CHAPTER THREE

Configuration

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Configuration

You can configure the Gemini drive's settings for optimum system performance. For most of these settings, configuration is optional—if you do nothing, the drive will use default values the very first time it powers up. If you change any settings, the new settings are saved automatically. Most changed settings are effective immediately, but some require that you issue a reset (software RESET command, reset input, or cycle power) before the drive acts upon them.

This chapter will give an overview of all software commands that configure drive settings. For more in depth descriptions about the software commands, see the separate *Gemini Programmer's Reference*.

At the end of this chapter, we have provided tuning procedures you can use to configure the Gemini drive's tuning settings.

Software Programs for Configuration

Two software programs are located on the Motion Planner CD-ROM. *Motion Planner* runs on a personal computer (PC). *Pocket Motion Planner* runs on a palm PC or Handheld Personal Computer (HPC) that uses Windows CE 2.0 or higher, or on a PC. These programs are also available on the Compumotor web site at http://www.compumotor.com.

Information about installing and using each of these software tools can be found in the *Gemini Programmer's Reference*.

Overview of Configuration Commands

Motion Planner and Pocket Motion Planner's configuration procedures present commands in groups organized by function. The overview below is organized similarly to the software's *Full Configuration* procedure. (*Express Setup*, which was discussed in *Chapter 2 Installation*, gives you fewer configuration options.)

Motor Settings

If you select a Compumotor motor from the list of motors the software presents to you, the software will send settings to the drive for the motor you selected. No further motor setting configuration is necessary on your part.

If you use a non-Compumotor motor, or choose to manually configure a Compumotor motor, use the following commands to configure motor settings. Also see *Appendix B – Using Non-Compumotor Motors* for additional instructions.

Command	Description
ERES	feedback resolution (encoder or resolver)
DMTIC	continuous current
DMTICD	continuous current derating
DMTKE	motor constant
DMTRES	line-to-line resistance
DMTJ	rotor inertia
DPOLE	number of pole pairs
DMTW	rated speed
DMTIP	peak current

DMTLMN	minimum line-to-line inductance
DMTLMX	maximum line-to-line inductance
DMTD	motor damping
DMTRWC	motor thermal resistance (winding to case)
DMTTCM	motor case (and heatsink) thermal time constant
DMTTCW	motor winding thermal time constant
DPWM	PWM switching frequency
DMTMAX	motor maximum temperature
SHALL	Hall sensor orientation

System Settings

The system settings configure the drive's mode of operation, resolution, direction, and fault modes.

Drive Settings

Command	Description	Options:
DMODE	mode of operation:	no mode defined
		torque control (±10V)
		velocity control (±10V)
		position control (step/direction)
		position control (step/direction inverted—inverts sense of direction signal)
		position control (clockwise/counterclockwise)
		encoder tracking[1]
		autorun[2]
		torque tuning mode
		velocity tuning mode
		position tuning mode
DRES	input step resolution	you enter a number (position mode only)
ORES	pseudo encoder output resolution	you enter a number
DMTLIM	torque limit	you enter a number
DMTSCL	torque scale	you enter a number
DMVLIM	velocity limit	you enter a number
DMVSCL	velocity scale	you enter a number

[1]Encoder tracking mode uses incoming quadrature encoder pulses to command motion.

[2]Autorun mode commands motion with no pulse source connected. It is used during Express Setup, and for troubleshooting.

Load Settings

Command	Description	Options:
LJRAT	load to rotor inertia ratio	you enter a number
LDAMP	load damping	you enter a number

Fault Settings

Command	Description	Options:
FLTSTP	fault on startup indexer pulses	can be turned on or off
FLTDSB	fault on disable	can be turned on or off
SMPER	maximum position error	you enter a number
SMVER	maximum velocity error	you enter a number
DIFOLD	enable current foldback	can be turned on or off
DMTAMB	motor ambient temperature	you enter a number
DHALL	fault on encoder/Hall mismatch	can be turned on or off

Input/Output (I/O) Settings

The I/O settings configure the drive's three digital inputs, three digital outputs, and two analog monitors.

