

CHAPTER

# 6

## SYSTEM SETUP AND DIAGNOSTICS



## Preliminary Concepts

Host Computer	A Windows PC running <i>Motion</i> Perfect 2.
Motor	A tuned servo drive / motor configuration for a servo axis or a stepper motor and drive combination
Prompt	When the controller is ready to receive a new command, the prompt >> will appear on the left hand side of the current line in the "terminal" under the "tools" menu
Axis Parameters	Can be written to or read from. For example the proportional gain of a servo axis has the name <b>P_GAIN</b> . It can be written to: <b>P_GAIN=0.5</b> or read from: <b>PRINT P_GAIN</b> . For further information see chapter 8.

## System Setup

A control system should be treated with respect as careless or negligent operation may result in damage to machinery or injury to the operator. For this reason the setting up of the system should not be rushed. This section describes a methodical approach to system configuration and is designed to gradually test each aspect of the system in turn, finally resulting in the connection of the motor. If followed cautiously no unexpected situations should arise.

In cases where the setup procedure for servo and stepper systems differ a separate description is provided for each. In multiple axis systems it is advantageous to set up one axis at a time. The following procedure applies both to all *Motion Coordinator* modules.

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Note:

*It is recommended that this section is read in full before attempting to operate the system for the first time.*

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## Preliminary checks

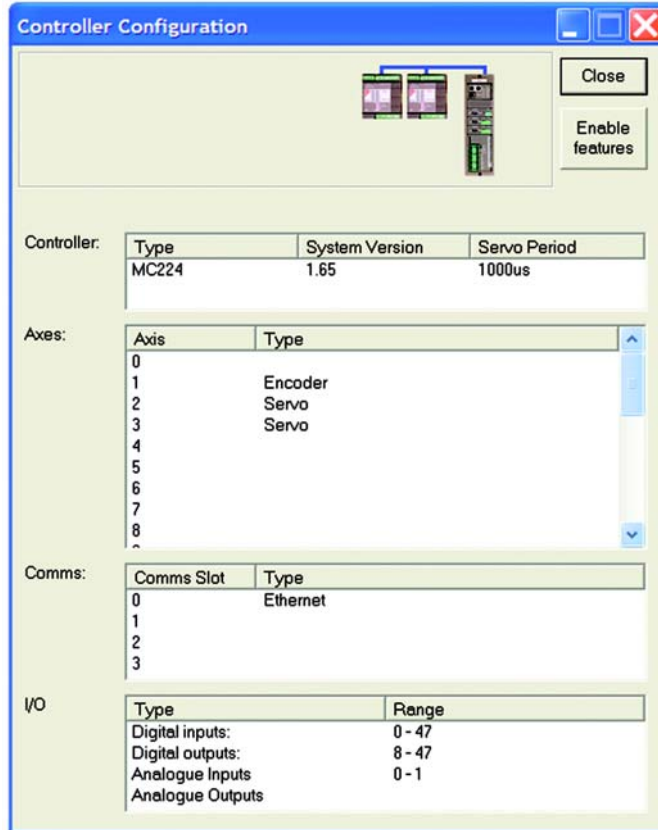
All wiring should be checked for possible misconnection and integrity before any power is applied.

- Disconnect all external connectors from the system, apart from the CANBus and ribbon cable bus (only required if using an Axis Expander module)
- Check bank selector switches on any Axis Expander modules, and the module address DIP switches on the CAN I/O
- Apply power to system and check the 24V power input on master module.
- Connect a serial (connector A), USB or Ethernet lead between the controller and an unused port on your PC.

## Checking Communications and System Configuration

- Ensure that the serial lead is connected between the *Motion Coordinator* master (serial connector A) and a free serial port on the computer.
- Apply 24V to the *Motion Coordinator*.
- Run *Motion Perfect* on the computer. When *Motion Perfect* detects a controller press the OK button. If this is the first time you have connected you will need to select the "New Project" option when *Motion Perfect* tries to ensure that your "Project" on the controller matches its copy on disk.
- When the "Project Consistent" message is received in the "Check Project" window you know:
  - 1 *Motion Perfect* has made a serial connection between your PC and the controller.
  - 2 *Motion Perfect* has an exact copy of the programs on the controller.
- The controller hardware configuration can now be checked using the "Controller configuration" option under the "Controller" menu. *Motion Perfect* draws a graphical representation of your system, as shown following.

