SL Series Servo

GE Fanuc Automation

Programmable Control Products

SL Series Servo

User's Manual

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Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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CIMSTAR	Modelmaster	Series 90	VersaPro
Field Control	Motion Mate	Series Five	VuMaster
GEnet	ProLoop	Series One	Workmaster

What's New in this Manual

The only two major changes in this version are the expanded section on how to wire the optional motor holding brakes in Chapter 4 and the addition of Appendix E, which discusses how to interface an SL system to an OCS or RCS Stepper Controller Module. Several smaller clarifications and corrections are found throughout the manual.

Content of this Manual

Chapter 1. **Before Operation:** Describes what tasks should be done before operating the SL Series servo amplifier.

Chapter 2. **SL Amplifier Feature Overview:** This chapter defines and describes the features of the SL Series servo amplifier.

Chapter 3. **Installation Guidelines:** Provides guidelines and dimensions for mounting the SL Series servo amplifier.

Chapter 4. **Wiring:** This chapter provides guidelines for wiring to the amplifier's power terminals, I/O and command interface connector CN I/F, encoder connector CN SIG, serial connector CN SER, and AC incoming power.

Chapter 5. **I/O Circuit Configuration and Function:** This chapter illustrates the configuration of the various types of I/O circuits: Topics covered are control inputs, control outputs, analog inputs, analog outputs, pulse command, counter clear, command pulse inhibit input, and motor encoder feedback interface.

Chapter 6. **Configuration Parameters:** Explains the purpose and scope of each configuration parameter and provides parameter-setting guidelines.

Chapter 7. **Tuning:** This chapter contains essential information on how to tune the servo system.

Chapter 8. **Operation:** Discusses how to configure the amplifier using either the Keypad and Front Panel display or the SLconfig software. It also discusses how to tune and monitor the SL amplifiers and save and restore configuration files.

Chapter 9. **Protection and Troubleshooting:** This chapter provides help for handling problems with your servo system.

Appendix A. **Operation with External Motion Controllers**

Appendix B. **CE Installation Requirements**

Appendix C. **Tables and Formulas**

Appendix D. **VersaMax High Speed Counter Interface**

Appendix E. **Interfacing the SL Servo to an OCS/RCS**

Related Publications

GFK-1464	***Motion Mate DSM302 for Series 90-30 PLCs User's Manual***
GFK-1742	***Motion Mate DSM314 for Series 90-30 PLCs User's Manual***
GFK-0781	***Motion Mate APM for Series 90-30 PLCs Follower Mode User's Manual***
GFK-0840	***Motion Mate APM for Series 90-30 PLCs Standard Mode User's Manual***

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Contents

Chapter 1 Before Operation

1.1 System Overview

The SL Series is a family of high performance brushless digital servos with very flexible command interface and user-configurable I/O functions. Amplifier configuration can be done using a front panel keypad and 6-digit LED display or more easily with the *SLconfig* software for a personal computer. The SL Series amplifiers can be configured for use with an external position controller using an analog velocity or torque command interface or in one of the three position control modes. The SL amplifiers support interface to CW Pulse/CCW Pulse, Pulse/Direction and quadrature encoder signals as a position command interface. The first two options are typically used to connect with stepper indexers when upgrading to servo control for improved machine performance. The third command option can be used for simple fixed ratio follower (electronic gearing) applications using an incremental master encoder.

The SL Series motors and amplifiers are designed and optimized as matched sets based on their rated power. Overload and possible component damage may occur if the motor and amplifier are not properly matched. Table 1-1 shows the proper pairing of the components.

The SL amplifiers rated from 30 to 400 Watt are available in either 115 VAC or 230 VAC models. All other models are rated for 230 VAC input. The 230 VAC models are intended to be operated from a three phase supply but can be used with a single phase power source if the torque output or ambient temperature is de-rated as specified in this manual. The motors rated 100 to 400 W are also available in 115 or 230 VAC ratings and must be properly matched with an amplifier of the same voltage rating. The 30 W and 50 W motors are only available in a 115/230 VAC rating while the 750 W to 5kW motors are rated for 230 VAC only. The amplifiers are referred to as either the Z-Series (30-750 Watt models) or the V-Series (1000-5000 Watt models). Although most of the I/O and parameter functions are shared by both series there are differences in the command and control interface on connector CN I/F, some user parameters, control power requirements and keypad/display menu options. These differences are presented throughout the manual.

The 30 to 1000 Watt SL Series motors are designed with standard NEMA shaft and flange mounting configurations for easy mounting to off-the-shelf gear reducers and couplings. The 750 Watt motor uses an oversized shaft diameter (0.625 inches) for the NEMA 34 mounting in order to handle the peak torque rating of this model. Motor models larger than 1kW have metric mounting configurations. All motors are available with an optional 24 VDC holding brake. These brakes are spring-set, electrically released models designed for holding stationary loads. The user must supply a separate brake power supply. The 30-750 Watt motors have flying leads with box style connectors for motor power, encoder and brake connections. The 1000 to 5000

Watt motors have MS style connectors and the brake power (when required) is integrated with the power connections.

Control interface to the SL Series amplifiers is accomplished with several different interface terminal blocks depending on the host controller. One version of the terminal board (IC800SLT001) provides a quick and easy connection to GE Fanuc's Motion Mate APM/DSM series motion controllers while the IC800SLT004 Breakout terminal board can be used with any third party motion controller or GE Fanuc OCS controller. Appendix A includes details on these terminal board interfaces.

The following sections outline what should be accomplished before operating the SL Series amplifier.

1.2 Unpacking and Inspecting Components

After opening the SL Series servo package, please verify the following:

1. Did you receive the correct model components? The model number of each component is shown on the carton and product labels.
2. Did you receive all items shown on the packing list?
3. Was anything damaged during shipment?

Note

If you find any damage, please contact your local dealer/distributor.

1.3 Storage

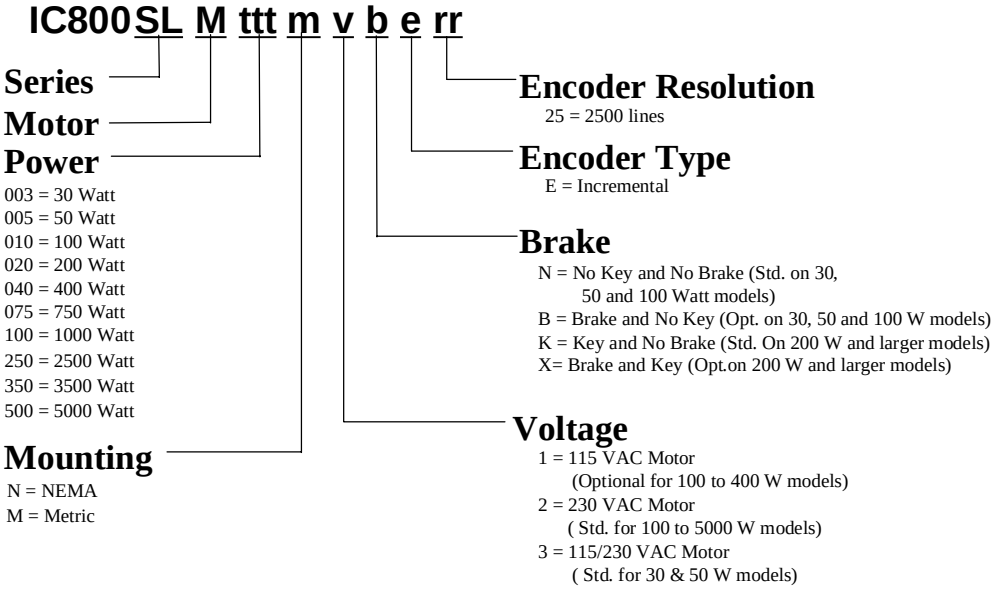
Store SL servo components in a clean, dry location that is not exposed to direct sunlight, rain, excessive temperatures (exceeding -20°C to 80°C), corrosive gasses or liquids.

For maximum protection, store all components in the original shipping container.

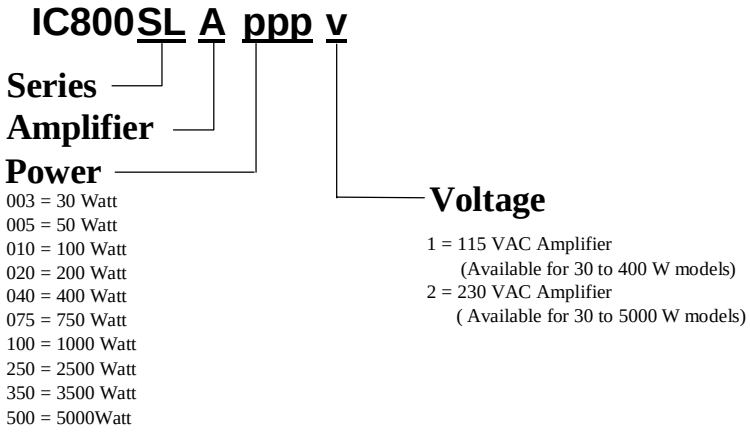
1.4 Part Numbers

The following figures show how to read the model number on the motor and amplifier.

1.4.1 Servo Motor Part Numbers



1.4.2 Servo Amplifier Part Numbers



1.4.3 Cable Part Numbers

IC800SL C t s xxx

SL Series

Cable Type

P = Motor Power Cable
E = Motor Encoder Cable
B = Motor Brake Cable
S = Amplifier Serial Cable
I = Amplifier Interface Cable
APM=APM Control Cable
FLY=Amplifier Interface Cable W/Flying

Length (meters)

010 = 1 Meter
020 = 2 Meter
030 = 3 Meter
050 = 5 Meter
100 = 10 Meter

Amplifier Series
(This field is not required for Control or Serial cables)

Z = Z-Series (30 - 750 W)
V = V-Series (1000-2500 W)
VL = V-Series Power and Brake Cables Only (Models Larger than 2.5kW)

Cable Type	Available Lengths				
	1 m	2m	3m	5m	10m
Motor Power Cables	N/A	N/A	N/A	X	X
Motor Encoder Cables	N/A	N/A	N/A	X	X
Motor Brake Cables	N/A	N/A	N/A	X	X
Serial Cables	N/A	X	N/A	N/A	N/A
APM Control Cables	X	N/A	X	N/A	N/A
Amplifier Interface Cables	X	N/A	X	N/A	N/A

X = available lengths

1.4.4 Accessory Part Numbers

Terminal Board Assemblies

IC800SL T xxx

SL Series

Terminal Block Type

001 = APM/DSM Interface (38 Terminals)
004 = Breakout Board for 3rd Party Controller Interface (54 Terminals)

Regeneration Resistors

IC800SL R xxx

SL Series

Regen Resistor Kits Type

001 = 50 ohm, 100 W w/ mounting hardware for all 115 VAC models
002 = 100 ohm, 225 W w/ mounting hardware for 230 VAC, 30-750 W models
003 = 20 ohm, 300 W w/ mounting hardware for 230 VAC, 1000 W models
004 = 15 ohm, 1000 W w/ mounting hardware for 230 VAC, 2500-5000 W models

1.5 Confirming System Components

The SL Series servo system consists of an amplifier and an AC servo motor from GE Fanuc. Each amplifier is designed to be used with specific GE Fanuc SL Series AC servo motors. Please refer to the following table for the correct combination of amplifier and motor.

Table 1-1. Z-Series Motor/Amplifier Compatibility

Series	Amplifier Model #	Applicable Motor				
		Motor Model #	Rated Output	Voltage	Rated Speed	Encoder Resolution
Z-Series	IC800SLA0031	IC800SLM003N3NE25 IC800SLM003N3BE25*	30 W	115VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0051	IC800SLM005N3NE25 IC800SLM005N3BE25*	50 W	115VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0101	IC800SLM010N1NE25 IC800SLM010N1BE25*	100 W	115VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0201	IC800SLM020N1KE25 IC800SLM020N1XE25*	200 W	115VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0401	IC800SLM040N1KE25 IC800SLM040N1XE25*	400 W	115VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0032	IC800SLM003N3NE25 IC800SLM003N3BE25*	30 W	230VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0052	IC800SLM005N3NE25 IC800SLM005N3BE25*	50 W	230VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0102	IC800SLM010N2NE25 IC800SLM010N2BE25*	100 W	230VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0202	IC800SLM020N2KE25 IC800SLM020N2XE25*	200 W	230VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0402	IC800SLM040N2KE25 IC800SLM040N2XE25*	400 W	230VAC	3000 RPM	2500 Lines
Z-Series	IC800SLA0752	IC800SLM075N2KE25 IC800SLM075N2XE25*	750 W	230VAC	3000 RPM	2500 Lines

* Denotes motors that have the optional 24 VDC holding brake (requires customer supplied power supply)

Table 1-2. V-Series Motor/Amplifier Compatibility

Series	Amplifier Model #	Applicable Motor				
		Motor Model #	Rated Output	Voltage	Rated Speed	Encoder Resolution
V-Series	IC800SLA1002	IC800SLM100N2KE25 IC800SLM100N2XE25*	1000 W	230VAC	3000 RPM	2500 Lines
V-Series	IC800SLA2502	IC800SLM250M2KE25 IC800SLM250M2XE25*	2500 W	230VAC	3000 RPM	2500 Lines
V-Series	IC800SLA3502	IC800SLM350M2KE25 IC800SLM350M2XE25*	3500 W	230VAC	3000 RPM	2500 Lines
V-Series	IC800SLA5002	IC800SLM500M2KE25 IC800SLM500M2XE25*	5000 W	230VAC	3000 RPM	2500 Lines

* Denotes motors that have the optional 24 VDC holding brake (requires customer furnished power supply)

Chapter 2

SL Amplifier Feature Overview

This chapter defines and describes the features of the SL Series servos. The SL family is comprised of the Z-Series and the V-Series components. The Z-Series covers servos from 30 Watt to 750 Watt continuous rating. The V-Series covers servos from 1,000 Watt to 5,000 Watt continuous rating. While many of the functions and configuration parameters are the same for both series, there are a number of differences that are described throughout this manual. One of the primary differences is the I/O configuration on the CN I/F interface connector of the amplifier. The V-Series uses a 50-pin interface connector and contains several signals not included on the Z-Series amplifiers. The Z-Series amplifiers use a 36-pin interface connector and use parameter configurations to assign different I/O functions to some of the connector pins (see Section 4.1 for more details).

Figures 2-1and 2-2 illustrate typical Z-Series and V-Series amplifiers.

2.1 Feature Location

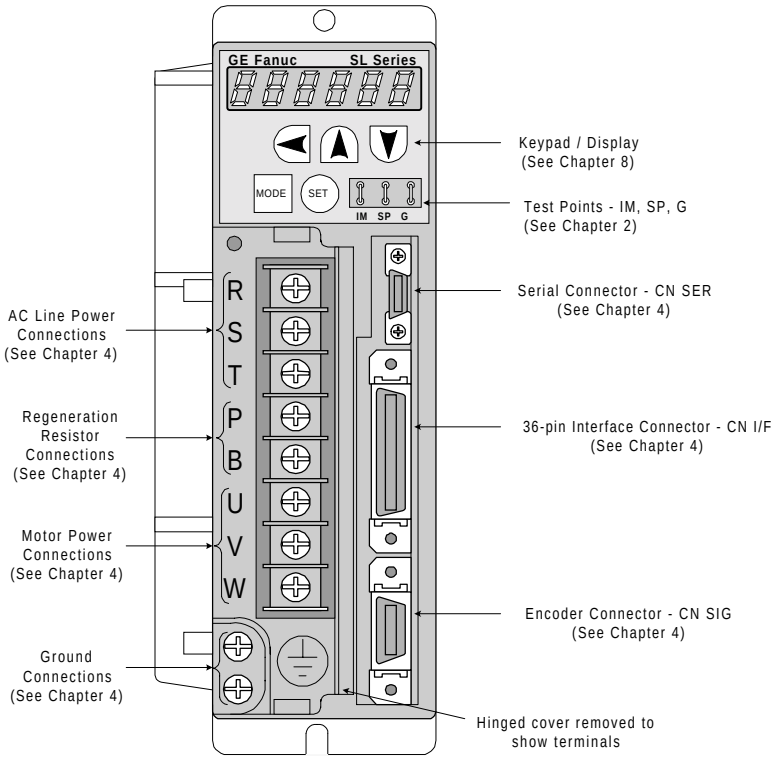


Figure 2-1. Z-Series (30W - 750W) SL Amplifier Features

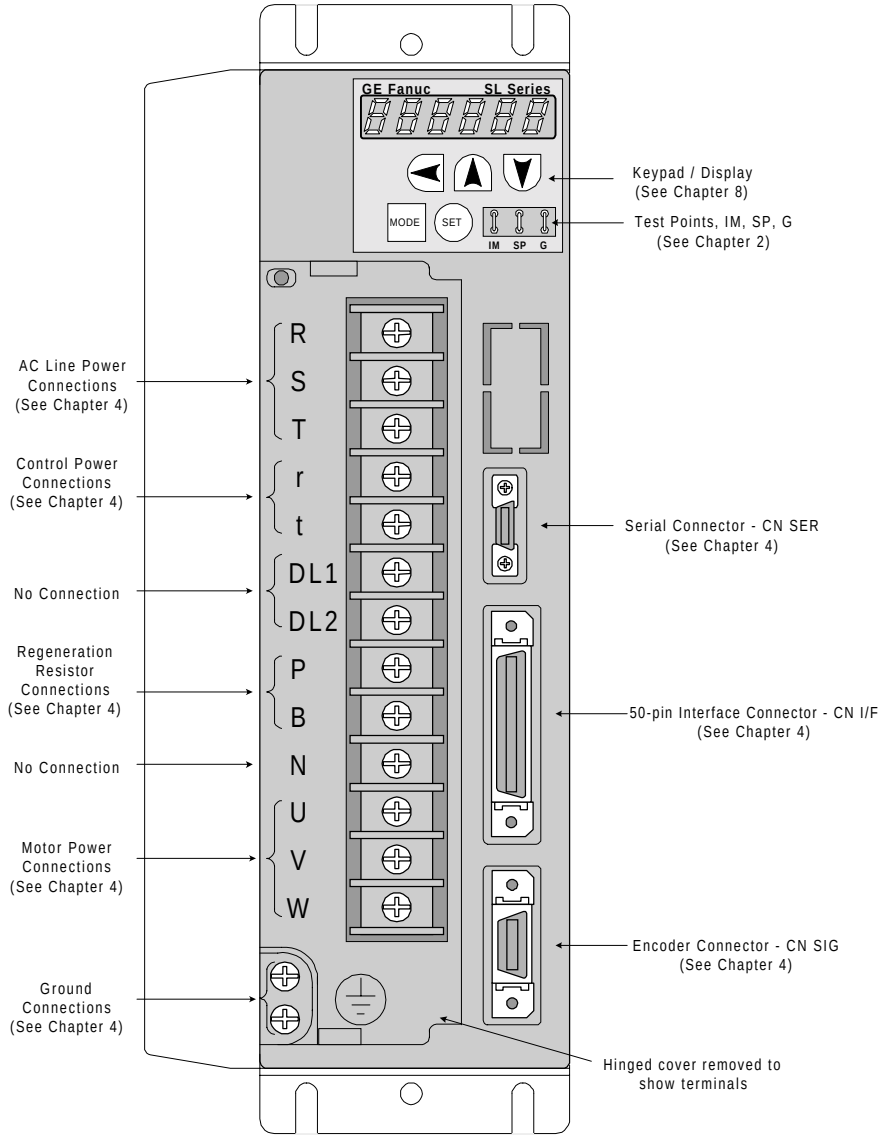


Figure 2-2. V-Series (1,000W – 5,000W) SL Amplifier Features

2.2 Rotational Direction Conventions

The direction of rotation of an SL Series motor is determined by the polarity of the command signal and several user parameters used to reverse direction for a set mode of operation. The operating modes shown below are configured by Parameter No. 02 (see Chapter 6-Parameters). The SL Series servos use the following directional conventions:

- **Position Control Mode** – The directional convention for the position control mode is determined by Parameter No. 28. This applies to input signals PULS1, PULS2, SIGN1 and SIGN2 on connector CN I/F pins 3-6 of the V-Series and pins 5-8 of the Z-Series. Directional conventions for these signals are described in the Parameter No. 29 section of Chapter 6.
- **Velocity Control Mode** - A positive velocity command input (SPR) is defined as a positive voltage applied to connector CN I/F pin 14 with respect to pin 15 (ground). When a positive command is applied and Parameter No. 14 -*Speed Command Polarity* is set to the default value (1), the motor will rotate counter-clockwise when viewed looking into the motor shaft. Changing Parameter No. 14 to 0 will reverse the direction of rotation for a positive command input.
- **Torque Control Mode** – A positive torque command input (TRQR) is defined as a positive voltage applied to connector CN I/F pin 34 with respect to pin 35 (ground) in the Z-Series, and pins 16 and 17, respectively, for the V-Series. When a positive command is applied and Parameter No. 1B-*Torque Command Polarity* is set to the default value (1), the motor will rotate counter-clockwise when viewed looking into the motor shaft. Changing Parameter No. 1B to 0 will reverse the direction of rotation for positive command input.
- **Rotational Convention for LED Display** – The directional convention on the amplifier LED display is fixed and cannot be changed by the user. Note that a positive value represents counter-clockwise motion, and a negative value represents clockwise motion, when viewed looking into the motor shaft.

Caution

When using the SL Series servos with an external position controller, such as the GE Fanuc APM300 or DSM300 series, it may be necessary to change Parameter No. 0D to invert the encoder output signal polarity when the command polarity is reversed in order to keep the command and feedback signals in synch. If these two signals are not in phase, a runaway condition can be created where the motor will accelerate to full speed and will not be under servo control. In that case, removing AC power or the Servo Enable signal must be used to stop the motor. It is recommended you use the Parameters to change signal polarity rather than reversing the physical wiring. As an alternative, the APM and DSM controllers have an Axis Direction configuration parameter that can be used to reverse motor direction for a given programmed move direction without inverting any of the SL amplifier signals. The default for this parameter in the APM/DSM is positive.

2.3 Specifications

Table 2-1. Z-Series Amplifier Specifications

Specification	Units	Amplifier Rating @ 20°C					
		30 W	50 W	100 W	200 W	400 W	750 W
Model Number	x = see Bus Power Supply, below	SLA003x	SLA005x	SLA010x	SLA020x	SLA040x	SLA075x
Continuous Current	115VAC Model A_{rms}	1.0	1.0	1.6	2.5	4.4	
	230VAC Model A_{rms}	1.0	1.0	1.0	1.6	2.5	4.3
Peak Current	115VAC Model A_{0-p}	4.3	4.3	6.9	10.5	18.3	
	230VAC Model A_{0-p}	4.3	4.3	4.3	6.9	10.5	18.3
Bus Power Supply	x=1	Single Phase 85 – 126 VAC, 50/60 Hz					
	x=2	170 – 253 VAC, 50/60 Hz, Single* or Three Phase					
I/O Power Supply	Voltage	12 to 24VDC ± 10%					
	Current	200 mA					
Loop Update Time	Position Loop	0.25 ms					
	Velocity Loop	0.25 ms					
	Current Loop	0.0417 ms				0.0833 ms	
Command Input Filter Time Constant	Pulse Command	1 µs					
	Velocity Command	50 µs					
	Torque Command	50 µs					
Weight	115 VAC Model lb. [kg]	1.98 [0.9]	1.98 [0.9]	1.98 [0.9]	2.2 [1.0]	2.64 [1.2]	
	230 VAC Model lb. [kg]	1.98 [0.9]	1.98 [0.9]	1.98 [0.9]	1.98 [0.9]	2.2 [1.0]	2.64 [1.2]
External Regenerative Resistor Options (Section 4.1.2)	Turn On Voltage	115 VAC Models: 195 VDC 230 VAC Models: 380 VDC					
	Continuous Power	115 VAC Models: 100 W 230 VAC Models: 225 W					
	Resistance (GE Fanuc kit)	115 VAC Models: 50 Ω 230VAC Models: 100 Ω					
	Maximum Current						
	115VAC Models	8 A	8 A	8 A	8 A	12 A	N/A
	230VAC Models	8 A	8 A	8 A	8 A	12 A	24 A
Environmental Data							
Humidity (non-condensing)	RH	90%					
Altitude	Feet [Meters]	3300 [1000]					
Ambient Temperature	°C	0 to 50 operating					
Storage Temperature	°C	-20 to 80					
Shock	G	15 (non-operating)					
Vibration	G	0.5 @ 10-150 Hz					

* Single-phase operation of 230 VAC models rated 200 W and larger require derating of the motor torque by 2.5% per °C above 40°C up to 50°C maximum.

Table 2-2. V-Series Amplifier Specifications

Specification	Units	Amplifier Rating @ 20°C			
		1000 W	**2500 W**	**3500 W**	**5000 W**
Model Number		SLA1002	SLA2502	SLA3502	SLA5002
Continuous Current	A_{rms}	7.2	15.9	21.6	28.5
Peak Current	A_{0-p}	30	68	92	120
Bus Power Supply	VAC	170 – 253 VAC, 50/60 Hz, Single* or Three Phase			
Control Power Supply	VAC	170-253VAC, 1ϕ, 50/60 Hz			
I/O Power Supply	Voltage	12 to 24VDC ± 10%			
	Current	500 mA			
Loop Update Time	Position Loop	0.26 ms	0.26 ms	0.26 ms	0.26 ms
	Velocity Loop	0.26 ms	0.26 ms	0.26 ms	0.26 ms
	Current Loop	0.0868 ms	0.0868 ms	0.0868 ms	0.0868 ms
Command Input Filter Time Constant	Pulse Command	1 µs			
	Velocity Command	50 µs			
	Torque Command	50 µs			
Weight	lb. [kg]	8.58 [3.9]	9.46 [4.3]	21.8 [9.9]	21.8 [9.9]
External Regenerative Resistor Options	Turn On Voltage	380 VDC			
	Continuous Power	300 W	1000 W		
	Resistance (GE Fanuc kit)	20 Ω	15 Ω		
	Maximum Current	40 A	40 A	40 A	40 A
Environmental Data					
Humidity (non-condensing)	RH	90%			
Altitude	Feet [Meters]	3300 [1000]			
Ambient Temperature	°C	0 to 50 operating			
Storage Temperature	°C	-20 to 80			
Shock	G	15 (non-operating)			
Vibration	G	0.5 @ 10-150 Hz			

* Single-phase operation of 230 VAC models rated 200 W and larger require derating of the motor torque by 2.5% per °C above 40°C up to 50°C maximum

Table 2-3. Z-Series Motor Specifications

Specification	Units	Motor Rating @ 20°C								
		SLM003	SLM005	SLM010		SLM020		SLM040		SLM075
		115/230V	115/230V	115V	230V	115V	230V	115V	230V	230V
Output Power	W	30	50	100		200		400		750
Continuous Stall Torque[1]	in-lb [Nm]	0.84 [0.095]	1.42 [0.16]	2.83 [0.32]		5.66 [0.64]		11.5 [1.3]		21.2 [2.4]
Peak Torque	in-lb [Nm]	2.48 [0.28]	4.25 [0.48]	8.4 [0.95]		16.9 [1.91]		33.6 [3.8]		62.8 [7.1]
Rated Speed	RPM	3000	3000	3000		3000		3000		3000
Maximum Speed	RPM	5000	5000	5000		5000		5000		4500
Feedback		2500 lines (10,000 counts/rev) Incremental Encoder (5 VDC±5% @ 0.3A; 250 kHz max.)								
Weight	lb [kg]	0.59 [0.27]	0.75 [0.34]	1.23 [0.56]		2.2 [1.0]		3.52 [1.6]		7.0 [3.2]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	0.139 [0.016]	0.225 [0.025]	0.546 [0.062]		1.474 [0.17]		3.208 [0.36]		11.62 [1.31]
Shaft Thrust Load	lb [kg]	6.6 [3]	13.2 [6]	13.2 [6]		22 [10]		22 [10]		33 [15]
Shaft Radial Load[2]	lb [kg]	11 [5]	15.4 [7]	15.4 [7]		55 [25]		55 [25]		88 [40]
Mechanical Time Constant	ms	1.8	1.2	0.8	0.77	0.62	0.63	0.48	0.54	0.45
Torque Constant	in-lb/A$_{(rms)}$ [Nm/A$_{(rms)}$]	0.91 [0.103]	1.42 [0.16]	1.86 [0.21]	3.28 [0.37]	2.39 [0.27]	3.72 [0.42]	2.66 [0.30]	4.78 [0.54]	5.4 [0.61]
Resistance (phase)	Ohms	4.0	4.2	1.9	5.7	0.91	2.3	0.41	1.46	0.43
Inductance (phase)	mH	2.4	2.8	1.7	5.0	3.2	7.8	1.9	5.1	3.2
Electrical Time Constant	ms	0.6	0.67	0.89	0.88	3.5	3.4	4.6	3.5	7.4
Continuous Current	A$_{(rms)}$	1.0	1.0	1.6	1.0	2.5	1.6	4.4	2.5	4.3
Optional Brake Data @ 20 °C (backlash = ±0.1°)										
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	0.026 [0.003]	0.026 [0.003]	0.026 [0.003]		0.26 [0.03]		0.26 [0.03]		0.78 [0.09]
Weight Adder	lb [kg]	0.44 [0.2]	0.42 [0.19]	0.44 [0.2]		0.88 [0.4]		0.88 [0.4]		1.54 [0.7]
Voltage	VDC± 10%	24	24	24		24		24		24
Current	A	0.26	0.26	0.26		0.36		0.36		0.43
Engage Time	ms	≤ 25	≤ 25	≤ 25		≤ 50		≤ 50		≤ 60
Release Time	ms	≤ 20	≤ 20	≤ 20		≤ 15		≤ 15		≤ 15
Torque	in-lb [Nm]	2.6 [0.29]	2.6 [0.29]	2.6 [0.29]		10.8 [1.3]		10.8 [1.3]		21.7 [2.5]
Environmental Data										
Humidity (non-condensing)	RH	85%								
Ambient Temperature (operating)	°C	0 to 40								
Storage Temperature	°C	-20 to 80								
Vibration[3]	G	5								
Shock	G	10								

[1] Torque shown is available up to a certain Ambient Temp. See Speed/Torque curve notes.
[2] Radial shaft loads are specified at a position centered along the length of the shaft.
[3] Vibration tests are described in the section "Motor Vibration Testing."

Table 2-4. V-Series Motor Specifications

Specification	Units	Motor Rating @ 20°C			
		SLM100	**SLM250**	**SLM350**	**SLM500**
Output Power	W	1000	2500	3500	5000
Continuous Stall Torque[1]	in-lb [Nm]	28 [3.18]	70 [7.94]	97 [11]	140 [15.8]
Peak Torque	in-lb [Nm]	84 [9.5]	210 [23.8]	294 [33.2]	421 [47.6]
Rated Speed	RPM	3000	3000	3000	3000
Maximum Speed	RPM	5000	5000	5000	4500
Feedback		2500 lines (10,000 counts/rev) Incremental Encoder (5 VDC±5% @ 0.3A; 250 kHz max.)			
Weight	lb [kg]	9.9 [4.5]	16.5 [7.5]	24 [10.9]	38 [17.3]
Rotor Inertia	in-lb-s^2 x 10^{-4} [kg-m^2 x 10^{-4}]	14.91 [1.69]	38.14 [4.31]	69.92 [7.90]	157.5 [17.8]
Shaft Thrust Load	lb [kg]	33 [15]	44 [20]	44 [20]	77 [35]
Shaft Radial Load[2]	lb [kg]	88 [40]	110 [50]	110 [50]	176 [80]
Mechanical Time Constant	ms	0.78	0.52	0.45	0.46
Torque Constant	in-lb/A$_{(rms)}$ [Nm/A$_{(rms)}$]	3.9 [0.44]	4.34 [0.49]	4.51 [0.51]	5.04 [0.57]
Resistance (phase)	Ohms	0.27	0.1	0.05	0.028
Inductance (phase)	mH	1.8	1.1	1	0.56
Electrical Time Constant	ms	6.7	11	20	20
Continuous Current	A$_{(rms)}$	7.2	15.9	21.6	28.5
Optional Brake Data @ 20°C (backlash = ± 0.1°)					
Inertia Adder	in-lb-s^2 x 10^{-4} [kg-m^2 x10^{-4}]	2.25 [0.26]	3.81 [0.43]	6.99 [0.79]	16.82 [1.9]
Weight Adder	lb [kg]	1.32 [0.6]	3.08 [1.4]	3.74 [1.7]	4.18 [1.9]
Voltage	VDC± 10%	24	24	24	24
Current	A	0.74	0.81	0.81	0.90
Engage Time	ms	≤ 50	≤ 50	≤ 80	≤ 110
Release Time	ms	≤ 15	≤ 15	≤ 15	≤ 50
Torque	in-lb [Nm]	43.3 [4.9]	69 [7.8]	104 [11.8]	143 [16.2]
Environmental Data					
Humidity (non-condensing)	RH	85%			
Ambient Temperature (operating)	°C	0 to 40			
Storage Temperature	°C	-20 to 80			
Vibration [3]	G	5			
Shock	G	10			

[1] Torque shown is available up to a certain Ambient Temp. See Speed/Torque curve notes.
[2] Radial shaft loads are specified at a position centered along the length of the shaft.
[3] Vibration tests are described in the next section "Motor Vibration Testing."

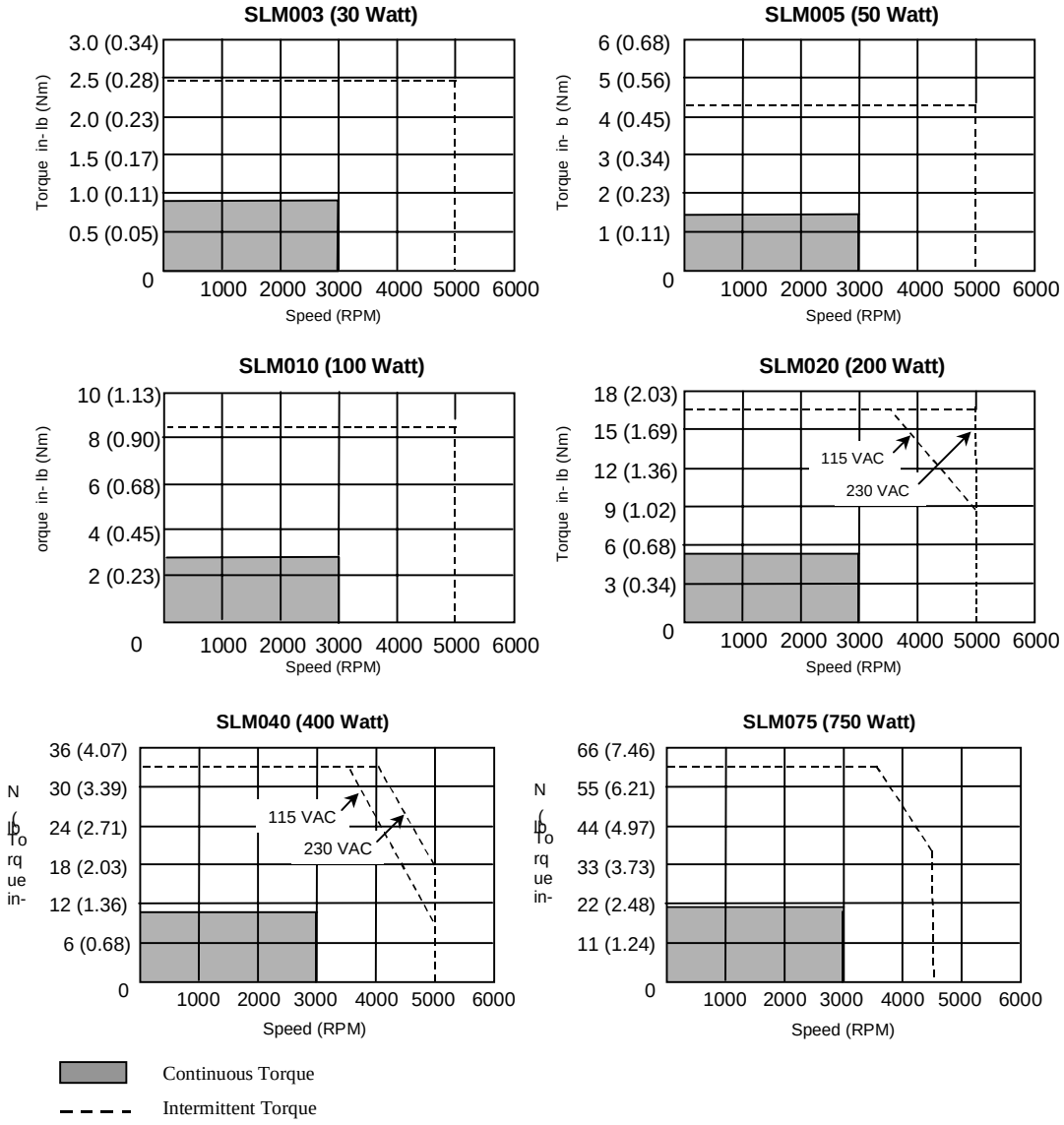
Motor Vibration Testing

There are two vibration tests for the SL series motors:

- **Sweep Test**. The motor is subjected to a 5G variable frequency test for eight hours in each of three axes (X, Y, Z). For the purpose of these tests, X axis is parallel with the motor shaft, Y axis is parallel with the encoder connector, and Z axis is at a 90 degree angle to X and Y. In this test, the vibration frequency increases from 20 to 3000 Hz. over a two minutes span, then decreases from 3000 to 20 Hz over a two minutes span. This pattern is repeated for a period of eight hours.
- **Resonance Point Test**. First, the resonant frequency having the highest vibration is identified while testing the motor with a 5G variable frequency (20 to 3000 Hz.) in three directions (X, Y, Z). Then, the motor is vibrated 10 million times in each direction (X, Y, Z) at the identified resonant frequency.

2.4 Motor Speed/Torque Curves

2.4.1 Z-Series Performance Curves

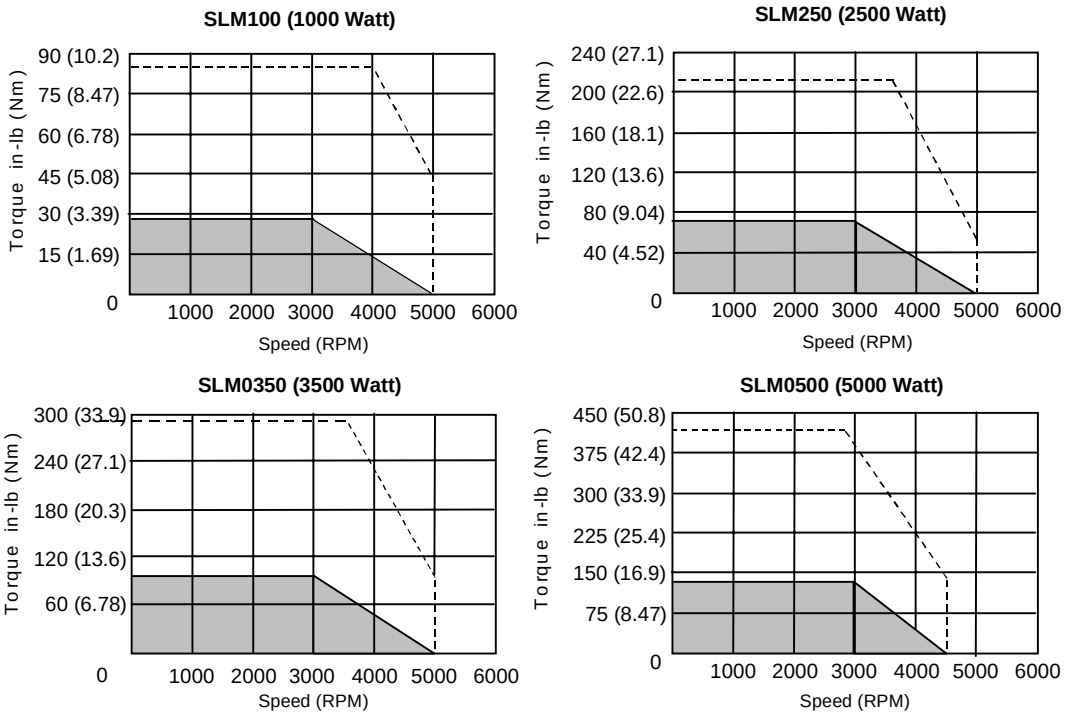


Note: Continuous torque available for each motor model depends on the ambient temperature. These curves depict the maximum continuous torque available for each model up to the following ambient temperatures:

- SLM003, SLM075 = 40 ºC
- SLM005, SLM040 = 20ºC
- SLM010, SLM020 = 30ºC

Higher ambient temperatures require motor derating as shown in the temperature derating curves later in this chapter.

2.4.2 V-Series Performance Curves



Continuous Torque

Intermittent Torque

Note: Continuous torque available for each motor model depends on the ambient temperature. These curves depict the maximum continuous torque available for each model up to the following ambient temperatures:

- SLM100 = 40 °C
- SLM250, SLM500 = 20°C
- SLM350 = 30°C

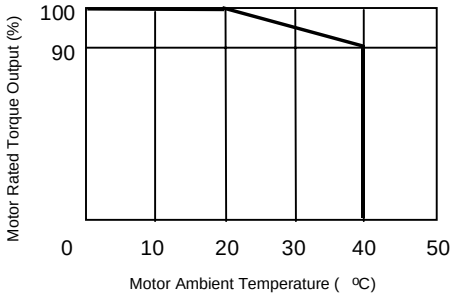
Higher ambient temperatures require motor derating as shown in the temperature derating curves

2.4.3 Derating Based on Ambient Temperature

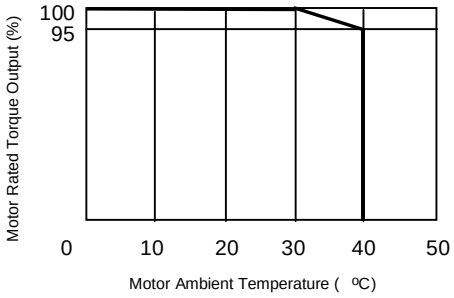
The SL Series motors produce the continuous torque shown in the speed/torque curves (Section 2.4), up to certain ambient temperature limits depending on the motor model. The following curves depict the continuous torque derating required for operation in higher ambient temperatures. The intermittent torque available does not need to be derated.

Motor Derating Based on Ambient Temperature

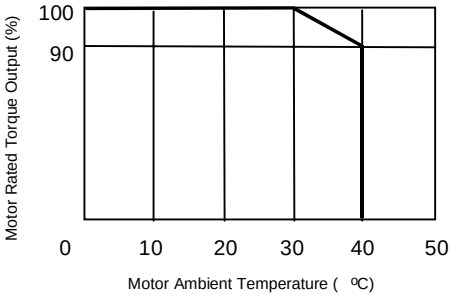
SLM005 / SLM040



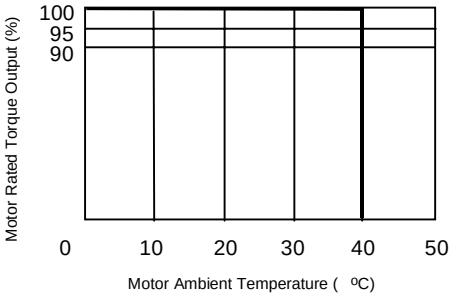
SLM010



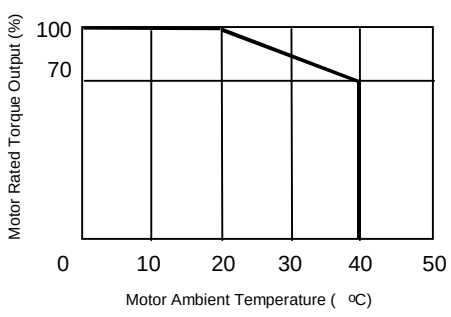
SLM020



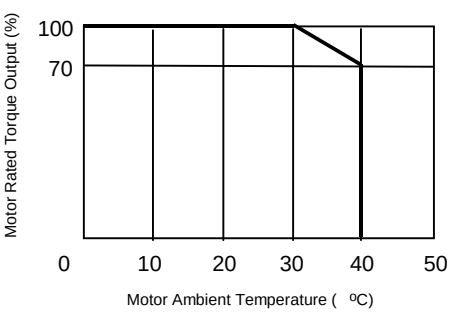
SLM003 / SLM075 / SLM100



SLM250 / SLM500



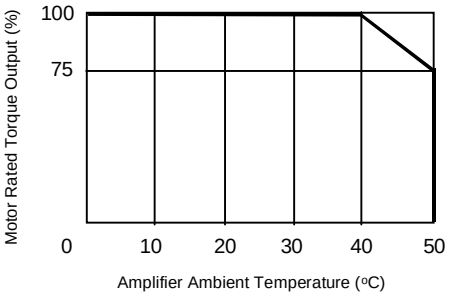
SLM350



Amplifier Derating for 230 VAC Single Phase Operation

Although the 230 VAC amplifiers can be operated with a single-phase input, they must be derated at ambient temperatures above 40°C, as shown in the following graph. This derating is concurrent with any derating of the motor output due to the motor ambient temperature, so the worst-case derating should be used. For example, lets examine the application of a 3500 Watt motor and amplifier where the amplifier is run on single phase in a 50°C ambient and the motor is run in a

40°C ambient. Comparing the graph for the SLM350 motor to the graph below, we see that the motor derating required for 40°C operation (30%) is higher than the motor derating required for 50°C single-phase amplifier operation (25%). So the 30% derating figure is used, which protects both motor and amplifier from thermal overload.



2.5 Motor Sealing

The SL series motors are designed to comply with an IP65 protection rating excluding the cable connector and shaft. The V-Series motors include a shaft oil seal as a standard feature while the Z-Series motors do not include a shaft seal. Adequate precautions should be taken when mounting the motors to ensure proper protection against excessive exposure to fluids and spray.

2.6 Motor Holding Brakes

As an option the SL Series motors are available with an integral parking brake. The brakes are designed for failsafe operation and must be energized to release the brake.

Note

The brake should only be used to hold motor position once the axis is stopped. Using the brake to stop a moving load may result in damage or premature failure of the brake mechanism. Use the dynamic brake function (see Section 2.8) or an external mechanical brake to stop moving loads during an emergency stop or loss of power.

The brakes require a finite time to engage and release the load as shown in the brake specifications in Tables 2-3 and 2-4. These times must be considered in the brake sequencing logic when employing brake motors on vertical axes to prevent the load from falling. The servo amplifier must remain enabled until the brake is fully engaged or the load will not be adequately restrained.

The SL amplifiers include a brake control output (BRK-OFF) that may be used to indirectly control brake activation. This output must be connected to an interposing relay (coil rated for 12-24 VDC; 50mA maximum) in the brake power supply. For Z-Series amplifiers the BRK-OFF output shares a terminal on the CN I/F interface connector with the servo ready (S-RDY) and zero speed detected (ZSP) functions. These functions are mutually exclusive and are selected by Parameter 3F. Parameter Nos. 0E and 0F determine the timing of the BRK-OFF output under various operating conditions. See Chapters 5 and 6 for more details on these parameters**. See Chapter 4, Section 4.1.2 for brake wiring details and diagrams.**

The brake power supply is the user's responsibility and must comply with the brake specifications shown in Tables 2-3 and 2-4. GE Fanuc offers a 24VDC, 5 amp DIN-rail mounted power supply (IC690PWR024) that may be appropriate as a brake supply on multi-axis systems. A panel mounting conversion kit is also available (IC690PAC001). Brake power cables are available from GE Fanuc in several pre-finished lengths as shown in Table 4-4.

2.7 NEMA Motor Mounting

The SL Series servo motors with ratings up to 1000 Watt are designed with standard NEMA shaft and flange sizes as shown in Table 2-5 to facilitate mounting to readily available gear reducers and actuators. Motor models larger than 1kW have metric mounting configurations. For dimensional information on these motors (including mounting dimensions), please see the mechanical drawings in Chapter 3.

Table 2-5. NEMA Mounting Sizes for SL Motors (30 to 1000 W only)

NEMA Size	Motor Model						
	SLM003	SLM005	SLM010	SLM020	SLM040	SLM075*	SLM100
NEMA 23	X	X	X				
NEMA 34				X	X	X	
NEMA 42							X

* The SLM075 (750 Watt) model has an oversized shaft diameter for the NEMA 34 frame size. This is required because the torque rating of this motor exceeds the capacity of the standard NEMA 34 shaft size. This condition is typical of high performance brushless servo motors that produce high peak torque relative to their frame size. For details about motor installation and dimensions, see Section 3-3.

2.8 Dynamic Brake Function

SL Series servos have a built-in dynamic brake for emergency stops. The dynamic brake uses the stored kinetic energy in the motor to generate braking torque. Since the braking torque is proportional to motor speed, the motor decelerates along an exponential velocity profile to a stop. The dynamic brake is activated in the following cases:

- When you turn off the main AC line power.
- When you disable the amplifier by removing the SRV-ON signal (see Section 5.7.2) the dynamic braking action is determined by the setting of Parameter No.0A (V-Series) or Parameter No.3E (Z-Series) as described in Section 6.3.
- When a protective (alarm) function is activated you can select the dynamic brake action using Parameter No.0A (V-Series) or Parameter No. 3D (Z-Series) as described in Section 6.3.
- If the CW overtravel limit switch (connected to the CWL input on connector CN I/F) is opened while the motor is running in the CW direction (viewed from the motor shaft). You can select whether or not to activate the dynamic brake using Parameter No. 0A as described in Section 6.3 (both V-Series and Z-Series).
- If the CCW overtravel limit switch (connected to the CCWL input on connector CN I/F) is opened while the motor is running in the CCW direction (viewed from the motor shaft). You can select whether or not to activate the dynamic brake using Parameter No. 0A as described in Section 6.3 (both V-Series and Z-Series).

Note

The dynamic brake is designed for emergency stops and should not be activated repeatedly over a short time period or the amplifier may be damaged.

The dynamic brake is effective in reducing the stopping distance of the motor when compared to allowing the motor to coast to a stop, but it is not as effective as a mechanical brake for holding axis position. Applications using vertical axes or other axes that require the load to be locked into position for long periods or while amplifier power is removed should use a motor with the optional holding brake.

2.9 Configuration and Monitoring

The SL Series amplifiers offer a wide variety of configuration options, tuning and monitoring functions. These functions are accessed using either the front panel keypad/display or the *SLconfig* PC based software. For initial configuration, the *SLconfig* software is more efficient and provides the ability to save the settings to a file for repeat applications or archiving. The keypad is convenient for quick adjustments during start-up or troubleshooting. The SL amplifier keypad is a tactile membrane type with five push buttons to navigate through the function menus.

The amplifiers also include a six-digit LED display that is used to display the menu functions, parameter data values, and a broad range of system status information. The user can configure motor speed, torque or position error as the default display on power-up (see Parameter No.01). When a fault occurs, the display will flash and the most recent eight errors can be displayed and the keypad can be used to clear the current alarm. Chapter 9 describes the protective functions of the SL Series and Chapter 8 provides details on how to use the keypad and *SLconfig* functions.

The SL amplifiers also include two test points on the front panel for monitoring motor speed feedback, position error (SP) or commanded torque (IM). These test points are bi-polar analog signals with user defined scaling (Parameter No.08) and are also available as outputs on the CN I/F interface connector for hardwired continuous monitoring by the machine controller or panel meter.

Other I/O available to monitor system status include a servo ready output (S-RDY), zero speed detection output (ZSP), alarm output (ALM), At-Speed/In-Position output (COIN) and, on the V-Series amplifiers only, an In-Torque-Limit output (TLC) and 3-bit error code output (EXOUT0,1,2).

2.10 Control Modes

The SL Series amplifiers can be configured for the following operating modes:

1. **Position Control Mode** – Accepts a variety of pulse command inputs to control the position of the motor. The user can configure the amplifier for CW/CCW pulse commands, Pulse/Direction commands or A/B Phase (encoder follower) pulse commands. This mode provides a convenient way to upgrade stepper systems to improve performance or for simple master/slave applications using a fixed (user defined) follower ratio. In this mode, the user can configure a position error limit that will trip the drive when exceeded and independent analog inputs (CWTL and CCWTL) are available to dynamically limit torque in the CW and CCW directions. The position error limit is user definable and can be disabled. A discrete input is available (CL) to allow the machine control system to clear the position error counter. Adjustments for the Position Control Mode include:
    - Position Loop Gain (Parameter No.20)
    - In-Position Detection Range (Parameter No.22)
    - Position Error Limit (Parameter No.23)
    - Position Error Limit Inhibit (Parameter No.24)
    - Pulse Command Ratio (Parameter Nos.25 and 26)

- Quadrature Pulse Input Multiplier (Parameter No.27)
- Pulse Command Input Polarity (Parameter No.28)
- Pulse Command Input Mode (Parameter No.29)
- Second Position Loop Gain (Parameter No.32; Z-Series only)
- Second Numerator of Pulse Command Ratio (Parameter No.35; Z-Series only)
- Pulse Command Filter Delay (Parameter No.36; Z-Series only)
- Position Error Counter Clear Mode (Parameter No.3C; Z-Series only)

2. **Torque Control Mode** – Accepts an analog torque command for motion controllers that require a torque command interface. This mode can also be used for direct control of torque or web tension. The SL amplifiers include an additional analog input (SPL) that can be used to dynamically vary the speed limit for torque mode control. Alternatively, the internal speed presets described above can be used for one or more fixed speed limits. Adjustments for Torque Control Mode include:
   - Torque Command Scaling (Parameter No.1A)
   - Torque Command Polarity (Parameter No.1B)
   - Torque Command Offset (Parameter No.1C)
   - Torque Command Filter (Parameter No.1D)

3. **Velocity Control Mode (default)** – This mode can be configured to accept either an analog velocity command or multiple internal preset speed commands selected using discrete inputs. The Z-Series amplifier supports up to four internal speed settings while the V-Series amplifiers support two speed presets. The Z-Series also has a mode where the user can switch between the analog command and up to three preset speeds using discrete inputs. When used with an external position controller, such as the GE Fanuc APM300 or DSM300 Series, the SL amplifier provides incremental encoder feedback to close the position loop. Independent analog inputs (CWTL and CCWTL) are available to dynamically limit torque in the CW and CCW directions. For speed control applications, the ZEROSPD clamp input can be used to prevent servo drift when the motor is stopped for long periods of time. Adjustments for Velocity Control Mode include:
   - Velocity Loop Gain (Parameter No.03)
   - Velocity Loop Integration Time Constant (Parameter No.04)
   - Velocity Feedback Filter (Parameter No.05)
   - Velocity Command Scaling (Parameter No.13)
   - Velocity Command Polarity (Parameter No.14)
   - Velocity Command Offset (Parameter No.15)
   - Internal/External Velocity Command Selection (Parameter No.16)
   - First Internal Speed (Parameter No.18)
   - Second Internal Speed (Parameter No.19)
   - Velocity Feed Forward (Parameter No.21)
   - Velocity Feed Forward Filter Time Constant (Parameter No.2B)
   - Second Velocity Loop Gain (Parameter No.30; Z-Series only)
   - Second Velocity Loop Integration Time Constant (Parameter No.31; Z-Series only)
   - Third Internal Speed (Parameter No.38; Z-Series only)
   - Fourth Internal Speed (Parameter No.39; Z-Series only)

The SL amplifiers can also be configured for dual control mode operation (Parameter No.02) where any two of these control modes can be selected using the C-MODE discrete input. Chapter 6 provides detailed descriptions of the parameters used to configure these modes.

2.11 Gain Switching

The Z-Series amplifiers allow the user to configure two different gain setting for the Position and Velocity Control Modes. The gains are configured by various parameter settings and Parameter No.33 determines the event that initiates the gain switch. The gain switch can be disabled, automatic (Position Control Mode only) or initiated by activating the GAIN input. For the automatic gain switching mode, Parameter No.34 configures a delay time used to initiate the second gain values. This time delay is referenced to the falling edge of the final pulse of the move command. For more information on gain switching, refer to the descriptions for the following parameters in Chapter 6:

- 2nd Velocity Loop Gain (Parameter No.30)
- 2nd Velocity Loop Integration Time Constant (Parameter No.31)
- 2nd Position Loop Gain (Parameter No.32)
- Second Gain Switching Mode (Parameter No.33)
- Automatic Gain Switching Delay Time (Parameter No.34)

2.12 Agency Compliance

The table below lists the compliance status of each SL series product for the following standards:

- **UL:** Refers to United States UL listing, UL508C (File Number E164620).
- **C-UL:** Refers to Canadian UL listing.
- **CE:** Refers to European Community's Low Voltage and EMC Directives (see Appendix B for application details to ensure compliance).

Table 2-6. SL Series Products Agency Compliance

Product	UL	C-UL	CE
SLA003x* Amplifier	Yes	Yes	Yes
SLA005x* Amplifier	Yes	Yes	Yes
SLA010x* Amplifier	Yes	Yes	Yes
SLA020x* Amplifier	Yes	Yes	Yes
SLA040x* Amplifier	Yes	Yes	Yes
SLA075x* Amplifier	Yes	Yes	Yes
SLA1002 Amplifier	Yes	Yes	Yes
SLA2502 Amplifier	No	No	Yes
SLA3502 Amplifier	No	No	Yes
SLA5002 Amplifier	No	No	Yes
SLM003 Motor	Yes	No	Yes
SLM005 Motor	Yes	No	Yes
SLM010 Motor	Yes	No	Yes
SLM040 Motor	Yes	Yes	Yes
SLM075 Motor	Yes	Yes	Yes
SLM100 Motor	Yes	Yes	Yes
SLM250 Motor	No	No	Yes
SLM350 Motor	No	No	Yes
SLM500 Motor	No	No	Yes

*Note: For amplifier model numbers shown with an x suffix, such as SLA003x, the x is a placeholder for a number that specifies the amplifier's bus power supply voltage. If the suffix is 1, the voltage is 115VAC; if the suffix is 2, the voltage is 230VAC. For example, SLA0031 specifies an SLA003-size (30-watt) amplifier with a 115VAC bus power supply voltage rating. SLA0032 specifies the same size amplifier, but with a 230VAC bus power supply voltage rating. See Table 2-1 for more details.

Chapter 3

Installation Guidelines

3.1 Amplifier Mounting Guidelines and Environmental Conditions

It is the user's responsibility to install the components in a suitable location. The servo amplifier must be installed in a location that satisfies the following environmental conditions:

1. **Atmosphere:** The circuitry and cooling fans must not be exposed to any corrosive or conductive contaminants.

2. **Ambient temperature:** 0°C to +50°C (operating)
   -20°C to 80°C (storage)

   Install the amplifier into ambient temperature conditions within the range of 0° C to +50° C. If the temperature exceeds this range, it may cause malfunction or damage to the amplifier. For 230VAC models using a single phase power supply it is necessary to limit the maximum ambient temperature to 40°C for full rated output.

   The servo amplifier heatsink and motor generate high temperatures. If the amplifier is housed in an enclosed control cabinet this heat load must be considered when evaluating the enclosure cooling requirements (see Section 3.6-*Power Dissipation* for details on amplifier losses). Use heat exchangers or cooling devices to maintain an ambient temperature of 50° C or less.

3. **Humidity:** 90% relative humidity or less (non-condensing)

4. **Vibration:** Less than 0.5 G at 10-150Hz

5. **Shock:** Less than 15 G (non-operating)

6. **Altitude:** No more than 1000m (3300 ft) above sea level for full rating. Contact GE Fanuc Applications Engineering for derating at higher elevations.

7. **Ventilation:** This amplifier is designed for vertical installation to ensure proper cooling. Install the amplifier with sufficient space for ventilation. Avoid mounting wireways and other adjacent components too close to the heatsink, top or bottom of the amplifier.

8. **Location:** Keep the following location guidelines in mind when selecting a site for the amplifier:

   - Do not install in places with high temperature, high humidity, dust, dirt, conductive powder or particulate, combustible gasses, or metal chips.

- Avoid places exposed to direct sunlight.
- Mount only to noncombustible materials such as metal.
- Do not stand/step on or put heavy articles on the amplifier or motor.
- The amplifier housing is rated IP20 and is not a waterproof enclosure. Do not use outdoors or in any unprotected environment.
- Avoid locations where there is exposure to radiation such as microwave, ultraviolet, laser light or X-rays.
- Do not block the inlet/exhaust ports, and prevent foreign objects from getting into the ports.
- Do not apply excessive stress, put heavy articles on, or pinch the cables.
- Do not install the amplifier near heating elements such as cabinet heaters or large wire wound resistors. When such installation is unavoidable, provide a thermal shield between the servo amplifier and the heating elements.
- Mount amplifiers and other heat producing components higher in the enclosure to avoid overheating other sensitive electronics installed in the same cabinet.
- The V-Series amplifier has mounting tabs that allows mounting either flush to a panel or through a cutout in the panel. When mounting through a panel, make sure the panel is of sufficient gauge to support the weight of the amplifier.

3.2 Installing the Amplifier

The SL Series Amplifiers are designed for panel mounting in electrical enclosures designed for industrial applications. Enclosure cooling or ventilation must be adequate to maintain the ambient temperature to within the component's specifications. Mount amplifiers vertically for proper cooling.

1. Firmly install the amplifier with screws and bolts without applying stress such as bending and twisting to the amplifier main unit.
2. Use M4 (#8) or M5 (#12) mounting screws or bolts.
3. Allow reasonable mounting clearance between adjacent units to ensure proper ventilation.

Cautions and Warnings for Installation and Operation

Since a misuse of the amplifier may lead to improper operation, or may damage the amplifier, carefully read the following cautions and warnings:

- Be sure to ground the amplifier properly using the ground terminals on the front of the amplifier. Proper grounding includes conforming to applicable national and local electrical codes. Refer to Chapter 4 for instructions.
- Do not apply higher than rated voltage to the power input terminals (R, S, and T).
- Do not apply the main input power to terminals other than terminals R, S, and T or damage will occur. Refer to Section 5-1-1 for wiring information.

- The power supply uses a capacitor filter. When you turn on power, a high charging current flows and you may see a large voltage drop. We recommend that you use an independent power supply for the amplifier(s) or install line reactors to limit the charging current.
- Do not perform a dielectric strength test or megger test on the amplifier or damage may occur. (When you perform a dielectric strength test or megger test to an external circuit, please disconnect all terminals to the amplifier so that no test voltage is applied to the amplifier.)
- Do not operate the amplifier under overload conditions (such as continuous overcurrent operation).
- When power is turned off, allow about 11 seconds before re-applying power. If this interval is too short, the system may not start up normally because its internal circuit is not properly initialized.
- If you use a ground fault breaker, use one rated for "Inverter," to withstand high frequency leakage current.
- Use the motor and amplifiers only in the designated combinations (Table 1-1 and Table 1-2).
- When transporting, use caution to prevent damage to the servo components. Do not grasp the cables when carrying.
- Do not apply excessive force to the amplifier front panel and side plates.

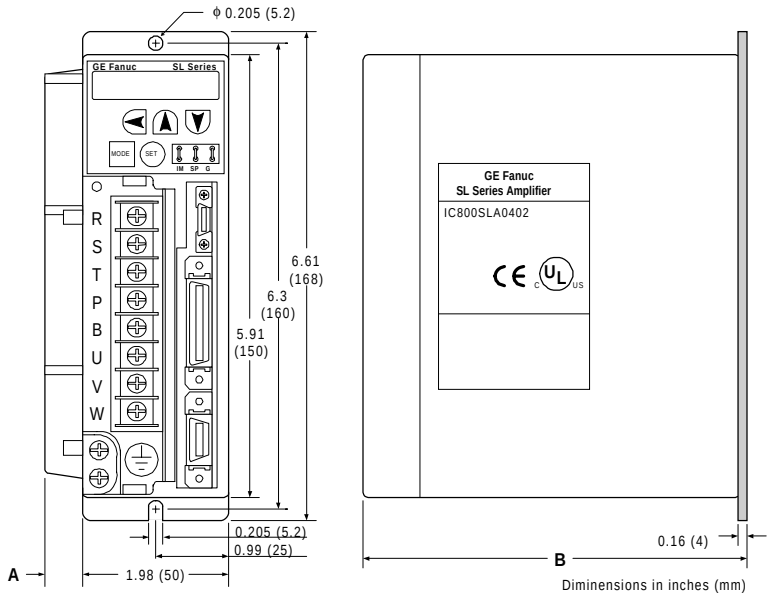
3.3 Installing the Motor

The SL Series servo motors are designed for either vertical or horizontal mounting and have a protection rating of IP65 (not including the connectors and shaft). The motors should be mounted in a location where the environmental conditions are within the specifications stated in Table 2-3 and Table 2-4. Use the following guidelines when mounting the motors:

- Observe the shaft radial and thrust load limits shown in Table 2-3 and Table 2-4. Loads exceeding these limits will cause premature failure of the motor. Excessive belt tension could cause bearing or shaft failure.
- Be sure to ground the motor using the ground wire in the motor power cable.
- Ensure that the motor cables are free from excessive stress, stretching, pinching or bending.
- To avoid damage, do not carry a motor by holding the cables or shaft.
- Do not apply excessive axial force or impact loads when installing the motor coupling or shaft pulley or the encoder may be damaged. See axial load limit ratings in tables 2-3 and 2-4.
- Install the motor in a location free from corrosive contaminants, dust, excessive water spray, or combustible gas.
- The shaft of the motor is treated with grease (Shell Oil Alvania No. 2) for corrosion protection during storage. Consider the effect of the grease on any plastic parts that are mated with the shaft.
- The optional motor brake should be used for holding stationary loads only. Do not use this brake to stop a moving load or reduced life or damage to the brake may occur. Apply this brake only after the motor is stopped. Use the dynamic braking feature of the amplifier to stop moving loads more quickly when power is removed from the amplifier (see Section 2.6).

3.4 Mounting Dimensions

3.4.1 Z-Series Amplifier Dimensions



Model	120V Versions		230V Versions	
	A	B	A	B
30-100 Watt	0	5.12 (130)	0	5.12 (130)
200 Watt	0.59 (15)	5.12 (130)	0	5.12 (130)
400 Watt	0.59 (15)	6.69 (170)	0.59 (15)	5.12 (130)
750 Watt	N/A	N/A	0.59 (15)	6.69 (170)

Figure 3-1. Z-Series Amplifier Dimensions

3.4.2 V-Series Amplifier Dimensions

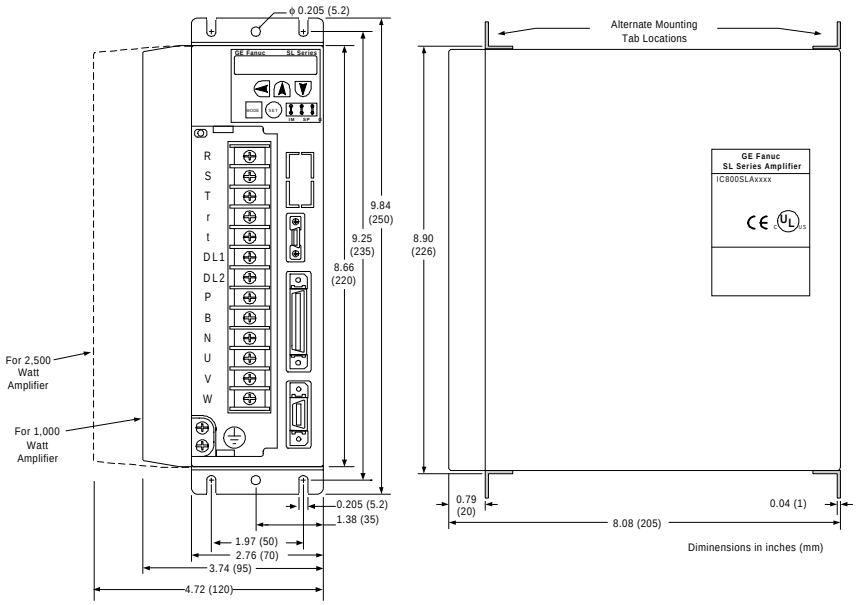


Figure 3-2. V-Series Amplifier Dimensions for 1,000 and 2,500 Watt Sizes

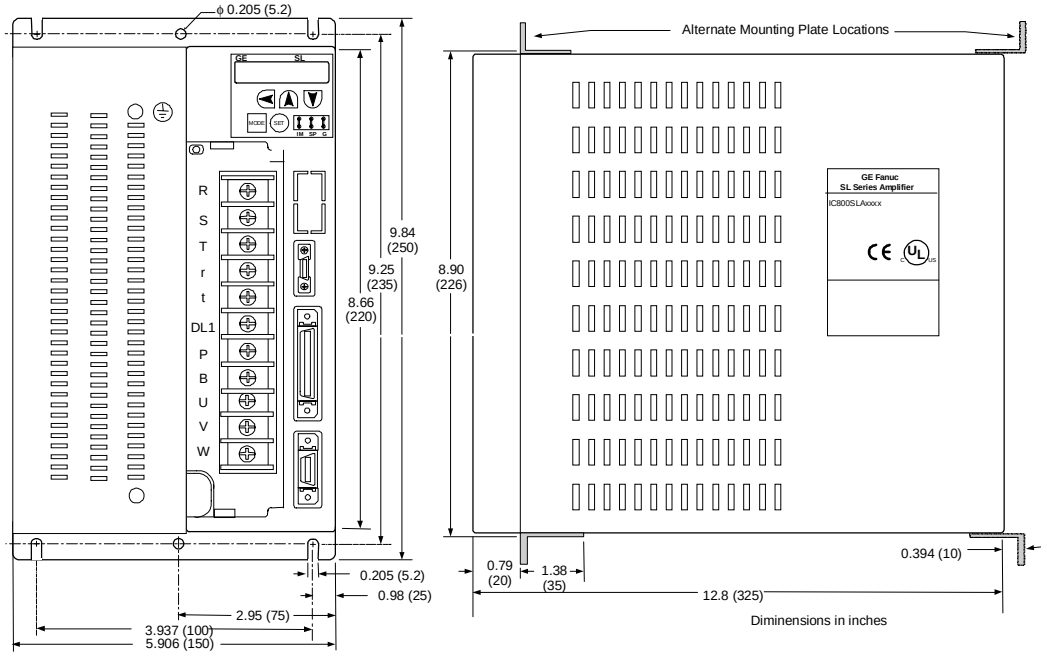
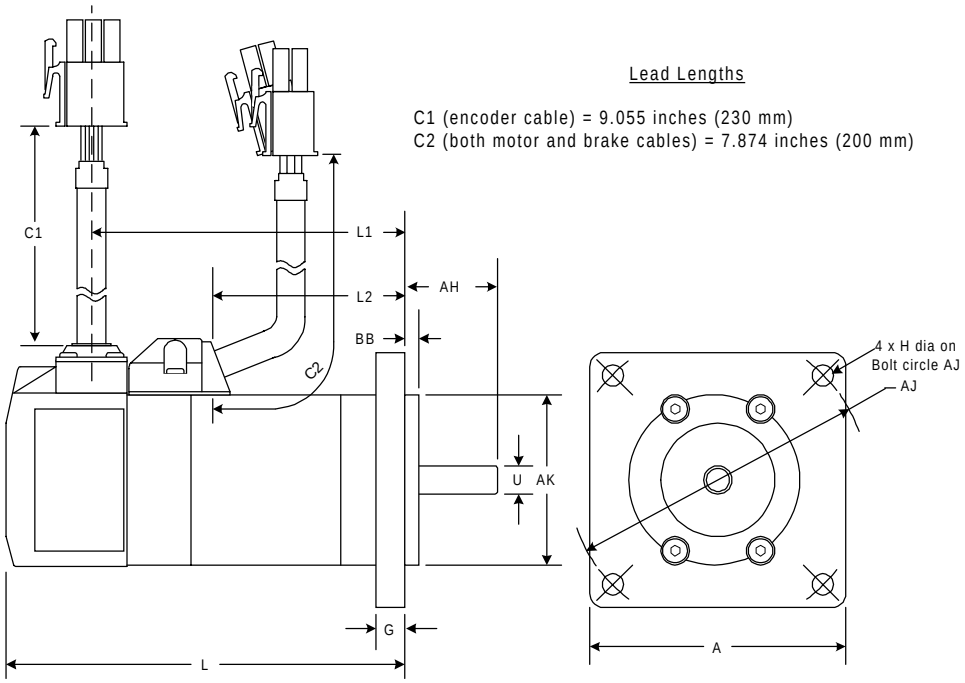


Figure 3-3. V-Series Amplifier Dimensions for 3,000 and 5,000 Watt Sizes

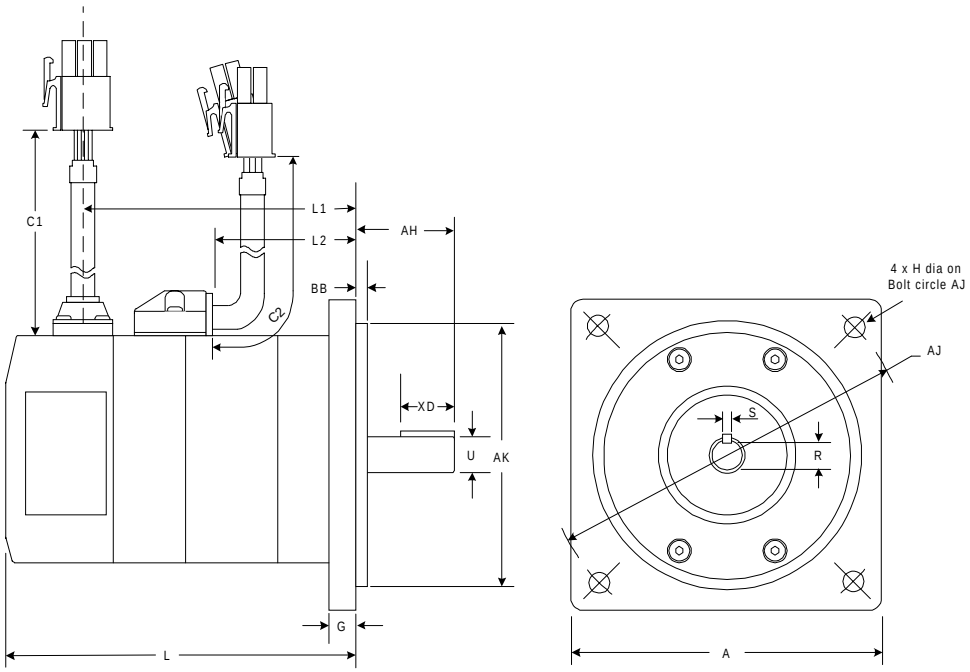
3.5 Motor Mounting Dimensions



Model	Units	A	AH	AJ	AK	BB	G
SLM003 (30 Watts)	inches	2.27 ± 0.024	0.7874 ± 0.028	2.625 ± 0.024	$1.502^{+0}_{-0.001}$	0.118 ± 0.008	0.236 ± 0.012
	mm	57.658 ± 0.6	20 ± 0.7	66.675 ± 0.6	$38.1508^{+0}_{-0.025}$	3 ± 0.2	6 ± 0.3
SLM005 (50 Watts)	inches	2.27 ± 0.024	0.7874 ± 0.028	2.625 ± 0.024	$1.502^{+0}_{-0.001}$	0.118 ± 0.008	0.236 ± 0.012
	mm	57.658 ± 0.6	20 ± 0.7	66.675 ± 0.6	$38.1508^{+0}_{-0.025}$	3 ± 0.2	6 ± 0.3
SLM010 (100 Watts)	inches	2.27 ± 0.024	0.7874 ± 0.028	2.625 ± 0.024	$1.502^{+0}_{-0.001}$	0.118 ± 0.008	0.236 ± 0.012
	mm	57.658 ± 0.6	20 ± 0.7	66.675 ± 0.6	$38.1508^{+0}_{-0.025}$	3 ± 0.2	6 ± 0.3

Model	Units	H	U	L	L (With Brake)	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM003 (30 Watts)	inches	0.1968 ± 0.010	$0.25^{+0}_{-0.0004}$	2.559	3.819	1.772	3.031	0.709
	mm	5 ± 0.25	$6.35^{+0}_{-0.009}$	65	97	45	77	18
SLM005 (50 Watts)	inches	0.1968 ± 0.010	$0.25^{+0}_{-0.0004}$	2.874	4.134	2.087	3.346	1.024
	mm	5 ± 0.25	$6.35^{+0}_{-0.009}$	73	105	53	85	26
SLM010 (100 Watts)	inches	0.1968 ± 0.010	$0.25^{+0}_{-0.0004}$	4.055	5.315	3.268	4.528	2.205
	mm	5 ± 0.25	$6.35^{+0}_{-0.009}$	103	135	83	115	56

Figure 3-4. Dimensions for 30-100 Watt SL Series Motors

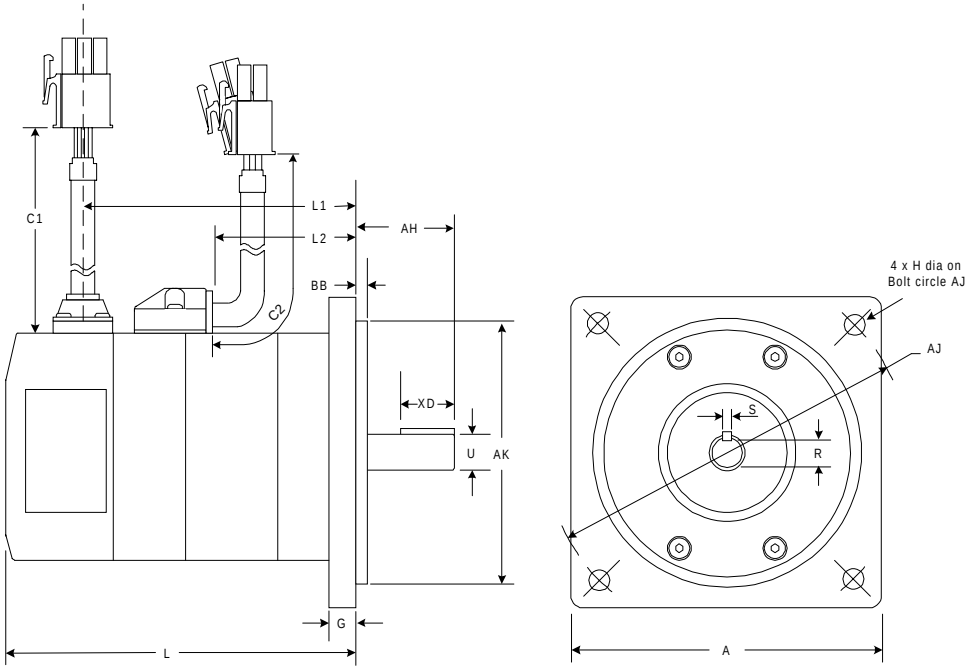


Model	Units	A	AH	AJ	AK	BB	G	H
SLM020 (200 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM020 (200 Watt)	inch	8.662	7.874	2.854	4.154	1.535
	mm	220	200	72.5	105.5	39

Model	Units	U	L	L (With Brake)	R	S	XD
SLM020 (200 Watt)	inch	$0.375^{+0}_{-0.0004}$	3.701	5.000	$0.3018^{+0}_{-0.015}$	$0.125^{+0}_{-0.002}$	$0.75^{+0}_{-0.016}$
	mm	$9.5250^{+0}_{-0.009}$	94	127	$7.666^{+0}_{-0.381}$	$3.175^{+0}_{-0.051}$	$19.050^{+0}_{-0.4}$

Figure 3-5. Dimensions for 200 Watt SL Series Motor

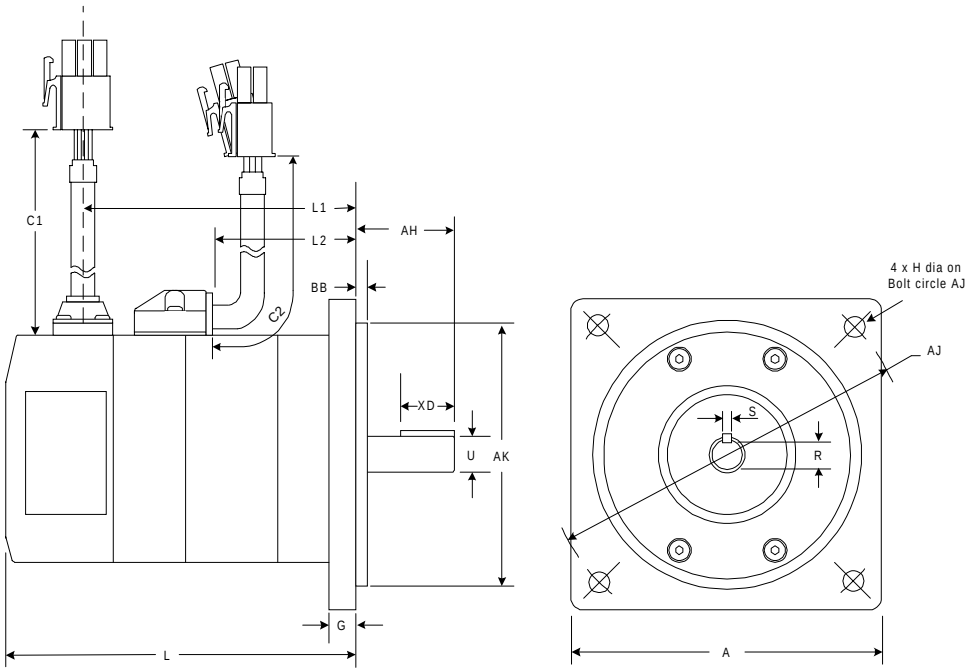


Model	Units	A	AH	AJ	AK	BB	G	H
SLM040 (400 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM040 (400 Watt)	inch	8.662	7.874	4.016	5.315	2.697
	mm	220	200	102	135	68.5

Model	Units	U	L (Without Brake)	L (With Brake)	R	S	XD
SLM040 (400 Watt)	inch	$0.375^{+0}_{-0.0004}$	4.862	6.161	$0.3018^{+0}_{-0.015}$	$0.125^{+0}_{-0.002}$	$0.75^{+0}_{-0.016}$
	mm	$9.5250^{+0}_{-0.009}$	123.5	156.5	$7.666^{+0}_{-0.381}$	$3.175^{+0}_{-0.051}$	$19.050^{+0}_{-0.4}$

Figure 3-6. Dimensions for 400 Watt SL Series Motor

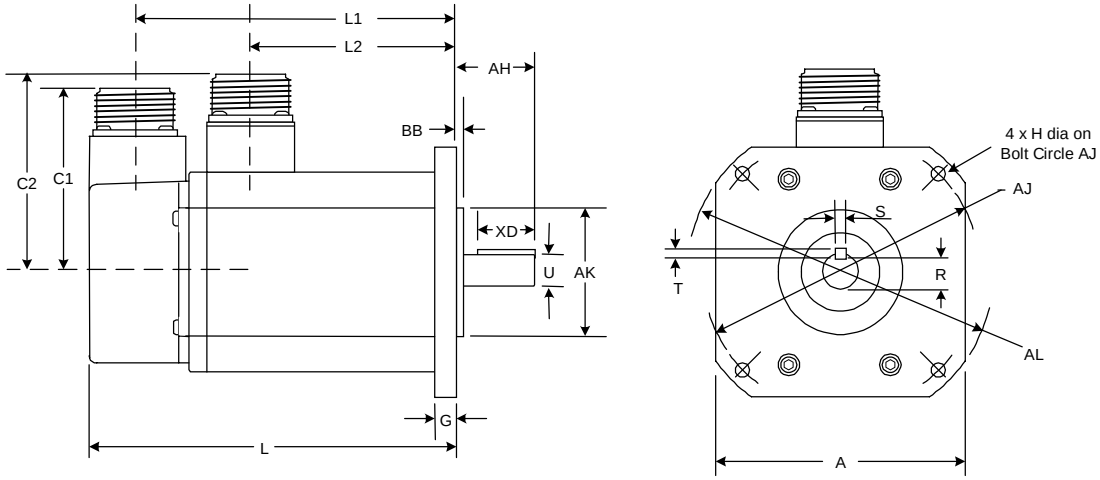


Model	Units	A	AH	AJ	AK	BB	G	H
SLM075 (750 Watt)	inch	3.42 ± 0.024	1.181 ± 0.028	3.875 ± 0.024	$2.877^{+0}_{-0.0012}$	0.118 ± 0.008	0.315 ± 0.012	0.2165 ± 0.010
	mm	86.868 ± 0.6	30 ± 0.7	98.425 ± 0.6	$73.0758^{+0}_{-0.030}$	3 ± 0.2	8 ± 0.3	5.5 ± 0.25

Model	Units	C1	C2	L1	L1 (With Brake)	L2 (With or Without Brake)
SLM075 (750 Watt)	inch	8.662	7.874	4.764	6.142	3.346
	mm	220	200	121	156	85

Model	Units	U	L (Without Brake)	L (With Brake)	R	S	XD
SLM075 (750 Watt)	inch	$0.625^{+0}_{-0.0004}$	5.610	6.988	$0.5165^{+0}_{-0.015}$	$0.1885^{+0}_{-0.002}$	$0.952^{+0}_{-0.016}$
	mm	$15.875^{+0}_{-0.011}$	142.5	177.5	$13.120^{+0}_{-0.383}$	$4.788^{+0}_{-0.051}$	$24.200^{+0}_{-0.4}$

Figure 3-7. Dimensions for 750 Watt SL Series Motor



Note: Shaft end play (axial) = 0.0118” (0.3 mm) or less

Model	Units	A	AH	AJ	AK	AL	BB	G
SLM100	inch	4.38	1.378	4.95	$2.188^{+0}_{-0.004}$	5.512	0.118	0.394
	mm	111.25	35	125.73	$55.575^{+0}_{-0.1}$	140	3	10
SLM250	mm	100	55	115	$95^{+0}_{-0.035}$	135	3	10
SLM350	mm	120	55	130/145*	$110^{+0}_{-0.035}$	162	3	12
SLM500	mm	130	65	145	$110^{+0}_{-0.035}$	165	6	12

Model	Units	C1	C2	L1	L1 (W/Brake)	L2	L2 (W/Brake)
SLM100	inch	3.31	3.62	6.012	7.087	3.858	4.843
	mm	84	92	155	180	98	123
SLM250	mm	84	97	207	232	153	178
SLM350	mm	84	111	214	239	160	185
SLM500	mm	84	119	257	282	202	227

Model	Units	H	U	L	L (W/Brake)	R	S	T	XD
SLM100	inch	0.2600	$0.625^{+0}_{-0.0005}$	6.890	7.874	$0.5165^{+0}_{-0.015}$	$0.1885^{+0}_{-0.002}$	0.1885	1.000
	mm	6.6	$15.875^{+0}_{-0.013}$	175	200	$13.120^{+0}_{-0.383}$	$4.788^{+0}_{-0.051}$	4.788	25.4
SLM250	mm	9	$19^{+0}_{-0.013}$	227	252	15.5	$6^{+0}_{-0.036}$	6	42
SLM350	mm	9	$22^{+0}_{-0.013}$	234	259	18	$8^{+0}_{-0.036}$	7	41
SLM500	mm	9	$24^{+0}_{-0.013}$	277	302	20	$8^{+0}_{-0.036}$	7	51

*Mounting holes on SLM350 are slotted to accommodate bolt circles (dimension AJ) from 130 through 145 mm.

