted) |
| DRn± | Define Reference input | (restricted) |
| RLnn | set Reference repeat Length | (restricted) |
| RMn | set continuous Reference Mode on/off | |
| RWbb | set Reference options Word | (restricted) |
| SRnn | Set maximum Reference correction | (restricted) |
| FRnn | set Filter on Reference error | (restricted) |
| LRnn | set Limit on Reference error | (restricted) |
| RF±nn | set Reference oFfset | (restricted) |
| RVnn | set Reference correction Velocity | (restricted) |
| RJ±nn | set Reference adJustment position | (restricted)(scaled) |
| RTnn | set Reference Timeout | (restricted) |
| ZHnn | set reference true High limit | (restricted) |
| ZLnn | set reference true Low limit | (restricted) |
| FHnn | set reference False High limit | (restricted) |
| FLnn | set reference False Low limit | (restricted) |
| RA[g:]n± | define Reference Accepted output | (restricted) |
| RHnn | set Reference Holdoff time | (restricted) |
| WF | Wait for reFerence signal | |
| DF | Display reFerence error | |

**Input/output commands**

| | | |
|---|---|---|
| SO[g:][n] | Set Output line(s) | |
| CO[g:][n] | Clear Output line(s) | |
| OC[g:]nn | Output Code value on expanded outputs | |
| RI[g:][n] | Read Input line(s) | (host) |
| RO[g:][n] | Read Output line state(s) | (host) |
| II[g:]n± | If Input true do command line | (host) |
| IO[g:]n± | If Output true do command line | (host) |
| MI[g:][n] | Mask Input(s) | |
| BI[g:][n] | inhiBit Input(s) | |
| EI[g:][n] | Enable Input(s) | |
| WI[g:]n± | Wait for Input line | |

**Configuration commands**

| | | |
|---|---|---|
| DZn | Define Zero marker input | (restricted) |
| DRn± | Define Reference input | (restricted) |
| DL[g:]n± | Define Limit switch input | (restricted) |
| DI[g:]n± | Define function Input | (restricted) |
| DX[g:]n± | Define eXpanded input lines | (restricted) |
| PSn± | define Position Snapshot input | (restricted) |
| MG[g:]bb | define input Mask Group | (restricted) |
| BG[g:]bb | define input inhiBit Group | (restricted) |
| DE[g:]n± | Define Error output | (restricted) |
| PO[g:]n± | define Position trigger Output | (restricted)(scaled) |
| OX[g:]n± | define eXpanded Output lines | (restricted) |
| BO[g:]n± | define Bound Overflow output | (restricted) |
| RR[g:]n± | define Reference Reject output | (restricted) |
| RA[g:]n± | define Reference Accepted output | (restricted) |
| OW[g:]n± | define Outside Window output | (restricted) |
| AE[g:]n± | define Analogue Error output | (restricted) |
| DU[g:]n± | Define Unipolar direction control output | (restricted) |
| UTnn | set Unipolar direction output delay Time | (restricted) |
| DBnn | set input DeBounce time | (restricted) |
| LI[g] | List Input line definitions | (host) |
| LO[g] | List Output line definitions | (host) |
| FSnn | Feedback Select encoder type | (restricted) |
| NBnn | set Number of Bits for ssi encoder | (restricted) |
| CF | ConFigure serial port options | (host)(restricted) |

**Timer/counter functions**

| | | |
|---|---|---|
| TC[g:]n± | define Timer/Counter output | (restricted) |
| LC[g:]n | List Counter value | |
| TK[g:]n± | define Timer/counter clocK input | (restricted) |
| TG[g:]n± | define Timer/counter Gate input | (restricted) |
| TZ[g:]n± | define Timer/counter reset input | (restricted) |

**Phase advance commands**

| | |
|---|---|
| PAnn | set Phase Advance scale factor |
| VTn | set Velocity averaging Time |
| BAnn | set map Base Advance |
| BTn | set map Base advance master speed averaging Time |