Digital Inputs

Command	Description	Options:
LH	hard limit disable	hard limits disabled
		negative limit only
		positive limit only
		both hard limits enabled
INLVL	input sense	active high or active low
INDEB	input debounce time	can be set in milliseconds

Digital Outputs

Command	Description	Options:
OUTLVL	output sense	active high or active low

Analog Monitors

Command	Description	Options:
DMONAV	analog monitor A variable	unused/turn off variable
		motor temperature
		drive temperature
		position error
		velocity setpoint
		actual velocity
		torque/force setpoint
		actual (electrical) torque
		velocity error
		phase A (or U) commanded current
		phase A (or U) actual current
		phase B (or V) commanded current
		phase B (or V) actual current
		d-axis commanded current
		d-axis actual current
		q-axis commanded current
		q-axis actual current
DMONAS	analog monitor A scaling[1]	you enter a percentage[1]
DMONBV	analog monitor B variable	same choices as DMONAV
DMONBS	analog monitor B scaling[1]	you enter a percentage[1]

[1]Monitor output is scalable from -2000% to +2000%, but is limited to ±10V peak to peak.

Communications Settings

The communication settings configure the drive for RS-232/485 communications.

RS-232/485

Command	Description	Options:
ERRLVL	error level	you enter a number
ECHO	echo enable	can be turned on or off
E	listening	can be turned on or off

Tuning Settings

Tuning settings are divided into two groups: primary and advanced. Tuning can be done in torque, velocity, or position mode. Tuning procedures for each of these modes are presented below. Relevant commands are:

Primary Tuning – Torque Mode Commands

Command	Description	Options:
DIBW	current loop bandwidth	you enter a number

Primary Tuning – Velocity Mode Commands

Command	Description	Options:
DVBW	velocity loop bandwidth	you enter a number

Primary Tuning – Position Mode Commands

Command	Description	Options:
DPBW	Position loop bandwidth	you enter a number

Advanced Tuning – All Mode Commands

Command	Description	Options:
DIBW	current loop bandwidth	you enter a number
DVBW	velocity loop bandwidth	you enter a number
DPBW	position loop bandwidth	you enter a number
SGIRAT	current (torque) damping ratio	you enter a number
DNOTAF	notch filter A frequency	you enter a number
DNOTAQ	notch filter A quality factor	you enter a number
DNOTBF	notch filter B frequency	you enter a number
DNOTBQ	notch filter B quality factor	you enter a number
DNOTLD	notch lead filter frequency	you enter a number
DNOTLG	notch lag filter frequency	you enter a number

Advanced Tuning – Velocity Mode Commands

All of the torque mode advanced tuning commands are available, plus:

Command	Description	Options:
SGVRAT	velocity damping ratio	you enter a number
SGINTE	integration ON/OFF	can be turned on or off

Advanced Tuning – Position Mode Commands

All of the torque mode advanced tuning commands are available, plus:

Command	Description	Options:
SGPSIG	position/velocity bandwidth ratio	you enter a number
SGPRAT	position damping ratio	you enter a number
SGINTE	integration ON/OFF	can be turned on or off

Tuning Procedures

During the *Express Setup* procedure in *Chapter 2 Installation*, the drive uses default values for tuning parameters, based upon the motor information you entered. That procedure assumes that the motor is unloaded. In the following tuning procedures, you will enter in system information that will characterize the load on the motor.

If you are operating the Gemini drive in torque mode, it is not necessary for you to enter in motor load information. The default tuning parameters for torque mode are set to provide suitable motor performance. Should you wish to modify the default values and fine tune you system, proceed to the *Torque Mode Tuning* section below.

The default tuning parameters for velocity and position modes are set to provide good, stiff motor shaft performance for a given load setting. With the default tuning parameters set in the *Express Setup* procedure, you need only set the system load-to-rotor inertia ratio and your system will be tuned.

Entering Load Settings

The main load setting you will adjust is LJRAT, which is the load-to-rotor inertia value for your system. The more accurately you know this value, the closer your tuning bandwidth settings will correspond to the actual dynamic performance of your system. If you only know this value approximately, you can adjust this value until you achieve the system performance you desire. The total system inertia is given by the following formula:

Total system inertia = *motor rotor inertia**(1 + *LJRAT*)

If your system has significant mechanical damping, you will also want to adjust the LDAMP setting which specifies system damping provided by the load. If you know that you have significant damping in your system from your load but do not know its exact value, you can adjust this value until you achieve the system performance that you desire.

