INSTALLATION
&
OPERATION MANUAL

Omega Series

Model SMA9115

Digital PWM Brushless Servo Amplifiers

GLENTEK

"Solutions for Motion Control"

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Overview

This manual guides the application engineer through the steps necessary for a successful installation of an application using the Omega series amplifiers. All features of the digital amplifier are explained and all necessary procedures for installation and tuning are covered. The following sections are presented in the order that would make installation easiest for most first time users of the amplifier.

The “Product Description” and “Features” sections contain information for the application engineer to determine if the Omega series amplifiers are appropriate for his application.

Next MotionMaestro© software is introduced. Enough material is given here to familiarize the application engineer with the tools necessary to setup and tune a motor using the Omega series amplifiers.

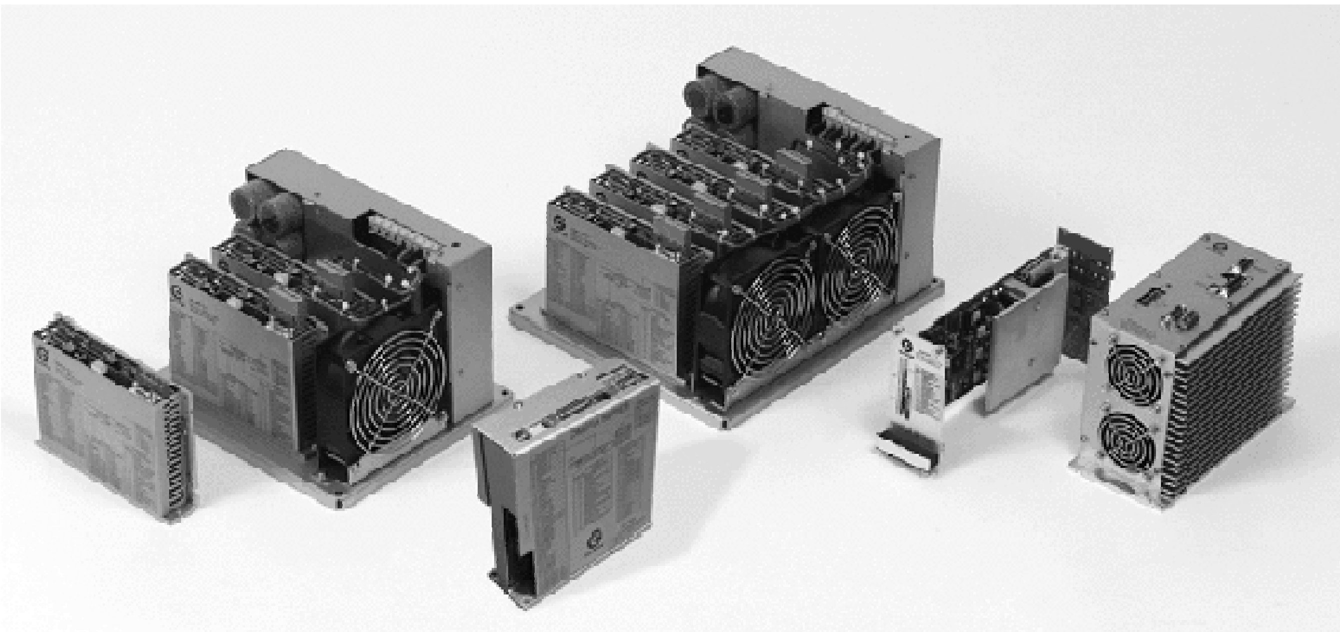
The hardware section outlines the hardware and connectors necessary to install a Omega series amplifier into an application.

Once these preliminaries are out of the way, the application engineer is brought through a step by step procedure that accomplishes system setup. In System Setup, the steps necessary to bring up and verify a fully functioning amplifier/motor combination is reviewed.

Finally, Tuning is covered where the application engineer can use MotionMaestro© to fine-tune the digital current or velocity loop to meet the specific demands of the application.

Product Description

Glentek's Omega Series Digital PWM Brushless Servo Amplifiers offer the latest in high performance DSP control of both rotary and linear brushless servo motors. With extensive utilization of surface mount technology and special heat transfer techniques, the Omega Series offers one of the world's most powerful products for a given form factor. The Omega Series is comprised of the following models:



Full Feature Servo Amplifier

The Full Feature servo amplifier operates in current (torque) mode or velocity (RPM) mode, accepts a +/-10V analog input as a command reference and commutates the motor sinusoidally for ultra smooth operation at low speeds. The amplifier utilizes an incremental encoder to derive the velocity signal and to commutate the motor. The absolute commutation angle is usually determined using Hall sensors or encoder Commutation tracks.

2-Phase Current Mode Servo Amplifier

The 2-Phase Current Mode servo amplifier accepts two +/-10V analog inputs as current command references for two of the motor phases. The third phase is derived from the two reference phases. This model amplifier does not use any feedback devices and is used with controllers that provide the commutation.

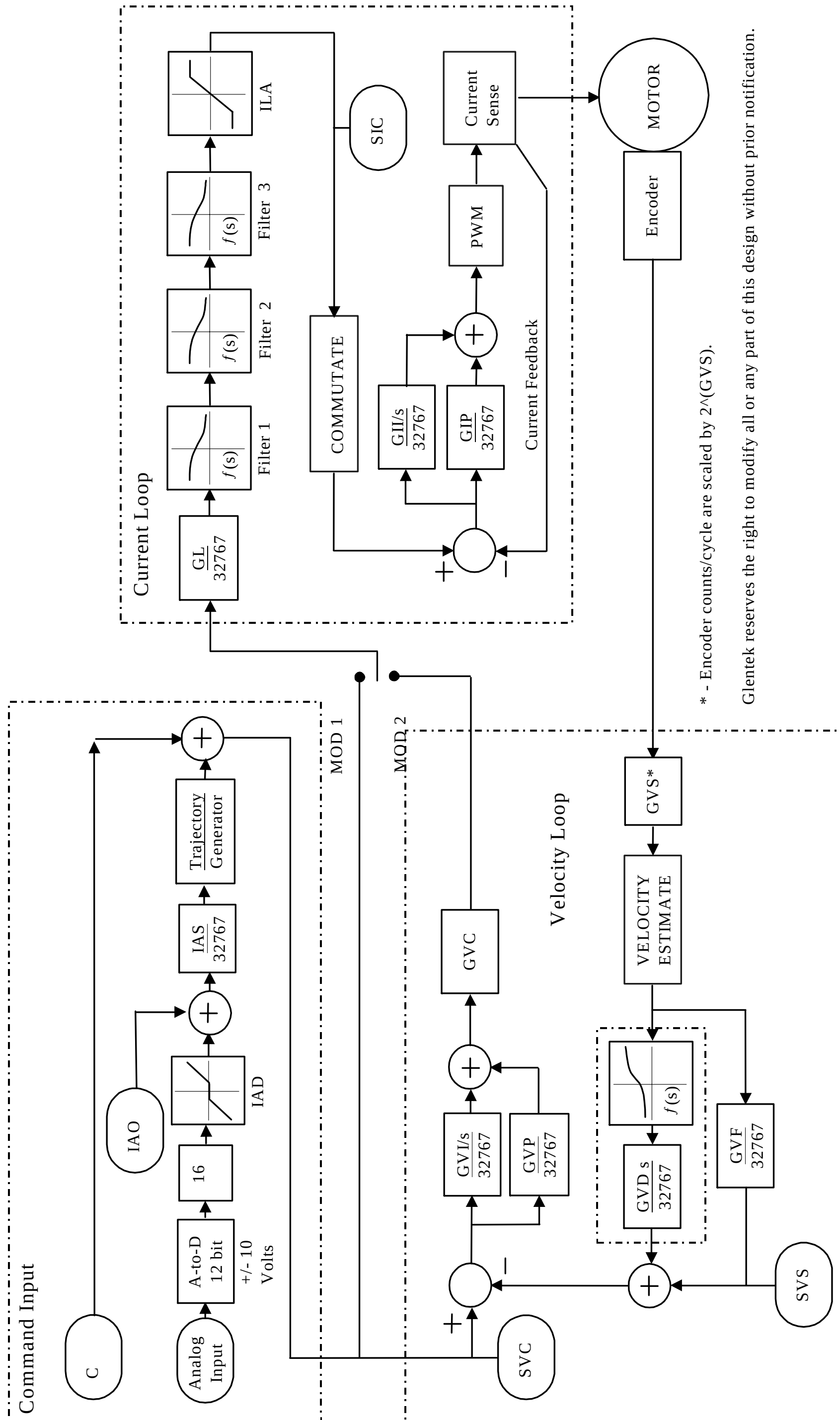
Note: This feature available upon request for high volume applications.

Features

- **Digital current loops:** Current loop bandwidths up to 3 kHz.
- **Digitally tuned:** All parameters set digitally. No potentiometers to adjust. DSP control for the ultimate in high performance.
- **Silent operation:** 25 kHz PWM standard.
- **Complete isolation:** Complete optical isolation between signal and power stage.
- **Wide operating voltage:** 70-340 VDC for Amplifier modules. All multi-axis versions can be ordered for operation from either 110-130 VAC or 208-240 VAC (single or 3-phase, 50/60 Hz).
- **Direct AC operation:** No transformer required for multi-axis chassis. The multi-axis chassis include DC power supply, cooling fans, soft-start circuitry and a regen clamp with dumping resistor.
- **Fault protection:** Short from output to output, short from output to ground, amplifier RMS over current, amplifier under/over voltage, amplifier over temperature.
- **RS-232:** High speed (115.2K baud) serial communication interface for set-up and tuning.
- **Software configurable:** Glentek's Windows™ based MotionMaestro© software pro vides ease of set-up and tuning with no previous programming experience required. This software is Windows™ 95/98/2000/ XP and NT compatible.
- **Non-volatile memory:** All parameters and positions are stored in non-volatile memory for reliable start up.
- **Dedicated inputs:** +/- position limits, inhibit and fault.
- **Dedicated outputs:** Selectable analog monitor signal, fault discrete and divided encoder output.
- **Encoder output divider:** The encoder input signal can be divided by user selectable integer 1-8 for the encoder output signal.
- **Encoder feedback:** Accepts encoder signals up to 4.3 MHz.
- **Status indicator:** 2 LED indicators: 1 Green for RUN and 1 Red for FAULT.
- **Sinusoidal commutation:** For the ultimate in efficiency and smooth motion, Commutates from almost any resolution linear or rotary encoder.
- **SMT construction:** Provides ultra compact size, cost competitive package and high reliability.
- **CE compliant:** All servo amplifiers are CE marked.
- **Parametric filtering:** Provides control engineers advanced filtering to eliminate unwanted system mechanical resonance.

Digital Amplifier Control Loop Diagram

Digital Amp Control Loop Diagram



* - Encoder counts/cycle are scaled by 2^(GVS).

Glentek reserves the right to modify all or any part of this design without prior notification.

Amplifier Setup Software

MotionMaestro© is Glentek's Windows based application software that was designed to communicate with the Omega series digital amplifier. MotionMaestro© has many dialogs with values shown in engineering units to make it easy to select and setup the features of the amplifier. MotionMaestro© utilizes the standard ASCII command set and protocols. Although it is not necessary to use MotionMaestro©, installation, setup and tuning is made easier through its use.

MotionMaestro© has many features that allow application engineers to easily configure a digital amp to an application. It has a terminal mode that operates at 115k baud transmission rates, an oscilloscope that can be used to monitor amplifier signals and a tuning dialog that can be used to control the motor input. By using the oscilloscope and tuning dialog, one can monitor step response to determine filter parameters for optimal control loop performance.

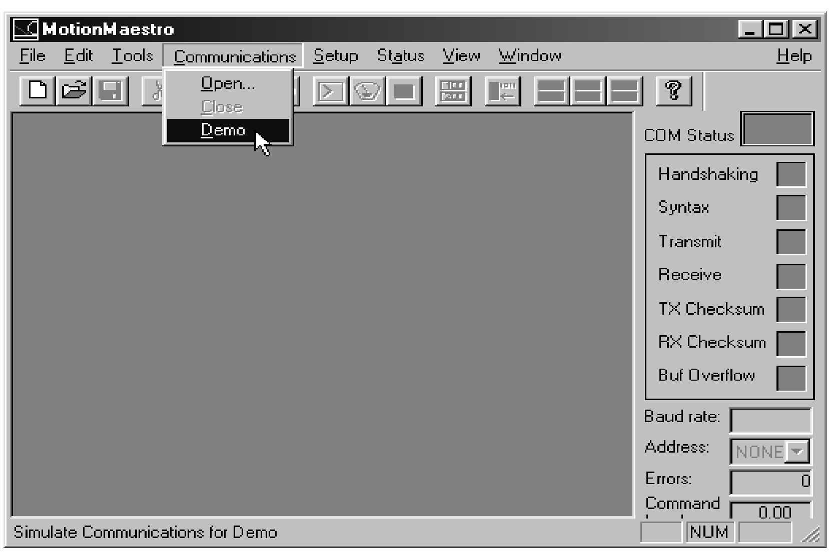
MotionMaestro© Installation

MotionMaestro© requires Windows95, Windows 98 SE, Windows ME, Windows NT 4.0, Windows 2000 or Windows XP operating system running on a PC with at least one serial port. It is suggested that you have no less than 3 megabytes of application program disk space remaining on the hard drive prior to installation. The MotionMaestro© install disk is setup to utilize Install Shield to simplify installation. There are only a few setup options offered. In general you can press NEXT or YES until installation is complete. When installation is completed, you will find a MotionMaestro© shortcut on the windows Start\Programs menu.

DO NOT RUN MOTIONMAESTRO© UNTIL YOU HAVE READ ALL OF THIS SECTION.

The MotionMaestro© installation program is named Setup.exe. It is found on disk1 of the distribution floppies or in the MotionMaestro© \disk1 directory of the distribution CD.

The installation will create a Glentek folder in the Program Files folder. A MotionMaestro©_X_X folder is created where _X_X matches the version number. You can have multiple versions of MotionMaestro© installed, if you wish, and they will be placed into their own directories.



Demo Mode - For exploring MotionMaestro without an amplifier connected

When MotionMaestro© is directed to establish communications with the amplifier, the amplifier is queried for a model ID and Firmware version. MotionMaestro© will configure itself and select the appropriate configuration files based on the amplifier returned values.

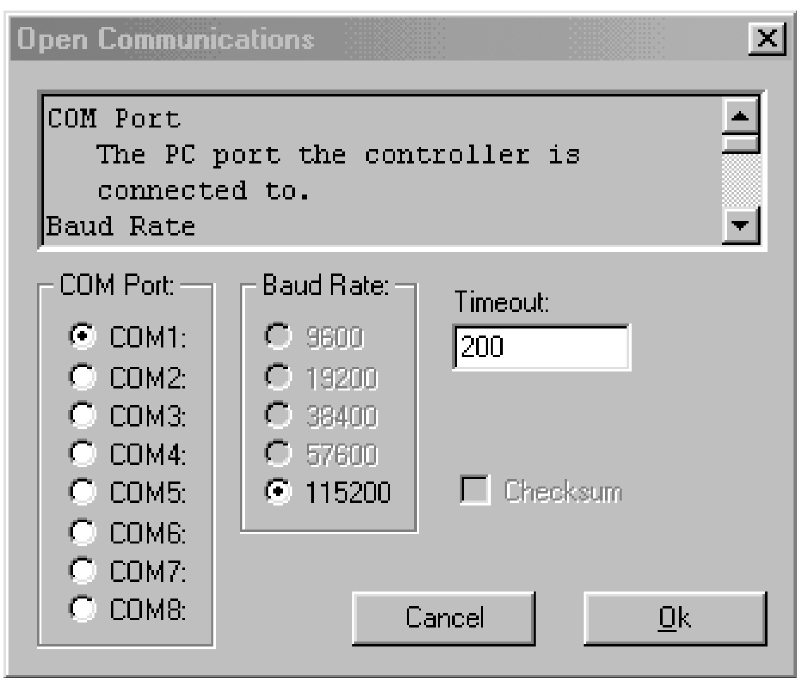
You can run MotionMaestro© without an amplifier attached and inspect the menu options and dialog. To run in demo mode pull down the Communications menu and select **Demo**. For communicating with an attached amplifier select **open** under the communications menu.

There are extensive help screens under the Help menu. Select Help Topics and you can read about the usage of MotionMaestro© and it's features.

MotionMaestro© amplifier setup features.

This section of this manual is an introduction to MotionMaestro's© features that are required for installation and setup of the Omega series amplifiers. Only those features of MotionMaestro© required for defining motor characteristics are covered. This is not meant to be a step by step tutorial. The "System setup" section is intended as a tutorial for motor setup. You may need to refer to this section when setting up a motor. The following features are reviewed here.

1. Opening of communications.
2. Model Information.
3. Digital I/O setup.
4. Mode setup.
5. Commutation setup.
6. Encoder setup.
7. Trajectory Generator
8. Filters
9. Oscilloscope
10. Terminal Window
11. Motor Parameters.
12. Motor Safety.
13. Amplifier Status.
14. Control Panel.
15. Motor Tuning.
16. Saving parameters.
17. Backing up a copy of amplifier parameters.



Open Communications dialog box

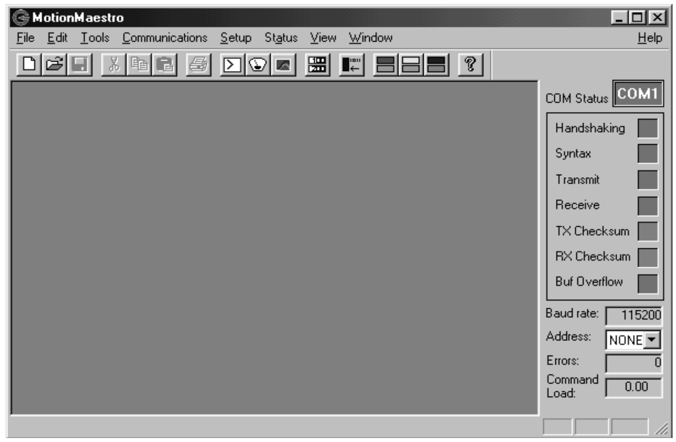
Opening of communications

Before MotionMaestro© can be used, communications must be established between the amplifier and the PC that MotionMaestro© is running on. Before opening communications in MotionMaestro©, you must have a serial communications cable (RS-232) wired as described in the hardware section of this manual. You may also need to set the serial port on your computer as described in the system setup section.

Open communications by selecting the "Open" option on MotionMaestro's© main menu tool bar.

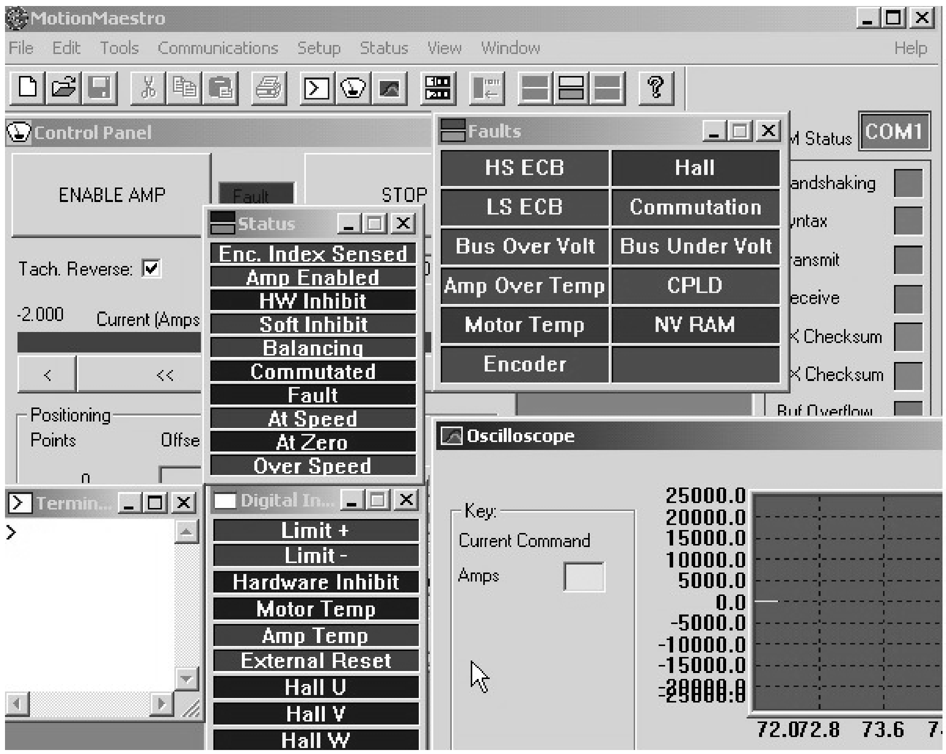
Select the COM port that you connected the serial port cable to and ensure that a baud rate of 115200 is selected. When you press OK MotionMaestro© will query the amplifier to determine what amplifier model is connected. If communications is established, you should see a screen similar to the following with all green communications status indicators.