Example:



This message would be produced by a *Motion Coordinator* MC224 with the following configuration:

- System Software version 1.65
- An Ethernet Comms daughter board in slot 0
- A encoder daughter board in axis slot 1.
- Two servo daughter boards in axis slots 2 and 3.
- 2 CAN16 I/O modules, which adds a further 32 I/O channels, making a total of 47 channels (All 47 can be used as inputs, channels 8-47 are bidirectional and may be used as input or output as required)
- A CAN Analog Inputs module providing input channels 0-7.

Check that the system description corresponds with the modules that are actually present. If this is not so, check the CANBus and ribbon cable connections and the settings of the address switches on any CAN or axis expander modules.

## Input/Output Connections

- Check each of the 24V input connections with a meter then connect them to the controller.
- Test each of the input channels being used for correct operation in turn. These may be easily viewed in the I/O window. Use "IO Status" under the "Tools" menu.
- Switch each output being used in turn for correct operation. These may be easily set with the IO status window.

## Connecting a Servo Motor to a Servo Daughter Board

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Note: *This description assumes the motor / drive combination has been already tested and is functioning optimally.*

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Each servo axis should be connected in turn.

- With the servo drive off or inhibited connect the motor encoder only (or the encoder emulation output from the servo drive).
- Check the encoder counts both up and down by looking at the measured axis position **MPOS** in the Axis parameter window of *Motion Perfect* ("Axis parameters" under the "Tools" menu) whilst turning the axis by hand.
- Ensure the **SERVO** axis parameter is set OFF (0) in the Axis parameter and that the **DAC** axis parameter is set to 0. It may be necessary to use the scroll buttons to view these parameters. This will force 0 volts out of the +/-10v output for the axis. Now connect the servo drive to the V+/V- connections.
- Enable the servo drive by clicking the "Drives disabled" button on the control panel. If the axis runs away the motor/drive combination must be re-checked. (Note: clicking "Drives disabled/ Drives enabled" is equivalent to issuing a **WDOG=ON** or **WDOG=OFF** command).  
The servo motor should now be powered and is likely to be creeping in one direction as the position servo has been switched OFF.
- Set a small positive output voltage by setting **DAC=25**. The motor should then move slowly forward - Check the encoder is counting up by looking at the **MPOS** axis parameter. If this is correct check that the motor reverses and the encoder counts down when **DAC=-25**.
- If the encoder counts down when a positive **DAC** voltage is applied. The motor or position feedback needs to be reversed.

This can be achieved by:

- Swap A and /A connections on the encoder input, or
- Swap BOTH motor terminals and tacho terminals (DC motors only!) On many digital brushless motors the direction can be reversed by a drive setting, or

- If the drive has differential inputs, reverse the voltage as it enters the drive. (This can cause problems with some servo-drives. The V- pins of the daughter board are internally connected inside the *Motion Coordinator* so the axis voltage outputs cannot float relative to each other), or
- set a negative **PP\_STEP** axis parameter. (This is not possible using SSI encoders)
- Set a negative **DAC\_SCALE** axis parameter.

We are now ready to apply the position servo as described following.

## Setting Servo Gains

The servo system controls the motor by constantly adjusting the voltage output which gives a speed demand to the servo drive. The speed demand is worked out by looking at the measured position of the axis from the encoder comparing it with the demand position generated by the *Motion Coordinator*.

The demand position is constantly being changed by the *Motion Coordinator* during a move. The difference between the demand position (Where you want the motor to be) and the measured position (Where it actually is) is called the following error.

The controller checks the following error typically 1000 times per second and updates the voltage output according to the "servo function". The *Motion Coordinator* has 5 gain values which control how the servo function generates the voltage output from the following error.

Default Settings:

Gain	Parameter Name	Value
Proportional Gain	<b>P_GAIN</b>	1.0
Integral Gain	<b>I_GAIN</b>	0.0
Derivative Gain	<b>D_GAIN</b>	0.0
Output Velocity Gain	<b>OV_GAIN</b>	0.0
Velocity Feedforward Gain	<b>VFF_GAIN</b>	0.0

A simple test program can be used to generate movement to and fro for examination of the motion profile generated on an oscilloscope. The oscilloscope should be connected to the tacho or velocity output from the servo drive.