Both the LJRAT and the LDAMP values can be set in the *Full Configuration* section of Pocket Motion Planner or in the *Full Setup* section of the Gemini wizard in Motion Planner. These values can also be set in the terminal modes of Pocket Motion Planner and Motion Planner. During the tuning process you may want to use the terminal emulator to establish appropriate values for these parameters and then upload and save the drive’s full configuration settings for use with other units.

Torque Mode Tuning

For most applications, the default tuning values for your drive/motor combination from the *Express Setup* procedure in *Chapter 2 Installation* will provide good performance. Use the following procedures if you need to adjust these values.

WARNING

This procedure causes the motor shaft to move. Make sure that shaft motion will not damage equipment or injure personnel.

Torque Mode Tuning Procedure

Primary Tuning Procedure

1. Disable the drive.
2. Configure the drive for *torque tuning mode* (DMODE15). In this mode, the drive commands a bipolar step change in current, proportional to the motor's continuous current rating, at a 10 Hz repetition rate. (The drive will ignore torque commands on its command input terminals which may come from an external device, such as a servo controller.)
3. Configure ANALOG MONITOR A to show *commanded* d-axis current (DMONAV16).
4. Configure ANALOG MONITOR B to show *actual* d-axis current (DMONBV17).
5. Connect one channel of your oscilloscope to the drive's ANALOG MONITOR A (pin 21). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).
6. Connect a second channel of your oscilloscope to the drive's ANALOG MONITOR B (pin 22). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).

   Adjust your oscilloscope to display commanded versus actual d-axis current. (The analog monitors can be scaled, in percent, with the DMONAS and DMONBS commands.)
7. Enable the drive and observe your system's response, using the oscilloscope. (The motor may move back and forth slightly.)

   Ringing or an oscillating response indicates that the current loop bandwidth is too high. To eliminate oscillations:
   - decrease bandwidth using the DIBW command.

   A sluggish response, or actual current that remains below commanded current, indicates that bandwidth is too low. To improve the response:
   - increase bandwidth by using the DIBW command. However, increasing bandwidth higher than the default value is usually not helpful.
8. After you achieve a satisfactory system response, reconfigure the drive for torque mode (DMODE2). This completes the primary tuning procedure.

   If you are unable to achieve a satisfactory response, proceed to the advanced tuning procedure below.

Advanced Tuning Procedure

1. Configure the drive for torque tuning mode (DMODE15), and connect an oscilloscope, as described in Steps 1 – 6 in the *Primary Tuning Procedure* above.
2. Enable the drive and observe your system's response.

   Ringing or an oscillating response indicates that the current loop bandwidth is too high, or the current loop damping is too low. To eliminate oscillations:
   - decrease bandwidth using the DIBW command; then, if necessary:
   - adjust damping by using the SGIRAT command. Use the value that gives the best performance.

   A sluggish response indicates that bandwidth is too low, or damping is too high. To improve the response:
   - increase bandwidth by using the DIBW command; then, if necessary:
   - adjust damping by using the SGIRAT command. Use the value that gives the best performance.
3. OPTIONAL: Null the Input Offset.

   First: command zero volts by using either of two methods:

   Method 1: connect your controller or command voltage source, and command zero volts; or:

   Method 2: disconnect the controller or command voltage source, and short CMD+ to CMD- (pin 23 to pin 24).

   Second: Issue a DCMDZ command to null any offset at the command input.
4. After you achieve a satisfactory system response, reconfigure the drive for torque mode (DMODE2). This completes the advanced tuning procedure.

If ringing or oscillations persist, and do not seem to be affected by bandwidth adjustments, you may need to use notch filters or lead/lag filters. See the *Filter Adjustments* procedure at the end of this *Tuning* section.