Figure 3-8. Dimensions for 1000 Watt to 5000 W SL Series Motors

3.6 Power Dissipation

Each SL Series Amplifier dissipates power that results in some enclosure heating. The table below shows the approximate power dissipation for each amplifier operating at rated outputs for use in determining enclosure size and cooling requirements. Values in the table do not include dissipation from an optional regeneration resistor.

Table 3-1. Power Dissipation

Amplifier Model Number	Description	Power Loss of Amplifier (W)
IC800SLA0031	30 Watt, 115 VAC	14.5
IC800SLA0051	50 Watt, 115 VAC	17.0
IC800SLA0101	100 Watt, 115 VAC	21.4
IC800SLA0201	200 Watt, 115 VAC	29.8
IC800SLA0401	400 Watt, 115 VAC	42.1
IC800SLA0032	30 Watt, 230 VAC	19.0
IC800SLA0052	50 Watt, 230 VAC	19.5
IC800SLA0102	100 Watt, 230 VAC	20.7
IC800SLA0202	200 Watt, 230 VAC	25
IC800SLA0402	400 Watt, 230 VAC	27
IC800SLA0752	750 Watt, 230 VAC	44
IC800SLA1002	1000 Watt, 230 VAC	77
IC800SLA2502	2500 Watt, 230 VAC	170
IC800SLA3502	3500 Watt, 230 VAC	280
IC800SLA5002	5000 Watt, 230 VAC	280

Chapter 4 Wiring

This chapter provides wiring guidelines for the SL amplifier power terminals, I/O and command interface connector (CN I/F), encoder connector (CN SIG), and serial connector (CN SER). It also describes installing the optional regeneration resistor and selecting AC incoming power wiring.

4.1 Wiring to the Amplifier Power Terminals

Use the following guidelines when connecting wires to the amplifier power terminals. Refer to Figure 4-1 for example wiring diagrams.

1. The cover of the power terminal block is secured with a screw. When wiring to the terminal block, remove the screw and gently pull open the cover to release the snap detent.
2. Tighten screw terminals to 7 lb-in. (0.79 Nm) maximum. Applying excessive torque to the screws may break the terminals.
3. Use wire that meets the following characteristics:
   - Use 60/75°C or higher rated wire only
   - Use copper conductors only
4. For the main power supply and control power supply, apply voltage as indicated below:

Supply	Model	Line
AC Line	230 VAC	170 to 253 VAC
	115 VAC	85 to 126 VAC
Control Power	230 VAC +10% –15% single phase (V-Series amplifiers only)	

5. The direction of rotation of the AC servo motor cannot be changed by exchanging the 3-phase power wiring as with an induction motor. Be sure to correctly match the amplifier motor output terminals with the motor power terminals. The direction of the motor can be changed using configuration parameters on the SL amplifier (see Parameter No.14 in Chapter 6) or on a GE Fanuc APM300 or DSM300 Series motion controllers.
6. Use insulated spring spade terminals for connecting the lead wires to each terminal. The terminals for amplifier models up to 2500 Watts use an M4 size screw (4 mm or 0.1575 inch diameter) and can accommodate terminal connectors up to 0.25 inches (6.35mm) wide. Amplifiers larger than 2500 Watts use M5 terminal screws (5mm or 0.1969 inch diameter).
7. Firmly connect the terminal for motor ground and terminal for amplifier ground to a low impedance earth connection at a single location. If an optional AC line filter is used, its ground

terminal should also be connected to this same point. Grounding the machine main unit is recommended using Class 3 Grounding [grounding resistance 100Ω or under, and wire diameter of 14 AWG (1.6mm^2) or larger for Z-Series amplifiers and 12 AWG (3.5 mm^2) or larger for V-Series amplifiers. The AWG sizes given are rounded to the sizes closest (on the larger side) to the given Metric sizes.].

8. After completing the wiring to the power terminals, close the terminal block cover and secure the cover with the screw to prevent accidental contact.

9. Install a surge absorber across all contact points of any electromagnetic contactors and relays used in the system to prevent erroneous operation due to noise spikes.

10. An electronic circuit breaker to shut off power to the amplifier in an emergency is recommended. When using a ground fault interrupter, use one rated for inverter duty to prevent high-frequency leakage current flowing to ground through stray capacitance from causing breaker malfunction. Also, the amplifiers draw a high inrush current when power is first applied in order to charge the DC link filter capacitors. Select AC line protection with this in mind.

11. An AC line filter for reducing RF noise and preventing erroneous operation is recommended. GE Fanuc does not provide line filters small enough for a single SL Series servo but does supply a 5.4kW unit (A81L-0001-0083#3C) that may be appropriate for multi-axis applications. Check with your local distributor for assistance.

12. After wiring, and before applying power to the amplifier, check for wiring errors once again.

13. The following table outlines the wiring requirements for the incoming AC power and motor wiring:

Table 4-1. AC Incoming Power Wiring

Applicable Model		Power Consumption	Circuit Breaker (rated current)	Main Circuit & Motor Wire Gauge	Control Power Wire Gauge
Rated Voltage	Rated Output	(At rated power)		(R, S, T, U, V, W, P, B)	(r, t)
115 VAC (1-Phase)	30 -50 W	0.3 kVA	10A	16 AWG (1.25 mm^2)	N/A
	100 W	0.4 kVA	15A	16 AWG (1.25 mm^2)	N/A
	200 W	0.5 kVA	15A	14 AWG (2 mm^2)	N/A
	400 W	1.0 kVA	15A	14 AWG (2 mm^2)	N/A
230 VAC (3-Phase)	30 - 100 W	0.3 kVA	5A	16 AWG (1.25 mm^2)	N/A
	200 W	0.5 kVA	10A	16 AWG (1.25 mm^2)	N/A
	400 W	0.9 kVA	10A	16 AWG (1.25 mm^2)	N/A
	750 W	1.3 kVA	15A	14 AWG (2 mm^2)	N/A
	1000 W	1.8 kVA	15A	12AWG (3.5 mm^2)	16 AWG (1.25 mm^2)
	2500 W	3.8 kVA	30A	12AWG (3.5 mm^2)	16 AWG (1.25 mm^2)
	3500 W	5.3 kVA	50A	12AWG (3.5 mm^2)	16 AWG (1.25 mm^2)
	5000 W	7.5 kVA	50A	12AWG (3.5 mm^2)	16 AWG (1.25 mm^2)

4.1.1 Wiring Cautions

Cautions and Warnings

Observe the following cautions when applying voltage:

- Be careful not to cross connect the wiring for the main power supply input terminals (R, S, T) and the output terminals for motor (U, V, W) or the amplifier may be damaged.
- Do not earth or short-circuit the output terminals for motor (U, V, W) while the system is energized or the amplifier may be damaged.
- On the V-Series amplifier, do not connect any wire to terminals N, DL1, and DL2.
- Terminals P and B are for connecting an optional external regenerative discharge resistor and are connected to high-voltage (see Section 4.1.2). To prevent electric shock, never touch terminals P and B or any of the other power terminals.

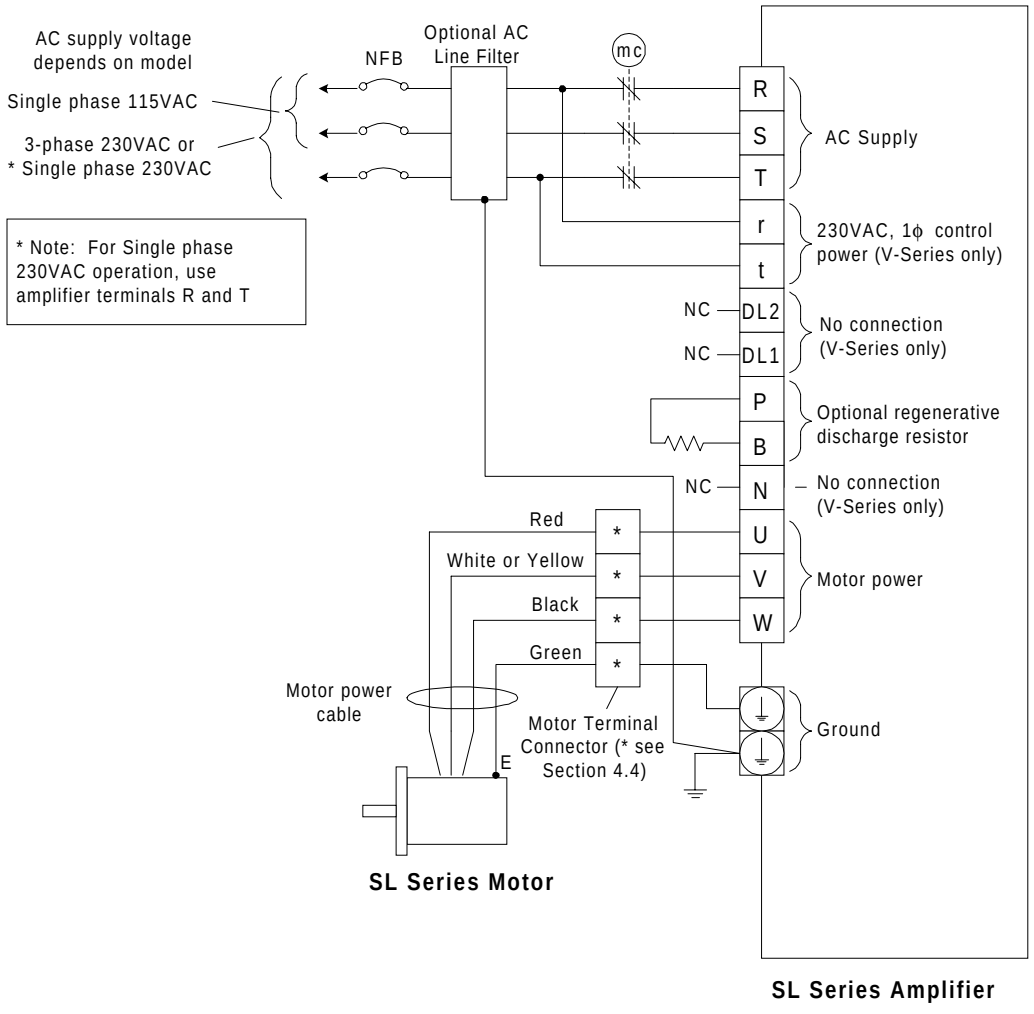
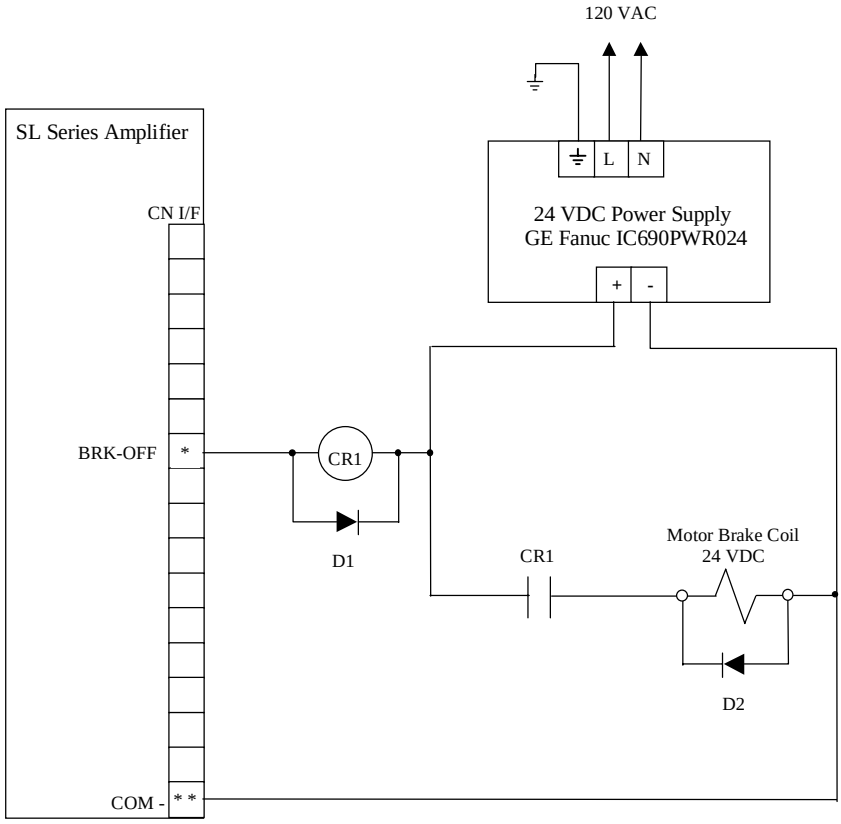


Figure 4-1. Example of Wiring to Power Terminal Block for V-Series and Z-Series Amplifiers

4.1.2 Wiring the Optional Motor Holding Brake

The next figure shows a wiring overview for the optional motor holding brake. The three following figures show motor holding brake wiring using the GE Fanuc terminal boards. Note that for the Z-Series amplifiers, parameter 3F must be set to a value of 1 to select the Brake Off (BRK-OFF) function on pin 27 of connector CN I/F. See Chapters 5 and 6 for information on setting Parameter 3F on the Z-Series amplifiers. On the V-Series amplifiers, pin 27 is dedicated to the BRK-OFF signal only, so no parameter change is necessary to activate this function. Parameter 0E controls timing of the BRK-OFF output on both the V-Series and Z-Series amplifiers, and Parameter 0F provides additional timing options for the Z-Series only; these can be used to configure a delay to compensate for the physical engagement time of the brake. These parameter settings are detailed in Chapters 5 and 6. Chapter 2 contains motor brake specifications, including engagement time values.



* BRK-OFF
Z-Series, pin 27
V-Series, pin 11

* * COM -
Z-Series, pin 28
V-Series, pin 41

CR1 – Control relay, Coil: 24 VDC/50mA or less,
Contact: rated for 1Amp DC continuous and break
D1 – Diode, 1A, 100 VDC, 1N4002 or equivalent
D2 – Diode, 3A, 100 VDC, 1N5401 or equivalent

Note: On the Z-Series, Pin 27 has to be configured for Brake Output using parameter 3F. See Chapters 5 and 6.

Figure 4-2. Wiring Overview for Optional Motor Brake

Z-Series Brake Wiring Using the IC800SLT001 Terminal Board

The IC800SLT001 terminal board is specifically designed to interface the SL-Series amplifiers to the GE Fanuc Series 90-30 APM or DSM motion control modules.

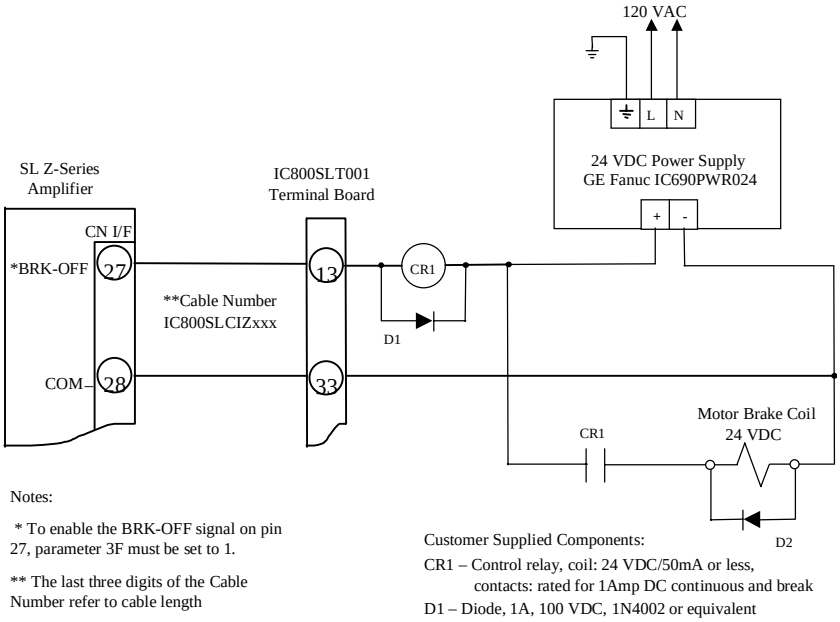


Figure 4-3. Z-Series Motor Brake Circuit for APM or DSM Applications

Z-Series Brake Wiring Using the IC800SLT004 Terminal Board

The IC800SLT004 is a general-purpose breakout terminal board used to interface to a wide variety of third-party controllers.

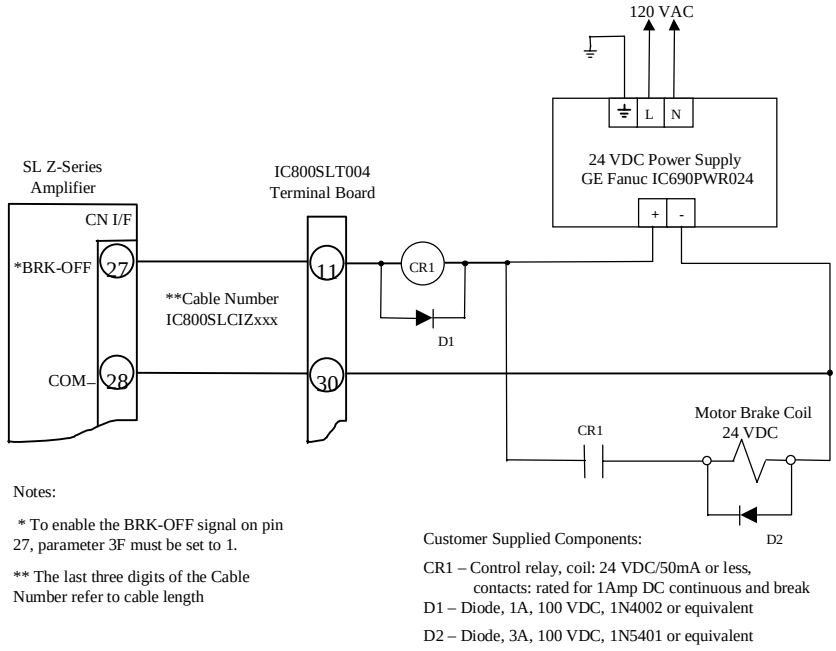


Figure 4-4. Z-Series Motor Brake Circuit for Third-Party Controllers

V-Series Brake Wiring Using the IC800SLT004 Terminal Board

The IC800SLT001 terminal board does not provide a BRK-OFF brake control output signal from the SL V-Series amplifiers due to lack of pin count on this terminal board. If using a motor brake with a GE Fanuc Series 90-30 APM or DSM motion control module, you can use the IC800SLT001 terminal board, but you must program brake control logic in the PLC ladder.

The IC800SLT004 terminal board is a general-purpose breakout terminal board used to interface to a wide variety of third-party controllers. As shown below, it does provide BRK-OFF signal connections for the SL V-Series amplifiers.

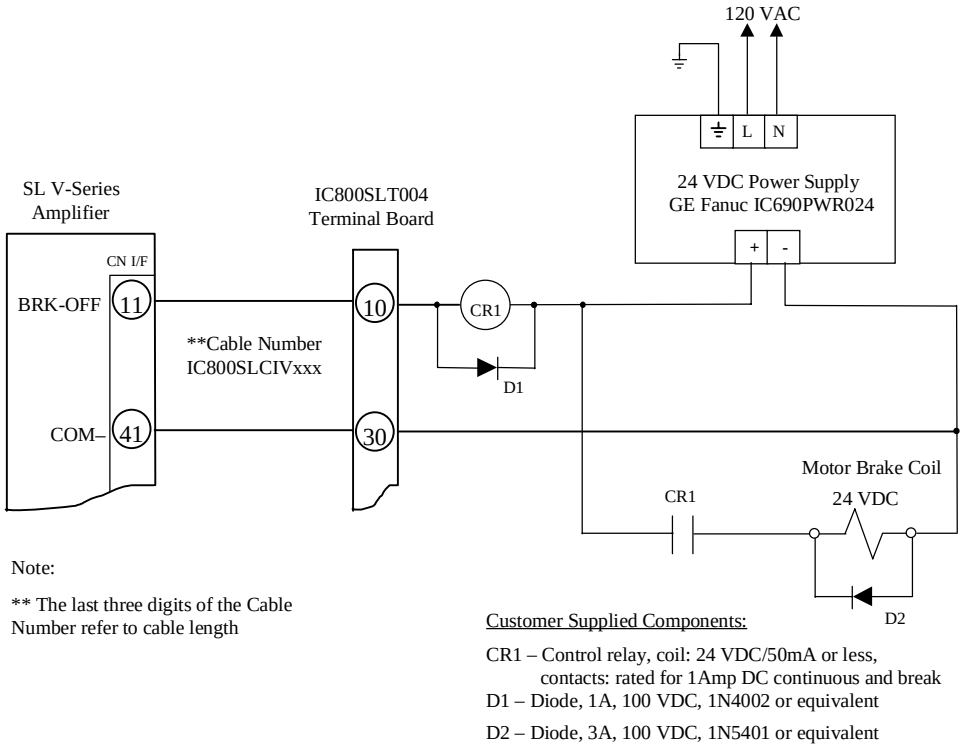


Figure 4-5. V-Series Motor Brake Circuit for Third-Party Controllers

4.1.3 Regenerative Discharge Resistor Selection and Wiring

Regenerative energy is normally created in applications with a high load inertia, high speed, vertical axes and/or frequent acceleration and deceleration. When decelerating a load, the stored kinetic energy of the load creates generator action in the motor causing energy to be returned to the servo amplifier. For light loads and low acceleration rates, the amplifier may be able to absorb and store this energy in the DC link filter capacitors. Otherwise, an optional external regenerative discharge unit must be installed.

The SL Series amplifiers do not include an internal regenerative discharge resistor. When an Overvoltage Error (Error Code 12) occurs during deceleration, the cause is usually excessive regeneration and requires an optional external regenerative resistor kit. GE Fanuc offers several different resistor kits (all kits include resistor mounting brackets) for the different SL amplifier models as shown in Table 4-2. Wiring between the resistor and the amplifier's P and B power terminals is not included in the kit and is the user's responsibility. Connections to the resistor can be made by soldering, using a fast-on type terminal of appropriate size or using a ring terminal bolted through the hole in the resistor terminal tab shown in Figure 4-6.

Caution

Under normal operation the regenerative discharge resistor may become very hot. To prevent being burned, never touch the resistor. Mount the resistor well away from heat sensitive components or wiring to prevent damage. Also, the terminals of this resistor are at a high voltage potential. Either insulate the connections or provide adequate shielding to prevent a shock hazard.

Table 4-2. Regenerative Discharge Resistor Kits

GE Fanuc Regenerative Discharge Resistor Kits	Amplifier Specifications					Recommended Resistor Kit Specifications		
	Amplifier Model	Motor Rated Output	Maximum Average Regen Current	Maximum Intermittent Regen Current	Minimum Allowable Regen. Resistance	Regenerative Resistance	Regenerative Capacity *	Peak Power
IC800SLR001	IC800SLA0031	30 W	5.1 A	8 A_{o-p}	20 Ω	50 Ω	100 W	760 W
	IC800SLA0051	50 W	5.1 A	8 A_{o-p}	20 Ω	50 Ω	100 W	760 W
	IC800SLA0101	100 W	5.1 A	8 A_{o-p}	20 Ω	50 Ω	100 W	760 W
	IC800SLA0201	200 W	5.1 A	8 A_{o-p}	20 Ω	50 Ω	100 W	760 W
	IC800SLA0401	400 W	8.2 A	12 A_{o-p}	16 Ω	50 Ω	100 W	760 W
IC800SLR002	IC800SLA0032	30 W	5.1 A	8 A_{o-p}	47 Ω	100 Ω	225 W	1444 W
	IC800SLA0052	50 W	5.1 A	8 A_{o-p}	47 Ω	100 Ω	225 W	1444 W
	IC800SLA0102	100 W	5.1 A	8 A_{o-p}	47 Ω	100 Ω	225 W	1444 W
	IC800SLA0202	200 W	5.1 A	8 A_{o-p}	47 Ω	100 Ω	225 W	1444 W
	IC800SLA0402	400 W	8.2 A	12 A_{o-p}	32 Ω	100 Ω	225 W	1444 W
	IC800SLA0752	750 W	7.5 A	24 A_{o-p}	16 Ω	100 Ω	225 W	1444 W
IC800SLR003	IC800SLA1002	1000 W	10.2 A	40 A_{o-p}	10 Ω	20 Ω	300 W	7220 W
IC800SLR004	IC800SLA2502	2500 W	10.2 A	40 A_{o-p}	10 Ω	15 Ω	1000 W	9627 W
	IC800SLA3502	3500 W	10.2 A	40 A_{o-p}	10 Ω	15 Ω	1000 W	9627 W
	IC800SLA5002	5000 W	10.2 A	40 A_{o-p}	10 Ω	15 Ω	1000 W	9627 W

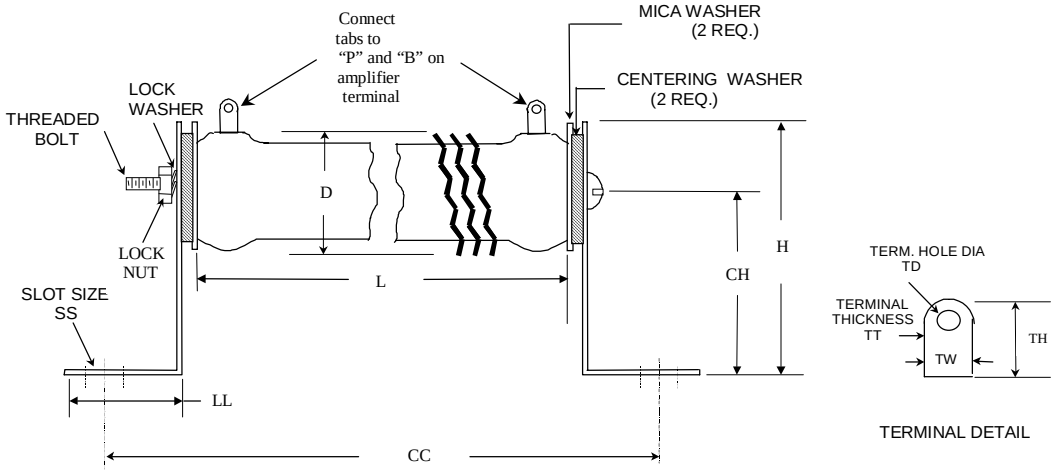
* Resistor continuous power rating are at 25°C ambient temperature. Derate power linearly at 0.3% per °C above 25°C.

The resistor values included with the kits are average values for a variety of conditions. Smaller capacity (wattage) resistors may work in some applications and larger resistors may be required in others. For example, the IC800SLR003 kit (20 ohm, 300 W) could be used with the IC800SLA0031 through IC800SLA0201 amplifiers if the recommended IC800SLR001 kit (50 ohm, 100 W) is insufficient. The lower the resistance value, the faster the regenerative energy can be dissipated. Applications with large inertial loads, high speeds, and high acceleration rates regenerate more energy and may require a resistor with a lower resistance and/or larger capacity (wattage). As an alternative, when the capacity or resistance of the standard external regenerative resistor is insufficient for the application, reducing load inertia, maximum speed, deceleration rate, increasing vertical axis counterbalance or some combination of these measures can decrease the regenerative energy. See Section 4.1.4 for details on selecting the proper resistor based on application requirements.

The wiring between the amplifier and the regenerative resistor should be kept as short as possible (less than 20 inches or 50cm) to prevent possible damage to the switching transistor from voltage transients due to cable inductance. The regenerative resistor may become very hot during normal operation. Therefore, route all wiring away from the resistor so that the wiring does not touch the resistor and has a minimum clearance of 3 inches (76mm).

Connect one terminal of the resistor to the amplifier's "P" power terminal and the other resistor terminal to the "B" amplifier power terminal. See Figures 4-1 and 4-6.

When mounting the resistor, tighten the lock nut sufficiently to compress the lock washer. Although the lock nut should be tightened securely, avoid over-tightening so as not to strip the bolt threads.



Part Number	Dimensions (in inches)										
	Resistor		Bracket					Terminal			
	L +/-.062	D Max.	H	CH	CC	LL	SS	TH	TW	TT	TD
IC800SLR001	6.50	.910	1.75	1.25	7.562	.750	.218 X.437	.562	.250	.020	.166
IC800SLR002	10.5	1.312	2.13	1.5	11.562	.875	.281 X.562	.625	.375	.020	.173
IC800SLR003	8.5	1.125	1.75	1.25	9.562	.750	.218 X.437	.625	.375	.020	.173
IC800SLR004	15	2.50	4.25	3.0	17.0	1.25	.281 X.562	.625	.500	.025	.188

Figure 4-6. Regenerative Discharge Resistor Mounting and Wiring

4.1.4 Calculating Regenerative Energy and Selecting a Discharge Resistor

Use the following calculation to determine the average regenerative energy that will be released in your application. This calculation ignores any losses due to resistance in the motor armature and lead wires since these are typically negligible compared to the other factors. Based on the calculations, select the appropriate regeneration resistor kit from Table 4-2. The regenerative capacity (wattage rating) of the selected resistor must **exceed** the average calculated regenerative energy from the equation below:

Average Regenerative Energy (Joules)	=	**Rotational Energy to be Released during Deceleration**	–	**Energy to be Consumed Through Axis Friction**	+	**(only in vertical axis operation) Vertical Energy to be Released During Downward Motion**
		(STEP 1)		**(STEP 2)**		**(STEP 3)**

STEP 1: Rotational Energy to be Released During Deceleration (E_d)

$E_d = (6.19\times10^{-4})\times(J_m + J_L)\times(\omega_i^2 - \omega_f^2)$ Joules

Where:

J_m Motor rotor inertia (lb-in-s^2)

SLM003 = 0.0000139	SLM075 = 0.001162
SLM005 = 0.0000225	SLM100 = 0.001491
SLM010 = 0.0000546	SLM250 = 0.003814
SLM020 = 0.0001474	SLM350 = 0.006992
SLM040 = 0.0003208	SLM500 = 0.015750

J_L	Load inertia reflected to motor shaft	(lb-in-s^2)
ω_i	Initial motor speed at the beginning of deceleration	(RPM)
ω_f	Final motor speed at the end of deceleration	(RPM)

STEP 2: Energy to be Consumed Through Axis Friction (E_f)

$E_f = (5.91\times10^{-3})\times t_a \times(\omega_i - \omega_f)\times T_f$ Joules

Where:

ω_i	Initial motor speed at the beginning of deceleration	(RPM)
ω_f	Final motor speed at the end of deceleration	(RPM)
t_a	Deceleration time (worst case)	(sec)
T_f	Axis friction torque (as seen by the motor)	(in-lb)

STEP 3: Vertical Energy to be Released During Downward Motion (E_v)

(This term applies only in vertical axis operation)

$$E_v = \left(1.182 \times 10^{-2}\right) \times T_h \times \omega_m \times \frac{D}{100} \text{ Joules}$$

where:

T_h	Upward supporting torque applied by the motor during downward rapid traverse to hold the load against gravity	(in-lb)
ω_m	Motor speed during downward rapid traverse	(RPM)
D	Duty cycle of downward vertical operation relative to the total cycle time. (Note: the maximum value of D is 50%)	(%)

STEP 4: Determine if a Regenerative Discharge Resistor Is Required

Determine the *Average Regenerative Energy* using the equation in the beginning of this section.

When the average regenerative energy produced **never** exceeds the maximum regenerative energy that is indicated in Table 4-3 below for the appropriate amplifier, a regenerative discharge resistor is **not** required:

Table 4-3. Maximum Allowable Regenerative Energy for Amplifiers

Amplifier Model	Rating	Max. Regenerative Energy Without an External Resistor Kit *
IC800SLA0031	30 Watt, 115 VAC	3.7 Joules
IC800SLA0032	30 Watt, 230 VAC	5.2 Joules
IC800SLA0051	50 Watt, 115 VAC	3.7 Joules
IC800SLA0052	50 Watt, 230 VAC	5.2 Joules
IC800SLA0101	100 Watt, 115 VAC	7.5 Joules
IC800SLA0102	100 Watt, 230 VAC	5.2 Joules
IC800SLA0201	200 Watt, 115 VAC	7.5 Joules
IC800SLA0202	200 Watt, 230 VAC	5.2 Joules
IC800SLA0401	400 Watt, 115 VAC	11.2 Joules
IC800SLA0402	400 Watt, 230 VAC	10.5 Joules
IC800SLA0752	750 Watt, 230 VAC	15.7 Joules
IC800SLA1002	1000 Watt, 230 VAC	31.4 Joules
IC800SLA2502	2500 Watt, 230 VAC	98.8 Joules
IC800SLA3502	3500 Watt, 230 VAC	150.5 Joules
IC800SLA5002	5000 Watt, 230 VAC	150.5 Joules

* Assumes nominal AC line voltage of 115 or 230 VAC. High line voltage will dramatically reduce the amount of regenerated energy the amplifier can absorb (for example, a 10% high line voltage will reduce the maximum regenerated energy to 43% of the values shown for 230 VAC models, and 89% for 115 VAC models).

If the calculated value exceeds the storage capability of the amplifier, then an external regenerative resistor is required (see Step 5).

STEP 5: Selecting a Regenerative Discharge Unit

If an external regenerative resistor kit is required, the following calculation will determine the appropriate resistor kit:

$$\text{Average Regenerative Power (W)} = \text{Average Regenerative Energy (Joules)} \times \frac{1}{T}$$

where:

T = Total cycle time (seconds)

Select a regenerative resistor with a rating that exceeds the average regenerative power as calculated above. If this value is greater than the regenerative capacity for the resistor kit shown in Table 4-2 a larger capacity resistor may be substituted. The larger resistor must have a resistance greater than the *Minimum Allowable Regen Resistance* shown in Table 4-2. Contact GE Fanuc if you require assistance in selecting the appropriate value.

STEP 6: Determine the Peak Power Requirements for the Resistor

The peak power determines the maximum rate at which the regenerated energy must be dissipated to prevent overvoltage faults on the amplifier. The peak power must be calculated for each period of the cycle where regeneration occurs by dividing the regenerated energy for that period by the time over which the energy is released.

Peak Power = Regenerated Energy/ Regeneration Time

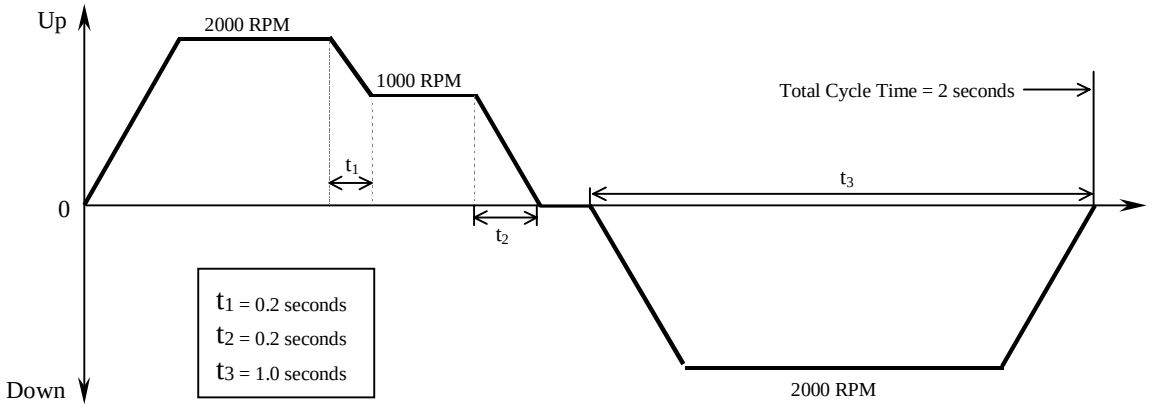
This value must be lower than the peak power for the resistor selected (see Table 4-2). If a non-standard resistor is substituted, its peak power can be calculated as follows:

230 VAC Amplifiers: Peak Power = 380^2 / R Watts
115 VAC Amplifiers: Peak Power = 195^2 / R Watts

where R is the resistance value for the selected resistor.

Application Example:

Assume a vertical axis using an SLM100 motor (J_m = 0.001491 lb-in-s^2) with a load inertia (J_L) of 0.0139 lb-in-s^2. The friction torque in the axis (T_f) is 10 in-lb and the torque that is required to support the load against gravity (T_h) is 10 in-lb. The axis requires the following compound velocity profile:



Since the example machine cycle involves a number of periods where regeneration occurs, the determination of the regenerated energy is more complicated. Regeneration occurs for each deceleration period when the axis is moving in the upward direction (against gravity) and during the

period when the axis is moving in the downward direction. The regeneration for each of these periods must be calculated as follows:

STEP 1a: Calculate the rotational energy during period t_1:

$$E_{d1} = (6.19x10^{-4}) \times (0.001491+0.0139) \times (2000^2 - 1000^2) = 28.58 \text{ Joules}$$

STEP 1b: Calculate the rotational energy during period t_2:

$$E_{d2} = (6.19x10^{-4}) \times (0.001491+0.0139) \times 1000^2 = 9.53 \text{ Joules}$$

STEP 2a: Calculate the energy absorbed by friction during period t_1:

$$E_{f1} = (5.91x10^{-3}) \times 0.2 \text{ sec} \times (2000 \text{ RPM} - 1000 \text{ RPM}) \times 10 \text{ in-lb} = 11.82 \text{ Joules}$$

STEP 2b: Calculate the energy absorbed by friction during period t_2:

$$E_{f2} = (5.91x10^{-3}) \times 0.2 \text{ sec} \times 1000 \text{ RPM} \times 10 \text{ in-lb} = 11.82 \text{ Joules}$$

STEP 3: Calculate the regenerative energy for downward motion during period t_3:
The duty cycle of the downward motion (D) is 50% since this part of the cycle is 1 second out of a total cycle time of 2 seconds or:

$D = (1 \text{ sec}/2 \text{ sec}) \times 100\% = 50\%$ Therefore:

$$E_v = (1.182x10^{-2}) \times 10 \text{ in-lb} \times 2000 \text{ RPM} \times 50\%/100\% = 118.2 \text{ Joules}$$

STEP 4: Calculate the average regenerative energy for the cycle (E_{avg}):

$$E_{avg} = 28.58 + 9.53 - 11.28 - 11.82 + 118.2 = 132.67 \text{ Joules}$$

Because the 132.67 Joules required is more than the 31.4 Joules allowed by the SLM100 amplifier, a regenerative resistor is required.

STEP 5: Determine the proper regeneration resistor size:
Since the total cycle time for the axis is 2 seconds the average regenerative power is:

Average Regenerative Power = 132.67 Joules/2 seconds = 66.3 Watts

Therefore, the standard 300 W resistor kit (IC800SLR003) shown in Table 4-2 has sufficient capacity for this application.

STEP 6: Check the peak power (P_{pk}) requirements for each regeneration period:

For period t_1: $P_{pk1} = 28.58$ Joules / 0.2 seconds = 142.9 Watts
For period t_2: $P_{pk2} = 9.53$ Joules / 0.2 seconds = 47.65 Watts
For period t_3: $P_{pk3} = 118.2$ Joules / 1 second = 118.2 Watts

The largest of these values is still less than the 7220-Watt rating of the IC800SLR003 resistor kit so the standard resistor can be used.

4.2 Wiring to Interface Connector CN I/F

Wiring to the interface connector CN I/F is different for the Z-Series and V-Series amplifiers. The Z-Series amplifiers have a 36-pin connector and the V-Series amplifiers have a 50-pin connector. Since the Z-Series amplifiers have fewer terminals, it is possible to reassign the input/output function available on some of the pins by using Parameter No.3F to select one of six different I/O configurations. Generally, the default setting (3F=0) will be best for most applications using the GE Fanuc APM300 or DSM300 Series motion controllers or other third-party position controllers. See Chapter 6 for more information on parameter settings.

All signal connectors on the SL Series amplifiers are a Mini-D style and require special tooling to properly manufacture the cable. Cables in several lengths are available from GE Fanuc for all of the amplifier connections, as shown in Table 4-4. Figures 4-7 and 4-8 show an overview of the connections to the CN I/F interface connector for each amplifier series. Chapter 5 provides more detailed information on the individual signal wiring and specifications.

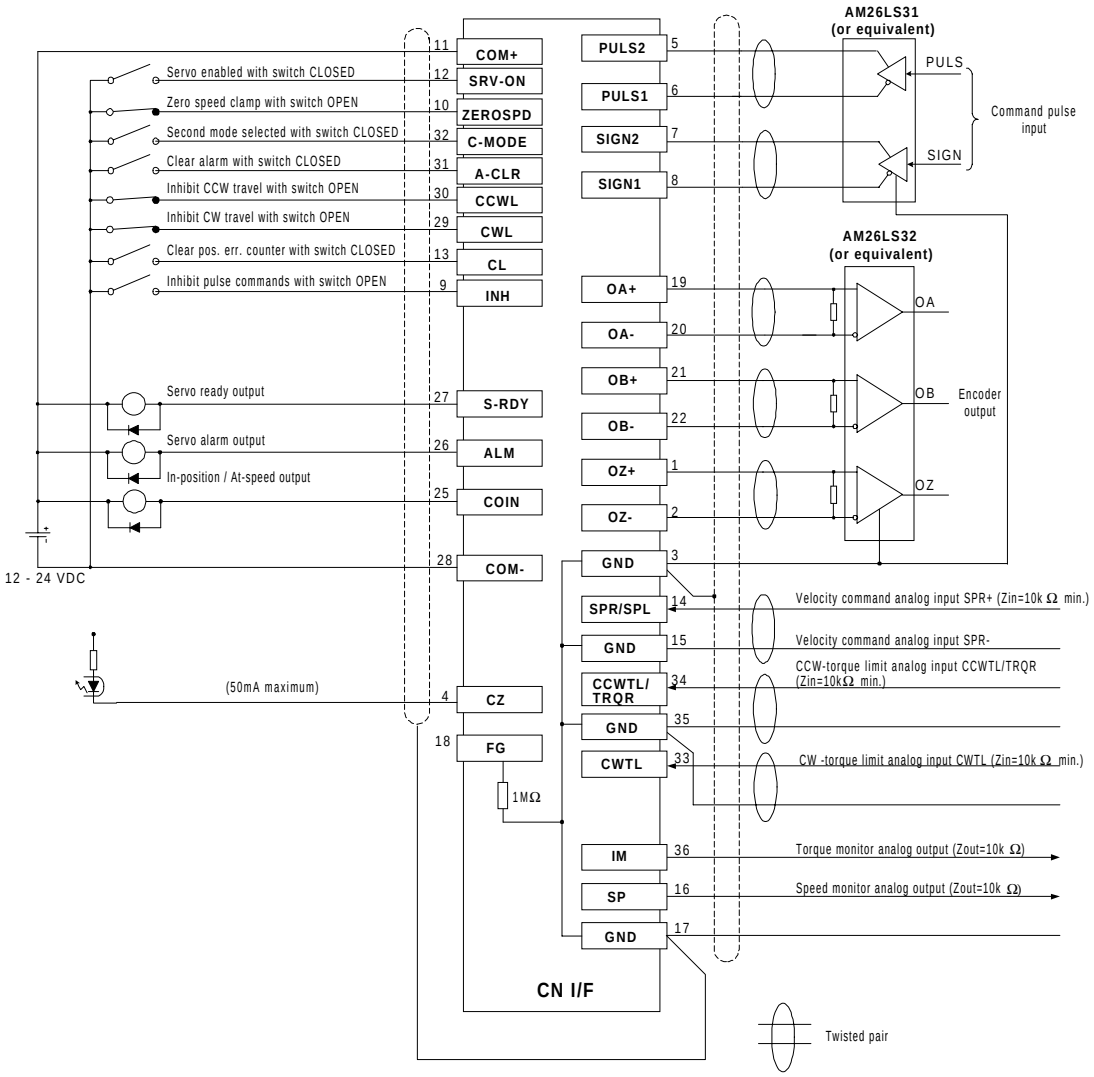


Figure 4-7. Interface Connector CN I/F for Z-Series Amplifiers with Parameter No.3F=0

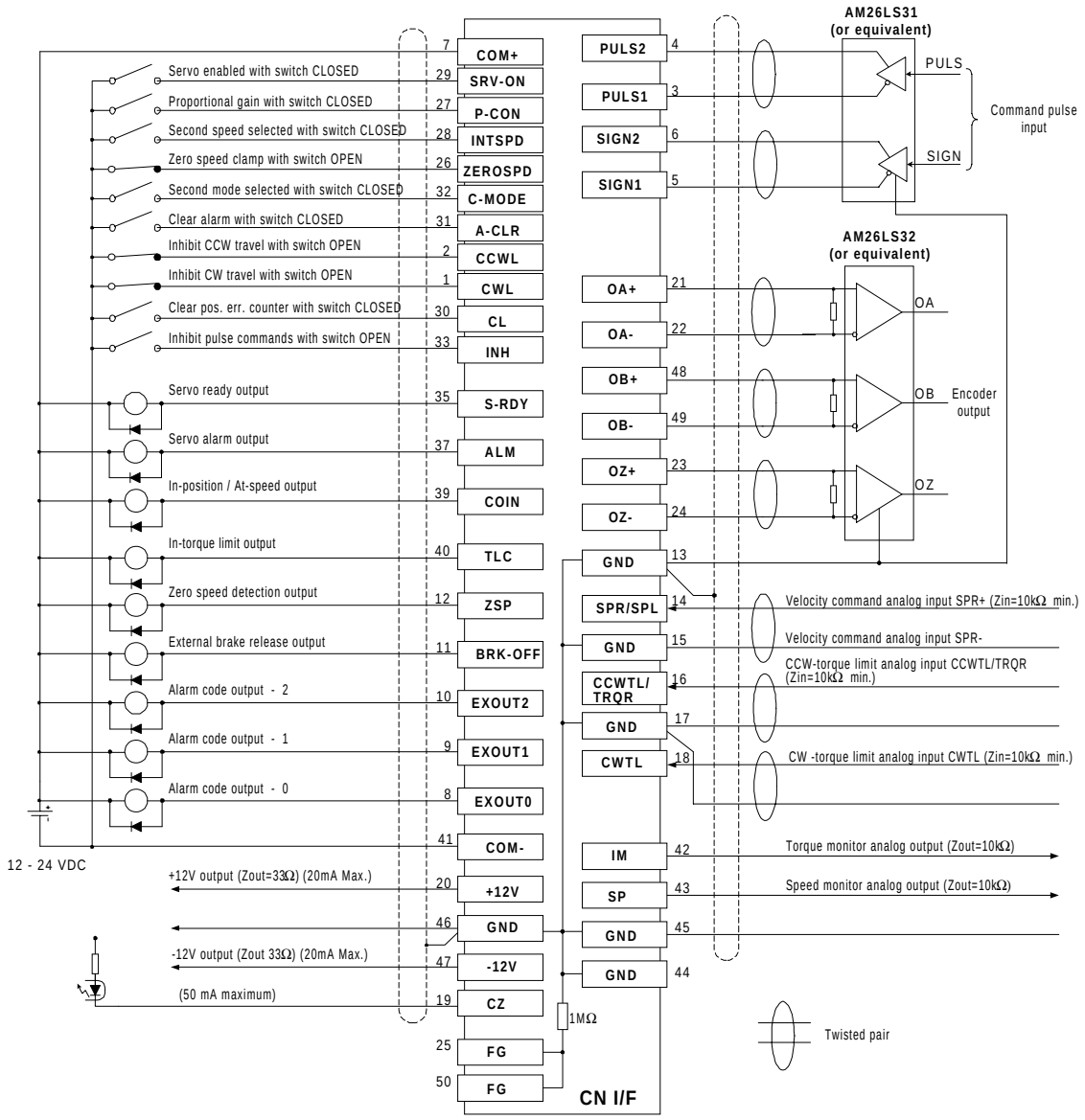


Figure 4-8. Interface Connector CN I/F for V-Series Amplifiers

Use the following guidelines when wiring to the interface connector:

1. Connect a power supply rated 12-24 VDC ± 10% between pins COM + and COM -.

> **Note**
>
> **This 24 VDC power must be connected to each SL series amplifier for the amplifier to operate. The current requirements are shown in the amplifier specification tables in Chapter 2.**

It is good practice to keep the wiring to the amplifier and other equipment as short as possible. 10 ft (3 meters) or shorter is recommended.

2. For best noise immunity, separate signal wiring from the power lines (R, S, T, U, V, W, P, B) as much as possible (12 inches or more). Avoid installing both signal and power wires in the same duct or binding them together.

3. To prevent amplifier damage, do not apply more than 24 VDC or 50 mA and avoid applying reverse polarity to any of the control output terminals on connector CN I/F shown in the table below:

Output	Amplifier Series
S-RDY	Both
ALM	Both
COIN	Both
BRK-OFF	Both
TLC	V-Series only
ZSP	Both
EXOUT 0	V-Series only
EXOUT 1	V-Series only
EXOUT 2	V-Series only

4. If you directly drive a relay with any of the control output terminals, install a reverse-biased diode in parallel with the relay as shown in Figures 4-7 and 4-8. If you do not install a diode, or install it in the wrong direction, damage to the amplifier may occur.

5. Use shielded, twisted-pair wires for the following signal lines on connector CN I/F: analog command input (SPR or TRQR), pulse command input (PULS and SIGN) or encoder output signals (OA, OB and OZ). Ground the cable shield to the signal ground (GND) of the amplifier. (Though the shield at the load end is normally left floating, in cases of extreme noise, connecting the shield at both ends to frame ground may provide better operation.)

   The frame ground terminal (FG) on connector CN I/F is connected to the earth screw terminal inside the amplifier.

4.3 Wiring to Encoder Connector CN SIG

The encoder feedback from the SL Series motor connects to the 20 pin Mini-D type CN SIG connector. GE Fanuc offers five and ten meter pre-finished cables for the encoder connections, as shown in Table 4-4. Special tooling is required to properly manufacture the Mini-D connector so it is strongly recommended that you use the cables available from GE Fanuc. Otherwise, follow the recommendations below when connecting the encoder signals from the motor:

1. For the encoder cable, use stranded twisted-pair wire at least 24 AWG ($0.18mm^2$) with an overall shield. [The AWG size is rounded to the size closest (on the larger side) to the given Metric size.]

2. The maximum cable length is 65 feet (20m). To minimize voltage drop, we recommend using two conductors for each of the two encoder power connections (see Figure 4-5).

3. Make sure the wiring between the motor encoder connector and the CN SIG connector is correct. Although the connections at the CN SIG connector are identical for the Z-Series and V-Series

amplifiers, the encoder connector on the motor is different. For the pin arrangement of the SIG connector for each amplifier series, refer to Figure 4-9.

4. To minimize effect of noise, be sure to connect the shield on the amplifier side of the cable to the frame ground (pin 20) of the CN SIG connector. The frame ground terminal is connected to the earth screw terminals inside the amplifier
5. Connect the shield wire on the motor side of the cable to the shield wire from the encoder as shown in Figure 4-9.
6. To prevent erroneous operation due to noise, separate encoder wiring from the power lines (R, S, T, U, V, W, P, B for both series and terminals r and t for the V-Series) as much as possible (12 inches or more is recommended). Do not pass them through the same duct or bind them together.
7. Do not make connections to pins 5, 6, 13, 14, 15, 16, and 19 of the CN SIG connector.

Caution

When using the SL Series servos with an external position controller, such as the GE Fanuc APM300 or DSM300 series, it may be necessary to change Parameter No. 0D to invert the encoder output signal polarity when the command polarity is reversed in order to keep the command and feedback signals in synch. If these two signals are not in phase, a runaway condition can be created where the motor will accelerate to full speed and will not be under servo control. In that case, removing AC power or the Servo Enable signal must be used to stop the motor. It is recommended you use the Parameters to change signal polarity rather than reversing the physical wiring. As an alternative, the APM and DSM controllers have a Motor Direction axis configuration parameter that can be used to reverse motor direction for a given programmed move direction without inverting any of the SL amplifier signals. The default for this parameter in the APM/DSM is positive.

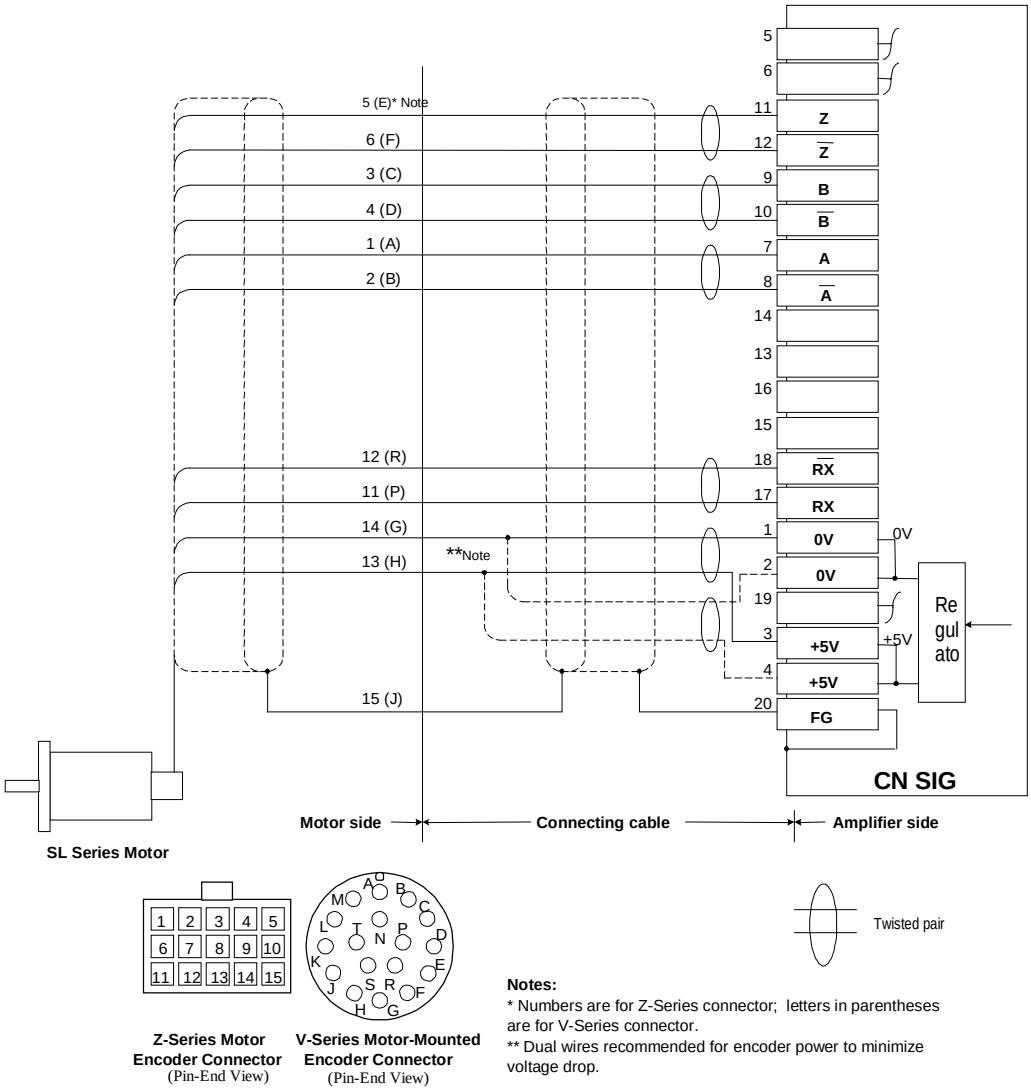


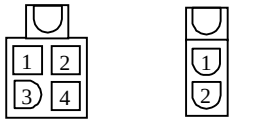
Figure 4-9. Example of Wiring to Encoder Connector CN SIG for V-Series and Z-Series

Note

To minimize the effects of noise be sure to connect the shield on the encoder cable to the CN SIG connector frame ground (pin 20) and connect the shield on the motor side to pin 15 for Z-Series or pin J for V-Series of the motor encoder connector.

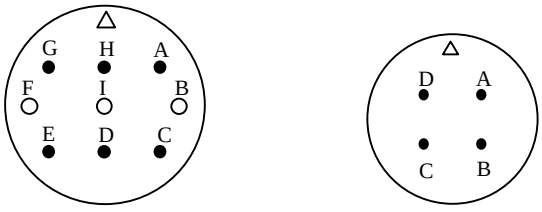
4.4 Motor Power and Brake Connector Pin-Outs

On the Z-Series motors (30 – 750 Watt), the connectors shown below are wired to the motors with short leads. On the V-Series motors (1.0 – 5.0 kW), the connectors shown are mounted on the motors. These designs are illustrated in the motor drawings in Chapter 3.



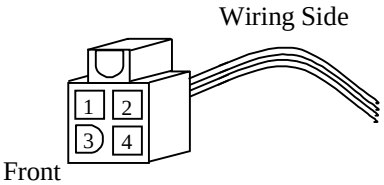
Motor Brake

Z-Series (Front View)

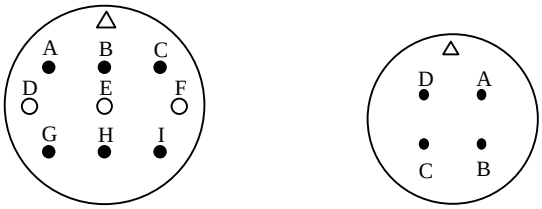


With Brake Without Brake

V-Series 1.0 – 2.5 KW (Front View)



Connector View Definition



With Brake Without Brake

V-Series 3.5 – 5.0 KW (Front View)

Z-Series Motor	
Pin No.	**Signal**
1	U
2	V
3	W
4	E

Z-Series Brake	
Pin No.	**Signal**
1	Brake
2	Brake

V-Series with Brake 1.0 – 2.5 KW	
Pin No.	**Signal**
G	Brake
H	Brake
C	NC
F	U
I	V
B	W
D	E
E	E
A	NC

V-Series with Brake 3.0 – 5.0 KW	
Pin No.	**Signal**
A	Brake
B	Brake
C	NC
D	U
E	V
F	W
G	E
H	E
I	NC

V-Series Without Brake	
Pin No.	**Signal**
A	U
B	V
C	W
D	E

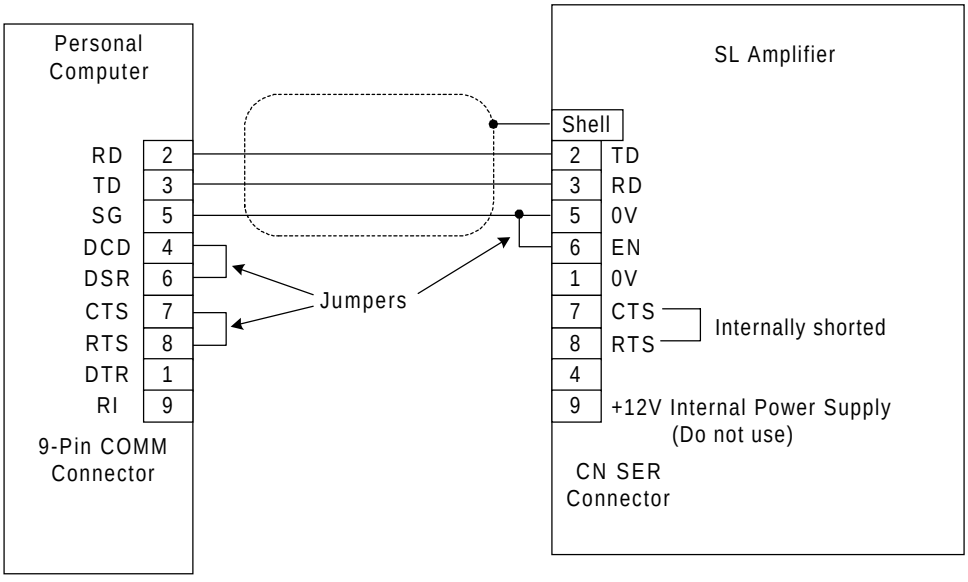
4.5 Wiring to Serial Connector CN SER

With an IBM compatible personal computer (PC) and SLconfig software (IC641SWP800), you can operate the SL Series amplifiers with the following functions: (see Section 8.2 for details)

- View/change each user parameter
- Upload/download parameter configurations between PC and amplifier
- Export and import parameter settings to and from computer files.
- View/change control mode (position/velocity/torque)
- View alarm conditions
- View/clear alarm history
- Monitor I/O status, motor speed, torque or position error
- Execute automatic or manual gain tuning
- Capture and view graphical waveform displays of various signals
- Save parameter data to non-volatile memory.

For connecting the personal computer to the amplifier, use the 2-meter long serial cable (IC800SLCS020) available from GE Fanuc. Only insert/remove the connector when power is removed from both the personal computer and the amplifier.

1. Insert the serial cable connector into the serial port connector (COM1 or COM2) on the personal computer and the CN SER connector of the amplifier (see Figure 2.1 or 2.2 and the figure below). The cable has a 9-pin female D-shell PC serial port connector, but includes an adapter for 25-pin PC serial port connectors.
2. After inserting, firmly tighten the screws to hold the connectors in place.



EIA232 (RS232) Signals

RD: Received Data — TD: Transmitted Data
SG: Signal Ground — DCD: Data Carrier Detect
DSR: Data Set Ready — CTS: Clear to Send
RTS: Ready to Send — DTR: Data Terminal Ready
RI: Ring Indicator

4.6 Cables and Connector Mates

All signal connectors on the SL Series amplifiers are Mini-D style and are available in solder type mates for customers who want to make their own cables. Cables in several lengths are available from GE Fanuc for all of the amplifier connections. It is strongly recommended that you use the cables available from GE Fanuc as shown in Table 4-4. GE Fanuc does not provide mating connectors for the SL Series amplifiers or motors; however, Tables 4-5 and 4-6 show details for the amplifier and motor connector parts available directly from the manufacturer.

Table 4-4. Cables Available from GE Fanuc

SL Series Cable	Amplifier Series	Amplifier Connector	Cable Length	GE Fanuc Catalog Number
Servo Interface Cable For Connection of Terminal Block Assemblies	Z-Series	CN I/F	1 Meter	IC800SLCIZ010
			3 Meters	IC800SLCIZ030
	V-Series	CN I/F	1 Meter	IC800SLCIV010
			3 Meters	IC800SLCIV030
Servo Interface Cable with Flying Leads For Connection of OCS or 3rd Party Controllers	Z-Series	CN I/F	3 Meter	IC800SLCFLYZ010
			6 Meters	IC800SLCFLYZ030
	V-Series	CN I/F	3 Meter	IC800SLCFLYV010
			6 Meters	IC800SLCFLYV030
APM300 Controller to IC800SLT00x Terminal Block Control Cable	Both	N/A	1 Meter	IC800SLCAPM010
		N/A	3 Meters	IC800SLCAPM030
DSM300 Controller to IC800SLT00x Terminal Block Control Cable	Both	N/A	1 Meter	IC693CBL324
		N/A	3 Meters	IC693CBL325
Serial Cable	Both	CN SER	2 Meters	IC800SLCS020
Motor Encoder Cable	Z-Series	CN SIG	5 Meters	IC800SLCEZ050
			10 Meters	IC800SLCEZ100
	V-Series	CN SIG	5 Meters	IC800SLCEV050
			10 Meters	IC800SLCEV100
Motor Power Cable	Z-Series	N/A	5 Meters	IC800SLCPZ050
			10 Meters	IC800SLCPZ100
	V-Series* 1kW to 2.5kW	N/A	5 Meters	IC800SLCPV050
			10 Meters	IC800SLCPV100
	V-Series* > 2.5kW	N/A	5 Meters	IC800SLCPVL050
			10 Meters	IC800SLCPVL100
Motor Power/Brake Power Cable	V-Series w/ Brake* 1kW to 2.5kW	N/A	5 Meters	IC800SLCBV050
			10 Meters	IC800SLCBVL100
	V-Series w/ Brake* > 2.5kW	N/A	5 Meters	IC800SLCBVL050
			10 Meters	IC800SLCBVL100
Brake Power Cable	Z-Series Only	N/A	5 Meters	IC800SLCBZ050
			10 Meters	IC800SLCBZ100

* The V-Series motors include the brake power connections in the power cable when required. Only one type of power cable is required. Z-Series motors use a separate brake power cable.

Table 4-5. Amplifier Mating Connectors

Amplifier Connector			Applicable Mating Connector			
Connector Name	**Series**	**Sumitomo 3M, Ltd (MDR Series) Part Number**	**Qty**	**Description**	**Sumitomo 3M, Ltd (MDR Series) Part Number**	**Amp (CHAMP .050 Series 2)**
CN I/F*	Z-Series	10236-52A2JL	1	Plug (Solder type)	10136-3000VE	2-175677-7
			1	Shell	10336-52A0-008	2-176293-7
	V-Series	10250-52A2JL	1	Plug (Solder type)	10150-3000VE	2-175677-5
			1	Shell	10350-52A0-008	2-178793-5
CN SIG	Both	10220-52A2JL	1	Plug (Solder type)	10120-3000VE	N/A
			1	Shell	10320-52A0-008	N/A

* Equivalent parts also available from Fujitsu (240R Series)

Connector Name	**Series**	**Part Number**	**Qty**	**Description**	**Daiichi Denshi Kogyo, Ltd. (DDK) Part Number**	**Amp (CHAMP .050 Series 2)**
CN SER	Both	DHF-RAA10-122ND	1	Connector	DHF-PDA10-2-A01	N/A

Table 4-6. Motor Mating Connectors

Connector Kit	Connector Function	Qty	Connector Description	Connector Part Number	Manufacturer
IC800SLMCONKITZ	Encoder	1	Socket	172163-1	AMP, Inc. or equivalent
		15	Contact	794058-3 or 770834-3	
	Power	1	Socket	172159-1	
		4	Contact	170366-1 or 170362-1	
	Brake	1	Socket	172157-1	
		2	Contact	170366-1 or 170362-1	
IC800SLMCONKITV	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power (No Brake)	1	MS-Shell*	MS3106B20-4S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVB	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power & Brake	1	MS-Shell*	MS3106B20-18S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVL	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power (No Brake)	1	MS-Shell*	MS3106B22-22S	
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
IC800SLMCONKITVLB	Encoder	1	MS-Shell*	MS3106B20-29S	Amphenol or equivalent
		1	Cable Clamp	MS3057-12A (97-3057-1012)	
		1	Bushing	3420-12 (9779-513-12)	
	Power & Brake	1	MS-Shell*	MS3106B24-11S	
		1	Cable Clamp	MS3057-16A (97-3057-1016)	
		1	Bushing	3420-16 (9779-513-16)	

* The connector shells shown for the 1-5 kW model servo motors are for straight mating connectors. For right angle connectors, substitute MS3108 for MS3106 in the part number.

NOTE: Equivalent parts from other vendors may be used for any of the connectors shown in Tables 4-5 and 4-6.

Chapter 5 I/O Circuit Configuration and Function

The following sections illustrate the configuration and functional detail for the various types of I/O circuits:

- Control inputs and outputs
- Analog inputs and outputs
- Pulse command
- Counter clear
- Command pulse inhibit input
- Motor encoder feedback interface

These I/O are located on connector CN I/F. On the Z-Series amplifiers, CN I/F is a 36 pin Mini-D type connector; on the V-Series amplifiers, CN I/F is a 50 pin Mini-D type connector. Observe the correct connections for each amplifier type. GE Fanuc offers prefinished cables and interface terminal block assemblies for an easy connection to the amplifier control signals (see Appendix A for more information). All connection diagrams in this chapter for Z-Series amplifiers are shown with default (Parameter 3F set to "0") signal functions. For other configurations of CN I/F functions, see Section 5.7.1. Take special note of any cautions and warnings provided with the configuration descriptions.

The control inputs and control outputs require an external DC power supply. Minimum requirements are specified in the following table. GE Fanuc's stand-alone power supply IC690PWR024 would be suitable for this application.

Control I/O Power Supply Specifications	
Z-Series Amplifiers	12 – 24 Vdc ± 10 % at 0.2A minimum
V-Series Amplifiers	12 – 24 Vdc ± 10 % at 0.5A minimum

Caution

Reversing polarity on the Control I/O supply will damage the amplifier.

This power supply is required for proper amplifier operation.

When you directly drive a relay with an output signal, install a reverse-biased diode in parallel with the relay as shown in Figures 5-3 and 5-4. If you do not install a diode or install it in the wrong direction, the amplifier may be damaged.