**Display commands**

| | | |
|---|---|---|
| DP | Display current Position | (scaled) |
| DD | Display Demand position | (scaled) |
| DV | Display current Velocity | (scaled) |
| DF | Display reFerence error | |
| DS | Display position Snapshot data | |
| DA | Display Analogue input | |
| DT | Display Time | (host) |
| BC | Display bound overflow Count | |
| TShh:mm:ss | Time Set | (host) |
| DM[nn] | set continuous Display Mode on | (host) |
| DO | Display mode Off | (host) |
| TR[nn] | enable/disable TRace mode | (host) |
| TWbb | set Trace options Word | |
| TIbb | set Input/output Trace options | |
| TF | Trace options oFf | (host) |
| DK | Display system constants | (host) |
| CDnn | set Character Delay | (host) |
| DWbb | set Display Word | (restricted)(host) |
| HE | print HElp display | (host) |
| LE | display Last Error | (host) |
| SYn | enable SYstem/channel prompts | (restricted)(host) |

### Analogue control commands

| | | |
|---|---|---|
| AMn | set Analogue control Mode | |
| APnn | set Analogue control Proportional gain | (restricted) |
| AInn | set Analogue control Integral gain | (restricted) |
| ADnn | set Analogue control Differential gain | (restricted) |
| ACnn | set Analogue Control setpoint | |
| TQnn | set TorQue control mode and setpoint | |
| OLnn | set analogue Output Limit | (restricted) |
| AWbb | set Analogue control options Word | (restricted) |
| ARnn | set/display Analogue Range distance | (restricted) |
| CR | Calculate Ratio from AR values | |
| XR | eXecute analogue Range initialization | |
| XTn/ll/hh | eXecute Torque control in position range | (restricted) |
| CWbb | set Control Word | (restricted) |
| AHnn | set Analogue input High limit | |
| ALnn | set Analogue input Low limit | |
| AE[g:]n± | define Analogue limit Error output | (restricted) |
| DA | Display Analogue input | |

### Variable commands

| | | |
|---|---|---|
| $var=nn | assign value to variable | (host) |
| WV$var | Wait for write to Variable | (host) |
| $var>cmds | define trigger variable | (restricted)(host) |
| VX | list trigger variables | (host) |
| MV[$var] | Mask trigger Variable(s) | (host) |
| EV[$var] | Enable trigger Variable(s) | (host) |
| LV$var | List Variable(s) | (host) |
| LXexpr | List eXpression | (host) |
| VE$var | define Error Variable | (restricted)(host) |
| VS$var | define Status Variable | (restricted)(host) |
| IFexpr | execute commands IF expression true | (host) |
| EL | ELse command | (host) |
| OP | configure Operator’s Panel | (restricted)(host) |

### Edit mode commands

| | | |
|---|---|---|
| ED | enter EDit mode | (restricted)(host) |
| GO | return to run mode | (restricted)(host) |

## 7.2 Prompts and Status Messages

| | |
|---|---|
| > | normal prompt in position control mode |
| : | motor off prompt |
| ? | parameter value prompt |
| I | Initialising to reference position |
| M | Moving to new position |
| P | executing a Profile move |
| S | Stopping under normal deceleration |
| T | Torque control mode |
| V | Velocity control mode |
| W | Waiting |
| X | executing a position mapping |
| ED: | system in Edit mode |

## 7.3 Error Messages

AH Analogue input High limit exceeded

AL Analogue input Low limit exceeded

B Binary number required

CT Clutch Timeout

D Decimal number required

DF command Decoding Failed

E Error - unrecognized command,
invalid parameter,
command not allowed at this time,
or several others

F Failed parameter save or checksum test

FA internal FAilure on axis controller module

G position error Greater than maximum

H Hexadecimal number required

Ln Limit switch detected

LH High position Limit exceeded

LL Low position Limit exceeded

MO Map demand position Overflow

N No room in memory

NI Input line too Noisy

O parameter Out of range

R Restricted command/parameter

RL Reference Limit error

RO Reference Overrun error

RT Reference Timeout error

SY System error

T motor Timeout

U line in Use

VA VAriable error

WF Watchdog test Failed

WT Watchdog Timeout

# A. Using SSI Encoders with the MiniPTS 2+1

## A.1 Introduction

The SRV-2 controller used in the MiniPTS 2+1 has the option to use absolute shaft encoders with a synchronous serial interface (SSI) as the position feedback device. This section describes how to configure the SRV-2 card for use with SSI encoders, and what changes are made in the software when the SSI option is selected.