Velocity Mode Tuning

For most applications, the default tuning parameters for velocity and position modes are set to provide good, stiff motor shaft performance for a given load setting. With the default tuning parameters set in the *Express Setup* procedure, you need only set the system load-to-rotor inertia ratio and your system will be tuned. If your system has significant mechanical damping, you may need to set the system damping as well. Should you wish to modify the default values and fine tune your system for velocity mode, use the following procedures.

WARNING

This procedure causes the motor shaft to move. Make sure that shaft motion will not damage equipment or injure personnel.

Velocity Mode Tuning Procedure

Primary Tuning Procedure

1. Disable the drive.
2. Configure the drive for *velocity tuning mode* (DMODE16). In this mode, the drive commands an alternating 2 rps step change in velocity, at a one second repetition rate.
3. Enable the drive and observe your system's response. (If necessary, you can connect an oscilloscope as described in *Advanced Tuning* below.)

   Ringing or an oscillating response indicates that the velocity loop bandwidth is too high. To eliminate oscillations:

   - decrease bandwidth using the DVBW command.

   A sluggish response indicates that velocity loop bandwidth is too low. To improve the response:

   - increase bandwidth by using the DVBW command.

   NOTE: Ringing, oscillations, or a sluggish response can also indicate inaccurate drive settings for LJRAT or LDAMP.
4. After you achieve a satisfactory system response, reconfigure the drive for velocity mode (DMODE4). This completes the primary tuning procedure.

   If you are unable to achieve a satisfactory response, proceed to the advanced tuning procedure below.

Advanced Tuning Procedure

1. Disable the drive.
2. Configure the drive for *velocity tuning mode* (DMODE16). In this mode, the drive commands an alternating 2 rps step change in velocity, at a one second repetition rate.

   (In some applications a different velocity profile may give better results. Choose a move similar to that required by your application, but using fast acceleration and deceleration rates. Be sure the maximum velocity of your move is well below the rated speed of your drive/motor combination.

   A square wave generator connected to the velocity input (in DMODE4) may also be used.)
3. Configure ANALOG MONITOR A to show velocity setpoint, which is *commanded* velocity (DMONAV4).
4. Configure ANALOG MONITOR B to show *actual* velocity (DMONBV5)
5. Connect one channel of your oscilloscope to the drive's ANALOG MONITOR A (pin 21). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).

6. Connect a second channel of your oscilloscope to the drive's ANALOG MONITOR B (pin 22). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).

   Adjust your oscilloscope to display commanded versus actual velocity. (The analog monitors can be scaled, in percent, with the DMONAS and DMONBS commands. You may need to set these to large values if the maximum velocity is small.)

7. Enable the drive and observe your system's response.

   Ringing or an oscillating response indicates that the velocity loop bandwidth is too high, or the velocity loop damping is too low. To eliminate oscillations:

   - decrease bandwidth using the DVBW command; then, if necessary:
   - adjust damping by using the SGVRAT command. Use the value that gives the best performance.
   - in applications with backlash or high static friction, disabling the velocity integrator (SGINTE0) can help improve stability.

   A sluggish response indicates that velocity loop bandwidth is too low, or velocity loop damping is too high. To improve the response:

   - increase bandwidth by using the DVBW command; then, if necessary:
   - adjust damping by using the SGVRAT command. Use the value that gives the best performance.

   NOTE: Ringing, oscillations, or a sluggish response can also indicate inaccurate drive settings for LJRAT or LDAMP.

8. OPTIONAL: Null the Input Offset

   First: command zero volts by using either of two methods:

   - Method 1: connect your controller or command voltage source, and command zero volts; or:
   - Method 2: disconnect the controller or command voltage source, and short CMD+ to CMD- (pin 23 to pin 24).

   Second: Issue a DCMDZ command to null any offset at the command input.

9. After you achieve a satisfactory system response, reconfigure the drive for velocity mode (DMODE4). This completes the advanced tuning procedure.

If ringing or oscillations persist, and do not seem to be affected by bandwidth adjustments, you may need to use notch filters or lead/lag filters. See the *Filter Adjustments* procedure at the end of this *Tuning* section.