5.1 Control Inputs

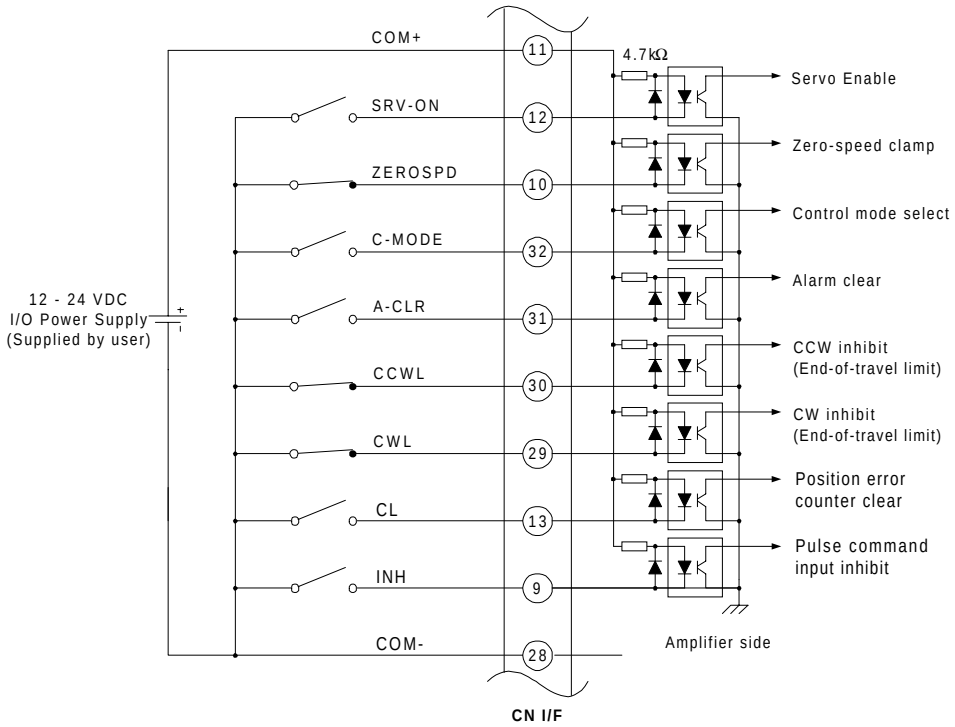


Figure 5-1. Control Inputs for Z-Series Amplifiers (30-750W) for Parameter 3F=0 (default)

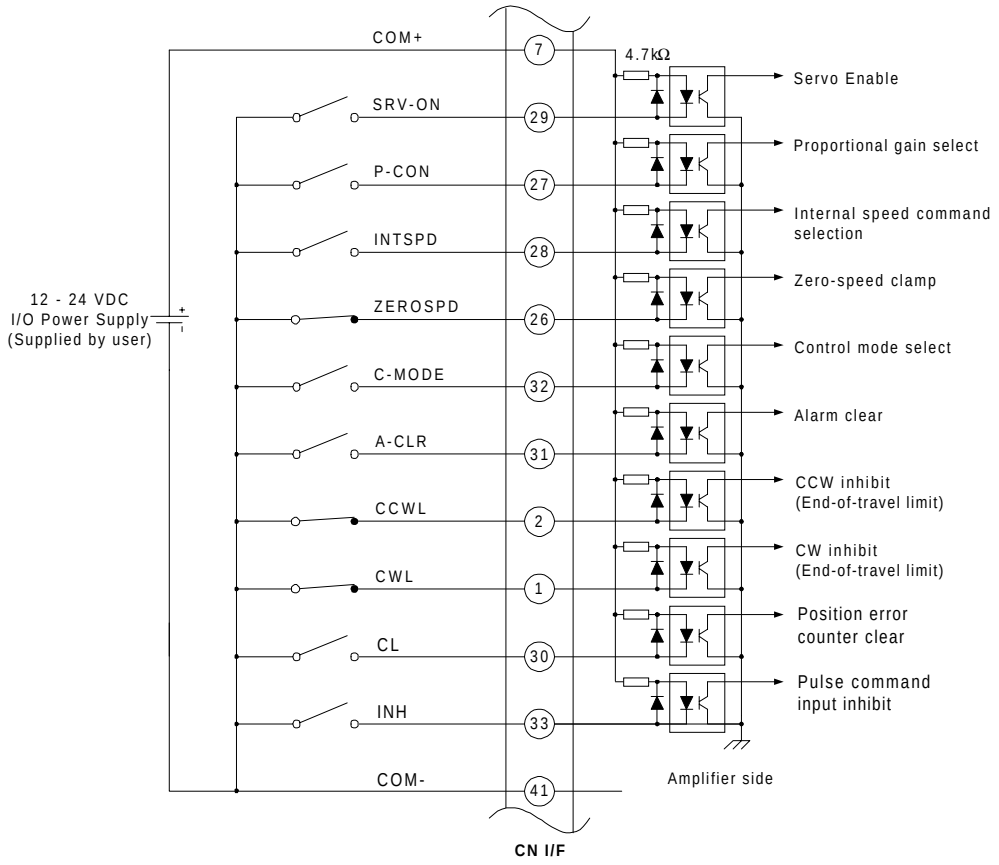


Figure 5-2. Control Inputs for V-Series Amplifiers (1000-5000W)

5.2 Control Outputs

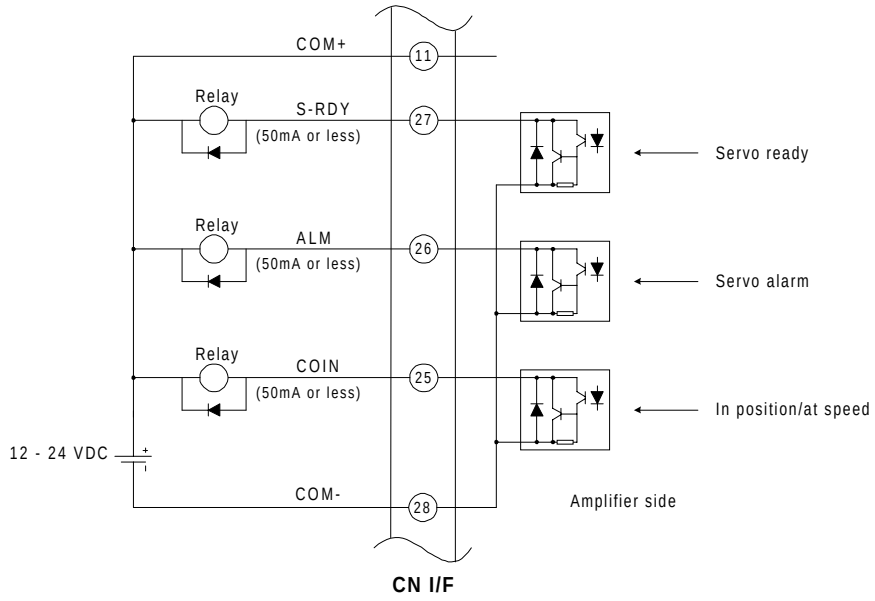


Figure 5-3. Control Outputs for Z-Series Amplifiers (30-750W) for Parameter 3F=0 (default)

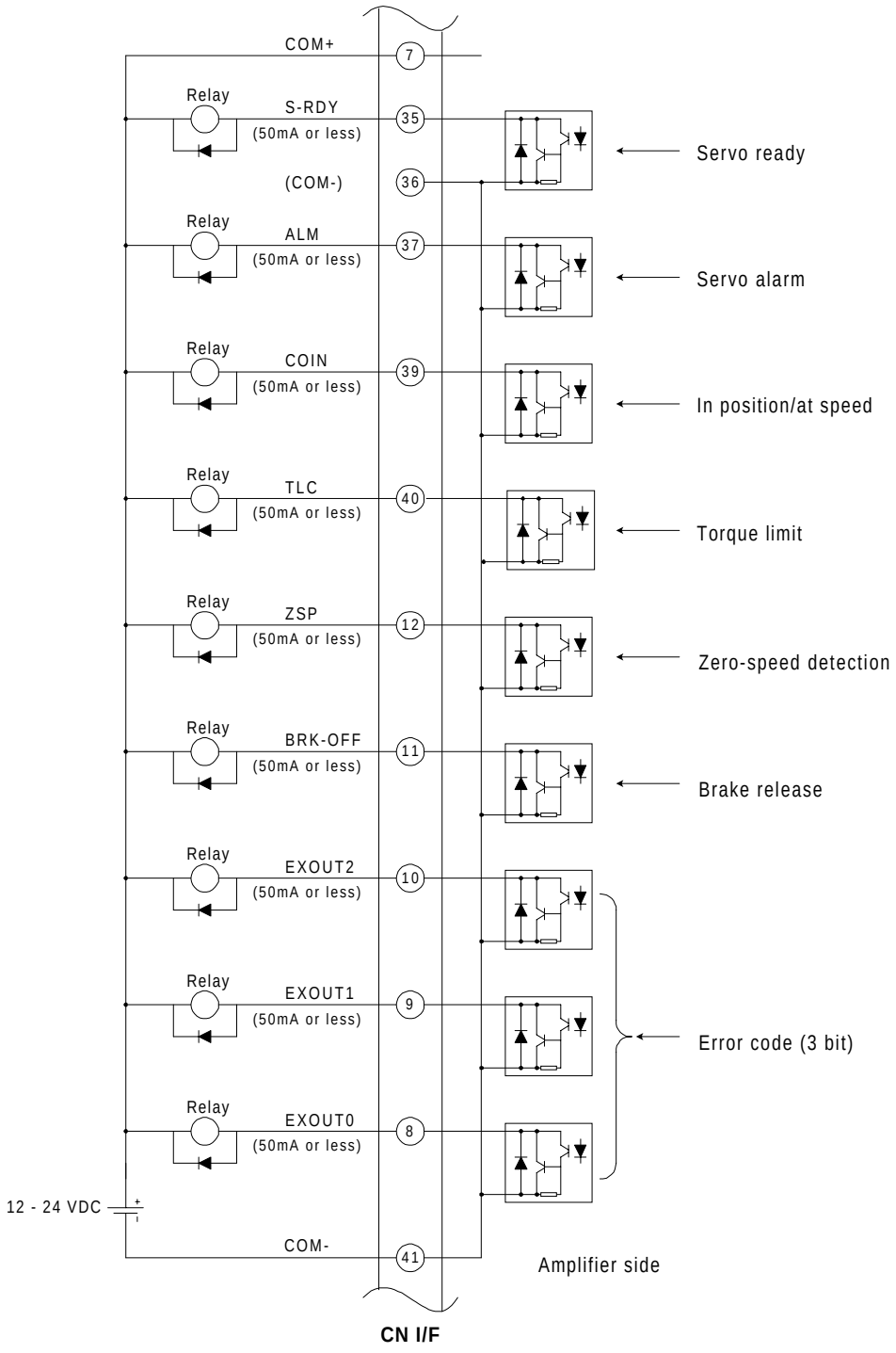


Figure 5-4. Control Outputs for V-Series Amplifiers (1000-5000W)

5.3 Analog Inputs

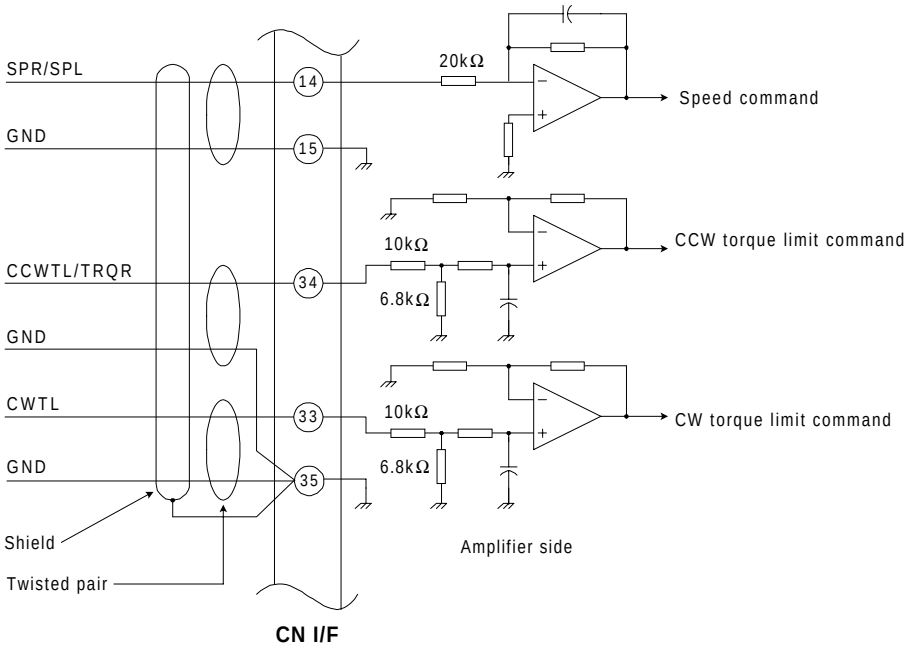


Figure 5-5. Analog Inputs for Z-Series Amplifiers (30-750W)

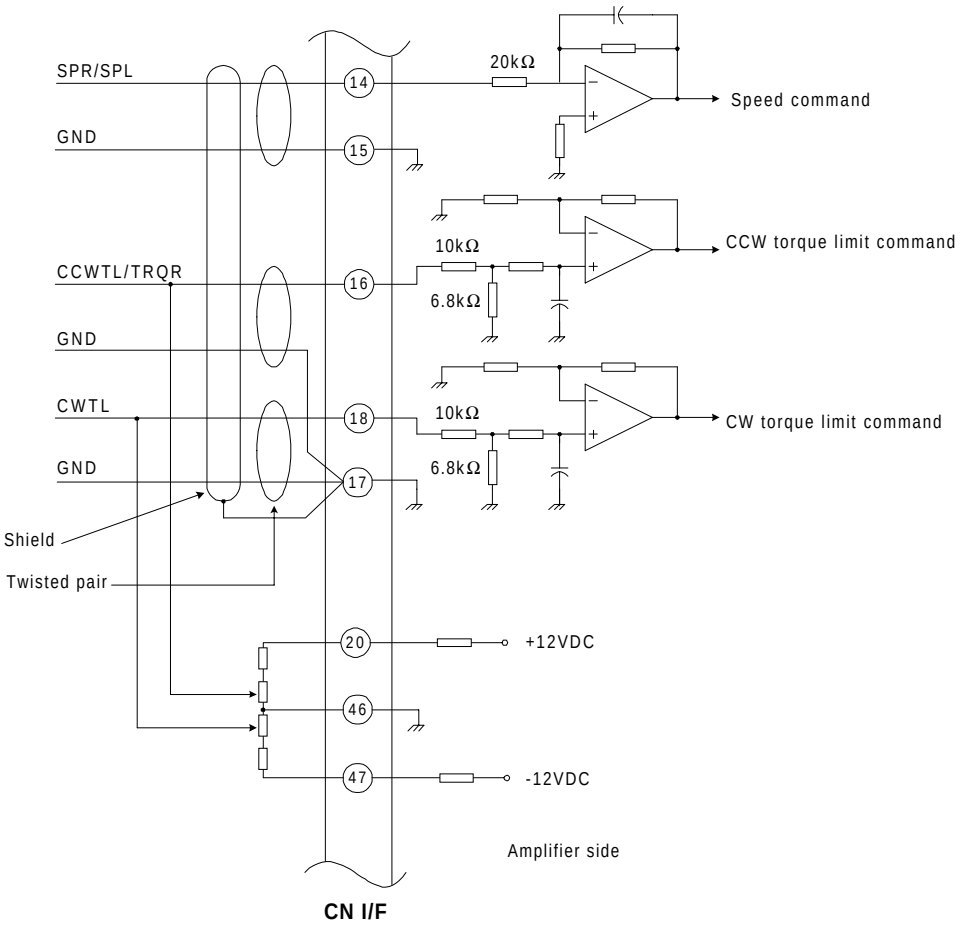


Figure 5-6. Analog Inputs for V-Series Amplifiers (1000-5000W)

The function of the SPR/SPL and CCWTL/TRQR inputs depend on the control mode selected by Parameter No.02, as shown below:

SPR/SPL Input
For Velocity Control Mode.....Speed command input (SPR) For Torque Control Mode.....Speed limit input (absolute value) (SPL) For Position Control Mode .....Inactive
CCWTL/TRQR Input
For Velocity or Position Control Mode..... CCW torque limit input (CCWTL) For Torque Control Mode..... Torque command input (TRQR)

See Chapter 6 for more detail on parameters.

5.4 Analog Outputs (Monitor Outputs)

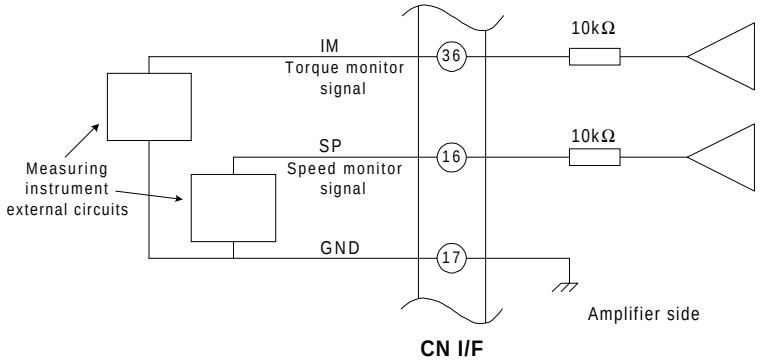


Figure 5-7. Analog Outputs for Z-Series Amplifiers (30-750W)

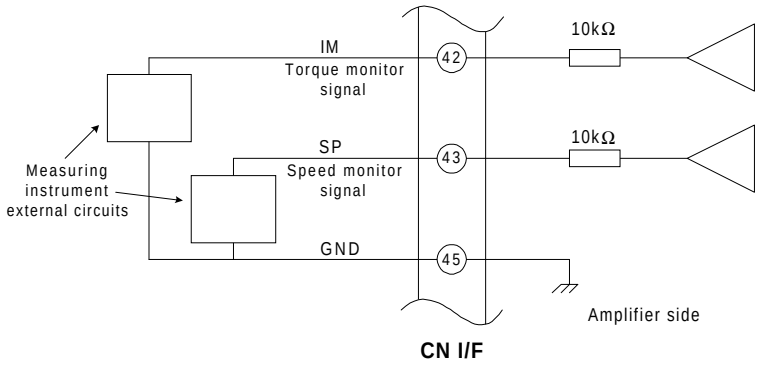


Figure 5-8. Analog Outputs for V-Series Amplifiers (1000-5000W)

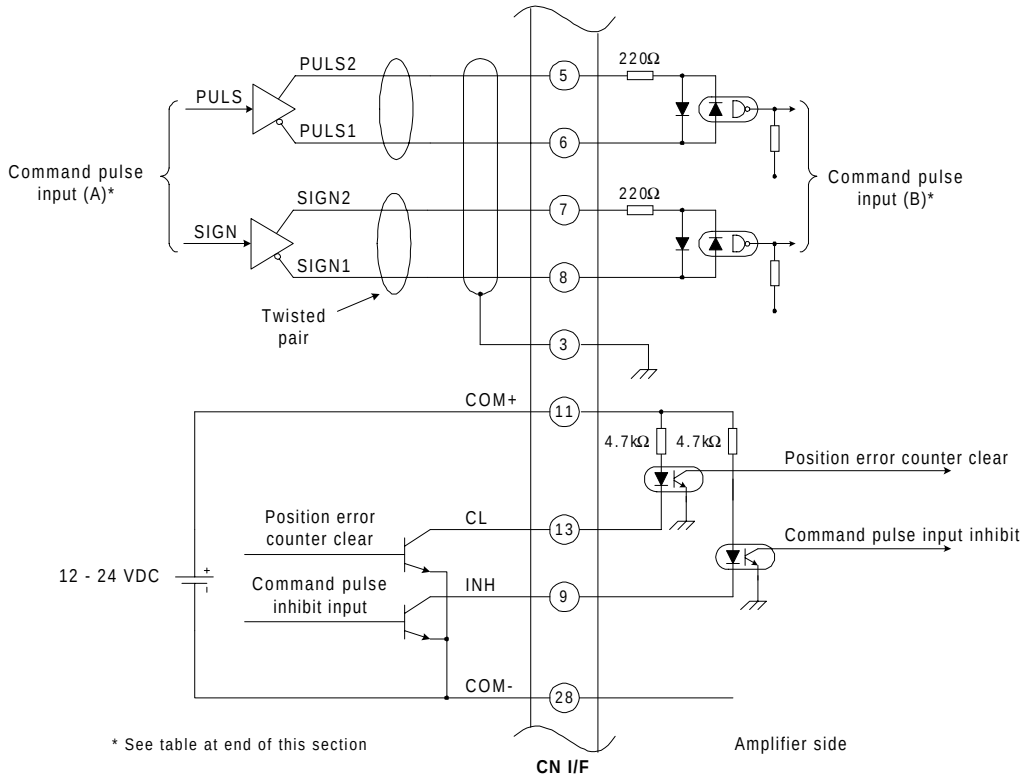
Both IM and SP have output impedance of 10KΩ. When you connect a measuring instrument or an external circuit to the IM or SP outputs, they should have high input impedance (1 MΩ or higher) in order to minimize signal error (such as a multimeter, oscilloscope, high impedance display meter, etc.).

The IM and SP outputs are also available as test points on the front of the amplifier. Both the front panel test point and the terminal output of the SP signal can be scaled by the user using Parameter No.08. The Function of the SP output signal can be configured as either motor speed or position error using Parameter No. 3B (Z-Series) or Parameter No. 08 (V-Series). See Chapter 6 for more details on configuration parameters.

5.5 Pulse Command, Counter Clear, Command Pulse Inhibit Inputs

The pulse command input can respond to either a line driver or an open collector interface, however, we recommend you use a line driver interface as shown in the following figure for greatest noise immunity. In the figures, the letters in parenthesis next to the command pulse input signals refer to whether the signal is on the supply side (A) or the amplifier side (B). The table near the end of this section lists the command pulse input logic levels for both the supply side and amplifier side for the two interface types (line drive or open collector).

Line Driver Interface



Open Collector Interface

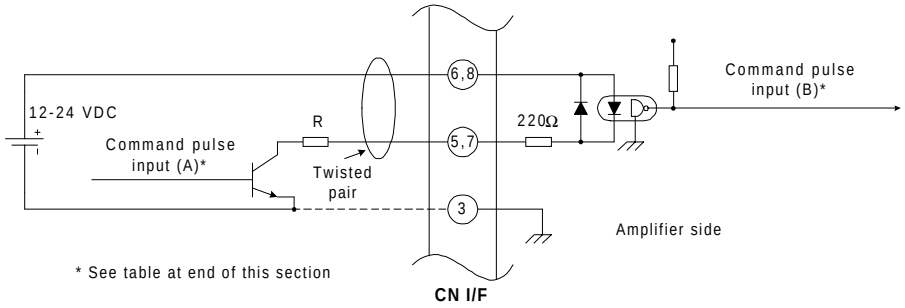
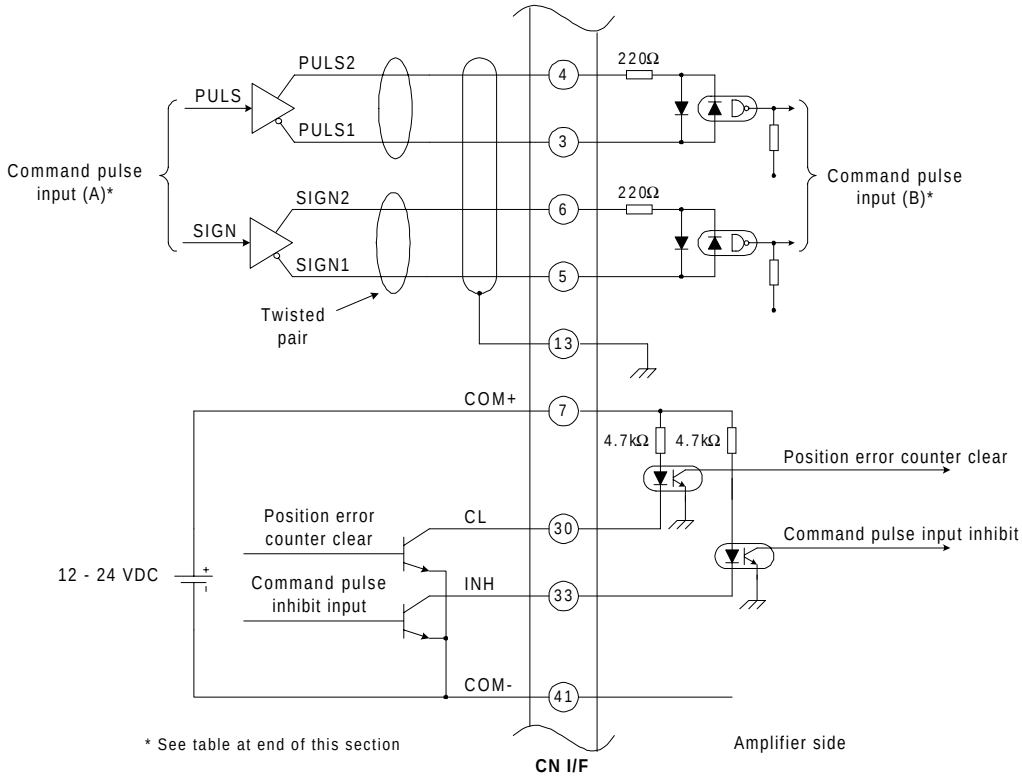


Figure 5-9. Line Driver and Open Collector Interface for Z-Series Amplifier (30-750W)

Line Driver Interface



Open Collector Interface

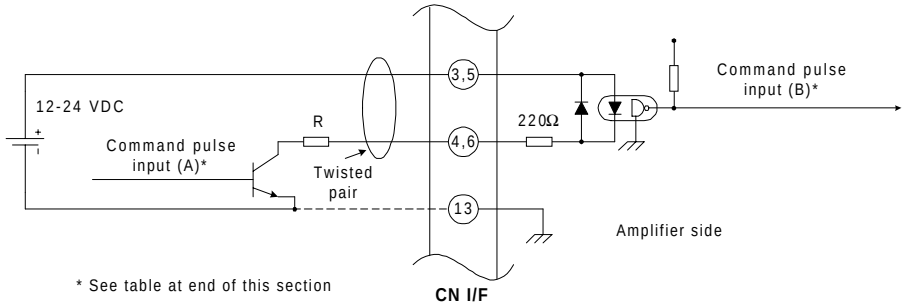


Figure 5-10. Line Driver and Open Collector Interface for V-Series Amplifier (1000-5000W)

Cautions

Keep the wiring for the pulse command input as short as possible (3 feet/1 meter or shorter recommended).

The maximum input pulse frequency is 200 kHz when using an open collector interface and 500 kHz when using a line driver interface.

When using the command pulse input with an open collector interface, you need to install a separate I/O power supply (12–24VDC) for pull-up. The higher the power supply voltage used (must not exceed the 24VDC maximum), the greater the signal noise immunity. Set the value of the series resistor "R" in the following formula (see Figures 5-9 and 5-10) so that the primary current of the opto-coupler is approximately 11mA.

$$R = \left(\frac{Vp - 1.5}{0.011 Amps} \right) - 220\ (Ohms)$$

Where:

Vp = I/O power supply DC voltage (between 12 and 24VDC)
R = Series resistance (Ω)

Examples: **Vp = 24VDC; R = 1.8 kΩ**
Vp = 12VDC; R = 750 Ω

Note

On the amplifier side, the logical sense of the command pulse input of the line driver interface is the inverse of the open collector interface, as shown in the table below. See Section 5.7.2 for more information on the pulse command signals. The command pulse input logic sense can be inverted inside the amplifier by changing Parameter No. 28.

Pulse Command Interface Type	Command Pulse Input (Figures 5-9 & 5-10)	
	(A) (Supply Side)	(B) (Amplifier Side)
Line driver interface	High	High
	Low	Low
Open collector interface	High	Low
	Low	High

If faults occur due to the influence of noise, it may be corrected by connecting signal GND on the pulse command input and signal GND on the amplifier (CN I/F pin 3 on the Z-Series or pin 13 on the V-Series). The dashed line in the open collector interface diagram in Figures 5-9 and 5-10 shows this connection.

Note

An open Command Pulse Inhibit (INH) input prevents the use of pulse command inputs. When the pulse command mode is used, it is necessary to connect the INH input to COM-. This can be accomplished by placing a wire jumper between the following pins on the CN I/F connector:

Z-Series Amplifiers: Jumper CN I/F pin 9 to pin 28

V-Series Amplifiers: Jumper CN I/F pin 33 to pin 41

5.6 Motor Encoder Output Interface

The SL Series amplifiers provide encoder output signals that can be used to provide motor position feedback to an encoder based motion controller. The encoder feedback from the SL series motor is processed through a scaling circuit that can be used to reduce the resolution of the encoder output in order to achieve higher speeds on motion controllers with a fixed frequency limit on the encoder interface circuit.

The standard 2500 PPR encoder resolution is reduced using the Encoder Output Ratio configured by Parameter Nos. 0B (numerator) and 0C (denominator). When using a scaling ratio other than 1 observe the cautions defined in the ratio parameter descriptions. See Chapter 6 for details on configuration parameters.

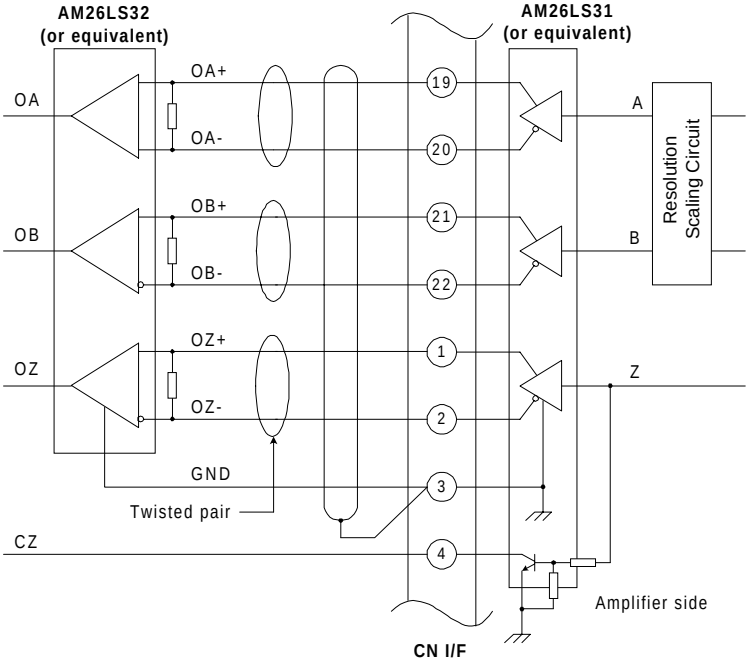


Figure 5-11. Encoder Output Interface Circuit for Z-Series Amplifiers (30-750W)

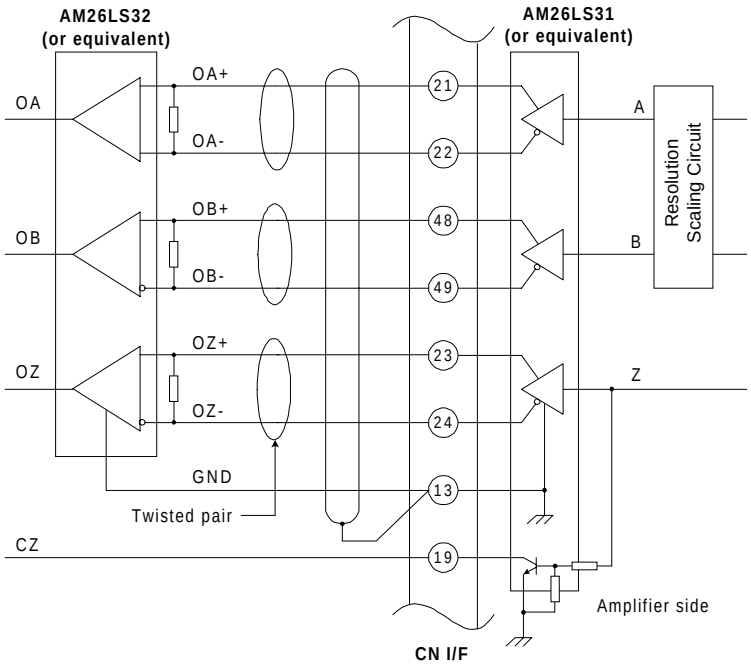


Figure 5-12. Encoder Output Interface Circuit for V-Series Amplifiers (1000-5000W)

The output pulses (A/B-phase) of the motor encoder are processed through the resolution scaling circuit and are then fed out through the line amplifier (AM26LS31) at the interface connector CN I/F. The marker pulse (Z-phase) is also fed out through connector CN I/F pin 4 (CZ) as an open collector output. If using the CZ signal, be sure to take proper precautions to minimize the influence of noise.

The encoder output signals should interface with a line receiver (AM26LS32 or equivalent). In this case, install an appropriate resistor (approximately 330 Ohms) between the line receiver inputs as shown in Figures 5-11and 5-12.

> **Note**
>
> For the marker pulse (Z-phase signal), the logic is reversed for the line receiver output (OZ) and the open collector output (CZ). See Parameter No. 0D in Chapter 6 for more information on the encoder output signal logic.

When you use the resolution scaling function for the encoder output signals, note the following:

- Pulse width of the marker (Z-phase) becomes relatively small, depending on the scaling ratio, compared to the width of the A or B phase signals after scaling. (See Chapter 6, *Configuration Parameters*, for more information.)
- When the scaling ratio is "1", the marker pulse is synchronized with the A-phase signal, and when the scaling ratio is not "1", they are unsynchronized.
- The scaling ratio must always be ≤ 1. The ratio cannot be used to increase the base resolution of the motor encoder.

Note

The scaling ratio set by Parameters 0B and 0C should be in the range of 1/32 to 1. For ratios other than 1, the duty cycles of the A and B phase output signals may not be 50%. (For a detailed description of these features, please see Chapter 6, *Configuration Parameters.*)

5.7 Input/Output Signal Function Descriptions

This section describes the operation of the various input and output signals on the SL Amplifier interface connector (CN I/F). The functional operation of many of the input and output signals is determined by the configuration of various parameters described in detail in Chapter 6, "Configuration Parameters."

5.7.1 I/O Reconfiguration for Z-Series Amplifiers Only

Since the Z-Series amplifiers have fewer terminals on the CN I/F connector, software reconfiguration of the I/O functions allows for greater application flexibility with limited I/O points. The Input/Output functions for some of the terminals can be selected by the user according to the setting of Parameter No. 3F.
Table 5-1 shows the interface connections for each of the six possible settings for Parameter 3F. An arrow in a cell of the table indicates the same function as the preceding cell in the table. Section 5.7.2 provides an in-depth description of each I/O function on connector CN I/F and Chapter 6, *Configuration Parameters,* provides detailed descriptions of parameters that affect these signal.

Table 5-1. Interface Connector Settings for Parameter 3F (Z-Series Amplifiers Only)

CN I/F Pin #	Settings for Parameter 3F (Z-Series Amplifiers Only)					
	0 (Default Setting)	1 (Configuration 1)	2 (Configuration 2)	3 (Configuration 3)	4 (Configuration 4)	5 (Configuration 5)
1	**OZ+** Encoder Z-Phase Output	←	←	←	←	←
2	**OZ-** Encoder Z-Phase Output	←	←	←	←	←
3	**GND** Signal Ground	←	←	←	←	←
4	**CZ** Z-Phase Output (Open Collector)	←	←	←	←	←
5	**PULS2** Pulse Command Input (+)	←	←	←	←	←
6	**PULS1** Pulse Command Input (-)	←	←	←	←	←
7	**SIGN2** Pulse Direction Input (+)	←	←	←	←	←
8	**SIGN1** Pulse Direction Input (-)	←	←	←	←	←
9	**INH** Pulse Command Inhibit Input	←	←	←	**INTSPD1** 1st Internal Speed Command Select Input	←
10	**ZEROSPD** Zero Speed Clamp Input	**DIV** Pulse Command Ratio Selection Input	Not Used	**DIV** Pulse Command Ratio Selection Input	**ZEROSPD** Zero Speed Clamp Input	←
11	**COM+** Control Signal Power Supply	←	←	←	←	←
12	**SRV-ON** Servo-Enable Input	←	←	←	←	←
13	**CL** Position Error Counter Clear Input	←	←	←	**INTSPD2** 2nd Internal Speed Command Select Input	←
14	**SPR/SPL** Velocity Command Input	←	←	←	←	←
15	**GND** Signal Ground	←	←	←	←	←
16	**SP** Speed Feedback Monitor Output	←	←	←	←	←
17	**GND** Signal Ground	←	←	←	←	←

CN I/F Pin #	Settings for Parameter 3F (Z-Series Amplifiers Only)					
	0 (Default Setting)	**1 (Configuration 1)**	**2 (Configuration 2)**	**3 (Configuration 3)**	**4 (Configuration 4)**	**5 (Configuration 5)**
18	**FG** Frame Ground	←	←	←	←	←
19	**OA+** Encoder A-Phase Output	←	←	←	←	←
20	**OA-** Encoder A-Phase Output	←	←	←	←	←
21	**OB+** Encoder B-Phase Output	←	←	←	←	←
22	**OB-** Encoder B-Phase Output	←	←	←	←	←
23	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
24	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
25	**COIN** In-Position or At-Speed Output	←	←	←	←	←
26	**ALM** Alarm Output	←	←	←	←	←
27	**S-RDY** Servo-Ready Output	**BRK-OFF** External Brake Release Output	←	←	←	**ZSP** Zero Speed Detected Output
28	**COM-** Control Signal Power Supply Ground	←	←	←	←	←
29	**CWL** CW Overtravel Limit Input	←	←	←	←	←
30	**CCWL** CCW Overtravel Limit Input	←	←	←	←	←
31	**A-CLR** Alarm Clear Input	←	←	←	←	←
32	**C-MODE** Control Mode Selection Input	**GAIN** Gain Selection Input	←	**P-CON** Velocity Loop Gain Type Selection Input	←	←
33	**CWTL** CW Torque Limit Input	←	←	←	←	←
34	**CCWTL/TRQR** CCW Torque Limit Input or Torque Command Input	←	←	←	←	←
35	**GND** Signal Ground	←	←	←	←	←
36	**IM** Torque Command Monitor Output	←	←	←	←	←

← Indicates the same function as the preceding block in the table.

5.7.2 I/O Functional Description

This section provides details for each function available on interface connector CN/IF. The "Parameter No. 3F" column in the table shows the appropriate setting(s) for this parameter in which each function is active. Functions labeled "All" are active for all values of Parameter No. 3F. The "I/O Signal Interface Diagram" column refers to I/O connection and specification details located in Section 5.7.3.

Note: The letters in parenthesis in the Title column refer to the control mode that the signal applies to. P = Position, V = Velocity, and T = Torque. Unless noted, these apply to both V-Series and Z-Series.

Table 5-2. Input/Output Signal Functional Descriptions

Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Control Signal Power Supply	COM +	All	7	11	Connect (+) of the control signal power supply (12–24Vdc) to COM+, and (-) to COM-. Power supply capacity requirements vary depending on configuration and loading of the control output circuits. (See Section 5.7.3 for more information.) Note: Allow extra capacity for future requirements.	N/A
	COM -	All	41	28		
Servo Enable Input (P, V, T)	SRV-ON	All	29	12	When the enable signal is connected to COM- of the control signal power supply, the dynamic brake will be released (see Parameter Nos. 0A and 3E) and the amplifier is enabled. When you open the connection to COM-, the amplifier is disabled, inhibiting current flow to the motor and, if applicable, the dynamic brake is activated and/or the position error counter is cleared. The V-Series amplifiers always clear the position error counter when the servo is disabled. The Z-Series amplifiers allow the user to select this option using Parameter No.3E. (See Section 2.3 for more information on the dynamic brake function and Chapter 9 on protective functions). **NOTES:** 1) When you enable the servo, make sure that the motor is stopped. 2) Allow at least a 50 ms delay after the amplifier is enabled before any command input is applied. Related Parameters: 0A, 3E, 0F, 0E	I-1
Pulse Command Inhibit Input (P)	INH	0, 1, 2, 3	33	9	This input enables pulse command input (PULS and SIGN inputs active) when connected to COM-. When not connected to COM- pulse command input is inhibited. When used with an external position controller such as the APM 300 or DSM300 Series or when the amplifier is configured for Velocity or Torque Control Mode (see Parameter No. 02) this input should be left OPEN. Related Parameters: 29, 02	I-1

<table>
<tr><th>Title</th><th>Symbol</th><th>Par. 3F
Z-Series</th><th>CN I/F
Pin #
V-Series</th><th>CN I/F
Pin #
Z-Series</th><th>Description</th><th>I/O
Signal
Interface
Diagram</th></tr>
<tr><td>1st Internal Speed Command Select Input

(V, T)</td><td>INTSPD1
(Z-Series)

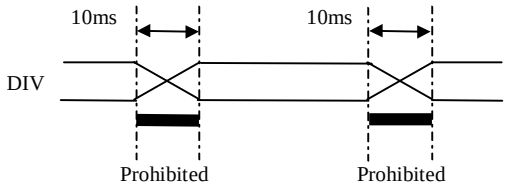
INTSPD
(V-Series)</td><td>4, 5</td><td>28</td><td>9</td><td>Z-Series amplifiers:
The INTSPD1 and INTSPD2 inputs are used to select from four fixed internal speed commands preset by the user using Parameter Nos. 18, 19, 38, and 39. Parameter No. 16 also allows the user to configure these inputs to select between three fixed speed commands and the analog velocity command (SPR).

V-Series amplifiers:
Only one input (INTSPD) is available and can be used to select between two preset speeds instead of four.
• When the internal speed command is enabled by Parameter No.16 the analog speed command (SPR) is ignored and the internal speed presets are enabled.
• The table below indicates how to select among the different speed settings. Connection to COM- is indicated as “L” and open to COM- is indicated as “H”.
<table><tr><th rowspan="2">Speed</th><th colspan="2">Z-Series</th><th>V-Series</th></tr><tr><th>INTSPD1</th><th>INTSPD2</th><th>INTSPD</th></tr><tr><td>Speed 1 (Para. No.18)</td><td>H</td><td>H</td><td>H</td></tr><tr><td>Speed 2 (Para. No.19)</td><td>L</td><td>H</td><td>L</td></tr><tr><td>Speed 3 (Para. No.38)</td><td>H</td><td>L</td><td>N/A</td></tr><tr><td>Speed 4 (Para. No.39)</td><td>L</td><td>L</td><td>N/A</td></tr></table>
Related Parameters: 16, 18, 19, 38, 39</td><td>I–1</td></tr>
<tr><td>2nd Internal Speed Command Select Input

(V-Series = N/A)
(Z-Series = V, T)</td><td>INTSPD2
(Z-Series only)</td><td>4, 5</td><td>N/A</td><td>13</td><td>See description for INTSPD1 above.</td><td>I-1</td></tr>
<tr><td>Position Error Counter Clear Input
(P)</td><td>CL</td><td>0, 1, 2, 3</td><td>30</td><td>13</td><td>When in Position Control Mode (see Parameter No. 02) you can clear the position error counter by connecting this input to COM-. You also inhibit command pulse input (PULS/SIGN) and motor encoder feedback pulse input by activating this input.
NOTE: For Z-Series amplifier, the clear signal must be at least 30µs long. For V-Series amplifiers, the clear signal must be at least 100µs long. This will ensure that the SL servo will capture any state transition.
Related Parameter: 3C</td><td>I–1</td></tr>
</table>

<table>
<tr><th>Title</th><th>Symbol</th><th>Par. 3F
Z-Series</th><th>CN I/F
Pin #
V-Series</th><th>CN I/F
Pin #
Z-Series</th><th>Description</th><th>I/O
Signal
Interface
Diagram</th></tr>
<tr><td>Zero-Speed Clamp Input

(V-Series = V)
(Z-Series = P, V, T)</td><td>ZEROSPD</td><td>0, 4, 5</td><td>26</td><td>10</td><td>This input can be used to prevent servo drift at zero speed caused by command signal offset or drift in the command signal A/D converter. When <u>not</u> connected to COM- a zero-speed command is set, forcing the motor to stop while maintaining holding torque.
NOTES:
1) Parameter No. 17 will inhibit the Zero Speed Clamp function when set to 1 (default).
2) The Zero Speed Clamp input is not active when the amplifier is configured for Position Control Mode (see Parameter No. 02 in Chapter 6 for details).
3) This input is connected to COM- on the IC800SLT001 terminal board when the SL Servo is used with GE Fanuc DSM or APM controllers.
Related Parameters: 02, 17</td><td>I–1</td></tr>
<tr><td>Pulse Command Ratio Selection

(V-Series = N/A)
(Z-Series = P, V, T)</td><td>DIV</td><td>1, 3</td><td>N/A</td><td>10</td><td>This input allows the user to select between two different numerator values for the Pulse Command Ratio used to scale the motor speed to the pulse command input frequency. The two numerator values are set by Parameters 25 and 35 (see Chapter 6).
When this signal is connected to COM-, the 2nd numerator value (Parameter No.35) is used to calculate the ratio. When this input is OPEN, the 1st numerator value (Parameter No.25) is used.
NOTES:
(1) Parameter No.26 sets the denominator of this ratio.
(2) You must wait at least 10ms after changing the state of the DIV input before command pulses will be recognized:
 

Related Parameters: 25, 26, 27, 28, 29, 35.</td><td>I–1</td></tr>
<tr><td>Control Mode Selection Input
(P, V, T)</td><td>C-MODE</td><td>0</td><td>32</td><td>32</td><td>C-MODE is used to select between two operating modes when the amplifier is configured for one of the three dual-mode control settings (Parameter No. 02 set to 3, 4, or 5):
<table><tr><td></td><td colspan="2">Mode</td></tr><tr><td>Par. No.
02 Setting</td><td>C-MODE
Input OPEN</td><td>C-MODE Input
Connected to COM-</td></tr><tr><td>4</td><td>Position</td><td>Velocity</td></tr><tr><td>5</td><td>Position</td><td>Torque</td></tr><tr><td>6</td><td>Velocity</td><td>Torque</td></tr></table>
Example: If Parameter 02 is set to 5, you can select between Position and Torque modes by switching the C-MODE input. When C-MODE is OPEN, Position is selected. When C-MODE is connected to COM-, Torque is selected.
Related Parameter: 02</td><td>I–1</td></tr>
</table>

<table>
<tr><th>Title</th><th>Symbol</th><th>Par. 3F
Z-Series</th><th>CN I/F
Pin #
V-Series</th><th>CN I/F
Pin #
Z-Series</th><th>Description</th><th>I/O
Signal
Interface
Diagram</th></tr>
<tr><td>Gain Selection Input

(V-Series = N/A)
(Z-Series = P, V, T)</td><td>GAIN</td><td>1, 2</td><td>N/A</td><td>32</td><td>For the Z-Series amplifiers this input allows you to select between two different position or velocity loop gains on-the-fly depending on which of these control modes is active. The gain values for each control mode are selected by the GAIN input as shown in the following table:
<table>
<tr><td>GAIN Input</td><td>Position Cont. Mode (Para. No.02=0)</td><td colspan="2">Velocity Control Mode (Para. No.02=1)</td></tr>
<tr><td>H</td><td>1st Position Gain (Par. No. 20)</td><td>1st Velocity Gain (Par. No. 03)</td><td>1st Vel. Int. Time Const. (Par. No. 04)</td></tr>
<tr><td>L</td><td>2nd Position Gain (Par. No. 32)</td><td>2nd Velocity Gain (Par. No. 30)</td><td>2nd Vel. Int. Time Const. (Par. No. 31)</td></tr>
</table>
When the GAIN input is connected to COM- (L) the second values for position loop or velocity loop gain are used instead of the primary gain values. Primary values are selected when GAIN input is OPEN (H).
This input shares a terminal on connector CN I/F with the P-CON and C-MODE functions and is active only when Parameter No. 3F is set to 1 or 2.
Parameter No.33- *2nd Gain Switching Mode* is a permissive to using this input and must be set to “2” to activate the GAIN input.
NOTE:
This function should not be used when using SL servos with an external position controller and is not available on V-Series amplifiers.

Related Parameters: 03, 20, 30, 32, 33, 34</td><td>I–1</td></tr>
<tr><td>Velocity Loop Gain Type Selection Input

(P, V, T)</td><td>P-CON</td><td>3, 4, 5</td><td>27</td><td>32</td><td>For Z-Series amplifiers this input selects between Proportional (P) or Proportional/Integral (PI) gain for the velocity loop. This input shares a terminal on connector CN I/F with the GAIN and C-MODE functions and is active only when Parameter No. 3F is set to 3, 4 or 5.
For Z-Series only, when connected to COM- only proportional velocity loop gain (set by Parameter Nos. 03 and 30) is used; when OPEN, the integral gain set by Parameter Nos. 4 and 31 is also used.
NOTE:
This input should not be used when using the SL servos with an external position controller.

Related Parameters: 03, 30, 31</td><td>I–1</td></tr>
</table>

Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Alarm Clear Input (P, V, T)	A-CLR	All	31	31	This input clears the alarm status for most errors when connected to COM- (reset signal width must be at least 120ms or more to ensure that it is captured). At the same time, the position error counter will also be cleared. **NOTE:** You cannot clear the following errors with the A-CLR input. You must first correct the source of the error, then cycle AC line power on the amplifier to reset these errors. • Overcurrent (code 14) • Encoder error (code 22) • DSP watchdog error (code 23; V-Series only) • CPU watchdog error (code 30) • EEPROM Check-sum error (code 36) • Parameter range error (code 84; V-Series only) • CPU Stack error (code 97; Z-Series only) • System error (code 98) • Other error (code 99) (See Chapter 9 for more details on error protection).	I–1
CCW Overtravel Limit Input (P, V, T)	CCWL	All	2	30	For axes driving linear mechanisms with a finite range of travel, the end of travel limits may be used to prevent overtravel. Connect this input to the limit switch for motion in the CCW direction looking into the motor shaft (see Section 2.2 for details on directional conventions). If the switch opens, the motor will generate no CCW torque (motion). When you do not require overtravel limits, you can inhibit this input using Parameter No.09, or connect a wire jumper from this terminal to COM-. Since this signal must be connected to COM- to enable CCW motion, the limit switch contact must be normally closed for normal range of travel. When this input is activated (open), you can select whether the motor coasts to a stop or activates the dynamic brake to slow the motor more quickly. Parameter No.0A is used to define this action. (See also Chapter 6 for details on configuration parameters). Related Parameters: 0A, 09	I–1
CW Overtravel Limit Input (P, V, T)	CWL	All	1	29	You can inhibit CW motion of the motor with this input. Refer to the CCW overtravel limit input description above for the functional description of this input.	I–1

Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Servo-Ready Output (P, V, T)	S-RDY	0	35	27	This output will turn ON, when the main power is on and no alarm is active on the amplifier. **NOTES:** 1) When you turn off the power but the main capacitor is still charged, the Servo-ready output remains ON until the capacitor discharges. 2) On the Z-Series amplifiers S-RDY (default) uses the same CN I/F pin as the BRK-OFF and ZSP output functions. These functions are selected by Parameter No. 3F and are mutually exclusive. 3) When the amplifier is used with a GE Fanuc DSM Series controller the IC800SLT001 interface terminal block includes an opto-coupled interface to the IN4 (Servo Ready) input on the DSM. The APM Series controllers do not have a Servo Ready input so this input must be incorporated into the machine control logic via a discrete input on the PLC. Related Parameters: 3F	O–1
External Brake Release Output (P, V, T)	BRK-OFF	1, 2, 3, 4	11	27	This output signal can be used to control a mechanical brake on the motor. This output is not designed to directly control the motor brake. An interposing relay (with a coil voltage of 12-24V and 50mA max.) must be used. The brake circuit should be designed so that the brake is released when this output is activated (transistor turned on). Parameter Nos. 0E and 0F determine the timing of the BRK-OFF output under various operating conditions. **NOTE:** On the Z-Series amplifiers BRK-OFF uses the same CN I/F pin as the S-RDY and ZSP output functions. These functions are selected by Parameter 3F and are mutually exclusive. Related Parameters: 0E, 0F, 3F	O–1
Zero Speed Detection Output (P, V, T)	ZSP	5	12	27	When the motor reaches a speed less than the speed set by Parameter No. 11 (the minimum detectable motor speed is 20 RPM or higher) the output is activated (transistor turns on). **NOTE:** On the Z-Series Amplifiers ZSP uses the same CN I/F pin as the S-RDY and BRK-OFF output functions. These functions are selected by Parameter 3F and are mutually exclusive. Related Parameters: 02, 11	O–1
Servo-Alarm Output (P, V, T)	ALM	All	37	26	This output turns OFF when the amplifier detects an error and activates a protective function. Parameter No. 3D (Z-Series) or 0A (V-Series) selects action taken by the appropriate amplifier series when an alarm occurs. **NOTE:** V-Series amplifiers also output additional fault information on the three EXOUT signals defined later in this section. (See Chapter 9 for more information on protective functions) Related Parameters: 0A, 3D	O–1

<table>
<tr><th>Title</th><th>Symbol</th><th>Par. 3F Z-Series</th><th>CN I/F Pin # V-Series</th><th>CN I/F Pin # Z-Series</th><th>Description</th><th>I/O Signal Interface Diagram</th></tr>
<tr><td>In-Position Output

(P)

or

At-Speed Output

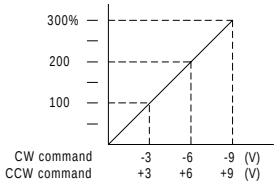
(V, T)</td><td>COIN</td><td>All</td><td>39</td><td>25</td><td>When in Position Control Mode: If the pulse count of the position error counter is within the In-Position parameter range (set using Parameter No.22) the COIN output is activated (transistor turns ON).
When in Velocity or Torque Control Mode:
This signal becomes an At-Speed signal. The COIN output is activated (transistor turns ON) when the motor reaches the speed preset by Parameter No.12 (see Chapter 6).
Related Parameters: 02, 12, 22</td><td>O–1</td></tr>
<tr><td>In-Torque-Limit Output
(V-Series only)

(V-Series = V, T)
(Z-Series = N/A)</td><td>TLC</td><td>N/A</td><td>40</td><td>N/A</td><td>For V-Series amplifiers configured for Velocity or Position Control Mode (see Parameter No.02) the TLC output turns ON when the torque limit function is operating. Parameter No. 06 or the CWTL/CCWTL analog inputs can be used to set the value for the amplifier torque limit. Parameter No.07 can be used to disable the CWTL/CCWTL analog torque limit inputs.
NOTE: When the CWTL/CCWTL limit inputs are enabled the SL amplifier will use the <u>smaller</u> torque limit value set by either the CWTL/CCWTL inputs or Parameter No.06.

Related Parameters: 02, 06, 07</td><td>O–1</td></tr>
<tr><td rowspan="3">Alarm Code Output
(V-Series only)

(V-Series = P, V, T)
(Z-Series = N/A)</td><td>EXOUT2</td><td>N/A</td><td>10</td><td>N/A</td><td rowspan="3">When a V-Series amplifier protective function operates, the ALM output is activated and an error code is output as a 3-bit signal for each error code. The relation of error codes and EXOUT signal output pattern is shown below.
<table>
<tr><th colspan="3">Error Code Output</th><th rowspan="2">Error Description</th></tr>
<tr><th>EXOUT2
CN I/F Pin 10</th><th>EXOUT1
CN I/F Pin 9</th><th>EXOUT0
CN I/F Pin 8</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>Normal Operation (no errors)</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>System error (98)
DSP Watchdog error (23)
CPU Watchdog error (30)</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>EEPROM Check-sum error (36)
Parameter Download error (84)
Command Pulse Ratio error (27)</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>Encoder error (22)
Drive Inhibit error (38)</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>Excessive position error (29)
Position Error Limit (24)
Over speed error (26)</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>Under Voltage error (13)
Over Voltage error (12)</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>Overload error (16)
Over Current error (14)</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>Other errors (99)</td></tr>
</table>
0 = Output transistor ON; 1 = Output transistor OFF</td><td rowspan="3">O–1</td></tr>
<tr><td>EXOUT1</td><td>N/A</td><td>9</td><td>N/A</td></tr>
<tr><td>EXOUT0</td><td>N/A</td><td>8</td><td>N/A</td></tr>
</table>

Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Velocity Command Input (V-Series = V) (Z-Series = V, T) or Speed Limit Input (V-Series = T) (Z-Series = V, T)	SPR/SPL	All	14	14	**When in Velocity Control Mode:** SPR is used as an analog velocity command input. You can set the velocity command input scaling (relation between the motor speed and the command input voltage level), and the polarity of the velocity command input using Parameter Nos.13 or 14 respectively (see Chapter 6). **When in Torque Control Mode:** When operating the SL amplifiers in Torque Control Mode a speed limit must be set before the servo can be operated. Varying the voltage level of this input uses this signal as a speed limit input (SPL) that can dynamically vary the motor speed limit. The relation between the speed limit and the input voltage level is determined by the value set in Parameter No.13 (see Chapter 6). **When in Position Control mode:** This input is inactive. **NOTES:** 1) The speed limit input is a bipolar signal and can limit both CCW and CW speed depending on the signal polarity. 2) The required speed limit for the Torque Control Mode can also be configured using the one or more of the internal speed settings (INTSPD inputs) instead of the analog SPL input (see Parameter No.18) Related Parameters: 13, 14, 15, 18	AI–1
	GND	All	15	15		

Title	Symbol	Para. 3F	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
CW Torque Limit Input (P, V)	CWTL	All	18	33	**When in Velocity or Position Control Mode:** The CWTL and CCWTL inputs are used to individually limit (respectively) the CW and CCW torque (current) of the motor. Apply negative command voltage (0 to -10Vdc) to CWTL with respect to GND to limit the CW torque, and positive command voltage (0 to +10Vdc) to CCWTL with respect to GND to limit the CCW torque. The relationship between the input voltage and the torque limit (relative to rated torque) is approximately 3V/100% rated torque as follows:  **NOTES:** 1) The CCWTL and CWTL inputs are inhibited through Parameter No.07-*Torque Limit Inhibit* as the default setting. To use these inputs Parameter No.07 must be reset to 0. (see Chapter 6) 2) Parameter No.06 also sets a torque limit that may conflict with the torque limit set using these analog inputs. When the CWTL/CCWTL limit inputs are enabled the SL amplifier will use the smaller value set by either the CWL/CCWL inputs or Parameter No.06. **When in Torque Control Mode:** This function is inactive. Related Parameters: 06, 07	AI–2
	GND	All	17	35		
CCW Torque Limit Input (P, V)	CCWTL	All	16	34		
	GND	All	17	35		
Torque Command Input (T)	TRQR	All	16	34	**When in Torque Control Mode:** This input is the analog torque command. You can set the torque command input scaling (relationship between command input voltage level and generated torque of the motor), and polarity using Parameters 1A and 1B respectively (see Chapter 6). Any offset voltage on the input signal can be corrected using Parameter No.1C and Parameter No.1D adjusts the time constant on a signal noise filter. Torque Mode requires that a velocity limit to be set using either the analog velocity command input (SPR/SPL) or the internal speed command (INTSPD). The analog signal (SPL) allows a dynamic velocity limit while the internal speed sets a fixed limit. Parameter No.16 is used to select which limit signal will be used. **NOTE:** This input shares the same CN I/F pin with the CCW torque limit input (CCWTL) function. These functions are selected using Parameter No.02 and are mutually exclusive. Related Parameters: 02, 16, 1A, 1B, 1C, 1D	AI–2
	GND	All	17	35		

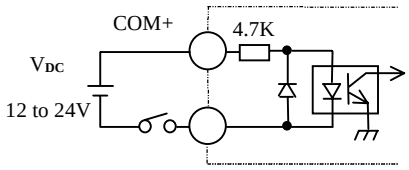
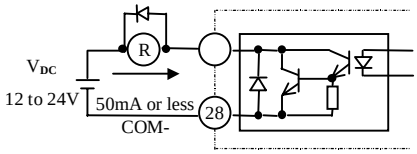
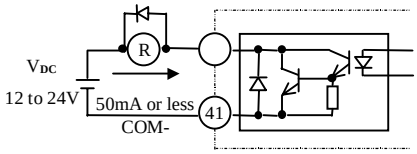
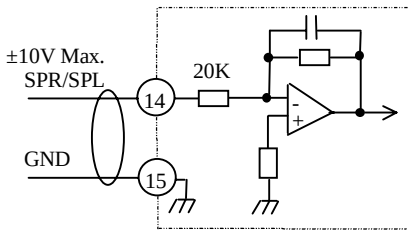
Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Speed Monitor Signal (P, V, T)	SP	All	43	16	The SP output is an analog voltage proportional to the actual motor speed or position error. This speed reference is determined from the actual speed feedback not the speed command. You can select between the motor speed and the position error setting using Parameter No.3B (Z-Series) or Parameter No. 08 (V-Series). The monitor output signal can also be re-scaled using Parameter No.08. Polarity of the monitor output is defined as follows: + signal = CCW rotation of motor viewing into the motor shaft - signal = CW rotation of motor viewing into the motor shaft This polarity cannot be changed by the user. **NOTE:** Output impedance of the SP signal is 10kΩ. Measuring instruments and circuits to which you connect the SP signal should have high input impedance. (1MΩ minimum) Related Parameters: 08, 3B	AO–1
	GND	All	45	17		
Torque Monitor Signal (P, V, T)	IM	All	42	36	The IM signal is an analog output with voltage proportional to the commanded torque (current) of the motor. Polarity of the torque monitor output is defined as follows: + signal = CCW rotation of the motor - signal = CW rotation of the motor The user cannot change this polarity. Scaling between output voltage of the torque monitor signal and the commanded motor torque is: 3V = 100% Rated Continuous Torque This signal is also available as a test point on the front of the amplifier. The torque monitor is only an approximation of motor torque. Winding tolerances of ±10% for the servomotors introduces a proportionate amount of uncertainty in the torque value reported by the IM signal. System dynamics and magnetic saturation may also result in instantaneous differences between actual and commanded torque values. **NOTE:** Output impedance of this signal is 10kΩ. Measuring instruments and circuits to which you connect this signal should have high input impedance (1MΩ minimum).	AO–1
	GND	All	45	17		

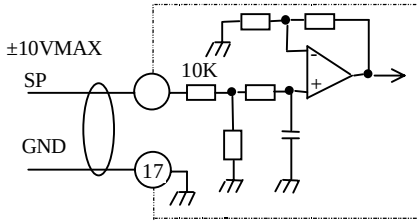
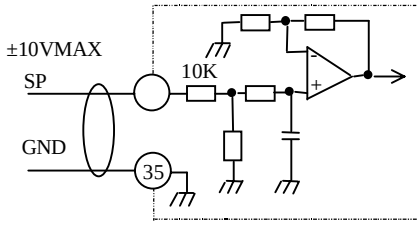
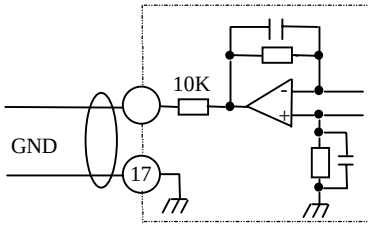
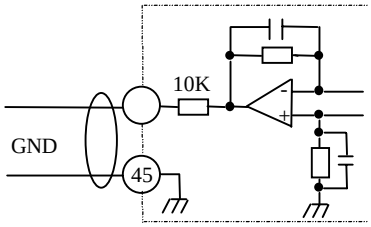
Title	Symbol	Par. 3F Z-Series	CN I/F Pin # V-Series	CN I/F Pin # Z-Series	Description	I/O Signal Interface Diagram
Pulse Command Input (P)	PULS1	All	3	6	This is a pulse command input to a high-speed photo-coupler IC for Position Control Mode. This mode is typically used for stepper emulation or simple encoder follower applications. You can select from the following pulse command types using Parameter No.29 (see Chapter 6). • Quadrature (2-phase) input (A/B-encoder) • CW (PULS)/CCW (SIGN) input • Pulse (PULS)/Direction (SIGN) input You can set a multiplication factor for the quadrature 2-phase input (multiplier of 1, 2, or 4), and select the polarity of the pulse command input using Parameters Nos.27 and 28 respectively. (see Chapter 6) **NOTE:** Input impedance of PULS and SIGN inputs is 220Ω. Related Parameters: 20,21, 22,23, 24,25,26, 27,28, 29, 36, 3C	DI–1
	PULS2	All	4	5		
	SIGN1	All	5	8		
	SIGN2	All	6	7		
A-phase Encoder Output (P, V, T)	OA+	All	21	19	The SL amplifiers include an incremental encoder output that can be used as position feedback for an external motion controller. Input pulses from the motor encoder are scaled by the Encoder Output Ratio (see Parameter Nos.0B and 0C in Chapter 6) and then fed out through the line amplifier (AM26LS31) after the scaling operation. You can select the logical sense of the B-phase or Z-phase signals relative to the A-phase signal using Parameter 0D. Related Parameters: 0B, 0C, 0D	DO–1
	OA-	All	22	20		
B-phase Encoder Output (P, V, T)	OB+	All	48	21		
	OB-	All	49	22		
Z-phase Encoder Output (P, V, T)	OZ+	All	23	1		
	OZ-	All	24	2		
	CZ	All	19	4	Open collector output of encoder marker pulse.	DO–2
Power Supply Output **(V-Series only)**	+12V	All	20	N/A	Control signal power supply output. The maximum allowable current is 20mA each for the +12V and -12V supplies.	N/A
	-12V	All	47	N/A		
	GND	All	46	N/A		
Signal Ground	GND	All	13, 15, 17, 44, 45, 46	3, 15, 17, 35	I/O signal ground	N/A
Frame Ground	FG	All	25, 50	18	Connected to the amplifier ground terminal through a 1 megohm resistor.	N/A

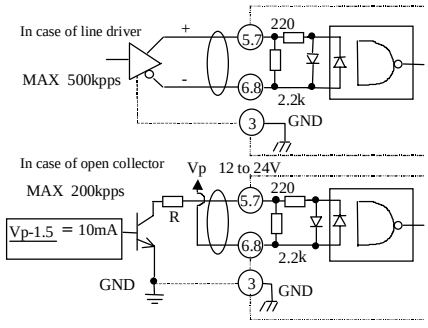
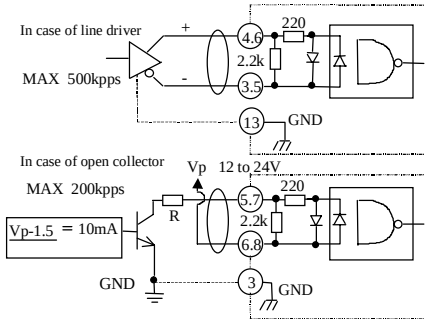
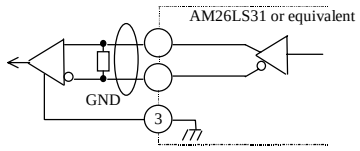
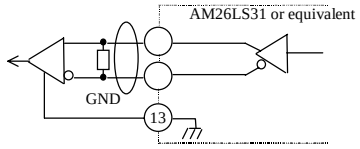
5.7.3 Input/Output Signal Interface (Circuit Diagrams)

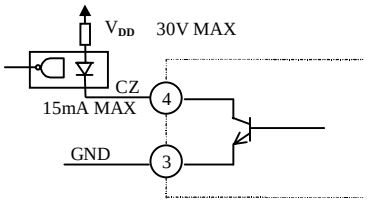
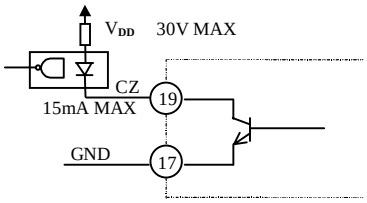
The I/O interface diagrams shown below apply to the signals as indicated in the "I/O Signal Interface" column in Table 5-2.

Table 5-3. I/O Interface Diagrams

Type	I/O Circuit Diagram	Electrical Data
I–1	**Z and V Series Amplifiers**  	1. Maximum input voltage in circuit: 26.4V 2. Minimum input voltage between COM+ and input terminal to turn the point ON: 10.2V 3. Minimum input voltage between COM+ and input terminal to turn the point OFF: 1.0V 4. Minimum input current between COM+ and input terminal to turn the point ON: 8mA 5. Maximum input current between COM+ and input terminal to turn the point OFF: 80 µA Applies to signals: SRV-ON, ZEROSP, DIV, C-MODE, GAIN, P-CON, A-CLR, CCWL, CWL, CL, INTSPD (V-Series only), INTSPD1 (Z-Series only), INTSPD2 (Z-Series only), INH
O–1	**Z Series Amplifiers**  Note: When driving a relay directly, a diode should be installed in parallel with the relay as shown. **V Series Amplifiers**  Note: When driving a relay directly, a diode should be installed in parallel with the relay as shown.	1. Maximum voltage drop when transistor output is: 1.5V or less at 50mA (maximum current) 2. Delay time of output transistor: <u>COIN output:</u> ON: 260 µs or less (V-Series) 500 µs or less (Z-Series) OFF: 260 µs or less (V-Series) 500 µs or less (Z-Series) <u>ALM and S-RDY outputs:</u> ON: 10 ms or less OFF: 10 ms or less Applies to signals: S-RDY, BRK-OFF, ZSP, ALM, COIN, TLC (V-Series only)
AI–1	**Z and V Series Amplifiers**  	1. Resolution of A/D converter: 11-bit plus sign 2. Full scale: -10.2V to +10.2V 3. Accuracy (reference data): 3% of full scale 4. Thermal drift: 5µV/°C 5. Input impedance: 20 kΩ Applies to signals: SPR/SPL

Type	I/O Circuit Diagram	Electrical Data
AI–2	**Z Series Amplifiers**  **V Series Amplifiers**  	1. Resolution of A/D converter: 11-bit plus sign 2. Full scale: -12.3V to +12.3V 3. Accaccuracy (reference data): 5% of full scale 4. Thermal drift: 10µV/°C 5. Input impedance: 10 kΩ minimum Applies to signals: CWTL, CCWTL, TRQR
AO–1	**Z Series Amplifiers**  **V Series Amplifiers**  	1. Voltage output range: SP: -8.2V to +8.2V IM: -10.2V to +10.2V 2. Resolution: 9-bit = 512 3. Output dynamic range: SP: -8.2V to +8.2V IM: -24.2V to +24.2V 4. Output impedance: 10 KΩ minimum 5. Accuracy: ± 10% or less

Type	I/O Circuit Diagram	Electrical Data
DI–1	**Z Series Amplifiers**  **V Series Amplifiers** 	1. Maximum permissible input voltage: 4.3V 2. Minimum input voltage to turn input ON: 3.5V 3. Maximum input voltage to turn input OFF: 2.2V 4. Minimum input current to turn input ON: 9mA 5. Maximum input current to turn input OFF: 250 µA Applies to signals: PULS1, PULS2, SIGN1, SIGN2
DO–1	**Z Series Amplifiers**  **V Series Amplifiers** 	Maximum output current: 14mA Applies to encoder output signals: OA+, OA-, OB+, OB-, OZ+, OZ-

Type	I/O Circuit Diagram	Electrical Data
DO–2	**Z Series Amplifiers**  **V Series Amplifiers**  	1. Maximum input voltage: 30V 2. Maximum voltage drop when transistor output is ON: 7V 3. Delay time of output transistor ON/OFF: 1µs or less 4. Maximum output current: 15mA Applies to encoder marker open collector output signal CZ

Chapter 6 Configuration Parameters

6.1 Overview of Configuration Parameters and Default Settings

The SL Series amplifiers have parameters which may be used to set/adjust various features and functions. You can view or adjust these parameters using either the keypad/display on the front of the amplifier or using the *Slconfig* software on a personal computer. The Z-Series amplifiers support parameters through 3F while the V-Series amplifiers support parameters through 2F. Parameters above that range are system parameters that are for factory use only. System parameters are read only and cannot be changed.

6.2 Parameter Overview Table and Default Values

The following table is a condensed listing of the parameters. Please refer to section 6.3 for more detailed information about each parameter. Some of the parameters are applicable to only one series (Z-Series or V-Series) and the adjustment range and factory default settings may vary by amplifier series.

Table 6-1. Configuration Parameters

Para. No.	Parameter Description	Control Mode (Note 1)	Z-Series Amplifiers (30-750 Watt Models)		V-Series Amplifiers (1 – 5 kW Models)	
			Range	Default	Range	Default
00	Axis Address	T/V/P	0-31	0	0 – 9	0
01	Power-up Display Options	T/V/P	0-3	1	0 – 2	1
02	Control Mode Selection	T/V/P	0-5	1	0 - 5	1
03	Velocity Loop Gain	V/P	25-3500 Hz	100	25 – 3500 Hz	100
04	Velocity Loop Integration Time Constant	V/P	1-1000 [ms]	50	1 – 1000 [ms]	50
05	Velocity Feedback Filter	T/V/P	0-7	4	0 - 4	4
06	Torque Limit (%)	T/V/P	0 – 400	300	0 – 400	300

Para. No.	Parameter Description	Control Mode (Note 1)	Z-Series Amplifiers (30-750 Watt Models)		V-Series Amplifiers (1 – 5 kW Models)	
			Range	Default	Range	Default
07	Torque Limit Inhibit	V/P	0-1	1	0-1	1
08	Speed Monitor Scaling	T/V/P	0-1	0	0 - 3	0
09	Overtravel Input Inhibit	T/V/P	0-1	1	0-1	1
0A	Dynamic Brake Mode Selection	T/V/P	0-1	0	0 - 3	0
0B	Numerator of Encoder Output Ratio	T/V/P	1-10000	2500	1 - 10000	2500
0C	Denominator of Encoder Output Ratio	T/V/P	1-10000	2500	1 – 10000	2500
0D	Encoder Output Signal Inversion	T/V/P	0 - 3	3	0 - 3	3
0E	Brake Output Delay Time-Stopped Motor	T/V/P	0-100	0	0-100	0
0F	Brake Output Delay Time-Moving Motor	T/V/P	0-100	0	N/A	N/A
10	Acceleration Rate Limit	V	0-5000	0	0 – 5000	0
11	Zero Speed Detection Level	T/V	0-10000 [RPM]	50	0-10000 [RPM]	50
12	At-Speed Output Detection Level	T/V	0-10000 [RPM]	1000	0 – 10000 RPM	1000
13	Velocity Command Scaling	T/V	10-2600	500	10 – 2600	225
14	Velocity Command Polarity	T/V	0-1	1	0-1	1
15	Velocity Command Offset	T/V	-127 to 127	0	-127 to 127	0
16	Internal/External Velocity Command Selection	T/V	0-2	0	0-1	0
17	Zero-Speed Clamp Inhibit	T/V	0-1	1	0-1	1
18	1st Internal Speed	T/V	-7000 to 7000	0	-7000 to 7000	0
19	2nd Internal Speed	T/V	-7000 to 7000	0	-7000 to 7000	0
1A	Torque Command Scaling	T	25 – 2500	225	25 – 2500	225
1B	Torque Command Polarity	T	0-1	1	0-1	1
1C	Torque Command Offset	T	-127 to 127	0	-127 to 127	0
1D	Torque Command Filter	T/V/P	0 – 2500	0	0 – 2500	0
1E	not used	-	-	-	-	-
1F	Deceleration Rate Limit (Z-Series only)	V	0-5000	0	N/A	N/A
20	Position Loop Gain	P	10-1000 [rad/s]	50	10-1000 [rad/s]	20
21	Velocity Feed Forward	P	0-100 [%]	0	0-100 [%]	0
22	In-Position Output Detection Range	P	0-32766 [Pulses]	10	0-32766 [Pulses]	10
23	Position Error Limit	P	1-32766	30000	1-32766	30000
24	Position Error Limit Inhibit	P	0-1	0	0-1	0
25	Numerator of Pulse Command Ratio	P	1-10000	10000	1-10000	10000

Para. No.	Parameter Description	Control Mode (Note 1)	Z-Series Amplifiers (30-750 Watt Models)		V-Series Amplifiers (1 – 5 kW Models)	
			Range	Default	Range	Default
26	Denominator of Pulse Command Ratio	P	1-10000	10000	1-10000	10000
27	Quadrature Pulse Input Multiplier	P	1-4	4	1-4	4
28	Pulse Command Input Polarity	P	0-3	0	0-3	0
29	Pulse Command Input Mode	P	0-3	1	0-3	1
2A	not used	-	-	-	-	-
2B	Velocity Feedforward Filter Time Constant	P	0-6400	0	0-6400	0
2C	not used	-	-	-	-	-
2D	(internal use)	-	-	-	-	-
2E	(internal use)	-	-	-	-	-
2F	(internal use)	-	-	-	-	-
30	2nd Velocity Loop Gain	V/P	25 – 3500	100	N/A	N/A
31	2nd Velocity Loop Integration Time Constant	V/P	1 – 1000	50	N/A	N/A
32	2nd Position Loop Gain	P	10 – 1000	50	N/A	N/A
33	2nd Gain Switching Mode	V/P	0 – 2	0	N/A	N/A
34	Automatic Gain Switching Delay Time	V/P	0 – 10000	10000	N/A	N/A
35	2nd Numerator of Pulse Command Ratio	P	1 – 10000	10000	N/A	N/A
36	Pulse Command Filter Delay	P	0 – 5	3	N/A	N/A
37	Jog Speed	T/V/P	0-500	300	N/A	N/A
38	3rd Internal Speed (Z-Series only)	T/V	-7000 to 7000	0	N/A	N/A
39	4th Internal Speed (Z-Series only)	T/V	-7000 to 7000	0	N/A	N/A
3A	(internal use)	-	-	-	-	-
3B	Analog Monitor Mode Selection	T/V/P	0-1	0	N/A	N/A
3C	Position Error Counter Clear Mode	P	0-1	0	N/A	N/A
3D	Alarm Action Selection	T/V/P	0-3	0	N/A	N/A
3E	Servo Disable Action Selection	T/V/P	0-7	0	N/A	N/A
3F	CN I/F Function Selection	T/V/P	0-5	0	N/A	N/A

Notes:

1. Symbols used in the Control Mode column refer to the amplifier control mode configured using Parameter No. 02 and are defined as follows:

T = Torque control mode

V = Velocity control mode

P = Position control mode

6.3 Details of User Parameters

The following table provides detailed descriptions of the functions of each user parameter. Parameters may be viewed or changed using either the amplifier keypad/display or with a personal computer running the *SLconfig* software.

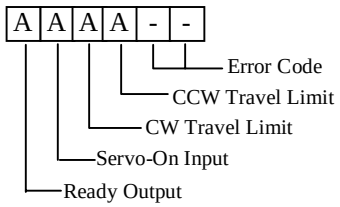
Note

When using a PC with the V-Series amplifiers the serial connection must be made before the amplifier is energized or the PC connection will not be recognized. Also, once connected to a PC the front panel keypad/display on the amplifier becomes inoperative and the display indicates "H-232C". Neither of these restrictions applies to the Z-Series amplifiers.

Default parameter options are shown in bold or are listed at the bottom of each parameter description.

Table 6-2. User Parameters

Parameter No.	Parameter Description	Adjustment Range	Function
0 0	Axis Address	Z-Series: 0-31 V-Series: 0-9	This parameter is a **future** provision to allow the user to set a node address for each SL Series amplifier on a multi-drop serial network when using a PC to configure multiple axes. This setting does not affect any servo operation and is not currently used other than as a reference to the user that may be used to differentiate multiple configuration files. (Default = 0)

Parameter No.	Parameter Description	Adjustment Range	Function
0 1	Power-up Display Options	Z-Series: 0-3 V-Series: 0-2	This parameter is used to select the type of data displayed on the amplifier LED display when you first apply power. 0 = Displays the value of the position error counter Range of display is –32767 to +32767 quadrature encoder pulses. If the error counter value exceeds this range, the display holds the respective upper or lower limit of the range. Display Polarity: (+) = CCW position error viewing into motor shaft (-) = CW position error viewing into motor shaft **1 = Displays the motor actual speed in RPM** Display Polarity: (+) = CCW motor rotation viewing into motor shaft (-) = CW motor rotation viewing into motor shaft 2 = Displays the commanded motor torque Range of display is -1500 to 1500 (Displayed value)x 0.2 = Commanded Torque (% of rated cont. torque) Example: If the displayed value is "+1500", the motor generates 300% of rated continuous torque in the CCW direction. Display Polarity: (+) = CCW torque viewing into motor shaft (-) = CW torque viewing into motor shaft 3 = Z-Series only display of Servo-On State/Error Code (A) = Active (-) = Not Active  **NOTES:** 1) When the polarity of the displayed value is positive the “+” sign will not be displayed. 2) The polarity of the display cannot be changed. The display will show a positive value when the motor is rotating Counter Clockwise and a negative value when the motor is rotating Clockwise, regardless of the setting of Parameter No. 14 – Velocity Command Polarity or Parameter No. 1B – Torque Command Polarity. 3) For the V-Series amplifiers the keypad/display is disabled when a PC is connected to the serial port at power-up (Default = 1)

Parameter No.	Parameter Description	Adjustment Range	Function
0 2	Control Mode Selection	0-5	This parameter is used to select the control mode from the following options: Single Mode: 0 = Position Control Mode (pulse command) **1 = Velocity Control Mode (analog command)** 2 = Torque Control Mode (analog command) Dual Mode: 3 = Position (1st.) / Velocity (2nd.) Control Mode 4 = Position (1st.) / Torque (2nd.) Control Mode 5 = Velocity (1st.) / Torque (2nd.) Control Mode When one of the dual modes (option 3, 4, or 5) is selected, you can select either the 1st. or 2nd. control mode using the Control Mode Select input (C-MODE) as follows: When C-MODE is not connected to COM-, the 1st control mode is active. When C-MODE is connected to COM-, the 2nd control mode is active. **NOTES:** 1) C-MODE should only be changed when the motor is at complete stop. Do not change control modes on the fly (see section 5.7.2 for more information on the C-MODE input). 2) When using SL amplifiers with GE Fanuc motion controllers such as the APM300 or DSM300, the default mode should be used. (Default = 1)
0 3	Velocity Loop Gain	25-3500 Hz	Adjusts the proportional and integral gain of the velocity amplifier. Larger gain values provide better servo response. Optimum value of the Velocity Loop Gain depends on the load inertia and the motor model. A value between 125 and 1000 Hz is typical depending on the stiffness of the machine mechanics and the ratio of load to motor inertia. Refer to Chapter 7 for additional details on tuning the amplifier. (Default = 100)
0 4	Velocity Loop Integration Time Constant	1-1000 (ms)	Integration time constant of the speed amplifier. Smaller values yield faster integration and lower following error. Values between 20 and 80 are typical. Refer to Chapter 7 for details on tuning the amplifier. **NOTE:** When set to the maximum value (1000), the integration time constant becomes infinite and the integration function is disabled. (Default = 50)

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>0 5</td><td>Velocity Feedback Filter</td><td>Z-Series:
0-7

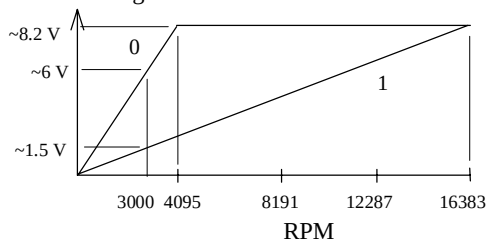
V-Series:
0-4</td><td>You can select the time constant of the digital low pass filter for the velocity feedback signal. Larger values reduce noise from the motor but reduce servo response (bandwidth) as shown in the table below.
We recommend you to set this to "4" unless you need high servo response.

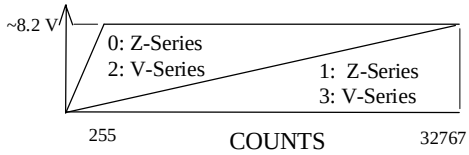
Filter Cutoff Frequency (Hz):
<table><tr><th rowspan="2">Series</th><th colspan="8">Parameter No. 05 Setting</th></tr><tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr><tr><td>Z-Series</td><td>-</td><td>1250 Hz</td><td>770 Hz</td><td>520 Hz</td><td>480 Hz</td><td>390 Hz</td><td>370 Hz</td><td>300 Hz</td></tr><tr><td>V-Series</td><td>-</td><td>1200 Hz</td><td>740 Hz</td><td>550 Hz</td><td>460 Hz</td><td>n/a</td><td>n/a</td><td>n/a</td></tr></table>
(Default = 4)</td></tr>
<tr><td>0 6</td><td>Torque Limit</td><td>0-400 (%)</td><td>The SL Series amplifiers are designed to output a maximum torque of 300% of the rated continuous torque for short periods of time. You can limit this maximum torque to a smaller value when required by the application.
The value is set as a percentage of the rated continuous torque (i.e. rated continuous torque = 100%).
Example: When the parameter setting is "200", permissible output torque is 200% (2 times) of the rated continuous torque.
For V-Series amplifiers the In-Torque-Limit output (TLC) is activated when the torque command exceeds the value set by this parameter. The TLC output is not available on Z-Series amplifiers.
NOTE: You cannot set a higher value than the factory set value configured by System Parameter No.66 (maximum output torque setting) for Z-Series amplifiers or System Parameter No.36 for V-Series amplifiers. Typically this value is 300%. If you set a higher value, the maximum output torque will be automatically adjusted to the value of the factory setting and a Parameter Range Error (Error Code 84) will be initiated (see Chapter 9).
(Default = 300)</td></tr>
<tr><td>0 7</td><td>Torque Limit Inhibit</td><td>0 - 1</td><td>This parameter disables the analog torque limit inputs (CWTL and CCWTL) on the CN I/F connector.
0 = Torque limit inputs are enabled (Position or Velocity Control Mode must be selected by Parameter No. 02).
1 = Torque limit inputs are disabled (Torque Control Mode must be selected by Parameter No.02).
NOTE: On the Z-Series, the torque command input (TRQR) and the CCWTL torque limit input share the same pin on the CN I/F connector and are mutually exclusive functions. This parameter determines which function is active on the connector.
NOTE: This parameter is not used in Torque Control Mode.