When communications cannot be opened, a dialog is presented indicating so. If you cannot open communications please check your cable, PC COM port settings and power to the amplifier.

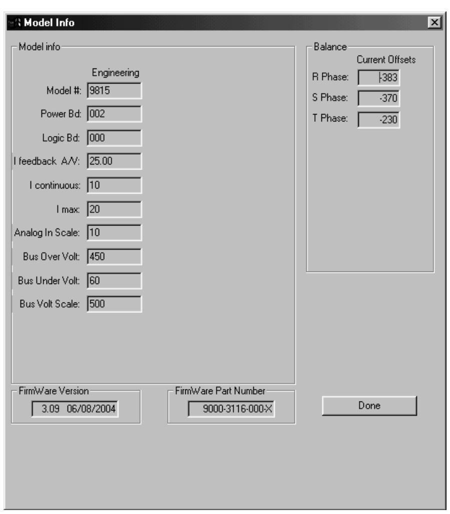


MotionMaestro’s main window

To the right, MotionMaestro’s main window is shown where communications are successfully opened and various setup and monitoring screens are activated. These active screens do not necessarily need to remain within MotionMaestro’s main window, they may reside anywhere on the Windows desktop.



MotionMaestro’s Sever activated windows.



Model Info Box.

Model Information

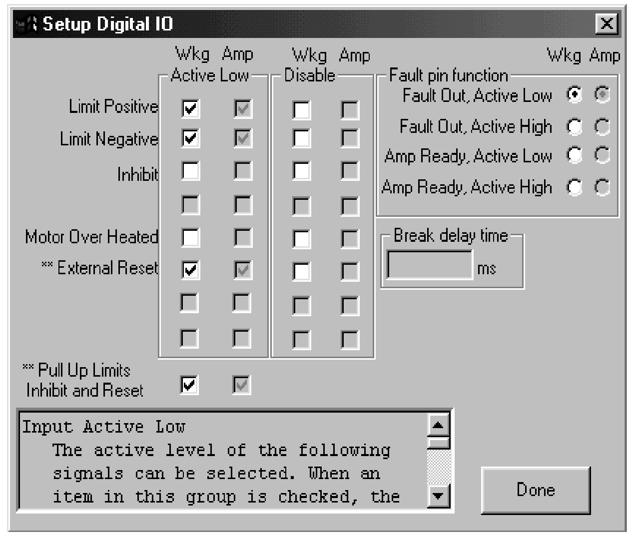
For informational purposes, you can refer to the Model Info dialog to view the design features and limits of the particular amplifier. To view this dialog, you must select the “Tools” option on MotionMaestro’s© main menu tool bar, then select “Model Info”.

Here you will be able to view your firmware version and date, amp model number, power board number and logic board number. In addition, MotionMaestro’s Model Info dialog window will display amplifier settings. For example, on the left these settings are current balance offsets, current feedback, continuous current and peak current settings. These settings, in addition to the Bus under-voltage and over-voltage settings, are useful informational tools and are required if the user performs his own scaling of amplifier values.

Digital I/O setup

The Digital I/O settings can be used to tailor the amplifier digital signal inputs to the requirements of your application. Failure to properly setup the Digital I/O signals may result in the amplifier powering up in a fault condition. (Or worse yet a reset condition). To view this dialog, select the “Setup” option on MotionMaestro’s© main menu tool bar, then select “Digital IO...”. Digital I/O signals can be active high or active low depending on the applications. The fault condition is a good example. From this window you can modify what state the amplifier considers to be a fault condition, either high or low.

On this window there are two sets of checkboxes, for each signal, Wkg and Amp. Amp displays the current amp setting while Wkg displays the users choice. The amp is automatically updated as the Wkg box changes.



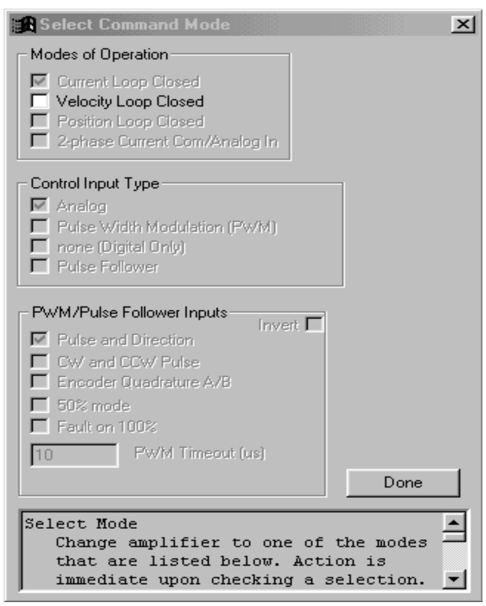
Dialog box for setting amplifier mode.

Amplifier mode setup

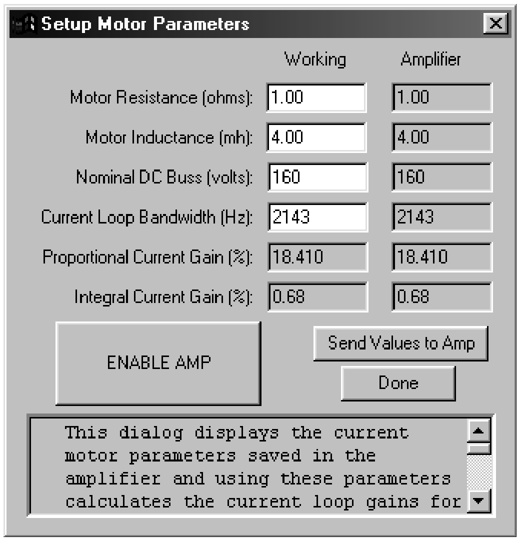
The full featured amplifier can operate in either current or velocity mode. By selecting the “Setup Mode...” item on the “Setup” option menu, you can configure the amplifier to operate in the desired mode.

MotionMaestro© uses the Mode setting to determine text and options on many of the dialog display windows. For example, when the Omega series amplifiers are in current mode, parameters on the **Tuning** dialog pertaining to the velocity loop are not available.

Engineering unit scaling used internally by MotionMaestro© is also adjusted to reflect proper units based on the mode.



Dialog box for setting amplifier mode.



Dialog box for entering motor parameters.

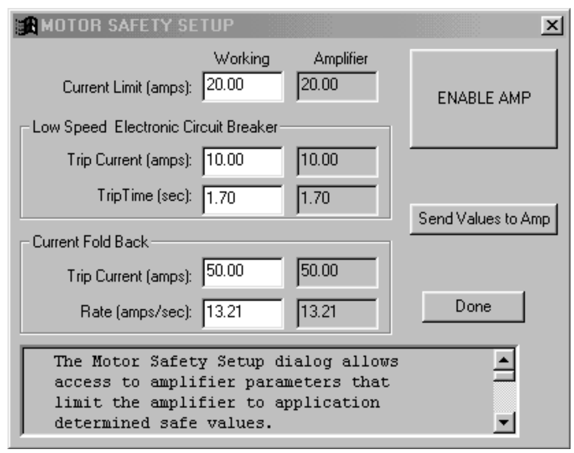
Motor Parameters

Select “Motor Parameters” on the “Setup” menu to activate the Motor Parameters dialog. The Motor Parameters dialog is used to set digital current loop gains. MotionMaestro© will calculate current loop gains based on the values entered. Select “Motor Parameters” on the “Setup” menu to activate this dialog.

Motor Resistance and Inductance are entered as phase to phase values. If these values are not indicated on the motor label, you can determine these values by measuring the resistance or inductance between two motor wires connecting two phases of the motor. Nominal DC bus voltage is the regulated bus voltage, 160 or 320 volts typically. Current loop bandwidth is a measure of the current loops responsiveness. Generally you want this to be as high as possible. A good starting point is 1500 Hz. In order to update the motor parameters in the amplifier, the amp must be disabled. You can do this by clicking on the “Disable/Enable Amp” button first then the “Send Values To Amp” button. Pressing F1 displays the dialogs help text. After the values are sent to the amp you may test the values by enabling the amp.

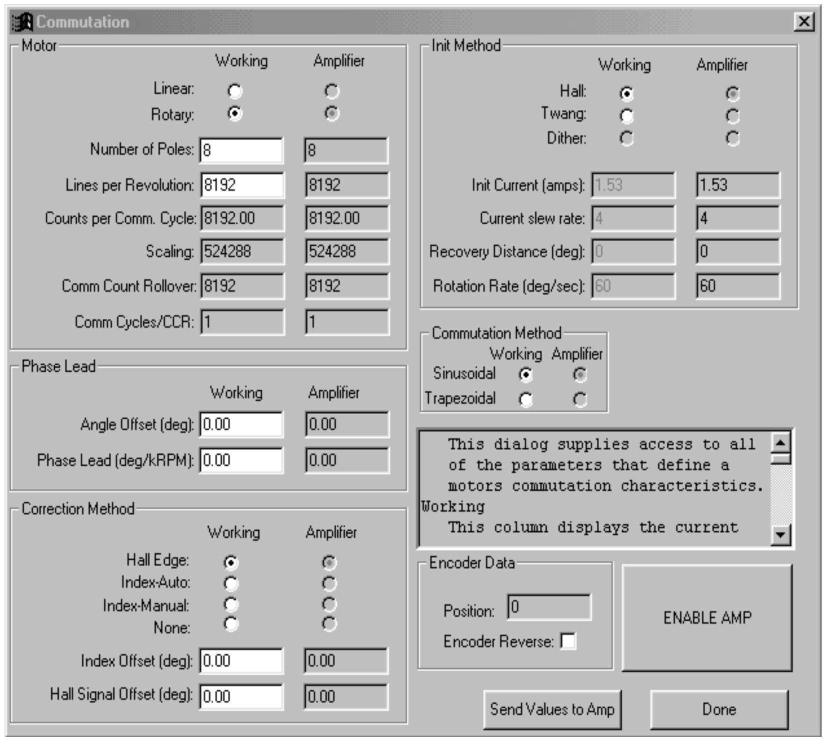
Motor Safety

Motor safety is where limits to protect the motor are entered. The “Motor Safety Setup” dialog is available from the “Setup” menu. There are two sets of boxes, one labeled Working, the other Amplifier. Amplifier displays the current amp setting while Working displays the users selection. Here you can setup a maximum current limit, current foldback and low speed Motor safety is where limits to protect the motor are entered. In order to update the motor parameters in the amplifier, the amp must be disabled. You can do this by clicking on the “Disable/Enable Amp” button first then the “Send Values To Amp” button. Pressing F1 displays the dialogs help text. After the values are sent to the amp, you may test the values by enabling the amplifier.



Dialog box for setting up motor safety parameters.

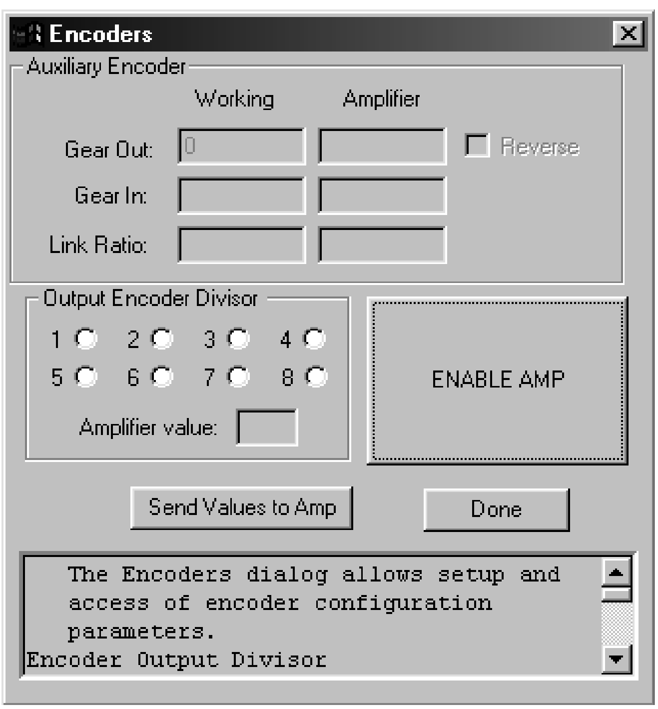
Commutation Setup



Dialog box for setting up motor commutation.

The Commutation dialog window allows you to define a motor's commutation characteristics. Here you specify motor commutation parameters, correction and initialization methods, and encoder positioning. In the motor section, most of the boxes are calculations based on your selected motor parameters. Select "Commutation…" on the "Setup" menu to activate the dialog on the right.

For initial setup most of the commutation screen can be ignored. For example, if Hall sensors are utilized they need to be selected under "Init Method". Then, "Hall Edge" needs to be chosen as correction type. Finally, "Number of Poles" and "Lines per Resolution" need to be entered (Rotary Motors). Selecting linear instead of rotary will display parameters that are specific to a linear motor. Edit boxes that are not available are values that are calculated based on other parameters entered. Encoder Scaling and Remainder are automatically calculated based on the motor and encoder values entered. The working column represents modified values that are sent to the amplifier when clicking the "Send Values to Amp" button. In order to update the commutation values, the amp must be disabled. You can do this by clicking on the "Disable/Enable Amp" button. All edit box parameters are described in the help dialog at the bottom of the dialog. You can activate this dialog by clicking on it and then you may scroll up and down through the help dialog with the up or down arrows. Press F1 to view the dialog help text in notepad. After the values are sent to the amplifier you may test the values by enabling the amplifier.



Encoder Setup Dialog

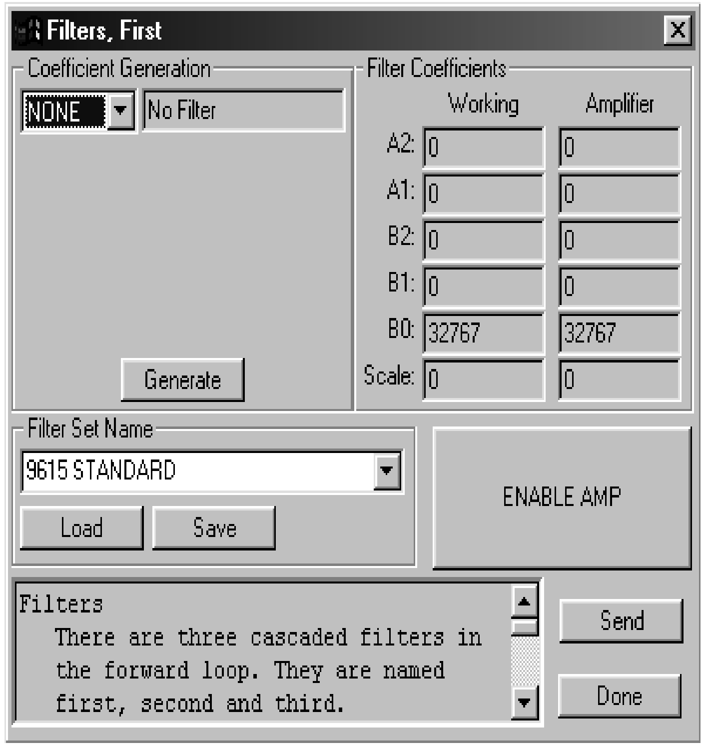
Encoder

To view the Encoder dialog window, you select the "Setup" option on MotionMaestro's© main menu tool bar, then select "Encoders...". The Encoders dialog allows setup and access to the encoder configuration parameters. Encoder Output Divider selects the frequency ratio between the encoder output connector and the encoder input. In addition, you may choose the gear and link ratio of an auxiliary encoder.

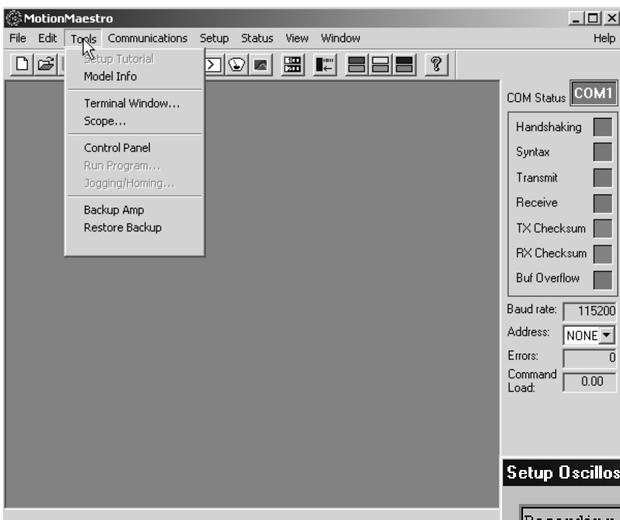
Filters

To view the filter dialog window, select the "Setup" option on MotionMaestro's© main menu tool bar, then select "Filters...". At this point, select which of the four filters you would like to view/program. Three of the filters are cascaded filters in the forward loop and one is a filter in the encoder feedback loop. All four filters can be edited and displayed at the same time, but need to be opened one a time.

From these windows, MotionMaestro© allows you to enter values for defined filter equations. These equations were derived using the Tustin transform to convert variables in the frequency domain to coefficients for the digital domain equations. The first step in generating new coefficients is to select the type of filter desired., such as LL1, LP1,CLP1, etc. Once the type of filter is selected, the appropriate input edit boxes will be displayed.



Filters Setup Dialog



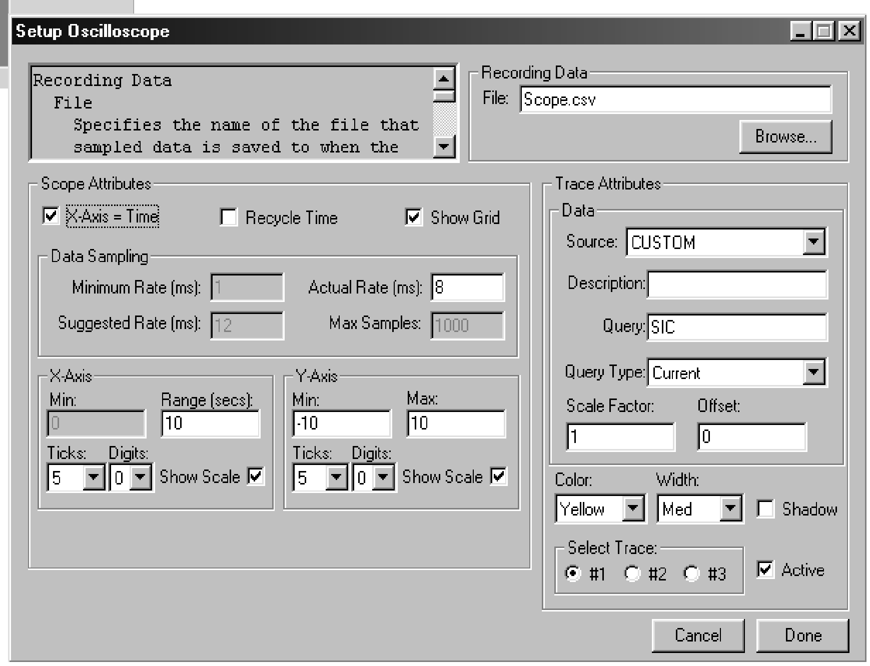
Oscilloscope Setup

The Oscilloscope can either be accessed under the "Tools" option on MotionMaestro's© main menu or via a button on the toolbar.

There is a "setup" window and a "trace display" window for the Oscilloscope. The Oscilloscope setup window provides for setup of the parameters needed to define the signals to be displayed on the Trace Window.

"Scope Attributes" define the X-Y attributes of the Trace display. An example is X-Axis = Time, this sets the units of the X axis to time. The range can be set for both the X and Y Axis, along with the data rate parameters.