Position Mode Tuning

For most applications, the default tuning parameters for velocity and position modes are set to provide good, stiff motor shaft performance for a given load setting. With the default tuning parameters set in the Express Setup procedure, you need only set the system load-to-rotor inertia ratio and your system will be tuned. If your system has significant mechanical damping, you may need to set the system damping as well. Should you wish to modify the default values and fine tune your system for position mode, use the following procedures.

WARNING

This procedure causes the motor shaft to move. Make sure that shaft motion will not damage equipment or injure personnel.

Position Mode Tuning Procedure

Primary Tuning Procedure

1. Disable the drive.
2. Configure the drive for *position tuning mode* (DMODE17). In this mode, the drive commands an alternating 1/4 revolution step change in position at a one second repetition rate.
3. Enable the drive and observe your system's response. (If necessary, you can connect an oscilloscope as described in *Advanced Tuning* below.)

   Ringing or an oscillating response indicates that the position loop bandwidth is too high. To eliminate oscillations:

   - decrease bandwidth using the DPBW command.

   A sluggish response indicates that position loop bandwidth is too low. To improve the response:

   - increase bandwidth by using the DPBW command.

   NOTE: Ringing, oscillations, or a sluggish response can also indicate inaccurate drive settings for LJRAT or LDAMP.
4. After you achieve a satisfactory system response, reconfigure the drive for position mode (DMODE6, DMODE7, or DMODE8). This completes the primary tuning procedure.

   If you are unable to achieve a satisfactory response, proceed to the advanced tuning procedure below.

Advanced Tuning Procedure

1. Disable the drive.
2. Configure the drive for *position tuning mode* (DMODE17). In this mode, the drive commands an alternating 1/4 revolution step change in position at a one second repetition rate.

   (In some applications a different move profile may give better results. Choose a move similar to that required by your application, but using fast acceleration and deceleration rates. Be sure the maximum velocity of your move is well below the rated speed of your drive/motor combination.
3. Configure ANALOG MONITOR A to show position error (DMONAV3).
4. Connect one channel of your oscilloscope to the drive's ANALOG MONITOR A (pin 21). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).
5. Adjust your oscilloscope to display position error. (The analog monitor can be scaled, in percent, with the DMONAS command.)
6. Enable the drive and observe your system's response. Position error will increase during acceleration, but should decay smoothly to near zero without significant ringing or instability.

   Ringing or an oscillating response indicates that the position loop bandwidth is too high, or the position loop damping is too low. To eliminate ringing or oscillations:

   - decrease bandwidth using the DPBW command; then, if necessary:
   - adjust damping by using the SGPRAT command. Use the value that gives the best performance.
   - in applications with backlash or high static friction, disabling the velocity integrator (SGINTE0) can help improve stability.
   - NOTE: In position mode, the velocity loop bandwidth tracks changes in position loop bandwidth by a ratio set by the SGPSIG command. In position mode, the DVBW command is ignored.

   A sluggish response indicates that position loop bandwidth is too low, or position loop damping is too high. To improve the response:

   - increase bandwidth by using the DPBW command; then, if necessary:
   - adjust damping by using the SGPRAT command. Use the value that gives the best performance.

   NOTE: Ringing or a sluggish response can also indicate inaccurate drive settings for LJRAT or LDAMP.

7. After you achieve a satisfactory system response, reconfigure the drive for position mode (DMODE6, DMODE7, or DMODE8). This completes the advanced tuning procedure.

If ringing or oscillations persist, and do not seem to be affected by the above adjustments, you may need to use notch filters or lead/lag filters. See the *Filter Adjustments* procedure below.

Filter Adjustments

If the previous tuning procedures did not eliminate ringing or oscillations, then mechanical resonances may be causing problems with your system's response.

Before trying the procedure below, we recommend that you check your mechanical system, especially the mechanical stiffness and mounting rigidity of your system. Use bellows or disk style couplers, not helical couplers. Once you have optimized your mechanical system, filters may allow increased performance, without causing system instability.

Filters can improve response by reducing system gain over the same frequencies that contain resonances. You can then increase the gain for frequencies outside this range, without exciting the resonance and causing instability.

The first procedure below describes how to set the drive's two notch filters, to reduce resonance and improve your system's response. The second and third procedures describe how to set the drive's lead and lag filters.