See Section 5.7.2 for details on the CWTL and CCWTL inputs.
(Default = 1)</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>0 8</td><td>Speed Monitor Scaling</td><td>Z-Series:
0-1

V-Series:
0-3</td><td>
Sets the full-scale value of the Speed/ Position Error Monitor signal (SP) connected to CN I/F pin 16 (Z-Series) or pin 43 (V-Series). For the Z-Series amplifiers, Parameter 3B is used to select the monitor function, while in the V-Series amplifiers, both scaling and function of the monitor are set by this parameter.
Z-Series:
<table>
<tr><th>Function</th><th>Scaling</th><th>Para. 08</th><th>Para. 3B</th></tr>
<tr><td rowspan="2">Motor Speed</td><td>4095 RPM</td><td>0</td><td>0</td></tr>
<tr><td>16383 RPM</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Position Error</td><td>255 Counts</td><td>0</td><td>1</td></tr>
<tr><td>32767 Count</td><td>1</td><td>1</td></tr>
</table>
V-Series:
<table>
<tr><th>Function</th><th>Scaling</th><th>Para. 08</th></tr>
<tr><td rowspan="2">Motor Speed</td><td>4095 RPM</td><td>0</td></tr>
<tr><td>16383 RPM</td><td>1</td></tr>
<tr><td rowspan="2">Position Error</td><td>255 Counts</td><td>2</td></tr>
<tr><td>32767 Counts</td><td>3</td></tr>
</table>
If the factory default setting of 4095 RPM full scale is insufficient, set the parameter to "1" to increase the monitor range.
Relationship between the position error in counts (quadrature encoder pulses) and the monitor output voltage is described in the following diagram:

Speed Monitor Scaling:


Position Error Monitor Scaling:


NOTE: Counts refers to quadrature encoder pulses (10,000 PPR).
(Default = 0)
</td></tr>
</table>

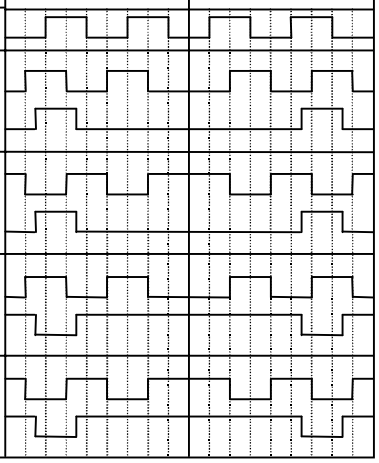
<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>0 9</td><td>Overtravel Input Inhibit</td><td>0-1</td><td>This parameter is used to disable the CW inhibit input (CWL) and CCW inhibit input (CCWL) on the servo interface connector CN I/F.
0 = Enable overtravel inputs
1 = Disable the overtravel inputs

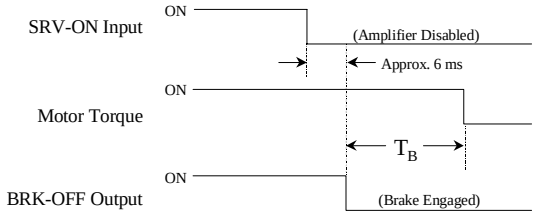
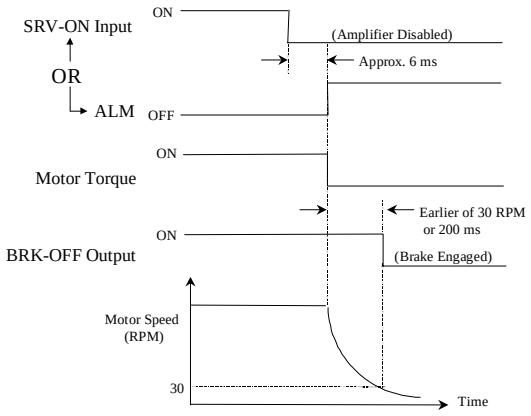
NOTE: If both CWL and CCWL inputs are open, the amplifier trips due to a CW/CCW overtravel input error (Error Code 38).
(Default = 1)</td></tr>
<tr><td>0 A</td><td>Dynamic Brake Mode Selection</td><td>Z-Series:
0 – 1

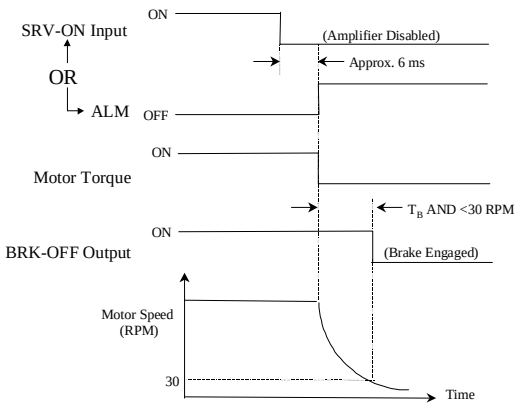
V-Series:
0-3</td><td>Enables/disables the dynamic brake function when the CW overtravel limit input (CWL) or the CCW overtravel limit input (CCWL) is activated. For the V-Series amplifiers this parameter also determines the braking action when the amplifier enable input (SRV-ON) is deactivated. Braking action when the servo is disabled is set for the Z-Series amplifiers using Parameter No. 3E. See Section 2.3 for more details on the dynamic brake function.

Z-Series Amplifiers:
<table><tr><th>Para. 0A</th><th>Braking Action when CWL/ CCWL Activated</th></tr><tr><td>0</td><td>Activate dynamic brake to stop motor</td></tr><tr><td>1</td><td>Motor coasts to a stop</td></tr></table>V-Series Amplifiers:
<table><tr><th rowspan="2">Parameter 0A Setting</th><th colspan="2">Braking Action</th></tr><tr><th>CWL/CCWL Input Activated</th><th>Servo Disabled or Alarm Activated</th></tr><tr><td>0</td><td>Brake to a stop</td><td rowspan="2">Brake to a stop and keep brake active after stop</td></tr><tr><td>1</td><td>Coast to a stop</td></tr><tr><td>2</td><td>Brake to a stop</td><td rowspan="2">Brake to a stop then disable dynamic brake</td></tr><tr><td>3</td><td>Coast to a stop</td></tr></table>Note: During a power loss to the amplifier the dynamic brake is activated to stop the motor and remains active after the motor has stopped.
(Default = 0)</td></tr>
<tr><td>0 B</td><td>Numerator of Encoder Output Ratio</td><td>1 - 10000</td><td>The SL Series amplifiers allow the standard 2500 PPR encoder resolution to be reduced by setting the numerator and denominator of the encoder output ratio. This ratio effects only the encoder output signals available on connector CN I/F.
This parameter sets the numerator of the scaling ratio for the encoder output signals. (See Parameter No.0C for more details on the ratio function.)
(Default = 2500)</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>0 C</td><td>Denominator of Encoder Output Ratio</td><td>1 - 10000</td><td>
This parameter sets the denominator of the scaling ratio for the encoder output signals available on connector CN I/F. Parameter 0B sets the numerator for this ratio. The formula below shows the general relationship between the parameters and the ratio.
$$\text{Scaling Ratio} = \frac{\text{Para.0B}}{\text{Para.0C}} \leq 1$$
NOTE: Due to the nature of the SL encoder-scaling algorithm only certain resolutions can be realized. The table below shows the resolutions and associated ratios that can be used. Resolution values between those shown in the table may cause unexpected operation and should not be used.
<table>
<tr><th>Desired Encoder Output Resolution (Lines)</th><th>Ratio</th><th>Numerator (Para. No 0B)</th><th>Denominator (Para. No. 0C)</th></tr>
<tr><td>2500 (default)</td><td>1</td><td>2500</td><td>2500</td></tr>
<tr><td>2000</td><td>0.8</td><td>2000</td><td>2500</td></tr>
<tr><td>1667</td><td>0.66</td><td>1667</td><td>2500</td></tr>
<tr><td>1429</td><td>0.572</td><td>1429</td><td>2500</td></tr>
<tr><td>1250</td><td>0.5</td><td>1250</td><td>2500</td></tr>
<tr><td>1111</td><td>0.444</td><td>1111</td><td>2500</td></tr>
<tr><td>1000</td><td>0.4</td><td>1000</td><td>2500</td></tr>
<tr><td>909</td><td>0.363</td><td>909</td><td>2500</td></tr>
<tr><td>833</td><td>0.333</td><td>833</td><td>2500</td></tr>
<tr><td>769</td><td>0.308</td><td>769</td><td>2500</td></tr>
<tr><td>714</td><td>0.286</td><td>714</td><td>2500</td></tr>
<tr><td>667</td><td>0.267</td><td>667</td><td>2500</td></tr>
<tr><td>625</td><td>0.25</td><td>625</td><td>2500</td></tr>
</table>
NOTES:
1) A scaling ratio less than or equal to 1 must be used. This function can not increase encoder output signal resolution.
2) Do not set a large ratio (such as 1/10000). We recommend you set a ratio between 1/32 and 1.
3) When you use the scaling ratio the marker pulse (Z-phase) is only synchronized with the A-phase pulse when the ratio is equal to 1. As a result, mis-positioning may occur in applications that set the home reference position using a logical AND function of the A-phase and Z-phase signals.
CAUTION: Scaling ratios other than 1 effect the relative duty cycle of the A-phase and B-phase encoder output signals. GE Fanuc Motion Mate APM300 and DSM300 series controllers use encoder error detection that requires a minimum time between relative transitions between the A-phase and B-phase encoder signals to insure proper detection of all pulses. Ratio values above 0.5 (resolutions > 1250 PPR) may result in an “Encoder Quadrature Error” on the motion controller at high motor speeds. The table below shows the maximum motor speed that may be used for each controller for a given
</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td></td><td></td><td></td><td>resolution.
<table>
<tr><td rowspan="2">Value</td><td colspan="2">Desired Encoder Output Resolution (PPR)</td></tr>
<tr><td>≤ 1250</td><td>1429 to 2500</td></tr>
<tr><td>Ratio</td><td>≤ 0.5</td><td>0.572 to 1</td></tr>
<tr><td>APM300 Max. Speed (RPM)</td><td>5000</td><td>2285</td></tr>
<tr><td>DSM300 Max. Speed (RPM)</td><td>5000</td><td>3475</td></tr>
</table>
(Default = 2500)</td></tr>
<tr><td>0 D</td><td>Encoder Output Signal Inversion</td><td>0 – 3</td><td>This parameter sets the phase relationship of the encoder output signals available on connector CN I/F. The B-phase and Z-phase (marker pulse) can be inverted relative to the fixed A-phase signal.
The table below represents each phase relation for CW and CCW rotation of the motor as viewed looking into the shaft.
<table>
<tr><td>Para.0D</td><td>Encoder Signal</td><td>CCW Motor Rotation</td><td>CW Motor Rotation</td></tr>
<tr><td></td><td>OA</td><td rowspan="2">  </td><td rowspan="2"></td></tr>
<tr><td>0</td><td>OB non-invert
OZ non-invert</td></tr>
<tr><td>1</td><td>OB inverted
OZ non-invert</td><td></td><td></td></tr>
<tr><td>2</td><td>OB non-invert
OZ inverted</td><td></td><td></td></tr>
<tr><td>3</td><td>OB inverted
OZ inverted</td><td></td><td></td></tr>
</table>
NOTE: This parameter has no effect on the motor encoder feedback signals wired to connector CN SIG.
(Default = 3)</td></tr>
</table>

Parameter No.	Parameter Description	Adjustment Range	Function
0 E	Brake Output Delay Time - Stopped Motor	0 – 100	On axes using the optional motor brake, this parameter controls the time (T_B) used to delay removal of motor torque when the amplifier is disabled (SRV-ON deactivated) to compensate for motor brake response time. Since mechanical brakes have a finite response time (armature pull-in time) to engage once power to the brake coil is removed, the SL Series amplifiers allow you to configure this time delay to maintain power on the motor for a short time, allowing the brake to engage. This is particularly important on vertical axes to prevent the axis from falling due to gravity while the brake is being engaged. See Chapter 2 for brake engagement time values. The SL Series amplifiers BRK-OFF output signal can be used to control an optional mechanical brake mounted inside the motor (see section 5.7.2 for more detail on the BRK-OFF signal). Time delay T_B is the approximate time between the deactivation of the BRK-OFF output (engaging the brake) and the removal of power from the motor as shown in the timing diagram below. This value should be set to a value approximately 10% higher than the engagement (armature pull-in time) for the particular motor brake. The relationship between the parameter value and the delay time (T_B) is: T_B (ms) = 2.1 (Set Value) **Motor Stopped:**  **Motor Moving (V-Series only):** If a V-Series amplifier is disabled or a fault occurs (ALM) while the motor is moving, the BRK-OFF output is turned OFF (Brake engaged) either when the motor speed falls below 30 RPM or 200 ms has elapsed (whichever occurs first) as shown in the diagram below. In this case the T_B delay time is <u>not</u> used. 

Parameter No.	Parameter Description	Adjustment Range	Function
			NOTES: 1) This delay is used only when the motor is stopped. For Z-Series amplifiers, Parameter 0F controls the BRK-OFF output action for a running motor. 2) This function is available on Z-Series amplifiers only if Parameter No. 3F is set to a value of 1, 2, 3 or 4. 3) SL motor brakes are a spring-set (fail-safe) type that must be energized to release the brake. When the BRK-OFF output is active, the motor brake is disengaged. 4) If a fault occurs which disables the amplifier while the motor is stopped, the BRK-OFF signal will be immediately turned OFF without the T_B delay. 5) There is approximately a 40 ms delay from the time an amplifier is enabled (SRV-ON activated) before torque is applied to the motor and the BRK-OFF output is activated. (Default = 0)
0 F (Z-Series only)	Brake Output Delay Time – Moving Motor	0 – 100	If a Z-Series amplifier is disabled (SRV-ON input deactivated) or if a fault (ALM) occurs while the motor is moving, the amplifier will dynamically brake the motor to a stop. (see section for Parameter 0A for more information on dynamic braking) For axes using an optional motor brake this parameter sets a delay time (T_B) for activating the BRK-OFF output used to control the motor brake. The BRK-OFF output will be turned OFF (brake engaged) after a time delay of T_B from the time the amplifier motor output is disabled as long as the motor speed is below approximately 30 RPM. If time T_B has elapsed and the motor speed is still higher than 30 RPM, the BRK-OFF output will remain ON until the speed drops below the threshold. This prevents damage to the motor brake. The relationship between the parameter value and T_B time delay is: T_B (ms.) = 2 (set value) The timing diagram for this function is shown below:  **NOTE:** This function is available on Z-Series amplifiers only if Parameter No. 3F is set to a value of 1, 2, 3 or 4. (Default = 0)

Parameter No.	Parameter Description	Adjustment Range	Function
1 0	Z-Series: Acceleration Rate Limit V-Series: Acceleration/ Deceleration Rate Limit	0 – 5000	You can set an acceleration rate limit (and deceleration rate limit for V-Series amplifiers) for the Velocity Control Mode (see Parameter No. 02) using this parameter. Deceleration rate limit for the Z-Series amplifiers is set independently using Parameter No. 1F. The relationship between the set value and the acceleration time is as follows: Set value = (Seconds/1000 RPM) x 500 Example: You want to accelerate from 0 RPM to 3000 RPM in 0.3 seconds. Then: Set value = (0.3 s / 3 kRPM) x 500 = 50 **NOTES:** 1) The acceleration limit function is not valid for the Position Control Mode or Torque Control Mode. 2) Do not use the acceleration limit function for the Velocity Control Mode if you are controlling the SL servo with an external position controller such as the GE Fanuc Motion Mate APM300 or DSM300 or servo instability may occur. (Set this parameter to "0" when used with an external position controller.) (Default = 0)
1 1	Zero Speed Detection Level	0 to 10000 (RPM)	Set the detection level of the Zero-Speed output (ZSP) directly in units of motor speed (RPM). If the motor speed is less than or equal to the set value, the ZSP output will be turned ON. The minimum detectable motor speed is 20 RPM. (See section 5.7.2 for more information on the ZSP output.) **NOTE:** The ZSP output is available on the Z-Series amplifiers only when Parameter No. 3F=5. When used with a GE Fanuc APM or DSM motion controller this function is not available since the Servo Ready (SRV-RDY) function is selected (Parameter No. 3F = 0). (Default = 50)
1 2	At-Speed Output Detection Level	0 – 10000 RPM	For Velocity Control Mode or Torque Control Mode (see Parameter No. 02), this parameter sets the detection level of the At-Speed output (COIN). The COIN signal will be turned ON when the motor speed exceeds the set value (RPM). **NOTE:** Since the COIN output is not used as an At-Speed signal for the Position Control Mode, this parameter is invalid for the Position Control Mode. (See Parameter No. 22 and Section 5.7.2 for more information on the COIN output.) (Default = 1000)

Parameter No.	Parameter Description	Adjustment Range	Function
1 3	Velocity Command Scaling	10 – 2600	This parameter sets the analog velocity command (SPR) input gain (relationship between the motor speed and the velocity command voltage). The method used to calculate the value depends on the amplifier series as follows: Z-Series: Set value = (desired motor RPM/ Max. Command Volts) V-Series: Set value = 0.45 x (desired motor RPM/ Max. Command Volts) Example: Maximum motor speed of 5000 RPM using a 10V command input for a V-Series amplifier: Parameter value = 0.45 x (5000 RPM/10 V) = 225 For Torque Control Mode (Z and V-Series): Either the Analog Velocity Command or the Internal Speed Commands must be used to configure a maximum speed limit for the servo. When approaching the speed limit, the motor torque decreases linearly to zero starting approximately 90 RPM before the speed limit is reached. The analog command can be used to dynamically vary the velocity limit or the different internal speed commands may be selected as described above to provide several discrete velocity limits. **NOTE:** When using the SL amplifier in a Velocity Control Mode with an external position controller, changing this parameter affects the distribution of loop gains and may cause servo instability (oscillation). (Default = 500 for Z-Series and 225 for V-Series amplifiers)
1 4	Velocity Command Polarity	0-1	This parameter is used to reverse the motor rotational direction for a given polarity of the analog velocity command input (SPR). 0 = Motor rotates CW with a (+) speed command **1 = Motor rotates CCW with a (+) speed command** **NOTES:** 1) When using the servo with an external position controller, be sure to match the polarity of the speed command input to the position controller to prevent errors. (See section 2.2 for rotational direction conventions) 2) When using an SL Series amplifier with a GE Fanuc APM300 or DSM300 motion controller the *Motor Direction* configuration parameter for these controllers MUST be set as POSITIVE in the APM/DSM hardware configuration for the system to function properly.

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td></td><td></td><td></td><td>(Default = 1)</td></tr>
<tr><td>1 5</td><td>Velocity Command Offset</td><td>-127 to 127</td><td>This parameter is used to make an offset adjustment for the analog velocity command input (SPR). This parameter is only valid for the Velocity and Torque Control Modes.
To make the offset adjustment, apply exactly zero volts to the velocity command input from the command source, or connect SPR to signal GND.
Adjust the value to minimize motor rotation (drift). Note that because of the resolution of this adjustment, you may not be able to eliminate all motor drift.
(Default = 0)</td></tr>
<tr><td>1 6</td><td>Internal/ External Velocity Command Selection</td><td>Z-Series: 0-2

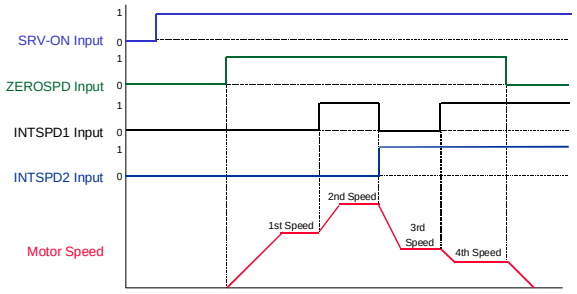
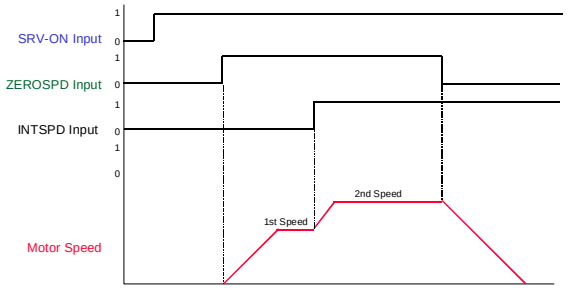
V-Series: 0-1</td><td>Velocity Control Mode:
This parameter selects between the analog velocity command input (SPR) and internal preset speed commands set using other parameters.
Torque Control Mode:
In torque mode the SL amplifiers require the user to configure a maximum velocity using either the analog velocity limit input (SPL) or the internal speed commands (INTSPD). When in torque mode, this parameter determines which source will be used to set this velocity limit (see the note below for more information).

The internal speed command function works differently between the Z-Series and V-Series amplifiers as described below.

Z-Series Amplifiers:
Z-Series amplifiers support four internal speed presets that are set using Parameter Nos. 18, 19, 38, 39. The four internal speed commands are selected based on the logical state of the ZEROSPD, INTSPD1 and INTSPD2 control inputs on the CN I/F connector as shown in the timing diagram below. The acceleration rate for the internal speed commands is set using Parameter No. 10 and the deceleration rate is set using Parameter No. 1F.
The INTSPD1 and INTSPD2 inputs are active only when Parameter 3F is set to 4 or 5 (see section 5.7.1).
The source of the speed command is selected as follows (see table):

0 = Enable analog velocity command only
1 = Enable 4 internal speed commands
2 = Enable first 3 internal speed commands and analog velocity command

<table>
<tr><th rowspan="2">INTSPD1</th><th rowspan="2">INTSPD2</th><th colspan="3">Parameter No. 16 Set Value</th></tr>
<tr><th>0</th><th>1</th><th>2</th></tr>
<tr><td>OFF</td><td>OFF</td><td>Analog Cmd.</td><td>Int. Speed 1</td><td>Int. Speed 1</td></tr>
<tr><td>ON</td><td>OFF</td><td>Analog Cmd.</td><td>Int. Speed 2</td><td>Int. Speed 2</td></tr>
<tr><td>OFF</td><td>ON</td><td>Analog Cmd.</td><td>Int. Speed 3</td><td>Int. Speed 3</td></tr>
<tr><td>ON</td><td>ON</td><td>Analog Cmd.</td><td>Int. Speed 4</td><td>Analog Cmd.</td></tr>
</table>
OFF = Open to COM-
ON = Connected to COM-</td></tr>
</table>

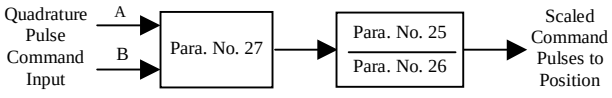
Parameter No.	Parameter Description	Adjustment Range	Function
			 **V-Series Amplifiers:** V-Series amplifiers support two internal speed presets set using Parameter No.18 and 19. The preset speed commands are selected based on the logical state of the ZEROSPD and INTSPD control inputs on the CN I/F connector as shown in the timing diagram below. The source of the speed command is selected as follows: **0 = Enable analog speed command** 1 = Enable internal speed commands The acceleration/deceleration rate used with internal speed commands is set using Parameter No. 10.  **NOTE:** When configured for Torque Control Mode (Z and V-Series), either the Analog Velocity Command or the Internal Speed Commands must be used to configure a maximum speed limit for the servo. When approaching the speed limit, the motor torque decreases linearly to zero starting approximately 90 RPM before the speed limit is reached. The analog command can be used to dynamically vary the velocity limit while the different internal speed commands (INTSPD) may be selected as described above to provide several discrete velocity limits. (Default = 0)

Parameter No.	Parameter Description	Adjustment Range	Function
1 7	Zero Speed Clamp Inhibit	0-1	This parameter enables/disables the zero speed clamp input (ZEROSPD) as follows: 0 = ZEROSPD input is enabled **1 = ZEROSPD input is disabled** **NOTES:** 1) As described in Section 5.7.2, the ZEROSPD input is active when not connected to the COM-. Therefore, if this parameter is set to "0" and the ZEROSPD input is OPEN, the zero-speed clamp is active and the motor will not rotate. A motor that is moving at the time the ZEROSPD input is activated will decelerate under servo loop control to a stop and will be held at zero speed. Parameter No. 10 sets the deceleration rate for the V-Series and Parameter No. 1F sets the deceleration rate for the Z-Series. 2) The ZEROSPD input is also is used to enable the internal speed commands (INTSPD) as described in Parameter No.16.
1 8	1st Internal Speed	-7000 to 7000 (RPM)	When the Internal Speed Command becomes valid (see Parameter No. 16), the first preset speed Internal Speed 1 is set using the following formula: **Z-Series Amplifiers:** Set value = Internal Speed 1 (RPM) **V-Series Amplifiers:** Set value = Internal Speed 1 (RPM)/ 2.88 **NOTE:** Polarity of the value indicates the following motor direction of rotation: (+) = Motor rotates CCW, viewing into the motor shaft (-) = Motor rotates CW, viewing into the motor shaft (See section 2.2 for rotational direction conventions.) (Default = 0)
1 9	2nd Internal Speed	-7000 to 7000 (RPM)	Set Internal Speed 2 in the same way as the first internal speed (see parameter No.18). (Default = 0)
1 A	Torque Command Scaling	25 to 2500	Sets the torque command (TRQR) input gain (relationship between the generated motor torque and the torque command input voltage) when operating in the Torque Control Mode (see Parameter No. 02 for control modes). The set value is determined using the following formula: $\text{Set value} = \frac{7.5 \times \text{Max Torque Required as a \% of Rated Cont. Torque}}{\text{Max. Command Input Voltage}}$ Example: If you want to obtain peak torque (300% of rated continuous torque) with a torque command input of 10 Volts: $\text{Set value} = \frac{7.5 \times 300\%}{10 \text{ Volts}} = 225$ **NOTE:** The actual value of torque generated at the motor shaft can vary as much as +/-10% from motor to motor based on winding variation tolerances, magnetic saturation, and temperature variances in the motor. (Default = 225)

Parameter No.	Parameter Description	Adjustment Range	Function
1 B	Torque Command Polarity	0-1	This parameter reverses the polarity (direction of the generated torque) of the analog torque command signal TRQR on connector CN I/F pin 16 (Z-Series) or pin 34 (V-Series). 0 = CW torque with a positive (+) torque command **1 = CCW torque with a positive (+) torque command** (See section 2.2 for rotational direction conventions.) (Default = 1)
1 C	Torque Command Offset	-127 to 127	This parameter sets an offset adjustment of the analog torque command input circuit. This parameter is only valid in the Torque Control Mode (see Parameter No. 02). Make the offset adjustment as follows: Apply exactly zero volts to the torque command input from the command source (TRQR) or connect TRQR directly to one of the signal GND terminals on connector CN I/F. Adjust this value to minimize or stop motor rotation (drift). Note that because of the resolution of this adjustment, you may not be able to eliminate all motor drift. (Default = 0)
1 D	Torque Command Filter	0 to 2500	Sets the time constant of the first order lag filter for the analog torque command input (TRQR) in order to reduce the effects of noise on the command input signal. Larger values provide better noise immunity but reduce the response (bandwidth) of the servo. The time constant is set using the following formula: Filter time constant (μs) = Set value x 10 **NOTES:** 1) Filter time constant is 0 (μs) when set value equals 0 to 49 (Z-Series) or 0-51 (V-Series). 2) When this filter is used, set Parameter No.05 = 0 (Velocity Feedback Filter disabled). (Default = 0)
1 F (Z-Series Only)	Deceleration Rate Limit	0 – 5000	For Z-Series amplifiers, this parameter sets the deceleration rate limit for the Velocity Control Mode only. The relationship between the parameter set value and deceleration time is shown as follows: Set value = (Seconds/1000 RPM) x 500 **NOTE:** Do not use the deceleration limit function for the Velocity Control Mode if you are controlling the SL servo with an external position controller (such as the GE Fanuc Motion Mate APM300 or DSM300) or servo instability may occur. (Set this parameter to "0" when using an external position controller.) (Default = 0)

Parameter No.	Parameter Description	Adjustment Range	Function
2 0	Position Loop Gain	10 - 1000 (rad/s)	This parameter is used to set the position loop gain when the amplifier is operating in the Position Control Mode (see Parameter No. 02). Larger gain values yield higher servo stiffness for greater positioning accuracy. Values between 40 and 160 are typical. **NOTE:** Values that are too large may cause oscillation or servo instability. Start with a low value and gradually increase the gain using small incremental adjustments. (Default = 50 for Z-Series and 20 for V-Series amplifiers)
2 1	Velocity Feed Forward	0 - 100 (%)	This parameter is used to add a velocity feed forward function for the Position Control Mode (see Parameter No. 02) when high-speed response is required (see Chapter 7 for more details on tuning the amplifier). Velocity feed forward helps to reduce following error. The velocity feed forward is set as a percentage of the position command signal. **NOTE:** Too large a value may cause servo instability (oscillation). We recommend you set this parameter to "0" unless you determine that high servo response is required. (Default = 0)
2 2	In-Position Output Detection Range	0 - 32766 (Counts)	This parameter sets the detection level for the In-Position output (COIN) when the amplifier is configured for Position Control Mode (see Parameter No. 02). The amplifier will monitor a move in process. When the number of Counts (quadrature encoder pulses) in the position error counter is within the In-Position range (± set value), the amplifier activates the COIN output (turns the output transistor ON). Feedback pulses of the motor encoder are multiplied by four (quadrature) before they are input to the position error counter, so the In-Position range in Counts is stated as follows: Set Value [Counts] = 4 x (motor encoder pulses for desired range) **NOTE:** The SL Series motor encoders have 2500 pulses per revolution of the motor which equates to 10,000 Counts per revolution. (Default = 10)

Parameter No.	Parameter Description	Adjustment Range	Function
2 3	Position Error Limit	0 - 32766	When in the Position Control Mode, this parameter sets the detection level for the position (following) error limit fault. The amplifier trips when the number of Counts in the position error counter exceeds the set value and generates an Error Code 24. Calculate the desired value using the following formula: $\text{Set value} = \frac{\text{Desired Position Error Limit (Counts)}}{16}$ **NOTES:** 1) The deceleration mode used to stop the motor when an alarm occurs is selected using Parameter No. 3D for Z-Series amplifiers and Parameter No. 0A for V-Series amplifiers. 2) This function can be disabled using Parameter No. 24. (Default = 30000)
2 4	Position Error Limit Inhibit	0-1	When the SL amplifier is configured for Position Control Mode (see Parameter No. 02), this parameter inhibits the Position Error Limit protective function set by Parameter No. 23. When this function is disabled, the amplifier will continue operating when the value of the position error counter exceeds the position error limit set by Parameter No. 23. **0 = Enable Position Error Limit Fault** 1 = Disable Position Error Limit Fault **NOTE:** When the position error limit detection is disabled, the position error counter will accumulate error counts until the maximum value of 134,217,728 is reached. At this point, the amplifier faults on a Position Error Counter Overflow alarm (Error Code 29). (Default = 0)
2 5	Numerator of Pulse Command Ratio	1-10000	In Position Control Mode, the SL Series amplifiers allow the user to scale the pulse command input (PULS/SIGN) so that a specific number of command pulses represent one revolution of the motor. This parameter sets the numerator of this pulse command ratio. Parameter No.26 sets the denominator of the ratio. **NOTE:** Setting extreme ratios may cause system performance problems (see notes for Parameter No. 26). (Default = 10000)

Parameter No.	Parameter Description	Adjustment Range	Function
2 6	Denominator of Pulse Command Ratio	1-10000	In Position Control Mode, the SL Series amplifiers allow the user to scale the pulse command input so that a specific number of command pulses represent one revolution of the motor. This parameter sets the denominator of this pulse command frequency-scaling ratio. We recommend you set the scaling ratio range as indicated by the following formula: $\frac{1}{50} \le \frac{\text{Set value of Numerator}}{\text{Set value of Denominator}} \le 20$ The formula relating the scaled pulse command frequency to the motor speed is as follows: $\frac{\text{Para.25}}{\text{Para.26}} = \frac{\text{Motor Speed [RPM]}}{0.006 \times \text{Pulse Command Frequency [PPS]}}$ Example: A stepper indexer outputs a maximum pulse command frequency of 500,000 PPS and the top motor speed required is 3000 RPM. The necessary ratio is calculated as: $\frac{\text{Para.25}}{\text{Para.26}} = \frac{3000\,[\text{RPM}]}{0.006 \times 500{,}000\ [\text{PPS}]} = 1$ **NOTES:** 1) Setting extreme ratios may cause system performance problems. 2) Set the ratio so that the pulse command frequency after multiplication by the ratio does not exceed the maximum command pulse frequency. (200 kHz for open collector pulse command interface or 500 kHz for line driver interface; see Section 5.5.) 3) Z-Series amplifiers allow a second numerator value to be specified by Parameter No. 35. The DIV input on CN I/F connector pin 10 is used to select between the two numerator values. (Default = 10000)
2 7	Quadrature Pulse Input Multiplier	1 to 4	This parameter allows the user to scale the A/B pulse command input frequency to match a particular motor speed using several fixed ratios. This parameter is active only when the amplifier is configured for Position Control Mode (see Parameter No. 02) and the pulse command type is selected as Quadrature (2-phase) Pulse Input (see Parameter No. 29). This parameter scales the A/B pulse inputs before they are scaled by the Pulse Command Scaling Ratio setup by Parameter No. 25 and 26 as shown below:  The multiplication value is set as follows: 1 = Pulse inputs multiplied by 1 2 = Pulse inputs multiplied by 2 3 = Pulse inputs multiplied by 4 **4 = Pulse inputs multiplied by 4**

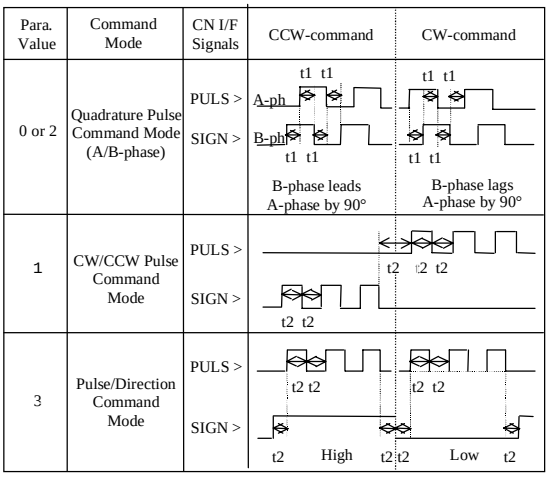
<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td></td><td></td><td></td><td>(Default = 4)
This allows the SL servo to act as a simple, fixed ratio encoder follower for electronic gearing applications. The formula relating the scaled A/B-Pulse frequency to the motor speed is as follows:

$$\text{Multiplier Value} = \frac{\text{Motor Speed (RPM)}}{0.006 \times \text{A/B Pulse Frequency [PPS]} \times (P25 \div P26)}$$

The table below shows the pulse command frequency for various motor speeds used for each of the scaling options:
<table><tr><td rowspan="4">A/B Pulse Command Frequency [PPS]</td><td>Set Value</td><td colspan="5">Motor Speed [RPM]</td></tr><tr><td></td><td>1000</td><td>2000</td><td>3000</td><td>4000</td><td>5000</td></tr><tr><td>1</td><td>166,666</td><td>333,333</td><td>500,000</td><td>666,666</td><td>833,333</td></tr><tr><td>2</td><td>83,333</td><td>166,666</td><td>250,000</td><td>333,333</td><td>416,666</td></tr><tr><td>3 or 4</td><td>41,666</td><td>83,333</td><td>125,000</td><td>166,666</td><td>208,333</td></tr></table>
NOTE: Chart assumes that P25 ÷ P26 = 1.
(Default = 4)</td></tr>
<tr><td>2 8</td><td>Pulse Command Input Polarity</td><td>0 to 3</td><td>When in Position Control Mode (see Parameter No. 02), you can set the logical sense of the position command input signals (PULS and SIGN) individually as shown below:
0 = PULS signal logic non-inverting,
SIGN signal logic non-inverting
1 = PULS signal logic inverting,
SIGN signal logic non-inverting
2 = PULS signal logic non-inverting,
SIGN signal logic inverting
3 = PULS signal logic inverting,
SIGN signal logic inverting
NOTE: Parameter No.29 shows a diagram indicating the directional conventions for the pulse command signals for the default setting for this parameter.
(Default = 0)</td></tr>
</table>

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>2 9</td><td>Pulse Command Input Mode</td><td>0 to 3</td><td>
In Position Control Mode (see Parameter No. 02), the SL Series amplifiers support three types of pulse commands selected as shown below:

0 or 2 = Quadrature (2-phase) Pulse input (A/B Phase)
1 = CW/CCW Pulse command input
3 = Pulse/Direction command input

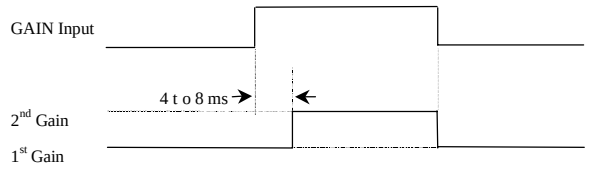
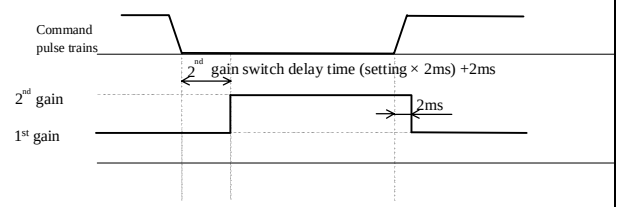


Minimum Required Pulse Width:
<table>
<tr><th></th><th>Line Driver Interface</th><th>Open Collector Interface</th></tr>
<tr><td>t1</td><td>2µs or longer</td><td>5µs or longer</td></tr>
<tr><td>t2</td><td>1µs or longer</td><td>2.5µs or longer</td></tr>
</table>

NOTES:
1) See section 5.5 for additional details on the pulse command signal interface.
2) Use Parameter No. 28 when the logical sense of the PULS and SIGN signals must be changed to accommodate the signal source. The directional conventions shown in the diagram above are for the Parameter No.28 default setting of 0.
(Default = 1)
</td></tr>
<tr><td>2B</td><td>Velocity Feed Forward Filter Time Constant</td><td>0 to 6400</td><td>
When the amplifier is configured for Position Control Mode (see Parameter No. 02) this parameter sets the time constant of velocity feed forward filter.

Filter time constant (µs) = Set value x 10
For set values between 0 to 49 (Z-series) or 0 to 51 (V-series) the time constant will be 0µs.
(Default = 0)
</td></tr>
</table>

Parameter No.	Parameter Description	Adjustment Range	Function
3 0 (Z-Series Only)	2nd Velocity Loop Gain	25 – 3500	For Z-Series amplifiers configured for Velocity Control Mode (see Parameter No. 02), this parameter sets an alternate (2nd) proportional gain of the velocity loop. The method used to switch between the 1st Velocity Loop Gain (set by Parameter No. 03) and 2nd Velocity Loop Gain is dictated by the value set in parameter No.33. By making this value larger, the proportional gain will be increased. The optimum value for the velocity loop gain varies with load inertia and the motor type. (Default = 100)
3 1 (Z-Series Only)	2nd Velocity Loop Integration Time Constant	1 – 1000	For Z-Series amplifiers configured for Velocity Control Mode, this parameter sets an alternate (2nd) Velocity Loop Integration Time Constant. The method used to switch between the 1st Velocity Loop Integration Time Constant (set by Parameter No. 04) and 2nd Velocity Loop Integration Time Constant is dictated by the value set in parameter No.33. By making this value smaller, the loop integration will be faster. **NOTE:** If the integration time constant is set to the maximum value (1000), the integration function is disabled. (Default = 50)
3 2 (Z-Series Only)	2nd Position Loop Gain	10 – 1000 (rad/s)	For Z-Series amplifiers configured for Position Control Mode, this parameter sets the alternative (2nd) position loop gain. The method used to switch between the 1st Position Loop Gain (set by Parameter No. 20) and 2nd Position Loop Gain is dictated by the value set in parameter No.33. By making the value larger, the position loop gain and the servo stiffness will be increased. **NOTE:** Too large a value may cause oscillation or servo instability. Start with a low initial value and make small incremental changes to optimize the gain values. (Default = 50)

Parameter No.	Parameter Description	Adjustment Range	Function
3 3 (Z-Series Only)	2nd Gain Switching Mode	0 –2	For Z-Series amplifiers, this parameter determines the switching mode for 2nd Velocity or Position Loop Gain values (set by Parameter No. 30 – 32) for the appropriate Position or Velocity Control Modes. **0 = Switching to 2nd gain is disabled** 1 = Enable automatic switching to 2nd gain values (see Parameter No. 34) 2 = Enable 2nd gain values using the GAIN input (CN I/F pin 32; see note 1) as shown in the following diagram:  **NOTES:** 1) For the Z-Series amplifiers, the GAIN input function shares connector CN I/F pin 32 with the C-MODE and P-CON functions (see section 5.7.2), making these functions mutually exclusive. Parameter 3F is used to select the desired function. 2) When using the SL Series amplifiers in Velocity Control Mode with an external position controller, switching the velocity loop gain is not recommended. Therefore, the GAIN input is not available on the APM/DSM Interface terminal block IC800SLT001, but is available on the breakout terminal block IC800SLT004. (Default = 0)
3 4 (Z-Series Only)	Automatic Gain Switching Delay Time	0 – 10000	For Z-Series amplifiers configured for Position Control Mode, this parameter configures a time delay used when switching between the 1st and 2nd gain values. The scaling on the time delay is as follows: Time Delay [ms] = 2 x Set value + 2 The time delay starts after the pulse train input for a given move command is complete, as shown in the following diagram. The gain switches from the 1st gain setting to the 2nd gain setting after the time delay. Two milliseconds after the next move command pulse train input begins, the gain switches back to the 1st gain value. Therefore, the 1st gain setting is used while the motor is moving (dynamic), and the 2nd gain setting is used while the motor is holding the load still (static).  **NOTE:** This function is only active when Parameter No. 33 is set

Parameter No.	Parameter Description	Adjustment Range	Function
			to 1. (Default = 10000)
3 5 (Z-Series Only)	2nd Numerator of Pulse Command Ratio	1 – 10000	For Z-Series amplifiers configured for Position Control Mode (see Parameter No. 02), this parameter sets a 2nd numerator value for the Pulse Command Frequency Ratio. The 1st numerator value for this ratio is set by Parameter No. 25 and the denominator is set by Parameter No. 26 (refer to Parameter No. 26 for more details on the Pulse Command Ratio function). The DIV input on connector CN I/F pin 10 is used to select between the two numerator values. **NOTE:** On the Z-Series amplifiers, the DIV input and the ZEROSPD input share the CN I/F pin 10 connection point and are mutually exclusive functions. Parameter No. 3F is used to select which functions are active at the CN I/F connections. This function is only valid when Parameter No. 3F is set to 1 or 3. (Default = 10000)
3 6 (Z-Series Only)	Pulse Command Filter Delay	0 –5	For Z-Series amplifiers configured for Position Control Mode (see Parameter No. 02), this parameter sets the time constant for a digital filter on the pulse command inputs (PULS/SIGN). Larger set values decrease the response to the Pulse Command inputs (i.e. more filtering) but provide better noise immunity. (Default = 3)
37 (Z-Series Only)	JOG Speed	0 –500 (Rpm)	For Z-Series amplifiers, this parameter sets the JOG speed in units of RPM. The Jog function can be initiated by the SLconfig software or from the keypad on the face of the amplifier. The Jog function is not available on the V-Series amplifier. (Default =300)
3 8 (Z-Series Only)	3rd Internal Speed	-7000 to 7000 (Rpm)	For Z-Series amplifiers configured for Velocity Control Mode (see Parameter No. 02), this parameter sets the 3rd Internal Speed in the same way as the first internal speed (see Parameter No. 18). (Default = 0)
3 9 (Z-Series Only)	4th Internal Speed	-7000 to 7000 (Rpm)	For Z-Series amplifiers configured for Velocity Control Mode (see Parameter No. 02), this parameter sets the 4th Internal Speed in the same way as the first internal speed (see Parameter No. 18). (Default = 0)
3 B (Z-Series Only)	Analog Monitor Mode Selection	0 –1	SL Series amplifiers provide an analog monitor signal (SP) on the front of the amplifier and on the interface connector CN I/F pin 16 (Z-Series) or pin 43 (V-Series). For Z-Series amplifiers only, this parameter selects the function of this monitor output as follows: **0 = Monitor motor speed (RPM)** 1 = Monitor position error (pulses) (Position Control Mode only) (Refer to section 5.7.2 - Speed Monitor Signal and Parameter No. 08 – Speed Monitor Scaling for more details.)
3 C (Z-Series Only)	Position Error Counter Clear Mode	0 –1	For Z-Series amplifiers configured for Position Control Mode, this parameter sets whether the Position Error Counter Clear input signal (CL) on connector CN I/F pin 13 (Z-Series) is edge or level sensitive. **0 = Clear counter on the signal level** 1 = Clear counter on the falling edge of the signal transition **NOTE:** For V-Series amplifiers, the counter is cleared on signal level only.

<table>
<tr><th>Parameter No.</th><th>Parameter Description</th><th>Adjustment Range</th><th>Function</th></tr>
<tr><td>3 D
(Z-Series Only)</td><td>Alarm Action Selection</td><td>0-3</td><td>For Z-Series amplifiers, this parameter determines if dynamic braking is used to stop the motor when an amplifier fault occurs. The options are shown in the following table:
<table>
<tr><th>Value</th><th>Alarm Occurs While Motor Is Moving</th><th>Alarm Occurs While Motor Is Stopped</th></tr>
<tr><td>0</td><td>DB to a stop</td><td>DB to a stop</td></tr>
<tr><td>1</td><td>Coast to a stop</td><td>DB to a stop</td></tr>
<tr><td>2</td><td>DB to a stop</td><td>Coast to a stop</td></tr>
<tr><td>3</td><td>Coast to a stop</td><td>Coast to a stop</td></tr>
</table>
(Default = 0)</td></tr>
<tr><td>3 E
(Z-Series Only)</td><td>Servo Disable Action Selection</td><td>0-7</td><td>For Z-Series amplifiers, this parameter determines if dynamic braking is used to stop the motor and if the position error counter is cleared when the amplifier is disabled by the SRV-ON input (connector CN I/F). The options are shown in the following table:
<table>
<tr><th>Value</th><th>Deceleration Mode</th><th>Action After Motor Stops</th><th>Position Error Counter</th></tr>
<tr><td>0</td><td>DB to stop</td><td>Keep DB ON</td><td>Clear</td></tr>
<tr><td>1</td><td>Coast to a stop</td><td>Keep DB ON</td><td>Clear</td></tr>
<tr><td>2</td><td>DB to stop</td><td>Turn DB OFF</td><td>Clear</td></tr>
<tr><td>3</td><td>Coast to a stop</td><td>Turn DB OFF</td><td>Clear</td></tr>
<tr><td>4</td><td>DB to stop</td><td>Keep DB ON</td><td>Retain</td></tr>
<tr><td>5</td><td>Coast to a stop</td><td>Keep DB ON</td><td>Retain</td></tr>
<tr><td>6</td><td>DB to stop</td><td>Turn DB OFF</td><td>Retain</td></tr>
<tr><td>7</td><td>Coast to a stop</td><td>Turn DB OFF</td><td>Retain</td></tr>
</table>
NOTE: The V-Series amplifiers always clear the position error counter when the amplifier is disabled.
(Default = 0)</td></tr>
<tr><td>3 F
(Z-Series Only)</td><td>Function Selection For Interface Connector CN I/F</td><td>0 –5</td><td>The Z-Series amplifiers allow the user to customize the I/O functions available on the servo interface connector (CN I/F). Some of the functions share a connection pin and are therefore mutually exclusive. Also, some of the functions are only available for certain operating modes as configured by Parameter No. 02. Therefore, the I/O configurations have been grouped with six options as shown below:
0 = Default
1 = Configuration 1
2 = Configuration 2
3 = Configuration 3
4 = Configuration 1
5 = Configuration 2
For details of pin assignment for each mode, refer to section 5.7.1 - I/O Configuration for Z-Series Amplifiers.
(Default = 0)</td></tr>
</table>

Chapter 7 Tuning

7.1 Tuning Overview

The SL Series amplifiers support an auto-tuning function that is designed to assist with the selection of values for the various gain parameters when configured for Position or Velocity Control Mode. When the amplifier is configured for Torque Control Mode no tuning is required. The Waveform Graphic option (PC Oscilloscope) in the SLconfig software can be used to optimize the gain values while graphically viewing the effect on system response. The individual gain parameters can also be adjusted manually using the front panel keypad on the amplifier or the Parameter Setting menu in the SLconfig software (see Chapter 8).

The following block diagram illustrates the relationship of the various gain components in the SL Series amplifiers:

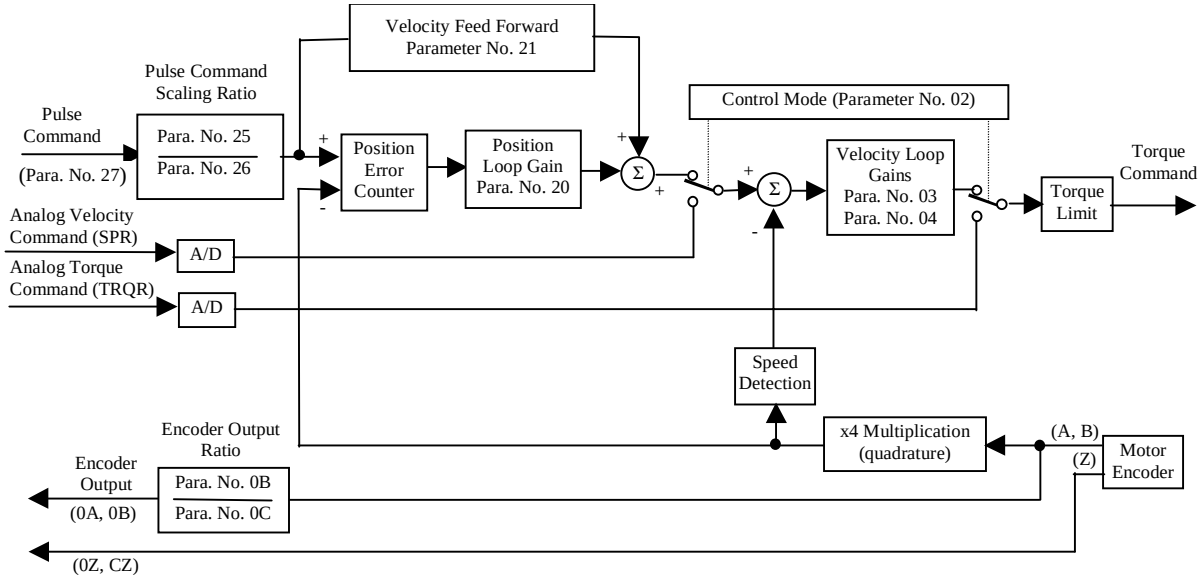


Figure 7-1. Equivalent Block Diagram

7.2 Tuning Guidelines

1. The optimum gain setting varies depending on the connected load. You may need to make gain adjustments when the load inertia changes significantly. If re-tuning is not feasible, the best compromise between optimum gain and system stability should be configured.
2. When operating in the Position Control Mode and the maximum value for the *Velocity Loop Integration Time Constant* (1000ms) is set, the *In-Position Output Detection Range* set using Parameter No.22 may not be achieved and the In-Position (COIN) output may not be activated. In this case, use a value of 100ms or less for the *Velocity Loop Integration Time Constant* or increase the value for the *In-Position Output Detection Range*.
3. If you use the SL Series servos for Velocity Control Mode in combination with an external positioning unit such as the GE Fanuc APM300 or DSM300, the Velocity Command Scaling (Parameter No.13) affects the overall position loop gain of the system. This parameter should be set before adjusting the position loop gains in the external motion controller.
4. High values for the gain settings may cause oscillation or instability. Excessive oscillation may damage the machine. In this case, lower the gain setting to stop the oscillation. If you cannot stop the oscillation, quickly disable the amplifier or cycle the main power to the amplifier. Then reset the gain to a lower value before re-enabling the amplifier.
5. In some cases, manual tuning should be used instead of auto-tuning:
   - Automatic gain tuning cannot be performed well due to the load conditions (e.g. High inertial mismatch between the load and motor)
   - The axis has a limited range of travel and cannot support the ± 2 motor revolutions required by the auto-tuning algorithm
   - Vibration or noise when stopping or running the axis after auto tuning is observed
   - Optimum response or stability with varying load conditions is required for maximum performance

7.3 Manual Tuning

When the amplifier is configured for Position Control Mode use the following procedure:

1. Set the *Velocity Feed Forward* (Parameter No. 21) to the minimum (0%). This is the factory default value.
2. Set the *Velocity Loop Gain* (Parameter No. 03) as high as possible (within the range that no oscillation occurs). Start with the default value of 100 Hz and gradually increase the value until the first sign of instability (oscillation). Then decrease the value by about 10 percent.
3. Next, set the *Position Loop Gain* (Parameter No.20) as high as possible (within the range that no oscillation occurs). Start with the default value of 50 rad/sec (Z-Series) or 20 rad/sec (V-Series) and gradually increase the value until the first sign of instability. Then decrease the value by about 10 percent.

Note

For larger values of *Position Loop Gain*, the machine stiffness (at stall) is increased, thus increasing the static positioning accuracy. However, higher gain may cause oscillation or servo instability. Set a value that is the best compromise between these factors.

4. Set the *Velocity Loop Integration Time Constant* (Parameter No.04) as low as possible. The smaller the value, the more responsive (higher bandwidth) the servo loop. High bandwidth results in improved dynamic accuracy and torque disturbance rejection. Start with the default value of 50 ms and gradually decrease the value until the first sign of instability (oscillation). Then increase the value by about 10 percent.

5. When you want to obtain a faster response to changes in the command, increase the *Velocity Feed Forward* gradually using Parameter No.21. If you set this value too high, it may cause velocity overshoot. The overshoot should be minimized (typically less than 10 % of the steady state velocity). You can observe the velocity overshoot using the Waveform Graphic mode in the SLconfig software.

When the amplifier is configured for Velocity Control Mode use the following procedure:

1. Adjust the *Velocity Loop Gain* and *Velocity Loop Integration Time Constant* to the optimum value by referring to steps 2 and 4 above.

2. If you have an oscilloscope, use the test points, SP (speed monitor signal) and IM (torque monitor), on the front of the amplifier. Then adjust the *Velocity Loop Gain* and *Velocity Loop Integration Time Constant* so that you obtain minimum overshoot of the speed monitor signal during acceleration/deceleration in response to a step command input, and minimum ripple of the torque monitor signal. You can also observe the velocity overshoot using the Waveform Graphic mode in the SLconfig software.

When the amplifier is configured for Torque Control Mode there are no tuning adjustments.

7.4 Automatic Tuning

7.4.1 Overview

When the SL Series amplifier is configured for Position or Velocity Control Mode, the automatic tuning function allows the amplifier to select the best gain values by determining the load inertia from the torque required to drive the motor.

Note

The maximum motor torque available during auto tuning is limited to the value set by Parameter No.06 -Torque Limit.

Caution

The CW and CCW Overtravel inputs (CWL and CCWL) are disabled during the auto tuning function, and the motor will move at least two complete revolutions in each direction. Ensure that the equipment coupled to the motor can be moved safely.

When the auto tuning function is unable to determine the load inertia, the amplifier gains are reset to the gain values in place before the auto tuning function was executed.

Warning

If servo oscillations or instability occurs during auto tuning, immediately shut off power or disable the servo and return gain to the default setting.

7.4.2 Conditions For Using Automatic Tuning

You can apply the automatic tuning function only when the following conditions are satisfied.

Table 7-1. Automatic Tuning Conditions

Factor	Applicable Conditions for Using the Automatic Tuning Function
Load Inertia	Load Inertia is more than 2 times, but less than 15 times the rotor inertia of the motor.
Mechanical Compliance and Resonance	Mechanical stiffness of the machine components should be as high as possible. Pay particular attention to the selection of the motor coupling, type of drive belts and drive shaft and ball screw diameters. Some belt driven systems may not tune properly due to excessive elasticity of the belts. Auto tuning may not work on machine axes with resonant frequencies lower than 400 Hz.
Backlash	Backlash of any gearing should be as small as possible. Planetary type gear reducers rated for servo applications are typically the best choice.
Load	Eccentric (unbalanced) load should be less than 1/4th of the rated continuous torque of the motor. Viscous (speed dependent friction) load torque should be less than 1/4th of the rated continuous torque of the motor.
Machine Design	No safety problem or machine damage is expected, even if an oscillation (servo instability) occurs. Machine design must allow at least two full revolutions of the motor in both the CCW and CW directions.

7.4.3 Automatic Tuning Procedure

The auto tuning function can be initiated from either the amplifier keypad (see Section 8.1.1.4) or from the SLconfig software (see Section 8.3.10.1 for Z-Series or 8.4.7 for V-Series).

Note

When using the SL servos with an external position controller you must disable or disconnect the motion controller before attempting to use the autotuning function. Most motion controllers such as the GE Fanuc APM or DSM will disable the SL amplifier (remove the SRV-ON signal) when the autotuning procedure attempts to move the motor. Since the SL amplifier must be enabled during the autotuning procedure an "Autotuning Error" is activated and the tuning procedure aborted.

Before starting the Automatic Gain Tuning procedure, you must set the Machine Stiffness Number.

The Machine Stiffness Number represents the desired performance (bandwidth) of the servo, based on the ability (design) of the machine. The Machine Stiffness Number ranges from 1 to 9. Higher values represent higher servo loop gains (more responsive servo performance).

Once a Machine Stiffness Number is selected, values are set for the Velocity Loop Integration Time Constant and Position Loop Gain, as well as an initial value for the Velocity Loop Gain. See the table below. The final values shown for the Velocity Loop Gain are examples for the load to motor inertia ratios shown. The actual value is dependent on the inertia ratio of the specific system and can be calculated in direct proportion to the ratio=1 value. For example, if the inertia ratio measured during auto tuning is 3.5 and a stiffness value of 1 is selected, the Velocity Loop Gain value set during auto tuning will be 87.5Hz (25 Hz x 3.5).

Table 7-2. Automatic Tuning Machine Stiffness Numbers

Machine Stiffness Number	Velocity Loop Gain (Parameter No. 03)			Velocity Loop Integration Time Constant (Para. No. 04)	Position Loop Gain (Para. No. 20)	APM/DSM Position Loop Time Constant (see note)
	Final Value if $(J_L + J_M)/J_M = 1$	Final Value if $(J_L + J_M)/J_M = 5$	Final Value if $(J_L + J_M)/J_M = 10$			
1	25 Hz	125 Hz	250 Hz	80 ms	40 rad/sec	25 ms
2	34.3 Hz	171 Hz	343 Hz	58 ms	55 rad/sec	18 ms
3	43.8 Hz	219 Hz	438 Hz	45 ms	70 rad/sec	14 ms
4	53.1 Hz	265 Hz	531 Hz	37 ms	85 rad/sec	12 ms
5	62.5 Hz	312 Hz	625 Hz	32 ms	100 rad/sec	10 ms
6	71.8 Hz	359 Hz	718 Hz	27 ms	115 rad/sec	9 ms
7	81.2 Hz	406 Hz	812 Hz	24 ms	130 rad/sec	8 ms
8	90.6 Hz	453 Hz	906 Hz	22 ms	145 rad/sec	7 ms
9	100 Hz	500 Hz	1000 Hz	20 ms	160 rad/sec	6 ms

When configured in the Position Control Mode, the SL amplifier uses the Position Loop Gain shown in the table. When configured for Velocity Control Mode, the amplifier temporarily switches to Position Control Mode to execute auto tuning and then switches back to Velocity

Control Mode. In that case, the SL Series amplifier does not use the value for Position Control Mode.

Note

The GE Fanuc APM300 and DSM300 Series motion controllers set position loop gain using the Position Loop Time Constant axis configuration parameter. When using the SL servo with an APM or DSM300, the Position Loop Time Constant equivalent to the SL servo Position Loop Gain can be computed as follows:

$$\text{Position Loop Gain (rad/sec)} = \frac{1000}{\text{Position Loop Time Constant (ms)}}$$

Table 7-2 shows the appropriate value that should be used for each Machine Stiffness Number. As a rule of thumb, the APM or DSM Position Loop Time Constant should be set to approximately ¼ to ½ of the minimum deceleration time required by the SL servo system. For controllers that use Position Loop Gain measured in units of radians/second, the SL servo value should be used in the external position loop. Using this rule, the initial Machine Stiffness Number can be determined based on system requirements rather than trial and error.

If the Machine Stiffness Number cannot be determined as indicated in the note above, start with a small value for Machine Stiffness, and then repeat the automatic gain tuning until you encounter oscillation, abnormal noise, or vibration. Then reduce the value to the highest setting free from any instability.

Caution

An error during the autotuning process does NOT disable or fault the amplifier. Be prepared to disable the amplifier or remove power if excessive oscillation occurs.

The motor will rotate approximately two revolutions CCW and two revolutions CW and then repeat the cycle. This cycle may be repeated a maximum of five times in order to optimize the settings.

The acceleration rate will be doubled each cycle starting with the third cycle. Depending on the state of the load, there may be some cases when auto tuning will be completed before 5 cycles or the acceleration will not change. These are not malfunctions.

To operate the Automatic Gain Tuning function:

1. Move the axis to a position where the motor is free to rotate two revolutions in each direction.
2. Inhibit any Pulse Command input (PULS/SIGN) from the source.
3. Enable the servo using the SRV-ON input.
4. Start the Automatic Gain Tuning.
5. Write new settings to EEPROM if no problem or error occurs during the tuning process. If you forget to write the values to memory the tuning setting will be lost when power is removed from the amplifier.

Note

If an alarm, servo disable, or position error counter clear (CL) input occurs during auto tuning, an auto tuning error is generated and the tuning procedure is aborted. When an error occurs, the gain values prior to starting autotuning are reset. The SL amplifier should be disconnected from any external position controller before using the autotuning function to prevent the controller from disabling the amplifier during tuning. For more details, see Section 8.1.1.4 and Chapter 9-"Protective Functions."

Chapter 8 Operation

The SL Series amplifiers have various user parameters which adjust/set the system performance or functions. These parameters allow the user to configure the SL servo system for their specific application requirements. The amplifiers also include a powerful array of monitoring and diagnostic functions to aid in the efficient start-up and troubleshooting of SL-based systems.

Examples of available functions include:

- Monitoring functions such as the control mode, position error counter, motor speed and generated torque (current)
- Viewing/changing parameter data and saving changes to EEPROM memory
- Displaying the status of control input and output signals connected to the interface connector, CN I/F
- Displaying/clearing of error codes and the error history (last 8 errors)
- Tuning the system
- Jogging the motor (Z-Series only)

There are two ways of operating these functions:

- Using the keypad and LED display on the front panel of the amplifier
- Using a Personal Computer (PC) and the *SLconfig* software

8.1 Keypad Operation and Display

The SL amplifier keypad is a tactile membrane type with five push buttons to navigate through the function menus. The amplifiers also include a six-digit LED display that is used to display the menu functions, parameter data values, and system status information. You can choose the power-up default function for the display by using Parameter No. 01 – Power-up Display Options. The available options are:

- Following Error (Counts)
- Motor Speed (RPM). This is the standard display default.
- Motor Torque (% of rated commanded continuous torque)

The layout of the keypad and key functions are shown in the diagram below:

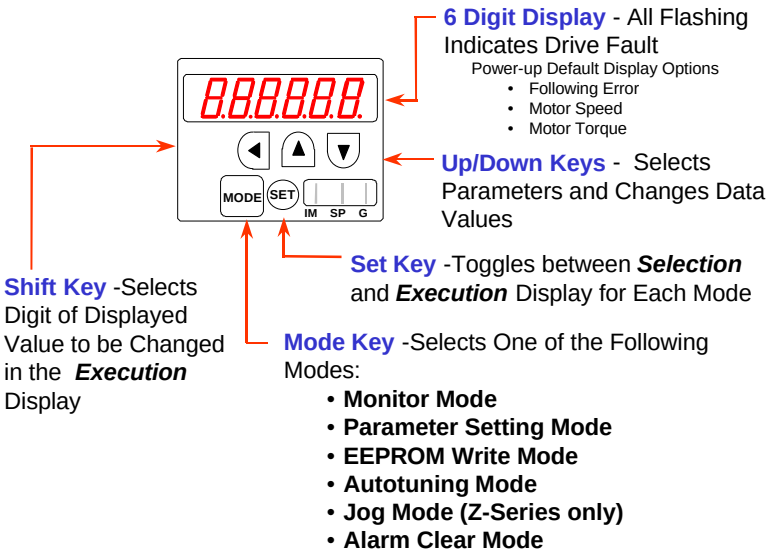


Figure 8-1. Diagram of the Front Panel/Display

The MODE key is used to select the appropriate mode. Each mode consists of a Selection Display and an Execution Display. The SET key is used to toggle between these two displays. The UP, DOWN and SHIFT keys are used to select options or execute each mode.

Key	Active…	Function
MODE	In the selection display	Selects the desired mode
SET	At any time	Toggles between the Selection Display or Execution Display
UP (↑) DOWN (↓)	Only when the flashing decimal point is displayed	Used to change data values, select parameters, or execute the operation
SHIFT (←)		Shifts to the next most significant digit (if more than one digit is displayed) when entering new data values

8.1.1 Keypad Menu Options

There are six modes (five for the V-Series) available as top level menus from the amplifier front panel keypad/display. These modes are selected using the MODE key when the amplifier is in the Selection Display. Once a specific mode is shown on the display, pressing the SET key activates the appropriate Execution Display as shown in Figure 8-2.

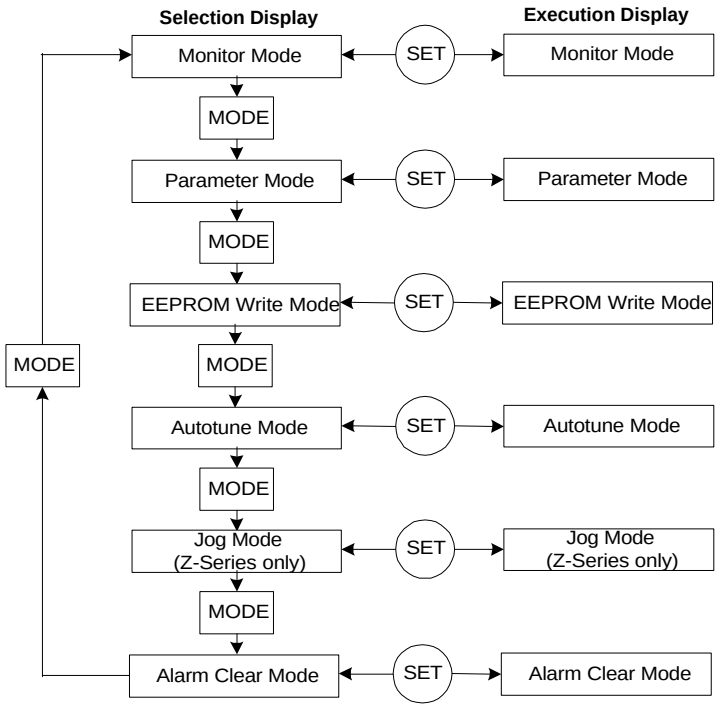


Figure 8-2. Keypad Menu Navigation

In the mode Selection Displays, the most significant digits in numerical fields consists of one or two letters followed by an underscore as shown below:

Mode	Selection Display
Monitor mode	dP_
Parameter setting mode	PA_
EEPROM writing mode	EE_SEt
Automatic gain tuning mode	At_
JOG mode (Z-Series only)	JOG
Alarm clear mode	A_CLr

Note

When all the figures on the display are flashing, the amplifier has faulted on an error.

8.1.1.1 Monitor Mode

When you turn on the SL amplifier power, the LED display defaults to the Monitor Mode Execution Display for either Following Error, Motor Speed or Motor Torque as configured by the setting for Parameter No. 01. The Monitor Mode is used to display a variety of status information for the SL servo that can be used during start-up or to troubleshoot system problems. Figure 8-3

shows the Monitor Mode options and the associated characters shown in the Selection Display for each option.

Position Error – Displays position error and direction in pulses

Motor Speed – Displays motor speed and polarity

Torque Output – Displays torque output and polarity

Control Mode – Shows current control mode (position, speed, or torque)

I/O Signal Status – Displays active/inactive state of selected I/O

Error Code/History – Scrolls through the last 8 errors in chronological order

Version – Shows version number of firmware

The Following Monitor Mode Selections are for the Z-Series Only:

Absolute Position – Absolute position relative to power-on position (0)

Velocity Command Input – Velocity command (range –2048 to 2047)

Servo-On – Enable, CW limit, CCW limit, and current error code status

CW Torque Limit Input – Value of CW external input (range –2048 to 2047)

CCW Torque Limit Input – Value of CCW external input (range –2048 to 2047)

Error Diagnosis – Quick view of many factors that can inhibit motion

Figure 8-3. Monitor Mode Selection Display Options

Use the UP/DOWN arrow keys on the amplifier to select a Monitor Mode option and then press the SET key to enter the Execution Display to view the data for that selection.

Position Error/Motor Speed/Torque Display

The Monitor Mode can be used to view the current value for either the Following (Position) Error (Counts), Motor Speed (RPM), or Motor Torque. Following Error is only valid if the amplifier is configured for Position Control Mode. The Selection Display and examples of typical Execution Displays for these three Monitor Mode options is shown in Figure 8-4.

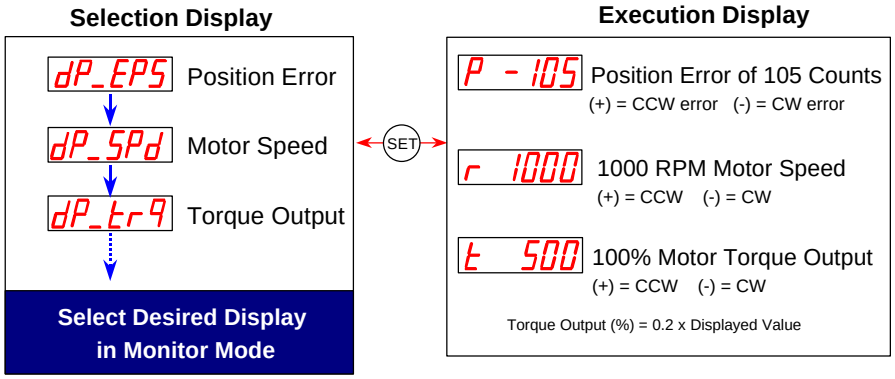


Figure 8-4. Display of Position Error, Motor Speed, or Motor Torque in the Monitor Mode

Control Mode Display

The Selection and Execution Displays for viewing the active control mode of the amplifier (set by Parameter No. 02) are shown in Figure 8-5.

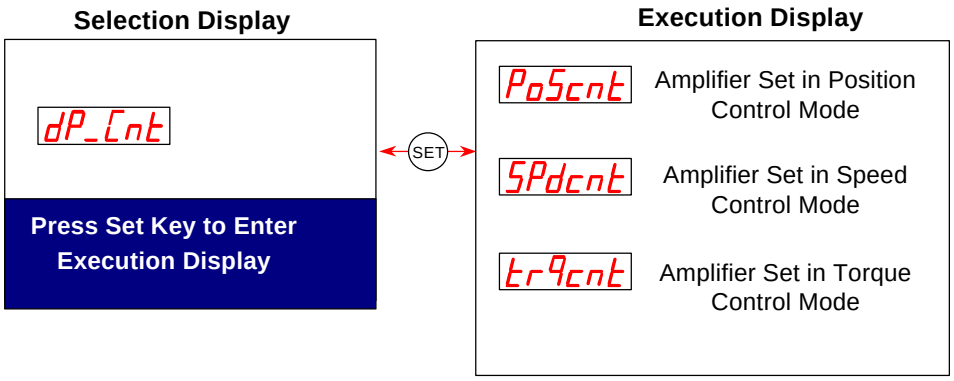


Figure 8-5. Display of Control Mode in the Monitor Mode

Error History Display

The Monitor Mode also allows the user to display the error history stored by the SL amplifier. The error history display shows the eight most recent errors in chronological order as shown in Figure 8-6.

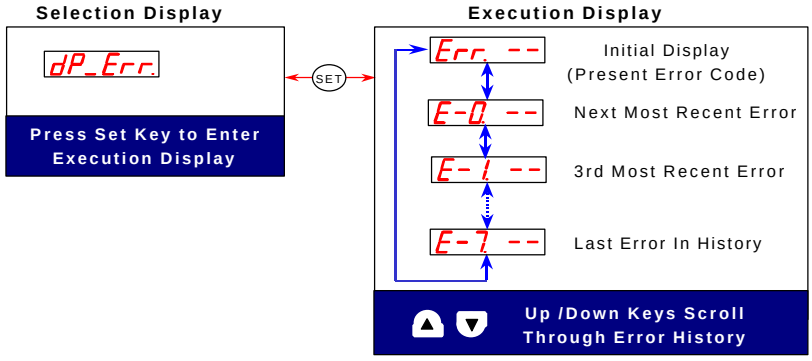


Figure 8-6. Display of Error History in the Monitor Mode

Servo-On Display (for Z-Series Only)

The Servo-On Monitor Mode can be used as a quick reference to show the current status of the CW/CCW overtravel limit inputs (CWL and CCWL), servo enable input (SRV-ON), servo ready output (S-RDY) and the current error code (if an error has occurred). An “A” indicates the particular discrete I/O is active and a dash indicates an inactive I/O signal as shown in Figure 8-7.

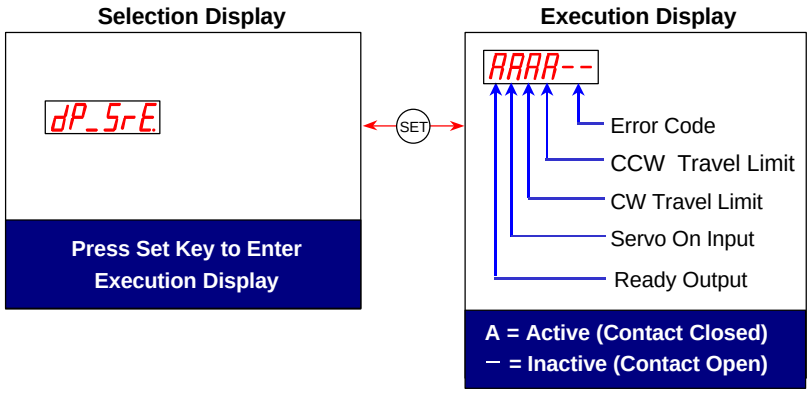


Figure 8-7. Z-Series Servo-On Display in the Monitor Mode

Error Diagnosis Display (for Z-Series Only)

The Monitor Mode also has an Error Diagnosis display (Z-Series amplifiers only) to assist in troubleshooting situations when you think the motor should be moving but no motion is present on the machine. The Execution Display for this option illuminates various segments on two of the display digits to indicate the status of certain conditions that could prevent motion. The display also indicates the current control mode and if the motor is moving and in which direction. Figure 8-8 identifies the display codes used in this mode.

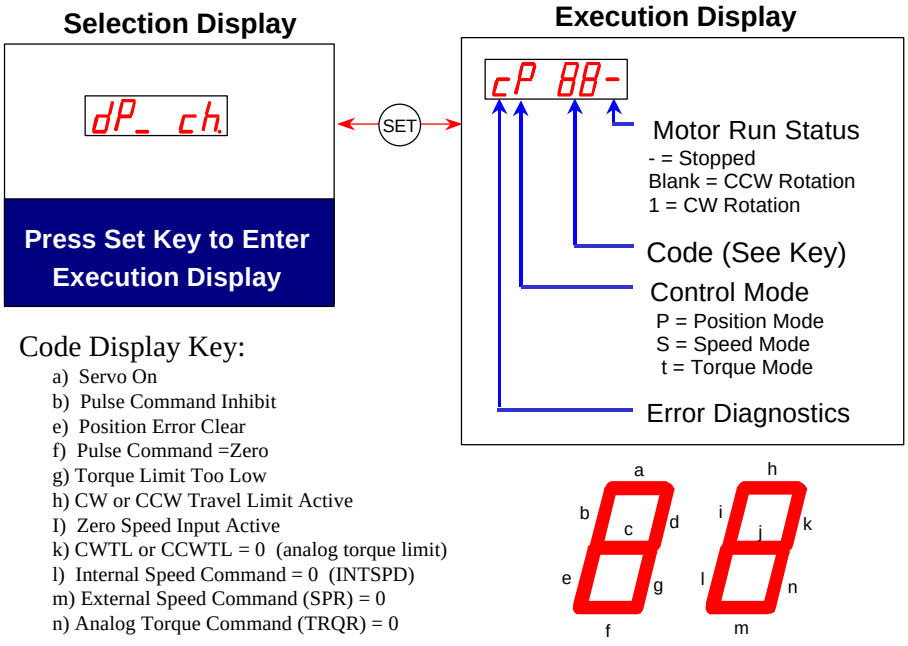


Figure 8-8. Z-Series Error Diagnosis Display in the Monitor Mode

Note

When the condition shown in the code display key is true the associated LED segment on the display is not illuminated.

I/O Signal Status Display

The I/O Signal Status Display in the Monitor Mode shown in Figure 8-9 allows the user to scroll through the status of the various control I/O signals connected to the servo interface connector CN I/F. Each I/O signal status is displayed in a round robin list grouped as inputs and outputs. Use the UP/DOWN keys on the amplifier to navigate through the list. Each I/O uses a hexadecimal number code and either an "A" display to indicate an active signal or a dash (-) display to indicate an inactive signal. The cross-references for the hexadecimal codes for each I/O are shown in Table 8-1 (Z-Series) and Table 8-2 (V-Series).

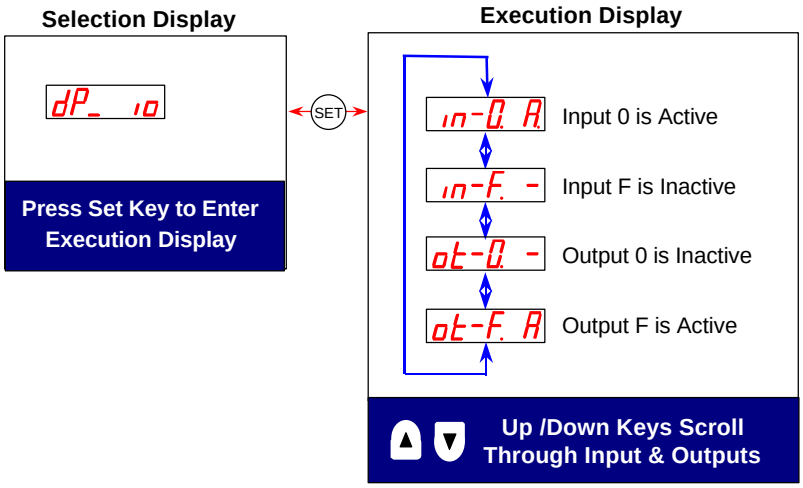


Figure 8-9. I/O Signal Status Display in the Monitor Mode

Input Signal			Output Signal		
No.	**Symbol**	**Description**	**No.**	**Symbol**	**Description**
0	SRV-ON	Servo enabled	**0**	S-RDY	Servo ready
1	A-CLR	Alarm clear	**1**	ALM	Servo alarm
2	CWL	CW end of travel limit	**2**		Not in use
3	CCWL	CCW end of travel limit	**3**		Not in use
4	CMODE	Control mode switch input	**4**	BRK-OFF	External brake release
5	ZEROSPD	Zero speed clamp input	**5**	COIN	In Position / At Speed
6	INTSPD1	Preset speed select input 1	**6**		Not in use
7		Not in use	**7**	ZSP	At zero speed
8	INH	Pulse command input inhibit	**8**		Not in use
9	PCON	Proportional gain select input	**9**		Not in use
A	CL	Clear position error input	**A**		Not in use
B	GAIN	Gain select input	**B**		Not in use
C	DIV	Feedback scaling switch input	**C**		Not in use
D		Not in use	**D**		Not in use
E	INTSPD2	Preset speed select input 2	**E**		Not in use
F		Not in use	**F**	DB	Dynamic brake release (internal signal)

Table 8-1. Z-Series Amplifier I/O Signal Status Display Code in the Monitor Mode

Input Signal			Output Signal		
No.	**Symbol**	**Description**	**No.**	**Symbol**	**Description**
0	SRV-ON	Servo enabled	**0**	S-RDY	Servo ready
1	A-CLR	Alarm clear	**1**	ALM	Servo alarm
2	CWL	CW end of travel limit	**2**	EXOUT0	Error code least significant bit
3	CCWL	CCW end of travel limit	**3**	EXOUT1	Error code middle bit
4	CMODE	Control mode switch input	**4**	EXOUT2	Error code most significant bit
5	ZEROSPD	Zero speed clamp input	**5**	BRK-OFF	External brake release
6	INTSPD	Preset speed select input 1	**6**	COIN	In Position / At Speed
7		Not in use	**7**	TLC	Torque Limit Detect
8	INH	Pulse command input inhibit	**8**	ZSP	At zero speed
9	PCON	Proportional gain select input	**9**		Not in use (not displayed)
A	CL	Clear position error input	**A**		Not in use (not displayed)
B		Not in use (not displayed)	**B**		Not in use (not displayed)
C		Not in use (not displayed)	**C**		Not in use (not displayed)
D		Not in use (not displayed)	**D**		Not in use (not displayed)
E		Not in use (not displayed)	**E**		Not in use (not displayed)
F		Not in use (not displayed)	**F**		Position Error Counter is Clear

Table 8-2. V-Series Amplifier I/O Signal Status Display Code in the Monitor Mode

Torque Limits and Velocity Command Input A/D Value Display (for Z-Series Only)

The Monitor Mode also supports the display of some of the analog input A/D values for signals on the CN I/F connector. The CW and CCW Torque Limit inputs (CWTL and CCWTL) and the Velocity Command input (SPR) would display in the Execution Display with a full-scale range of –2048 to 2047 representing approximately ± 10.2 VDC on the input. A positive value represents CCW rotation (or torque that will produce CCW rotation) of the motor.