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Example: PRINT "Enter Axis Number ":INPUT VR(0)
BASE(VR(0))
SPEED=20000
ACCEL=200000
DECEL=200000
WHILE TRUE:
  MOVE(1000)
  WAIT IDLE
  WA(100)
  MOVE(-1000)
  WAIT IDLE
  WA(100)
WEND
```



The editor built into *Motion Perfect* may be used to enter the test program. Click on **Program, New** from the pull down menus and enter a program name, replacing the name **UNTITLEDx**. Now click on the EDIT button and an edit window will be opened where the program shown above may be typed in. See the *Motion Perfect* section for more details on how to use the editor. Once the program is entered, it can be run by clicking on the red button next to its name or the RUN button in the Controller Status panel.

The servo gain parameters may be set to achieve the desired response from the servo system. The desired response can vary depending on the type of machine.

Different gain settings can be used to obtain:

**Smoothest motor running**

This can be achieved by using low proportional gain values, adding output velocity gain adds smoothing damping at the expense of higher following errors.

**Low following errors during complete motion cycle**

This can be achieved by using velocity feed forward to compensate for following errors together with higher proportional gains.

**Exact achievement of end points of moves**

This can be achieved by using integral gain in the system together with proportional gain. However overshoot will occur at the end of rapid deceleration.

Typically a combination of the above is required.

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Note: *The system should be set with proportional gain alone firstly starting with the default value of 1.0 The other gains should then be introduced if necessary according to the descriptions which follow.*

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## Proportional Gain

**Description** The proportional gain creates an output voltage,  $O_p$  that is proportional to the following error  $E$ .

$$O_p = K_p \times E$$

Axis parameter is called **P\_GAIN**

**Syntax:** **P\_GAIN=0.8**

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**Note:** *All practical systems use proportional gain, many use this gain parameter alone.*

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## Integral gain

**Description** The Integral gain creates an output  $O_i$  that is proportional to the sum of the errors that have occurred during the system operation.

$$O_i = K_i \times \int E$$

Integral gain can cause overshoot and so is usually used only on systems working at constant speed or with a slow acceleration.

Axis parameter is called **I\_GAIN**

**Syntax:** **I\_GAIN=0.0125**

## Derivative gain

**Description** This produces an output  $O_d$  that is proportional to the rate of change in the following error and speeds up the response to changes in error whilst maintaining the same relative stability.

$$O_d = K_d \times \delta_e$$

This gain may create a smoother response. High values may lead to oscillation.

Axis parameter is called **D\_GAIN**

**Syntax:** **D\_GAIN=5**

## Output Velocity Gain

**Description** This increases the system damping, creating an output that is proportional to the change in measured position.

$$O_{ov} = K_{ov} \times \delta P_m$$