WARNING

These procedures cause the motor shaft to move. Make sure that shaft motion will not damage equipment or injure personnel.

Notch Filter Adjustment Procedure

1. Configure the analog monitor to show q-axis current (DMONAV19).
2. Configure the drive for torque mode (DMODE2).
3. Configure DMTLIM to approximately 1/3 of the default value for your Compumotor motor.
4. Connect one channel of your oscilloscope to the drive's ANALOG MONITOR A (pin 21). Connect your oscilloscope's ground to the drive's ANALOG GROUND (pin 25).
5. Connect a sine wave generator, with the amplitude set to minimum, to the drive's torque command input, pin 23. (Connect the signal generator's ground to the drive's CMD-, pin 24, and also to the drive's analog ground, pin 25.)

   You may need to adjust the DC offset of the generator periodically to keep the load within its travel limit.
6. Slowly sweep the sine wave frequency, observing the oscilloscope or the load. Start at low amplitude, increasing gradually to a level that gives an observable response. Find the frequency that gives the maximum response. (If no oscilloscope is available, you may be able to find this frequency by sound or by touch).
7. Note the frequency that causes the maximum response.
8. Configure the drive for the appropriate tuning mode (torque, velocity, or position). Observe the system's response to the tuning mode's step input.
9. Set the notch filter to the frequency noted in Step 7 (DNOTAF command).
10. Using the DNOTAD command, slowly increase the depth of the notch filter from 0.0 to 1.0 until the ringing decreases.
11. Compare the response to a step input to the response you observed in *Step 8*. Ringing should be reduced or eliminated.

12. Adjust the Q of the filter (DNOTAQ command) until ringing is controlled, using the following guidelines:
    - Set Q as low as possible. Resonances change with load; therefore, your system will be more robust with a lower Q value.
    - If Q is too low, system stiffness will be reduced outside the resonant range.
    - If Q is too high, the response peak may merely shift in frequency.
13. After reducing the resonance, you may notice a second resonance. Use the second notch filter (DNOTBF, DNOTBD and DNOTBQ) to reduce the second resonance. Follow the same procedure as outlined in steps 1 – 10 above.
14. If you are done adjusting filters, reconfigure DMTLIM to its default value. Otherwise, proceed to the *Lag Filter Adjustment* procedure below.

Lag Filter Adjustment Procedure

The lag filter can act as a low pass filter, and reduce the effects of electrical noise on the command input signal in torque mode. (It can also reduce the effects of resonance at low frequencies—below 60 Hz—where the notch filters are not effective.)

1. As described in Steps 2 – 3 in the *Notch Filter Adjustment* procedure above, reduce DMTLIM and connect an oscilloscope.
2. Verify that the lead filter is turned off (DNOTLDØ).
3. Configure the drive for the appropriate tuning mode (torque, velocity, or position). Observe the system's response to the tuning mode's step input.
4. Choose a value for the lag filter (DNOTLG) that reduces low frequency resonance and provides satisfactory system performance.
5. If you are done adjusting filters, reconfigure DMTLIM to its default value. Otherwise, proceed to the *Lead/Lag Filter Adjustment* procedure below.

Lead/Lag Filter Adjustment Procedure

The lead filter can counteract the effects of the lag filter at higher frequencies. Do not use the lead filter by itself—if you use the lead filter, you must also use the lag filter.

1. As described in Steps 2 – 3 in the *Notch Filter Adjustment* procedure above, reduce DMTLIM and connect an oscilloscope.
2. Set the lag filter (DNOTLG) as described above.
3. Configure the drive for the appropriate tuning mode (torque, velocity, or position). Observe the system's response to the tuning mode's step input.
4. Choose a value for the lead filter (DNOTLD) that improves system performance. This value will typically be higher in frequency than the lag filter setting.
5. You must choose a value for the lead filter that is *higher* in frequency than the lag filter value. However, do not set the lead filter higher than four times the lag filter frequency, or a drive configuration warning will result, and the drive will use the previous filter settings.
6. If you are done adjusting filters, reconfigure DMTLIM to its default value.