Absolute Position Display (for Z-Series Only)

The Absolute Position display in the Monitor Mode is not functional. This mode requires absolute encoder feedback, which is not currently available for the SL Series servos.

Version Number Display (for Both Series)

The version number of the amplifier firmware can be viewed by selecting the Version Number display in the Monitor Mode. See Figure 8-3 for the Selection Display for this option.

8.1.1.2 Parameter Mode

The amplifier keypad can be used to view or edit the setting for any of the user parameters. Use the UP/DOWN keys on the amplifier to scroll through the Selection Display to the parameter number you want to change. The Selection Display format for the parameters is PA_rxx where "xx" represents the hexadecimal parameter number and "r" indicates a parameter that requires the amplifier power to be cycled to activate the new value (Parameter No. 27, 28, 29 and 3F). With the desired parameter number displayed, press the SET key to enter the Execution Display to view or change the parameter value. Once in the Execution Display, the current value of the parameter is displayed. The SHIFT key is used to select the digit of the data value to be changed. The flashing decimal follows the selected digit. With the desired digit selected, use the UP/DOWN keys to increment or decrement the value. Pressing the UP or DOWN key once will change the value by 1. Press and hold the UP or DOWN keys to rapidly change the value. If many parameters must be changed, the SLconfig software is a more effective tool. Examples of the displays for the V-Series Parameter Mode are shown in Figure 8-10 (the Z-Series is similar).

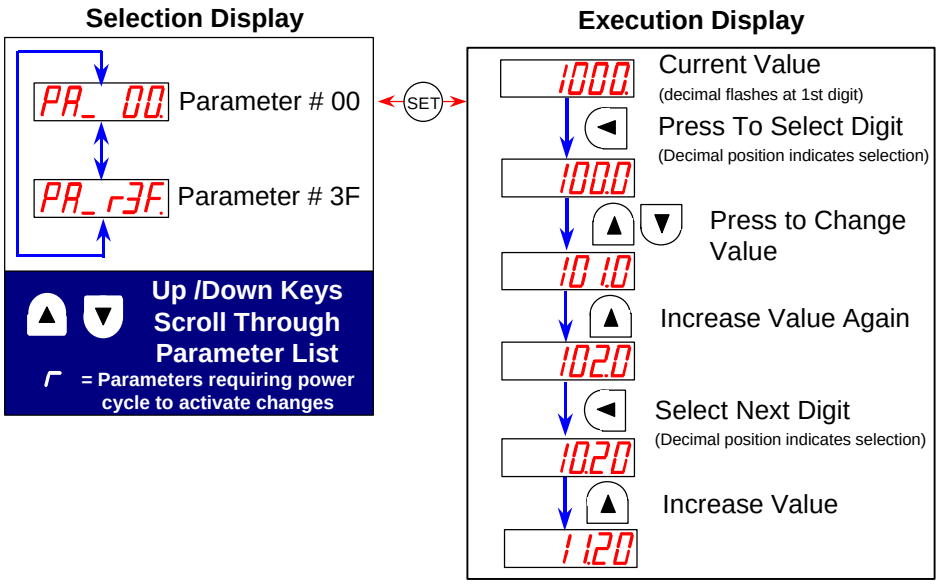


Figure 8-10. V-Series Parameter Mode Display Example

Note

Once all desired parameter values have been changed, the new data values must be saved to EEPROM memory or they will be lost when power is removed from the amplifier. See Section 8.1.1.3 for details on using the keypad for this procedure.

8.1.1.3 EEPROM Write Mode

The SL servo amplifiers use EEPROM non-volatile memory to store parameter configurations set by the user. Whenever parameter data is change using either the amplifier keypad or SLconfig PC software the new values must be stored to memory or they will be lost when power is removed from the amplifier. To write the changes using the keypad, select the EEPROM Write Mode in

the Selection Display (EE_SEt) and press the SET key. Once in the Execution Display, press and hold the UP key to begin the process. Dashes will be displayed and then the word “start”. Wait until the word “finish”, “reset,” or “error” appears on the display as shown in Figure 8-11. If “reset” is displayed, the amplifier power must be cycled before some of the new values are activated. If “error” appears on the display, there was a problem saving the data. Repeat the process. If an error continues after repeated attempts, the amplifier is defective and must be replaced.

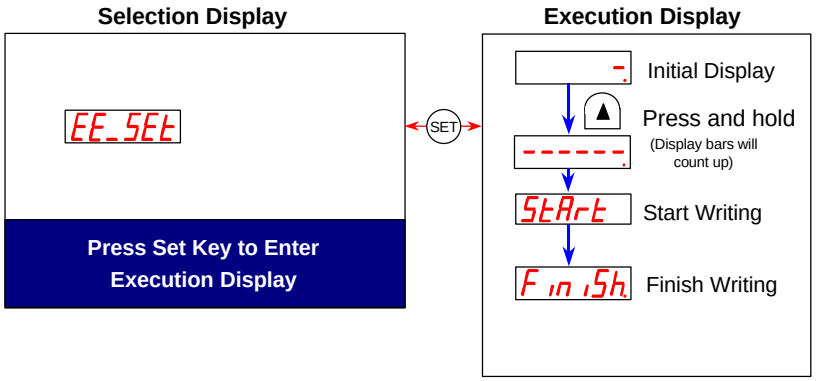


Figure 8-11. EEPROM Write Mode Displays

8.1.1.4 Autotuning Mode

Autotuning Overview

The Autotuning feature is designed to assist you in setting the SL amplifier gain values. Autotuning should be performed with the actual operating load attached. Please review Chapter 7 before proceeding with the Autotuning function. After autotuning, if you wish to make further manual gain adjustments to optimize performance, you can use the Online Monitor feature of the SLConfig software. However, in general, autotuned systems with intertial ratios of less than 6:1 will usually not require further adjustment.

Warning

The SL motor will make several rotations in both directions while the Auto Autotuning routine is running. Before starting this routine, make sure that the motor can be turned safely at least 3 revolutions in each direction. This must be done to avoid possible injury to personnel or damage to equipment.

Autotuning with an External Motion Controller (such as APM or DSM)

If using an external motion controller, such as a GE Fanuc Series 90-30 APM or DSM, be aware that the autotuning function is only used to tune the SL Amplifier’s velocity loop. The position loop, which is closed in the external controller, must be disabled during autotuning and tuned separately, according to the procedure for the external controller. So, for autotuning purposes, any connected motion controller should produce an enable signal to the SL Amplifier, but no analog command (command output should be held to zero). If using a GE Fanuc APM or DSM, you can ensure that the analog command is held to zero by temporarily setting the APM or DSM

Pos Loop TC to Zero and FF% to zero. Or, alternately, command a Force D/A to zero in the APM or DSM. See Appendix A for more information on using the SL-Series amplifiers with external controllers.

For a third-party motion controller, you must disable or disconnect its analog command output to the SL amplifier. However, the SL amplifier must be enabled, which consists of closing the contact between the SRV-ON input and the COM– input.

Autotuning Procedure

In the Selection Display use the UP/DOWN keys to choose the desired Machine Stiffness Number. The Selection Display uses the form "At_1-x" where "x" is the Machine Stiffness Number. Once the desired stiffness number is displayed, press the SET key to enter the Execution Display.

To begin the autotuning process, press and hold the UP key. A series of dashes and the word "start" will be displayed. Wait until "finish" or "error" is displayed. If an error is encountered during autotuning, try repeating the process. If the error display persists, review the conditions for autotuning in Section 7.4.2 and correct any problems before trying again, or use manual tuning as described in Section 7.3.

Caution

An error during the autotuning process does NOT disable or fault the amplifier. Be prepared to disable the amplifier or remove power if excessive oscillation occurs.

Possible causes of an autotuning error are (1) disabling the SL amplifier or activating the Position Error Counter Clear input (CL) during the tuning process, (2) excessive load inertia (>15 times the motor inertia,) (3) mechanical resonance in the machine, or (4) interference from an external motion controller (see "Autotuning with an External Motion Controller" above). When an error occurs, the gain values prior to starting autotuning are reset. Figure 8-12 shows the displays for the Autotuning Mode.

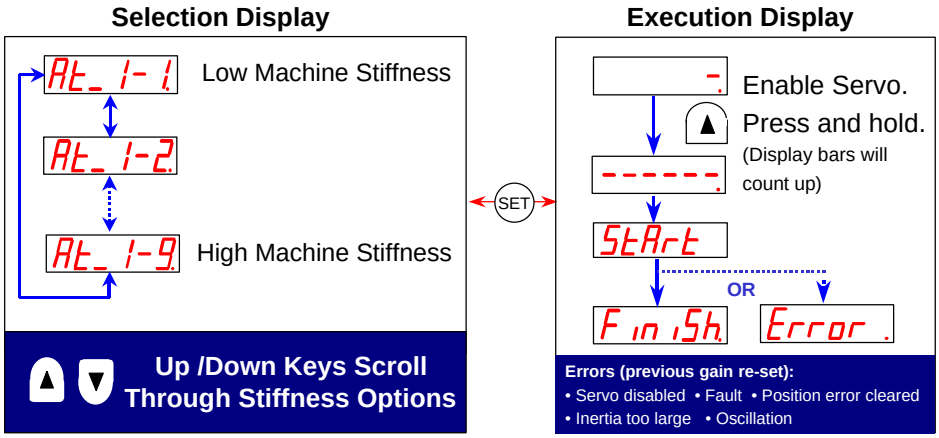


Figure 8-12. Autotuning Mode Displays

Note

Once the tuning parameters have been set by the autotuning function, the new gain values must be saved to EEPROM memory or they will be lost when power is removed from the amplifier. See Section 8.1.1.3 for details on using the keypad for this procedure.

8.1.1.5 Jog Mode (Z-Series Only)

The Z-Series amplifiers support a jog function from the amplifier keypad. The jog velocity is set by Parameter No. 37 and is limited to a maximum value of 500 RPM.

Note

The amplifier must be disabled using the SRV-ON input (it must be open) before activating the jog function. Make sure the SRV-ON input is NOT connected to the COM- terminal. Also, Parameter No. 3E must be set to 0 to 3.

Select the Jog Mode at the Selection Display and press the SET key. Once in the Execution Display, press and hold the UP key until "ready" appears on the display. Then press and hold the SHIFT key while the decimal point increments to each display digit and then "Srv_on" is displayed. At this point the servo should be enabled. If "error" is displayed try repeating the jog sequence again making sure the SRV-ON input is inactive. Now press the UP key (CCW motor rotation) or DOWN key (CW motor rotation) to jog the motor in the desired direction. Pressing the SET key will disable the amplifier. Figure 8-13 shows the Jog Mode displays.

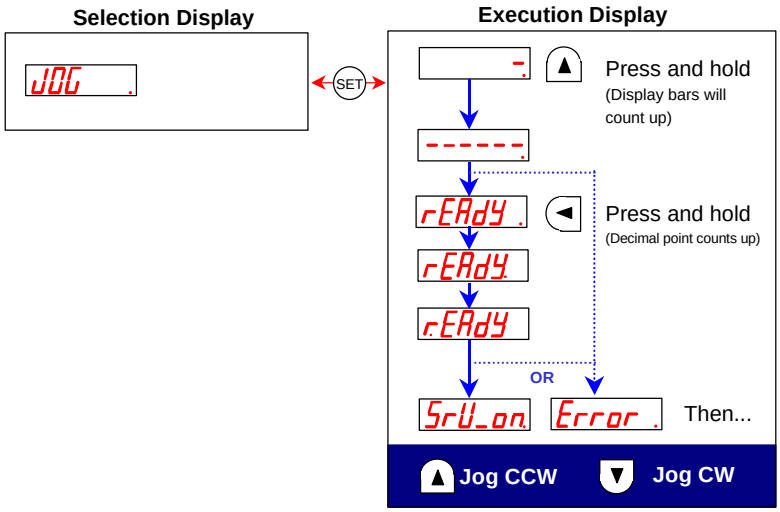


Figure 8-13. Jog Mode Displays

8.1.1.6 Alarm Clear Mode

The amplifier keypad can be used to clear most alarms when an error occurs. Alarms can also be cleared using the alarm clear discrete input (A-CLR). The amplifier LED display will flash when an alarm occurs. To execute the alarm clear function, select the Alarm Clear Mode from the Selection Display (A_CLr) and press the SET key. In the Execution Display, press and hold the UP key until "Start" is displayed. Keep holding the UP key until "Finish" or "Error" is displayed. If "Error" display, it may be the result of trying to clear an error that requires a power cycle reset on the amplifier, as described in the note below. Figure 8-14 shows the alarm clear process using the amplifier keypad.

Note

Not all errors can be cleared using the alarm clear function. The following errors require power to be cycled on the amplifier to reset the error:

Overcurrent protection (error code 14)
Encoder error protection (error code 22)
Self-diagnostic error (error codes 36,84,98,23 and 30)

See Chapter 9 for more information on protective functions of the SL Series amplifiers.

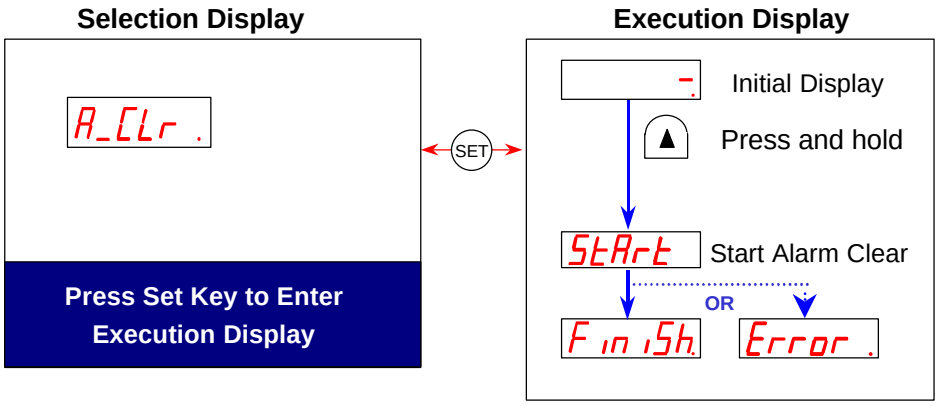


Figure 8-14. Alarm Clear Mode Displays

8.2 SLconfig Computer Software

8.2.1 SLconfig Software Overview

This software is an MS-DOS program that will run either on a computer using MS-DOS only, or on a computer running Windows. It communicates with an SL Series amplifier through the computer's standard RS-232C serial port. This software can be used to view and change amplifier parameters; create, back up, and restore parameter files; and monitor amplifier operation.

8.2.1.1 SLconfig Software Version Information

The SLconfig software consists of the following three files:

- **SLconfig.exe:** This file is used to start the software, and it produces the main startup screen, which is used to select which amplifier series (V-Series or Z-Series) you wish to work with. When you select an amplifier series from this screen, one of the following two files is activated:
- **SLV1.exe:** This file contains the program for the V-Series amplifiers.
- **SLZ1.exe:** This file contains the program for the Z-Series amplifiers.

Each file has its own revision level. These can be read from each file's startup screen. For examples of this see figure 8-17 for the Main Startup Screen, Figure 8-18 for the Z-Series Startup Screen, and Figure 8-52 for the V-Series.

8.2.1.2 SLconfig Requirements

- The SLconfig software is designed to communicate with SL Series amplifiers only.
- Your computer should be an MS-DOS®-based or Windows®-based personal computer.
- You must use your computer's COM1 or COM2 serial port (user selectable). COM1 is the default.
- Use MS-DOS Version 6.2 or later.
- A special serial cable is required to connect your computer to the SL amplifier. Order by specifying GE Fanuc Catalog Number IC800SLCS020.

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8.2.1.3 Connecting your Computer to the SL Amplifier

These instructions apply to both the V-Series and Z-Series amplifiers.

- Please make sure that all power to the amplifier and to the computer is turned off.
- Insert the 10-pin plug of the GE Fanuc IC800SLCS020 serial cable to the "CN SER" connector on the SL Series Amplifier. Next, insert the other end of the cable into the RS-232C (serial) connector on the personal computer. Use the 9-pin to 25-pin adapter supplied with the cable if your computer has a 25-pin serial port connector. Note that this serial cable will work with both V-Series and Z-Series SL amplifiers.
- Turn on your computer first, then turn on power to the SL Series amplifier.

Note

Failure to follow the sequence above could result in a communications error.

8.2.2 SLconfig Installation and Startup

8.2.2.1 Installing the SLconfig Software

SLconfig is distributed on a 3.5” floppy disk. There is no installation or setup program on the SLconfig disk, so installation primarily consists of copying the SLconfig files to a directory (folder) on your computer’s hard drive, and adding a line to your computer’s CONFIG.SYS file.

Installing on a Windows System

- Create a folder on your computer’s hard drive called “SLconfig,” using File Manager or Windows Explorer.
- Use File Manager or Windows Explorer to copy the SLconfig files from your floppy drive to the SLconfig folder you just created on your hard drive.
- Windows 95 users can use Windows Explorer to create a shortcut to the SLconfig.exe file and place it on the Windows 95 Desktop, if desired. To set the shortcut properties, right-click the shortcut, select Properties on the shortcut menu, select the Program tab, and set the properties as shown in the SLconfig.exe Properties dialog box below. In this example, COM1 will be used as the PC’s serial port. For COM2, it would have been necessary to add a space, then a –S2 to the end of the Cmd. line: expression so that the complete expression would have been:

C:\SLCONFIG\SLCONFIG.EXE –S2

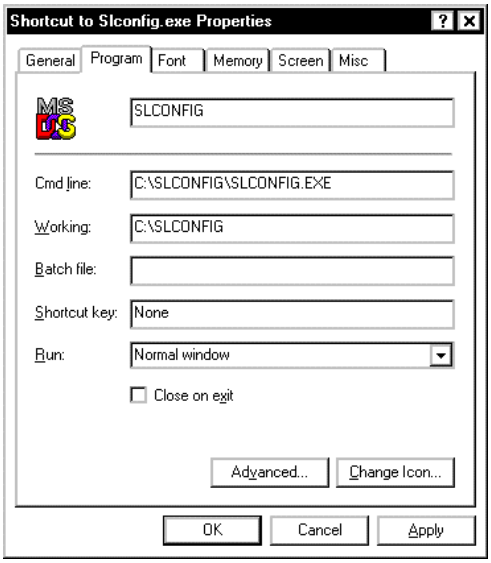


Figure 8-15. Windows 95 Properties box for SLconfig Software

- Also, it is recommended you run your window in full screen mode. To set up this property, click the Screen tab in the Properties dialog box shown above, and select Full Screen.

- If using Windows 95, add the following line to your CONFIG.SYS file (be aware that you must reboot your computer before this takes effect):

  DEVICE=C:\WINDOWS\COMMAND\ANSI.SYS

- If using Windows 3.1, add the following line to your CONFIG.SYS file (be aware that you must reboot your computer before this takes effect):

  DEVICE=C:\DOS\ANSI.SYS

Installing on an MS-DOS-Only Computer

- Create a directory on your computer's hard drive called "SLconfig" using the MD ("Make Directory") command.
- Use the Copy command to copy the SLconfig files from your floppy drive to the SLconfig directory that you just created on your hard drive.
- Add the following line to your config.sys file (be aware that you must reboot your computer before this takes effect):

  DEVICE=C:\DOS\ANSI.SYS

- Use the IC800SLCS020 (GE Fanuc catalog number) serial cable to connect from the SL amplifier to your computer's serial port. This cable is 2 meters long, and it comes with an adapter that allows it to work with either a 9-pin or 25-pin computer serial port.

8.2.2.2 Starting the SLconfig Software

Starting on an MS-DOS-only computer

- Activate your computer's DOS prompt, then change, if necessary, to the drive where the SLconfig software is installed (probably the C: drive).
- Change to the directory where the SLconfig files are installed.
- If you wish to use your computer's COM1 port, type in Slconfig. If you wish to use your computer's COM 2 port, type in SLconfig –s2 (note the space between SLconfig and –s2). Then press the Enter key and the SLconfig software will start running and will bring you to the Main Startup screen, shown in Figure 8-17.

Starting on a Windows-Type Computer

There are several ways to run the SLconfig software on a Windows-type computer. Some are outlined below. The first way listed, "Running from the MS-DOS prompt" is the recommended method.

- **Running from the MS-DOS prompt**. Select the MS-DOS icon on your Windows computer. If you do not have an MS-DOS icon, click the Start button on the Windows 95 Taskbar, highlight Programs on the menu, then drag your mouse across to the "MS-DOS Prompt" selection on the sub-menu. This will take you to an MS-DOS prompt. Use the previous directions for running from an MS-DOS prompt in the previous section "Starting on an MS-DOS Only Computer."

- **Running from the Windows 95 Run Dialog Box** – This method allows you to select either serial port.
    - Click the Start button on the taskbar.
    - Select Run. The Run dialog box will display.
    - The Run dialog box gives you an "Open" box where you can type in your command to start the software. Be sure to include the complete path when using this method. In the following example, the –s2 option is shown for using COM2.

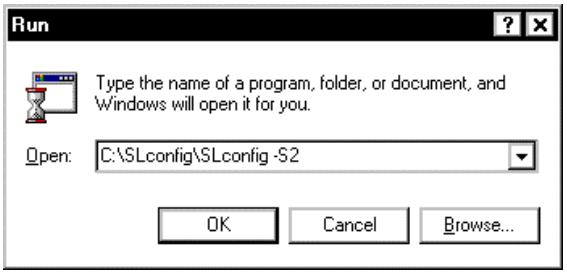


Figure 8-16. Running from the Windows 95 Run Dialog Box

- **Running in a window in Windows 95**.
    - Click the SLconfig shortcut icon on the Windows 95 desktop.

      Or,
    - If no shortcut exists, click the Start button on the Windows 95 Taskbar, highlight Programs on the menu, and then drag your mouse across to the SLconfig selection on the sub-menu. This will start SLconfig running and will bring you to the Main Startup screen, shown in figure 8-18.

8.2.2.3 SLconfig Main Startup Screen

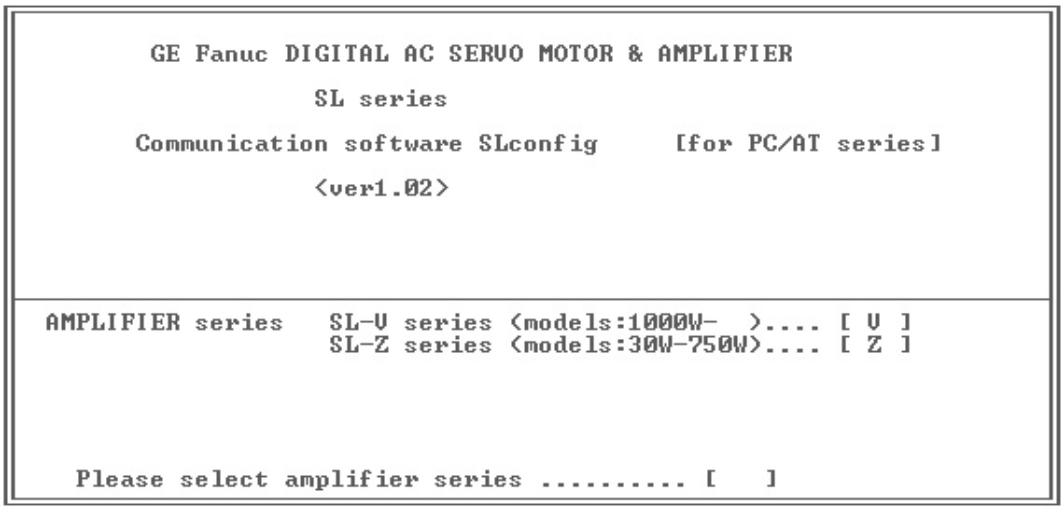


Figure 8-17. SLconfig Main Startup Screen

Note that the software version number for the Main Startup screen file (SLconfig.exe) is displayed on this screen.

At this point in the startup procedure, you have to indicate which SL Series you wish to work with during this session, the V-Series or Z-Series. Since there are basic differences in the software, the instructions are written in two separate sections:

- Z-Series instructions start in section 8.3.
- V-Series instructions start in section 8.4.

Note

On a Windows 95 system, if you disconnect the serial cable or turn off power to a V-Series SL amplifier while the SLconfig software is running, the only way to exit SLconfig is to use the <Ctrl><Alt><Del> key combination, select SLconfig from the Close Program dialog box, then click the End Task button. In order to resume the SLconfig session, reconnect the cable to the SL amplifier with amplifier power off, then turn the amplifier back on.

8.2.3 Basic operation

8.2.3.1 Keyboard Functions

The following table defines the function of control keys used by the SLconfig software:

Keys	Function
Cursor control (“arrow”) keys: ↑ ↓ ← → On some computers, instead of arrow symbols, these keys may be labeled UP, DOWN, LEFT, and RIGHT.	The cursor control keys are used to move the cursor up, down, left, or right. Use to select items within a menu. The item selected is highlighted in reverse video (white letters on a black background). After a menu item is selected, it can be activated with the Enter key. Note that on some computer keyboards that have eight arrow keys, the Diagonal key beneath the Right arrow key may have to be used instead of the Right arrow key.
Numeral keys: 0 to 9	Numeral keys are used to select an item from a menu or to key in a value.
Esc key	Indicates the ESCAPE key. This key is used to EXIT a screen in the Z-Series software only.
Enter or ↵ key	This is also known as the RETURN key. This key is used to activate a highlighted menu selection or enter keyed-in numerical data.
BS or ← key (*see note in box to the right)	This indicates the Backspace key. When pressed once, it erases the character to the left of the cursor. When pressed repeatedly or held down, it erases a string of characters in the left direction. ***NOTE:** The Backspace key often has the same symbol as the Left arrow cursor control key. To distinguish the two, the four cursor control keys are grouped together, but the Backspace key is usually in the same row as the number keys near the top of the keyboard.

8.2.3.2 Selecting from a Menu

There are two ways to select from a menu:

- Each item on a menu is numbered. To select an item, simply type the number of your selection.
- Highlight your selection using the Up or Down arrow key, then press the Enter key.

8.2.3.3 Exiting From a Screen

You can exit from a screen in two ways:

- Select EXIT from a menu.
- On the Z-Series only, press the Esc (Escape) key on your computer’s keyboard.

8.3 Using the SLconfig Software with a Z-Series Amplifier

Follow the previous startup instructions to arrive at the Main Startup Screen, then proceed with the following instructions.

- Press the "Z" key to select the Z-Series software. The software will display the Z-Series Startup screen and will begin establishing communications with the amplifier.
- When the program establishes communications with the amplifier, it will display a message confirming this, as shown in the figure below. If you get an error message instead, check to make sure that you selected the correct amplifier series (Z). Also check that your serial cable is connected correctly, especially at the personal computer, which may have more than one communications port. Make sure the correct port was selected when starting the SLconfig software. Also make sure that input power to your amplifier is turned on.

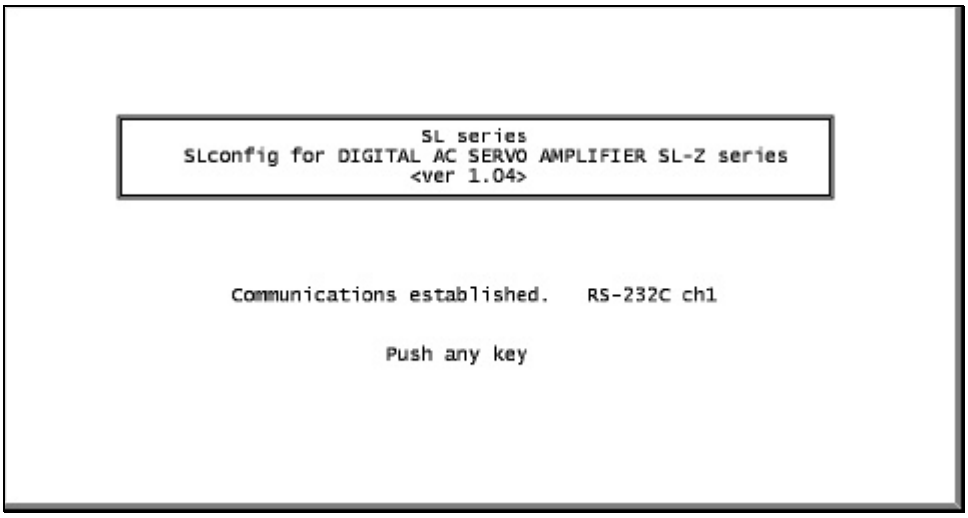


Figure 8-18. The Z-Series Amplifier Startup Screen

- Press a key. The Z-Series Main Menu, shown in the next figure, will display:

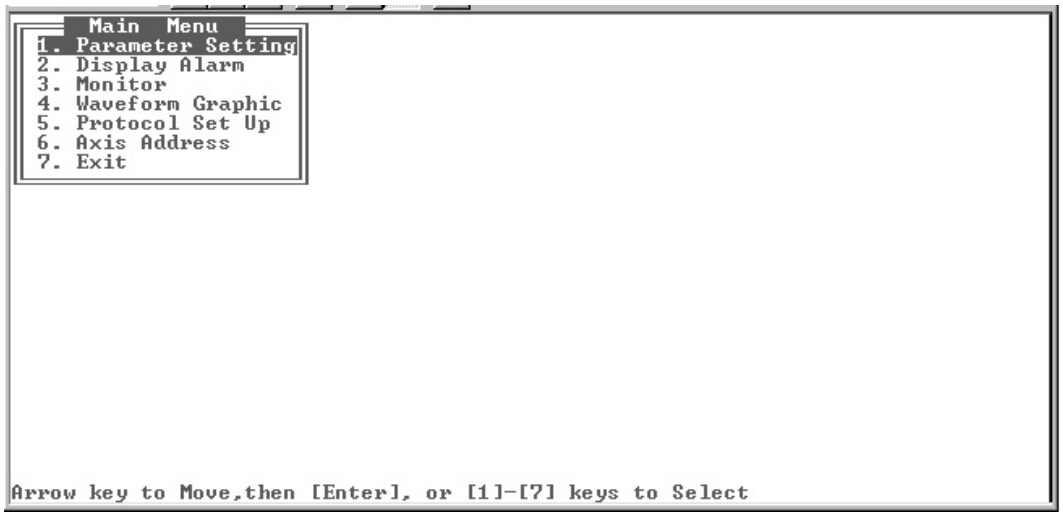


Figure 8-19. Main Menu, Z-Series

Note that while the SL Series amplifier is communicating with a personal computer, the amplifier's front panel key operation will be disabled.

8.3.1 Exiting the Z-Series SLconfig Program

There are three ways to exit the Z-Series SLconfig program:

- From the Main Menu, press the "7" key. Then press the "Y" key to verify the exit.
- From the Main Menu, highlight the menu item "Exit" using the Down arrow key (↓), then press Enter. Next, press the "Y" key to verify the exit.
- Press the Escape key, and then press the "Y" key to verify the exit.

8.3.2 The Z-Series Parameter Menu

The Parameter Menu is used to view or change the current parameter values.

The Parameter Menu is accessed from the Main Menu by pressing the "1" key, or by highlighting (in reverse video as shown in the figure) "Parameter Setting" and pressing the Enter key. Once this is done, the Parameter Menu will be added to the screen to the right of the Main Menu, as shown in the next figure. Note the double line around the Parameter Menu, indicating that it is the active menu.

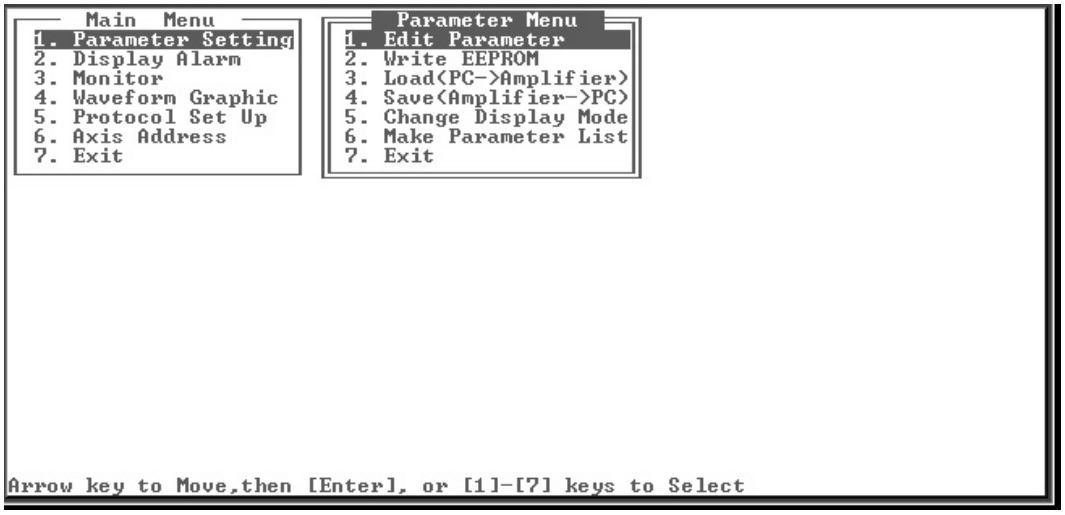


Figure 8-20. Parameter Menu, Z-Series

The Parameter Menu has seven selections:

1. **Edit Parameter:** Lets you view or change current parameter values.
2. **Write EEPROM:** Used to write the contents of the amplifier's volatile RAM memory into the amplifier's built-in non-volatile EEPROM memory.
3. **Load <PC® Amplifier>:** Lets you copy a configuration file from the personal computer into the amplifier's RAM memory. This is useful for restoring a file to an amplifier, or for copying the same file into multiple amplifiers. You are prompted to specify a file name and location (path).
4. **Save <Amplifier® PC>:** For copying the contents of the amplifier's RAM memory to a file on the personal computer. This is useful for creating a backup copy of an amplifier's current configuration file. You are prompted to specify a file name and location (path). Note that you are limited to an 8-character file name with an extension length of 3 characters. The default extension is .PRM.
5. **Change Display Mode:** Lets you change the way an individual parameter's data is displayed. Your choices are decimal or hexadecimal.
6. **Make Parameter List:** For creating a text file of the parameter settings. You are prompted to specify a file name and location (path) where the file will be stored on your PC. Note that you are limited to an 8-character file name with an extension length of 3 characters. The default extension is .TXT. This text file can be opened and printed by any standard text editor program such as Microsoft Word, Wordpad, or Notepad.

7. **Exit:** For exiting out of the Parameter Menu back to the Main Menu. This has the same function as pressing the Escape key.

8.3.2.1 The Edit Parameter Pages

Press the "1" key to select "Edit Parameter" from the Parameter Menu. The Edit Parameter submenu page will display as shown in the following figure.

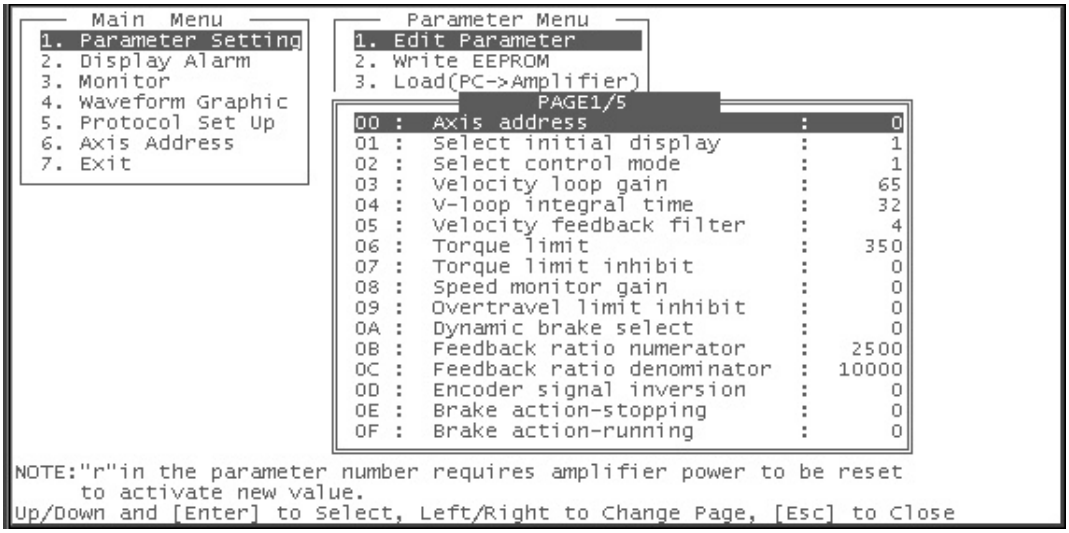


Figure 8-21. Edit Parameter Page 1/5, Z-Series

There are five separate user parameter pages and three additional system parameter pages. The user parameter page in the figure above is labeled "PAGE 1/5" (1 of 5). The three system pages are labeled "System : PAGE 1/3," etc., and they can be viewed, but not edited. To move to the other pages, use the left or right arrow keys. The other parameter pages are shown below:

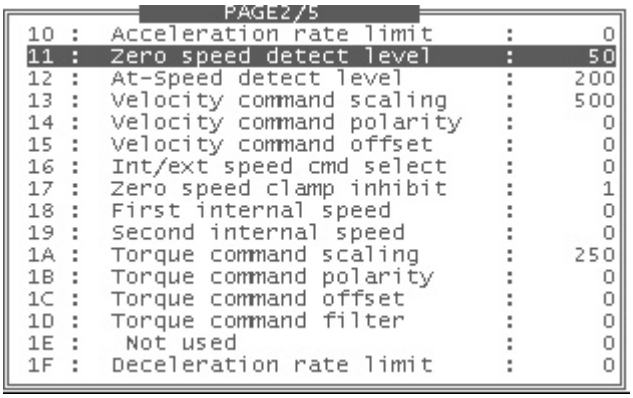


Figure 8-22. Edit Parameter PAGE 2/5, Z-Series

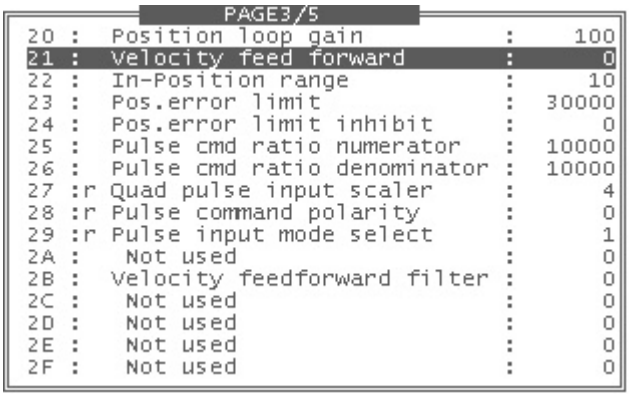


Figure 8-23. Edit Parameter PAGE 3/5, Z-Series

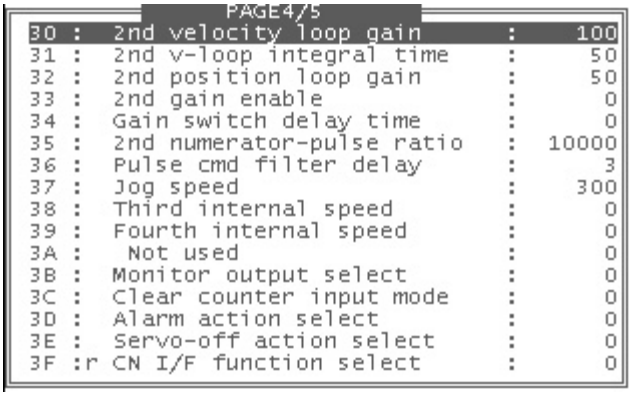


Figure 8-24. Edit Parameter PAGE 4/5, Z-Series

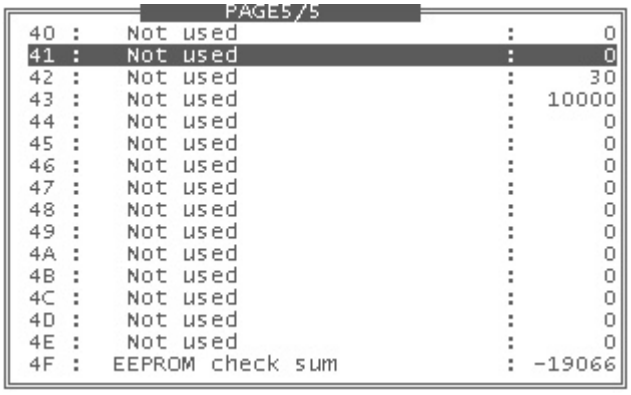
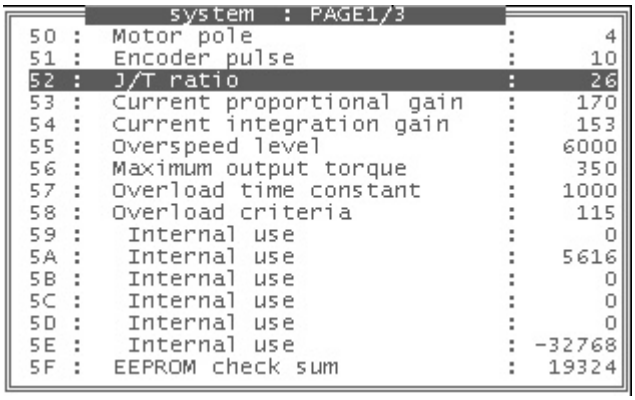


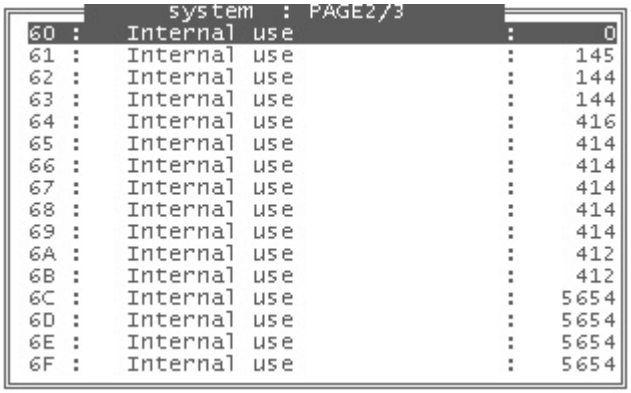
Figure 8-25. Edit Parameter PAGE 5/5, Z-Series



system : PAGE1/3

50 :	Motor pole	: 4
51 :	Encoder pulse	: 10
52 :	J/T ratio	: 26
53 :	Current proportional gain	: 170
54 :	Current integration gain	: 153
55 :	Overspeed level	: 6000
56 :	Maximum output torque	: 350
57 :	Overload time constant	: 1000
58 :	Overload criteria	: 115
59 :	Internal use	: 0
5A :	Internal use	: 5616
5B :	Internal use	: 0
5C :	Internal use	: 0
5D :	Internal use	: 0
5E :	Internal use	: -32768
5F :	EEPROM check sum	: 19324

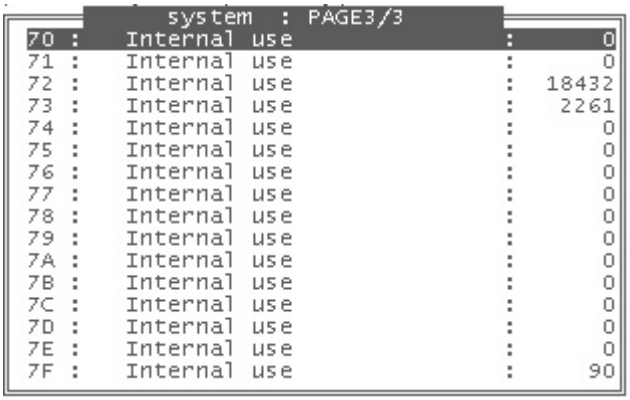
Figure 8-26. Edit Parameter System Page 1/3, Z-Series



system : PAGE2/3

60 :	Internal use	: 0
61 :	Internal use	: 145
62 :	Internal use	: 144
63 :	Internal use	: 144
64 :	Internal use	: 416
65 :	Internal use	: 414
66 :	Internal use	: 414
67 :	Internal use	: 414
68 :	Internal use	: 414
69 :	Internal use	: 414
6A :	Internal use	: 412
6B :	Internal use	: 412
6C :	Internal use	: 5654
6D :	Internal use	: 5654
6E :	Internal use	: 5654
6F :	Internal use	: 5654

Figure 8-27. Edit Parameter System Page 2/3, Z-Series



system : PAGE3/3

70 :	Internal use	: 0
71 :	Internal use	: 0
72 :	Internal use	: 18432
73 :	Internal use	: 2261
74 :	Internal use	: 0
75 :	Internal use	: 0
76 :	Internal use	: 0
77 :	Internal use	: 0
78 :	Internal use	: 0
79 :	Internal use	: 0
7A :	Internal use	: 0
7B :	Internal use	: 0
7C :	Internal use	: 0
7D :	Internal use	: 0
7E :	Internal use	: 0
7F :	Internal use	: 90

Figure 8-28. Edit Parameter System Page 3/3, Z-Series

8.3.2.2 Parameter Identification

An individual parameter is identified by a two-digit, hexadecimal number. The first (most significant) digit identifies the parameter group (0 – 7). The second digit is a parameter number (0 – F). For example, Parameter No. 0B, "Feedback ratio numerator," is in parameter group 0 and has a parameter number of B. It can be found on parameter PAGE 1/5. Similarly, Parameter 37, "Jog Speed," is in group 3, with a parameter number of 7. It is found on parameter PAGE 4/5.

8.3.2.3 Editing a Parameter, Z-Series

This procedure describes how to use the software to change parameter values, but does not tell you how to determine the best value for the parameters. That subject is covered in detail in Chapter 6 of this manual. Note that parameters numbered 40 through 7F, found on parameter PAGE 5/5 and the three System parameter pages, cannot be edited.

.Use the following procedure for editing parameters:

- **Disable the SL Series amplifier.**

Warning

Some parameters substantially change the motion of the motor because of their function (e.g. Parameter No. 02 "Select control mode", No. 14 "Analog command polarity", No. 25, 26 "Pulse cmd ratio numerator/denominator", etc.). Before changing these parameters, be sure the servo axis is disabled.

- On the applicable parameter page, press the number key corresponding to the parameter to be edited, or highlight the desired parameter, then press the Enter key. The Change Parameter window will open, as shown in the next figure.

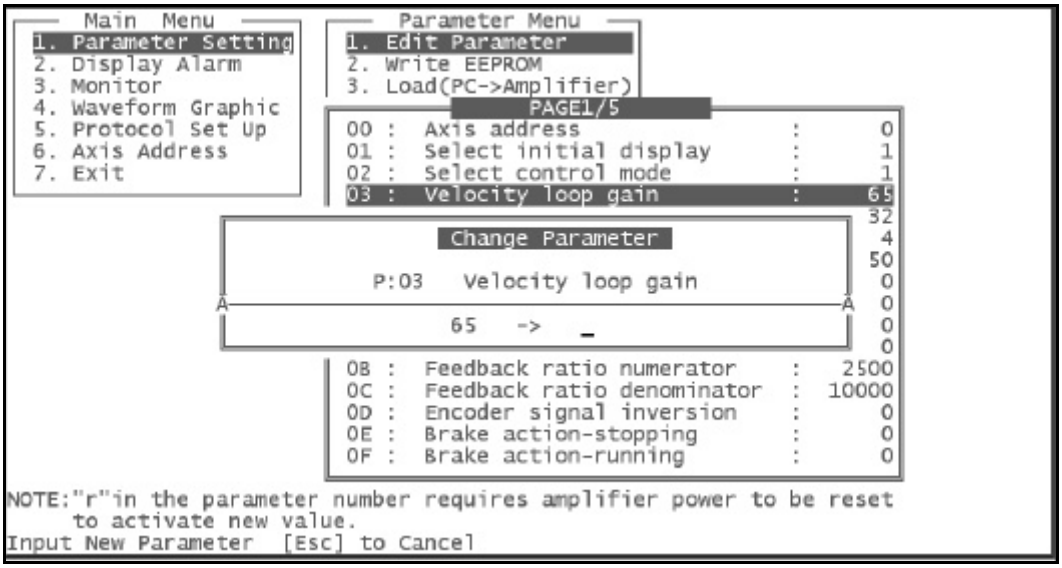


Figure 8-29. Change Parameter Window, Z-Series

- Key in a new value. You may enter a value in standard decimal format or in hexadecimal ("hex") format. To enter a number in hex format use a prefix of 0X (Zero X) before the number. For example, the hex number "1FE5" would be entered as "0X1FE5." Note that hex entries are not case sensitive (either upper case or lower-case letters may be used). When a number is entered in hex format, the screen display of that number is automatically changed from its default of decimal to hex format. You can also manually change the display format by using the instructions found below in Section 8.3.2.7, titled "Changing a Parameter's Display Mode."
- Press the Enter key to enter the new value. If you change your mind, you can cancel and return to the parameter page by pressing the Escape key instead of the Enter key.

Remember, the parameter changes you make are only stored to the SL amplifier's volatile RAM memory. The changes will not remain in effect if power is cycled to the amplifier, because when the amplifier is powered down, RAM memory is cleared. And when the amplifier is powered up, the contents of the amplifier's EEPROM are written into RAM memory. Therefore, any parameter changes you wish to retain should be written into the amplifier's non-volatile EEPROM memory using the following procedure:

8.3.2.4 Writing Z-Series Parameter Values to EEPROM

Warning

While the computer is writing to EEPROM, do not turn off power to either the amplifier or the computer before the message "Operation Successful" is displayed. If you turn off power while writing to EEPROM is in progress, the data may be corrupted.

- On the Parameter Menu, select "Write EEPROM." The Write EEPROM window will display.
- You will be prompted with the message "Write Parameters to EEPROM? (Yes/No)."
- Press the "Y" key and the write to EEPROM will be performed. If you change your mind, press the "N" key to return to the Parameter Menu without writing to the EEPROM. If you pressed the "Y" key you will see the message "Operation Successful, Push any key."

Parameters Requiring a Power Cycle to Activate

Some parameters require that power be cycled to the SL amplifier before they become effective. These special parameters are marked with an "r" on the parameter screens. For example, parameter 27 is shown on-screen as "27 :r Quad pulse input scaler : 4." The following four parameters are in this category:

- 3F on Parameter Page 4/5.
- 27, 28, and 29 on Parameter Page 3/5.

Note

Remember to write the new values to EEPROM memory before you cycle amplifier power or the changes will be lost.

8.3.2.5 Loading a Parameter File From PC to Amplifier

This function lets you load an existing parameter file from your computer to an SL Z-Series amplifier. This function is useful for restoring parameter values to an existing amplifier, or writing them to a new amplifier.

- On the Parameter Menu, press the "3" key to select "Load (PC → Amplifier)." The Load window will display:

- A default path is shown in this window. You may choose to save your file in the default directory shown, or specify a different one. Both choices are discussed below.

Using the Default Path/Directory, Keying in a File Name

- To load a file from the default directory, key in a name on the Filename: line. The name should be of an existing parameter file. It will probably have the default .PRM extension.
- Press the enter key. The message "Operation Successful. Push any key" will display.

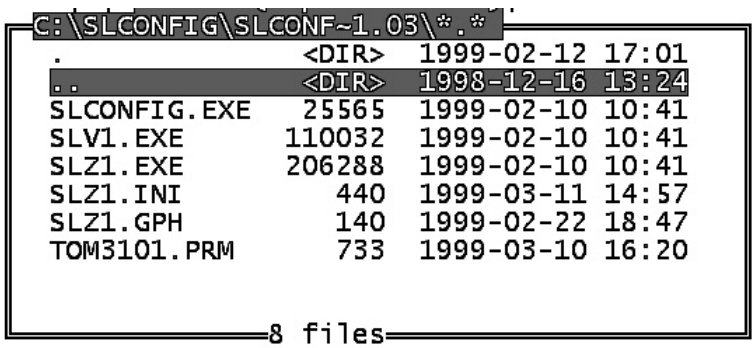
Note: If you enter an incorrect file name, the message "Can't Open Selected File, Push any key" will display. If you enter a correct file name, but not of a parameter file, the message "Error in Selected File or File Transfer, Push any key" will display.

- Press any key to return to the Parameter Menu.

Selecting File from Directory List of Default Path/Directory

If you do not know the exact name of the file to be loaded, you can select it from a directory list of the default directory files. This method helps minimize file name errors.

- Press the Tab key on your computer's keyboard. A list of all files in the default directory will display.



- Use the arrow keys to highlight the desired parameter file. It will probably have the default .PRM extension.
- Press the Enter key. The Load window will display the file name on the Filename: line.
- Press Enter to load the file. The message "Operation Successful, Push any key" will display.
- Press a key to return to the Parameter Menu.

Specifying a Path/File Name

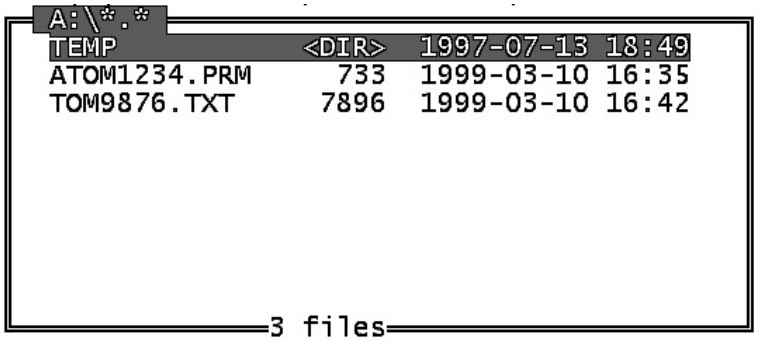
You may wish to load a parameter file from different location than the default. For example, you may wish to load it from a floppy disk.

- Type the directory path on the Filename: line. To select a file from your computer's floppy disk A: drive, insert your floppy disk into the drive, then type A: on the Filename: line.

Note When Using the A: Drive

If you specify that the file be loaded from your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key. If you press the "F" (Fail) key, the load operation will be stopped and the Load window will display an error message. If you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the save operation.

- Press the Enter key. A box with a list of files will display.



- If you wish to see the files in a subdirectory, such as the one called TEMP in the figure above, highlight it as shown and press the Enter key. You will then see a list of files in the TEMP subdirectory.
- Use the arrow keys to highlight the desired file in the TEMP subdirectory.
- Press the Enter key. The highlighted file will appear on the Filename: line, and the new current subdirectory will be listed on the Path: line.
- Press the Enter key. The file will be loaded to the amplifier and the message "Operation Successful, Push any key" will display.
- Press a key to return to the Parameter Menu.

8.3.2.6 Saving a Parameter File from Amplifier to PC

- On the Parameter Menu, press the "4" key to select "Save (Amplifier → PC)." The Save window will display:

A default path is shown in this window. You may choose to save your file in the default directory shown, or specify a different one. Both choices are discussed below.

Saving to the Default Directory

- Key in a file name of your choice, limited to 8 characters, on the Filename: line. The software will add a .PRM extension by default.
- Press the Enter key. When the file is written, the message "Operation Successful, Push any key" will display.
- Press a key to return to the Parameter Menu.

Saving to a Directory you Specify

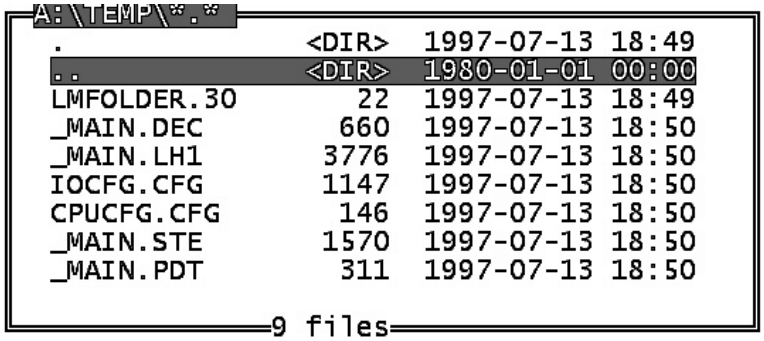
You may wish to specify a different location for your saved files than the default directory. For example, you may wish to save your file to a floppy disk in your computer's A: Drive. The following procedure describes how to specify a different path/directory.

- To save to a different directory on the C: Drive, press the Tab key. To save to the A: drive, type A: on the Filename: line and press the Enter key. In either case, you will see a list of files for the location you specified.

Note When Using the A: Drive

If you specify that the file be saved to your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key. If you press the "F" (Fail) key, the save operation will be stopped and the Save window will display the message "The file cannot be opened." If you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the save operation.

- To change to a different directory, use the arrow keys to highlight that directory name in the file list, then press the Enter key. You will now see a file list for the directory you just specified. Note: If the file list is too large to fit in one window, use the arrow keys to scroll up and down the list. The number of files in the directory is noted at the bottom of the window.
- If you wish to move up one level in the directory structure, place the cursor on the line that has a double dot for a directory name, as shown in the figure below, then press the Enter key.



- When you are in the correct directory, press the Escape key to return to the Save window. The Path: line of the Save window will now show the directory you specified as the current one.
- Key in a file name on the Filename: line. Limit your file name to 8 characters. The software will automatically assign a .PRM extension by default.
- Press the Enter key. When the file is written, the message "Operation Successful, Push any key" will display.
- Press a key to return to the Parameter Menu.

8.3.2.7 Changing a Parameter's Display Mode

The Change Display Mode feature lets you view parameter values in either decimal or hexadecimal format. Only one parameter can be changed at a time with this feature (there is no global change function available). Use the following procedure to change a parameter's display mode:

- On the Parameter Menu, press the "5" key to select "Change Display Mode." A parameter page will display with a list of parameters. If the parameter you wish to change is on that page, use the Up or Down arrow key to highlight it. If the parameter you wish to change is not on the current page, you can change pages using the Right or Left arrow key.
- Once the desired parameter is highlighted, press the Enter key. The numerical format for that parameter's value will change. To change it back, press the Enter key again. The Enter key toggles the display between decimal and hexadecimal for the highlighted parameter.
- Repeat this procedure, if desired, for other parameters. When done, press the Escape key to return to the Parameter Menu.

8.3.2.8 Making a Parameter List

This feature lets you create a text file that lists all of your parameter settings. This list would be useful for documenting your final parameter settings, or it could be e-mailed or faxed to a technical support person who is helping you troubleshoot a startup problem. The text file can be opened in a text or word processing program and viewed or printed from there. The parameter list contains:

- Date and time the list was created

- Parameter type (user or system)
- Parameter number
- Parameter name
- Parameter value.

- To make a parameter list, press the "6" key on the Parameter Menu. A Save window will display. A default path is shown in this window. You may choose to save your file in the default directory shown, or specify a different one. Both choices are discussed below.

(insert figure)

Using the Default Path/Directory

- To use the default path, key in a name on the Filename: line. The name should be 8 characters or less. The software will add the extension .TXT by default.
- Press the enter key. The message "Operation Successful. Push any key" will display.
- Press any key to return to the Parameter Menu.

Specifying a Path/Directory

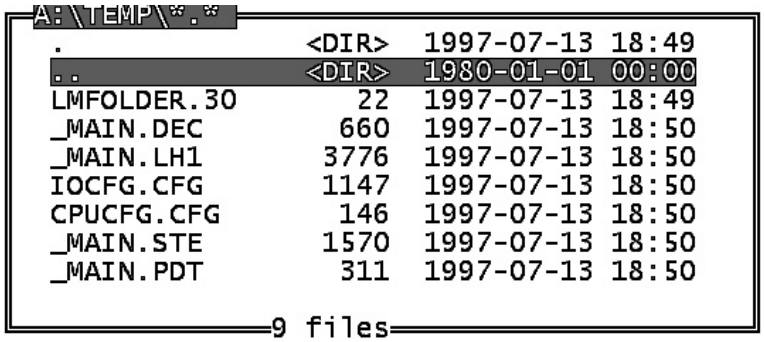
You may wish to write the file to a different location than the default.

- To save to a different directory on the C: Drive, press the Tab key. To save to the A: drive, type A: on the Filename: line and press the Enter key. In either case, you will see a list of files for the location you specified.

Note When Using the A: Drive

If you specify that the file be saved to your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key. If you press the "F" (Fail) key, the save operation will be stopped and the Save window will display the message "The file cannot be opened." If you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the save operation.

- To change to a different directory, use the arrow keys to highlight that directory name in the file list, then press the Enter key. You will now see a file list for the directory you just specified. Note: If the file list is too large to fit in one window, use the arrow keys to scroll up and down the list. The number of files in the directory is noted at the bottom of the window.
- If you wish to move up one level in the directory structure, place the cursor on the line that has a double dot for a directory name, then press the Enter key. See the figure below.



- When you are in the correct directory, press the Escape key to return to the Save window. The Path: line of the Save window will now show the directory you specified as the active one.
- Key in a file name on the Filename: line. Limit your file name to 8 characters. The software will automatically assign a .TXT extension by default.
- Press the Enter key. When the file is written, the message "Operation Successful, Push any key" will display.
- Press a key to return to the Parameter Menu.

Viewing or Printing the List with Microsoft Word

- To open the file in Microsoft Word, start Word, then click File on the Menu Bar and select Open. The Open dialog box will display.
- In the Files of type: box, make sure that All files (*.*) is displayed. This will allow you to see files with .TXT extensions in the Name list.
- Use the arrow keys to highlight the desired file in the Name list, then click the OK button. Word will display a Convert File dialog box.
- In the Convert File dialog box, use the arrow keys to highlight Text Only, then click the OK button. You will now see your parameter list displayed in a columnar format. An example of a partial list is shown in the figure below. **Note that the parameter values in this figure are only examples. They may not be the correct settings for your system.** To print the list, use Word's normal printing procedure.

```
date 03/10/1999  time 16:42:38

                  Parameter Name          :Parameter Value   :
-------------------------------------------------------------
  user  00 :  Axis address                 :         0   :
  user  01 :  Select initial display      :         1   :
  user  02 :  Select control mode         :         1   :
  user  03 :  Velocity loop gain          :        65   :
  user  04 :  V-loop integral time        :        32   :
  user  05 :  Velocity feedback filter    :         4   :
  user  06 :  Torque limit                :       350   :
  user  07 :  Torque limit inhibit        :         1   :
  user  08 :  Speed monitor gain          :         0   :
  user  09 :  Overtravel limit inhibit    :         1   :
  user  0a :  Dynamic brake select        :         0   :
  user  0b :  Feedback ratio numerator    :     10000   :
  user  0c :  Feedback ratio denominator  :     10000   :
```

Figure 8-30. Partial Parameter List as Displayed in Microsoft Word

8.3.3 The Alarm Menu, Z-Series

The Alarm Menu is accessed from the Main Menu by pressing the "2" key, or by highlighting (in reverse video as shown in the figure) "Display Alarm" and pressing the Enter key. Once this is done, the Alarm Menu will be added to the screen to the right of the Main Menu, as shown in the next figure. Note the double line around the Alarm Menu, indicating that it is the active menu.

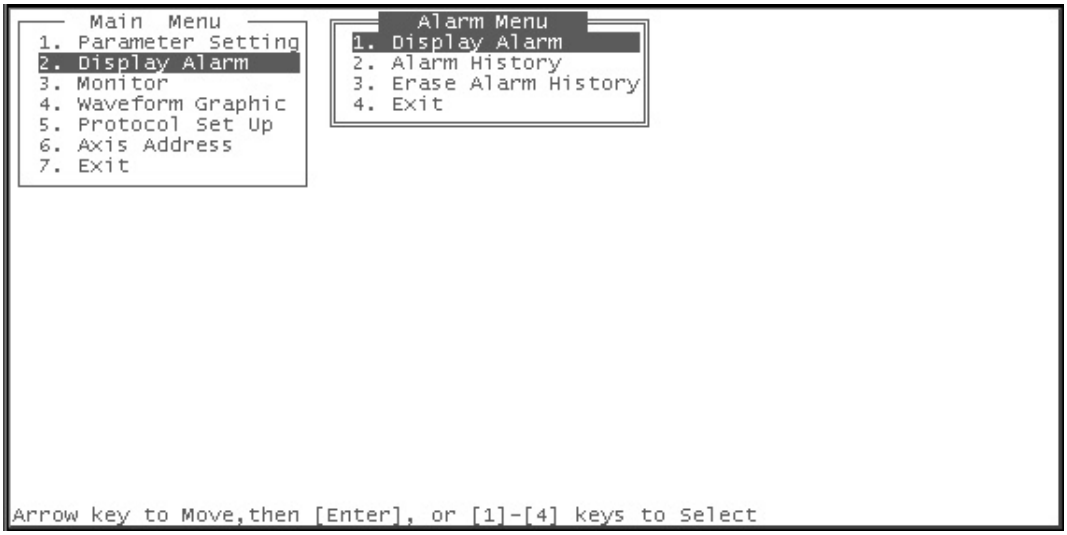


Figure 8-31. The Alarm Menu, Z-Series

Note: The alarms viewed on these screens each have a unique Alarm Code Number. These are listed in Chapter 9, which provides instructions on how to handle each alarm.

The Alarm Menu has four selections:

- **Display Alarm:** Displays only the current alarm.
- **Alarm History:** Displays the last eight alarms in chronological order.
- **Erase Alarm History:** Erases the eight alarms from the Alarm History memory, leaving it blank.
- **Exit:** Exits back to the Main Menu.

8.3.3.1 Displaying the Current Alarm, Z-Series

The current alarm, if there is one, can be displayed from the Alarm Menu by pressing the "1" key. This will cause the Alarm Data window to display the current alarm as shown in the following figure. If there is no current alarm, a "code00 : No error" message will display, as shown.

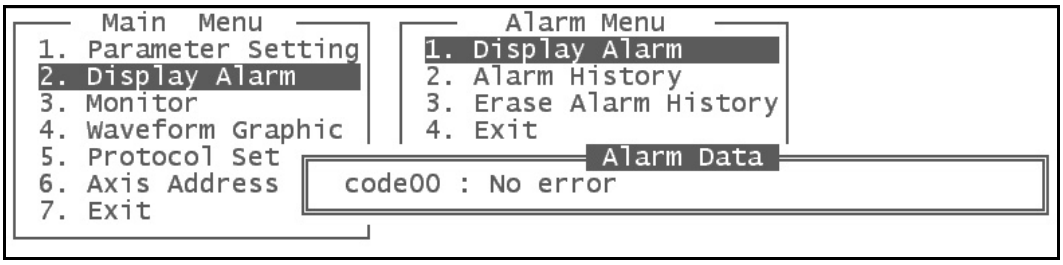


Figure 8-32. Z-Series Display Alarm Window

8.3.3.2 Displaying the Z-Series Alarm History Window

The SL amplifier retains its last eight alarms in non-volatile memory. They can be viewed in the Alarm History window. The Alarm History window can be displayed by pressing the "2" key on the Alarm Menu. The following figure shows the result. Note that if there no alarms to report or there are less than eight alarms, the positions containing no alarm will read "code00 : No error."

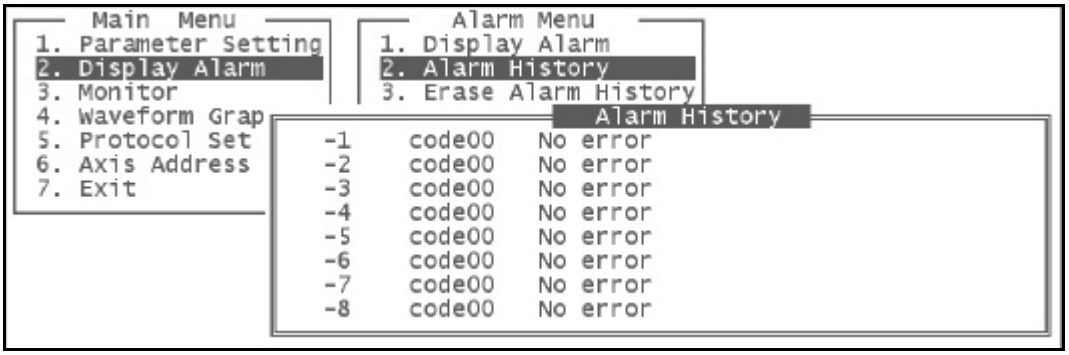


Figure 8-33. Alarm History Window, Z-Series

8.3.3.3 Alarm Codes

Each alarm has its own code number. A listing of these codes and instructions on how to handle each one can be found in Chapter 9.

8.3.3.4 Erasing the Z-Series Alarm History List

You may wish to erase the alarm history list after correcting a problem. To erase the list, press the "3" key on the Alarm Menu. This will produce the message "Erase Alarm History? (Yes/No)." To erase, press the "Y" key. To retain the alarm history and return to the Alarm Menu, press either the "N" key, or the Escape key.

Pressing the "Y" key will result in the message "Operation Successful, Push any key." Press any key to return to the Alarm Menu.

8.3.4 The Z-Series Monitor Menu

The Monitor Menu gives you the ability to check the status of various signals in the SL amplifier.

The Monitor Menu is accessed from the Main Menu by pressing the "3" key, or by highlighting (in reverse video as shown in the figure) "Monitor" and pressing the Enter key. Once this is done, the Monitor Menu will be added to the screen to the right of the Main Menu, as shown in the next figure. Note the double line around the Monitor Menu, indicating that it is the active menu.

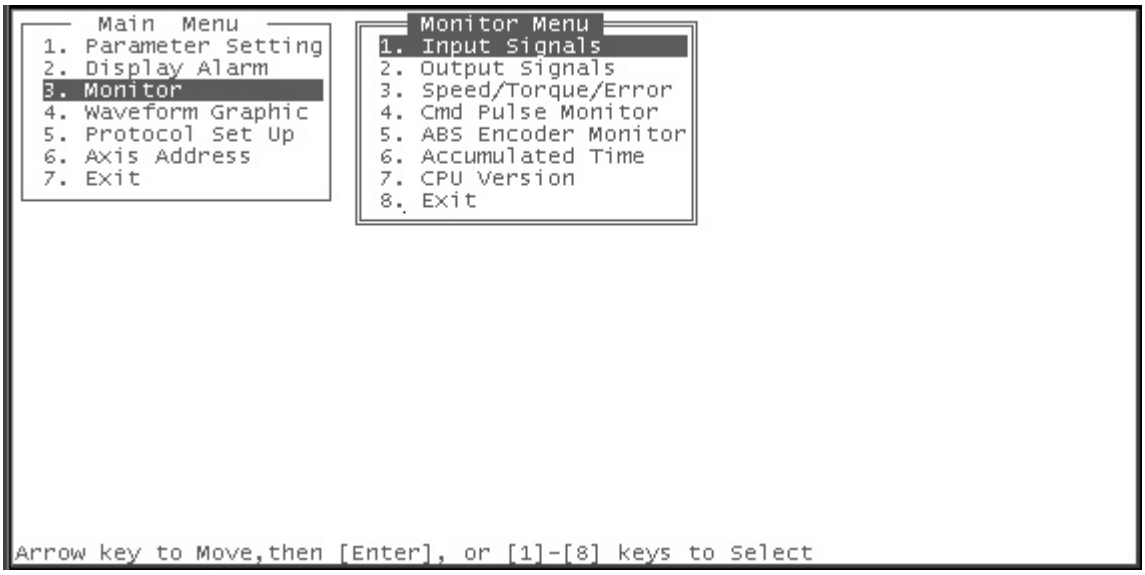


Figure 8-34. The Monitor Menu, Z-Series

The selections on the Monitor Menu let you view the status of various SL amplifier signals. Note that there may be an instantaneous difference between actual values and displayed values due to the inherent time delay in communications between the amplifier and the computer. The Monitor Menu has eight selections, which are described, in the following section.

- **Input Signals:** Displays the status of input signals.

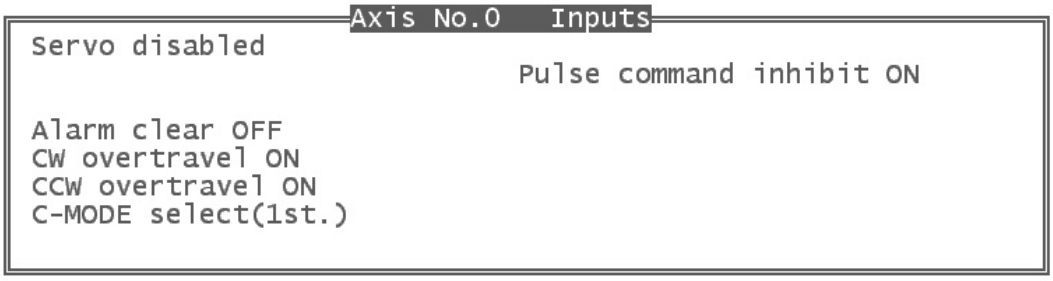


Figure 8-35. Input Signals Window of Monitor Menu, Z-Series

- **Output Signals:** Displays the status of output signals.

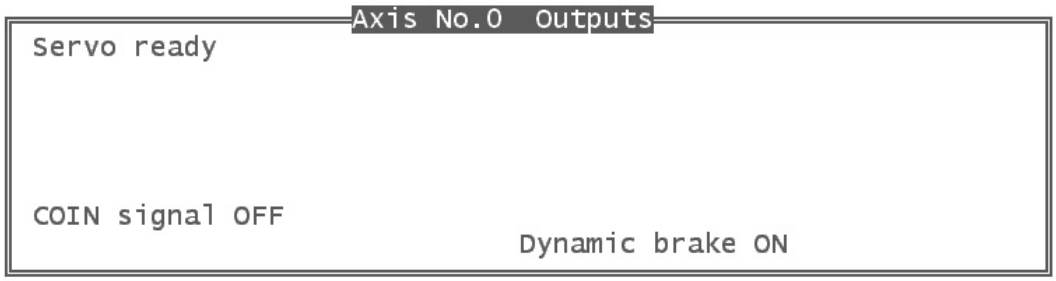


Figure 8-36. Output Signals Window of Monitor Menu, Z-Series

- **Speed/Torque/Error:** Displays the actual motor velocity (labeled "Speed" in the window) in RPM, the Torque command as a % of continuous rated torque, and the number of counts stored in the position error counter. Polarity shown in this window indicates motor direction: "+" indicates CCW direction; "-" indicates CW direction. Note that no '+" sign is displayed.

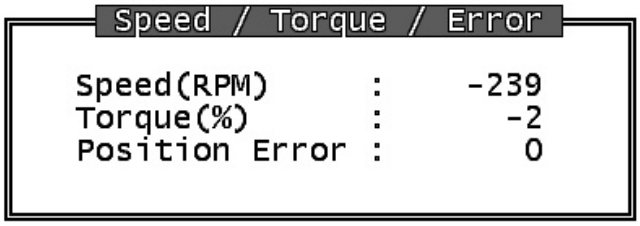


Figure 8-37. Speed/Torque/Error Window of Monitor Menu, Z-Series

- **Cmd Pulse Monitor:** Displays total number of command pulse counts, the present motor velocity in RPM, the number of encoder counts, and the number of position error counts.

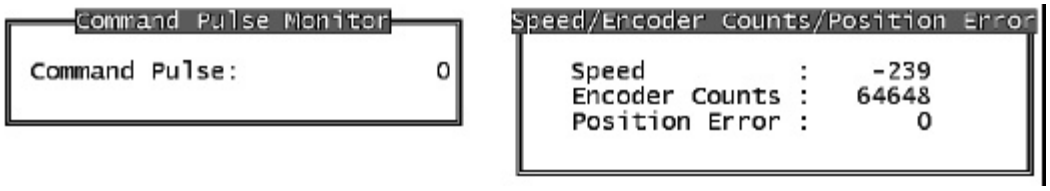


Figure 8-38. Command Pulse Monitor Window of Monitor Menu, Z-Series

- **ABS Encoder Monitor:** The Absolute Encoder feature is not currently offered on the SL Series. Although this window may show a value, it has no valid meaning.

- **Accumulated Time:** This window displays the total accumulated time that the amplifier has been powered up in its lifetime including about 20 hours of factory burn-in and test. This accumulated time value is the equivalent of the odometer reading on an automobile. The time is displayed in hours and minutes with a resolution of 30 minutes. In the figure below, the elapsed time shown is 222 hours and 0 minutes. This value is not re-settable by the user. Note that new amplifiers may show some accumulated time on this monitor due to factory test time.

Figure 8-39. Accumulated Time Monitor Window of Monitor Menu, Z-Series

- **CPU Version**: Displays the firmware version number of the amplifier's CPU.

Figure 8-40. CPU Version Window of the Monitor Menu, Z-Series

8.3.5 The Z-Series Waveform Graphic Menu

The Waveform Graphic Menu is accessed from the Main Menu by pressing the "4" key, or by highlighting (in reverse video as shown in the figure) "Waveform Graphic" and pressing the Enter key. Once this is done, the Waveform Graphic Menu will be added to the screen to the right of the Main Menu, as shown in the next figure. Note the double line around the Waveform Graphic Menu, indicating that it is the active menu.

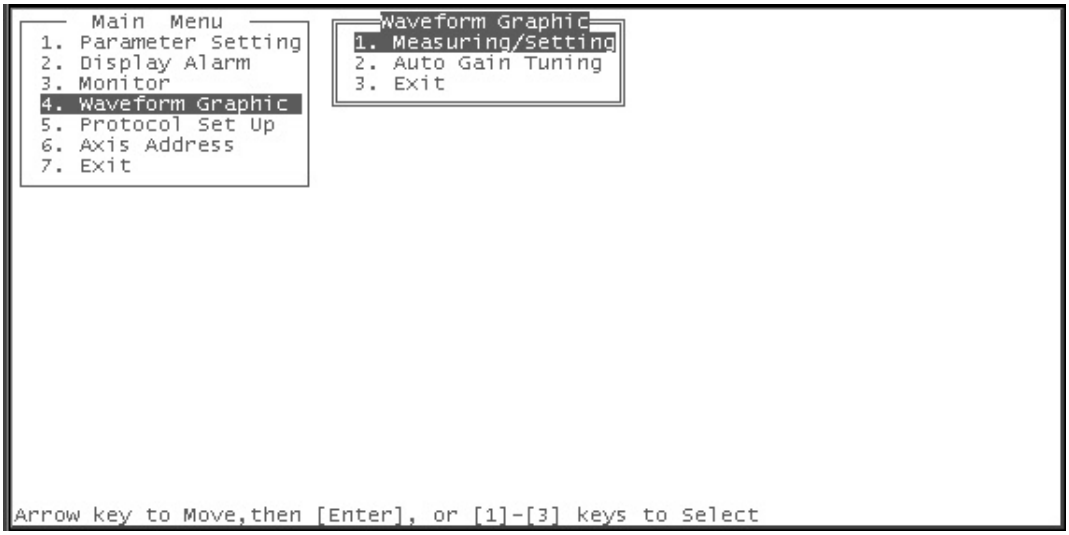


Figure 8-41. The Waveform Graphic Menu, Z-Series

The Waveform Graphic Menu has three selections:

- **Measuring/Setting:** Used to generate waveforms of the SL system's response. Also used to change tuning parameters to improve system performance.
- **Auto Gain Tuning:** Used to run the Automatic Gain Tuning routine. This routine automatically turns the motor shaft, measures the response, and adjusts tuning parameters.
- **Exit:** Returns you to the Main Menu

8.3.5.1 The Z-Series Measuring /Setting Feature

This feature can be used to graph the response of the SL Amplifier, save the waveform graph in a file on your computer, change amplifier gain parameter settings, and save the changes to EEPROM memory in the SL amplifier.