## A.2 Axis configuration for SSI encoder : J4

The SSI encoder option is enabled by installing jumper links as follows.

| Mode | SSI encoder | Normal encoder |
|---|---|---|
| Channel 1 | Link 1–2, 3–4 | Remove 1–2, 3–4 |
| Channel 2 | Link 5–6, 7–8 | Remove 5–6, 7–8 |
| Channel 3 | Link 9–10, 11–12 | Remove 9–10, 11–12 |

Please refer to the SRV-2 hardware manual for more configuration details.

## A.3 Encoder feedback options

Encoder feedback options are selected by the FS parameter on each axis. If the option selected is for an SSI encoder, then the NB parameter sets the number of bits used. This allows each axis to be configured for SSI encoders from 12 bit single turn up to 24 bit multiturn. Note that each axis may be set for a different encoder feedback option.

## A.4 Using the SSI encoder for absolute position feedback

If an incremental position mode is selected by the feedback select parameter FS, then the MiniPTS 2+1 system behaves in exactly the same way as for normal incremental encoders. The absolute SSI encoder is simply used to measure the change in position at each sample, not the absolute position.

If an absolute position mode is selected, then the system behaviour is modified to make use of the absolute position information from the encoder. In this case, the absolute position from the encoder is used as the feedback position for the control closed loop.

The MiniPTS 2+1 system allows most of the normal facilities to be used in absolute position feedback modes. The main areas where changes apply are listed here.

- The RF reference offset parameter is used to define an offset applied to the absolute position data received from the encoder. The current absolute position is given by the sum of the encoder position and RF. This allows the absolute zero position to be defined as required, without having to align the encoder to any specific position.
- The SB parameter is available and bounds wraparound operates as normal. This allows the absolute encoder to be used in multi-turn applications.
- The IN command is used to reset the current position to the absolute position value given by the sum of the encoder data and the reference offset RF. This value is then subject to wraparound by calculating the remainder when divided by the SB parameter, and the absolute position is set to this remainder.
- The IB initialize bounds and WF wait for reference commands are not available.
- The BL backlash correction parameter has no effect.
- All referencing facilities are disabled. Reference parameters may be set and read as normal, but referencing cannot be enabled, and has no effect.
- The reference timeout check is not executed, and the RT parameter has no effect.
- The ZC command is available, and operates as normal. It allows the current absolute position to be defined as required, without having to align the encoder to any specific position. The position value given with the ZC command is again subject to wraparound by taking the remainder when divided by SB.

## A.5 Speed Limits with SSI Encoders

When the SSI encoder option is selected, and the number of data bits is less than 15, the system imposes a lower maximum speed limit on the SV and SS commands. This is because the system must correctly identify the direction of motion for any change in position, and thus the maximum change in position in any one sample is plus or minus half the number of counts from the encoder. The maximum values allowed for the SV and SS commands are shown in the table below.

| Number of data bits | Maximum speed (counts per second) |
|---|---|
| 24–15 | 4 000 000 |
| 14 | 2 000 000 |
| 13 | 1 000 000 |
| 12 | 500 000 |

**Table 4: Speed limits with SSI encoders**

The speed limits at the lower encoder resolutions are equivalent to a maximum encoder speed of about 7000 r.p.m.

## A.6 Connections

SSI encoders are connected to the same connectors on the MiniPTS 2+1 as normal incremental encoders. The table below gives the details for connecting a typical SSI encoder to the MiniPTS 2+1.

| Signal | 9 way socket pin number |
|---|---|
| CLK + | 1 |
| DATA + | 2 |
| not used | 3 |
| Encoder + supply | 4 |
| Screen | 5 |
| CLK – | 6 |
| DATA – | 7 |
| not used | 8 |
| Encoder 0V | 9 |