This parameter can be useful for smoothing motions but will generate high following errors. Note that a NEGATIVE OV\_GAIN is required for damping.

Axis parameter is called **ov\_GAIN**

**Syntax:** **ov\_GAIN=-5**

## Velocity Feed Forward Gain

**Description** As movement is created by following errors at high speed the following error can be quite appreciable. To overcome this the Velocity Feed Forward creates an output proportional to the change in demand position so creating movement without the need for a following error.

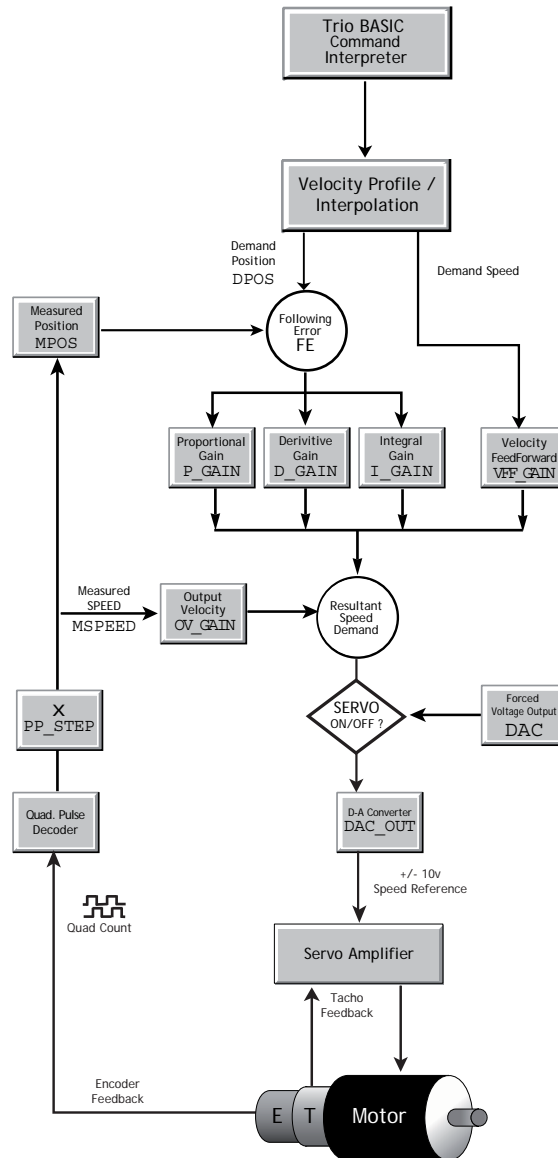
$$O_v = K_{vff} \times \delta P_d$$

Axis parameter is called **vff\_GAIN**

**Syntax:** **vff\_GAIN=10**

The VFF\_GAIN parameter can be set by minimising the following error at a constant machine speed AFTER the other gains have been set.

## Servo Loop Diagram



## Diagnostic Checklists

Problem	Potential reasons
No Status LEDs on any module	<ul style="list-style-type: none"> <li>Power Supply</li> </ul>
LEDs lit on Master but not on other modules	<ul style="list-style-type: none"> <li>Ribbon cable / Bank select switch</li> </ul>
OK LED ON & Status LED flashing	<ul style="list-style-type: none"> <li>Following error on at least one axis. The axis demand position and measured position exceed the programmed limit</li> </ul>
Motor runs away without issuing a move command	<ul style="list-style-type: none"> <li>tacho/drive polarity</li> <li>encoder/controller polarity</li> <li>gains (drive and/or controller)</li> </ul>
Motor runs away upon issuing a move command	<ul style="list-style-type: none"> <li>tacho feedback</li> <li>encoder feedback</li> <li>gains (drive and/or controller)</li> </ul>
Motor does not move upon issuing a move command	<ul style="list-style-type: none"> <li>wiring (enables/inhibits/limits on drive and controller)</li> <li>check status on all axes</li> <li>drive power</li> <li>feedhold applied</li> <li>speed, acceleration and/or deceleration set to zero</li> <li>servo set off/watchdog set off</li> <li>gains (drive and/or controller)</li> <li>axis is already running a move which has not completed - Check MTYPE and NTYPE</li> </ul>
Axis goes out on following error after a time	<ul style="list-style-type: none"> <li>speed being requested requires more than 10v - check drive tacho gain and motor/ drive speed characteristics.</li> <li>drive shutting down on current limit after a time</li> </ul>

Problem	Potential reasons
Axis losing position	<ul style="list-style-type: none"><li>• encoder coupling</li><li>• encoder signal (wire length, differential/single ended encoder)</li><li>• mechanics</li></ul>
<i>Motion</i> Perfect cannot "connect" with the controller	<ul style="list-style-type: none"><li>• Controller running a program which transmits on serial port 0. If this prevents <i>Motion</i> Perfect connecting to the controller, open Terminal screen in <i>Motion</i> Perfect unconnected mode and type a "halt" command at the command prompt.</li><li>• Faulty or unconnected serial cable</li><li>• <i>Motion</i> Perfect baudrate, data bits, parity or stop bits have been changed. - Adjust to default of 9600 baud, 7 data bits, 2 stop bits, even parity under the "Options" menu.</li><li>• Check <i>Motion</i> Perfect version. The latest version can be downloaded from <a href="http://www.triomotion.com">www.triomotion.com</a></li></ul>