The Measuring/Setting feature is accessed from the Waveform Graphic Menu by pressing the "1" key, or by highlighting (in reverse video as shown in the figure) "Measuring/Setting" and pressing the Enter key. The first page (there are three pages) of the Measuring/Setting feature is shown in the following figure. The other pages can be accessed by pressing the Arrow keys. The Arrow keys cycle through all of the parameters, regardless of which screen they are on. So, for example, if the last parameter (Trigger Position) was selected on the screen in the following figure, pressing the Down arrow would cause the next screen to display with the top parameter on that

screen highlighted. Using the Left arrow key is, in general, a faster way to move from screen to screen.

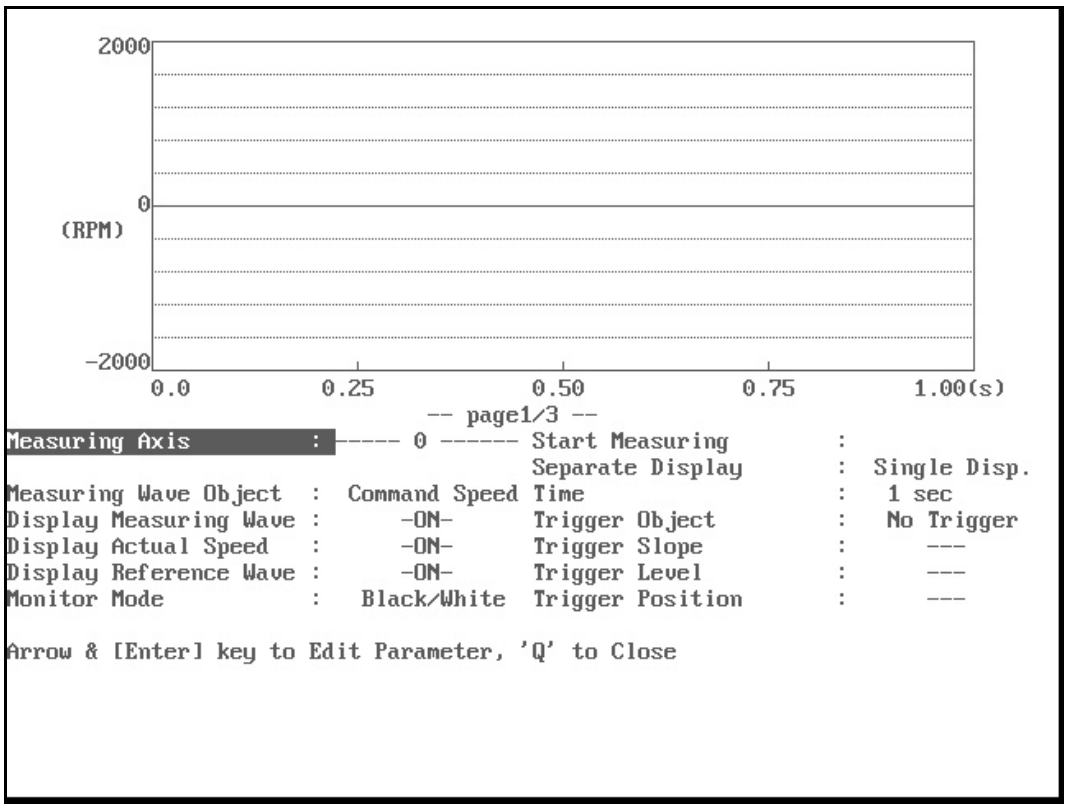


Figure 8-42. Waveform Graphic Measuring/Setting Screen 1, Z-Series

This screen has several selectable items:

- **Measuring Axis:** This displays the Axis Number defined by Parameter No.00.
- **Measuring Wave Object:** Selects which object to plot against the Actual Speed waveform. Choices are Position Error, Commanded Speed, or Output Torque. If you set this screen up to display two separate waveforms, the item selected in this field will display on the bottom graph and the Actual Speed will display on the top graph. This is described later in the "Dual Waveform Display" section.
- **Display Measuring Wave:** Lets you toggle the display of measured data (selected in the Measuring Wave Object field) ON or OFF by placing the highlight on this field and pressing the Enter key.
- **Display Actual Speed:** Lets you toggle the display of Actual Speed ON or OFF by highlighting this field and pressing the Enter key.
- **Display Reference Wave:** Lets you toggle the display of Reference Data ON or OFF by placing the highlight on this field and pressing the Enter key.
- **Monitor Mode:** Lets you switch between Monochrome and Color. If you have a color monitor connected to your computer, you can view the waveforms in color by setting this field to Color. The graph structure and nomenclature displays in black and white for both settings.

- **Start Measuring:** Lets you start the graph generation process by highlighting this field and pressing the Enter key. You can also start the graph generation process by pressing the Spacebar on your computer's keyboard, regardless of which field is highlighted.
- **Separate Display:** Lets you toggle between single or dual display by highlighting this field and pressing the Enter key. When dual display is selected, you will see two individual graphs displayed on the screen. The top graph displays the Actual Speed, and the bottom graph displays the parameter you specify in the Measuring Wave Object field.
- **Time:** Lets you scale the time axis (X or horizontal axis) of the graph by increments of 1 second (range is 1 to 127). To change, highlight this field, then key in a number. The number you enter will represent the full-scale value for the time (X) axis. Waveform data is captured for the time period specified in this parameter. If a waveform is being displayed when this parameter is changed, it will be redisplayed, but will either not all fit on the graph or will only take up a portion of the graph, depending on whether the time value is decreased or increased. **Note: If this field is set to zero, you will not be able to capture any waveforms.**
- **Trigger Object:** Lets you select whether or not to use the trigger function for signaling the start of data collection. The Enter key toggles this field between "Actual Speed" and "no trigger." The trigger feature is especially useful for capturing the acceleration or deceleration portions of a waveform. It eliminates the need to manually synchronize the start of waveform capture with the starting or stopping of the motor.
- **Trigger Slope:** Lets you select whether to trigger on the Rising or Falling edge of the "Actual Speed" trigger signal. The Rising edge setting lets you capture the acceleration portion of the waveform, and the Falling edge setting lets you capture the deceleration portion. The Enter key toggles this field between the two choices. When the Trigger Object field is set to "no trigger," this Trigger Slope field is not used.
- **Trigger Level:** Sets the "Actual Speed" value to be used as a trigger if the Trigger Object field is set to "Actual Speed." The range is –10000 to +10000 RPM. To set, highlight this field and key in a value. When the Trigger Object field is set to "no trigger," this Trigger Level field is not used.
- **Trigger Position:** Used to set a starting position for the waveform on the graph. This allows you to view pre-trigger or post trigger waveform events. The Enter key is used to toggle among the following fractions of the full-scale timebase: 0, 1/8, 1/4, 1/2 3/4, or 7/8. When the Trigger Object field is set to "no trigger," this Trigger Position field is not used.
- **Q to Close:** When you press the "Q" key, two things happen:
    - The current graph settings are saved on your hard drive in file SLZ1.GPH. This file will be saved in the directory containing the SLconfig software. Note that only the settings are saved in this file, not the actual waveform data. (How to save waveform data is described later in this section in the description of the Save Waveform Data field.)
    - You exit out to the Waveform Graphics menu.

8.3.6 Z-Series Waveform Graphic Measuring/Setting Screen 2

This screen has the same graph as the other Waveform Graphic Measuring Setting screens, but with different parameters.

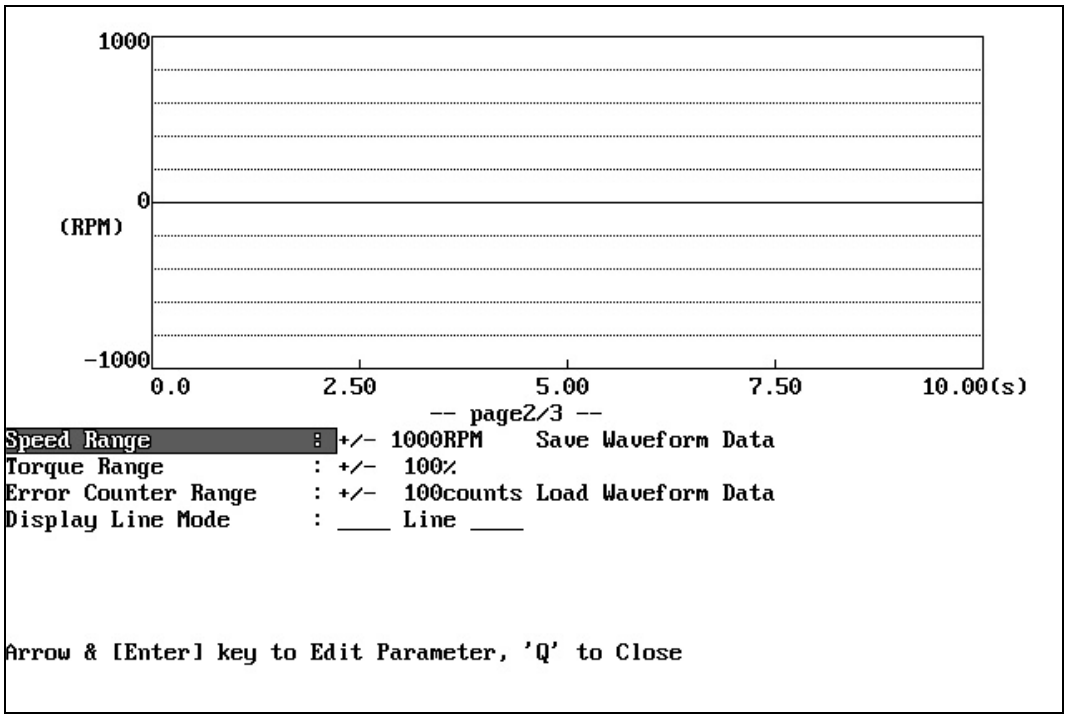


Figure 8-43. Waveform Graphic Measuring/Setting screen 2, Z-Series

- **Speed Range +/-:** Lets you set the full-scale value, between 0 and 6,000 RPM, for the graph's Y-Axis (vertical axis) if Commanded Speed is selected in the Measuring Wave Object field on Waveform Graphic Screen 1. Note that the value you set here will be used for both the positive and negative ends of the vertical axis. If you enter a value of zero in this field, the software will Auto-Range the setting for you. The minimum Auto-Range setting is 500 RPM.
- **Torque Range +/-:** Lets you set the full-scale value, between 0 and 500%, for the graph's Y-Axis (vertical axis) if Output Torque is selected in the Measuring Wave Object field. Note that the value you set here will be used for both the positive and negative ends of the vertical axis. If you enter a value of zero in this field, the software will Auto-Range the setting for you. The minimum Auto-Range setting is 100%.
- **Error Counter Range:** Lets you set the full-scale value, between 0 and 1,000 counts, for the graph's Y-Axis (vertical axis) if Error Counter is selected in the Measuring Wave Object field. Note that the value you set here will be used for both the positive and negative ends of the vertical axis. If you enter a value of zero in this field, the software will Auto-Range the setting for you. The minimum Auto-Range setting is 500 counts.
- **Display Line Mode:** Selects whether the waveforms will display in solid or dotted lines. The Enter key toggles between the two selections.
- **Save Waveform Data:** Lets you save the waveform point data to a file.
- **Load Waveform Data:** Lets you load the waveform data point data from a file.

8.3.6.1 Saving Waveform Data, Z-Series

- Highlight the Save Waveform Data field and press the Enter key. The Save window will display. The file name field will be blank.
- Key in a filename. Limit it to eight characters. The software will give it an extension of .WAV. If you already have a waveform data file that you wish to overwrite, press the Tab key and scroll down through the file list until you highlight the desired file name. Press the Enter key to input the highlighted file name.
- Press the Enter key to save the file to your PC directory containing the SLconfig software. The message "Operation successful, Push any key" will display.

8.3.6.2 Loading Waveform Data, Z-Series

- Highlight the Load Waveform Data field and press the Enter key. The Load window will display.
- Key in a filename to load, or press the Tab key and scroll down through the file list until you highlight the desired file name. Press the Enter key to input the file name.
- Press the Enter key to load the file. The message "Operation successful, Push any key" will display.

8.3.6.3 Opening and Printing Your Saved Waveform File with Excel Software

You can open your file into an Excel spreadsheet and view, plot, or print it from there using standard Excel features such as the Print selection on the File menu.

When you open your waveform file, Excel will prompt for how your data is separated. Select "Comma" since the waveform file is formatted in Comma Separated Variable (CSV) format.

The Comma Separated Variable (CSV) format separates the captured data into five groups. Each group has space for 500 data points.

Group	Data Units
Time	Milliseconds
Actual Speed	RPM
Commanded Speed	RPM
Output Torque	% of rated continuous torque
Error Counter (position error)	Encoder counts

Only three of the five groups will have captured data. Which groups have data depends upon how the Sampling Wave Object field was set (on the Waveform Graphics screen) when you saved your waveform file. The choices are as follows:

Sampling Wave Object Setting	Resulting Data in Waveform Data File
Commanded Speed	Time, Actual Speed, Commanded Speed
Torque Output	Time, Actual Speed, Torque Output
Error Counter	Time, Actual Speed, Position Error

You will see all five group headings displayed on the Excel spreadsheet, but the columns for the two unused groups will have all zeroes.

8.3.7 Z-Series Waveform Graphic Measuring/Setting Screen 3

This screen has the same graph as the other Waveform Graphic screens, but with different parameters.

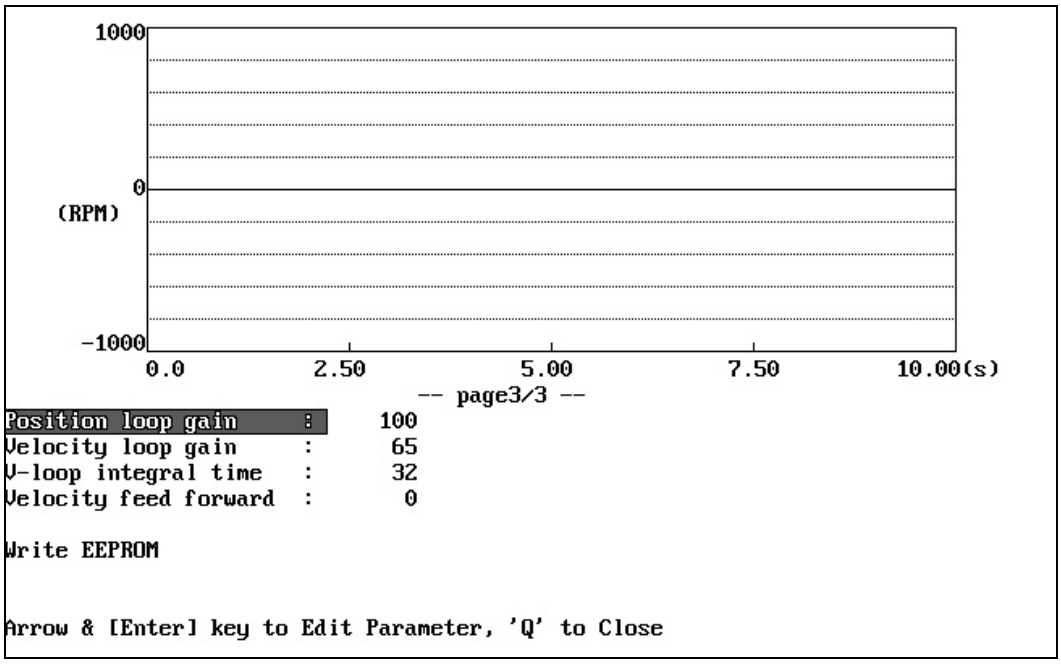


Figure 8-44. Waveform Graphic Measuring/Setting Screen 3, Z-Series

This screen has the following parameter fields. Determining proper values for these parameters is described in Chapter 6.

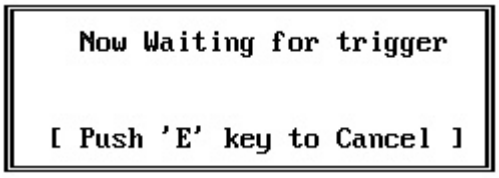
- **Position loop gain**
- **Velocity loop gain**
- **V-loop integral time**
- **Velocity feed forward**

8.3.8 Basics of Generating a Waveform, Z-Series

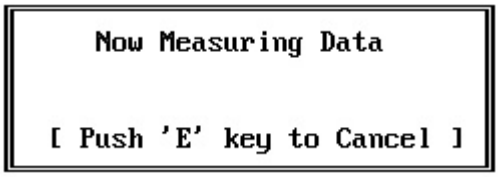
Warning

Generating a waveform requires that the motor be run. Before running the motor, be sure that it can be done safely and ensure there is a quick method to disable or remove power from the amplifier if servo oscillation occurs. Be familiar with how to stop the motor quickly, should it be required. Failure to heed these warnings could result in injury to personnel and damage to equipment.

- Set the various parameters for the waveform display that you desire.
- Press the Spacebar from any screen (or place the highlight on the Start Measuring field on Waveform Graphic Screen 1 and press the Enter key). If you are set up for trigger operation (Trigger Object parameter set to Actual Speed), you will see the following message:



- Start the SL motor. Once the trigger occurs, the message will change to the following:



- When the measurement is done the waveform will display. See an example in the next figure. Note that the "Measuring Data" time is directly related to the value you place in the Time field.
- Stop the SL motor.

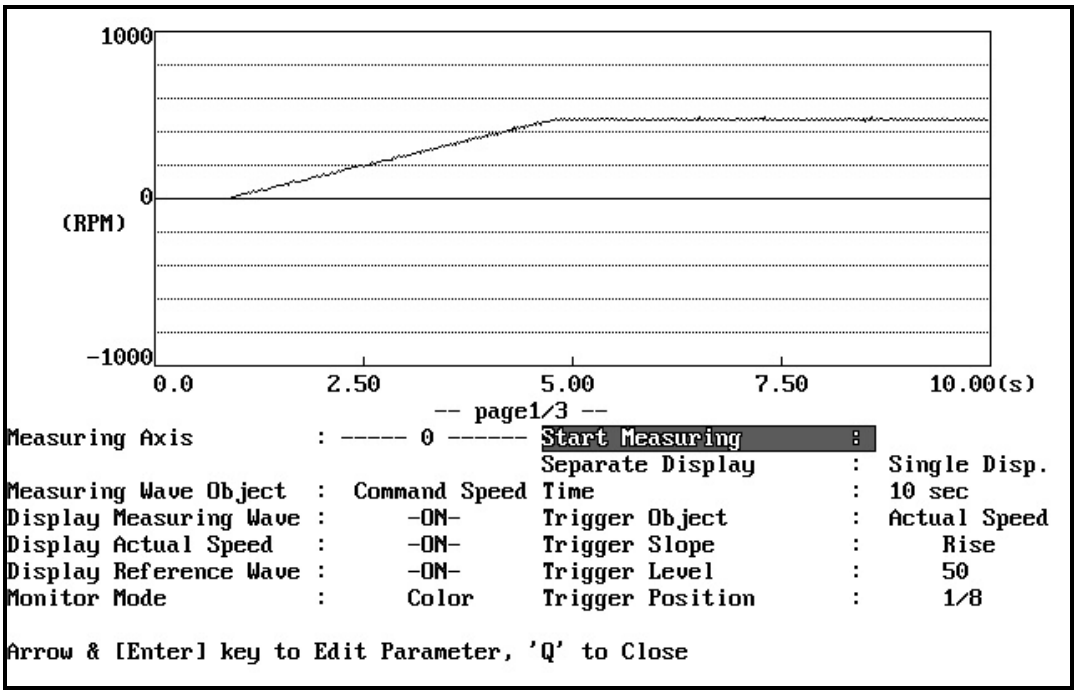


Figure 8-45. Sample Waveform, Z-Series

8.3.9 Tuning Procedure, Z-Series

Warning

The tuning process requires that the motor be run. You should set up a test program or procedure to do this. . Before running the motor, be sure that it can be done safely. Also, changing the parameter values on this screen can have a significant impact on motor operation. Be familiar with how to stop the motor quickly, should it be required. Failure to heed these warnings could result in injury to personnel and damage to equipment.

The Waveform Graphic Measuring/Setting Screen 3 serves as a convenient tool to help you tune your system. Use the following basic procedure:

- Set the parameters on the other two Measuring/Setting screens to display the desired waveform. Use the trigger feature by setting the Trigger Object parameter to Actual Speed and setting the other Trigger parameters appropriately). Then display this screen.
- Press the Spacebar on your computer's keyboard. That will start the measuring process, and the software will wait for the trigger. Start the motor running. When the motor speed reaches the trigger level, measurement will begin. After a few seconds, the waveform will be displayed. Note the response displayed by the wave shape. This will serve as your starting or baseline waveform.
- Change the value of one of the parameters on this screen (it is recommended you only change one parameter at a time while performing this procedure) using the following method:
    - Stop the SL motor.

- Place the highlight on the desired parameter field and press the Enter key. The Change Parameter window will display.
- Key in a new parameter value.
- Press the Enter key. The new value will be written to the SL amplifier's RAM memory.

- **Before proceeding, be sure you know how to shut off the motor quickly, in case a parameter change results in unstable operation.** Press the Spacebar on your computer's keyboard. That will start the waveform generation process, and the software will wait for the trigger.
- Start the motor running. After a few seconds (depending on your Time parameter setting), the waveform will be displayed. The effects of your parameter change can be observed on the waveform by comparing it with what you observed about the previous waveform.
- Make further parameter changes as desired by repeating the above process until you are satisfied with your tuning settings. Generally speaking, you will be trying to achieve a high degree of response while staying a reasonable distance below the point of instability.
- Once your settings are final, highlight the Write EEPROM field and press Enter if you wish to save the settings to EEPROM.

8.3.10 Dual Waveform Display, Z-Series

Two separate graphs can be viewed on one screen by setting the Separate Display parameter to "Separate Disp." With these two graphs, you will be able to display two separate waveforms that are generated simultaneously. In the example shown below, the Torque Range parameter was set to 10%, and the Speed Range parameter was set to Auto Scale. The upper graph is displaying Actual Speed, and the lower graph is displaying Output Torque (set in the Measuring Wave Object parameter).

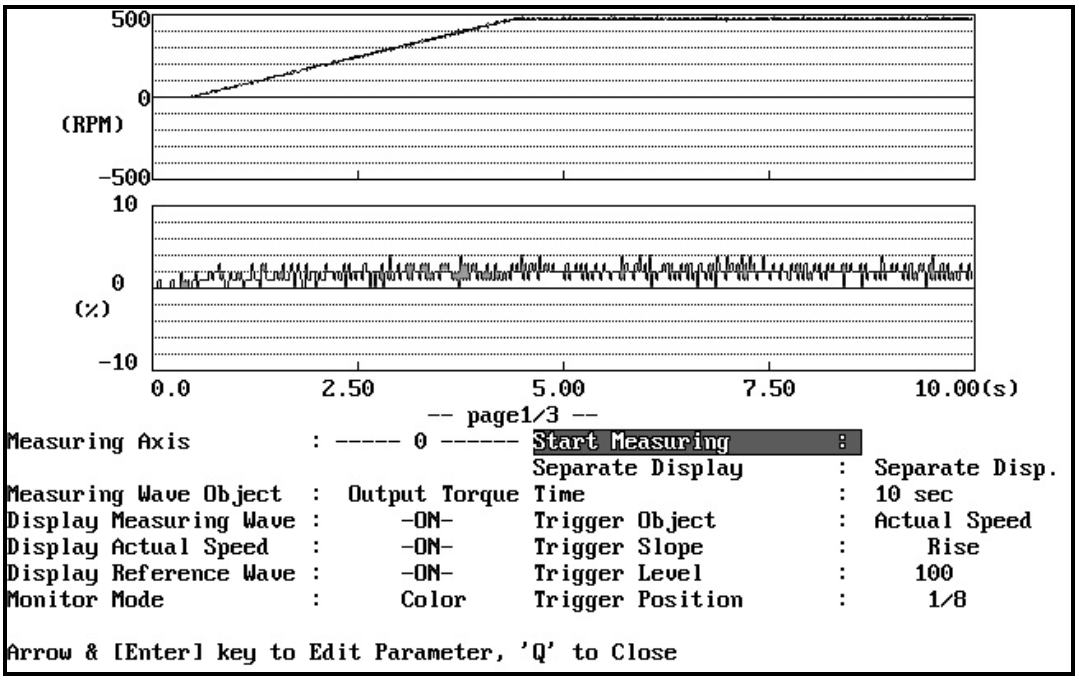


Figure 8-46. Dual Waveform Display, Z-Series

8.3.10.1 The Auto Gain Tuning Routine, Z-Series

Refer to Chapter 7, "Tuning," for the details of this function. Carefully read and understand the applicable ranges and notes, before using this function.

Autotuning Overview

The autotuning function is designed to assist you in setting the SL amplifier gain values. Autotuning should be performed with the actual operating load attached. Please review Chapter 7 before proceeding with the autotuning function. After autotuning, if you wish to make further manual gain adjustments to optimize performance, you can use the Online Monitor feature of the SLConfig software. However, in general, autotuned systems with intertial ratios of less than 6:1 will usually not require further adjustment.

Warning

The SL motor will make several rotations in both directions while the autotuning routine is running. Before starting this routine, make sure that the motor can be turned safely at least 3 revolutions in each direction. This must be done to avoid possible injury to personnel or damage to equipment.

Autotuning with an External Motion Controller (such as APM or DSM)

If using an external motion controller, such as a GE Fanuc Series 90-30 APM or DSM, be aware that the autotuning function is only used to tune the SL Amplifier's velocity loop. The position loop, which is closed in the external controller, must be disabled during autotuning and tuned separately, according to the procedure for the external controller. So, for autotuning purposes, any connected motion controller should produce an enable signal to the SL Amplifier, but no analog command (command output should be held to zero). If using a GE Fanuc APM or DSM, you can ensure that the analog command is held to zero by temporarily setting the APM or DSM Pos Loop TC to Zero and FF% to zero. Or, alternately, command a Force D/A to zero in the APM or DSM. See Appendix A for more information on using the SL-Series amplifiers with external controllers.

For a third-party motion controller, you must disable or disconnect its analog command output to the SL amplifier. However, the SL amplifier must be enabled, which consists of closing the contact between the SRV-ON input and the COM– input.

Procedure

The Auto Gain Tuning routine is started from the Waveform Graphic Menu by pressing the "2" key, or by highlighting (in reverse video as shown in the figure) "Auto Gain Tuning" and pressing the Enter key. The Auto Gain Tuning screen is shown in the following figure.

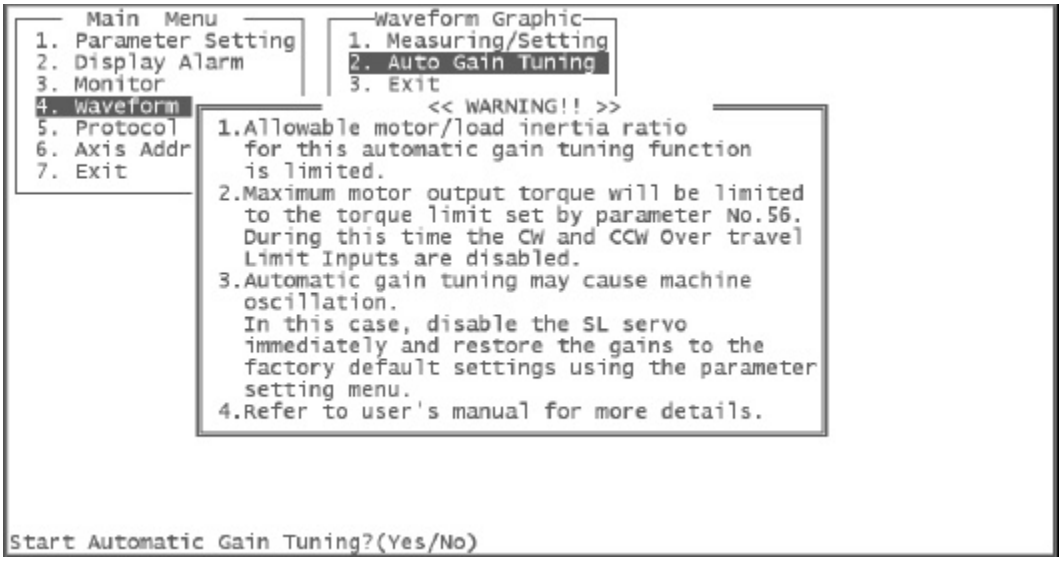


Figure 8-47. Auto Gain Tuning Screen 1, Z-Series

- Press the "Y" key to start Automatic Gain Tuning. If you wish to cancel, press the "N" key to return to the Waveform Graphics Menu. If you press the "Y" key, the following window will display:

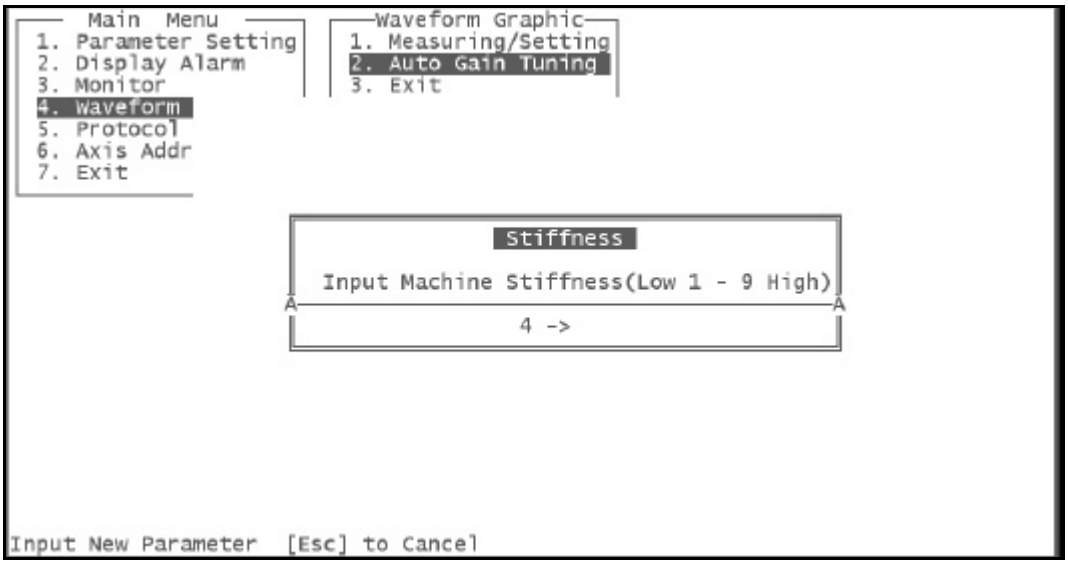


Figure 8-48. Auto Gain Tuning Screen 2, Z-Series

- Key in a new Machine Stiffness value, if desired, then press the Enter key (see Chapter 7 for tuning details). If you do not wish to change the Machine Stiffness value, enter the same value as the current value, then press the Enter key.
- **Before proceeding, check that the motor can be turned safely. This is necessary to avoid injury to personnel and equipment (see Warning note at the beginning of this section).**
- If an error occurs during autotuning refer to Sections 7.4 and 8.1.1.4 for more information.

When ready to proceed, press the Enter key. The Auto Gain Tuning routine will begin running, the motor will turn several times, and the following screen will display while the routine is running (Note the message “Now Executing Automatic Gain Tuning”):

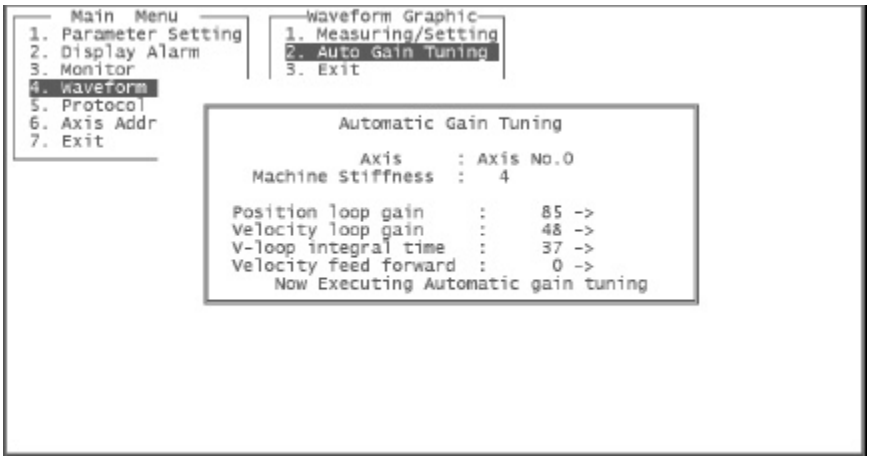


Figure 8-49. Auto Gain Tuning Screen 3, Z-Series

Once the Automatic Gain Tuning routine is complete, the following screen will display. Note the message “Automatic Gain Tuning Complete” and the prompt “Write Parameters to EEPROM? (Yes/No)” at the bottom of the screen.

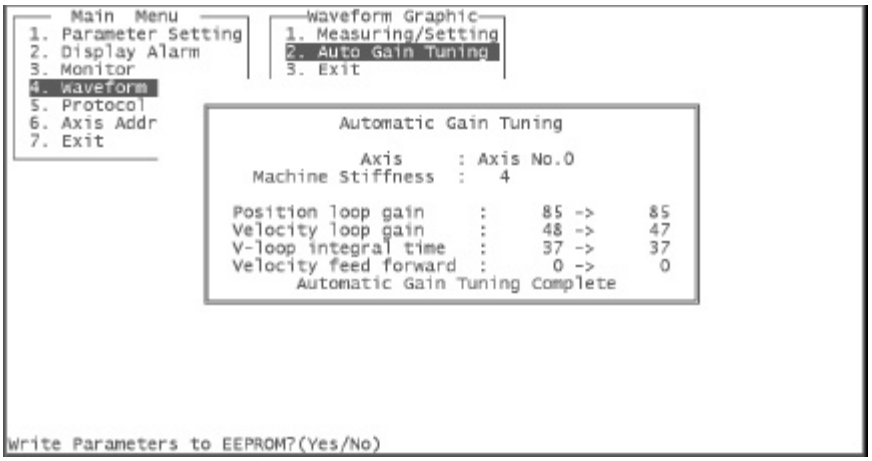


Figure 8-50. Auto Gain Tuning Screen 4, Z-Series

If you wish to save the parameter values generated by the Automatic Gain Tuning routine, press the "Y" key to write the parameters to EEPROM. If you do not wish to write these parameters to EEPROM, press the "N" key to return to the Waveform Graphics screen.

Caution

While the computer is writing to EEPROM, do not turn off power to either the amplifier or the computer before the message "Writing to EEPROM is complete" is displayed. If you turn off power while writing to EEPROM is in progress, the data may be corrupted.

8.3.11 Z-Series Protocol Setup Window

The Protocol Setup Window is accessed from the Main Menu by pressing the "5" key, or by highlighting (in reverse video as shown in the figure) "Protocol Setup" and pressing the Enter key. Once this is done, the Protocol Setup Window (called "Setup" in the window heading) will be added to the screen to the right of the Main Menu. The following figure shows this window. Note the double line around the Setup Window, indicating that it is the active item on the screen.

This window contains two communications parameters for your computer's RS-232 serial port. The Time Out setting has a range of 1 to 255 seconds. The Retry Count has a range of 1 to 10 times. Note that the default settings will work properly in most cases. To change one of these settings:

- Use the Up or Down arrow key to highlight the desired item.
- Key in a new value.
- Press the Enter key to input the new value.

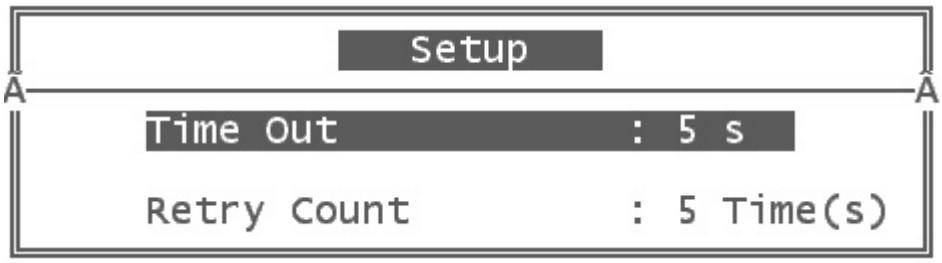


Figure 8-51. Protocol Setup Window, Z-Series

8.3.12 Z-Series Axis Address Window

Since the SL Series does not currently support multi-drop communications, there is no need to assign an axis address using Parameter No.00. However, this parameter may be useful as a tag for identifying which axis is associated with the configuration file. This tag can be viewed in the Measuring Axis field on the Waveform Graphic Screen 1 shown in Figure 8-42.

8.4 Using the SLconfig Software on a V-Series Amplifier

8.4.1 SLconfig V-Series Startup and Main Menu

Follow the previous startup instructions, detailed in Section 8.2.2.2 to arrive at the Main Startup Screen, then proceed with the following instructions:

- Press the “V” key to select the V-Series software.
- When the V-Series software is first started, the startup window shown in the next picture will display only for a few seconds if communications are established with the amplifier. It will display a message verifying successful communications. Note that this startup window contains the SLconfig software version number for the V-Series file.

```
+-------------------------------------------------+
|  Communication software ---- SLconfig(ver.3.17 ) |
|           for IBM PC/AT MS-DOS Ver 6.2           |
|                                                  |
|                                                  |
+-------------------------------------------------+
|                                                  |
|  Communications established.   RS-232C ch1       |
+-------------------------------------------------+
```

Figure 8-52. Startup Window for the V-Series Software

After displaying for a few seconds, the startup window will be replaced by the Main Menu Screen:

```
    +----------------------------------------+
    | ALL DIGITAL SERVO AMPLIFIER            |
    |                                        |
    |                                        |
    |                                        |
    |                                        |
    +----------------------------------------+



       <<< select_MENU >>>
--------------------------------------------------------------------------------
 MENU No.0  ------ Parameter Setting
 MENU No.1  ------ Control state
 MENU No.2  ------ Error condition
 MENU No.3  ------ Error history
 MENU No.4  ------ Automatic gain tuning
 MENU No.5  ------ Waveform graphic
 MENU No.6  ------ File operation/Return to MS-DOS
================================================================================
          Select Menu No.
          ( Select 'Q' to quit a menu )
            MENU No. (0 - 6) =
```

Figure 8-53. V-Series Main Menu Screen

The V-Series Main Menu has the following selections:

- **Parameter Setting:** Provides a way to view or change amplifier parameter settings.
- **Control State:** Displays the status of input and output signals on the amplifier’s CN I/F front panel connector.

- **Error Condition:** Displays the current status of error signals.
- **Error History:** Displays a history list of the last eight errors.
- **Automatic Gain Tuning:** Provides a way to automatically perform an initial tuning of the servo system.
- **Waveform Graphic:** Provides a waveform capture feature that lets you configure, capture, and display waveforms on the computer screen. It also provides a way to change a tuning parameter, then observe the effect graphically by generating a new waveform. This lets you perform final tuning adjustments beyond the basic tuning routine provided by the Automatic Gain Tuning feature.
- **File Operation/Return to MS-DOS:** Provides a way to save or load parameter files from disk. It also provides a way to exit the SLconfig software.

8.4.2 Parameter Setting Screen, V-Series

You select the initial “Parameter Setting” screen by entering “0” on the Main Menu screen.

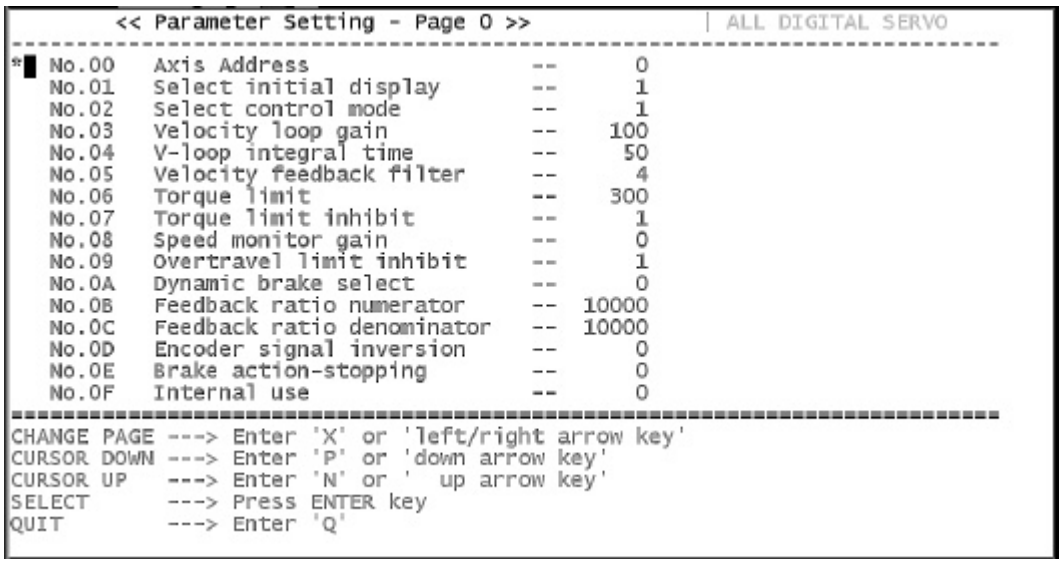


Figure 8-54. Parameter Setting – Page 0 Screen, V-Series

Parameter Identification

The Parameter Setting menu has a total of 4 pages (screens), numbered 0 through 3. These 4 pages or screens correspond to 4 groups of parameters, numbered 0 - 3. An individual parameter is identified by a two-digit hexadecimal number. The first digit (most significant) identifies the parameter group (0 – 3). The second digit identifies a particular parameter in the group. For example, Parameter No. 0B indicates parameter group 0, parameter B. It can be found on parameter page 0 (see the previous figure).

Similarly, Parameter No. 2B is located on parameter page 2 (see figure on next page). In order to change to one of the other parameter pages, use the Left or Right Arrow keys, or press the “X” key.

Power Cycle Requirement

Some parameters require that power be cycled before they take effect after being changed. These are marked on the parameter screens with a lower case letter “r.” Parameter Setting Page 2, shown on the next page, contains some of these special parameters.

```
        << Parameter Setting - Page 1 >>              | ALL DIGITAL SERVO
-------------------------------------------------------------------------
*  No.10   Accel/Decel rate limit        --       0
   No.11   Zero speed detect level       --      50
   No.12   At-Speed detect level         --    1000
   No.13   Velocity command scaling      --     225
   No.14   Velocity command polarity     --       0
   No.15   Velocity command offset       --       2
   No.16   Int/ext speed cmd select      --       0
   No.17   Zero speed clamp inhibit      --       1
   No.18   First internal speed          --       0
   No.19   Second internal speed         --       0
   No.1A   Torque command scaling        --     250
   No.1B   Torque command polarity       --       0
   No.1C   Torque command offset         --       0
   No.1D   Torque command filter         --       0
   No.1E
   No.1F   Internal use                  --   16384
=========================================================================
CHANGE PAGE ---> Enter 'X' or 'left/right arrow key'
CURSOR DOWN ---> Enter 'P' or 'down arrow key'
CURSOR UP   ---> Enter 'N' or '  up arrow key'
SELECT      ---> Press ENTER key
QUIT        ---> Enter 'Q'
```

Figure 8-55. V-Series Parameter Setting [PAGE 1]

```
        << Parameter Setting - Page 2 >>              | ALL DIGITAL SERVO
-------------------------------------------------------------------------
*  No.20   Position loop gain            --      20
   No.21   Velocity feed forward         --       0
   No.22   In-Position range             --      10
   No.23   Pos. error limit              --   30000
   No.24   Pos. error limit inhibit      --       0
   No.25   Pulse cmd ratio numerator     --   10000
   No.26   Pulse cmd ratio denominator   --   10000
   No.27 r Quad pulse input scaler       --       4
   No.28 r Pulse command polarity        --       0
   No.29 r Pulse input mode select       --       1
   No.2A
   No.2B   Velocity feedforward filter   --       0
   No.2C
   No.2D
   No.2E
   No.2F   Internal use                  --   29696
=========================================================================
CHANGE PAGE ---> Enter 'X' or 'left/right arrow key'
CURSOR DOWN ---> Enter 'P' or 'down arrow key'
CURSOR UP   ---> Enter 'N' or '  up arrow key'
SELECT      ---> Press ENTER key
QUIT        ---> Enter 'Q'
```

Figure 8-56. V-Series Parameter Setting [PAGE 2]

```
        << Parameter Setting - Page 3 >>            | ALL DIGITAL SERVO
-------------------------------------------------------------------------
*  No.30 r Motor pole                    --      4
   No.31 r Encoder pulse                 --     10
   No.32   J/T ratio                     --     60
   No.33   Current proportional gain     --    150
   No.34   Current integration gain      --     10
   No.35   Overspeed level               --   6000
   No.36   Maximum output torque         --    300
   No.37   Overload time constant        --   1000
   No.38   Overload criteria             --    115
   No.39
   No.3A
   No.3B
   No.3C
   No.3D
   No.3E
   No.3F   Internal use                  --  24576
=========================================================================
CHANGE PAGE ---> Enter 'X' or 'left/right arrow key'
CURSOR DOWN ---> Enter 'P' or 'down arrow key'
CURSOR UP   ---> Enter 'N' or '  up arrow key'
SELECT      ---> Press ENTER key
QUIT        ---> Enter 'Q'
```

Figure 8-57. V-Series Parameter settings [PAGE 3]

8.4.3 How to Set or Change V-Series Parameters

On the parameter pages, the cursor position is indicated by an asterisk (*) and a small highlight in the left margin of the screen. To make a selection from a parameter menu, move the cursor next to the desired parameter using the Up or Down arrow keys (↑ ↓), or the P (Previous) or N (Next) keys of the computer, then press the Enter key.

A message relating to the parameter that you want to change will be displayed at the bottom of the screen, and a procedure message will be displayed on the right side of the screen near the middle.

You can key in the new value for the parameter, then press the “Y” key to verify it.

Note that there are some parameters that you cannot change, such as the one labeled “Internal Use” at the bottom of each page, or parameters such as “Motor Pole Setting.” If you happen to select one of these parameters, press the Enter key to de-select it.

Warning

Some parameters substantially change the motion of the motor because of their function (e.g. Parameter No. 02 “Select control mode”, No. 14 “Analog command polarity”, No. 25, 26 “Pulse cmd ratio numerator/denominator”, etc.). Before changing these parameters, be sure the servo axis is disabled.

8.4.3.1 Parameter Change Example, V-Series

The following example shows how to change the data of Parameter No. 0B ,”Feedback ratio numerator,” from the initial value of 10000 to a new value of 500.

- **Turn off the Enable input (SRV-ON) to the amplifier. This is a safety precaution to prevent unexpected motion. See the Warning above.**

- Use the Up or Down arrow key to position the cursor (asterisk) next to Parameter No. 0B.
- Press the Spacebar key. The bottom of your screen will display Parameter No. 0B and provide some details about this parameter.
- At the Enter New Value Prompt, key in the value 500, then press the Enter key. Your screen will now look like the following figure:

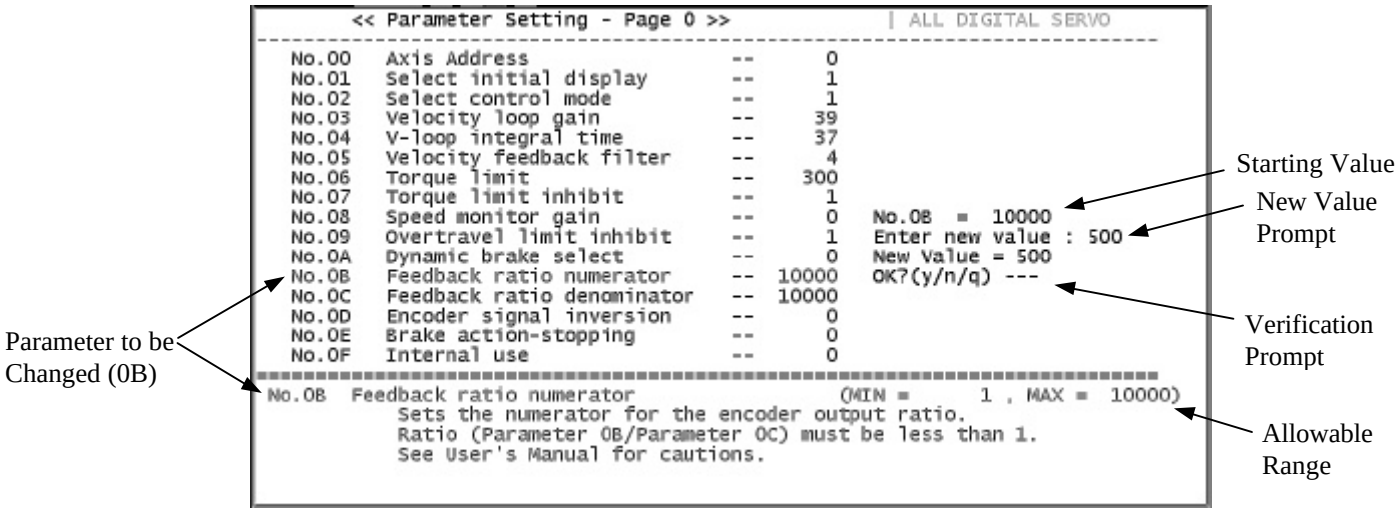


Figure 8-58. Example of changing a parameter, V-Series

You now have three verification choices, Y, N, or Q, detailed in the next three paragraphs.

- If you wish to proceed with your new value, then at the Verification Prompt, enter Y (Yes) to verify the new value and press the Enter key. The bottom section of your screen will now change to look like the following figure.

```
CHANGE PAGE ---> Enter 'X' or 'left/right arrow key'
CURSOR DOWN ---> Enter 'P' or 'down arrow key'
CURSOR UP   ---> Enter 'N' or '  up arrow key'
SELECT      ---> Press ENTER key
QUIT        ---> Enter 'Q'
```

- If you make a mistake or change your mind, you can enter N (No) at the Verification Prompt instead, and the new value will not take effect.
- Use the above process to edit other parameters, if desired. When done, enter the letter Q (Quit). You will be prompted with a message "Select 'Y' to write data into EEPROM or select 'N' to quit" at the bottom of the screen
    - If you press Y to write the new values into the amplifier's EEPROM memory, the message "Writing to EEPROM in progress" will be displayed. When the writing is finished, "Writing to EEPROM is complete" will be displayed. Press the Enter key.
    - If you press N, you will exit without writing to EEPROM.

Caution

While the computer is writing to EEPROM, do not turn off power to either the amplifier or the computer before "Writing to EEPROM is complete" is displayed. If you turn off power while writing to EEPROM is in progress, the data may be corrupted.

If you select [N] and do not write the data into EEPROM, the new settings (except for Parameters 27, 28, and 29, discussed below) will only be active in the amplifier's volatile RAM working memory. Therefore, old data prior to the parameter edit session will be restored after you cycle amplifier power.

For the following three parameters, changed values become valid only after you cycle the amplifier power. Therefore, they must be written into EEPROM in order to take effect.

Parameter No.27 Quad pulse input scaler

Parameter No.28 Pulse command polarity

Parameter No.29 Pulse input mode select

If you change the value of any of these three parameters, the following message will be displayed at the right side of the screen:

Change to this parameter
becomes effective only
after power is reset.
Press ENTER key

8.4.4 Status Display Screen, V-Series

The Status Display screen is used to monitor the status of discrete Input and Output bits, as well as five other control parameters. Entering 1 ("Control state") on the Main Menu screen activates the Status Display screen, shown in the next figure.

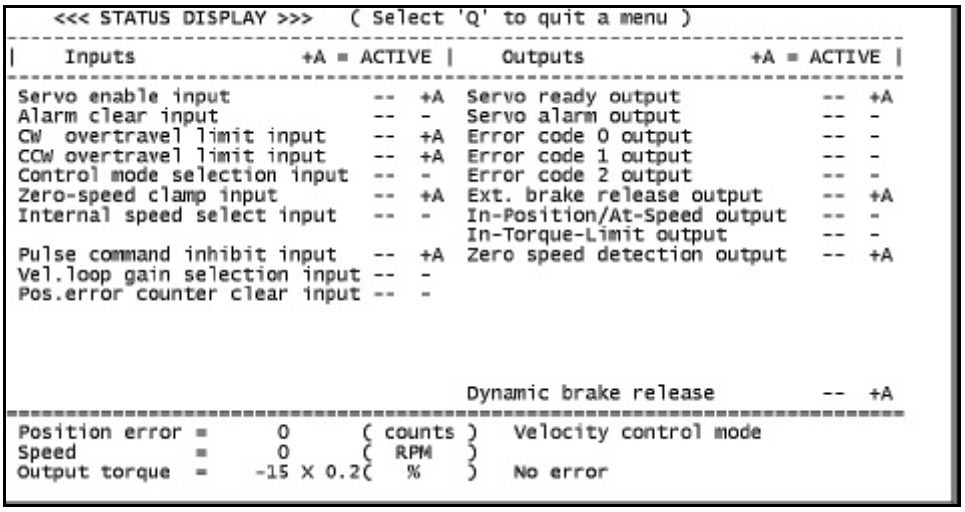


Figure 8-59. Status Display Screen (Menu No. 1), V-Series

Details of the Status Display Screen:

- You can monitor the state of the control input/output signals on the amplifier interface connector, CN I/F. This is useful for checking the wiring and I/O devices connected to that connector. During machine check-out or troubleshooting, this screen could be displayed while the input devices were being manually actuated. As a switch is toggled, its status should change on this screen. See section 5.7.2 for functional descriptions of each I/O connection.
- Signals marked with "+A" are active, and with "-" are inactive.
- You can monitor the following five control states:
  - **Position error:** Displays the number of counts in the Position Error counter. Positive polarity indicates CCW direction, negative polarity indicates CW direction.
  - **Speed:** Displays current motor velocity in RPM. Positive polarity indicates CCW direction, negative polarity indicates CW direction.
  - **Output torque:** Displays the torque command. Positive polarity generates CCW torque, negative polarity generates CW torque. Displayed value times 0.2 represents the percentage of the motor rated continuous torque.

    Example: If the displayed value is -1000, this represents 200% of the rated continuous torque in the negative direction (-1000 x 0.2 = -200).
  - **Control mode:** Displays the active control mode. The Control mode is set in parameter number 02. The choices are Velocity, Position, or Torque.

- **Error:** Displays the error code if any error occurs. Under normal conditions, “No error” will be displayed.

- Communication between the amplifier and the computer is a serial communication using the RS232C standard. Due to serial communication speed limitations, the displayed values of position error, speed, and output torque have some delay from the actual values.
- Enter “Q” to return to the Main Menu.

Note that the bottom portion of this screen is duplicated on the Error Display screen, discussed in the next section.

8.4.5 Error Display, V-Series

This screen lets you view an active error (if there is one). You can select "Error Display" by pressing the "2" key on the Main Menu. In the figure below, an active Encoder error is shown on the Error Display screen. Note that each error listed on this screen has one of the following indications:

- +A: Indicates an active error condition.
- - (dash symbol): Indicates a normal or no error condition.

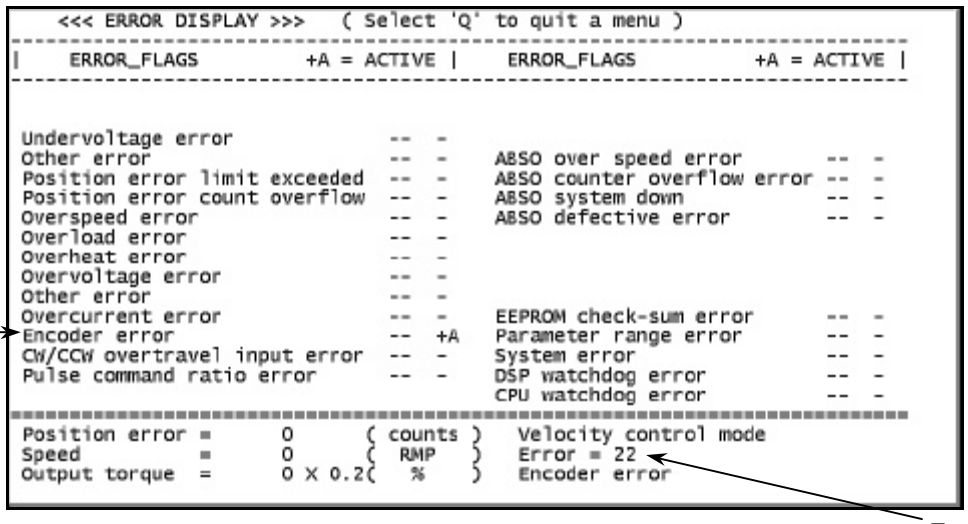


Figure 8-60. Error Screen Showing an Encoder Error, V-Series

Each type of error has an associated code number. For example, in the figure above, the Encoder error has a code of 22. See Chapter 9 for Error Code handling procedures.

Press the "Q" key to exit the Error Display screen and return to the Main Menu.

Note that the bottom portion of this screen is duplicated on the Status Display Screen, discussed in the previous section.

8.4.6 Error History Display, V-Series

An SL amplifier stores the last 8 errors in a section of non-volatile memory. You can view the record of these latest 8 errors by entering "3" at the Main Menu screen. This will display the following "Error History Display" screen:

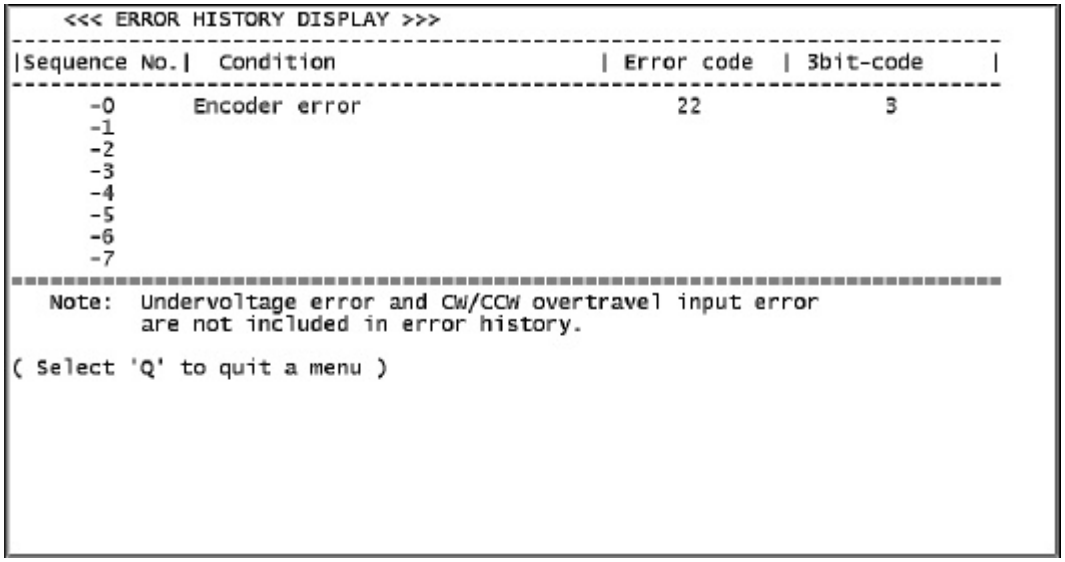


Figure 8-61. Error History Display, V-Series

- In the Sequence Number field, "- 0" represents the latest error, and higher numbers represent progressively older errors.
- "Undervoltage errors" and "Overtravel limit input errors" will not be stored in the error history, even though the amplifier trips. Therefore, when these errors occur, the current error displayed on the Error Display screen will not match the content of the – 0 error on this Error History Display screen.
- Press the "Q" key to exit the Error History Display screen and return to the Main Menu.

Note that if there are not eight errors in the Error History memory, some error positions will be blank as shown in the previous figure. See Chapter 9 for Error Code details.

8.4.6.1 V-Series 3-Bit Code

Each Error has been assigned both an Error Code and 3-Bit code. The Error Codes are discussed in Chapter 9 and the 3-Bit Codes are discussed in Chapter 5. The following is an abbreviated discussion of the 3-Bit Codes.

The 3-Bit Codes are used to communicate the SL V-Series amplifier's internal errors to external devices, such as a Programmable Logic Controller or an alarm system. The signals from the 3-Bit Code are sent to three pins on the SL amplifier's front panel CN I/F connector. The following table indicates the state of the signals on the three pins for the different errors. Note that the three

bits are only able to indicate 8 unique patterns. Therefore, since there are more than 8 Error Codes, some of the 3-bit codes correspond to more than one Error Code.

Error Code Output			Error Description
EXOUT2	**EXOUT1**	**EXOUT0**	
CN I/F Pin 10	**CN I/F Pin 9**	**CN I/F Pin 8**	
0	0	0	Normal Operation (no errors)
0	0	1	System error (98) DSP Watchdog error (23) CPU Watchdog (30)
0	1	0	EEPROM Checksum error (36) Parameter Download error (84) Command Pulse Ratio error (27)
0	1	1	Encoder error (22) Drive Inhibit error (38)
1	0	0	Excessive position error (29) Position Error Limit (24) Over Speed Error (26)
1	0	1	Under Voltage error (13) Over Voltage error (12)
1	1	0	Overload error (16) Over Current error (14)
1	1	1	Other errors (99)

Figure 8-62. 3-Bit Error Code to CN I/F Connector Mapping Table

In the table above:

- A “1” indicates that the output transistor for that circuit is turned off, which lets the pin “float” high at power supply level.
- A “0” indicates that the output transistor for that circuit is turned ON, which pulls the pin low to near ground level potential.

8.4.7 Automatic Gain Tuning, V-Series

Refer to Chapter 7, "Tuning," for the details of this function. Carefully read and understand the applicable ranges and notes, before using this function.

Autotuning Overview

The autotuning function is designed to assist you in setting the SL amplifier gain values. Autotuning should be performed with the actual operating load attached. Please review Chapter 7 before proceeding with the autotuning function. After autotuning, if you wish to make further manual gain adjustments to optimize performance, you can use the Online Monitor feature of the SLConfig software. However, in general, autotuned systems with intertial ratios of less than 6:1 will usually not require further adjustment.

Warning

The SL motor will make several rotations in both directions while the autotuning routine is running. Before starting this routine, make sure that the motor can be turned safely at least 3 revolutions in each direction. This must be done to avoid possible injury to personnel or damage to equipment.

Autotuning with an External Motion Controller (such as APM or DSM)

If using an external motion controller, such as a GE Fanuc Series 90-30 APM or DSM, be aware that the autotuning function is only used to tune the SL Amplifier's velocity loop. The position loop, which is closed in the external controller, must be disabled during autotuning and tuned separately, according to the procedure for the external controller. So, for autotuning purposes, any connected motion controller should produce an enable signal to the SL Amplifier, but no analog command (command output should be held to zero). If using a GE Fanuc APM or DSM, you can ensure that the analog command is held to zero by temporarily setting the APM or DSM Pos Loop TC to Zero and FF% to zero. Or, alternately, command a Force D/A to zero in the APM or DSM. See Appendix A for more information on using the SL-Series amplifiers with external controllers.

For a third-party motion controller, you must disable or disconnect its analog command output to the SL amplifier. However, the SL amplifier must be enabled, which consists of closing the contact between the SRV-ON input and the COM– input.

Procedure

Enter "4" at the main menu to select the "Automatic Gain Tuning" screen, shown in the following figure. Note the two selections (G or Q) and the display of the Gain Parameters' current values at the bottom of the screen. **Note: The values shown on this screen are examples only. They are not necessarily the correct values for your system.**

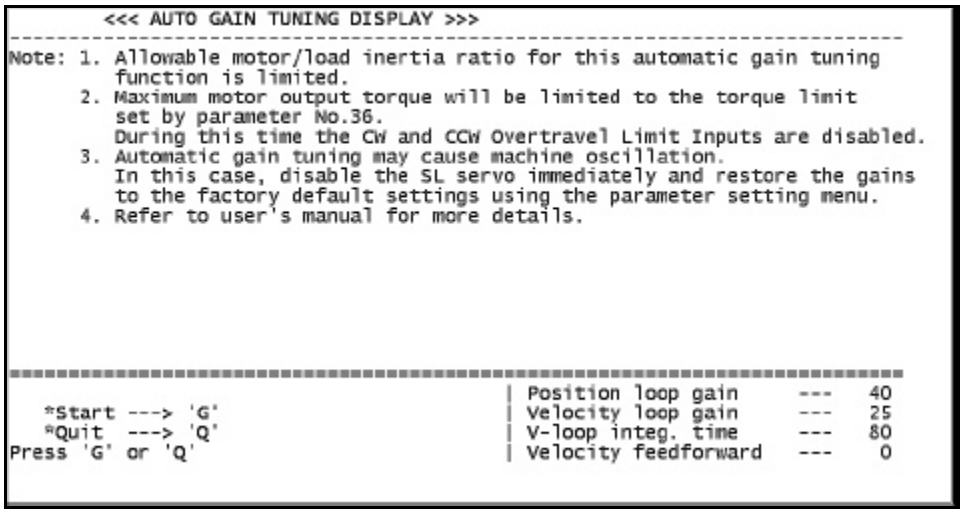
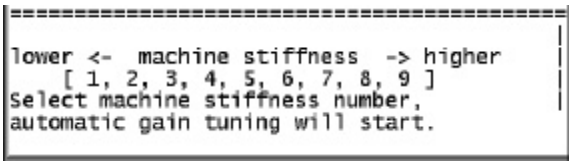


Figure 8-63. Automatic Gain Tuning Display, V-Series

- To begin autotuning, press the "G" key. The message in the lower left corner of the screen will change as shown in the next picture:



- Key in a stiffness number. (Refer to Chapter 7 for a discussion on how to determine the correct machine stiffness number.) The Automatic Gain Tuning routine will start, and the message in the lower left corner will change to say "Automatic Gain Tuning in Progress." When the routine is finished, the screen will again look like the previous figure, except that the new parameter values calculated by the Automatic Gain Tuning routine will be displayed in the lower right corner of the screen.
- When you press Q to quit this menu, you will be prompted whether you want to save your changes in EEPROM. If the automatic tuning result appears satisfactory, key in "Y" to save to EEPROM. If the result is not satisfactory, key in "N" to not save the new gain values. Then you will be returned to the Main Menu.
- If an error occurs during autotuning refer to Section 7.4 and *.1.1.4 for more information.

8.4.8 Waveform Graphic Screen, V-Series

When "5" is entered on the Main menu screen, the "Waveform graphic" screen is displayed, as shown in the next figure. This screen lets you display waveforms for position error, actual motor speed, speed command, and torque command.
This screen includes functions for manual tuning, parameter setting, and automatic gain tuning, making it very useful for tuning adjustments.

Notice that the Waveform graphic screen has two separate parts. The top portion of the screen contains a Display Area for showing motion waveforms. The lower part of the screen is a Message Area containing menu or setting fields.

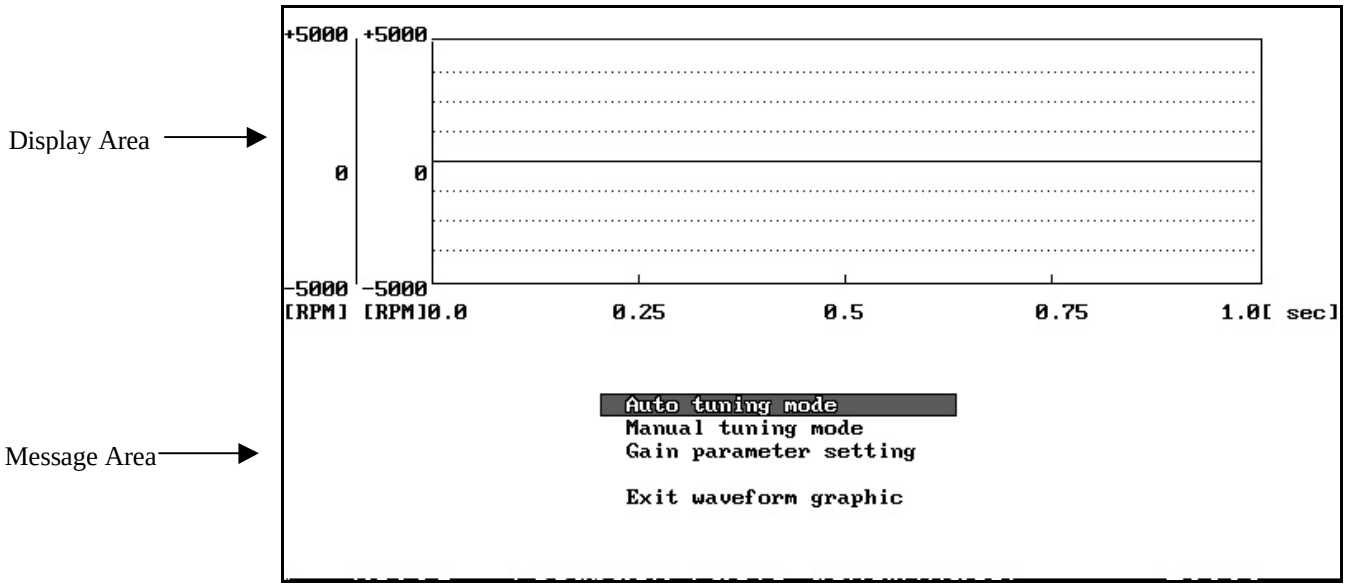


Figure 8-64. Initial display of Waveform Graphic Screen, V-Series

To select an item in the Message Area of this screen, place the cursor (reverse video) on the desired item using the Up or Down arrow keys, then press the Enter key to activate. You can choose from the following selections:

- **Auto Tuning Mode:** This selects the Automatic Gain Tuning Display screen, described in the previous section. This screen is used for initial tuning. (See Section 8.4.7)
- **Manual Tuning Mode:** Provides a way to manually "fine-tune" the servo while observing tuning changes graphically on the screen. Manual tuning should only be done after initial tuning has been performed either with the Auto Tuning routine or from the Gain Parameter Setting screen.
- **Gain Parameter Setting:** Selects the Gain Parameter Setting screen. Used for initial gain tuning.
- **Exit Waveform Graphic:** Exits to the Main Menu

8.4.8.1 Manual Tuning Mode, V-Series

The Manual Tuning Mode is intended to optimize the tuning parameters after they have been set initially using either the Automatic Gain Tuning routine, or the Gain Parameter Setting procedure. If you have not performed one of these, please do so before performing Manual Tuning.

Selecting Manual Tuning Mode from the Waveform Graphics Screen will bring you to this first Manual Tuning screen:

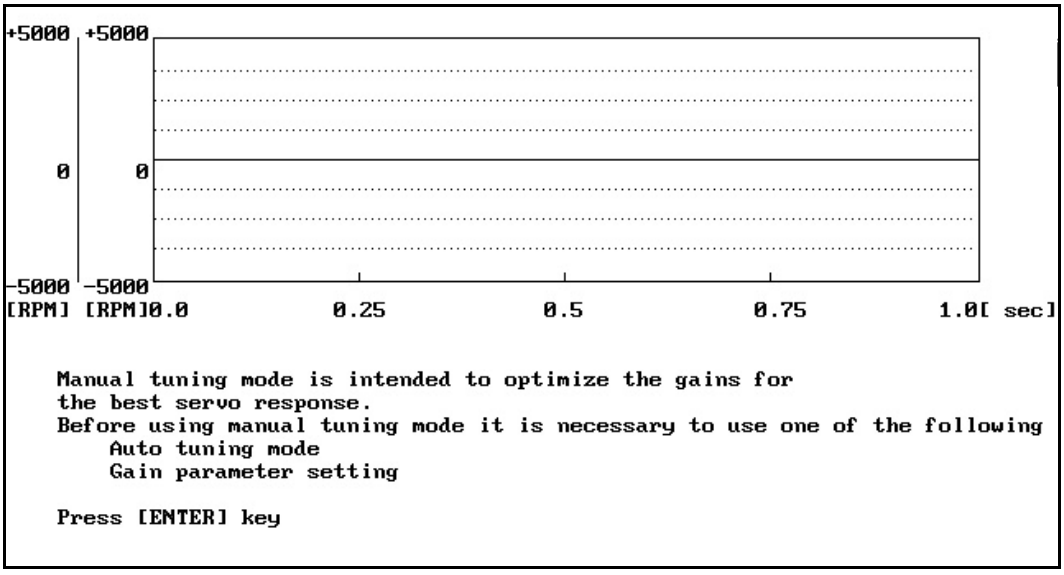


Figure 8-65. Manual Tuning Screen 1, V-Series

If you have performed an initial tuning procedure (Automatic Gain Tuning or Gain Parameter Setting) and wish to proceed with Manual Tuning, press the Enter key. You will now see the following screen:

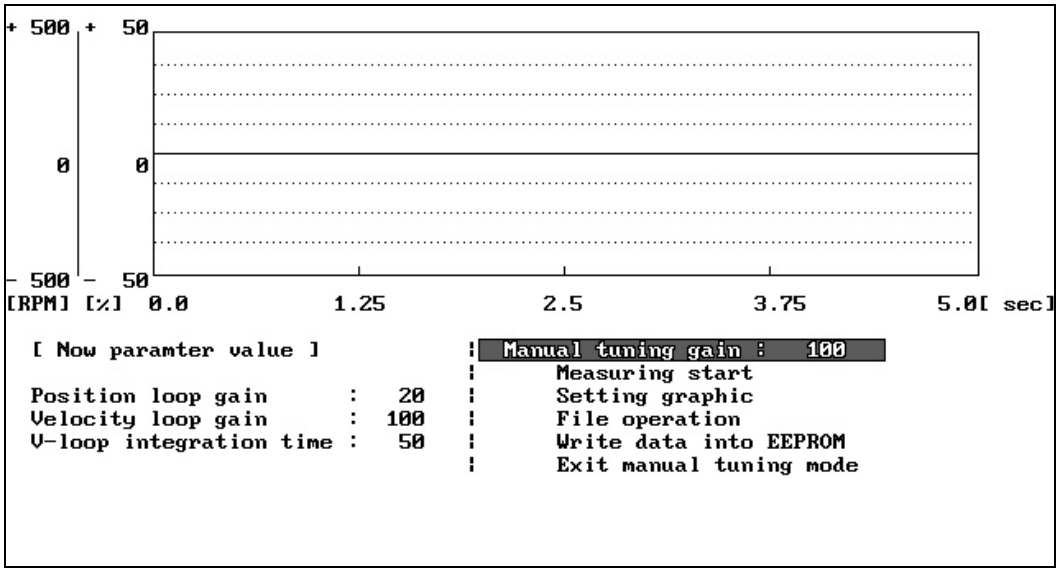


Figure 8-66. Manual Tuning Screen 2, V-Series

This screen has the following parameters:

- **Manual Tuning Gain:** Changing this parameter's value changes, at the same time, the other three parameters on the left side of the screen (Position loop gain, Velocity loop gain, and V-Loop integration time), because they are set up in an interlocked relationship on this screen. If you wish to change these parameters individually, you can do so from the Gain parameter setting screen.
- **Position Loop Gain:** Cannot be changed directly on this screen. See the "Manual tuning gain" item above.
- **Velocity Loop Gain:** Cannot be changed directly on this screen. See the "Manual tuning gain" item above.
- **V-Loop Integration Time**: Cannot be changed directly on this screen. See the "Manual tuning gain" item above.
- **Measuring Start**: Lets you initiate the start of waveform generation. Highlighting this field and pressing the Enter button will take you to the "Waiting for trigger" message. Once the trigger occurs, the message will change to "Transferring data."
- **Setting Graphic**: Accesses the Setting graphic screen, described earlier in this section.
- **File Operation**: Accesses the File operation screen, described earlier in this section.
- **Write data into EEPROM**: Writes parameter data to the SL amplifier's non-volatile EEPROM memory. Note that when you highlight this field and press the Enter key, the parameter write will immediately occur. You will not be given a chance to change your mind.

8.4.8.2 Using the Manual Tuning Screen to Fine-Tune the V-Series Servo

This screen can be used to fine tune the gain parameters that were set by the Auto Gain Setting routine. Following is the basic method for using this screen:

Warning

Generating a waveform requires that the motor be run. Before running the motor, be sure that it can be done safely. Be familiar with how to stop the motor quickly, should it be required. Failure to heed this warning could result in injury to personnel and damage to equipment.

- Move from this screen to the Setting Graphic screen and set up the graphical display for your tuning session.
- Exit back to this screen (Manual Tuning screen).
- Run the motor and capture a waveform using the Measuring Start selection.
- Change the parameters using the Manual Tuning Gain parameter.
- Run the motor again and capture another waveform.
- Compare the change in response between the last two waveforms.

- Continue to change the parameters, run the motor, and capture the waveforms until desired tuning results are realized.
- Save your settings by selecting “Write data into EEPROM.”

8.4.9 V-Series File Operation Screen

This screen is accessed from the Manual Tuning screen or the Gain Parameter Setting screen. It provides a way to save or load waveform data.

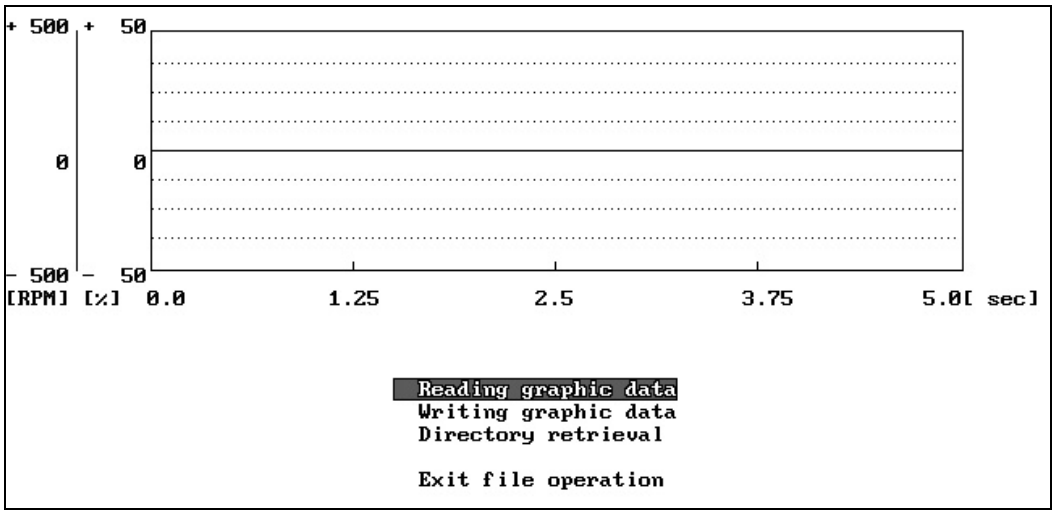


Figure 8-67. File Operation Screen, V-Series

This screen has the following selections:

Reading Graphic Data: This lets you read and display an existing disk file containing waveform data.

Writing Graphic Data: Lets you save the current waveform data to a disk file.

Directory Retrieval: Lets you view a listing of files in a directory you specify.

Exit File Operation: Exits back to the previous screen.

8.4.9.1 Reading Graphic Data, V-Series

To read and display waveform data from an existing file, follow these steps:

- Highlight Reading Graphic Data and press the Enter key.
- At the “Filename:” prompt, key in the name of the file you wish to retrieve.
- Press the Enter key. The file will be read and the waveform will display on the graph. If you entered a comment when you saved the file, it will be displayed below the graph. In the example in the next figure, the comment “This is just a test” can be seen.