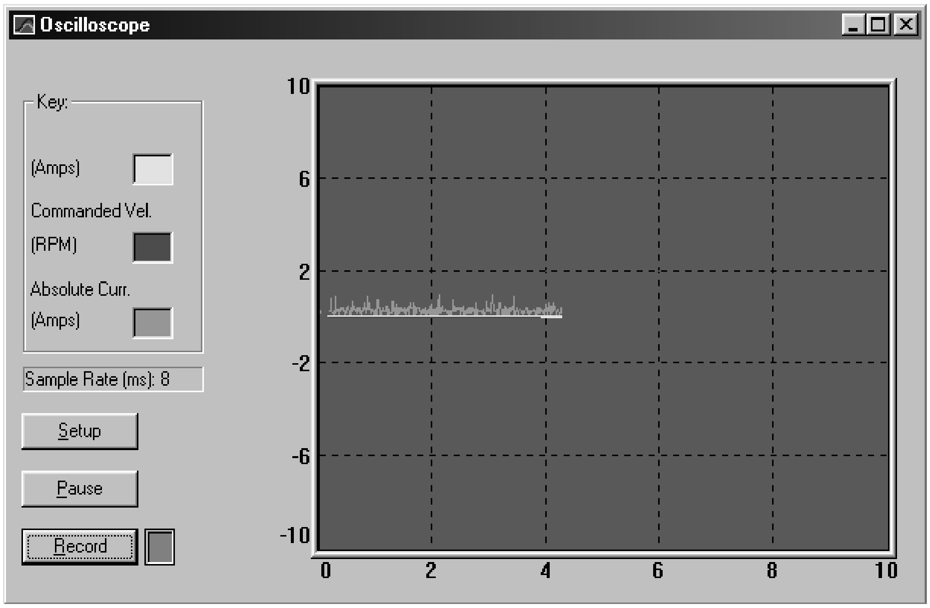
"Trace Attributes" alters the data source and turns on/off different traces. You can monitor up to three traces at one time. All traces are color coded on the Oscilloscope Trace screen.



Setup Screen

The Recording Data section is useful for recording test data to a file. The “File” specifies the name of the file that sampled data will be saved to when the record button is activated on the “Trace display” window. By default these files are saved as .csv file type. When .csv is the file type, the files can be viewed with Microsoft EXCEL.

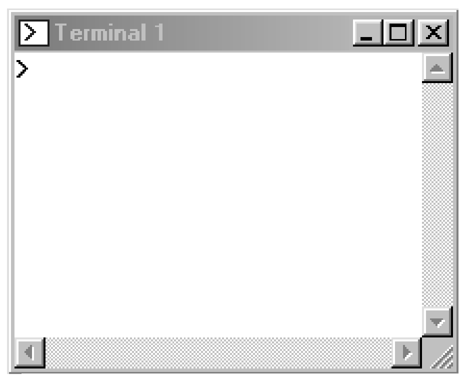
The Oscilloscope Trace display screen can display up to three active traces on the display. Each trace is color coded and labeled in the key. The sample rate is also displayed for convenience. The screen can be resized for versatility. Depressing the record button will allow you to record a portion of the trace waves. When record is activated a red light will be displayed near the button.



Oscilloscope Display Screen

Terminal Window

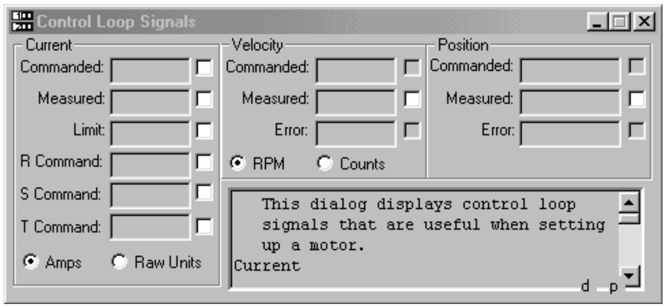
The Terminal Window can either be accessed under the “Tools” option on MotionMaestro’s© main menu or via a button on the toolbar. The Terminal has direct communication to the amplifier. You can command the amplifier by typing commands to the terminal window. For example, typing BV then the enter key will send the request to read the Bus Voltage in the amplifier. If you wanted to change the Bus Voltage you would type BV200 then press enter. This would change the Bus Voltage to 200. Query command use just the ASCII letters of the command, where set commands use both Letters and a numerical value for an argument. Caution must be used when this window is activated due to the possibility of entering commands which would have undesirable effects.



Terminal Window

Amplifier Status

MotionMaestro© has a variety of status displays that assists the application engineer in setting up amplifier or diagnosing a amplifier setup. Rather than showing all possible status on one dialog, MotionMaestro© has been designed so that only those applicable to the situation at hand can be displayed. These dialogs continuously send queries to the amplifier to determine the amplifiers current status. The size and location of each status display is saved when exiting the display. When returning to the status the last size and position is used in positioning the window. F1 can be pressed to obtain help on the various items or status in the current dialog.



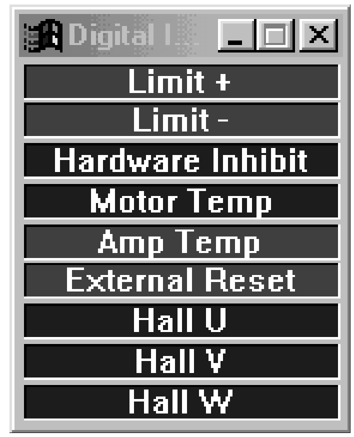
Dialog for observing control loop status

Control Loop Signals

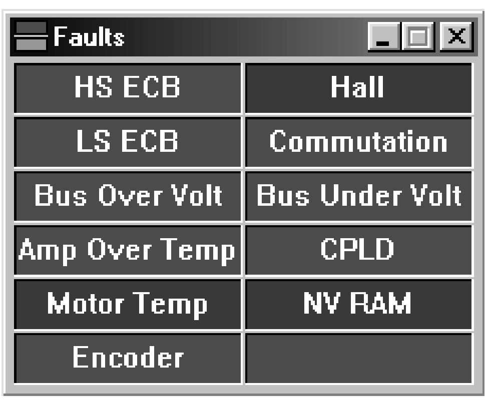
This dialog is useful for determining if an amplifier control loop is responding properly. Commanded and measured current can be displayed as well as the motors current velocity and position. Display this dialog by selecting “Status\Control Loop Signals...” or by utilizing MotionMaestro’s toolbar.

Digital Inputs

This dialog indicates the state of digital inputs coming into the amplifier. Digital inputs are those inputs that can be characterized as being active or inactive. They are typically associated with one of the controller input and output signal pins. See the associated pin in the hardware section for a description of the digital input of interest. Display this dialog by selecting “Status\Inputs\Digital…” or by utilizing MotionMaestro’s toolbar .



Status Display Digital inputs.



Amplifier fault status display.

Faults

Faults occur on conditions that make it impossible to operate the amplifier in a safe and stable condition. When a fault condition occurs, the amplifier is disabled. The amplifier must be reset by either recycling the power or with software (Control Panel dialog). Conditions that cause faults are over currents, high or low bus voltages, excessive operating temperatures, and faulty sensors or amplifier hardware. An external fault can be generated by the controller through the /FAULT pin. See the hardware section for additional information on /FAULT. Display this dialog by selecting “Status\Faults ” or by utilizing MotionMaestro’s toolbar.

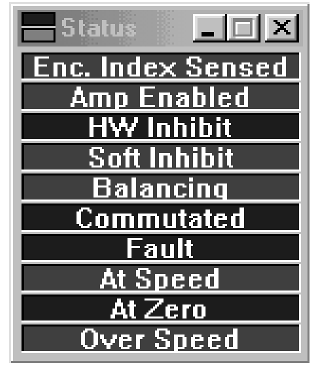
Warnings

A warning status indicates that the amplifier is fully operational, but that it is operating in an unusual mode or in a condition that warrants attention. Current fold back is such a condition. Display this dialog by selecting “Status\Warnings…” or by utilizing MotionMaestro’s toolbar.

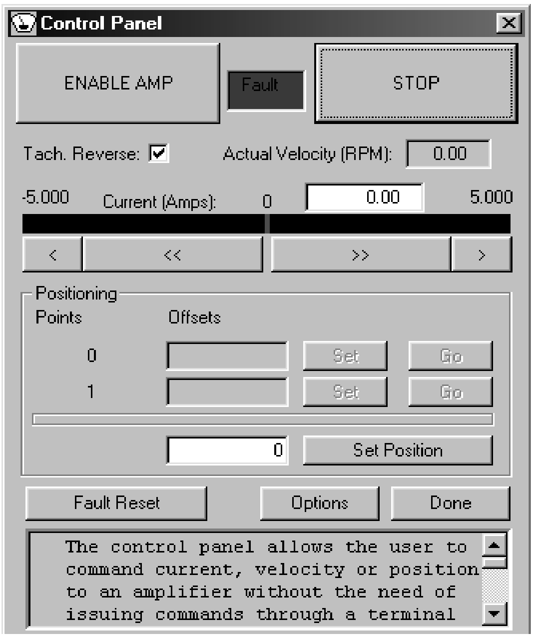
The Warning dialog

Status

All other amplifier conditions that are not a fault or warning are displayed on the Status dialog. This status display is useful for diagnostics, setup or monitoring during operation. Display this dialog by selecting "Status \System Status…" or by utilizing MotionMaestro's toolbar.



The System status display.



The Control Panel display

Control Panel

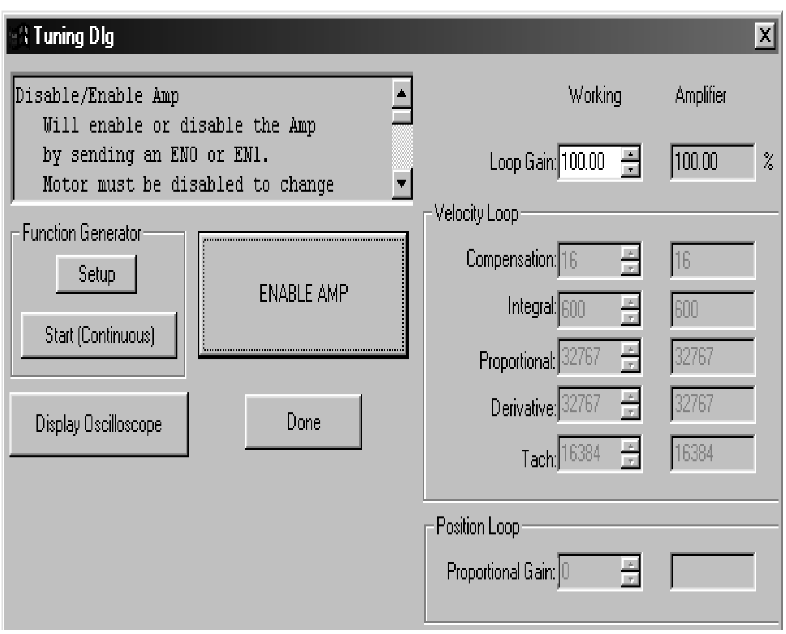
A properly connected motor can be controlled using the control panel. The control panel displays the amplifiers commanded current or velocity along with the motors actual velocity. From the control panel, you can easily command the motor. The control panel can be accessed through the "Tools" pull down menu or from the control panel icon on the tool bar.

You may set positioning offsets or an exact position by depressing the "Set Position" button. The Option button will allow you to set the maximum and minimum current, velocity, and position.

Motor Tuning

Fine tuning of motor control loop parameters is accomplished with the "Tuning" dialog. This dialog is accessed through the "Servo Tuning" item on the "Setup" menu and is shown below.

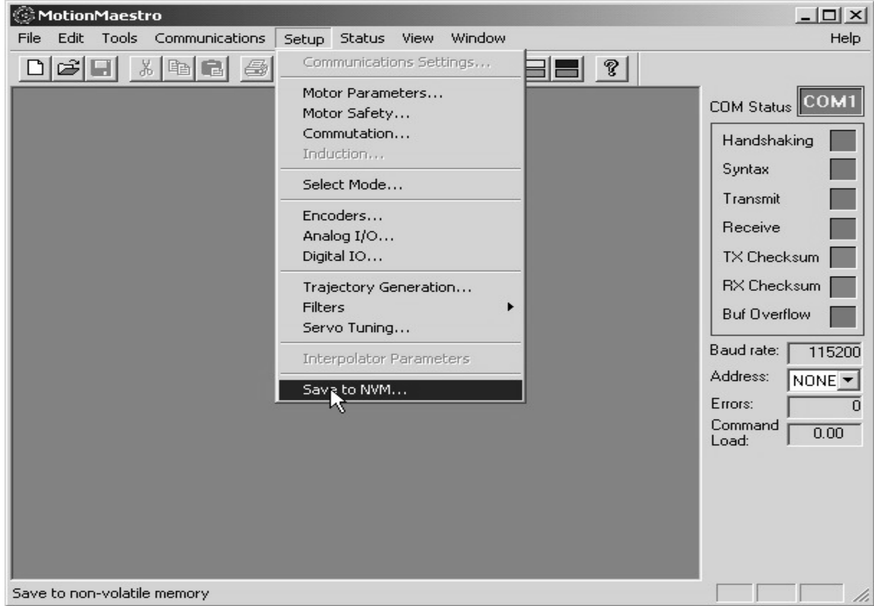
This dialog has many tools and features for tuning a motor. Real time motor velocity is always available. One can activate the motor with the "Continuous Step Response" button of the Function Generator. Then by viewing the response pattern on the scope you can see if changes to the tuning parameters improve or diminish performance. If in Velocity mode, velocity loop parameters can be altered. The Oscilloscope can query the amplifier down to a period of 4 milliseconds, which is adequate for most tuning requirements. The Tuning section describes in detail how a motor is tuned.



Dialog box for tuning the motor.

Saving parameters to non-volatile memory

After a motor is configured and tuned to the applications satisfaction, the parameters must be saved to the amplifier's non-volatile memory. Upon power up or reset, the last saved parameters are loaded in the amplifier. The parameters can be saved to non-volatile memory by selecting the "Save to NVM…" option on the setup menu, as illustrated below.

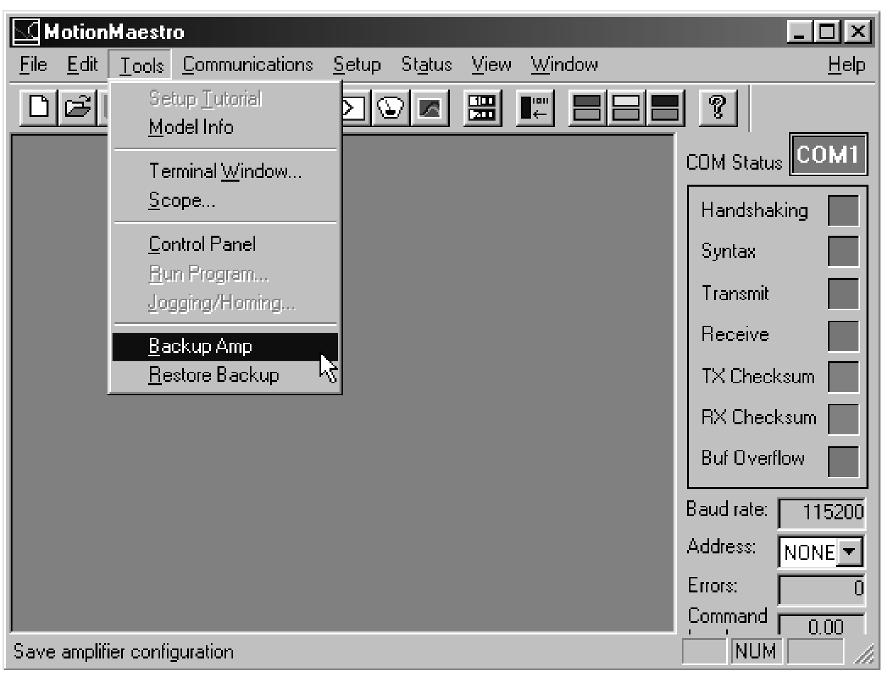


Saving parameters to amplifier non-volatile memory

Creating a back up copy of amplifier parameters on disk

An amplifier's current parameter settings can be saved to a file on a disk that can later be used to configure another amplifier or to restore an amplifier's parameter settings. This is useful in production environments or where an application has several similar motors.

Select "Backup Amp" on the "Tools" menu to backup these parameters. You will be presented with a Windows style "Save File" dialog. Here you can give the file a meaningful name and location to save the file to. Restore backed up files to an amplifier with the "Restore Backup" selection.



Backing up amplifier parameters to a file on a disk.

Hardware

This section describes the amplifier connections and how they are used in the typical application. Refer to the amplifier's installation drawing in Appendix K. This drawing indicates the location of the pins described below along with the location of the connector they can be found on.

LED INDICATORS

Two LED indicators are provided to determine the general operating condition of the amp.

Note: MotionMaestro can be utilized to obtain more detailed operating and /or fault conditions.

LED INDICATORS		
RED	GREEN	CONDITION
OFF	OFF	NO POWER
OFF	ON	ENABLED
ON	OFF	FAULT
ON	ON	INHIBIT

Controller Input and Output Signals

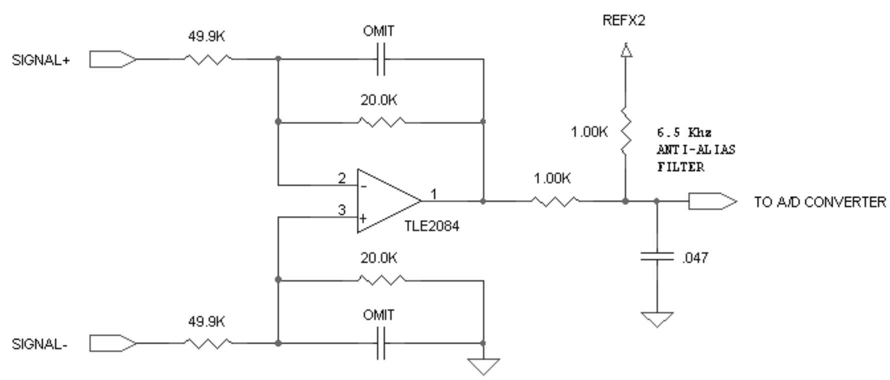
Signals that typically are connected to an external controller are described in this section. These signals include: the primary command signal interface to the amplifier, an encoder output signal, limits, inhibits, analog output and common.

The following is a list and description of the possible controller I/O signals that can be found on an installation drawing.

Signal	Description
SIGNAL 1	Command signal analog input 1, differential signal input.
SIGNAL 2	Command signal analog input 2, differential signal input.
ANALOG OUT	User configurable analog output.
+ LIMIT	Inhibits the motor in the plus direction.
- LIMIT	Inhibits the motor in the minus direction.
INHIBIT	Inhibits the motor in both directions.
/FAULT	Active low fault, Output.
ENCODER A	Encoder A channel Output
ENCODER B	Encoder B channel Output
ENCODER Z	Encoder Z index Output (reference)
COMMON	Common for all signals and shields

Command signal, Analog input

Pins SIGNAL 1(+) and SIGNAL 1(-) are the command input pins. The command input takes a differential analog signal as referenced to the amplifiers' ground. Input voltage is expected to range from -10 volts to +10 volts. The analog signal is converted using a 12 bit ADC. The analog input stage is a difference amplifier with a differential input impedance of 10 Kohm. If a single-ended input is desired, then Signal(-) should be connected to Signal common, and the command input should be connected to Signal(+). This will maintain the proper input gain for a +/-10V input range. In this configuration, the single-ended input impedance is 5 Kohm. If the signal polarity is incorrect, the signal gain may be inverted in the software setup using MotionMaestro© (e.g. –50% instead of +50%.)



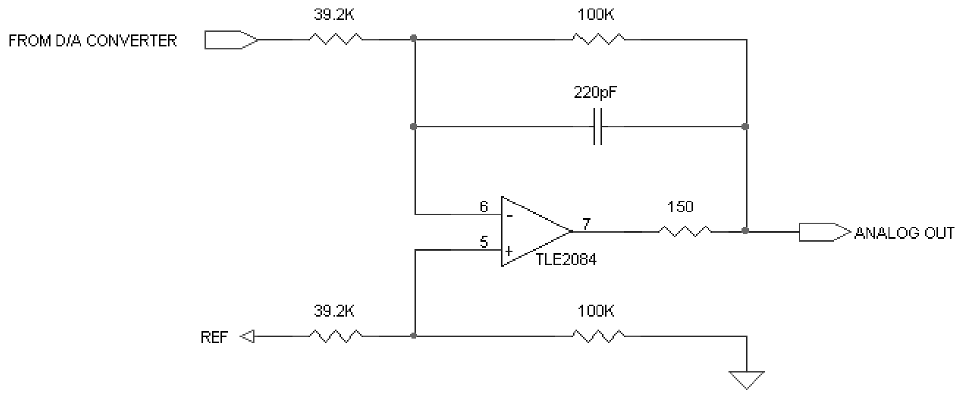
Command signal analog input design.

Analog output

ANALOG OUT is an user selectable analog output. The output ranges from -10 volts to +10 volts and has an 8 bit (256 step) resolution. The following signals can be selected through MotionMaestro© as signals that can be monitored on ANALOG OUT.