**Table 5: SSI encoder connections**

## A.7 Suggested encoder types

| Type no. | Manufacturer | | |
|---|---|---|---|
| ROC 424 | Dr. Johannes Heidenhain GmbH<br>Dr.-Johannes-Heidenhain-Straße 5<br>D-8225 Traunreut | Telephone<br>Fax. | +49 (0) 86 69 / 31-0<br>+49 (0) 86 69 / 50 61 |
| CE-65 | T+R Electronic GmbH<br>D-7218 Trossingen<br>Eglishalde 8<br>Postfach 1552 | Telephone<br>Fax. | +49 (0) 7425 / 228-0<br>+49 (0) 7425 / 228-33 |
| AG 661 | Max Stegmann GmbH<br>D-7710 Donaueschlingen<br>Dürrheimer Straße 36<br>Postfach 1560 | Telephone<br>Fax. | +49 (0) 771 / 807-0<br>+49 (0) 771 / 807100 |
| GEL 150 range | Lenord, Bauer & co. GmbH<br>Dohlenstraße 32<br>D-4200 Oberhausen 11<br>(Königshardt) | Telephone<br>Fax. | +49 (0) 208 99 63-0<br>+49 (0) 208 67 62 92 |

U.K. distributors for these are shown below.

| Manufacturer | U.K. Distributor | | |
|---|---|---|---|
| Heidenhain | Heidenhain (G.B.) Ltd.<br>200 London Road<br>Burgess Hill<br>West Sussex RH15 9RD | Telephone<br>Fax. | +44 (0) 1444 247711<br>+44 (0) 1444 870024 |
| T+R | Sensor Consultants Ltd.<br>Streatley Hill<br>Streatley<br>Reading<br>Berks RG8 9RD | Telephone<br>Fax. | +44 (0) 1491 824774<br>+44 (0) 1491 824747 |
| Stegmann | Stegmann U.K. Ltd.<br>413 Warwick Road<br>Birmingham | Telephone<br>Fax. | +44 (0) 121 333 5551<br>+44 (0) 121 333 5501 |
| Lenord + Bauer | Motor Technology (UK) Ltd.<br>Motec House<br>Chadkirk Industrial Estate<br>Romiley<br>Stockport<br>Cheshire SK6 3LE | Telephone<br>Fax. | +44 (0) 161 427 3641<br>+44 (0) 161 427 1306 |

Note that usually the SSI interface option, the number of counts per turn and the number of turns must all be specified.

# B. LED Status Codes

## B.1 Introduction

The SRV-2 two/three axis controller hardware used in the MiniPTS 2+1 is fitted with three 7 segment LED displays. These are used to indicate the state of each axis, and also to indicate some error conditions on any axis. These displays are useful to show any activity on the unit, and to identify that an error has occurred, without a terminal or host system connected to the serial port.

The following pages show the status and error code values currently used on the SRV-2 controller module.

## B.2 Status Codes

On the SRV-2 module used in the MiniPTS 2+1, the three digits normally show the current status for all three axes. The top digit shows the status for channel 1, and the bottom digit for channel 3. The status codes are updated any time an axis changes state. This is particularly useful to show activity in command sequences. Note that a waiting status code overrides any other status code until the wait condition terminates.

| Display | Mode | |
|---|---|---|
| 0 | MO | Motor off |
| P | PC | Position control |
| 1 | VC | Velocity control mode |
| 2 | MA, MR | Move to absolute or relative position |
| 3 | XP | Executing a profile |
| 4 | XM | Executing a position mapping |
| 5 | ST | Stopping |
| 6 | IN, IB | Initialising |
| 7 | TQ | Static torque control |
| 8 | Reset | Initial display at power-up |
| 9 | WT, WI, WA, WR, WF, WB, WC | Waiting |

## B.3 Error Codes

If a motor error occurs on any axis, then the three digit display indicates an error code. The motor error code remains on the LED display until the next PC command is executed on any channel.

| Prefix | Error type | Code | |
|---|---|---|---|
| E | Errors | 01 | Position error |
| | | 02 | Timeout error |
| | | 03 | High position limit |
| | | 04 | Low position limit |
| | | 05 | Reference timeout |
| | | 06 | Reference out of limits |
| | | 07 | Reference overrun |
| | | 08 | Watchdog timeout |
| | | 09 | Map update timeout |
| | | 10 | Map position overflow |
| | | 11 | Analogue input high limit |
| | | 12 | Analogue input low limit |
| | | 13 | Encoder counter fault |
| | | 14 | SSI encoder too noisy |
| L | Limit switch | xx | Limit switch input detected |
| | | First digit = input group number | |
| | | | Second digit = line number |
| FA | Fault | 00-18 | System fault code |

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