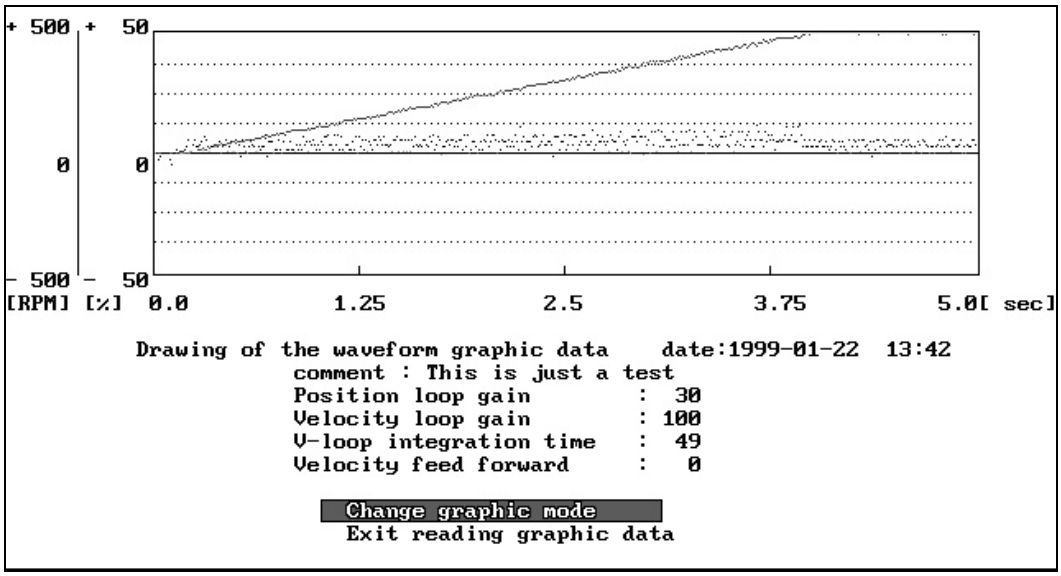


Figure 8-68. Reading and Displaying a Waveform Graphic Data File, V-Series

8.4.9.2 Writing Graphic Data, V-Series

Note: Before you can write graphic (waveform) data to your floppy disk or hard drive, you must have captured some waveform data. If you try this procedure without current waveform data, you will see the message "No waveform graphic data was measured. Retry after measuring waveform graphic data." So, if you have waveform data to write, follow these steps:

- Highlight Writing Graphic Data and press the Enter key.
- At the "Input the file name" prompt, key in the name you wish to call your file. You are limited to 8 characters for the file name.
- Press the Enter key. You will now see the prompt "Input comment (20 characters or less)."
- Key in your comment text or leave this field blank if you prefer. However, entering a descriptive comment can help identify the waveform if you choose to view it later, because the comment will display on the screen along with the waveform.
- Press the Enter key. The file will be written. Note that the writing process will probably be too fast for you to see a status message.

8.4.9.3 Directory Retrieval, V-Series

If you do not know or cannot remember the name of a waveform graphic file, you can check it using the Directory Retrieval screen.

- Highlight Directory Retrieval on the File Operations screen and press the Enter key. You will see the prompt "Enter the directory name:"
- Key in the name of the directory you wish to see or press the Enter key to see the default directory. The directory containing your SLconfig files is the default directory.
- You will see a list of the files in the directory you selected. Note that this is a view-only directory and it doesn't allow you to select a file from this screen, so take careful note of the exact file name you wish to work with.
- Press Enter to return to the File Operations screen.

8.4.9.4 Setting Graphic Screen, V-Series

The Setting Graphic Screen can be accessed either from the Manual Tuning or Gain Parameter Setting screens.

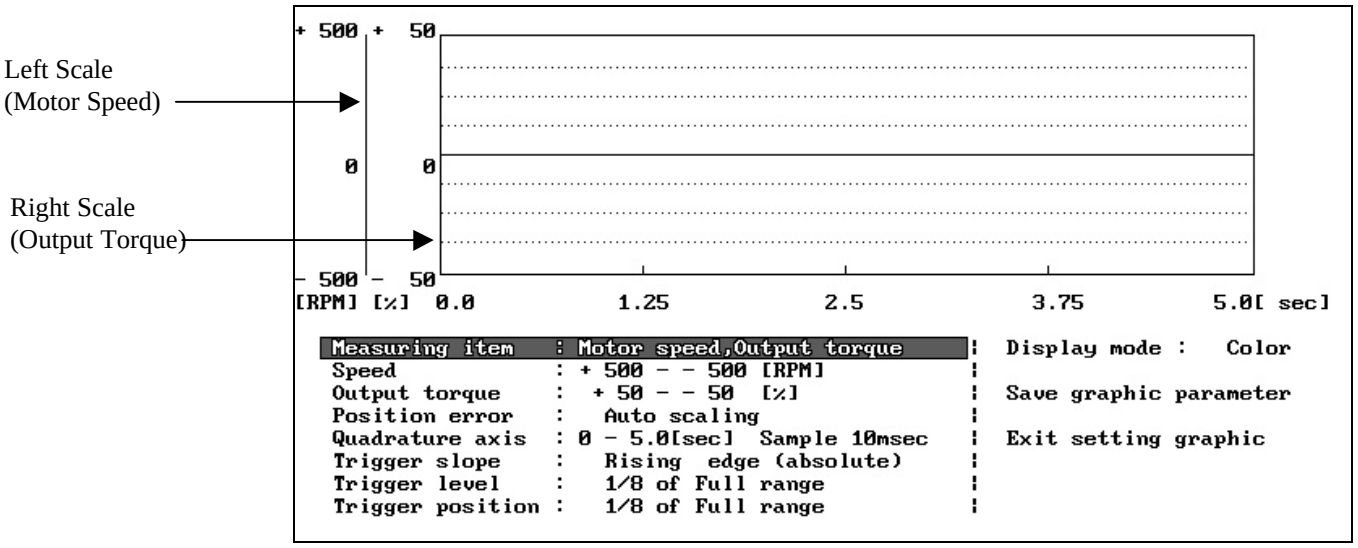


Figure 8-69. Setting Graphic Screen, V-Series

This screen is used to set up the graphic display. It does not have any provision for generating a graph. Use the Left and Right Arrow keys and the Enter key to change a selection. This screen has the following parameters:

- **Measuring Item:** This graph will display two waveforms. This parameter lets you select from among the following combinations to display on the graph:
  - Motor speed and Commanded Speed
  - Motor Speed and Position Error
  - Motor Speed and Output Torque
- **Speed:** Sets the graph's Motor Speed range on the Left Scale of the vertical axis. Choices are 500 RPM, 1000 RPM, 2000 RPM, and Auto Scaling. This is the parameter that the trigger feature uses for its input. If you wish to set a Trigger Level value, this Speed parameter must be set to a number, not to the Auto Scaling setting.
- **Output Torque:** Sets the graph's Output Torque range on the vertical axis. Choices are 50, 100, 200, 500, or Auto Scaling.
- **Position Error:** Sets the graph's Position Error range on the vertical axis. Choices (in counts) are 10, 20, 50, 100, or 200, or Auto Scaling.
- **Quadrature axis:** Sets the graph's time range on the horizontal axis. Choices are 0 – 250 mSec, sample 2 mSec; are 0 – 500 mSec, sample 2 mSec; are 0 – 1 sec, sample 2 mSec; are 0 – 2 sec, sample 4 mSec; are 0 – 5 sec, sample 10 mSec.
- **Trigger slope:** Sets the slope for the trigger signal to either the Rising edge or Falling edge of the Motor Speed waveform, or to No trigger.

- **Trigger level:** Sets the trigger level to 1/8, 1/4, or 1/2 of Full Range. Note that if the Speed parameter is set to Auto scaling, this Trigger level parameter will be blanked out.
- **Trigger position:** Sets the position on the graph's horizontal axis for the start of the waveform. Choices are 1/8, 1/4, or 1/2 of the horizontal scale.
- **Display mode:** Sets the color for the waveform display. Choices are Mono or Color. Note that for either setting, the graph structure and scales are displayed in black and white.
- **Save Graphic Parameter:** Lets you save your graph settings in a disk file for later use. The file name is SLconfig.grp.
- **Exit Setting Graphic:** Exits to the previous screen.

8.4.10 Gain Parameter Setting Screen, V-Series

The Gain Parameter Setting screen, shown in the next figure, is selected from the Waveform Graphics screen.

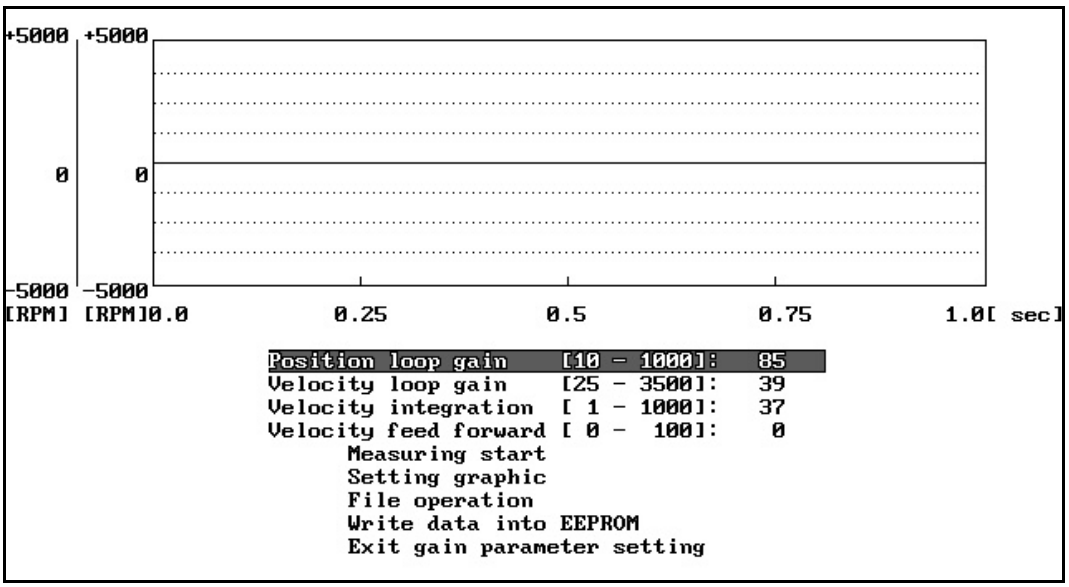


Figure 8-70. Gain Parameter Setting Screen, V-Series

This screen has the following parameters:

Position loop gain [10 – 1000]: Allows you to either key in a value or increment or decrement the current value with the Right or Left arrow key. To increment or decrement a value by a factor of 10, hold down the Shift key while using the Right or Left arrow key.

Velocity loop gain [25 – 3500]: Allows you to either key in a value or increment or decrement the current value with the Right or Left arrow key. To increment or decrement a value by a factor of 10, hold down the Shift key while using the Right or Left arrow key.

Velocity integration [1- 1000]: Allows you to either key in a value or increment or decrement the current value with the Right or Left arrow key. To increment or decrement a value by a factor of 10, hold down the Shift key while using the Right or Left arrow key.

Velocity feed forward [0 – 100]: Allows you to either key in a value or increment or decrement the current value with the Right or Left arrow key. To increment or decrement a value by a factor of 10, hold down the Shift key while using the Right or Left arrow key.

- **Measuring Start**: Lets you initiate the start of waveform generation. Highlighting this field and pressing the Enter button will take you to the "Waiting for trigger" message. Once the trigger occurs, the message will change to "Transferring data."
- **Setting Graphic**: Accesses the Setting Graphic screen, described earlier in this section.
- **File operation**: Accesses the File Operation screen, described earlier in this section.
- **Write data into EEPROM**: Writes parameter data to the SL amplifier's non-volatile EEPROM memory. Note that when you highlight this field and press the Enter key, the

parameter write will immediately occur. You will not be given a chance to change your mind.

- **Exit Gain parameter setting:** Exits back to the previous screen.

Troubleshooting Graph Problems

Note that if parameters are not set correctly on this screen, it is possible that only part of your waveform or none at all will be displayed on the graph. If you encounter a problem, recheck the settings on this screen. Examples:

- The amplitude of the measured Motor Speed waveform exceeded the full-scale value that you set for the graph in the Speed parameter.
- The time value chosen may be too short to capture the full waveform. If it takes the motor 1 second to reach full speed, and you set the Quadrature Axis time value to 0-250 mSec, you will not see the full acceleration waveform.

For the above two problems, you could try setting the scale values to their highest settings or to Auto Scale to start with. Then generate a waveform and adjust the settings lower to optimize the display.

- If you did not see any waveform at all, and you are using the trigger feature, the actual value may have never reached the value of the trigger setting. Try setting the trigger level substantially lower and try again. Once you obtain a waveform, you can readjust the trigger level to an optimum value.
- When a waveform containing a high frequency component (such as a torque waveform) is displayed, it may look somewhat different from the actual waveform due to sampling distortion (samples are taken periodically, not continuously). To minimize sampling distortion, choose a time value in the Quadrature Axis field that gives the shortest possible sampling period (2 mSec).

8.4.11 File operation / Return to MS-DOS mode, V-Series

You can access the “File operation/Return to MS-DOS” menu by entering “6” on the Main Menu. From this menu, you can save Parameter Data to a file on your computer, load Parameter data from a file to the amplifier, or Exit the SLconfig software.

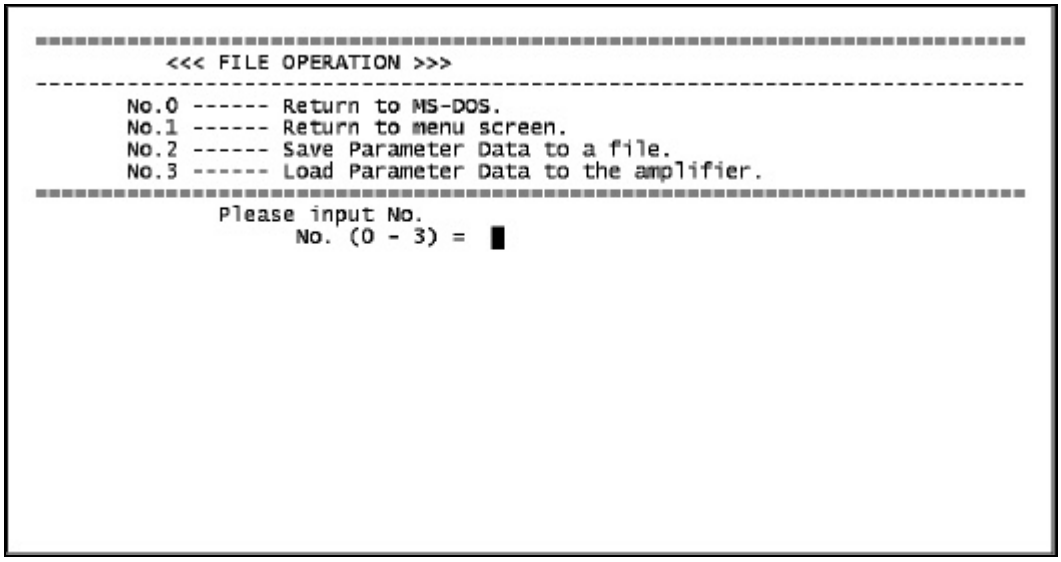


Figure 8-71. File operation / Return to MS-DOS display, V-Series

8.4.12 Saving Parameters to a Disk File, V-Series

- Select menu item “2” on the File Operation screen. The following message will appear briefly at the bottom of the screen.

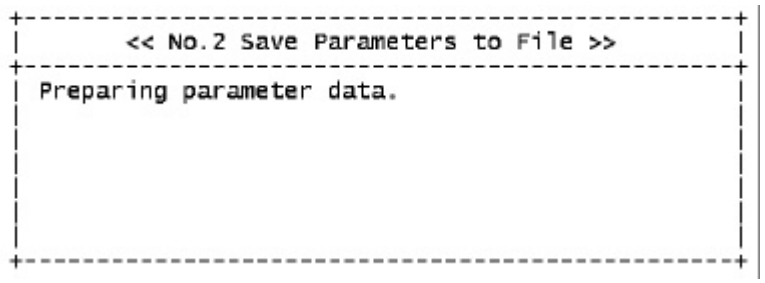


Figure 8-72. Parameter save display 1, V-Series

After parameter data is ready to be saved, the following message displays:

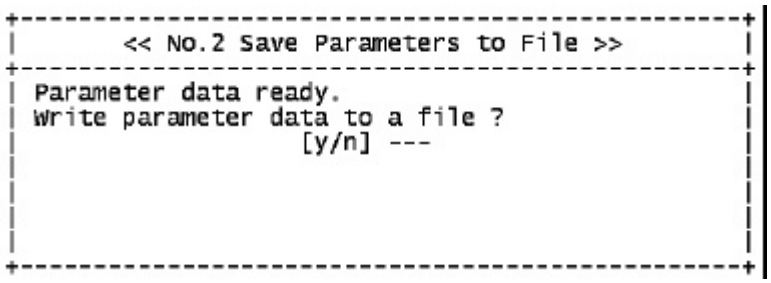
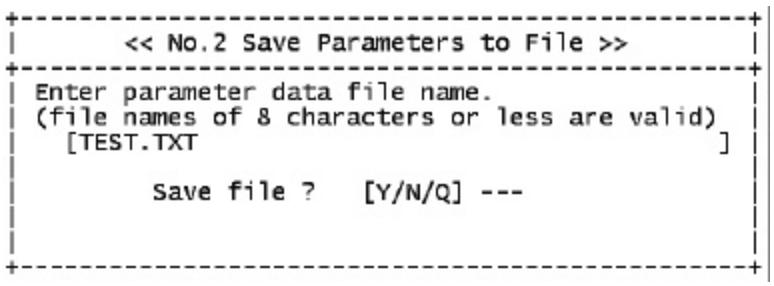
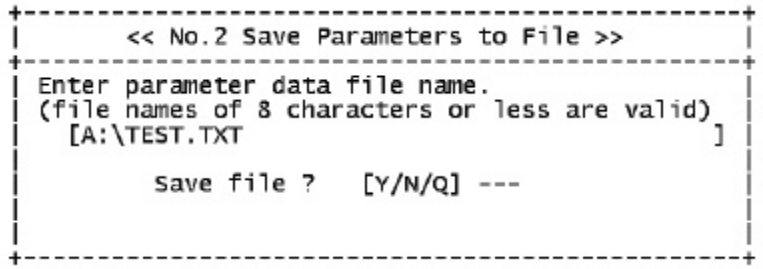


Figure 8-73. Parameter Save Display 2, V-Series

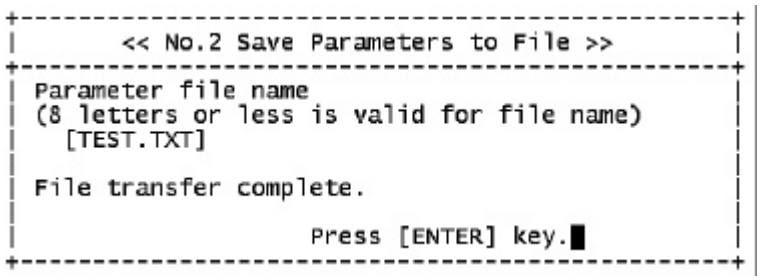
- In response to the prompt, “Write parameter data to a file?” press the Y key. Then, at the following prompt, key in a file name. In the example below, the file name TEST.TXT was entered as the file name. This will write the file, by default, to the SLconfig directory (folder) on your hard drive since no path information was provided. Your window should look similar to the following one:



As an alternative, you could specify a path as well as a file name, if, for example, you wished to save your file to a floppy disk in your computer’s A: drive. Before using the A: drive, please read “Note When Using the A: Drive” below.



- Press “Y” to save the parameter file. Press “N” to key in a different file name. Press “Q” to exit to the File Menu. If you press “Y,” the file will be saved and the following window will display:



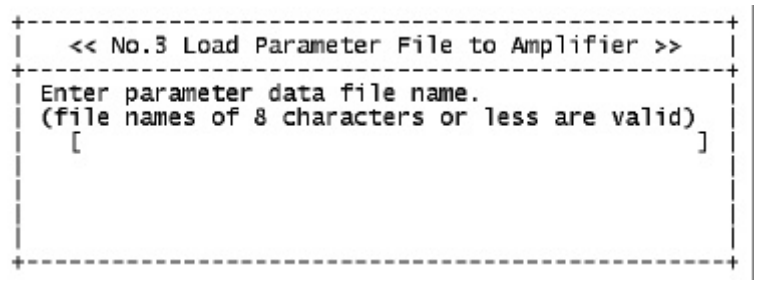
- Press the Enter key to exit to the File Menu.

Note When Using the A: Drive

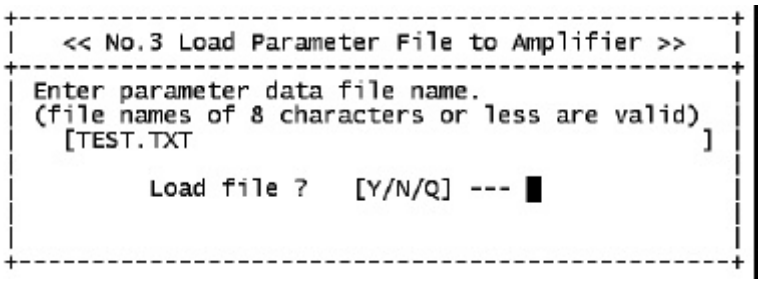
If you specify that the file be saved to your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key. If you press the "F" (Fail) key, the save operation will be stopped and the Save window will display an error message. If you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the save operation.

8.4.13 Loading a Parameter File From Disk, V-Series

- Press the "3" key on the File operation screen to display the Load Parameter window.



- At the prompt, key in a file name. In the example below, the file name TEST.TXT was entered as the file name. This will write the file, by default, to the SLconfig directory (folder) on your hard drive since no path information was provided. Your window should look similar to the one in the next figure.



- As an alternative, you could specify a path as well as a file name, if, for example, you wished to save your file to a floppy disk in your computer's A: drive. In that case, for your file name,

you would key in A:\TEST.TXT. Before using the A: drive, read "Note When Using A: Drive" below.

- Press "Y" to load the parameter file. Press "N" to key in a different file name. Press "Q" to exit to the File Menu. If you press "Y," the message "Parameter data is being loaded to amplifier" will display briefly. Then the message "Parameter transfer complete" will be displayed.

Note When Using the A: Drive

If you specify that the file be loaded from your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key. If you press the "F" (Fail) key, the save operation will be stopped and the Load window will display an error message. If you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the load operation.

```
+-------------------------------------------------+
|   << No.3 Load Parameter File to Amplifier >>   |
+-------------------------------------------------+
| Parameter file name                             |
| (8 letters or less is valid for file name)      |
|   [TEST.TXT]                                    |
|                                                 |
| Parameter transfer complete.                    |
|                                                 |
|                     Press [ENTER] key.          |
+-------------------------------------------------+
```

Note

The above procedure only loads the parameter data from a file to the volatile memory (RAM) of the amplifier. If you turn off power to the amplifier before writing the data to EEPROM, this parameter data will be erased.

To write parameter data from the amplifier's RAM memory to its EEPROM memory, use the following procedure:

- Return to the File Operation menu.
- Return to the Main Menu screen by entering "1"from the File Operation menu.
- On the Main Menu screen, press the "0" key to select the Parameter Setting/Change Mode screen.
- Press the "Q" key. A message will display asking whether or not you want to write to EEPROM.
- Press the "Y" key to Save the parameter data to EEPROM.

8.5 Trouble shooting the SLconfig Software

8.5.1 Startup and Display Problems

Problem: The software wouldn't run when I tried to start it.

Possible reason and solution:

The software may be installed in a different directory or folder than the one currently selected. Change to the directory where the SLconfig software is installed. It is probably on your computer's C: drive and in a directory called "SLconfig."

Problem: When starting the software, I get the message "Communication error."

Possible reasons and solutions:

- Communication cable may not be connected on one or both ends, it may be loose, or it may be connected to the wrong serial (COM) port on your computer.
- No power is supplied to the servo amplifier.
- Wrong amplifier model was selected (V-Series or Z-Series).
- The software version may not be compatible with the firmware version in the amplifier.
- The communications cable may have been connected to the amplifier after the amplifier was already powered up. Use this sequence:
    - With both amplifier and PC turned off, connect the serial cable to both units.
    - Turn on the PC first, then turn on the amplifier.
    - Next, start the SLconfig software.

Problem: My computer screen displays strange characters when I start SLconfig.

Possible reason and solution:

The computer's CONFIG.SYS file lacks the ANSI.SYS DEVICE statement.

- **For MS-DOS-only or Windows 3.1 computers**, add the following line to the CONFIG.SYS file (be aware that you must restart your computer for this to take effect):

  DEVICE=C:\DOS\ANSI.SYS

- **For Windows 95 computers**, add the following line to the CONFIG.SYS file (be aware that you must restart your computer for this to take effect):

  DEVICE=C:\WINDOWS\COMMAND\ANSI.SYS

If one of the above DEVICE statements doesn't solve this problem on your computer, it is probably because the ANSI.SYS file is not in the standard location on your computer. In that case, you can search your hard drive for its location, then use that location (path) in the DEVICE statement.

Problem: My Screen Displays "AXIS*%" and the Computer Appears to be Frozen.

Possible reasons and solutions:

- Under certain problem conditions, when the program is exited, you may see the following display on the screen:

  AXIS*%

  This is the SLconfig prompt, and the user does not normally see it because, when the program starts, it runs through this prompt automatically. However, under abnormal conditions it may display. To handle this situation, type the word "menu" at this prompt, then press the Enter key. This will take you to the SLconfig Main Menu where you can resume using the software, or select Exit to quit.

8.5.2 Graph Problems

Problem: I do not see a waveform or only part of a waveform on my Waveform Graphic Screen.

Possible reasons and solutions:

If parameters are not set correctly on this screen, it is possible that only part of your waveform or none at all will be displayed on the graph. If you encounter a problem, recheck the settings on this screen. Examples:

- The amplitude of the measured Motor Speed waveform exceeded the full-scale value that you set for the graph in the Speed parameter.
- The time value chosen may be too short to capture the full waveform. If it takes the motor 1 second to reach full speed, and you set the Quadrature Axis time value to 0-250 mSec, you will not see the full acceleration waveform.

For the above two problems, you could try setting the scale values to their highest settings or to Auto Scale to start with. Then generate a waveform and adjust the settings lower to optimize the display.

- If you did not see any waveform at all, and you are using the trigger feature, the actual value may have never reached the value of the trigger setting. Try setting the trigger level substantially lower and try again. Once you obtain a waveform, you can readjust the trigger level to an optimum value.
- For the Z-Series, if the Time parameter on the Waveform Graphic Measuring/Setting Screen is set to 0 (zero), no waveform will be captured.

Problem: The waveform appears distorted on my Waveform Graphic Screen.

Possible reason and solution:

- When a waveform containing a high frequency component (such as a torque waveform) is displayed, it may look somewhat different from the actual waveform due to sampling distortion (samples are taken periodically, not continuously). To minimize sampling distortion, choose a time value in the Quadrature Axis field that gives the shortest possible sampling period (2 mSec).

8.5.3 Problem Using the Computer's A: Drive

Problem: I forgot to put a disk in my A: drive and got an error message. What is the best way to correct this situation?

If you specify that a file be saved to, or loaded from, your computer's A: drive, but forget to put your diskette in the drive, you will get the error message "Not ready reading drive A. Abort/Retry/Fail?" **To correct this situation, insert the diskette into the A: drive and press the "R" key (Retry), then the Enter key.** If you press the "F" (Fail) key, the save operation will be stopped and the Save or Load window will display an error message. (This is not too bad because you can press a key and return to the previous menu where you can resume the procedure from there.) However, if you press the "A" (Abort) key, the SLconfig software will shut down and you will have to restart it, then work your way back through the menus to this menu in order to resume the save or load operation.

Chapter 9

Protective Functions and Troubleshooting

9.1 Protective Functions

9.1.1 Overview

The SL Series amplifiers have extensive protective functions that monitor power-up initialization and normal operation of the servo. If during the operation of the servo one of the protective functions trips the amplifier and activates the alarm output, refer to the details of this section to determine the cause. For troubleshooting other operational problems, refer to Section 9.2, "Troubleshooting."

When the amplifier trips, the following actions occur:

- The amplifier is disabled (stops current flow to the motor).
- The motor, if moving, coasts or is dynamically braked to a stop according to the options set in Parameter No.0A (V-Series) or Parameter No.3D (Z-Series) as defined in Section 6.3.
- All digits of the amplifier 7-segment LED will flash.
- The ALM output on connector CN I/F is activated. (see Section 5.7.2)
- On V-Series amplifiers the three EXOUT output signals on connector CN I/F represent a 3-bit error code that can be used for remote diagnostics on a host PLC or machine controller. (see Section 5.7.2)
- The position error counter is cleared.

9.1.2 Protective Function Descriptions

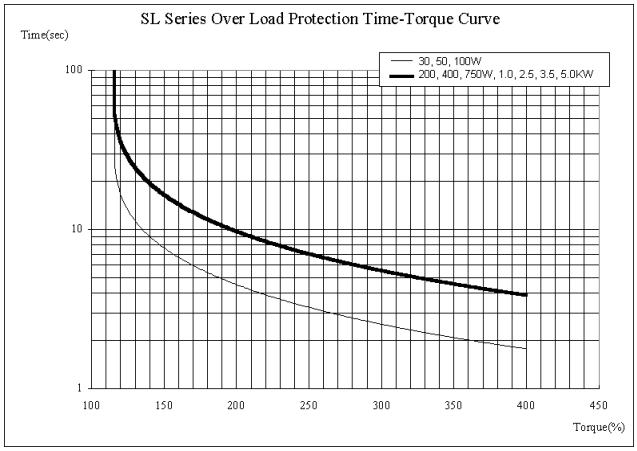
When a fault occurs it is stored in the error history as a two-digit code. The SL amplifiers have an error history feature that stores the eight most recent error codes in non-volatile FIFO memory. You can display the error history using the keypad/display on the front of the amplifier (see Section 8.1.1.1) or on a PC using the *Monitor* screen in the *SLconfig* software (see Section 8.2). Table 9-1 shows the various error codes and their descriptions. Some errors require cycling the AC power to the amplifier in order to reset the fault. These errors are indicated in the table under the "Power Cycle Reset Required" column. All other errors can be reset using either the alarm clear input (A-CLR) on connector CN I/F, or the amplifier keypad (see Section 8.1.1.6-*Alarm Clear Mode*).

Caution

The SL Series amplifiers and motors utilize dangerous voltage levels. When troubleshooting system problems, use appropriate precautions to prevent exposure to these potentially lethal voltages. Only experienced personnel with adequate knowledge of the system operation should attempt to diagnose system problems.

Table 9-1. Error Codes and Descriptions

Protective Function	Error Code	Description	Power Cycle Reset Required	Corrective Actions
Over Voltage	12	The DC link voltage at converter exceeds approximately 400 VDC for a 230 VAC amplifier or 200 VDC for a 115 VAC amplifier due to excessive regenerative energy or high AC line voltage fluctuations.	No	**Excessive Regenerative Energy:** 1) Add regenerative resistor option to amplifier or decrease the regenerative resistance to a lower value (see Section 4.1.2) 2) Reduce motor deceleration rate by: • Increasing deceleration times • Reducing top motor speed 3) Reduce load inertia as seen by the motor by: • Increasing the gear reduction ratio • Reducing the load mass 4) Counter balance overhung vertical loads **High AC Line Voltage:** 1) Reduce AC line voltage to within specifications
Under Voltage	13	The DC link voltage at converter drops below 153 VDC for 230 VAC models or 78 VDC for 115 VAC models due to transient power loss (brownout) or low AC line voltage.	No	1) Check if AC supply voltage is within the allowable range. 2) Check the voltage drop on the AC supply lines, especially when the servo is accelerating. 3) Check for an open phase or loose connections on the power supply.
Over Current	14	Output current of the amplifier increases to 450% of rated continuous current. The detection circuit for this error has a 10 µs filter time constant.	Yes	1) Check each motor lead, including connector and cables, for a short circuit after removing power from the system and disconnecting the motor. A shorted motor or cable should be replaced. 2) With the motor disconnected from the amplifier, check for any deterioration of insulation resistance between motor leads (U, V, W) and motor ground (E). If motor shows leakage to ground, replace the motor. Recurrence of this error after the above checks represents a malfunction. Shut off power immediately and replace the amplifier.

<table>
<tr><th>Protective Function</th><th>Error Code</th><th>Description</th><th>Power Cycle Reset Required</th><th>Corrective Actions</th></tr>
<tr><td rowspan="2">Overload</td><td>16</td><td>Axis continuous current demand exceeds amplifier ratings.</td><td>No</td><td>1) Extend acceleration/deceleration time and/or machine cycle time (increase dwell times)
2) Reduce load on the motor
3) Reduce machine friction
4) Increase gear ratio as motor speed range allows
5) Verify tuning. Oscillations in the motor current may cause excessive RMS current and motor heating (see Chapter 7)
6) Counter balance loads and/or add a holding brake on vertical axes
7) Replace servo with a larger model</td></tr>
<tr><td colspan="4">
<table>
<tr><th>Amplifier Size</th><th>Time Constant (Sec)</th><th>Protection Torque Limit</th></tr>
<tr><td>30 – 100W</td><td>500</td><td>115%</td></tr>
<tr><td>200 – 5000W</td><td>1000</td><td>115%</td></tr>
</table>


</td></tr>
<tr><td>Encoder Error</td><td>22</td><td>Errors on encoder wiring (such as broken or loose wire) or encoder malfunction</td><td>Yes</td><td>1) Check all wiring and connections between the amplifier and motor encoder for miswiring, shorts or open circuits (see Section 4.3 for proper encoder wiring).
2) Check the encoder power supply voltage directly at the motor encoder (5VDC ±5%), especially when long cables are used.
3) Replace the motor.</td></tr>
<tr><td>DSP Watchdog Error</td><td>23</td><td>The watchdog timer on the amplifier DSP (Digital Servo Processor) has timed out due to a malfunction.</td><td>Yes</td><td>Cycle power on the amplifier to reset. If this error occurs again immediately remove power and replace the amplifier.</td></tr>
</table>

Protective Function	Error Code	Description	Power Cycle Reset Required	Corrective Actions
Position Error Limit	24	Position error exceeds the allowable range set by Parameter No.23. This error applies only when the amplifier is configured for Position Control Mode (see Parameter No.02)	No	1) Check if motor runs when position command (PULS/SIGN inputs) is applied. 2) Check setting for the Position Error Limit using Parameter No.24. Increase the value to the largest following error that can be tolerated by the application. 3) Check saturation of the torque command using the torque monitor output or test point (see Section 5.7.2 for detail on the IM output). If the voltage on the monitor reaches approximately 9 VDC the torque command is in saturation and the motor is no longer able to keep up with the position command. If saturation occurs during acceleration: • Reduce the load inertia or acceleration rate • Increase the gear ratio as motor speed range allows • Reduce machine friction • Reduce vertical axis counterbalance as motor continuous rating allows. Counterbalancing increases inertia seen by the motor but reduces the torque required to oppose gravity 4) Set value of Parameter No.06–*Torque Limit* to 300% if it is set to a lower value. 5) Verify gain adjustments and increase if possible. Higher gains improve the servo's ability to follow the commanded motion profile. (see Chapter 7–*Tuning* for details) 6) Disable the Position Error Limit function using Parameter No. 24. In most positioning applications you do not want to disable this limit since excessive position error represents poor servo performance. Disabling this function can lead to a position error counter overflow (see Error Code 29).

Protective Function	Error Code	Description	Power Cycle Reset Required	Corrective Actions
Overspeed	26	Motor speed exceeded the limit set by System Parameter No.55 for Z-Series amplifiers or System Parameter No.35 for V-Series amplifiers. System parameter can be viewed but not changed by the user. This limit is typically 1.2 times the rated maximum speed.	No	1) Check if velocity command is excessive (Velocity Control Mode only). 2) Check if pulse command input frequency or Pulse Command Ratio (Parameter Nos.25 and 26) are too high (Position Control Mode only). 3) Check if excessive velocity overshoot occurs during acceleration due to improper setting of servo gains (see Chapter 7-*Tuning*). The speed monitor output or test point (SP) can be used for this measurement (see Parameter No.08-*Speed Monitor Scaling*). 4) Verify that the motor power connections on terminals U, V and W are correct (see Section 4.1-*Wiring to the Amplifier Power Terminals*). 5) Make sure that an overhauling load is not back driving the motor.
Pulse Command Ratio Error	27	Amplifier trips when the Pulse Command Ratio (Parameter Nos. 25 & 26) is too high.	No	Set pulse frequency ratio so that the pulse command frequency after applying the ratio is less than the maximum pulse input frequency of 500 kHz for a line driver or 200 kHz for an open collector interface (see Section 5.5).
Position Error Counter Overflow	29	Position error exceeds 2^{27} (134,217,728) Counts (quadrature encoder pulses). This error should only occur if the Position Error Limit is disabled by Parameter No.24. Otherwise, the Position Error Limit fault (Error Code 24) should occur before enough error accumulates to overflow the counter.	No	Check the same items as Error Code 24 above.
CPU Watchdog Error	30	The watchdog timer on the amplifier CPU has timed out due to a malfunction.	Yes	Cycle power on the amplifier to reset. If this error occurs again immediately remove power and replace the amplifier.
EEPROM Check-sum Error	36	The parameter data read from EEPROM memory at power up is corrupted.	Yes	1) Set all parameters again and write into EEPROM. 2) If several attempts to re-save parameter data fails to correct this error then replace the amplifier.

Protective Function	Error Code	Description	Power Cycle Reset Required	Corrective Actions
CW/CCW Overtravel Input Error	38	Amplifier trips when both CCW and CW overtravel inhibit inputs (CWL & CCWL on connector CN I/F) are activated (turned OFF) at the same time.	No	1) Check for errors in limit switch wiring or in the I/O power supply connected to the CCW/CW inhibit inputs. 2) If no travel limits are used, the CWL/CCWL inputs must be disabled by setting Parameter No.09 to 1 (default) or connecting the inputs to COM- with a wire jumper. 3) Check for excessive start-up delay of the I/O power supply (12 to 24 VDC). This supply should be applied before AC power to the amplifier.
Parameter Range Error	84	V-Series only. Range checking during parameter download from *SLconfig* detected an improper value such as excessive encoder output ratio, torque limit or velocity gain. *SLconfig* software displays "Download Error".	Yes	1) Make sure the servo is disabled (SRV-ON signal OPEN) before downloading parameters from the *SLconfig* software. 2) Check for the following invalid conditions: • Parameter No.0B > Parameter No.0C • Parameter No.06 > Sys. Parameter No.36 • 3.2*(Para.03)(Para.32)/Para.31 >32767
CPU Stack Error	97	Z-Series only. Amplifier trips due to an error during power-up self-diagnostics.	Yes	Cycle power on the amplifier to reset. If any of these errors occur again immediately remove power and replace the amplifier.
System Error	98	Amplifier trips due to an error during power-up self-diagnostics.	Yes	
Other Error	99	Hardware error.	Yes	

In order to restart the amplifier after an alarm, remove the source of the error and then reset the alarm by cycling the power or activating the alarm clear signal (A-CLR) as indicated by the value in the "Power Cycle Reset Required" column in Table 9-1 above.

The overload protection (Error Code 16) may be cleared using the alarm clear signal input after approximately 10 seconds have elapsed since the alarm was activated.

Note

When an "Automatic gain tuning error" occurs see Section 7.4-"Automatic Tuning," for details on troubleshooting this error.

9.2 Troubleshooting

If an operational problem occurs that is not caused by one of the protective functions of the amplifier, check the following list and then take the proper action. Examples include:

- Motor does not rotate (see Table 9-2)
- Unstable rotation occurs (see Table 9-3)
- Poor positioning accuracy (see Table 9-4)
- Machine home reference is not in the right position (see Table 9-5)
- Motor speed is limited (see Table 9-6)

Table 9-2. Motor Does Not Rotate

Cause	Check	Possible Causes/Solutions
Errors in the main power supply wiring or motor power cable. (see Section 4.1)	Is the power to the amplifier turned on?	If the power is not turned on, the display LEDs do not light up on front of the amplifier. Check for open circuits, blown fuses or tripped breakers.
	Is the amplifier power supply (R, S, T) connected properly? The V-Series amplifier has separate control power terminals (r, t) . Be sure they are wired properly.	Phase rotation is not important but at least two phases must be connected for the servo to operate. NOTE: Single-phase operation of 230 VAC models may require derating.
	Is the motor power cable connected properly to the motor and amplifier (U, V, W)?	The phasing on the motor wiring must be correct. If the phase wiring to the motor is incorrect, the motor will not rotate. Verify continuity and proper connection on each power lead and the ground wire and correct any errors.
Parameter configuration or control input errors	If Parameter No.09-*Overtravel Limit Inhibit* is set to zero (enable the overtravel inputs) then check whether the overtravel limit switches, inputs CWL and CCWL on the CN I/F connector, are open.	When either of the overtravel limit inputs is OPEN, torque output in that direction is disabled. If both inputs are OPEN the motor will not rotate (see Section 5.7.2). If limit switches are not required on the machine set Parameter No. 09 = 1 (default) to disable the inputs.
	Check whether the value of user Parameter No.06-*Torque Limit* is set to zero.	If the value of the torque limit parameter is set to zero, the motor does not generate torque. Reset the parameter to a higher value.
	Check if the ZEROSPD input is OPEN and Parameter No.17 = 0 (ZEROSPD input is enabled) when the amplifier is configured for Velocity or Torque Control Mode.	When the ZEROSPD input is enabled and not connected to COM-, the amplifier is clamped to zero speed regardless of the command input level. This mode is used to prevent servo drift while the motor is stopped. If this function is not required reset Parameter No17 to zero (default) to disable the ZEROSPD input.
	Check whether the value of user Parameter No.23-*Position Error Limit*, is set to a value close to "1".	When this value is small, the motor starts to rotate and as soon as the positioning error limit is exceeded the protective function activates and stops rotation of the motor. Increase the parameter setting to a larger value.
	If the amplifier is in Position Control Mode (see Parameter No.02) check if the pulse command inhibit input (INH on connector CN I/F) or position error counter clear input (CL on connector CN I/F) is connected to COM-.	When the INH input is OPEN, the pulse command inputs (PULS/SIGN) are disabled and the motor will not rotate even if a command is present. For Velocity or Torque Control Mode, this input should be left OPEN. When the CL input is connected to COM-, the motor will not rotate even if a command is present.
	Wrong velocity command source is selected.	Check the setting for Parameter No.16-*Internal/External Velocity Command Selection*. This parameter selects between the analog velocity command and the internal preset speed commands. Verify that the desired command source is selected.
Motor brake is engaged	If the motor includes the optional holding brake, check if the brake is set (de-energized).	The motor brake is a spring set, electrically released type. Power must be applied to release the brake before motion is commanded. If the brake is engaged while the motor is being commanded to move, the brake may be damaged.

Table 9-3. Unstable Rotation

Cause	Check	Possible Causes/Solutions
Voltage fluctuation of the power supply	Check whether the capacity of the power supply or the transformer is too small for the load causing excessive voltage droop.	When the voltage of the power supply is too low, the maximum speed of the motor may be reduced causing poor servo performance.
Pulse command input noise or frequency limits (Position Control Mode only) (See Section 5.5)	Check whether command cable is properly shielded and that the shield is properly grounded	When the countermeasures against noise and signal crosstalk are not effective, the amplifier may operate erratically.
	Check if there is any distortion or noise on the command from the external controller.	When there is distortion or noise on the command, normal operation can not be expected since the amplifier can not differentiate these from the real command signal. Check the external controller and wiring again.
	Verify that the pulse command frequency does not exceed the allowable limit based on the command interface connection type.	The pulse command frequency is limited to 200 kHz for an open collector interface and 500 kHz for a line driver interface.
Pulse Command Ratio too high	When operating in Position Control Mode (see Parameter No.02), check the value of the Pulse Command Ratio set by Parameter No. 25 (numerator) and No.26 (denominator).	Large ratios (>20) cause a lot of motor movement for a small command input. This leads to reduced positioning accuracy and very jerky motion that can excite system resonances. Reduce the ratio and increase the pulse command frequency to obtain higher motor speeds.
Load Problems	Check whether the load inertia is within specified range of motor inertia (see Chapter 7-*Tuning*).	When load inertia is beyond the adjustable range, lower the load inertia, increase the size of the motor, or change gear ratio between the motor and load to more closely match the load inertia to the motor inertia. Large mismatches in load and motor inertia aggravate system resonances and can cause servo instability (oscillation).
	Check whether the friction load is excessive.	When the friction load is extremely high, hunting due to a condition known as "stick/slip" may occur around the stopping position. Although this phenomenon is reduced when the velocity loop is configured only for proportional gain (Parameter No.04=1000), the positioning error will increase as a result of eliminating the integral gain.
	Check if the load change is excessive. Once tuned for a given load inertia, the servo may become unstable if the load changes appreciably.	If the value is beyond the adjustable range, lower the load inertia, increase the capacity of the motor, or change gear ratio, etc.
	Check whether there is a mechanical resonance or mechanical binding or failure. Check the motor coupling, timing belt, gearing, ball screw, etc.	If… • The torsional stiffness of the coupling or ball screw is too low • The tension or stiffness of the timing belt is too low • Backlash in the gearing or ball screw is excessive Then the machine may resonate (vibrate) at one of the natural frequencies of the mechanical system. Correct the mechanics to increase the resonant frequencies to at least 500 Hz.
Improper gain settings (See Chapter 7)	Check whether the servo gain settings are too high for the given load conditions.	Adjust tuning parameters for stable operation: • No.03-*Velocity Loop Gain* • No.04-*Velocity Loop Integration Time Constant* • No.20-*Position Loop Gain*
Check the motor encoder signals	Check installation of the encoder feedback wiring between the motor and the amplifier and, if used, check the encoder output signal wiring between the controller and amplifier for proper shielding and grounding.	When the countermeasures against noise are not effective, the amplifier may operate erratically. See Sections 4.3 and 5.6 for more details on the encoder wiring.

Table 9-4. Poor Positioning Accuracy

Cause	Check	Possible Causes/Solutions
Improper encoder or pulse command scaling	When using one of the pulse command input modes, check whether Parameter No.25-*Numerator of Pulse Command Ratio* and No.26-*Denominator of Pulse Command Ratio*, are set properly.	This ratio sets the relationship between the number of command pulses required for one motor rotation. When the setting of the Pulse Command Ratio is incorrect the move length is also incorrect. See Section 6.2 for details on these parameters.
	When using an external position controller, check the encoder resolution configured by the Encoder Output Ratio (Parameter Nos.0B and 0C).	This ratio sets the resolution of the encoder output signals used by an external position controller to control the position of the motor. The best positioning accuracy that is possible is ± 1 count of the configured resolution. Note that there are 4 counts for each encoder pulse set by this ratio since the encoder pulses use a quadrature (x4) multiplication circuit. See Section 6.2 for more details on these parameters.
Incorrect program or controller configuration	Check whether the positioning program and configuration of the external position controller are set properly.	Correct the positioning program or configuration of the external controller. Also, check the gain setting of the external position controller. Low gain will result in poor servo performance.
Signal noise	Look for unsuppressed relay coils or other magnetic circuits or devices that are in operation near the amplifier or cables.	Check the countermeasures against noise. Check the following signals for evidence of noise: • Servo enable signal (SRV-ON) • Clear counter signal (CL) • Pulse command inputs (PULS & SIGN) • Motor encoder feedback signals (A, B, Z) • Encoder output signals (OA, OB, OZ) Suppress all relay coils.
	Verify that proper countermeasures against noise on signal cables have been implemented.	Check the countermeasures against noise. Check the following signals for noise: • Servo enable signal (SRV-ON) • Clear counter signal (CL) • Pulse command inputs (PULS & SIGN) • Motor encoder feedback signals (A, B, Z) • Encoder output signals (OA, OB, OZ) Proper shielding and grounding and separation of signal wiring and power wiring will eliminate the source of most induced signal noise that may cause erratic operation.
	Noise on encoder feedback signals	Increase the value of Parameter No.05-Velocity Feedback Filter. This decreases the cutoff frequency of the low pass filter. This reduces signal noise but also reduces the servo response (bandwidth).
Incorrect gain settings	Check if the velocity loop is configured for proportional gain only or has too little integral gain.	If Parameter No. 04-*Velocity Loop Integration Time Constant* is set to 1000, only proportional gain is used in the velocity loop. Positioning accuracy at the end of a move will be decreased and settling time increased if the gain is too low. Reduce the value of the time constant to increase the integral gain.
	The position loop gain is too small.	If Parameter No. 20-*Position Loop Gain* is too small, it takes longer to position and will have reduced accuracy. Increase the gain as high as possible while still maintaining good servo stability.

Table 9-5. Machine Home Reference is not in the Right Position

Cause	Check	Possible Causes/Solutions
The home offset is inconsistent	Unusual operation of the home sensor.	Check the wiring of the home sensor, take proper countermeasures against signal noise, or replace the home sensor. Check home sensor mounting. It should not be loose or over-tightened. Check home sensor for signs of physical damage.
	The position of the encoder Z-phase signal and the home sensor do not overlap.	Move the position of the Z-phase of the encoder to the middle of the active position range of the home sensor.
Active range of the home sensor is too small	Does the motor slow down around the home position?	Reduce the home speed or increase the active range of the home sensor.
Noise on the Z-phase of the motor encoder.	Check shielding and installation of the encoder cable between the motor and the amplifier (connector CN SIG) and, if an external position controller is used, check the encoder output cable shielding and installation.	Take proper measures to prevent noise on the encoder signals. See Sections 4.3 and 5.6 for more details on the encoder wiring.
	Verify that the waveform of the encoder is normal.	If the waveform is abnormal, and if you have taken appropriate countermeasures against noise, the encoder may be damaged.
Chattering or improper operation of the home sensor	Is there a problem with the home sensor?	Try replacing the home sensor.
	Verify that the power supply for the home sensor is on and that no noise is on the signal.	Correct any wiring errors or shielding/grounding problems with the wiring.

Table 9-6. Motor Speed is Limited

Cause	Check	Possible Causes/Solutions
Position loop gain is too low	When the amplifier is in Position Control Mode check the value for Parameter No.20-*Position Loop Gain*.	If the gain is too low the position error of the amplifier will saturate before the desired speed is obtained. Increase the position loop gain as recommended in Chapter 7-*Tuning*.
Velocity loop gain is too low	When the amplifier is in Velocity Control Mode check the value for Parameter No.03-*Velocity Loop Gain*.	If the gain is too low the velocity error of the amplifier will saturate before the desired speed is obtained. Increase the velocity loop gain as recommended in Chapter 7-*Tuning*. Also, try increasing the value for Parameter No.04-*Velocity Loop Integration Time Constant*.
Pulse command frequency too high	When in Position Control Mode, the maximum frequency of the pulse command inputs is limited by the type of command interface used. An open collector interface will allow command input up to 200 kHz maximum while a line driver interface will allow input up to 500 kHz. (See Section 5.5)	Reduce the pulse command frequency to within the allowable limits and increase the Pulse Command Ratio set by Parameter No.25 (numerator) and No.26 (denominator) as recommended in the description for these parameters in Chapter 6.
Pulse Command Ratio is too low	When in Position Control Mode, Parameter No.25 (numerator) and No.26 (denominator) set the Pulse Command Ratio. This ratio scales the number of command pulses required to move the motor one revolution. (See Chapter 6-*Configuration Parameters*.)	For a given pulse command input frequency, this ratio determines the speed of the motor. Increase the ratio within the limits discussed in the parameter description in Chapter 6.
Torque limit set too low	Check the value for Parameter No.06-*Torque Limit* and Parameter No.07-*Torque Limit Inhibit*.	If the torque limit is too low, the servo can not generate sufficient torque to overcome system friction and loads. The limit is set either by Parameter No.06 or by the torque limit analog inputs (CWTL & CCWTL). Increase the limit or disable the analog torque limit inputs by setting Parameter No.07=1 (default).
Acceleration limit set too low	Check Parameter No.10-*Acceleration Rate Limit*.	If the acceleration limit is set too low, the motor may not have sufficient time to achieve the desired speed for short moves. Increase the acceleration limit.
Velocity command scaling set too low	When in Velocity Control Mode check the value of Parameter No.13-*Velocity Command Scaling*.	This parameter sets the desired motor speed for a given command input voltage. If the setting is too low, the speed of the motor will be limited.

Appendix A

Operation with External Motion Controllers

A.1 Overview

The SL Series servos can be used with the GE Fanuc APM300 or DSM300 Series motion control modules for the Series 90™-30 Series PLC or with other third party motion controllers. To assist you in connecting to these controllers, two terminal board assemblies are available for the SL-Series Servo Amplifiers:

IC800SLT001 (SL-Series Servo to APM/DSM Interface Terminal Board)
Used to interface the SL-Series Servo Amplifiers with GE-Fanuc's motion control products (the APM301 and APM302 or the DSM302 with firmware version 1.4 and higher). The terminal board provides screw terminal connections for many signals that must be connected to field devices or the host controller. Signals between the motion controller and servo amplifier pass through the terminal board assembly and are not brought out as screw terminals. Post-type test points are available for the encoder signals and velocity command signal.

IC800SLT004 (SL-Series Servo Breakout Terminal Board)
Used with SL-Series amplifiers to provide screw terminal connections for interfacing the signals on the amplifiers to third party position controllers, stepper indexers or host velocity/torque controllers.

Notes

Each Terminal Board is shipped with DIN-rail mounting feet installed. The parts for converting the terminal board to panel mounting are included with the terminal board. Instructions for converting a terminal board to panel-mount are included later in this appendix.

A.2 SL-Series Servo to APM/DSM Terminal Board

The IC800SLT001 SL-Series Servo to APM/DSM Terminal Board is used to connect the GE-Fanuc motion control modules to the SL-Series servo amplifiers. The terminal board contains one 36-pin connector, labeled **APM/DSM,** and one 50-pin connector, labeled **AMPLIFIER**.

If an APM is used for the motion controller, cable IC800SLCAPM010 (1 meter) or IC800SLCAPM030 (3 meters) connects from the **APM/DSM** connector (PL2) to the axis connector on the APM faceplate as shown in Figure A-1. If a DSM is used for the motion control, cable IC693CBL324 (1 meter) or IC693CBL325 (3 meters) connects from the terminal board **APM/DSM** connector (PL2) to the axis connector on the DSM faceplate as shown in Figure A-2.

For V-Series amplifiers (1000-5000 Watt), servo interface cable IC800SLCIV010 (1 meter) or IC800SLCIV030 (3 meters) connects from the **AMPLIFIER** connector (PL1) to the CN I/F interface connector on the SL Series amplifier. For Z-Series amplifiers (30-750W), servo interface cable IC800SLCIZ010 (1 meter) or IC800SLCIZ030 (3 meters) connects from the terminal board **AMPLIFIER** connector (PL1) to the CN I/F interface connector on the SL Series amplifier as shown in Figures A-1 and A-2.

The SL-Series Servo to APM/DSM Terminal Board also contains square post test points on the board to connect monitoring/test equipment during start-up or troubleshooting the system. These test points provide signal access to the encoder output signals from the amplifier and the analog velocity command signal from the motion controller.

Note

Test/Monitoring equipment should only be connected to the square posts while power to the system is turned off to prevent damage to the motion controller, amplifier, or motor. Monitoring equipment should not be connected during normal operation of the system to prevent these connections from introducing noise into the command or feedback signals.

Thirty-eight screw terminals are provided on the IC800SLC001 terminal board for connection to user devices.

Eleven 130V MOVs are installed between terminal points 11-18 and 29-36 and frame ground (S terminals) for improved noise suppression.

The I/O terminals support a wire gauge of 14-28 AWG. Maximum screw torque that should be applied is 5 inch-pounds.

Note

Two of the screw terminals are labeled **S** for **Shield**. A short earth ground wire should be connected from one of the **S** terminals directly to a panel earth ground. The cable shields for any user devices should be connected to either of the **S** terminals.

For installations that must meet IEC electrical noise immunity standards, the terminal board must be placed in an enclosure (to meet the ESD criteria only). For additional information, refer to *Installation Requirements for Conformance to Standards,* GFK-1179.

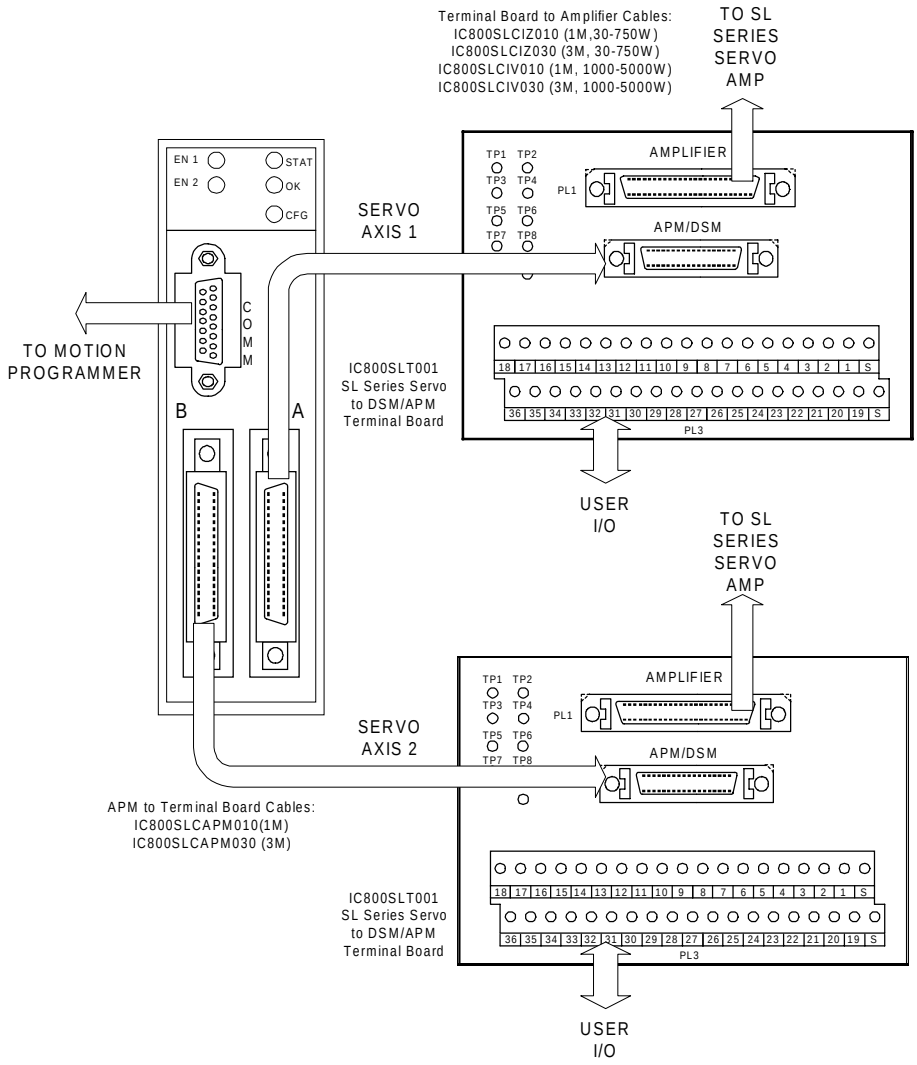


Figure A-1. APM300 Interface to IC800SLT001 Terminal Board

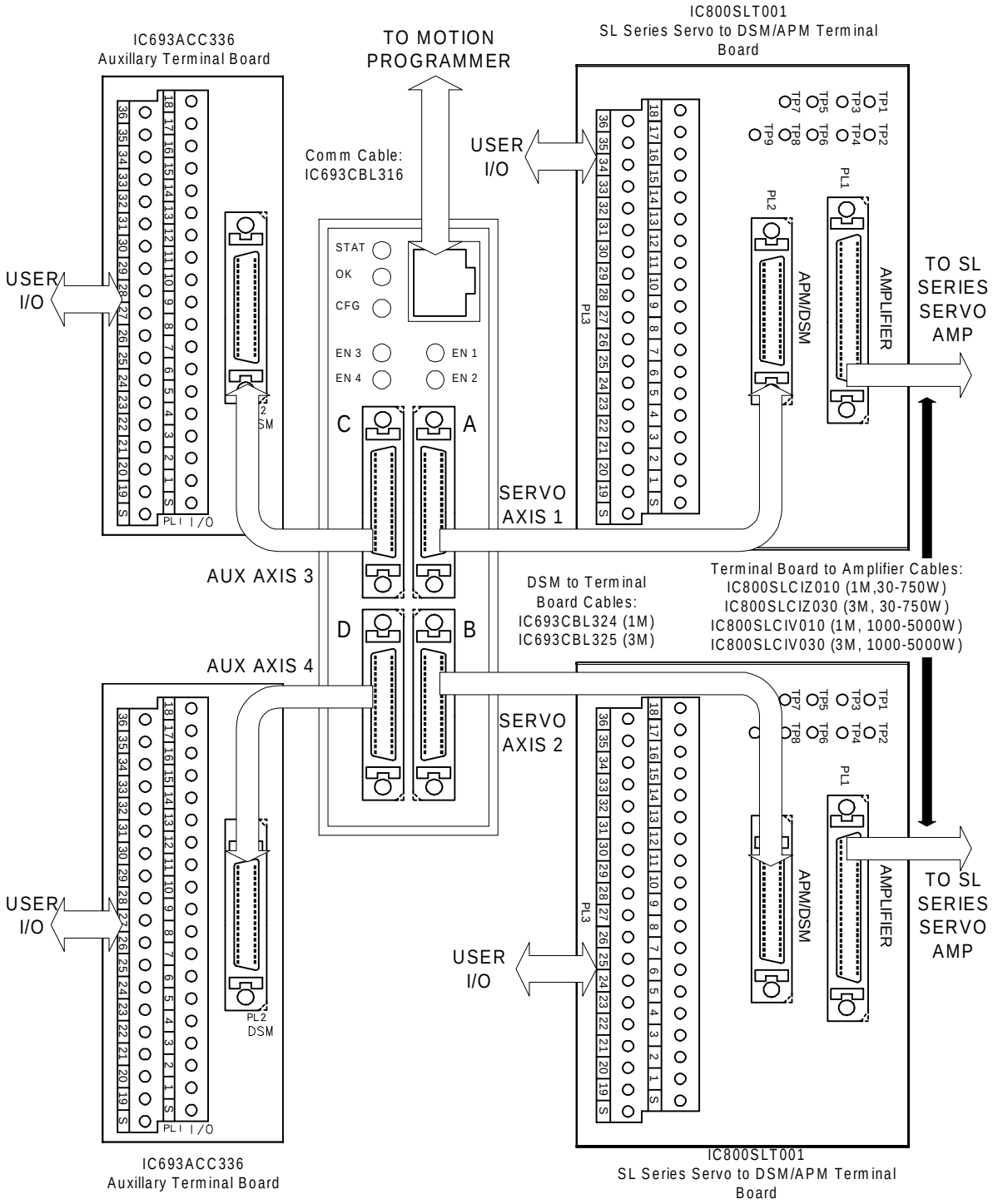


Figure A-2. DSM302 Interface to IC800SLT001 Terminal Board

The function assigned to each screw terminal of the IC800SLT001 terminal board varies depending on the GE Fanuc motion controller used. Some of the I/O functions available on the SL amplifiers are not available on screw terminals since these functions typically are not required when used with an external position controller. Tables A-1through A-3 below show the terminal functions for each controller option.

Table A-1. IC800SLT001 Screw Terminal Assignments for APM Standard Mode (See Figure A-1, A-3 & A-4)

TB Screw Terminal	Circuit Type	APM To Terminal Block Interface (Standard Mode Only)			Amplifier To Terminal Block Interface			
		From TB PL2 Conn Pin	To APM Module		From TB PL1 Conn Pin	To SL Amplifier CN I/F Connector		
			Axis 1 (A) Signal Name	Axis 2 (B) Signal Name		V-Series	Z-Series	Signal Name
1	+5V Power	A9	+5V	+5V				
2	-10V Analog Input				18	18	33	CWTL
20	+10V Analog Input				16	16	34	CCWTL
3	+/-10V Analog Differential Input	B1	Reserved	AIN (+)				
21		A2	Reserved	AIN (-)				
4	DSM only							
22	DSM only							
5	5V Differential Input on Axis 1 and 5V Single-Ended Outputs on Axis 2	B3	STROBE1 (+)/ CTL01 (+)	CTL10				
24		A4	STROBE1 (-)/ CTL01 (-)	CTL09				
6	5V Differential Input on Axis 1 and 5V Single-Ended Outputs on Axis 2	B2	STROBE2 (+)/ CTL02 (+)	CTL12				
25		A3	STROBE2 (-)/ CTL02 (-)	CTL11				
7	+/-10V Analog Output				42	42	36	IM
8	+/-10V Analog Output				43	43	16	SP
19, 23, 26	0V	A1, B8	0V	0V	13, 17, 45, 46	17	35	GND
9	DSM only							
27	DSM only							
10	DSM only							
28	DSM only							
11	24V Positive Logic Input	B5	OT1+/CTL05	OT2+/CTL07				
29	24V Positive Logic Input	A5	OT1-/CTL06	OT2-/CTL08				
12	24V Positive Logic Input	A6	HOME1/ CTL03	HOME2/ CTL04				
30	Common for inputs on Terminals 11, 12, and 29	B4	INCOM1	INCOM2				
13	24V Active Low Output				35	35	27	S-RDY
14	24V Active Low Output				37	37	26	ALM
15	24V Negative Logic Input				31	31	31	A-CLR
16	24V Negative Logic Input				1	1	29	CWL
17	24V Negative Logic Input				2	2	30	CCWL
18, 31, & 32	+24VDC User Power Input				7	7	11	COM+
33, 34, 35, & 36	Common for the 24 VDC Power Input				26	26		ZEROSP
					34, 36, 38, 41, 26	41	28	COM-
S (2 pins)	Cable Shield	B12	SHIELD	SHIELD	25, 50	25, 50	18	FG

Table A-2. IC800SLT001 Screw Terminal Assignments for APM Follower Mode (See Figure A-1, A-5 & A-6)

TB Screw Terminal	Circuit Type	APM To Terminal Block Interface (Follower Mode Only)			Amplifier To Terminal Block Interface			
		From TB PL2 Conn Pin	To APM Module		From TB PL1 Conn Pin	To SL Amplifier CN I/F Connector		
			Axis 1 (A) Signal Name	Axis 2 (B) Signal Name		V-Series	Z-Series	Signal Name
1	+5V Power	A9	+5V	+5V				
2	-10V Analog Input				18	18	33	CWTL
20	+10V Analog Input				16	16	34	CCWTL
3	5V Differential Input on Axis 1 and +/-10V Analog Differential Input on Axis 2	B1	Z3 (+) / CTL02 (+)	AIN (+)				
21		A2	Z3 (-) / CTL02 (-)	AIN (-)				
4	DSM only							
22	DSM only							
5	5V Differential Input	B3	A3 (+)	Reserved				
24		A4	A3 (-)	Reserved				
6	5V Differential Input	B2	B3 (+)	Reserved				
25		A3	B3 (-)	Reserved				
7	+/-10V Analog Output				42	42	36	IM
8	+/-10V Analog Output				43	43	16	SP
19, 23, 26	0V	A1, B8	0V	0V	13, 17, 45, 46	17	35	GND
9	DSM only							
27	DSM only							
10	DSM only							
28	DSM only							
11	24V Positive Logic Input	B5	DRIVE1 OK/ CTL05	DRIVE2 OK/ CTL07				
29	24V Positive Logic Input	A5	HOME3/ CTL06	CTL08				
12	24V Positive Logic Input	A6	HOME1/ CTL03	HOME2/ CTL04				
30	Common for Inputs on Terminals 11, 12, and 29	B4	INCOM1	INCOM2				
13	24V Active Low Output				35	35	27	S-RDY
14	24V Active Low Output				37	37	26	ALM
15	24V Neg Logic Input				31	31	31	A-CLR
16	24V Neg Logic Input				1	1	29	CWL
17	24V Neg Logic Input				2	2	30	CCWL
18, 31, & 32	+24VDC User Power Input (Required)				7	7	11	COM+
33, 34, 35, & 36	Common for the 24 VDC Power Input				26	26		ZEROSPD
					34, 36, 38, 41,	41	28	COM-
S (2 pins)	Cable Shield	B12	SHIELD	SHIELD	25, 50	25, 50	18	FG

Table A-3. IC800SLT001 Screw Terminal Assignments for DSM Analog Mode (See Figure A-2 & A7)

TB Screw Terminal	Circuit Type	DSM To Terminal Block Interface (Analog Mode Only)			Amplifier To Terminal Block Interface			
		From TB PL2 Conn Pin	To DSM Module		From TB PL1 Conn Pin	To SL Amplifier CN I/F Connector		
			Axis 1 (A) Signal Name	Axis 2 (B) Signal Name		V-Series	Z-Series	Signal Name
1	+5V Power	4	P5V_ENC	P5V_ENC				
2	-10V Analog Input				18	18	33	CWTL
20	+10V Analog Input				16	16	34	CCWTL
3	+/-10V Analog Differential Input	7	AIN1P_A	AIN1P_B				
21		25	AIN1M_A	AIN1M_B				
4	+/-10V Analog Differential Input	8	AIN2P_A	AIN2P_B				
22		26	AIN2M_A	AIN2M_B				
5	5V Single-Ended I/O	9	IO5_A	IO5_B				
24	5V Single-Ended I/O	10	IO6_A	IO6_B				
6	5V Single-Ended I/O	11	IO7_A	IO7_B				
25	5V Single-Ended I/O	12	IO8_A	IO8_B				
7	+/-10V Analog Output				42	42	36	IM
8	+/-10V Analog Output				43	43	16	SP
19, 23, 26	0V	22, 23, 27, 28, 29, 30	0V	0V	13, 17, 45, 46	17	35	GND
9	5V Differential Output	13	OUT2P_A	OUT2P_B				
27		31	OUT2M_A	OUT2M_B				
10	5V Differential Output	14	OUT3P_A	OUT3P_B				
28		32	OUT3M_A	OUT3M_B				
11	24V Positive Logic Input	16	IN9_A	IN9_B				
29	24V Positive Logic Input	34	IN10_A	IN10_B				
12	24V Positive Logic Input	17	IN11_A	IN11_B				
30	Common for Inputs on Terminals 11, 12, and 29	35	INCOM_A	INCOM_B				
13	24V Active Low Output	5 *	IN4_A	IN4_B	35	35	27	S-RDY
14	24V Active Low Output				37	37	26	ALM
15	24V Negative Logic Input	18	OUT1P_A	OUT1P_B	31	31	31	A-CLR
16	24V Negative Logic Input				1	1	29	CWL
17	24V Negative Logic Input				2	2	30	CCWL
18, 31, & 32	+24VDC User Power Input (Required)				7	7	11	COM+
33, 34, 35, & 36	Common for the 24 VDC Power Input	36	OUT1M_A	OUT1M_B	26	26		ZEROSPD
					34, 36, 38, 41,	41	28	COM-
S (2 pins)	Cable Shield	B12	SHIELD	SHIELD	25, 50	25, 50	18	FG

* Pin 5 of the DSM Connection is connected to the output of an opto-coupler circuit driven by the S-RDY signal from the amplifier.

A.3 I/O Wiring and Connections

The figure below illustrates the functional connections for the IC800SLT001 terminal board when an APM in Standard Mode is used for the motion controller on Axis1. For optional motor brake wiring, please see Section 2.6 of Chapter 2.

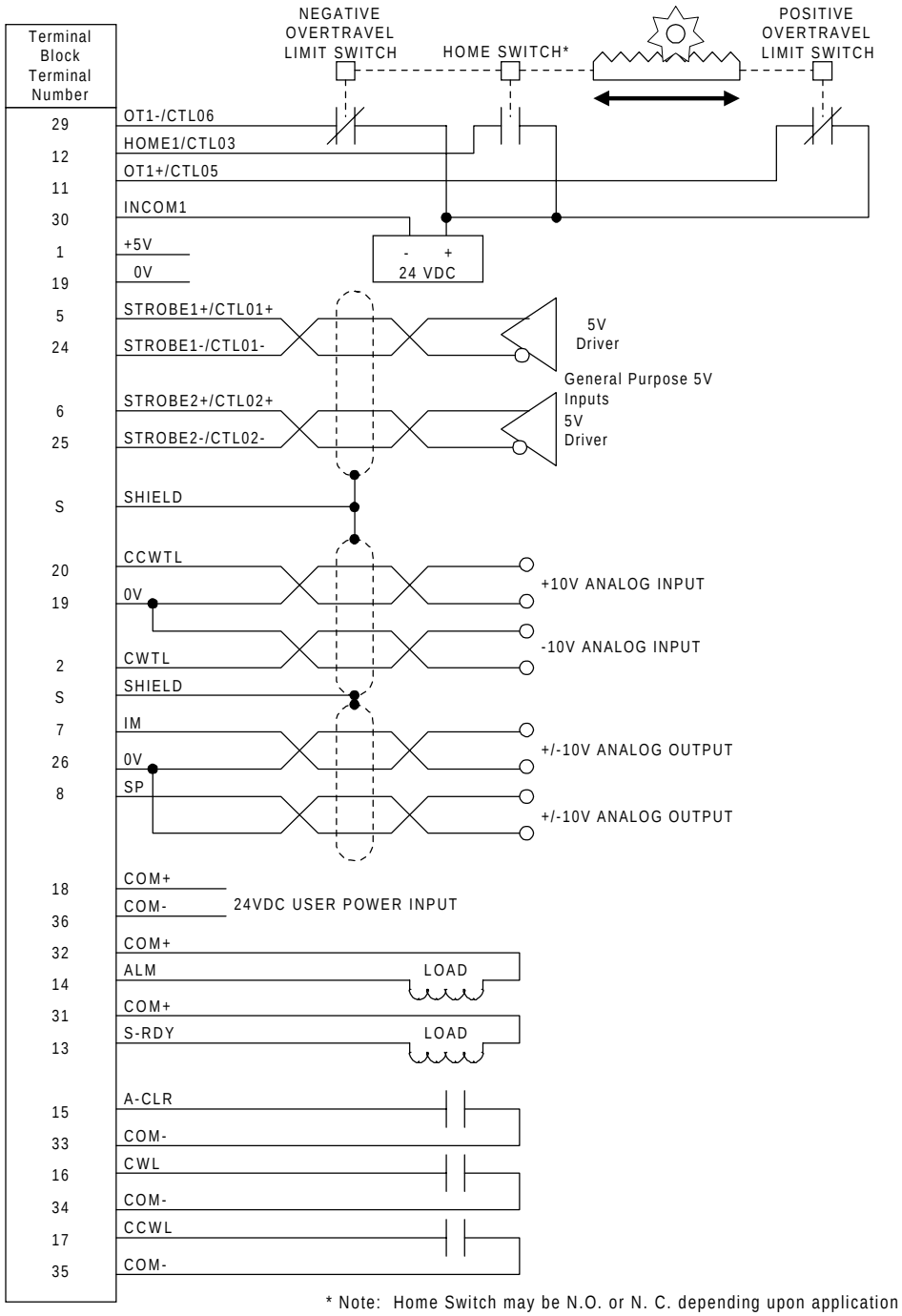


Figure A-3. IC800SLT001 Terminal Board Wiring Diagram: APM Standard Mode Axis 1

The figure below illustrates the functional connections for the terminal board when an APM in Standard Mode is used for the motion controller on Axis 2. For optional motor brake wiring, please see Section 2.6 of Chapter 2.

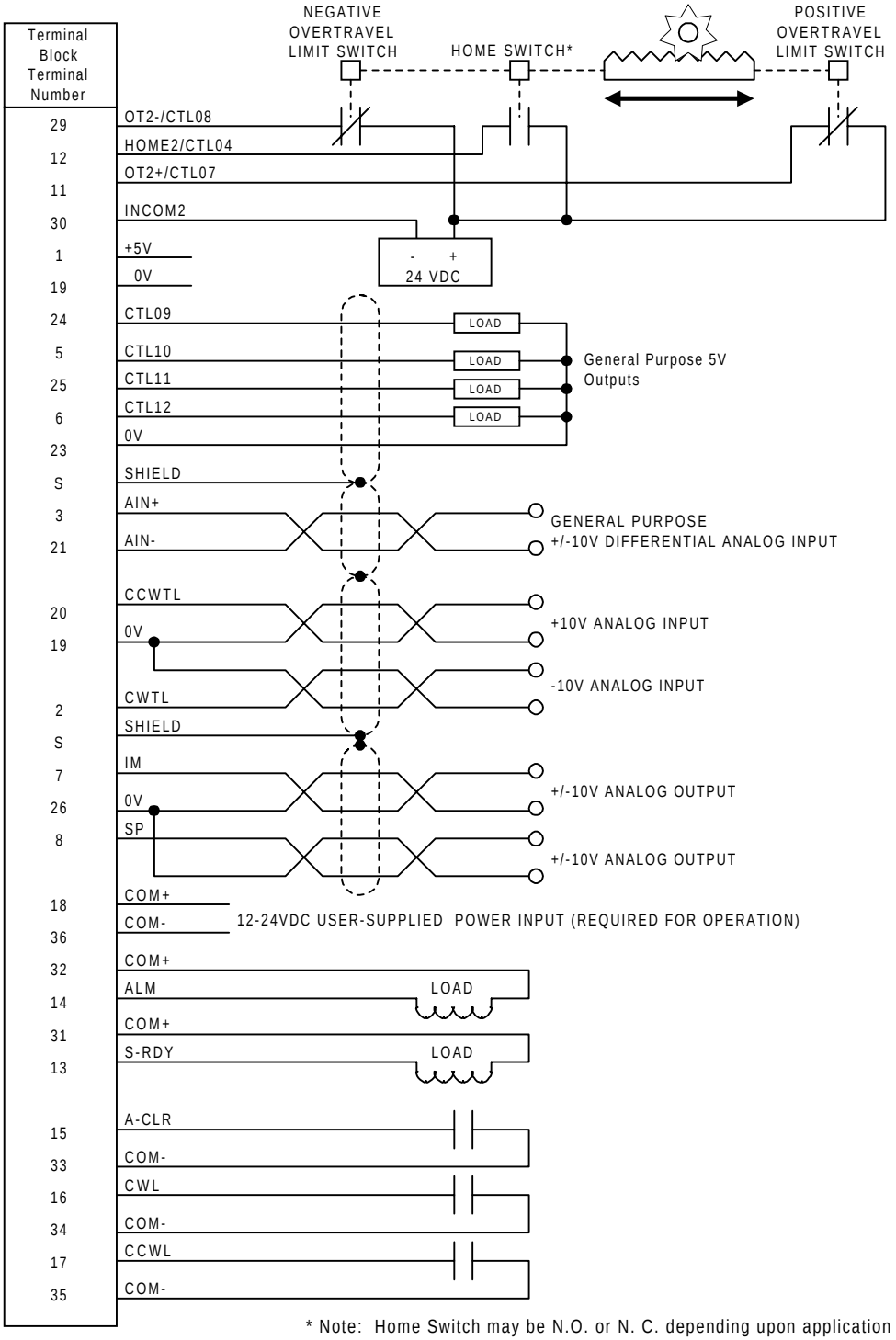


Figure A-4. IC800SLT001 Terminal Board Wiring Diagram: APM Standard Mode Axis 2

The figure below illustrates the functional connections for the terminal board when an APM in Follower Mode is used for the motion controller on Axis1. For optional motor brake wiring, please see Section 2.6 of Chapter 2.