Test Voltage	- A user defined constant test voltage.
Command	- ANALOG INPUT scaled, offset and dead band adjusted.
Absolute Current	- The absolute current that is being delivered by the amplifier.
Encoder Velocity	- A raw velocity, proportional to encoder counts per servo interrupt.
Velocity	- Velocity scaled as Command, Encoder Velocity * Tach gain.
Commanded Current	- Current command to the amplifier.
R Phase	- Current command to the R phase of the motor.
S Phase	- Current command to the S phase of the motor.

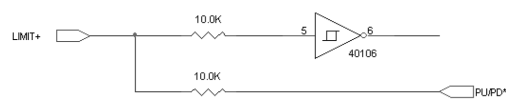
The analog output can be used to monitor amplifier signals at the servo update frequency. By doing so, the application engineer can determine the amplifiers true response to commanded signals. The analog output is for reference use only. It is not intended for control purposes. At power on, its value is undetermined until the power on reset has completed. During some amplifier functions, this output is temporarily disabled. These functions include saving and recalling parameters from non-volatile memory. The output is filtered to minimize the switching noise from the PWM amplifier. The analog output is updated once per PWM cycle.



Analog Output design

Discrete Inputs

Limit+, Limit– and Hardware inhibit are all single ended discrete inputs using the following circuit.



Discrete Input Design

Limits

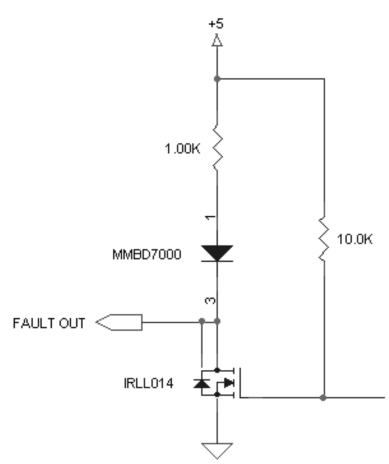
The signals LIMIT+ AND LIMIT- can be active low or active high based on a user selected setting, (See Digital I/O Setup). If + LIMIT is activated then positive current through the motor is brought to zero. If - LIMIT is activated then negative current through the motor is brought to zero. These pins are normally high at 5 volts. Although when the current is brought to zero the motor is free to rotate by externally applied forces.

Amplifier Hardware Inhibit

An external discrete input is available for amplifier INHIBIT. When activated the amplifier is disabled and both the RED and GREEN LED's will be on. The motor is free to rotate via externally applied forces. This pin can be configured as active high or low, (See Digital I/O Setup).

Amplifier fault Output

An external discrete fault output is available. This is normally a high signal. A fault condition triggers the output transistor presenting a low signal. If a fault condition is sensed within the amplifier, a low signal will be presented. The following circuit is used.



Fault Output Design

Encoder output

The encoder out signals are differential output signals. The Encoder output pins are a buffered, divided down representation of the motor's encoder. The motor's encoder can be divided by 1-8. Encoder channels A, B and Z are available as pins ENC A+ OUT, ENC A– OUT, ENC B+ OUT, ENC B– OUT, ENC Z+ OUT and ENC Z– OUT.

Note: There is an approximately 192nS delay from when the amplifier receives the encoder signals to when they are out putted. There is no change in the signals.

External encoder power

The external encoder power (+5V) must be applied through J7 to provide power needed for logic circuitry and the encoder.

Note: +5VDC power should be a minimum of 500mA per amplifier.

Power Input and Output Signals

The signal names for power are listed below:

Pin Name	Description
BUS INPUT-	Input - Negative side of DC bus voltage.
BUS INPUT+	Input - Positive side of DC bus voltage.
PHASE T	Output - Motor phase T.
PHASE S	Output - Motor phase S.
PHASE R	Output - Motor phase R.

Bus power

DC bus power is received at pins BUS INPUT- and BUS INPUT+. DC bus power is used for the current section of the amplifier. It accepts 70VDC up to 340VDC on the BUS INPUT-/BUS INPUT+ terminals.

Motor power

Motor power is delivered at pins MOTOR OUT (PHASE) T, S and R. The motor power is Pulse Width Modulated signals used to drive the motor.

NOTE: It is best not to connect the motor power pins until it is established that the logic section is working and operational. This means that with the DC bus pins connected, one should be able to communicate with the amplifier via a serial cable and the motor encoder and Hall sensors should be functioning properly. This can all be determined without connecting the motor power.

PC Interface

The PC interface can be found at the HOST connector. An RS-232 interface is on the external of the amplifier. This port is the primary means of communication with the amplifier for setup and control. The port utilizes a 4 pin Molex type connector.

Molex female Pin - Description	Glentek Amplifier Molex male
1 - Ground	GND
2 - Received Data	RX
3 - Transmitted Data	TX
4 - N/C	N/C

Encoder Feedback

The following pin description defines the main encoder input port.

Signal	Description
+5V ENC	5V Encoder power (output)
ENCODER A	Encoder A channel input
ENCODER B	Encoder B channel input
ENCODER Z	Encoder Z channel input
HALL U	Hall sensor U input
HALL V	Hall sensor V input
HALL W	Hall sensor W input
COMMON	Common for encoder power and shield

Encoder channels A, B and Z

The encoder input uses a 3-stage filter in determining if encoder inputs have changed. An encoder edge is considered valid if it holds a single state for three full encoder clock cycles. An encoder clock cycle is 1/26MHz. If an encoder clock is running at a perfect 50% duty cycle, then the shortest possible edge time is 1/26Mhz. Since the signal must pass through the 3-stage filter, the **minimum edge time** for an encoder signal is 3/26MHz or 115ns. This is equivalent to a single channel signal frequency of 8.67Mhz/2 (there are two edges in an encoder signal) or 4.33Mhz. Since encoder signals are not perfectly square or perfectly at a 50 percent duty cycle, the maximum encoder frequency will be somewhat below this.

If the Z channel on the encoder is being utilized, and the Z channel signal width is equal to ½ or a full quadrature pulse, then this signal rate is not affected. If the Z pulse is a quarter of a full quadrature pulse then the minimum edge time is increased to 231ns.

The Z channel is not edge sensitive such that swapping Z+ and Z- does not change the behavior of the amplifier.

Hall channels U, V and W

Compatible with differential or single-ended commutation tracks or Hall sensors. Single-ended connections should be made to the "+" input while leaving the "-" input unconnected.

Amplifier/Motor Integration

This section outlines how to connect an amplifier to a motor and how to ensure that the amplifier is correctly connected to the motor. This section is written with the concept of using MotionMasetroó as the user interface. Having completed the amplifier/motor integration the motor is ready to be tuned for the application.

External wiring of the amplifier.

Serial Port

Purchase or manufacture a serial cable as described under the description for PC Interface (page 23). Connect the female DB-9 connector to the PC that has your terminal software installed. Place the other end of the cable into the HOST port of the amplifier. The default serial settings for this amp are:

Baud rate:	115200
Data bits:	8
Stop bits:	1
Parity:	None

There is no settable software protocol. Set your PC to raw ASCII.

Encoder

Manufacture an encoder cable that will be connected to the encoder feedback port. Use the pin out description under Encoder Feedback above (page 24) and the installation drawing as a guide.

For the encoder, wire differential channels A, B and Z to the matching amplifier pins. Wire the encoder +5 volt to pin +5V ENC. Wire the encoder ground to a COMMON pin.

Hall sensor wires should be wired to their matching amplifier pins HALL U+, HALL V+ and HALL W+. A rotation of the motor should activate Hall U, V and W sequentially.

IMPORTANT: Use proper shielding for the encoder logic cable. Tie amplifier common to encoder ground and cable shield. **DO NOT** tie cable shield or encoder ground to motor case.

Power

Testing of the logic section requires that only the bus power terminals B+ and B- be connected. Connect an appropriate DC bus voltage, see Ratings and Specifications, to these pins.

DO NOT CONNECT THE MOTOR POWER CABLE.

Applying Power to the Logic Section

Apply external +5V to J7 to power up the logic section. A red LED will turn on.

Execute the communications software that is on your PC. Open a terminal window and press Enter on the keyboard. If the amplifier is communicating properly with the PC, the amplifier will respond with a “>” prompt. Each pressing of Enter will result with this prompt.

Parameter Setup

Start MotionMaestro©, establish communications with the amplifier, and enter the "Setup\Select Mode" dialog. Ensure that the amplifier is configured for current mode. **Motor/amplifier checkout is done in current mode.** After checkout is completed you may change to velocity mode if desired.

Enter the "Setup\Commutation" dialog. Configure the amplifiers commutation characteristics as indicated on the dialog. For rotary motors enter the lines per revolution, not encoder counts. This should be found on the encoder nameplate (if lines per revolution and number of poles are not documented for the motor (See appendix "Determining Encoder Resolution and Number of Poles"). This number will need to be derived if linear scales are used. Disable the amp, if it is not already, and send the parameters to the amplifier. Select an appropriate commutation initialization method. (See "Selection of a commutation initialization method" in appendix "Amplifier Terms and Technology").

NOTE: When any parameter that controls commutation is changed, it is necessary to reset the amplifier after saving the new parameters. This is achieved by executing RST from a terminal window or clicking the Fault Reset button on the control panel.

NOTE: If you are using Hall sensors to maintain commutation, you may want to fine tune your commutation. Hall sensors are typically not perfectly aligned with the amp. Set the Commutation Angle Offset to an appropriate value in MotionMaestro's© "Setup\Commutation" dialog.

Enter the "Setup\Motor Parameters" dialog. Enter the motor resistance, inductance, the bus voltage and the current loop frequency appropriate to the application.

Disable the amplifier and send the parameters to the amplifier.

Enter the "Setup\Motor Safety" dialog. Set the Current limit to the rated limit of the motor or the rated limit of the amplifier, whichever is smaller. Set the fold back threshold to a value under the current limit. How much the threshold is set under the current limit depends on the dynamics of your application. Start with a value 5 percent under the current limit. If you are not using current fold back then set the fold back threshold to a value above or equal to the current limit. Set the Electronic Circuit Breaker (ECB) values. The low speed ECB protects the motor and amplifier from conditions when the current remains at the current limit for excessive periods of time. Set the LS/ECB threshold to the maximum continuous current of the motor or amplifier, whichever is less. Start with a 2 to 3 second filter time.

Disable the amplifier and send the parameters to the amplifier.

At this point you may want to save the parameters in non-volatile memory. Select "Setup\Save to NVM" from the menu bar.

You may also choose to save the current parameters in the amplifier by saving them to hard disk. Select "Tools\Backup Amp" from the menu bar.

Phasing the Motor

If you are matching a motor to the amplifier and you have not received a motor with your amplifier from Glentek, then perform Appendix D ("Matching motor phase leads to amplifier commands using Hall sensors").

Applying Power to the Motor

Connect the motor power leads phase R, S, and T (or phase A, B and C) to the amplifier. Be careful to follow the manufacturers phasing sequence when connecting these leads. Ensure that the motor ground is properly grounded to the amplifier's chassis ground.

NOTE: Turning power on may move the motor, do not have the motor shaft connected to the machine at this time.

Turn the DC bus power on.

Enable the amplifier if it is not already enabled.

NOTE: Green LED should turn on.

Open the control panel.

Slowly increase the commanded current in the positive (+) direction until the motor moves. Note the velocity. It should also be positive. If it is not, then check, or uncheck, the Tach Reverse checkbox.

NOTE: If the motor locks up, re-check the phasing of the motor.

Zero the commanded current.

Disable the amplifier and send the parameters to the amplifier.

Save parameters to NVM.

You are now ready for tuning. Before advancing further save these parameters to non-volatile memory.

Velocity Tuning

Tuning is a process where coefficients in the amplifier's internal equations are matched to the application (motor). Glentek amplifiers can be tuned for two modes of operation: **Current mode** and **Velocity mode**. For Glentek's digital amplifiers, MotionMaestro© can be used to assist in tuning the motor amplifier for the best response in your application.

Current mode tuning must be completed before **Velocity** mode tuning. Current mode tuning is accomplished by entering the motor parameters on the **Motor Parameters** set-up dialog. It is very important the values match the values of the application (motor). This includes the bus voltage applied to the amplifier. The proper **Current** mode parameters are internally calculated based on motor parameters and selected bandwidth. To complete current tuning, the amplifier needs to be checked so as a positive current causes a positive **tach** or encoder reading. This verification is done in **Current mode** from the **Control Panel** dialog. For mode selection see Amplifier Mode Setup in the Amplifier Setup software section.

Example of accomplishing the Current tuning verification is as follows:

1. Turn the power on without connecting the motor power leads to the amplifier, and configure the amplifier in current mode by choosing "Current Loop Closed" option under "Modes of Operation". Actually this is done by deselecting all other modes. The current mode is default and can not be deselected.
   MotionMaestro©: Setup > Select Mode…
2. Save to NVM.
   MotionMaestro©: Setup > Save to NVM…
3. Turn the power off, and connect the motor leads to the amplifier.
   Note: Make sure to connect the motor leads so the motor is phase to the amplifier properly. Refer to Appendix D and F for motor phasing.
4. Turn the power back on, and open the "Control Panel" window.
   MotionMaestro©: Tools > Control Panel, or Control Panel icon on the tool bar.
5. Press ">>" (positive command) button until "Actual Velocity (RPM)" box displays motor RPM other than 0.
   Note: 1. The "Actual Velocity (RPM)" should show a positive number
   2. If the "Actual Velocity (RPM)" shows a negative number when positive current was commanded, check "Tach Reverse" box.
6. Try the opposite direction by pressing "<<" button until the motor rotates to the other direction.
   Note: The "Current (Amps)" box and "Actual Velocity (RPM)" boxes should indicate the negative numbers.
7. Stop the motor and close the "Control Panel".

Having completed Current tuning, put the amplifier in **Velocity Mode**.

1. Choose "Velocity Loop Closed" option under "Modes of Operation".
   MotionMaestro©: Setup > select Mode…
2. The motor should be tight.
   Note: If the motor runs away, turn the power off, or press the emergency button on your system, immediately. Then, repeat steps 1 through 7.
3. Save the configuration to non-volatile memory.
   MotionMaestro©: Setup > Save to NVM…

Start velocity tuning

1. Under the SETUP pull down on the main window menu bar select the "Servo Tuning" dialog window, and enter the following values.
   MotionMaestro: Setup > Servo Tuning…

1.1 Set “Loop Gain” at 100.
1.2 If compensation is selectable set to conservative value. Set “Compensation” at 0 or 1 or if experienced set to desired value.

2. Next, setup a excitation signal needed during velocity tuning. **MotionMaestro:** In the “Function Generator” group of the tuning dialog window Press “Setup” and do the followings.

   2.1 “Tuning Setup” dialog window will appear.
   2.2. Enter “BaseVelocity (RPM)”. 0 RPM.
   2.2. Enter “Target Velocity (RPM)”. (200 or your selection) Try to keep it under 1000 RPM.
   2.3. Enter “Step Duration (secs) (at target time), and “Inter-Step Dwell (secs) (at base time).
   2.4. Choose “Step Direction”.
   2.5. Choose “Test Mode”.
   Note: If you are not sure of values for function generator, use default settings.

   2.5. Select “OK” to close window.

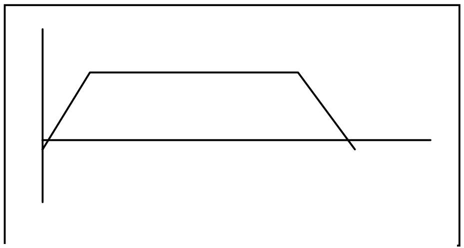
Your application may require that you use an analog input that is slewed properly by your applications external control. This can be accomplished by creating an alternate function generator. Apply the desired step input voltage from your system controller to the analog inputs of the amplifier.

3. Next the Scope function needs to be setup and started to display the system velocity response. Press the “Display Oscilloscope” button on the Tuning Dialog window to open the “Setup Oscilloscope” dialog window, and do/select the followings.
   3.1. Select X-Axis = time
   3.2. Enter Data sampling “Actual Rate (mS)”select time equal to or greater than the shown default. The shown default is calculated based o MotionMaestoã activity and could be too high if activity is increased.
   3.3. Select under “Data Attributes” “Source dropdown” the “Velocity Measured” option
   3.4. Enter “ X-Axis Range”: oscilloscope sweep speed
   3.5. Enter “ Y-Axis Range”: Sets the Y axis plus and minus maximum values.
   Note: The maximum values should be higher than the actual “Target Velocity (RPM)” from step 2.2.
   3.6. Press “Done” to display oscilloscope
   Note: 1. You can always go back to the “Setup Oscilloscope” window to reset the ranges by clicking “Setup” in the “Oscilloscope” window.
   2. You should see a trace scanning across the scope. If you do not, press “Setup” button, and adjust the scope until a trace is visible.

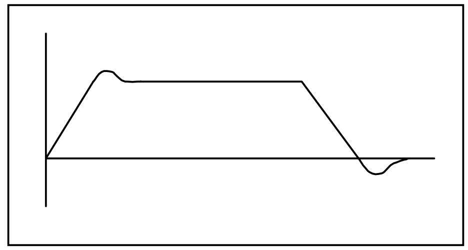
4. Go back to the “Tuning Setup” window, and press the “Start (continuous)” button in the function generator group.
   Note: Press “OK” when the “Execute Test” pop up window appears.

5. Slowly increase the “Compensation” until the oscilloscope waveform shows critically damped response or just one hook overshoot.
   Note: 1. This should be achieved without the system becoming unstable.
   2. The compensation can be increased or decreased by the up and down arrow keys on the keyboard when the compensation edit box on tuning dialog of MotionMaestro has the focus.

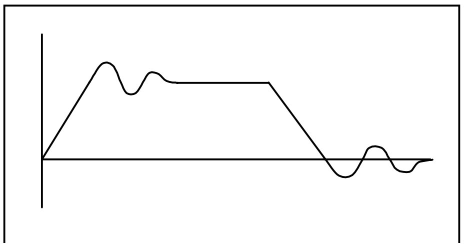
The following illustrations provide a reference for the waveforms on the Oscilloscope. Figure B, a one hook over shoot signal is a practical target to aim for.



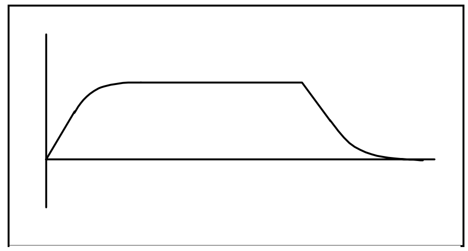
A.) Critically Damped Signal.



B.) 1 Hook Overshoot Signal



C.) Under Damped Signal



D.) Over Damped Signal

7. Additional settings:
   Note: In most cases, increasing or decreasing compensation value should tune the amplifier to the application. However, if you still cannot achieve the desired performance, work with some gains listed below.

Gain	Default	Response
Integral	600	If the gain is too high, the system may "hunt" (at low frequency). If the gain is too low, the motor may not overcome the friction or load, and could cause static position error in the system.
Proportional	32767	A high gain gives high stiffness but may oscillate. A low gain gives stable system but gives low stiffness.
Derivative	32767	A high gain gives slower step response but may allow higher proportional gain without oscillation. A low gain gives faster step response but may have overshoot or "ringing" response.
Tach	16384	Velocity feedback gain

   Integral, Proportional, and Derivative gains result in a coefficient which is calculated as the value entered over 32767. The compensation term acts as scalar of each coefficient

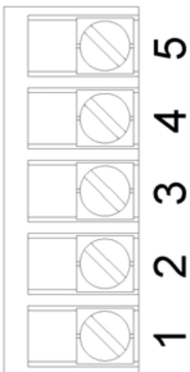
8. When you are satisfied with the tuning, save the parameters to non-volatile memory.

When tuning is complete you can save the amplifier parameters to an ASCII text file with Motion-Maestro's Backup command. You will find this command under the Tools pull-down menu. Select Backup Card. You will be prompted for a file name. The file can later be found under the application directory with a bk file type descriptor. At a later time this file can be used to quickly load default parameters for an application.