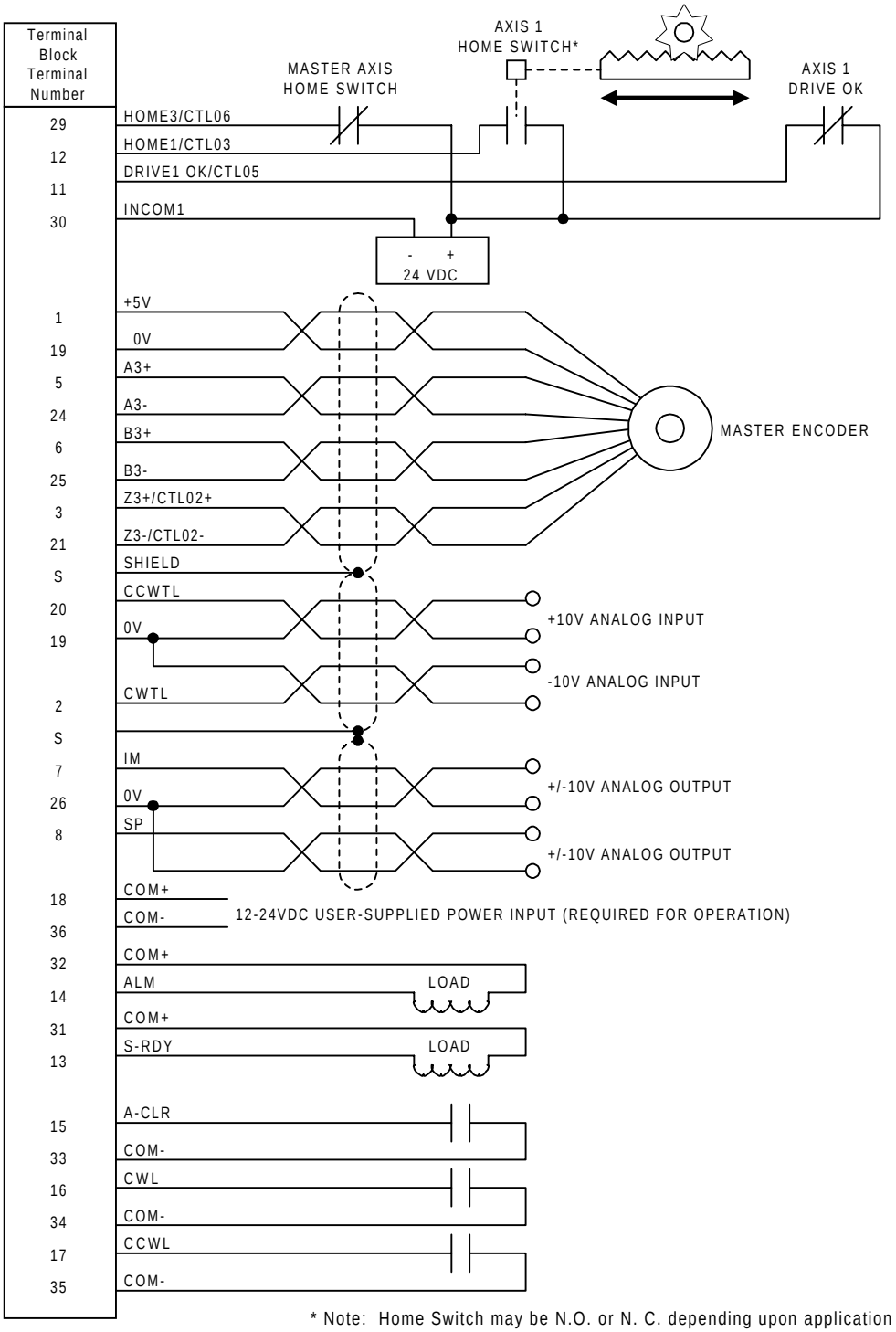
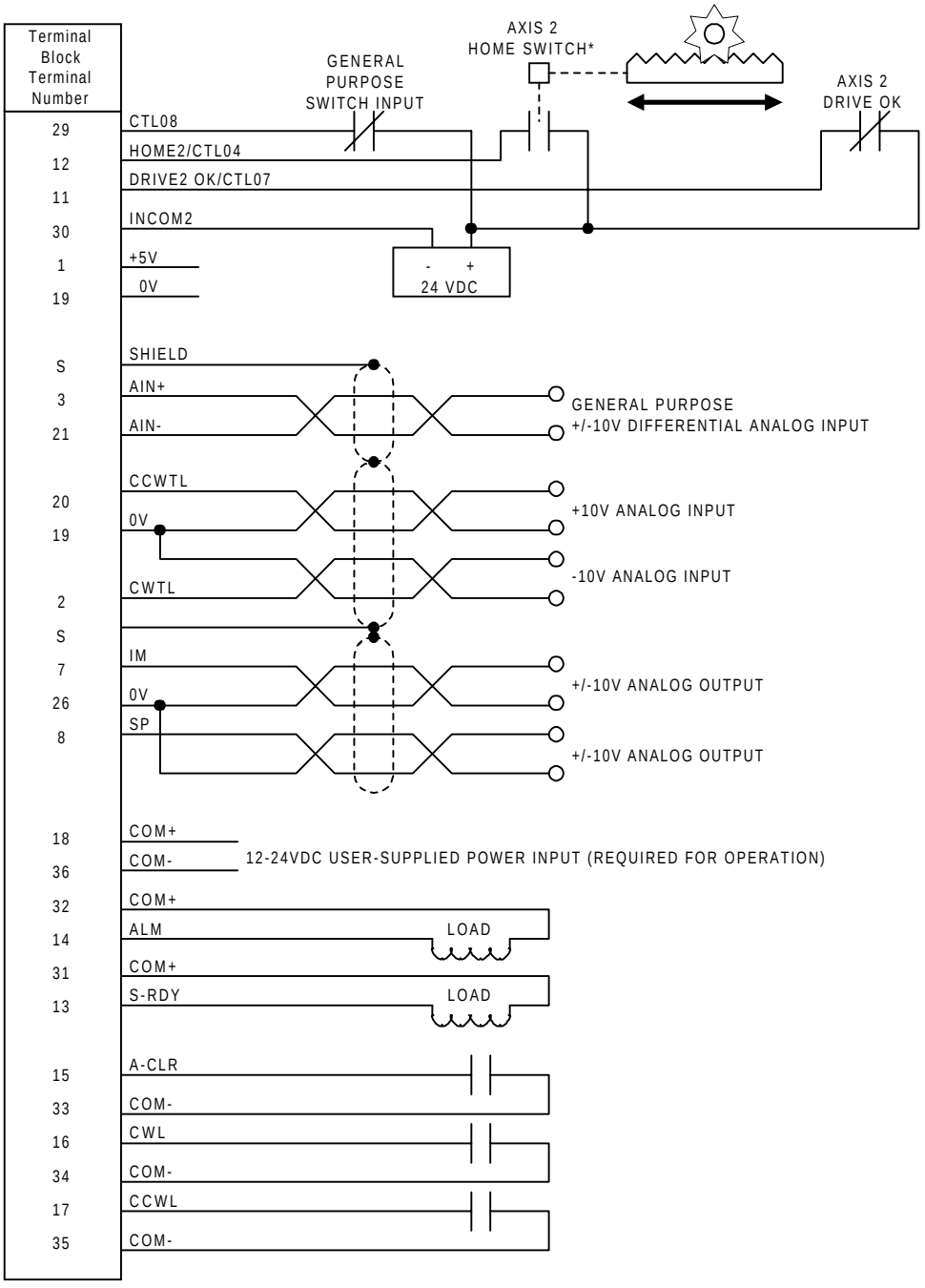


Figure A-5. IC800SLT001 Terminal Board Wiring Diagram: APM Follower Mode Axis 1

The figure below illustrates the functional connections for the terminal board when an APM in Follower Mode is used for the motion controller on Axis2. For optional motor brake wiring, please see Section 2.6 of Chapter 2.



* Note: Home Switch may be N.O. or N. C. depending upon application

Figure A-6. IC800SLT001 Terminal Board Wiring Diagram: APM Follower Mode Axis 2

The figure below illustrates the functional connections for the terminal board when a DSM in Analog Mode is used for the motion controller. For optional motor brake wiring, please see Section 2.6 of Chapter 2.

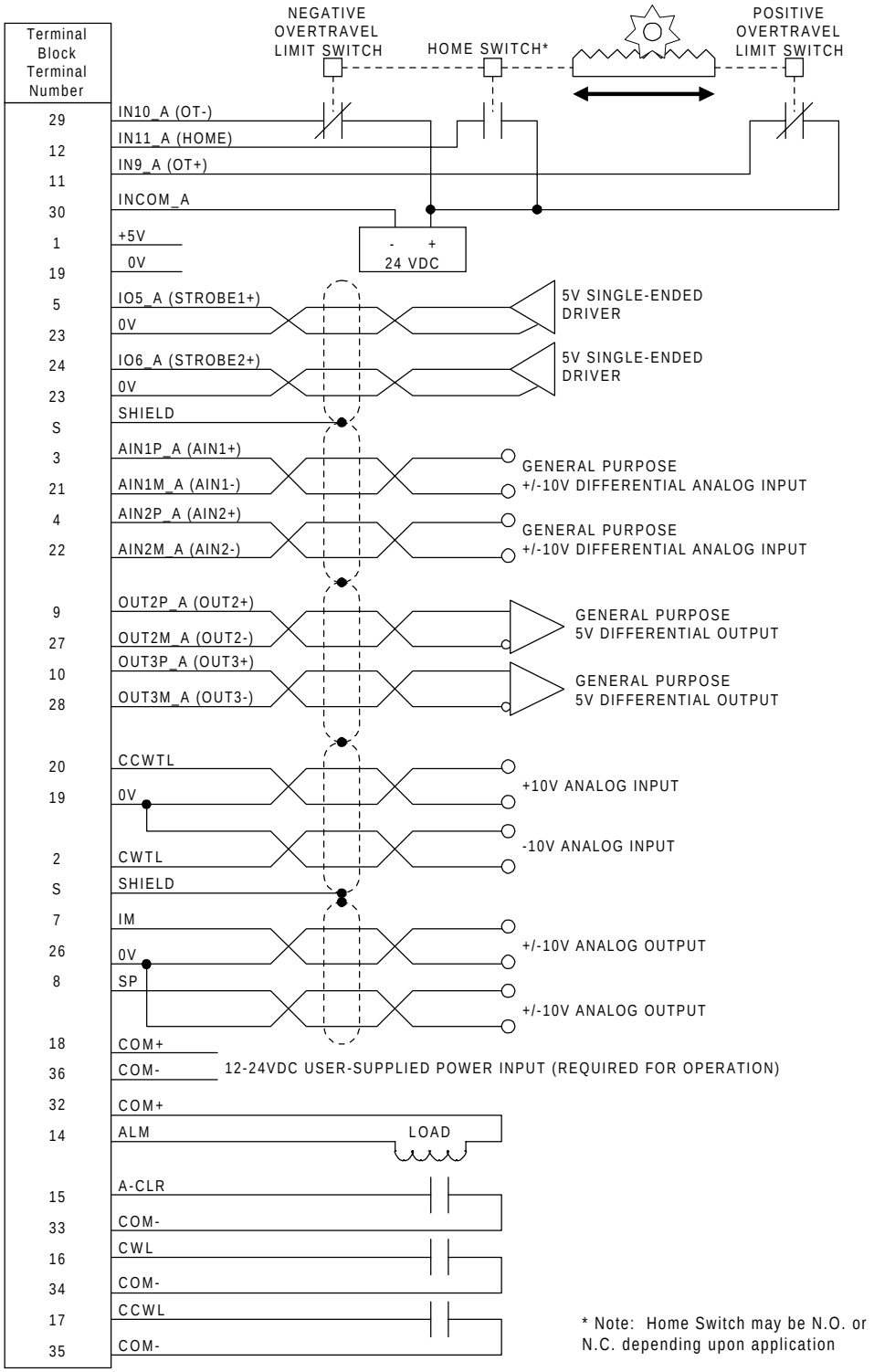
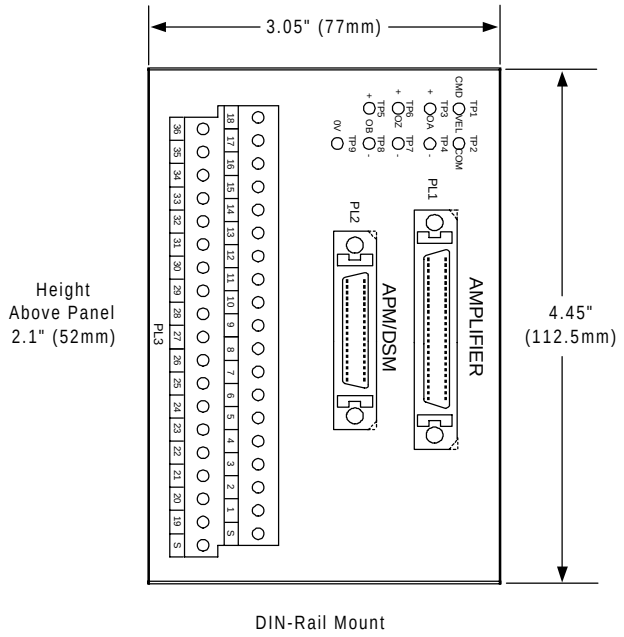


Figure A-7. IC800SLT001 Terminal Board Wiring Diagram: DSM Analog Mode

A.3.1 IC800SLT001 Mounting Dimensions

The IC800SLT001 Terminal Board assembly is designed for either panel mounting or DIN-rail mounting. See the section "Converting Terminal Boards to Panel Mounting" later in this chapter. Dimensions for both mounting styles are shown in Figure A-8 below.



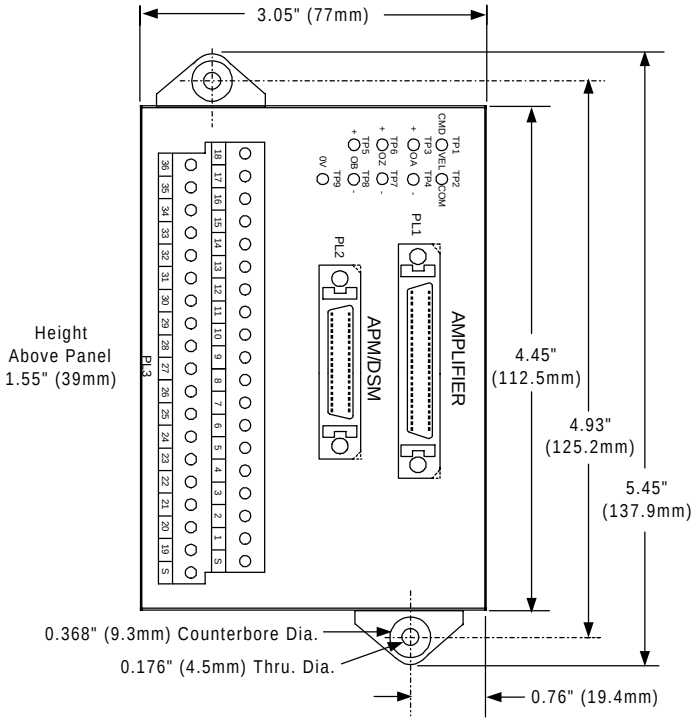


Figure A-8. IC800SLT001 Terminal Board Mounting Dimensions

A.3.2 Test Points

The IC800SLT001 terminal board includes nine post –type test points for monitoring pass through signals that are not available on screw terminals. Connections to the test points should only be made when power is removed from the system. Be careful not to short adjacent test points together. The function of each test point is defined below. Also, be aware that these test points are not positioned in numerical order on the terminal board.

Note

Test/Monitoring equipment should only be connected to the test point posts while power to the system is turned off to prevent damage to the motion controller, amplifier, or motor. Monitoring equipment should not be connected during normal operation of the system to prevent these connections from introducing noise into the command or feedback signals.

Test Point	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9
Function	Velocity Command	Velocity Command Common	Encoder Output +OA	Encoder Output -OA	Encoder Output +OB	Encoder Output +OZ	Encoder Output -OZ	Encoder Output -OB	Signal Common (GND)

A.4 Breakout Terminal Board (IC800SLT004)

The IC800SLT004 Breakout Terminal Board is used to provide screw terminal connections for the interface signals on the SL Series amplifiers. This terminal board provides a convenient interface to third party motion controllers, stepper indexers or velocity/torque controllers.

The terminal board contains a single 50-pin connector, labeled **AMPLIFIER** (PL1). For V-Series amplifiers (1000-5000Watt), servo interface cable IC800SLCIV010 (1 meter) or IC800SLCIV030 (3 meters) connects from the **AMPLIFIER** connector (PL1) to the CN I/F interface connector on the SL Series amplifier. For Z-Series amplifiers (30-750W), servo interface cable IC800SLCIZ010 (1 meter) or IC800SLCIZ030 (3 meters) connects from the terminal board **AMPLIFIER** connector (PL1) to the CN I/F interface connector on the SL Series amplifier

Fifty-four screw terminals are provided on the Breakout Terminal Board for connections to the amplifier's interface signals.

Twenty-one 130V MOVs are installed between terminal points 11-18 and 29-36 and frame ground (S terminals) for improved noise suppression.

The I/O terminals support a wire gauge of 14-28 AWG. Maximum screw torque that should be applied is 5 inch-pounds.

Note

Two of the screw terminals are labeled **S** for **Shield**. A short earth ground wire should be connected from one of the **S** terminals directly to a panel earth ground. The cable shields for any user devices should be connected to either of the **S** terminals.

For installations that must meet IEC electrical noise immunity standards, the Breakout Terminal Board must be placed in an enclosure (to meet the ESD criteria only).

For additional information, refer to *Installation Requirements for Conformance to Standards*, GFK-1179.

A.4.1 Terminal Functions

TableA-4. IC800SLT004 Terminal Board Screw Terminal Assignments

TB Screw Terminal	Circuit Type	Amplifier To Terminal Board Interface Connection				
		TB	V-Series Amplifier		Z-Series Amplifier	
		PL1 Conn. Pin	CN I/F Terminal	Signal Name	CN I/F Terminal	Signal Name*
1	Open Collector Output	19	19	CZ	4	CZ
2	5V Line Driver Output	23	23	OZ+	1	OZ+
20		24	24	OZ-	2	OZ-
3	5V Line Driver Output	48	48	OB+	21	OB+
21		49	49	OB-	22	OB-
4	5V Line Driver Output	21	21	OA+	19	OA+
22		22	22	OA-	20	OA-
5	High Speed Opto Input (220 ohm in series)	5	6	SIGN2	7	SIGN2
23		6	5	SIGN1	8	SIGN1

TB Screw Terminal	Circuit Type	Amplifier To Terminal Board Interface Connection				
		TB	V-Series Amplifier		Z-Series Amplifier	
		PL1 Conn. Pin	CN I/F Terminal	Signal Name	CN I/F Terminal	Signal Name*
6	High Speed Opto Input (220 ohm in series)	3	4	PULS2	5	PULS2
24		4	3	PULS1	6	PULS1
7	+/-10V Analog Input	14	14	SPR/SPL	14	SPR/SPL
25	Signal Ground	15	15	GND	15	GND
8	24V Negative Logic Input	1	1	CWL	29	CWL
26	24V Negative Logic Input	2	2	CCWL	30	CCWL
9	24V Active Low Output	40	40	TLC		
10	24V Active Low Output	11	11	BRK-OFF		
11	24V Active Low Output	35	35	S-RDY	27	S-RDY/ ZSP/ BRK-OFF
12	24V Active Low Output	8	8	EXOUT0		
13	24V Active Low Output	9	9	EXOUT1		
14	24V Active Low Output	10	10	EXOUT2		
27	24V Active Low Output	39	39	COIN	25	COIN
28	24V Active Low Output	12	12	ZSP		
29	24V Active Low Output	37	37	ALM	26	ALM
36	-12VDC Power Out, 20mA max.	47	47	-12V		
37	+12VDC Power Out, 20mA max.	20	20	+12V		
38	+/-10V Analog Output	42	42	IM	36	IM
39	+/-10V Analog Output	43	43	SP	16	SP
41	-10V Analog Input	18	18	CWTL	33	CWTL
42	+10V Analog Input	16	16	CCWTL/ TRQR	34	CCWTL/ TRQR
44	24V Negative Logic Input	27	27	P-CON		
45	24V Negative Logic Input	28	28	INTSPD		
46	24V Negative Logic Input	31	31	A-CLR	31	A-CLR
47	24V Negative Logic Input	33	33	INH	9	INH/INTSPD1
48	24V Negative Logic Input	30	30	CL	13	CL/ INTSPD2
49	24V Negative Logic Input	26	26	ZEROSPD	10	ZEROSPD/ DIV
50	24V Negative Logic Input	29	29	SRV-ON	12	SRV-ON
51	24V Negative Logic Input	32	32	CMODE	32	C-MODE/ GAIN/ P-CON
18, 19, 40, 43	Signal Ground	13, 17, 44, 45, 46	13, 15, 17, 44, 45, 46	GND	13, 15, 17, 35	GND
15, 16, 17	+24VDC User Power Input	7	7	COM+	11	COM+
30, 31, 32, 33, 34, 35, 52	Common for the 24 VDC Power Input	41, 34, 36	41	COM-	28	COM-
S (2 pins)	Frame Ground (Cable Shield)	25, 50	25, 50	FG	18	FG

*** Some pins on the Z-Series amplifiers (**30-750 W**) have multiple functions. The function of these pins is dependent on the setting for Parameter No.3F.**

A.4.2 IC800SLT004 Mounting Dimensions

The IC800SLT004 Terminal Board assembly is designed for either panel mounting or DIN-rail mounting. See the section "Converting Terminal Boards to Panel Mounting" later in this chapter. Dimensions for both mounting styles are shown in Figure A-9 below.

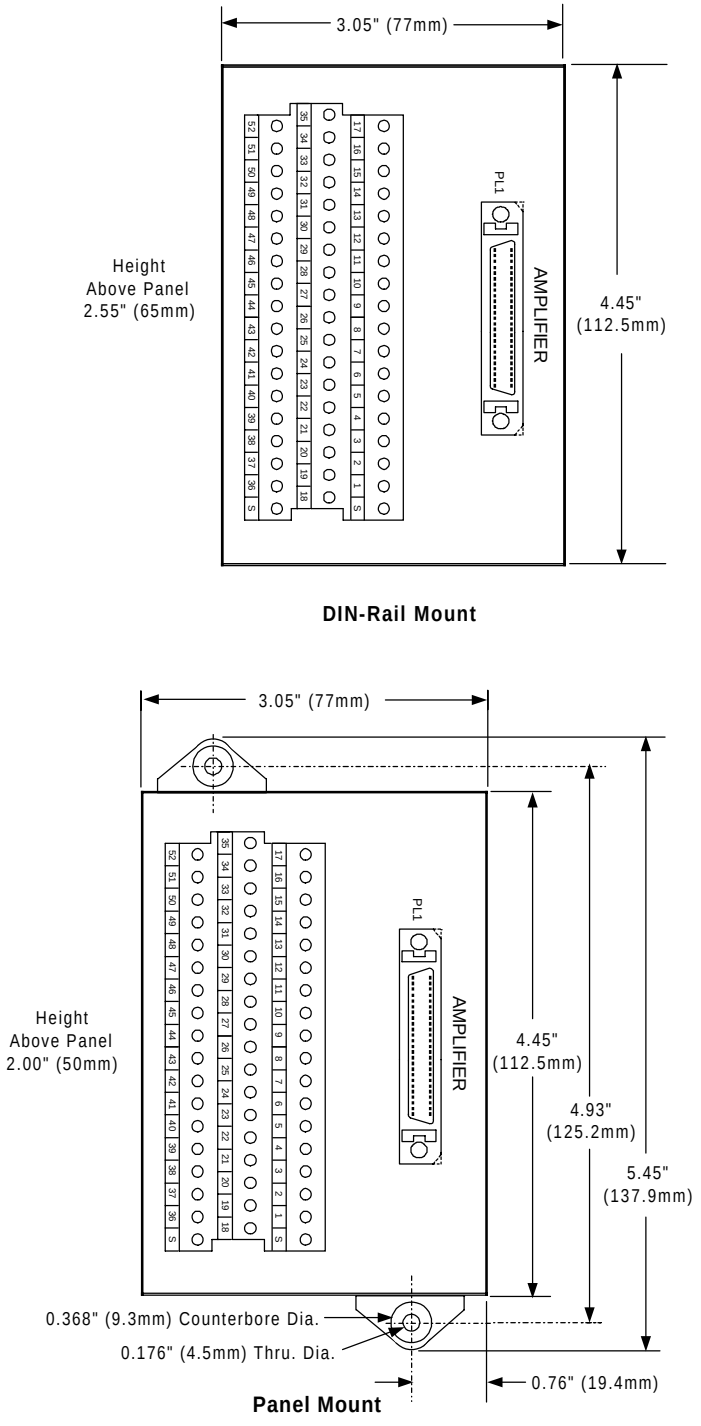


Figure A-9. IC800SLT004 Breakout Terminal Board Mounting Dimensions

A.5 I/O Wiring

A.5.1 I/O Cable Grounding and Separation

Properly routing signal cables, amplifier power cables and motor power cables in addition to installation of proper Class 3 grounding will insure reliable operation. Typically, Class 3 grounding specifies a ground conductor with a minimum wire diameter that is larger than the power input wire diameter, connected via a maximum 100 ohm resistance to an earth ground. Consult local electrical codes and install the system in conformance to local regulations.

When routing signal lines, separate them from the amplifier input power lines and motor power lines. Table A-5 indicates how to separate the various cables.

Table A-5. Cable Separation

Group	Signal	Action
A	Amplifier Power Motor Power Master Control Contactor (MCC) Coil (The MCC switches amplifier input power)	Separate by a minimum 4 inches (10cm) from group “B” signals by bundling separately or use electromagnetic shielding (grounded steel plate) between signal types. Use a noise suppressor for MCC coil.
B	APM/DSM to Terminal Board Cable (IC800SLCAPMxxx or IC693CBL32x) Terminal Board to Amplifier Interface Cable (IC800SLCIxxxx)	Separate by a minimum 4 inches (10cm) from group “A” signals by bundling separately or use electromagnetic shielding (grounded steel plate) between signal types. Terminate all required individual cable shield grounds and grounding bar connections as shown in Chapter 4-"Wiring"

A.5.2 Signal Cable Grounding

The signal cables used with the SL Series amplifiers and DSM302 motion controller contain shields that must be properly grounded to ensure reliable operation. Figures A-10 and A-11 below show cable grounding recommendations for typical installations. The following points should be considered:

1. For installations using the DSM motion controller, the DSM302 faceplate ground wire must be connected to a reliable panel ground. This wire is included with the DSM controller.
2. The IC800SLT001 and IC800SLT004 Terminal Boards provide two screw terminals labeled **S** (shield). A short ground wire must be connected from one of the **S** terminals to a reliable panel ground.
3. For installations which must meet IEC electrical noise immunity standards (CE Mark), cable shield grounding clamps (A99L-0035-0001) and a grounding bar (44B295864-001) must be used at the SL-Series amplifier end of the servo amplifier interface cable (IC800SLCIZ0xx or IC800SLCIV0xx) and the DSM end of the DSM control cable (IC693CBL324/325). See Figure A-12 for details on grounding bar and clamp.

For additional information, refer to *Installation Requirements for Conformance to Standards*, GFK-1179, and Appendix B of this manual.

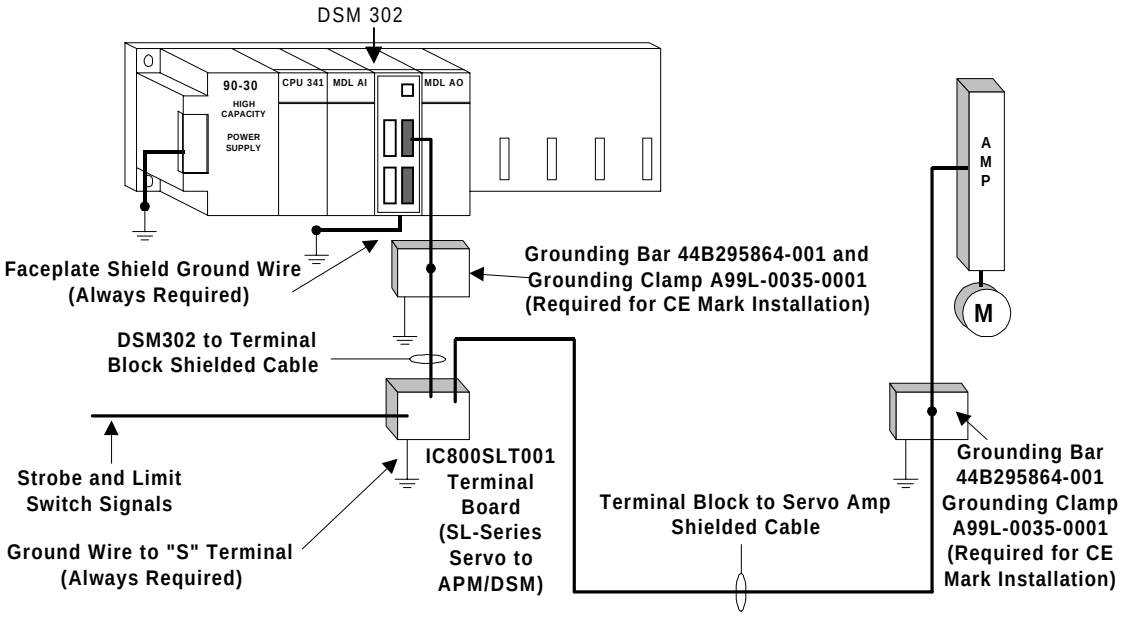


Figure A-10 Cable Grounding for installations using a DSM300 Series Motion Controller

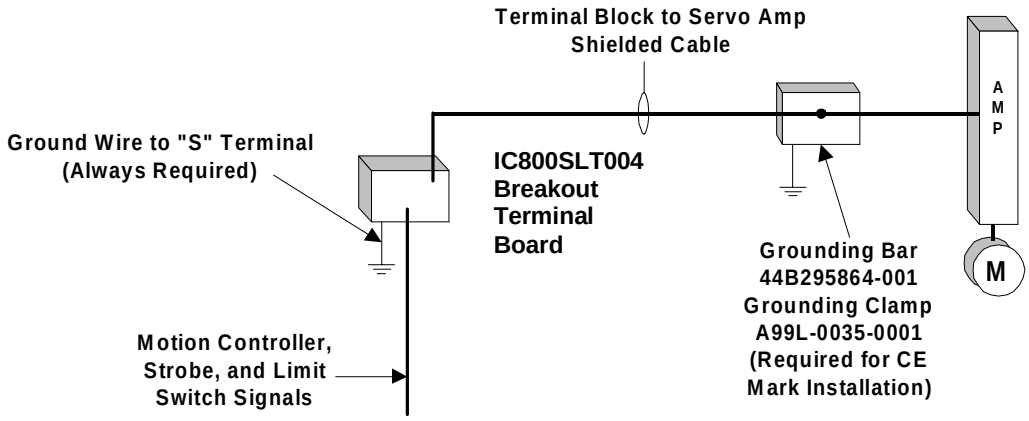


Figure A-11. Cable Grounding for Installations Using the IC800SLT004 Breakout Terminal Board

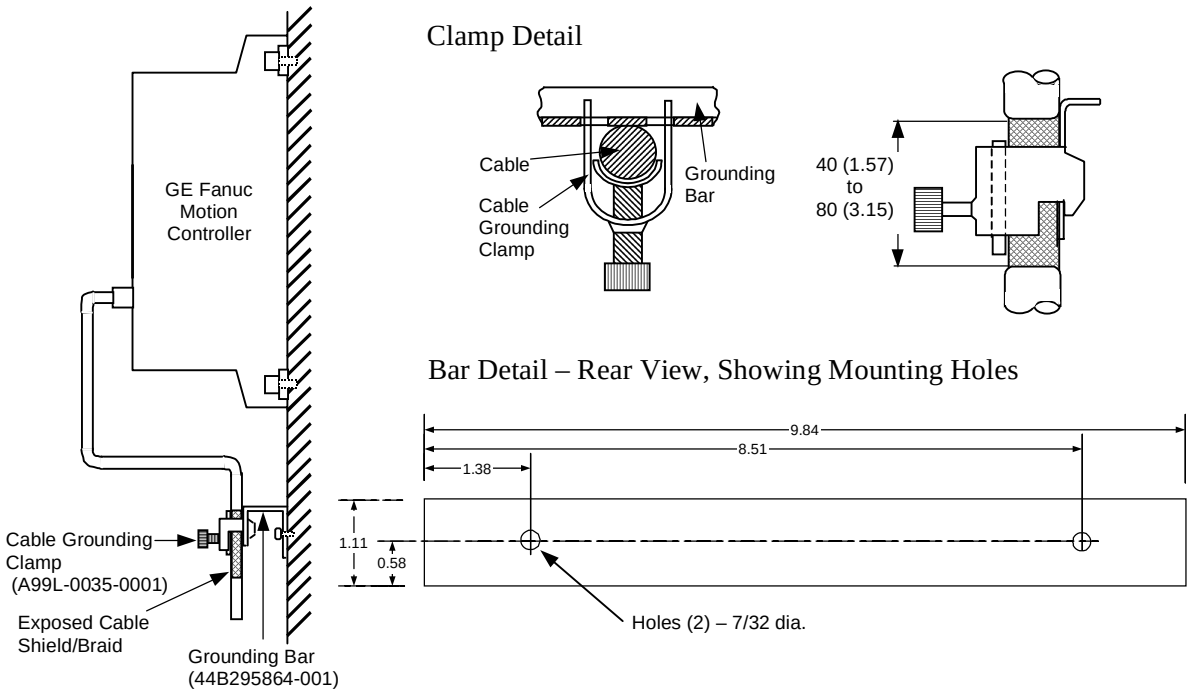


Figure A-12. Detail of Cable Grounding Clamp (A99L-0035-0001) and Bar (44B295864-001)

A.5.3 Converting Terminal Boards to Panel Mounting

The SL-Series Servo to APM/DSM terminal board is shipped configured for DIN-rail mounting. The instructions in this section guide you in converting the board to its optional panel mounting configuration.

The following table and drawings describe the various components used in either the DIN-rail or panel mount assembly options and show a side view of the board configured for DIN-rail mounting

TableA-6. Terminal Board Assembly Components

Plastic Component Part Number	Description	Quantity	Mounting Option
UMK-BE 45	Base Element	2	DIN, Panel
UMK-SE 11.25-1	Side Element	2	DIN, Panel
UMK-FE	Foot Element	2	DIN
UMK-BF*	Mounting Ear	2	Panel

* Parts shipped with terminal boards for optional panel mounting.

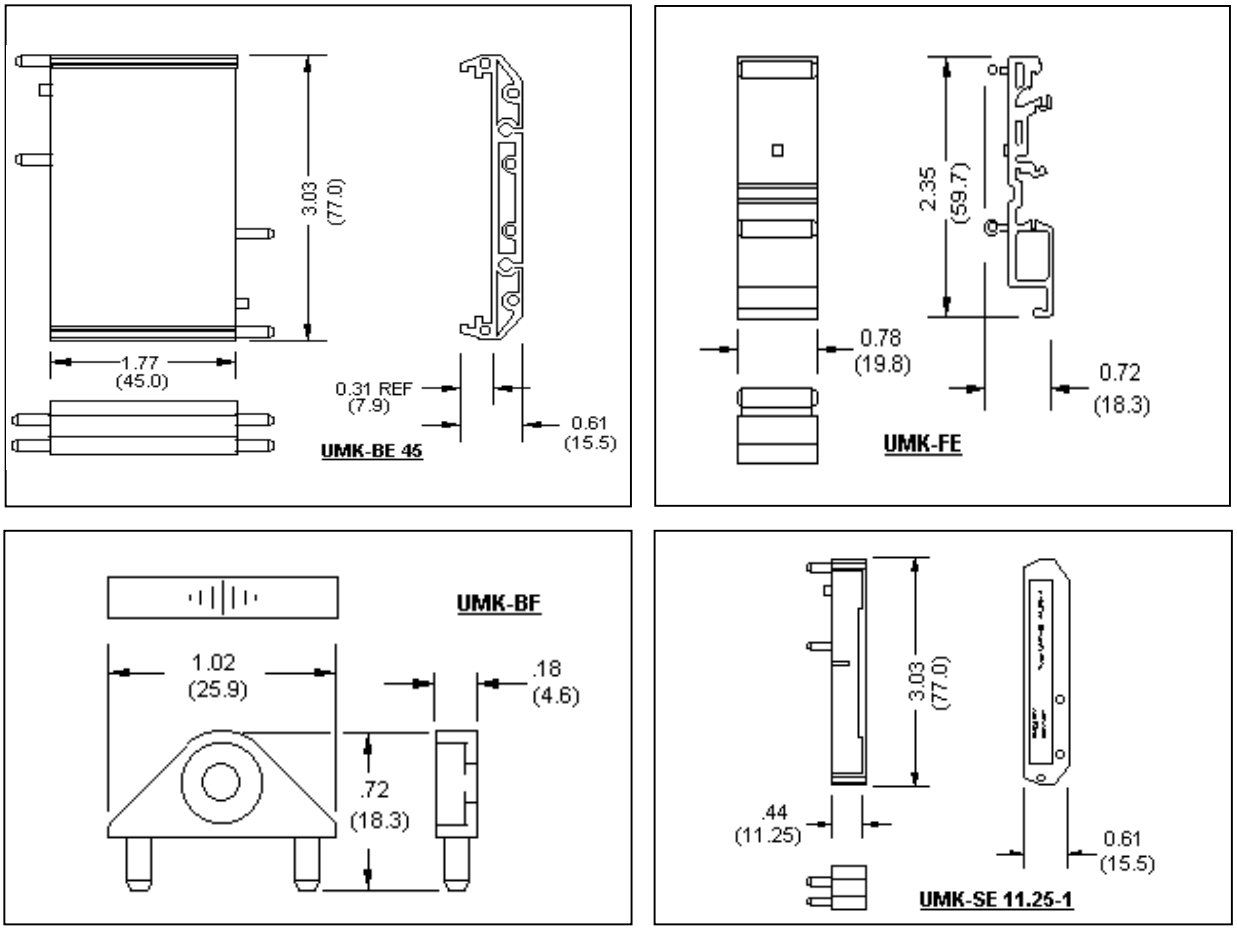


Figure A-13. Terminal Board Mounting Base Assembly Drawings

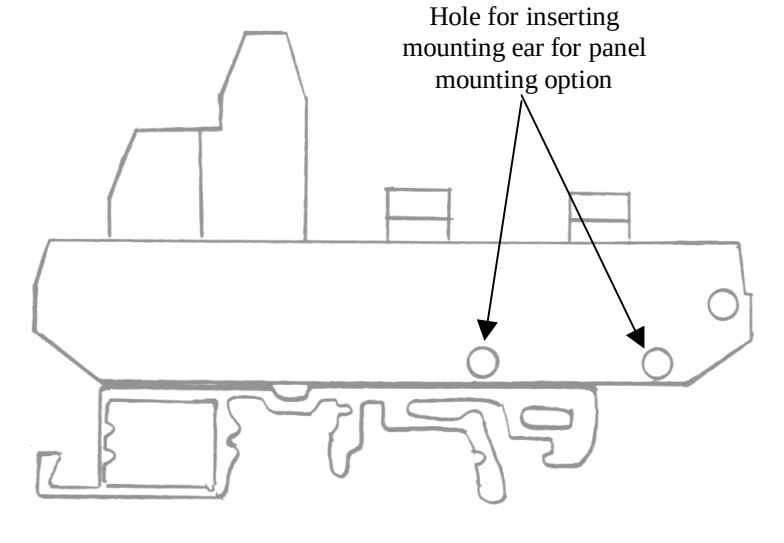


Figure A-14. Terminal Board Assembly Side View (DIN-rail mounting foot installed)

The following procedure should be used to convert the IC800SLT001 or IC800SLT004 terminal board to its panel mounting form. Remember to save all removed parts for possible conversion back to DIN-rail mounting at a later date.

1. Carefully remove one UMK-SE 11.25-1 side element from the UMK-BE 45 base element. If a screwdriver or other device is used, exercise extreme caution to avoid damaging either the plastic parts or the circuit board.
2. Slide the UMK-FE foot element off the base element. Save this part for possible future use in converting the terminal board back to its DIN-rail mounting configuration.
3. Snap the side element, removed in step 1 above, back into the base element.
4. Insert one UMK-BF mounting ear into the appropriate two holes in the side element as shown in Figure A-14. Note in Figure A-13 that the mounting ear has a recessed hole for inserting a (user-supplied) screw for mounting the terminal board. The recessed hole should face upwards to accommodate the head of the mounting screw.
5. Repeat steps 1-4 above for the other side of the terminal board.

Appendix B

CE Installation Requirements

B.1 Compliance with EC Directives (CE Mark)

EC Directives are issued by the European Council and are intended for the determination of common technical requirements and certification procedures within the European community. The texts of the directive are restricted to the essential requirements. Technical details are or will be determined by European harmonized standards.

After verification, affixing a CE mark certifies the conformity to the EC directive. Within the EC there are no commercial barriers for a product with the CE mark.

AC servo is considered a component in the EC directive that will be built in machinery and equipment. For this reason, a supplier of AC servos is not required to affix the CE mark on the product.

However, to facilitate compliance with the Machinery Directive, the SL Series servos are designed to comply with the standards associated with Low-Voltage and EMC Directives.

For additional information, please refer to GE Fanuc publication GFK-1179, *Installation Requirements for Conformance to Standards.*

B.2 Peripheral Devices

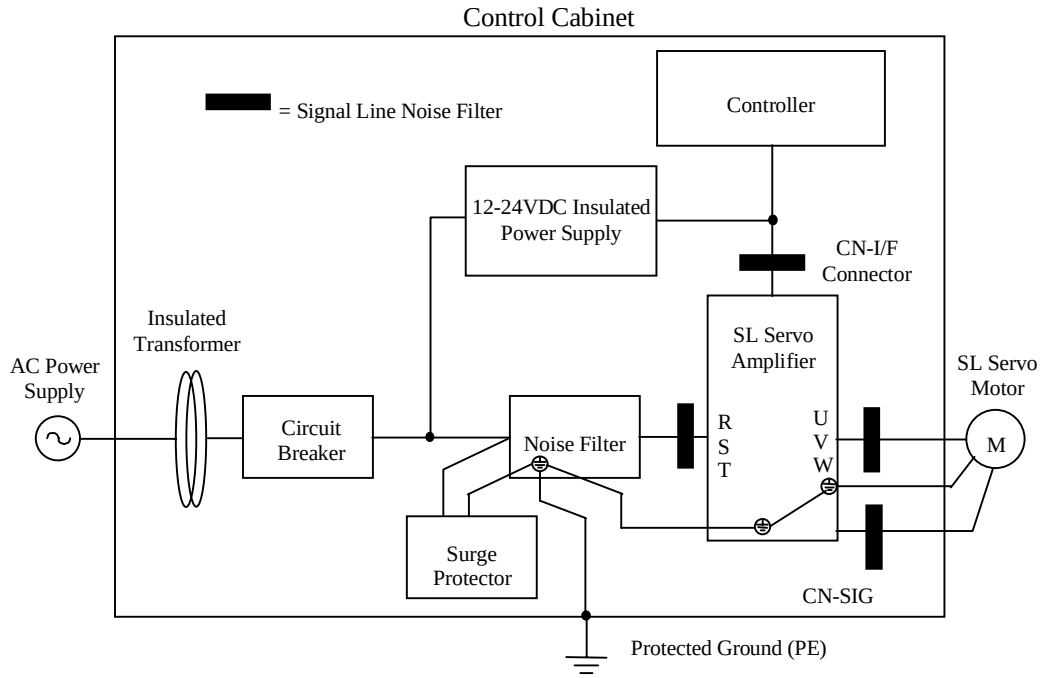


Figure B-1. Peripheral Devices Required for System Compliance

B.2.1 Installation

Voltage		Single-phase, 100 to 120V, +10% to -15% , 50/60Hz (Z-Series only),
		Three-phase, 200 to 230V, +10% to -15%, 50/60Hz
Overvoltage Category		Category 2 (IEC664)
Pollution Level		Level 2 (IEC 664)
Installation Condition	Temperature	Working : 0 to 50°C Storage : -20 to 80°C
	Humidity	Working / Storage : 90% RH or less (non-condensing)
	Vibration	4.9m/s (0.5G or less), 10 to 150 Hz (Continuous operation is not allowed at resonance point)
	Altitude	3300 Feet (1000 m) or less

B.2.2 Power Supply

The servo amplifier must be used according to over-voltage category II that is defined in IEC664. Over-voltage category II requires that the main AC power input use an isolation transformer with double windings, which complies with EC directive EN60742. For the I/O interface power supply, use an insulated 12 ~ 24VDC unit that is CE marked, or meets EN60950 requirements.

B.2.3 Input Power Circuit Breaker

Install an IEC or TUV authorized three-phase circuit protector between the servo amplifier and AC supply as shown in Figure B-1. The rated current requirement differs depending on the model of SL servo amplifier.

Table B-1. Circuit Breaker Specifications

Servo Amplifier Rating		Circuit Breaker				
Voltage	**Amp. Output Power**	**Rated Current**	**Rated Voltage**	**Short Circuit Tripping Capacity**	**Dielectric Strength**	**Example Part* (Sanken Air Packs Co., Ltd.)**
Single-phase 115V	≤200W	10A	250 VAC 50/60 Hz	1500 A @ 250 V 50/60 Hz	3000V for 1 minute (1 mA max. leakage current)	IELH-1-11-63-10A-M
	=400W	15A				IELH-1-11-63-15A-M
3-phase 230V	≤400W	10A				IELH-1-11-63-10A-M
	750W-1kW	15A				IELH-1-11-63-15A-M
	2.5 kW	20A				IELH-1-11-63-20A-M
	>2.5kW	50A				IELH-1-11-63-50A-M

* Equivalent parts to the ones shown may be used

B.2.4 Grounding

For prevention of electric shock, connect the protective earth terminal (⏚) of the servo amplifier with the protective earth (PE) of the control panel as shown in Figure B-1.

There are two protective earth terminals provided on the amplifier. Do not wire them together on a panel earth terminal.

B.3 Compliance with EMC Directive

The SL Series servo system is designed to comply with the standards related to the EMC Directive under certain installation conditions (e.g. wiring distance between the amplifier and motor). These test conditions are not always indicative of actual installation conditions on a specific machine. Therefore, it is the machine manufacturer's responsibility to ensure that the final product is compliant with the LVD and EMC directives.

B.3.1 Noise Filter for AC Supply

To comply with the EMC Directive it is necessary to install noise filters on the main AC supply to the amplifier as shown in Figure B-1. An example of a compliant noise filter is shown in the table below. Equivalent parts from other manufacturers may be substituted.

Table B-2. AC Supply Noise Filters Specifications

Servo Amplifier Rating		Noise Filter Example				
Voltage specification	**Amp. Output Power**	**Voltage Rating**	**Current Rating**	**Leakage Current**	**Typ. Attenuation Differential Mode**	**Model**
Single-phase 115V	≤200W	250 V_{rms} 50/60 Hz	10A	1 mA @ 250V_{rms}	0.15 – 80Mhz 40 dB	3SUP-A10H-ER-4 (Okaya Electric Industries, Ltd.)
3-phase 230V	≤400W					
Single-phase 115V	≥400W		30A		0.2 – 80MHz 35 dB	3SUP-A30H-ER-4 (Okaya Electric Industries, Ltd.)
3-phase 230V	750W-2.5kW					
	>2.5kW		50A			3SUP-A50H-ER-4 (Okaya Electric Industries, Ltd.)

B.3.2 Surge Protector

To comply with the EMC Directive it is necessary to install a surge protector on the supply line of the noise filter as shown in Figure B-1. The same protector can be used on all SL Servo systems.

Table B-3. Surge Suppressor Specifications

Voltage Rating	Nominal Discharge Current* (8/20 µs)	Max. Std. Lightning Impulse*	Max. Front-of-Wave Lightning Impulse* (10kV/µs)	Max. Residual Voltage*	Surge Protector Example
250 VAC 50/60 Hz	2500 A	2kV	3kV	2kV	R-A-V-781BXZ-4 (Okaya Electric Industries, Ltd.)

* Terminal to ground.

B.3.3 Noise Filter for Signal Lines

To comply with the EMC Directive it is necessary to install noise filters on all signal cables connected to the SL Series amplifier as shown in Figure B-1.

Table B-4. Signal Line Noise Filter Specifications

Impedance	Temp. Range	Construction	Vibration	Noise Filter
10-100 Mhz=80Ω min. 100-500MHz=150Ω min.	-40 to 80°C	Ferrite Core	10-55Hz Amplitude: 0.762 mm X,Y, Z Each 2 hours	ZCAT3035-1330 (TDK Corporation)

Appendix C Tables and Formulas

Standard ASCII (American Standard Code for Information Interchange) Codes

Char.	Dec.	Hex.
NUL	0	00
SOH	1	01
STX	2	02
ETX	3	03
EOT	4	04
ENQ	5	05
ACK	6	06
BEL	7	07
BS	8	08
HT	9	09
LF	10	0A
VT	11	0B
FF	12	0C
CR	13	0D
SO	14	0E
SI	15	0F
DLE	16	10
DC1	17	11
DC2	18	12
DC3	19	13
DC4	20	14
NAK	21	15
SYN	22	16
ETB	23	17
CAN	24	18
EM	25	19
SUB	26	1A
ESC	27	1B
FS	28	1C
GS	29	1D
RS	30	1E
US	31	1F
SP	32	20
!	33	21
”	34	22
#	35	23
$	36	24
%	37	25
&	38	26
’	39	27
(	40	28
)	41	29
*	42	2A

Char.	Dec.	Hex.
+	43	2B
,	44	2C
-	45	2D
.	46	2E
/	47	2F
0	48	30
1	49	31
2	50	32
3	51	33
4	52	34
5	53	35
6	54	36
7	55	37
8	56	38
9	57	39
:	58	3A
;	59	3B
<	60	3C
=	61	3D
>	62	3E
?	63	3F
@	64	40
A	65	41
B	66	42
C	67	43
D	68	44
E	69	45
F	70	46
G	71	47
H	72	48
I	73	49
J	74	4A
K	75	4B
L	76	4C
M	77	4D
N	78	4E
O	79	4F
P	80	50
Q	81	51
R	82	52
S	83	53
T	84	54
U	85	55

Char.	Dec.	Hex.
V	86	56
W	87	57
X	88	58
Y	89	59
Z	90	5A
[	91	5B
\	92	5C
]	93	5D
^	94	5E
_	95	5F
`	96	60
a	97	61
b	98	62
c	99	63
d	100	64
e	101	65
f	012	66
g	103	67
h	104	68
i	105	69
j	106	6A
k	107	6B
l	108	6C
m	109	6D
n	110	6E
o	111	6F
p	112	70
q	113	71
r	114	72
s	115	73
t	116	74
u	117	75
v	118	76
w	119	77
x	120	78
y	121	79
z	122	7A
{	123	7B
|	124	7C
}	125	7D
~	126	7E
“	127	7F

AWG to Metric Wire Size Conversion

Since there is not an exact correspondence between American AWG wire sizes and metric sizes, the metric values in the following table are close approximations. If you need greater precision, contact your wire supplier.

AWG to Metric Wire Size Conversion	
AWG Size	**Metric Cross Section in square millimeters (mm^2)**
1	42.4
2	33.6
4	21.2
6	13.2
8	8.37
10	5.26
12	3.31
14	2.08
16	1.31
18	0.82
20	0.52
22	0.32
24	0.21
26	0.13
28	0.081
30	0.051

Temperature Conversion

Formulas

°C = 5/9(°F – 32)

°F = (9/5 x °C) + 32

Table

Celsius to Fahrenheit Conversion (to nearest degree)					
Degrees Celsius	**Degrees Fahrenheit**	**Degrees Celsius**	**Degrees Fahrenheit**	**Degrees Celsius**	**Degrees Fahrenheit**
-50	-58	50	122	145	293
-45	-49	55	131	150	302
-40	-40	60	140	155	311
-30	-22	65	149	160	320
-25	-13	70	158	165	329
-20	-4	75	167	170	338
-15	5	80	176	175	347
-10	14	85	185	180	356
-5	23	90	194	185	365
0	32	95	203	190	374
5	41	100	212	195	383
10	50	105	221	200	392
15	59	110	230	205	401
20	68	115	239	210	410
25	77	120	248	215	419
30	86	125	257	220	428
35	95	130	266	225	437
40	104	135	275	230	446
45	113	140	284	235	455

Miscellaneous Equivalents

1 ounce (weight) =	28.35 grams
1 pound (weight) =	453.6 grams
1 pound (weight) =	16 ounces
1 pound (force) =	4.448 newtons
1 short ton (weight)=	907.2 kilograms
1 short ton (weight)=	2,000 pounds
1 horsepower (power)=	550 foot-pounds per second
1 horsepower (power) =	746 watts of electrical power
1 kilowatt (power) =	1.341 horsepower
1 kilowatt-hour (energy or work) =	3,412.142 Btu
1 kilowatt-hour (energy or work) =	1,000 watts/hr.
1 watt (power) =	3.412 Btu/hr.
1 watt (power) =	1 joule/sec.
1 joule/sec. (power) =	1 watt
1 joule (energy)=	1 newton-meter
1 Btu =	0.293 watt
1 Btu =	778.2 foot-pounds
1 Btu =	252 gram-calories
1 Btu (energy)=	1055 joules
1 newton-meter (torque or work) =	0.7376 pound-feet
1 newton-meter (torque or work) =	8.851 pound-inches
1 pound-foot (torque or work) =	1.3558 newton-meters
1 pound-inch (torque or work) =	0.113 newton-meters
1 ounce-inch (torque or work) =	72 gram-centimeters
1 degree (angular) =	0.0175 radians
1 minute (angular) =	0.01667 degrees
1 radian (angular) =	57.3 degrees
1 quadrant (angular) =	90 degrees

Fraction-Decimal-Metric Equivalents

Fraction (Inch)	Decimal (Inch)	Metric (mm)
1/64	0.01562	0.397
1/32	0.03125	0.794
3/64	0.04688	1.191
1/16	0.06250	1.588
5/64	0.07812	1.984
3/32	0.09375	2.381
7/64	0.10938	2.778
1/8	0.12500	3.175
9/64	0.14062	3.572
5/32	0.15625	3.969
11/64	0.17188	4.366
3/16	0.18750	4.763
13/64	0.20312	5.159
7/32	0.21875	5.556
15/64	0.23438	5.953
1/4	0.25000	6.350
17/64	0.26562	6.747
9/32	0.28125	7.144
19/64	0.29688	7.541
5/16	0.31250	7.938
21/64	0.32812	8.334
11/32	0.34375	8.731
23/64	0.35938	9.128
3/8	0.37500	9.525
25/64	0.39062	9.922
13/32	0.40625	10.319
27/64	0.42188	10.716
7/16	0.43750	11.113
29/64	0.45312	11.509
15/32	0.46875	11.906
31/64	0.48438	12.303
1/2	0.50000	12.700

Fraction (Inch)	Decimal (Inch)	Metric (mm)
33/64	0.51562	13.097
17/32	0.53125	13.494
35/64	0.54688	13.891
9/16	0.56250	14.288
37/64	0.57812	14.684
19/32	0.59375	15.081
39/64	0.60938	15.478
5/8	0.62500	15.875
41/64	0.64062	16.272
21/32	0.65625	16.669
43/64	0.67188	17.066
11/16	0.68750	17.463
45/64	0.70312	17.859
23/32	0.71875	18.256
47/64	0.73438	18.653
3/4	0.75000	19.050
49/64	0.76562	19.447
25/32	0.78125	19.844
51/64	0.79688	20.241
13/16	0.81250	20.638
53/64	0.82812	21.034
27/32	0.84375	21.431
55/64	0.85938	21.828
7/8	0.87500	22.225
57/64	0.89062	22.622
29/32	0.90625	23.019
59/64	0.92188	23.416
15/16	0.93750	23.813
61/64	0.95312	24.209
31/32	0.96875	24.606
63/64	0.98438	25.003
1	1.00000	25.400

English and Metric Equivalents

This section is based upon information published on the World Wide Web by the U.S. government's National Institute of Standards and Technology (NIST). For further information, visit their web site at www.nist.gov.

Units of Length (Underlined Figures are Exact)						
Units	**Inches**	**Feet**	**Yards**	**Millimeters**	**Centimeters**	**Meters**
1 inch =	1	0.083 333	0.027 777	25.4	2.54	0.025 4
1 foot =	12	1	0.333 333	304.8	30.48	0.304 8
1 yard =	36	3	1	914.4	91.44	0.914 4
1 mile =	63,360	5,280	1,760	1,609,344	160,934.4	1,609.344
1 mm =	0.0393 700	0.003 280 8	0.001 093 6	1	.1	.001
1 cm =	0.393 700 8	0.032 808	0.010 936	10	1	0.01
1 meter =	39.370 08	3.280 840	1.093 613	1000	100	1

Units of Area (Underlined Figures are Exact)					
Units	**Square Inches**	**Square Feet**	**Square Yards**	**Square Centimeters**	**Square Meters**
1 square inch =	1	0.006944	0.000 771 604 9	6.451 6	0.000 645 16
1 square foot =	144	1	0.111111	929.030 4	0.092 903 04
1 square yard =	1296	9	1	8,361.273 6	0.836 127 36
1 square mile =	4,014,489,600	27,878,400	3,097,600	25,899,881,103.36	2,589,988.110 336
1 square centimeter =	0.155 000 3	0.001 076 391	0.0001195990	1	0.0001
1 square meter =	1,550.003	10.763 91	1.195 990	10,000	1

Units of Volume (Underlined Figures are Exact)			
Units	**Cubic Inches**	**Cubic Feet**	**Cubic Yards**
1 cubic inch =	1	0.000 578 703 7	0.000 021 433 47
1 cubic foot =	1,728	1	0.037 037 04
1 cubic yard =	46,656	27	1
1 cubic centimeter =	0.061 023 74	0.000 035 314 67	0.000 001 307 951
1 cubic decimeter =	61.023 74	0.035 314 67	0.001 307 951
1 cubic meter	61,023.74	35.314 67	1.307 951

Units of Volume (Underlined Figures are Exact)			
Units	**Milliliters (Cubic Centimeters)**	**Liters (Cubic Decimeters)**	**Cubic Meters**
1 cubic Inch =	16.387 064	0.016 387 064	0.000 016 387 064
1 cubic foot =	28,316.846 592	28.316 846 592	0.028 316 846 592
1 cubic yard =	764,554.857 984	764.554 857 984	0.764 554 857 984
1 cubic centimeter =	1	0.001	0.000 001
1 cubic decimeter =	1,000	1	0.001
1 cubic meter =	1,000,000	1,000	1

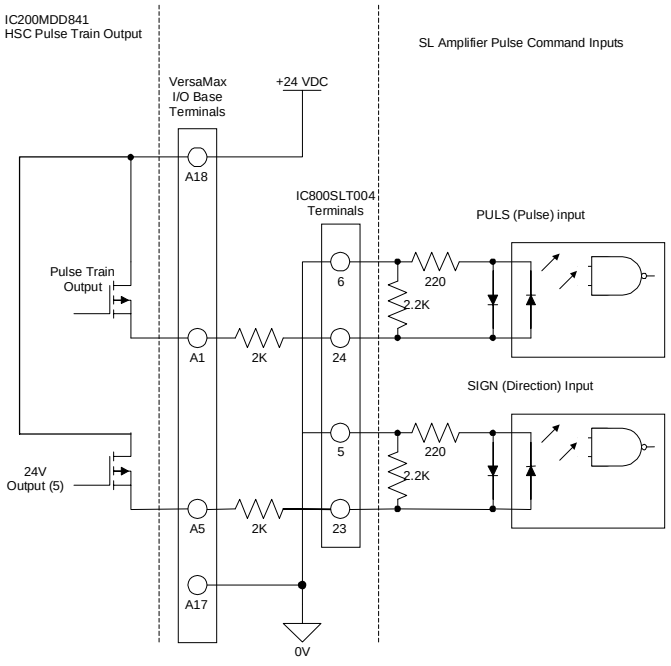
Appendix D

VersaMax High Speed Counter Interface

Interfacing the IC200MDD841 Module to the SL Series Servo Amp

The IC200MDD841 VersaMax High Speed Counter (HSC) module can be configured to produce a Pulse Train (PT) output on four of its outputs (terminals A1 – A4). One of these PT outputs can be used to drive an SL Series servo. The following diagram shows an example of the HSC Pulse Train 1 output (pin A1) connected to the pulse input of an SL Series amplifier. The HSC output on pin A5 sends a count sign (direction) to the SL Series amplifier. Both the VersaMax and SL Series amplifier must be configured appropriately for this to work. **Please note that when using one of these pulse train outputs to drive an SL Series servo, the maximum theoretical speed attainable is 614.4 RPM.** This is based on the IC200MDD841's maximum PT output frequency of 5120 Hz, the SL Series amplifier's maximum pulse multiplier value of 20 (parameters 25 and 26), and the SL Series encoder resolution of 10,000 counts per revolution.

For information on the IC200MDD841 module, refer to GFK-1504B (or later version).



Appendix E Interfacing the SL Servo to an OCS/RCS

Application Overview

This appendix discusses how to apply an OCS (Operator Control Station) or RCS (Remote Control Station) Stepper Controller Module to control an SL Z-Series (30 - 750 Watts) servo system in pulse and direction mode. The examples shown in this appendix discuss interfacing to an OCS; however, this information, for the most part, also applies to an equivalent RCS.

Benefits of this Application

- Low Cost installation for simple “point to point” positioning applications. Perfect for “feed to length” applications with or without registration.
- Capable of high resolution (10,000 counts per motor rev) vs. typical, non-microstepping stepper solutions (200 –400 counts per rev).
- The SL Servo has all the traditional servo advantages over stepper systems: smaller size, lower power usage, acceleration torque, flat torque response, etc.
- Autotune functionality in the SL Series system & system performance monitor with SLconfig software.
- SL Servo provides true closed loop position control.
- Flexible system architecture; each OCS/RCS may support up to 3 axes (assuming that at least 1 I/O board is needed per system) and 64 OCS/RCS systems may be networked over the built in CAN fieldbus.
- The OCS has a built in operator interface that may be optionally used if desired. An RCS may be used if no operator interface is required. The RCS (Remote Control Station) provides basic OCS functionality but, unlike the OCS, is not equipped with a display and keypad.
- Single point of connect configuration and programming using Cscape Software.
- The Stepper module includes the motion essentials, over-travel inputs, home switch inputs, jog control, acceleration/deceleration control, stall detection, position verification.
- Cscape OCS/RCS software is “motion” friendly with graphical online motion calculator.

Materials List

The SLconfig software & cable (IC641SWP800 & IC800SLCS020) are not required but are very useful for setup and testing purposes. A minimum list of materials is included in the following table.

Table E-1. Basic Materials List

Part Number	Description
IC300OCS100	OCS Main Unit
GFK-1631	IC300OCS100 User Manual
IC300OSW232	OCS Software (Cscape)* & Cable
IC800SLT004	SL Terminal Block
IC800SLAxxxx	Z Series Amplifier
IC800SLCPZ050	Z Series Motor Cable (5 meter)
IC690PWR024	Standalone 24VDC power supply

Part Number	Description
IC300STP100	OCS Stepper Module
GFK-1644	IC300STP100 User Manual
GFK-1581	SL Servo User's Manual (this manual)
IC800SLCIZ010	Z Series Interface Cable (1 meter)
IC800SLMxxxxxxxxx	Z Series Motor
IC800SLCEZ050	Z Series Encoder Cable (5 meters)

* Cscape software also available as a free download from www.gefanuc.com/support

Power Requirements

A 24 VDC power supply is required for the OCS (160ma base + power for STP100) and for the SL amplifier (250ma). The GE Fanuc IC690PWR024 standalone power supply is a suitable choice.

Wiring

Most of the system wiring can be installed quickly by using GE Fanuc prefabricated cables. Follow instructions in this manual to connect the servo system. Figure D-1 shows the minimum wiring requirements; however, it is likely that your application will require additional components such as limit switches, pushbuttons, etc.

Caution

When powering up for the first time, ensure that the axis can be moved safely. Be prepared to put the system into Emergency Stop condition or to shut down the power quickly if servo instability (oscillation) occurs.

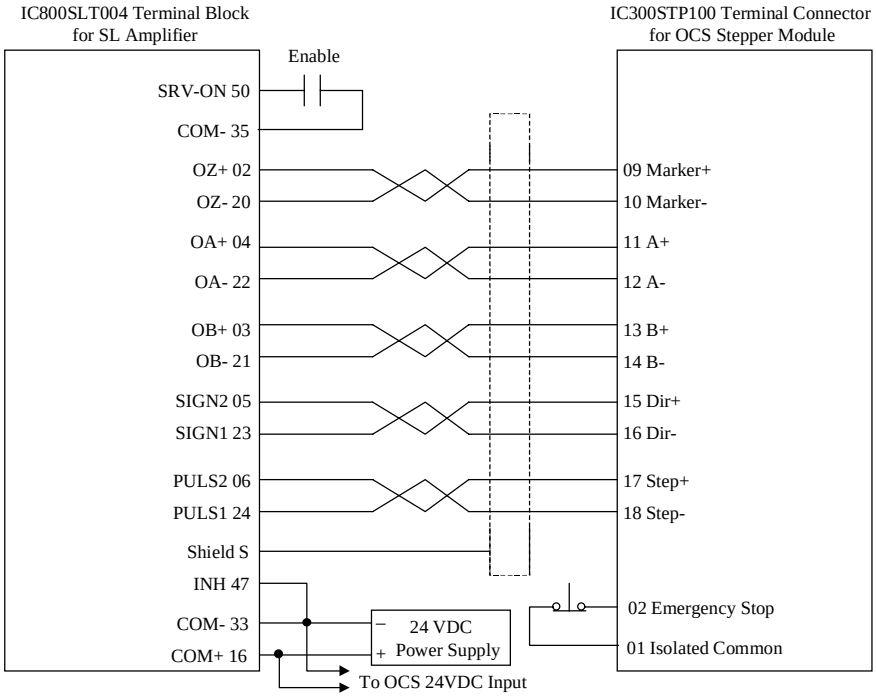


Figure E-1. Basic Wiring Diagram

SL Amplifier Configuration

The following is the complete configuration for the SL amplifier copied from a 100-watt system used to test this application. These parameters are explained elsewhere in this manual. You may change amplifier parameter values as needed via the amplifier front panel or the SLconfig software. After the parameters are changed, be certain to save them to EEPROM in the amplifier and power cycle the amplifier. Run the autotuning function after the power cycle with a low (2-4) machine stiffness value. Save the settings to EEPROM again.

For completeness, all the SL parameters are listed in the following table, but only a few need to be changed from default values for this application. A file (Ocs_demo.prm) containing this parameter configuration is contained in zip file OCS_SL.ZIP, which can be downloaded free of charge from www.gefanuc.com/support. The parameters indicated with an "*" in the rightmost column of the following table have been changed from default values; all others are at their default values.

Table E-2. SL Amplifier Parameter Listing

		Parameter Name	Parameter Value	
user	00 :	Axis address	0	
user	01 :	Select initial display	1	
user	02 :	Select control mode	0	*
user	03 :	Velocity loop gain	25	*
user	04 :	V-loop integral time	45	*
user	05 :	Velocity feedback filter	4	
user	06 :	Torque limit	300	
user	07 :	Torque limit inhibit	1	
user	08 :	Speed monitor gain	0	
user	09 :	Overtravel limit inhibit	1	
user	0a :	Dynamic brake select	0	
user	0b :	Feedback ratio numerator	1000	*
user	0c :	Feedback ratio denominator	2000	*
user	0d :	Encoder signal inversion	3	
user	0e :	Brake action-stopping	0	
user	0f :	Brake action-running	0	
user	10 :	Acceleration rate limit	0	
user	11 :	Zero speed detect level	50	
user	12 :	At-Speed detect level	1000	
user	13 :	Velocity command scaling	500	
user	14 :	Velocity command polarity	1	
user	15 :	Velocity command offset	0	
user	16 :	Int/ext speed cmd select	0	
user	17 :	Zero speed clamp inhibit	1	
user	18 :	First internal speed	0	
user	19 :	Second internal speed	0	
user	1a :	Torque command scaling	250	*
user	1b :	Torque command polarity	0	*
user	1c :	Torque command offset	0	
user	1d :	Torque command filter	0	
user	1e :	Not used	0	
user	1f :	Deceleration rate limit	0	
user	20 :	Position loop gain	70	*
user	21 :	Velocity feed forward	0	
user	22 :	In-Position range	10	
user	23 :	Pos.error limit	30000	
user	24 :	Pos.error limit inhibit	0	
user	25 :	Pulse cmd ratio numerator	2000	*
user	26 :	Pulse cmd ratio denominator	1000	*
user	27 :r	Quad pulse input scaler	4	
user	28 :r	Pulse command polarity	2	*
user	29 :r	Pulse input mode select	3	*
user	2a :	Not used	0	
user	2b :	Velocity feedforward filter	0	
user	2c :	Not used	0	
user	2d :	Not used	0	
user	2e :	Not used	0	
user	2f :	Not used	0	
user	30 :	2nd velocity loop gain	100	
user	31 :	2nd v-loop integral time	50	
user	32 :	2nd position loop gain	50	
user	33 :	2nd gain enable	0	
user	34 :	Gain switch delay time	0	*
user	35 :	2nd numerator-pulse ratio	10000	
user	36 :	Pulse cmd filter delay	3	
user	37 :	Jog speed	300	
user	38 :	Third internal speed	0	
user	39 :	Fourth internal speed	0	
user	3a :	Not used	0	
user	3b :	Monitor output select	0	
user	3c :	Clear counter input mode	0	
user	3d :	Alarm action select	0	
user	3e :	Servo-off action select	0	
user	3f :r	CN I/F function select	0	

OCS Configuration

You will need the following minimum revision OCS products to use a stepper module.

OCS Firmware Version 7.37 OCS BIOS Version 3.39

OCS FPGA Version 2.3 Cscape Version 2.3

The I/O configuration is set up to work with the OCS997 (8I &8Q) board on the unit. Simply snap the stepper board on top of the OCS997. The Cscape file, SL_Step.csp (included in the OCS_SL.ZIP file, which may be downloaded from www.gefanuc.com/support), contains a demo program and OI screens for the OCS100 unit that may be modified as needed.

The following two screen images are the stepper configuration screens from Cscape.

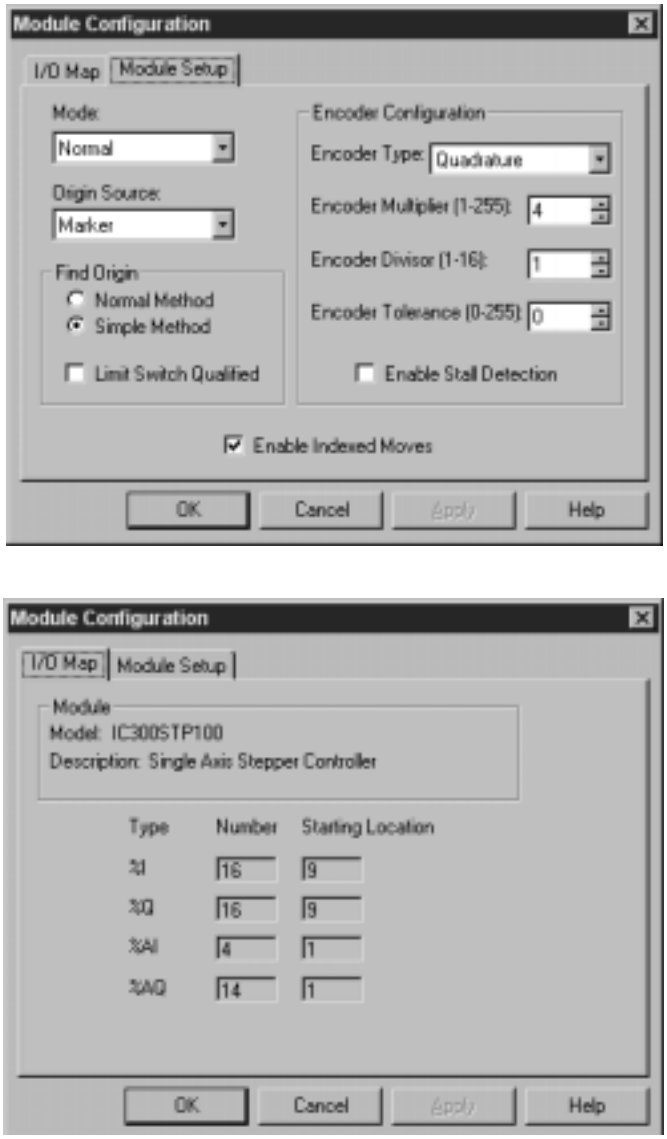


Figure E-2. Cscape Configuration Screens

Selecting Appropriate User Units.

The following section provides a configuration overview and a detailed example of selecting appropriate parameter values, i.e. “how to scale user units for the system”.

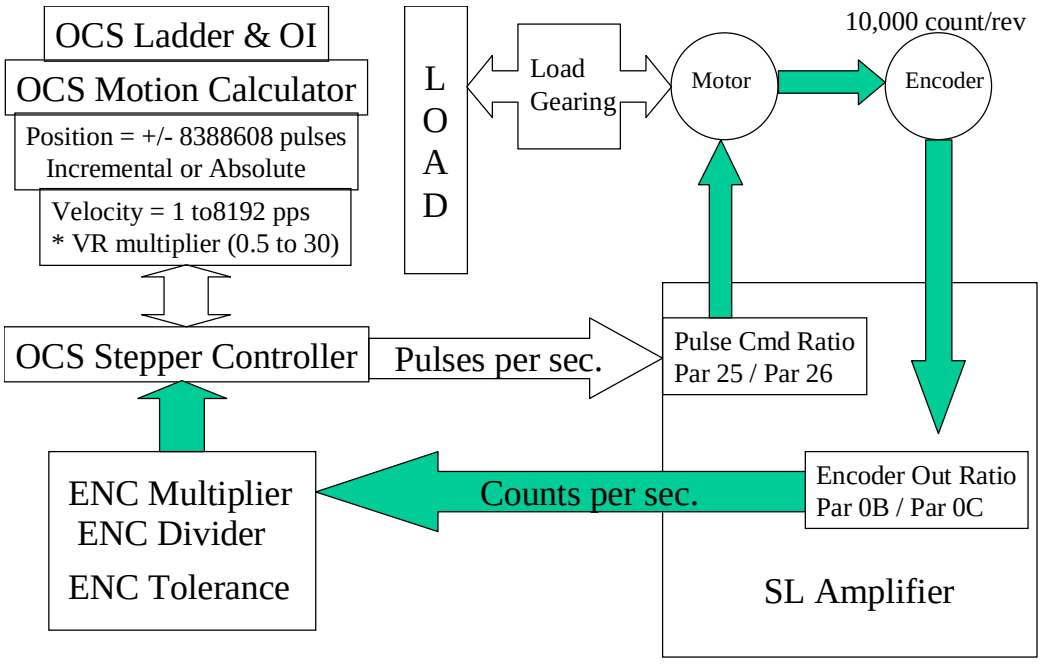


Figure E-3. Configuration Overview

Application Notes

- The load gearing plays a major role in position and velocity.
- The motor mounted encoder is fixed at 10,000 counts per motor revolution.
- The SL Series servomotor will move the number of encoder counts commanded by the OCS Step Pulse Command (in pulses per second) multiplied by the SL Pulse Command ratio (Parameter 25 / Parameter 26). This ratio allows the user to scale the number of Step Pulses from the OCS required to move the SL servomotor a given number of motor encoder counts.
- The SL Servo amplifier will output servomotor encoder counts based on the rotation of the servomotor multiplied by the SL Series configuration for Encoder Output Ratio (Parameter 0B / Parameter 0C). These counts will be used as feedback pulses by the OCS Stepper module.
- The SL Servo Encoder Output Ratio has a limited number of allowed ratio values i.e. 1, 0.8, 0.66, 0.572, 0.5, 0.444, 0.4, 0.363, 0.333, 0.308, 0.286, 0.267, or 0.25.
- The SL Servo Pulse Command Ratio should be the inverse of the Encoder Output Ratio i.e. if ENC Out = 0.5 (1/2) then Pulse CMD= 2 (2/1). This allows the OCS Step Pulse Commands to be equal to the OCS Pulse Feedback and enables OCS Stepper module Position Valid Detection to function.

- The OCS Stepper configuration in Cscape for Encoder Multiplier and Encoder Divider should be 4/1 to make the servomotor mounted encoder quadrature counts and the Pulse Feedback match the OCS Step Pulse Commands.
- The OCS Stepper module motion program Velocity Commands are always in the range of 1-8191. Velocity, that is Step Pulse Commands per second, output from the stepper module is a function of the Velocity Command multiplied by a Velocity Resolution (VR) value.
- The OCS Stepper module Velocity Resolution, as used in motion commands, is fixed at certain intervals and each VR value has an associated maximum velocity, i.e. (VR = Max Velocity) 30=245730pps, 10=81910pps, 5=40995pps, 2=16382pps, 1=8191pps or 0.5=4095pps.

Example Application

Let's assume that you have a linear application using a ball screw that will be directly coupled to the SL Servo. (In many applications a gearing connection between the servomotor and the load will be used and will need to be considered.) The pitch in the ball screw acts as gearing in this example. Our example ball screw has a linear nut movement of one inch per two screw revolutions (1" screw, 2 pitch or 0.5" lead) and is speed rated to 1000 RPM. You want to program movement in decimal inches and obtain the best resolution without exceeding the speed rating of the screw.

1. Calculate the load gearing (2:1 in this example) and determine how many motor encoder counts are represented per user unit. The SL servomotor encoder is fixed at 10,000 counts per motor revolution, so 20,000 servomotor encoder counts = 1 inch of movement at the load.
2. Look at the allowable SL Servo Encoder Output Ratios (see bullet above) and determine which of the available ratios will yield a user unit representative of inches. We are scaling OCS Feedback Pulses, so we need to convert the 20,000 counts per inch of servomotor encoder counts to an engineering unit. Choosing a ratio of 0.5 means (20,000 * 0.5 = 10,000) that one inch of movement at the load would be represented by 10,000 Feedback Pulses (1.0000 inch). Set parameter 0B=1000 and parameter 0C=2000 in the SL amplifier to yield a 0.5 ratio.
3. Determine the maximum move distance for a single move. The OCS stepper will allow a maximum move of +/- 8,388,608 user units. Using the scaling selected in step number 2 above, we can calculate a maximum move of about +/- 838 inches (8,388,608 user units / 10,000 user units per inch). This is plenty of distance for a move in this example. If it is not enough distance for a maximum move in your application, go back to step number 2 and select a smaller Encoder Output Ratio.
4. Set the SL Servo Pulse Command ratio (Parameter 25 / Parameter 26) to the inverse of the SL Encoder Output ratio. For this example, since the Encoder Output Ratio is 0.5 (1000/2000), set the Pulse Command ratio =2 (Par. 25=2000 / Par.26=1000).
5. Set the OCS stepper configuration for Encoder Multiplier to 4 and the Encoder Divider to 1 to convert the SL Servo servomotor encoder quadrature counts output to pulses.
6. Using the above examples, if you wish the axis to move one inch, command 10,000 user units. The value in the OCS Motor Position registers (%AI + 0) will indicate the command 10,000. Additionally, after the move, the OCS Encoder Position registers (%AI + 2) will also indicate 10,000. You may use the very good math functions in the OCS to manipulate these values for display or operator entry purposes.
7. Now that we have set the user units, we need to determine which velocity resolution (VR) multiplier to use in the OCS motion calculator. We determined that the ball screw in this

application can operate up to 1000 RPM. One thousand RPM is the same as 16.666 rev/sec (1000 RPM / 60 sec.). In this application the load gearing does not apply to velocity since we are directly coupled to the ball screw (motor speed = screw speed). For other types of gearing the load velocity requirements would be affected by the gearing in use. The motor mounted encoder (10,000 counts / rev.) at 16.666 rev/sec will be operating at 166,660 counts/sec at 1000 RPM at the ball screw. Since we previously set the SL Servo Pulse Command Ratio at 2, it will take ½ the number of OCS command pulses per second (OCS command pps * pulse command ratio = motor encoder counts moved), to generate the 1000 RPM at the load. This means we need a pulse command velocity of at least 83,330 pps from the OCS to get 1000 RPM at the load.

8. Look at the velocity resolution and maximum velocity settings from the step above. The closest VR resolution is 10 = 81,910 pps max. This is good because we never want to exceed the 1000-RPM on the ball screw. Use the VR setting for 10 pps. A value of 60 in %AQ+2 register or in the motion calculator is equal a VR of 10 pps.

9. If you wish, you can determine what the velocity resolution and max commanded velocity would be for the above application in RPM at the load. The selected velocity resolution (VR) is 10pps. The SL Servo in this application has a Pulse Command Ratio of 2. The command to the servomotor that will cause the servomotor to move a similar number of encoder counts (OCS command * pulse command ratio) is 20 counts per sec or 1,200 counts per minute (20 cps * 60 sec.). Since the SL servomotor encoder is fixed at 10,000 counts/rev, motor movement for the minimum 10 pps of OCS command would be 0.12 RPM (10pps command *2 pulse cmd ratio = 20 cps *60 sec = 1,200 cpm / 10,000 counts/rev = 0.12 RPM). The maximum possible velocity command in the OCS is 8191. Given the application above, the maximum possible velocity of 8191 * 0.12 RPM = maximum load velocity of 982.92 RPM maximum. We strongly suggest using the OCS math functions to change velocity values entered by an operator into the units needed by the motion calculator.

10. What can you do if the maximum velocity is not fast enough? First try increasing the velocity resolution value (VR). If you are already at the maximum 30 pps setting for VR then you must go back to step 2 above and choose a smaller SL Amplifier Encoder Output Ratio.

Source Material

This appendix is based upon GE Fanuc Application Bulletin H-04-99-01.

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