APPENDIX A

A - Servo Drive Connections

Servo Drive Motor and Power Connector

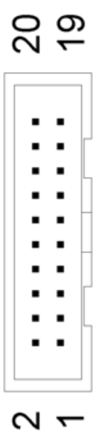


Module Power/Motor Designations

Pin#	I/O	Name	Function
1	Input	B-	DC Bus -
2	Input	B+	DC Bus +
3	Output	T	Motor Phase T
4	Output	S	Motor Phase S
5	Output	R	Motor Phase R

Table A-1

Servo Drive Motor Encoder Connector - Encoder Feedback

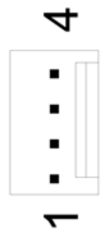


Encoder Feedback

Designations Pin#	I/O	Name	Function
1	Power	+5 ENC	Encoder +5 VDC Power
2	Power	COMMON	Encoder Common
3	Power	+5 ENC	Encoder +5 VDC Power
4	Power	COMMON	Encoder Common
5	Input	Enc A+	Encoder Channel A+
6	Input	Enc A-	Encoder Channel A- (not)
7	Input	Enc B+	Encoder Channel B+
8	Input	Enc B-	Encoder Channel B-(not)
9	Input	Enc Z+	Encoder Channel Z+
10	Input	Enc Z-	Encoder Channel Z- (not)
11	Input	Hall U+	Hall Sensor U+ Signal
12	Input	Hall U-	Hall Sensor U- Signal (not)
13	Input	Hall V+	Hall Sensor V+ Signal
14	Input	Hall V-	Hall Sensor V- Signal (not)
15	Input	Hall W+	Hall Sensor W+ Signal
16	Input	Hall W-	Hall Sensor W- Signal (not)
17	Input	N/C	No Connection
18	Input	COMMON	Common
19	Power	COMMON	Common
20	Power	COMMON	Common

Table A-2

Servo Drive Serial Communications Connector

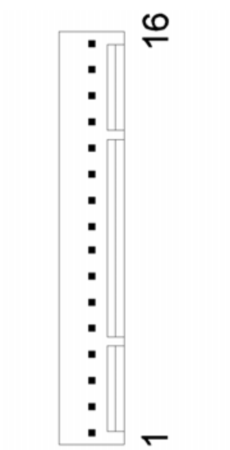


RS-232 Communications Designations

Pin#	Function
1	Common
2	RX
3	TX
4	N/C

Table A-3

Controller I/O Connectors

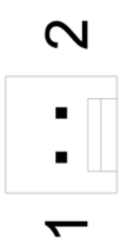


Controller I/O Connection Designations

Pin#	I/O	Name	Function
1	Input	Signal 1 +	Analog 1 command signal +
2	Input	Signal 1 -	Analog 1 command signal – (not)
3		Common	Common
4	Output	ABS Current	Absolute current out
5	Output	Analog OUT	Analog OUT
6	Input	+ Limit	Limit switch +
7	Input	- Limit	Limit switch -
8	Input	Inhibit	Hardware inhibit
9	Output	Fault Out	Fault out
10	Output	Encoder A +	Encoder A + output
11	Output	Encoder A -	Encoder A - output
12	Output	Encoder B+	Encoder B+ output
13	Output	Encoder B-	Encoder B- output
14	Output	Encoder Z+	Encoder Z+ output
15	Output	Encoder Z-	Encoder Z- output
16		Common	Common

Table A-4

Logic Power External 5VDC Input Connector



External 5VDC Input Connection Designations

Pin#	Function
1	EXT 5V (500mA min)
2	COMMON

Table A-5

APPENDIX B

B - Communication Error Codes

This appendix contains definitions of error codes read from an amplifier. Errors may be returned in response to a command sent via a serial line. MotionMaestro© displays the following response when the amplifier returns an error.

```
ERROR= nn
>
```

The following list defines the error associated with each of the error codes nn.

Error #	Definition
·	Power indicator
0	Unknown error
1	Invalid command
2	Checksum error
3	Reserved
4	Invalid command argument
5	Reserved
6	Reserved
7	Reserved
8	Reserved
9	Reserved
10	Reserved
11	Reserved
12	Reserved
13	Reserved
14	Reserved
15	Motor is enabled
16	Inhibit is active
17	Parameter is locked

APPENDIX C

C - SMA9115 Ratings and Specifications

This appendix contains specifications for the application engineer which are necessary to utilize the SMA9115 amplifiers.

Power, Input and Output

Amplifier Model Number	Input power (Buss Voltage B+)	Output Power (Current)		Available Packaging Configurations
		RMS	Peak	
SMA9115-002 or SMA9115-005	70-190 VDC or 190-340 VDC	10	20	Module, 2-Axis Chassis & 4-Axis Chassis
SMA9115-000 or SMA9115-003	70-190 VDC or 190-340 VDC	15	30	
SMA9115-001 or SMA9115-004	70-190 VDC or 190-340 VDC	20	40	

Signal Inputs

Input Source	Maximum Voltage VDC	Minimum Impedance Ohms	Current Gain Amp/Volt
Differential	13	10,000	0 - 5
Single Ended	13	10,000	0 - 5

Digital Inputs

Input Source	Specification
Limit +	See *
Limit -	See *
Inhibit	See *

* 40V max. -.5V min. Terminated by 10K Ohms. Digital inputs have hysteresis with thresholds at 1/3 and 2/3 of 5V.

Outputs

Output	Specification
Fault Out	Active low, open collector output can sink 500 mA max.
Analog Out	User selectable D/A. Output capable of driving 2K ohm load at 5 Volts.
Encoder Outputs:	EIA-422-A differential line driver, 2631 compatible.

System

Feature	Specification
Frequency response	
Velocity Loop:	Implementation dependent.
Current Loop:	Typical, depending on motor inductance, 2kHz typical. (Bandwidths available up to 3 kHz.)
Dead band:	Parameterized.

Notes

1) All data in this section is based on the following ambient conditions: 120 degrees F (50 °C) maximum.
2) Forced air cooling is required to meet the maximum power ratings specified.
3) The amplifier module (SMA9115) requires an external DC power supply, and +5VDC for encoder power and amplifier logic.

APPENDIX D

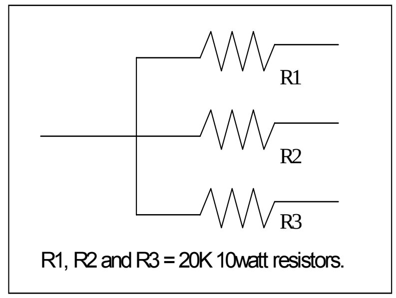
D - Matching motor phase leads to amplifier commands using Hall sensors.

Below you will find the steps necessary to insure that the command phases of a digital amplifier are properly matched to any three-phase motor that has Hall sensors. This method applies to a fully digital amplifier with digital current loops. Section labeled “System Setup” must have been completed before attempting this appendix.

Please read this procedure prior to working with the motor and amplifier.

It is intended that this procedure be done once by the engineering staff, whereupon they will incorporate the findings into production drawings, wiring labels and procedures.

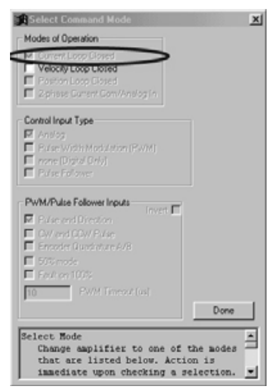
A) Locate or prepare the required equipment.
   1. A 2 channel oscilloscope
   2. A 3-phase Y-connected resistive load as illustrated below.
   3. A computer with MotionMaestro© installed.



Specification for resistive load

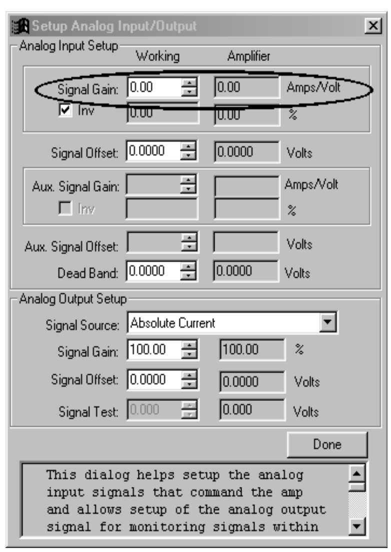
B) With the power off, connect the motor encoder outputs and the Hall sensor outputs to the amplifier. **Leave the motor power leads disconnected**. Connect the RS232 serial cable from the amplifier to the serial port on the computer (MotionMaestro©).

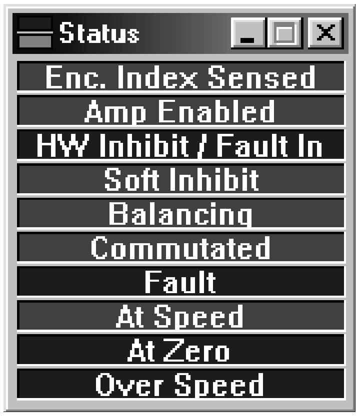
C) Apply power to the amplifier and establish communications between the amplifier and MotionMaestro©.

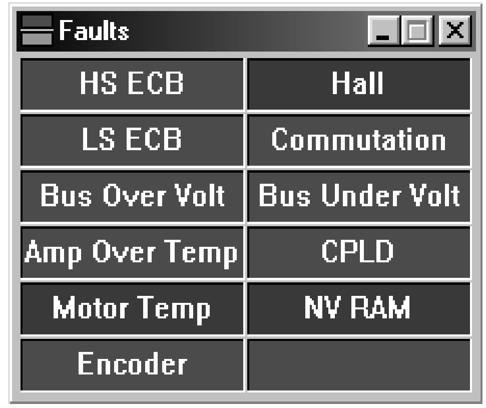


D) Prepare the amplifier using the following dialogs.

   1.) Insure that the amplifier is in **current mode**. Deselect all modes except the **current mode**.
   2.) Set the analog command input signal gain to zero. Use the Setup Analog Input/Output dialog as shown.

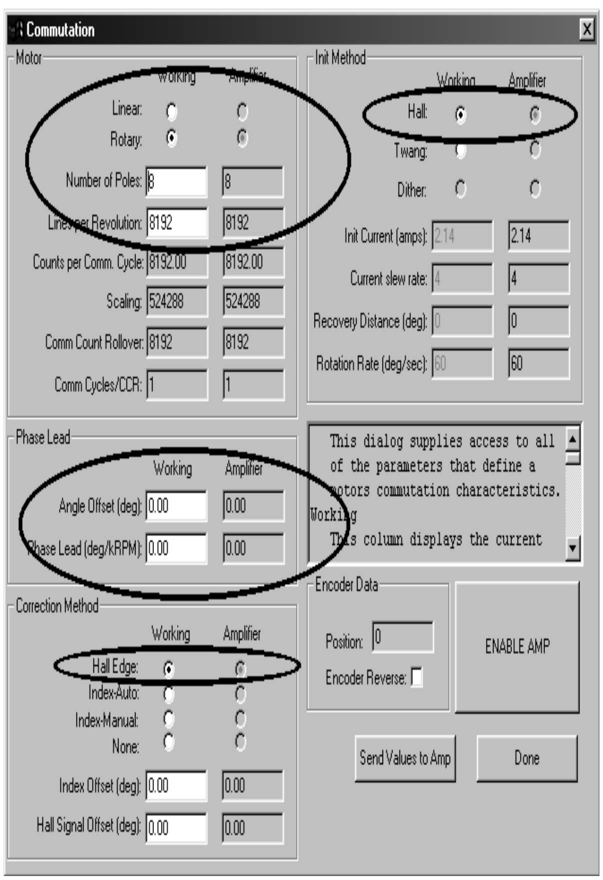






3.) Check then clear all faults by referring to the Amplifier Faults and Amplifier Status displays on the toolbar. For example, if there is an External Inhibit status warning you must open the Setup Digital IO dialog and check the inhibit box, then fix all remaining amplifier faults. After all faults have been corrected a fault reset must be completed. You may perform a reset by typing RST at the terminal window or by opening the Control Panel and depressing the "**Fault Reset**" button. **Commutation alignment can not begin until all faults are cleared**.

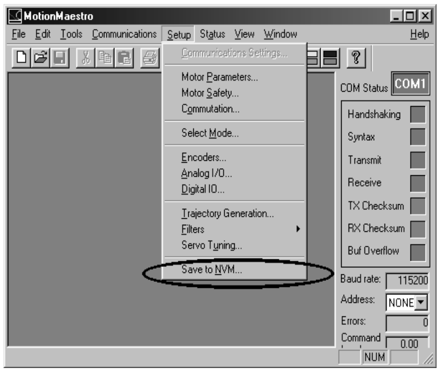
E) From the MotionMaestro© "Setup" menu, open the "Commutation" dialog and setup the following items:

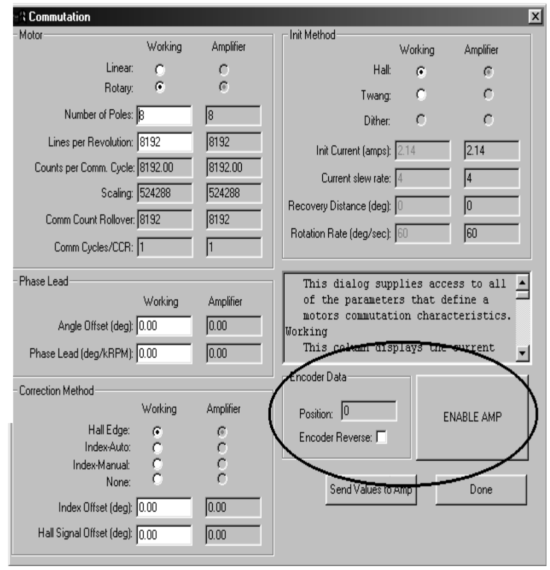


1) Motor type. Are you phasing a rotary or linear motor?
2) **Number of Poles.
3) **Encoder resolution.
4) Commutation angle offset = 0 (+ or -30 degrees if Halls aligned phase to neutral)
5) Commutation phase advance gain = 0
6) Init Method = Hall
7) Correction Method = Hall
8) Depress "Send Values To Amp" button

NOTE: ** Refer to Appendix F if motor Poles and Encoder Resolution are unknown.

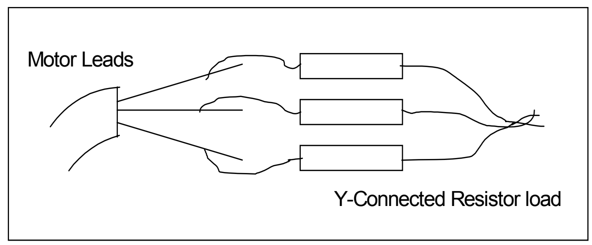
F) With the Commutation dialog still open, enable the amplifier. You will see on the amp, one segment lit on the seven segment display. This display segment indicates the Hall state. Rotate the motor shaft by hand, such that the segments rotate clockwise as viewed from the top of the drive. Verify the Encoder Data Position counts up in the Commutation dialog. If not, check the Encoder Data Reverse box. The Encoder Data Position should now count up as the seven segment display cycles clockwise.





G) Save the new settings by selecting “Save to NVM” from the Setup menu. Answer Yes when prompted to save.

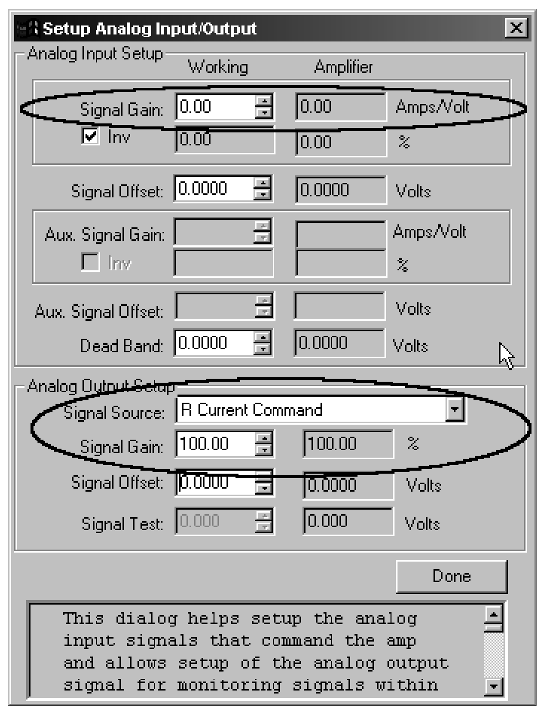
H) Connect the 3-phase Y-connected resistor load to the **Motor** power leads for monitoring the motor back EMF (BEMF). **NOTE: do not connect the motor leads or the resistor load to the amplifier.**



3-phase Y-connected resistor load

I) Connect the channel 1 scope probe to the amplifiers Analog Out pin. Connect the channel 1 scope common to the amplifiers Common pin. Set the channel 1 vertical scale to around **2V per division**. From the “Setup Analog Input/Output” dialog, Set the Analog Output Signal Source to “R Current Command” and directly below change the Analog Output Signal Gain to 100 percent.

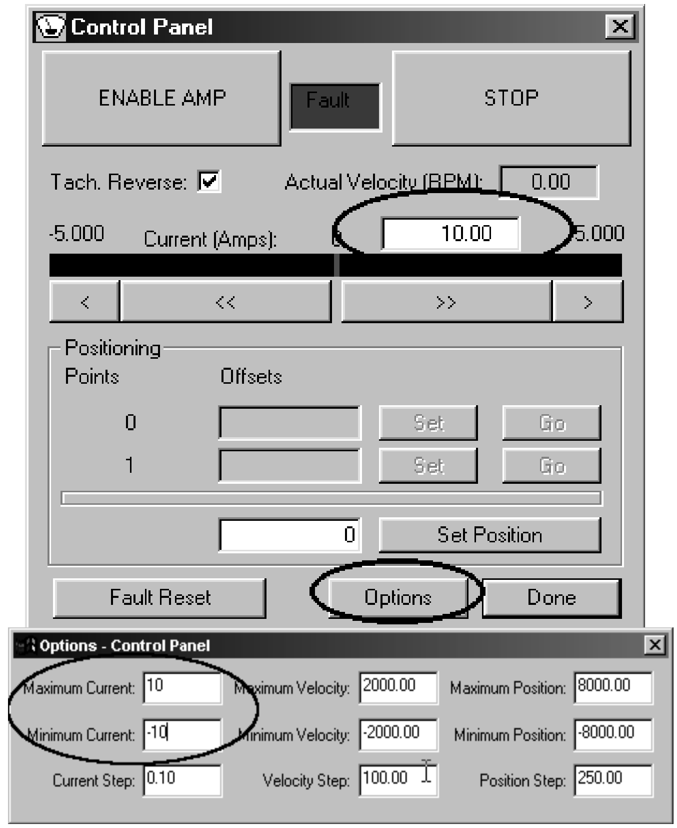
J) Connect the channel 2 scope probe to one of the motors leads. Connect the channel 2 scope common to the center of the Y-connected resistor load. Set the channel 2 vertical scale to around **2V per division**. Set the horizontal scale to around **100 ms per division**. Scaling may need to be changed in order to best see the data.



K) Open the Control Panel. The square colored status box will give you the amplifier status. If the box is yellow or disabled then press the “Enable/Disable Amp” button. If the box is red the amp has a fault and must be cleared before you can proceed.

L) From the Control Panel, apply a digital current command of **10 amps** to the amplifier. To do this you may have to expand the range that can be commanded from the control panel by selecting the Options button.

M) **Find the phase R motor lead.**
Rotate the motor by hand and verify the trace on channel 1 (phase R current command) follows a sinusoidal pattern. Move the channel 2 scope probe to each motor lead to determine which BEMF waveform is in phase or 180° out of phase with the phase R command. Label this lead Phase R.



NOTE: For each phase, R, S and T, one direction of rotation should cause the back EMF (BEMF) to be in phase with the command while the reverse rotation direction should cause the BEMF to be 180° out of phase. Determine which direction of rotation is in phase for the phase R motor lead, then rotate the motor in that same direction when determining the S and T motor leads. Once the phases are labeled, double check that the phase R and S motor leads result in waveforms that are in phase with the corresponding digital current commands on the amplifier when rotating the motor in the same direction for both.

ALSO: This method of matching motor leads to the amplifier requires that the motor's Hall sensors transitions are aligned with the motor phase to phase BEMF zero crossings. If the Hall sensors are aligned with the motor's phase to neutral BEMF, then the commutation offset angle must be set to ±30 degrees (you have to try both) before comparing the commands to the BEMF waveforms.

N) **Find the phase S motor lead.**
In MotionMaestro©, change the Analog Output Signal Source *S Current Command*. Place the channel 2 scope probe on one of the two remaining motor leads. Rotate the motor in the same direction that was used for phase R above. Determine which of the remaining two leads of the motor result in a waveform that is in phase with the phase S command. Label this lead Phase S. Move the channel 2 probe to the remaining motor lead.

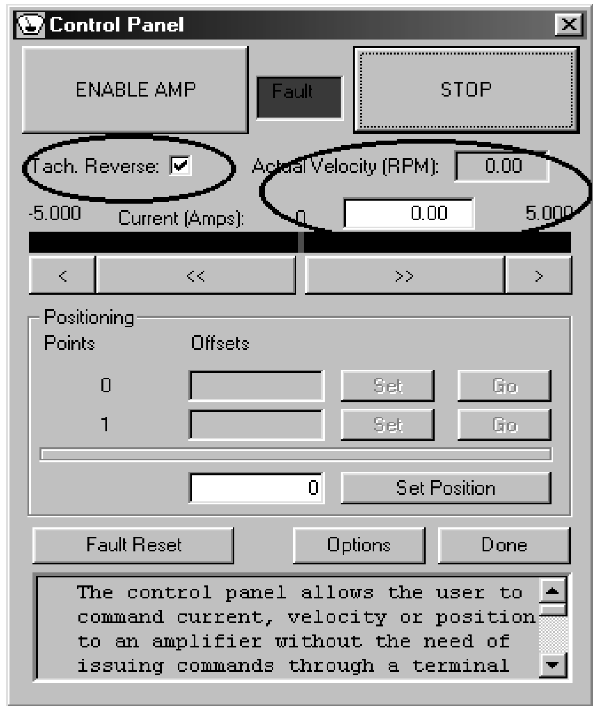
O) **Find the phase T motor lead.**
Same procedure as above with the analog output source set to *T Current Command*. If phase R and phase S where properly found, phase T will be the remaining motor wire. Label this lead phase T.

P) Set the current command back to **0 by clicking the STOP button on the Control Panel.** Reset any current limits, foldback thresholds to the desired operational settings. Reset the Control Panel options to appropriately safe values. Set the Analog Input Signal Gain back to the desired operational value.

Q) Save the settings by selecting "Save to NVM" from the Setup menu.

R) Remove the amplifier's power. Remove the scope probes. Connect the motor R, S, and T leads to the amplifier's R, S, and T terminals respectively.

S) Apply power to amplifier. The amplifier should still be in **Current Mode** and **Enabled** (unless the external inhibit is active). From the Control Panel, see following picture, issue a digital current command of **0.5 to 2 amps**, enough so the motor begins to rotate.



T) While the motor is rotating, verify that the sign of the actual velocity matches the sign of the commanded current. If NOT mark the **Tach Reverse** checkbox on the control panel and verify that the signs now match. Command the opposite polarity current to the motor, **-.5 to -2.0 amps** and verify that the motor reverses direction and runs at approximately the same speed. The signs of the current command and actual velocity should still match.

U) Set the current command back to 0 by clicking on the **STOP** button of the Control Panel. Save the settings by selecting “Save to NVM” from the setup menu.

The motor should now be properly commutated and phased.

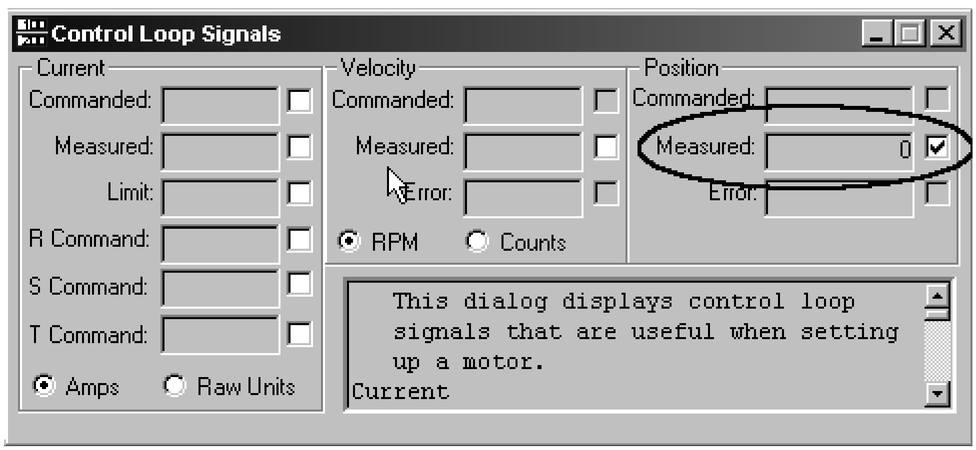
APPENDIX E

E – Determining Encoder Resolution and Number of Poles.

A) **Encoder Resolution**

From the MotionMaestro© Status menu, open the "Control Loop Signals" dialog . Check the box that allows you to monitor "Measured" "position" of the encoder, then mark a start position on the motor shaft. Turn the shaft 360 degrees clockwise and monitor the encoder position in the Control Loop Signals dialog. Note the change in encoder counts. Take the change in encoder counts per 1 revolution (360 degrees) and divide by four (4). This is your Lines of Resolution that you will enter in your Commutation dialog. (Note: For better accuracy, you may rotate by 10 turns and divide by 40 instead of 4.)

Common encoder line counts include but are not limited to 250. 256. 500, 512, 1000, 1024, 2000. 2048, 2500, 4096, 5000, 8192, and 10,000 lines/revolution.

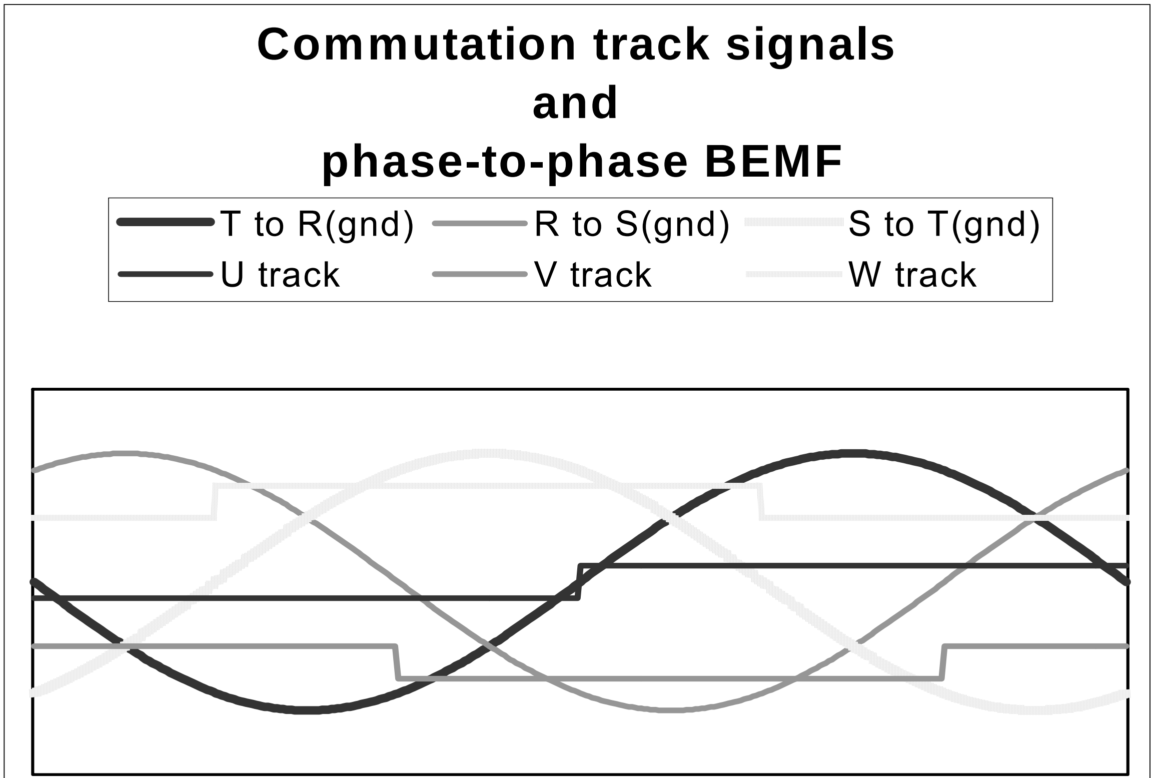


B) **Number of Poles** (Note: requires Hall sensors)

Enable the amplifier. Mark a start position on the motor shaft. You will be monitoring the seven segment display on the amplifier as shaft is rotated. Note the lit segment before rotating the motor shaft, now turn the shaft 360 degrees clockwise. As you are rotating shaft, count the number of times the seven segment display goes through a full led rotation. Take the number of full LED cycles and multiply by two. This is the Number of Poles that you will enter in your Commutation dialog.

APPENDIX F

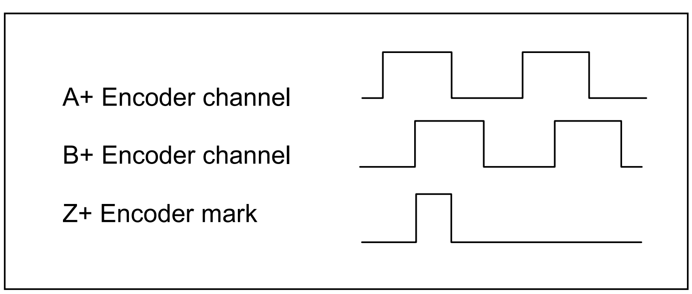
F– Commutation track / Hall signals and phase-to-phase BEMF.



-180 to 180 degrees
As measured turning motor CW looking at face of motor.
When in hall pll mode and with a standard wound Glentek motor,
LED display will transition in a CW direction.

Encoder Outputs

The following illustrates the encoder signals for a standard Glentek motor that is correctly commutated where the encoder is not reversed (FER=0) and the tachometer feedback is reversed (TR=1).



APPENDIX G

G – European Union EMC Directives

Electromagnetic Compatibility Guidelines For Machine Design

This document provides background information about Electromagnetic Interference (EMI) and machine design guidelines for Electromagnetic Compatibility (EMC).

Introduction

Perhaps no other subject related to the installation of industrial electronic equipment is so misunderstood as electrical noise. The subject is complex and the theory easily fills a book. This section provides guidelines that can minimize noise problems.

The majority of installations do not exhibit noise problems. However, these filtering and shielding guidelines are provided as counter measures. The grounding guidelines provided below are simply good grounding practices. They should be followed in all installations.

Electrical noise has two characteristics: generation or emission of electromagnetic interference (EMI); and response or immunity to EMI. The degree to which a device does not emit EMI, and is immune to EMI is called the device's Electromagnetic Compatibility (EMC).

Equipment, which is to be brought into the European Union legally, requires a specific level of EMC. Since this applies when the equipment is brought into use, it is of considerable importance that a drive system, as a component of a machine, be correctly installed.

"EMI Source-Victim Model" shows the commonly used EMI model. The model consists of an EMI source, a coupling mechanism and an EMI victim. A device such as servo drives and computers, which contain switching power supplies and microprocessors, are EMI sources. The mechanisms for the coupling of energy between the source and victim are conduction and radiation. Victim equipment can be any electromagnetic device that is adversely affected by the EMI coupled to it.

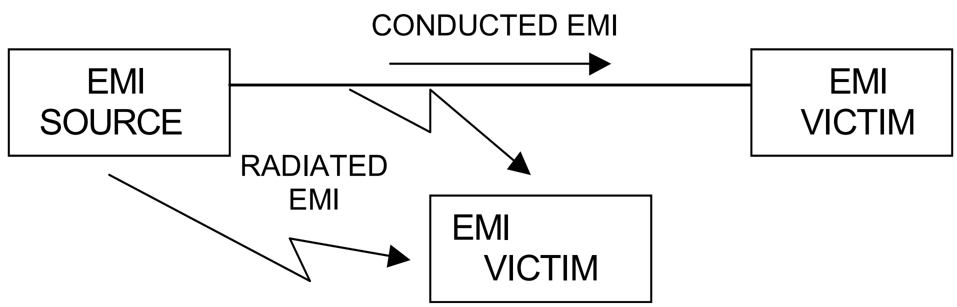


Figure 1- EMI Source-Victim Model

Immunity to EMI is primarily determined by equipment design, but how you wire and ground the device is also critical to achieving EMI immunity. Therefore, it is important to select equipment that has been designed and tested for industrial environments. The EMI standards for industrial equipment include the EN61000-4-X series (IEC 1000-4-X and IEC8O1-X), EN55011 (CISPR11), ANSI C62 and C63 and

MIL-STD-461. Also, in industrial environments, you should use encoders with differential driver outputs rather than single ended outputs, and digital inputs/outputs with electrical isolation, such as those provided with optocouplers.

The EMI model provides only three options for eliminating the EMC problem:

- Reduce the EMI at the source,
- Increase the victim's immunity to EMI (harden the victim),
- Reduce or eliminate the coupling mechanism,

In the case of servo drives, reducing the EMI source requires slowing power semiconductor switching speeds. However, this adversely affects drive performance with respect to heat dissipation and speed/torque regulation. Hardening the victim equipment may not be possible, or practical. The final and often the most realistic solution is to reduce the coupling mechanism between the source and victim. Filtering, shielding and grounding can achieve this.

Filtering

As mentioned above, high frequency energy can be coupled between circuits via radiation or conduction. The AC power wiring is one of the most important paths for both types of coupling mechanisms. The AC line can conduct noise into the drive from other devices, or it can conduct noise directly from the drive into other devices. It can also act as an antenna and transmit or receive radiated noise between the drive and other devices.

One method to improve the EMC characteristics of a drive is to use an isolation AC power transformer on the amplifier's input power. This minimizes inrush currents on power-up and provides electrical isolation. In addition, it provides common mode filtering, although the effect is limited in frequency by the interwinding capacitance. Use of a Faraday shield between the windings can increase the common mode rejection bandwidth, (shield terminated to ground) or provide differential mode shielding (shield terminated to the winding). In some cases an AC line filter will not be required unless other sensitive circuits are powered off the same AC branch circuit.

NOTE:“ Common mode” noise is present on all conductors that are referenced to ground. “Differential mode” noise is present on one conductor referenced to another conductor.

The use of properly matched AC line filters to reduce the conducted EMI emitting from the drive is essential in most cases. This allows nearby equipment to operate undisturbed. The basic operating principle is to minimize the high frequency power transfer through the filter. An effective filter achieves this by using capacitors and inductors to mismatch the source impedance (AC line) and the load impedance (drive) at high frequencies.

For drives brought for use in Europe, use of the correct filter is essential to meet emission requirements. Detailed information on filters is included in the manual and transformers should be used where specified in the manual.

AC Line Filter Selection

Selection of the proper filter is only the first step in reducing conducted emissions. Correct filter installation is crucial to achieving both EMIL attenuation and to ensure safety. All of the following guidelines should be met for effective filter use.

1) The filter should be mounted to a grounded conductive surface.

2) The filter must be mounted close to the drive-input terminals, particularly with higher frequency emissions *(5-30* MHz). If the distance exceeds 600mm (2 feet), a strap should

be used to connect the drive and filter, rather than a wire.

3) The wires connecting the AC source to the filter should be shielded from, or at least separated from the wires (or strap) that connects the drive to the filter. If the connections are not segregated from each other, then the EMI on the drive side of the filter can couple over to the source side of the filter, thereby reducing, or eliminating the filter effectiveness. The coupling mechanism can be radiation, or stray capacitance between the wires. The best method of achieving this is to mount the filter where the AC power enters the enclosure. “AC Line Filter Installation” shows a good installation and a poor installation.

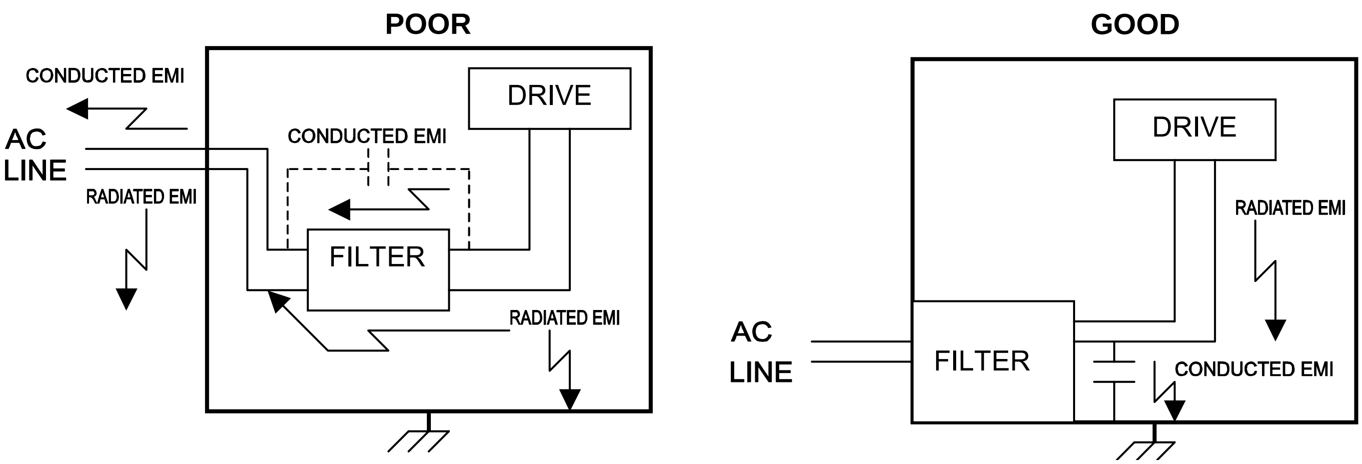


Figure 2- AC Line Filter Installation

When multiple power cables enter A unfiltered line can contaminate a filtered line external to the enclosure. Therefore, all lines must be filtered to be effective. The situation is similar to a leaky boat. All the holes must be plugged to prevent sinking.

WARNING

Large leakage currents exist in AC line filters. They must be grounded properly before applying power. Filter capacitors retain high voltages after power removal. Before handling the equipment, voltages should be measured to determine safe levels prior to handling the equipment. Failure to observe this precaution could result in severe bodily injury.

If the filter is mounted excessively far from the drive, it may be necessary to mount it to a grounded conductive surface, such as the enclosure, to establish a high frequency (HF) connection to that surface. To achieve the HF ground, direct contact between the mounting surface and the filter must be achieved. This may require removal of paint or other insulating material from the cabinet or panel.

The only reasonable filtering at the drive output terminals is the use of inductance. Capacitors would slow the output switching and deteriorate the drive performance. A common mode choke can be used to reduce the HF voltage at the drive output. This will reduce emission coupling through the drive back to the AC line. However, the motor cable still carries a large HF voltage and current. Therefore, it is very important to segregate the motor cable from the AC power cable. More information on cable shielding and segregation is contained in the section on shielding.

Grounding

High frequency (HF) grounding is different from safety grounding. A long wire is sufficient for a safety ground, but is completely ineffective as a HF ground due to the wire inductance. As a rule of thumb, a wire has an inductance of 8 nH/in regardless of diameter. At low frequencies it acts as constant impedance, at intermediate frequencies as an inductor, and at high frequencies as an antenna. The use of ground straps is a better alternative to wires. However the length to width ratio must be *5:1,* or better yet 3:1, to remain a good high frequency connection.

The ground system's primary purpose is to function as a return current path. It is commonly thought of as an equipotential circuit reference point, but different locations in a ground system may be at different potentials. This is due to the return current flowing through the ground systems finite impedance. In a sense, ground systems are the sewer systems of electronics and as such are sometimes neglected.

The primary objective of a high frequency ground system is to provide a well-defined path for HF currents and to minimize the loop area of the HF current paths. It is also important to separate HF grounds from sensitive circuit grounds. "Single Point Ground Types" shows single point grounds for both series (daisy chain) and parallel (separate) connections. A single point, parallel connected ground system is recommended.

Figure 3-Single Point Ground Types

A ground bus bar or plane should be used as the "single point" where circuits are grounded. This will minimize common (ground) impedance noise coupling. The ground bus bar (GBB) should be connected to the AC ground, and if necessary, to the enclosure. All circuits or subsystems should be connected to the GBB by separate connections. These connections should be as short as possible and straps should be used when possible. The motor ground conductor must return to the ground terminal on the drive, not the GBB.

Shielding and Segregation

The EMI radiating from the drive enclosure drops off very quickly over distance. Mounting the drive in an enclosure, such as an industrial cabinet, further reduces the radiated emissions. The cabinet should have a high frequency ground and the size of the openings should be minimized. In addition, the drive is considered an "open" device that does not provide the proper IP rating for the environment in which it is installed. For this reason the enclosure must provide the necessary degree of protection. An IP rating or Nema rating (which is similar to IP) specifies the degree of protection that an enclosure provides.

The primary propagation route for EMI emissions from a drive is through cabling. The cables conduct the EMI to other devices, and can also radiate the EMI. For this reason, cable segregation and shielding are important factors in reducing emissions. Cable shielding can also increase the level of immunity for a drive. For example:

- Shield termination at both ends is extremely important. The common misconception that shields should be terminated at only one end originates from audio applications with frequencies <20 kHz. RF applications must be terminated with the shield at both ends, and possibly at intermediate points for exceptionally long cables.

- When shielded cables are not terminated at the cable connection and pass through the wall of a cabinet, the shield must be bonded to the cabinet wall to prevent noise acquired inside the cabinet from radiating outside the cabinet, and vice versa.

- When shielded cables are terminated to connectors, the shield must be able to provide complete 360^0 coverage and terminate through the connector backshell. The shield must *not* be grounded inside the connector through a drain wire. Grounding the shield inside the connector couples the noise on the shield to the signal conductors sharing the connector and virtually guarantees failure to meet European EMC requirements.

- The shield must be continuous. Each intermediate connector must continue the shield connection through the backshell.

- All cables, both power and signal should use twisted wire pairing.

The shield termination described above provides a coaxial type of configuration, which provides magnetic shielding, and the shield provides a return path for HF currents that are capacitively coupled from the motor windings to the frame. If power frequency circulating currents are an issue, a 250 VAC capacitor should be used at one of the connections to block 50/60 Hz current while passing HF currents. Use of a properly shielded motor cable is essential to meet European EMC requirements.

The following suggestions are recommended for all installations.

1. Motor cables must have a continuous shield and be terminated at both ends. The shield must connect to the ground bus bar or drive chassis at the drive end, and the motor frame at the motor end. Use of a properly shielded motor cable is essential to meet European EMC requirements.

2. Signal cables (encoder, serial, and analog) should be routed away from the motor cable and power wiring. Separate steel conduit can be used to provide shielding between the signal and power wiring. Do not route signal and power wiring through common junctions or raceways.

3. Signal cables from other circuits should not pass within 300 mm (1 ft.) of the drive.

4. The length or parallel runs between other circuit cables and the motor or power cable should be minimized. A rule of thumb is 300 mm (1 ft.) of separation for each 10 m (30 ft.) of parallel run. The 300 mm (1 ft.) separation can be reduced if the parallel run is less than 1 m (3 ft.).

5. Cable intersections should always occur at right angles to minimize magnetic coupling.

6. The encoder mounted on the brushless servomotor should be connected to the amplifier with a cable using multiple twisted wire pairs and an overall cable shield. Encoder cables are offered in various lengths that have correct terminations.

Persistent EMI problems may require additional countermeasures. The following suggestions for system modification may be attempted.

1. A ferrite toroid or “doughnut” around a signal cable may attenuate common mode noise, particularly RS-232 communication problems. However, a ferrite toroid will not help differential mode noise. Differential mode noise requires twisted wire pairs.

2. Suppress each switched inductive device near the servo amplifier. Switch inductive devices include solenoids, relay coils, starter coils and AC motors (such as motor driven mechanical timers).

3. DC coils should be suppressed with a “free-wheeling” diode connected across the coil.

4. AC coils should be suppressed with RC filters (a 200 Ohm 1/2 Watt resistor in series with a *0.5* uF, 600 Volt capacitor is common).

Following these guidelines can minimize noise problems. However, equipment EMC performance must meet regulatory requirements in various parts of the world, specifically the European Union. Ultimately, it is the responsibility of the machine builder to ensure that the machine meets the appropriate requirements as installed.

RECOMMENDATIONS FOR GLENTEK AMPLIFIERS

All amplifiers installed in a NEMA 12 enclosures or equivalent with wiring in metal conduit or enclosed metal wire trough (see Shielding and segregation).

Use Glentek shielded feedback and motor cables.

An AC line filter properly installed in a NEMA 12 enclosure or equivalent (see Filtering).

AC line filters for single-phase applications

1A-15A	input current, 120-250VAC use: Corcom 15ET1 or equivalent.
15A-25A	input current, 120-250VAC use: Corcom 25FC10 or equivalent.
25A-36A	input current, 120-250VAC use: Corcom 36FC10 or equivalent.

AC line filters for 3-phase applications

1A-25A	input current, 120-250VAC use: Corcom 25FCD10 or equivalent.
25A-36A	input current, 120-250VAC use: Corcom 36FCD10 or equivalent.
36A-50A	input current, 120-250VAC use: Corcom 50FCD10 or equivalent.
50A-80A	input current, 120-250VAC use: Corcom 80FCD10 or equivalent.

EUROPEAN UNION
DECLARATION OF INCORPORATION
MOTION CONTROL SYSTEMS

Classified as Components of Machinery

Model Series SMA9115

Council Directive	89/336/EEC	EMC Directive
Council Directive	89/392/EEC	Machinery Directive
Council Directive	73/23/EEC	Low Voltage Directive

The Products cited below and their accessories comply with the following Safety of Machinery Standards when installed and operated in accordance with the Instructions provided in the Operation & Installation Manuals. The products are declared to comply by virtue of Design Third Party Evaluations and Testing. EMC Testing and Product Safety Evaluations and Risk Assessments were conducted by NATIONAL TECHNICAL SYSTEMS, an independent Nationally Recognized Test Laboratory, located in Fullerton, CA 92631, USA.

As components of Machinery, please be advised that:

1. These are not individually classified as machinery within the scope of directive 89/392/EEC.
2. These are intended to be incorporated into machinery or to be assembled with other machinery to constitute machinery covered by directive 89/392/EEC, as amended.
3. As such, do therefore not in every respect comply with the provisions of directive 89/392/EEC.

SAFETY STANDARDS

EN60292 - 2	Safety of Machinery – Basic Principals	
EN60204	Electrical Equipment of Industrial Machines	
	Collateral Test Standards, Specified by EN60204	
EN50011:1991	Emissions Limits for Industrial, Scientific And Medical (ISM) RF Equipment	Class A Conducted and Radiated
EN61000-4-2	Electrostatic Discharge Immunity	Level 2
EN61000-4-3	Radiated Emission Immunity	Level 2
EN61000-4-4	Electric Fast Transients Burst	Level 3

Manufacturers Name:	GLENTEK INC.
Manufacturers Address:	208 Standard Street El Segundo, CA 90245, USA
Description of Equipment:	Motion Control Systems including Amplifiers and Servo Motors
Model Number(s):	SMA9115. The above amplifier modules packaged in the following configurations: -2A-1, -2A-2, -4A-3, -4A-4 and all the fan power configurations: 1, 2.

The undersigned hereby declares that the equipment specified above conforms to the noted Directives and Standards.

Refer to Technical Construction File GTK 99408.

MANUFACTURER

Helen M. Vasak

HELEN M. VASAK

SECRETARY-TREASURER

6-10-05

Prepared By: National Technical Systems, Fullerton, CA
Confirmed By: Chuck Helton, Director of Product Safety

APPENDIX H

H - Amplifier Terms and Technology

This appendix contains information that describes and explains the terms and concepts referred to in this manual. The information contained here is generic to amplifiers and motion control technology in general and does not apply specifically to the SMA9115 amplifier. The TERMS section is a glossary that defines the terms used when discussing amplifiers. The TECHNOLOGY section describes methods or concepts that involves the usage of multiple terms.

TERMS

Analog Current Command Mode

Analog current mode, also called Torque mode or Current mode, indicates that the amplifier is being commanded by an analog signal and that the amplifiers' control loop is controlling current. This command mode is used when one needs to control torque. The analog signal, in volts, is a scaled representation of desired current as measure at the output. For instance -10 volts to 10 volts at the analog input becomes -15 amps to 15 amps at the amplifiers output. The scaling is different for different amplifiers.

Analog Velocity Command Mode

Analog velocity mode indicates that the amplifier is being commanded by an analog signal and that the amplifiers' control loop is controlling velocity. This command mode is used when one needs to control the speed of some device. The analog signal, in volts, is a scaled representation of desired velocity as measured at the output. For instance -10 volts to 10 volts at the analog input becomes -3000 rpm to 3000 rpm at the device being moved. The scaling is can often be configured by the application engineer.

Command Mode

A term used to refer to the method by which a command is given to an amplifier. The amplifier uses this command in its' control loop as a target to be achieved. The command mode usually includes how the amplifier is to interpret the command. That is, is the command to represent current, velocity or position. There are many forms and methods by which commands are submitted to an amplifier. Traditionally the command was given as an analog voltage input to the amplifier. Today there is analog, digital, serial communications or some combination of these.

Commutation

Commutation is the term used to describe the method by which current is applied to the windings of a motor such that the applied current moves the motor in a desired direction, or to a desired position, with the minimum current. Brushes are the method of commutation in a brush motor. In a three phase brushless motor, Sinusoidal Commutation is the usual method of commutation. See Sinusoidal Commutation.

Commutation Initialization Method

In order to properly commutate a brushless motor, the servo drive must know the absolute position of the rotor with respect to the motor windings in the stator. Since incremental shaft encoders only supply "relative" rotor position, the servo drive must perform a power-on, phase-finding scheme to determine the absolute position of the shaft. This is known as commutation initialization. Once the absolute position is determined, the position from the encoder can be used to maintain the absolute position. The SMA9115 amplifier requires the addition of Hall sensors or commutation tracks to initially determine the absolute position of the rotor. Commutation tracks are simulated Hall sensors built into the shaft encoder.

Hall Commutation Initialization

Hall commutation initialization is a method that relies on sensors to give an approximation of the initial commutation angle of a motor. Hall initialization uses Hall sensors or commutation tracks (simulated Hall sensors built into the shaft encoder) to determine the rotor angle. In a brushless motor three Hall sensors are used to detect rotor position. The three Hall sensors employed are commonly named U, V and W; S1, S2 and S3; or A, B and C. The l sensors are digital (on/off) devices and therefore the combination of the three can result in eight different states. The sensors are aligned with the motor in a way that causes the output of the sensors to transition through six of the eight possible states as the motor is rotated through 360 electrical degrees. Each Hall state corresponds to 60 electrical degrees. Only one sensor changes states at any given transition.

At power up, the servo drive reads the state of the Hall sensors and from this state can determine within ±30 electrical degrees where the motor shaft is located. This is close enough to start commutating the motor, so the servo drive uses this approximation as the actual rotor position. Once motion is commanded (position, velocity or torque), the servo drive starts commutating with this value and watches for a transition of the Halls state. Upon this transition, the servo drive knows the exact location of the rotor shaft and updates the commutation angle based on this known location.

This method, unlike Twang or Dither, does not move the rotor shaft at power up. Instead, it uses a non-optimal commutation angle at start-up and corrects to the optimal commutation angle upon the first Hall state transition once motion is commanded.

Sinusoidal Commutation

In sinusoidal commutation a sinusoidal current is applied to each phase of the motor to cause the motor to rotate. In a three phase motor, the relationship of the currents applied in the three phases for a positive rotation of the rotor is:

$$IR(\theta e) = I * \sin(\theta e),$$
$$IS(\theta e) = I * \sin(\theta e - 120°),$$
$$IT(\theta e) = I * \sin(\theta e - 240°);$$

where:

IR, IS, and IT are the currents applied to phase R, S, and T respectively,
I is the amplitude of the commanded current,
θe is the “electrical angle” of the applied currents.

The relationship between the electrical angle, θc, and the mechanical angle (the angle of the rotor), θm, is:

$$\theta m = \theta c \times 2/N,$$

where

N is the number poles in the motor.

For example, a 4-pole motor (two North poles and two South poles) will rotate 180 mechanical degrees as the currents applied are varied through 360 electrical degrees.

APPENDIX I

I - Amplifier Model Numbering

This appendix explains the model numbering system for Glentek's Omega Series Digital servo amplifiers. The model numbering system is designed so that you, our customer, will be able to quickly and accurately create the model number for the amplifier that best suits your needs. This manual contains complete model numbering information for the following amplifier types:

SMA9115 Amplifier Model Numbering

The following tables are used to fill in the different parts of the model number. Refer to these when constructing a model number for your requirements.

XXX	Power	Power Input Voltage	Continuous Current (Amps)	Peak Current (Amps)
		Module (VDC)		
000	Standard	190 - 340	15	30
001	High	190 - 340	20	40
002	Low	190 - 340	10	20
003	Standard	70 - 190	15	30
004	High	70 - 190	20	40
005	Low	70 - 190	10	20

MM	Mounting
Omit	1 - axis Module
2A	2 - axis Chassis
4A	4 - axis Chassis

N	Number of Amplifiers Installed
1	1 Amplifier Installed
2	2 Amplifiers Installed
3	3 Amplifiers Installed
4	4 Amplifiers Installed

F	Fan Power
1	115VAC
2	230VAC

SMA9115 Amplifier Module Numbering Key

SMA9115 Module

SMA9115 - XXX - 1

Model number key:

SMA9115 Designates an Omega Series fully digital Surface Mount Amplifier.

XXX Power board Configuration Code.

1 Single amplifier module.

Example:

SMA9115 - 000 - 1

Module

Standard Power, 190 - 340VDC

SMA9115 Multi - Axis Amplifier

SMA9115 - XXX - MM - N - F

Model number key:

SMA9115 Designates an Omega Series fully digital Surface Mount Amplifier.

XXX Power board Configuration Code.

MM Mounting Configuration Code.

N Number of amplifiers installed.

F Fan Power..

Example:

SMA9115 - 003 - 4A - 3 - 1

115VAC Fan
Three amplifier modules installed
Four axis chassis, AC Input
Standard power, 110 - 130 VAC

Appendix J
Factory Repair & Warranty

Factory Repair

Should it become necessary to return an servo drive to Glentek for repair, please follow the procedure described below:

1. Reassemble the unit, if necessary, making certain that all the hardware is in place.
2. Tag the unit with the following information:
   - A. Serial number and model number.
   - B. Company name, phone number, and name of representative returning the unit.
   - C. A brief notation explaining the malfunction.
   - D. Date the unit is being returned.
3. Repackage the unit with the same care and fashion in which it was received. Label the container with the appropriate stickers (e.g.: FRAGILE: HANDLE WITH CARE).
4. Contact a Glentek representative, confirm that the unit is being returned to the factory and obtain an RMA (Return Material Authorization) number. The RMA number must accompany the unit upon return to Glentek.
5. Return the unit by the best means possible. The method of freight chosen will directly affect the timeliness of its return.

Glentek also offers a one-day repair service in the unlikely event that your system is down and you do not have a replacement servo drive module.

Warranty

Any product, or part thereof, manufactured by Glentek, Inc., described in this manual, which under normal operating conditions, in the plant of the original purchaser, thereof proves defective in material or workmanship within one year from the date of shipment by us, as determined by an inspection by us, will be repaired or replaced free of charge, FOB our factory, El Segundo, California, U.S.A. provided that you promptly send to us notice of the defect and establish that the product has been properly installed, maintained, and operated within the limits of rated and normal usage, and that no factory sealed adjustments have been tampered with. Glentek's liability is limited to repair or replacement of defective parts.

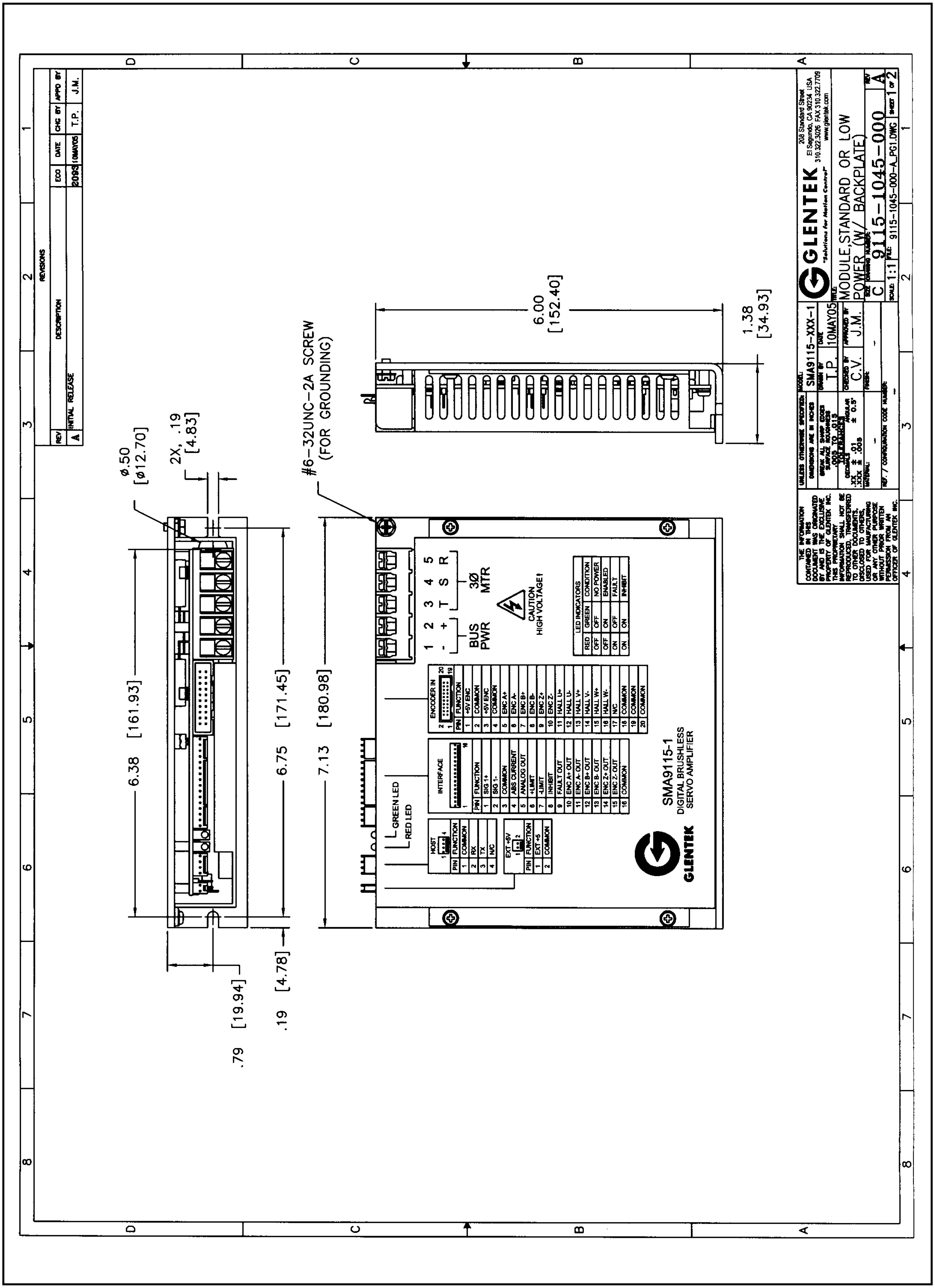
Any product or part manufactured by others and merely installed by us, such as an electric motor, etc., is specifically not warranted by us and it is agreed that such product or part shall only carry the warranty, if any, supplied by the manufacturer of that part. It is also understood that you must look directly to such manufacturer for any defect, failure, claim or damage caused by such product or part.

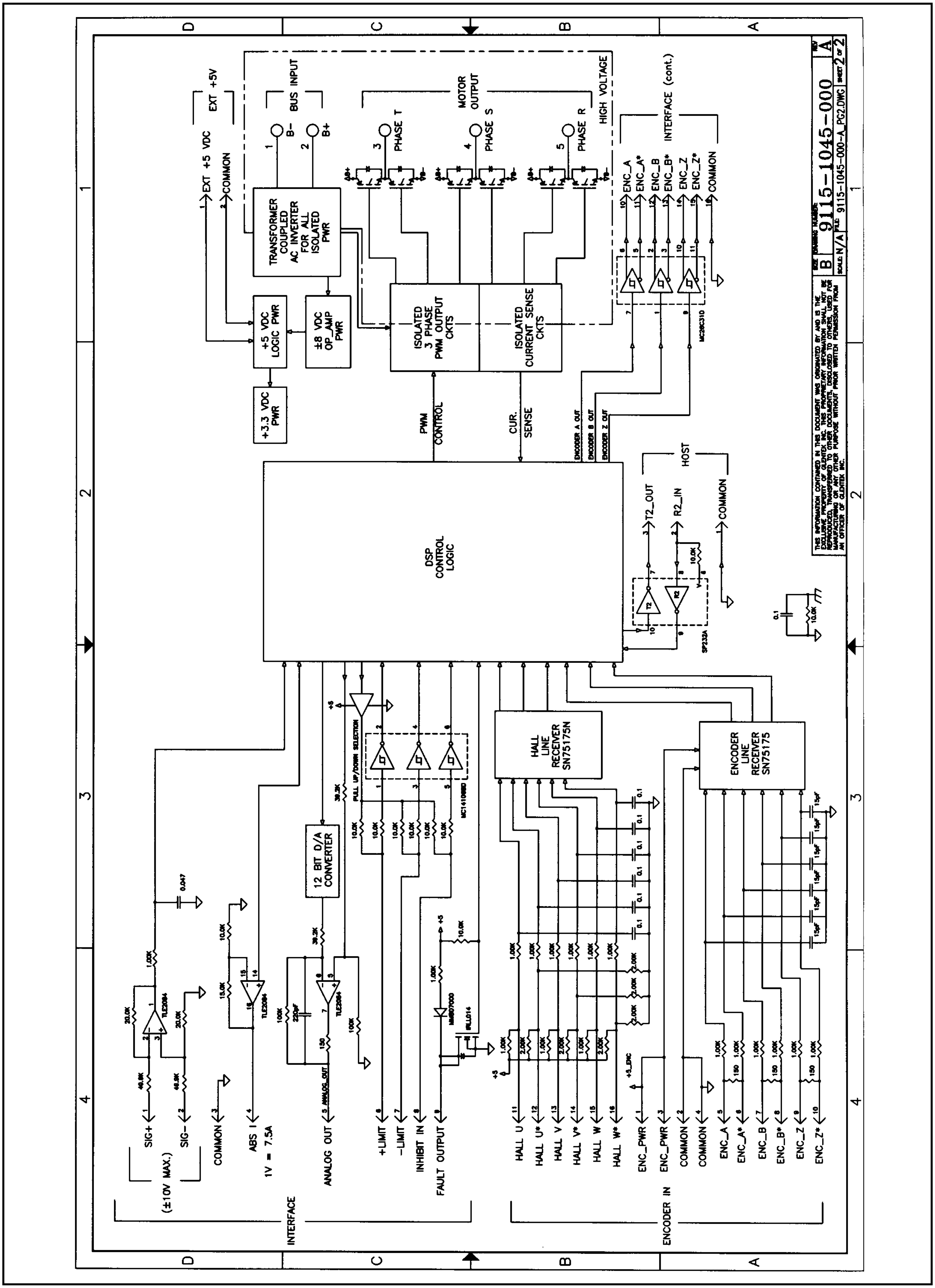
Under no circumstances shall Glentek, Inc. or any of our affiliates have any liability whatsoever for claims or damages arising out of the loss of use of any product or part sold to you. Nor shall we have any liability to yourself or anyone for any indirect or consequential damages such as injuries to person and property caused directly or indirectly by the product or part sold to you, and you agree in accepting our product or part to save us harmless from any and all such claim

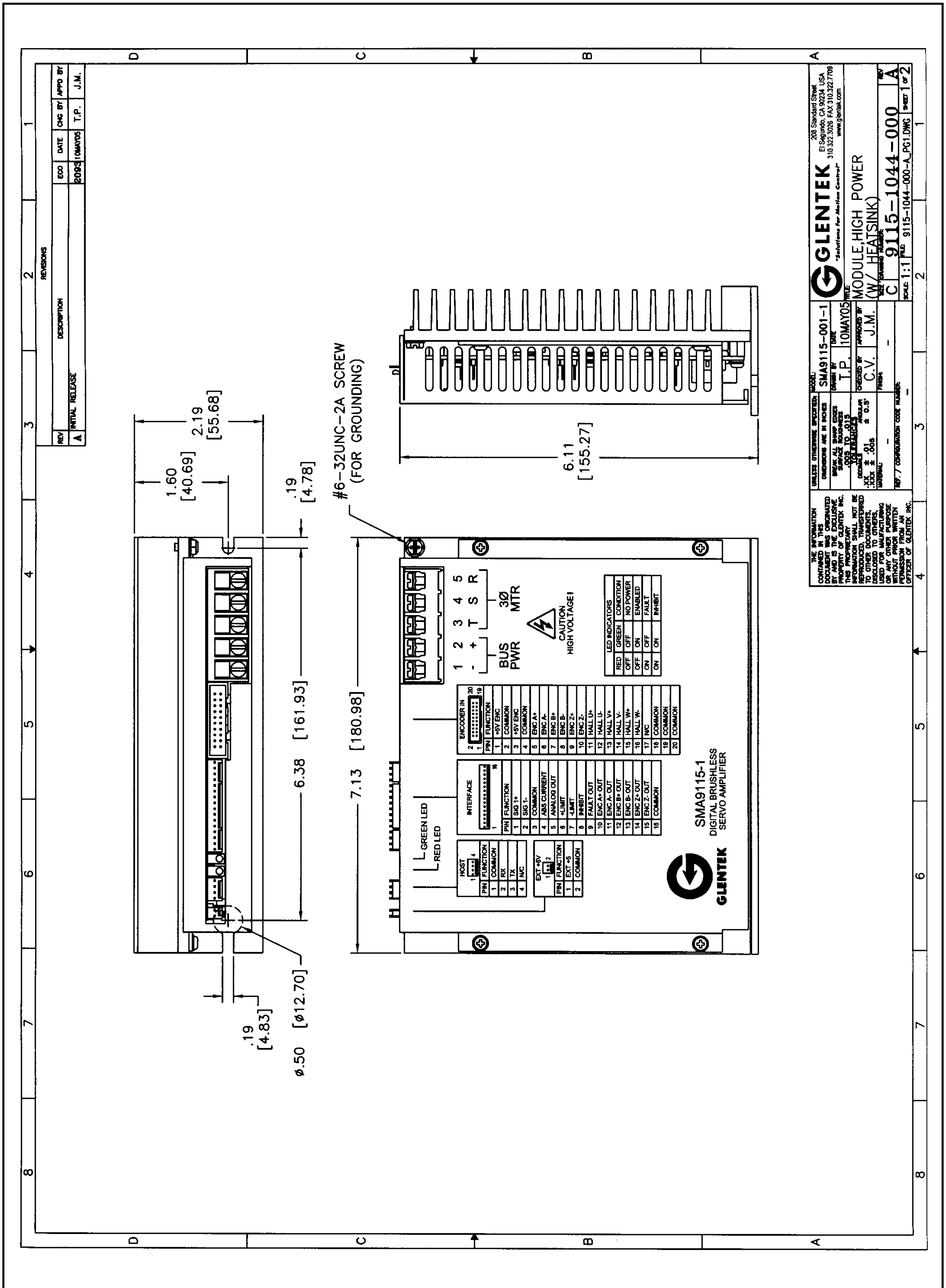
APPENDIX K

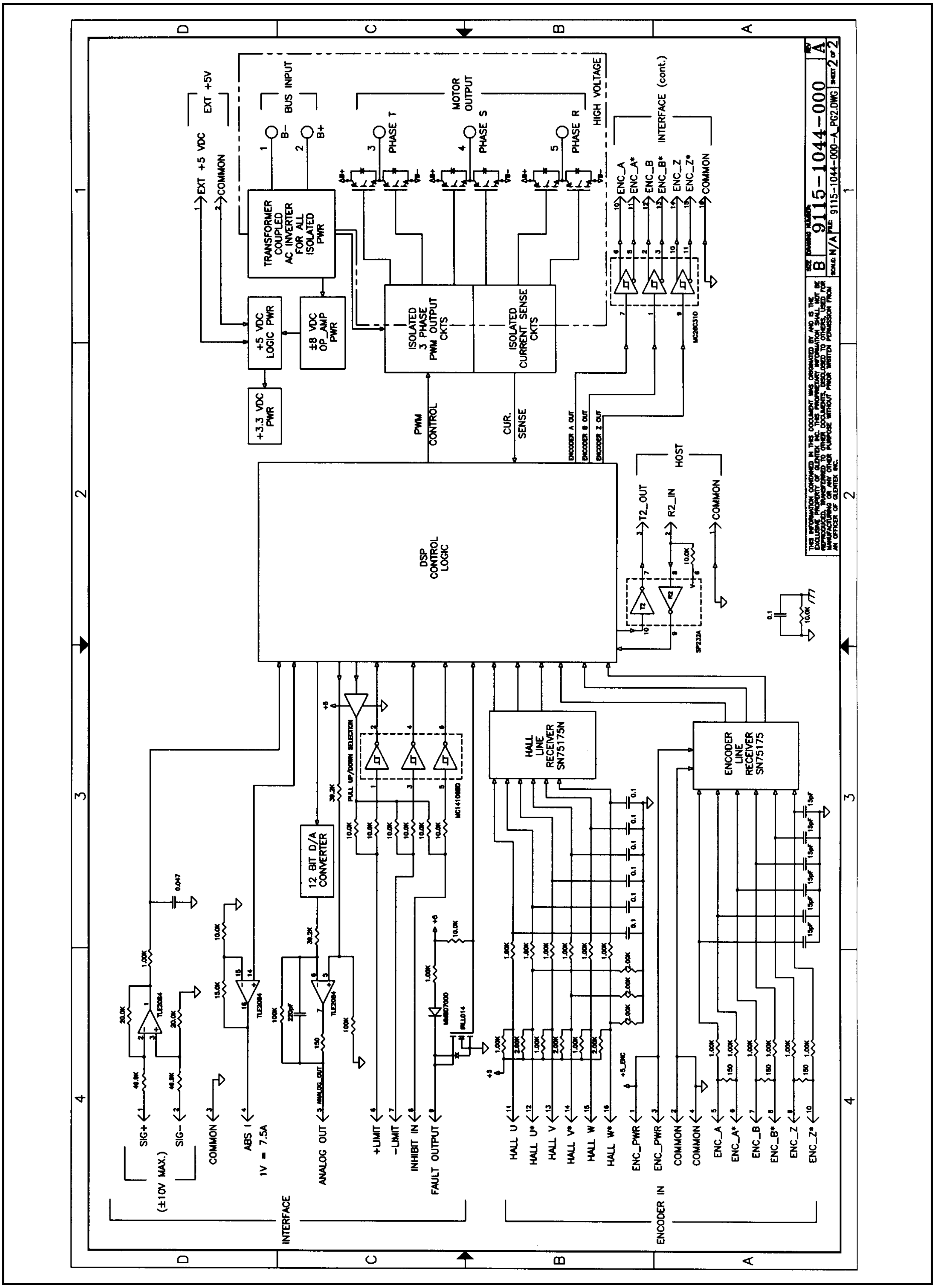
K– Drawings

SMA9115-1	Standard Power Amplifier Module (9115-1045-000-A)
	Block Diagram (9115-1045-000-A)
SMA9115-1	High Power Amplifier Module (9115-1044-000-A)
	Block Diagram (9115-1044-000-A)
SMA9115-2A-2	2 axis base plate chassis installation
	Standard Power (9115-1041-000-A)
SMA9115-2A-2	2 axis base plate chassis installation
	High Power (9115-1040-000-A)
SMA9115-4A-4	4 axis base plate chassis installation
	Standard Power (9115-1043-000-A)
SMA9115-4A-4	4 axis base plate chassis installation
	High Power (9115-1042-000-A)
GP8600-70	Power Supply Assembly (8600-7030-000-D)

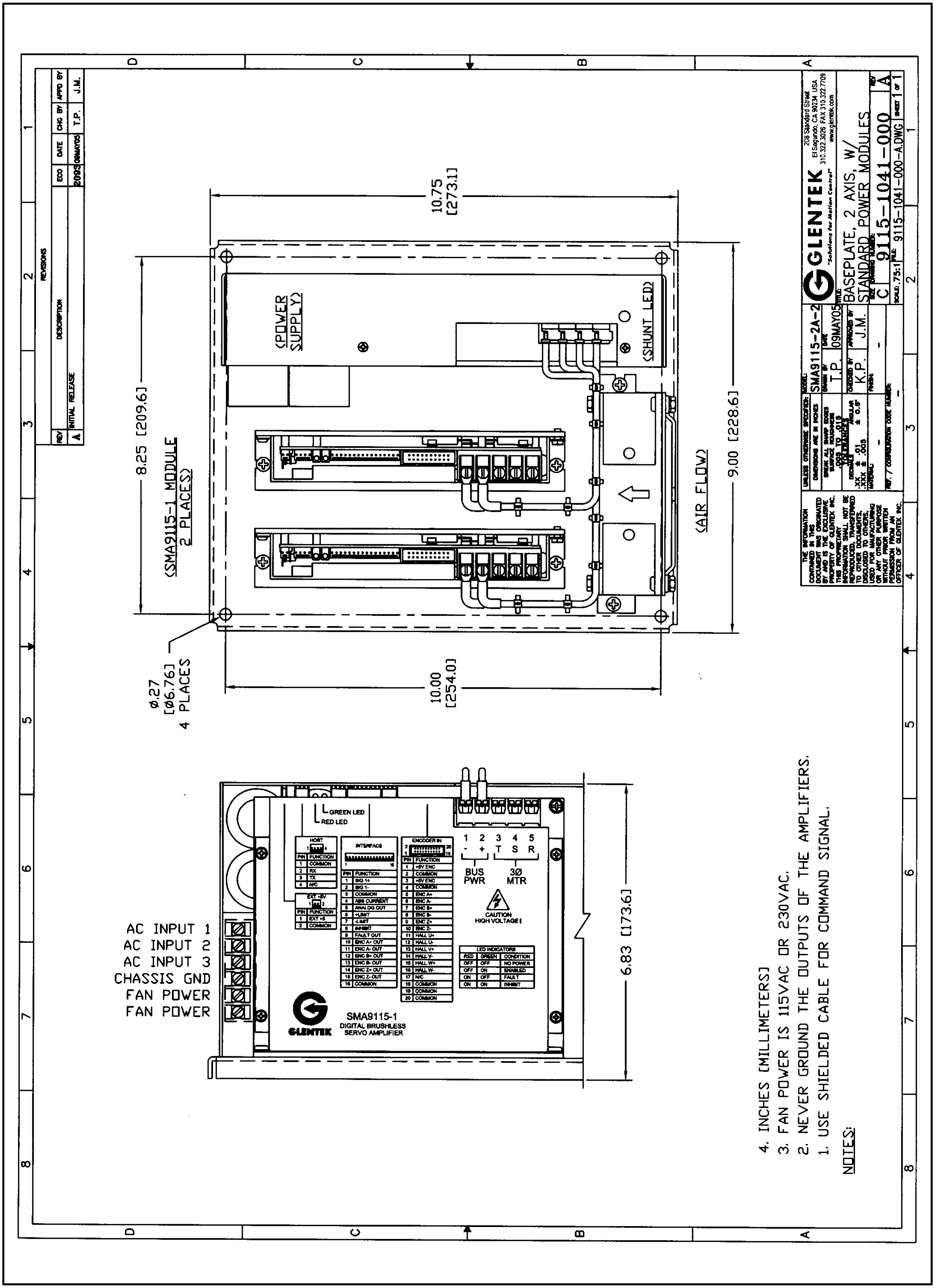

GLENTEK
"Solutions for Motion Control"
208 Standard Street
El Segundo, CA 90234 USA
310.322.3026 FAX 310.322.7709
www.glentek.com
MODULE,STANDARD OR LOW
POWER (W/ BACKPLATE)
C 9115-1045-000 A
SCALE: 1:1
9115-1045-000-A_PG1.DWG
SHEET 1 OF 2
SMA9115-XXX-1
T.P.
10MAY05
C.V.
J.M.
REVISIONS
INITIAL RELEASE
2093
10MAY05
T.P.
J.M.
6.00
[152.40]
1.38
[34.93]
#6-32UNC-2A SCREW
(FOR GROUNDING)
ø.50
[ø12.70]
2X, .19
[4.83]
6.38 [161.93]
6.75 [171.45]
7.13 [180.98]
.79 [19.94]
.19 [4.78]
BUS
PWR
3Ø
MTR
CAUTION
HIGH VOLTAGE!
LED INDICATORS
ENCODER IN
INTERFACE
HOST
EXT +5V
GREEN LED
RED LED
SMA9115-1
DIGITAL BRUSHLESS
SERVO AMPLIFIER


TRANSFORMER COUPLED AC INVERTER FOR ALL ISOLATED PWR
+5 VDC LOGIC PWR
±8 VDC OP_AMP PWR
+3.3 VDC PWR
ISOLATED 3 PHASE PWM OUTPUT CKTS
ISOLATED CURRENT SENSE CKTS
BUS INPUT
MOTOR OUTPUT
HIGH VOLTAGE
PHASE T
PHASE S
PHASE R
INTERFACE (cont.)
ENC_A
ENC_A*
ENC_B
ENC_B*
ENC_Z
ENC_Z*
COMMON
PWM CONTROL
CUR. SENSE
DSP CONTROL LOGIC
HOST
T2_OUT
R2_IN
12 BIT D/A CONVERTER
HALL LINE RECEIVER SN75175N
ENCODER LINE RECEIVER SN75175
SIG+
SIG−
(±10V MAX.)
ABS I
1V = 7.5A
ANALOG OUT
+LIMIT
−LIMIT
INHIBIT IN
FAULT OUTPUT
INTERFACE
HALL U
HALL U*
HALL V
HALL V*
HALL W
HALL W*
ENC_PWR
ENCODER IN
9115-1045-000
A

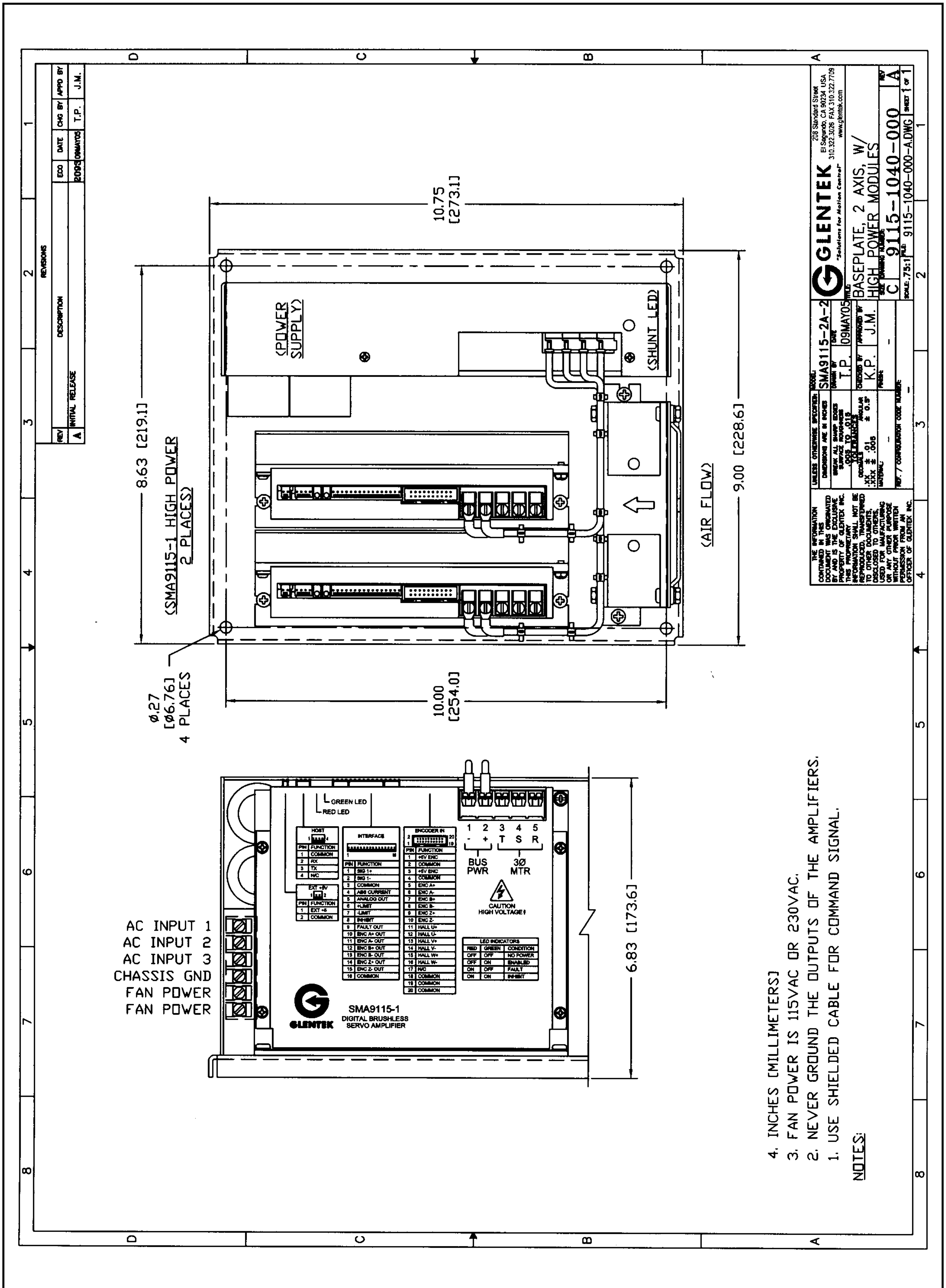

#6-32UNC-2A SCREW (FOR GROUNDING)
2.19 [55.68]
1.60 [40.69]
.19 [4.78]
6.11 [155.27]
6.38 [161.93]
7.13 [180.98]
.19 [4.83]
ø.50 [ø12.70]
BUS PWR
3Ø MTR
CAUTION HIGH VOLTAGE!
GREEN LED
RED LED
SMA9115-1
DIGITAL BRUSHLESS SERVO AMPLIFIER
GLENTEK
MODULE,HIGH POWER (W/ HEATSINK)
9115-1044-000
9115-1044-000-A_PG1.DWG
SMA9115-001-1
10MAY05
208 Standard Street
El Segundo, CA 90234 USA

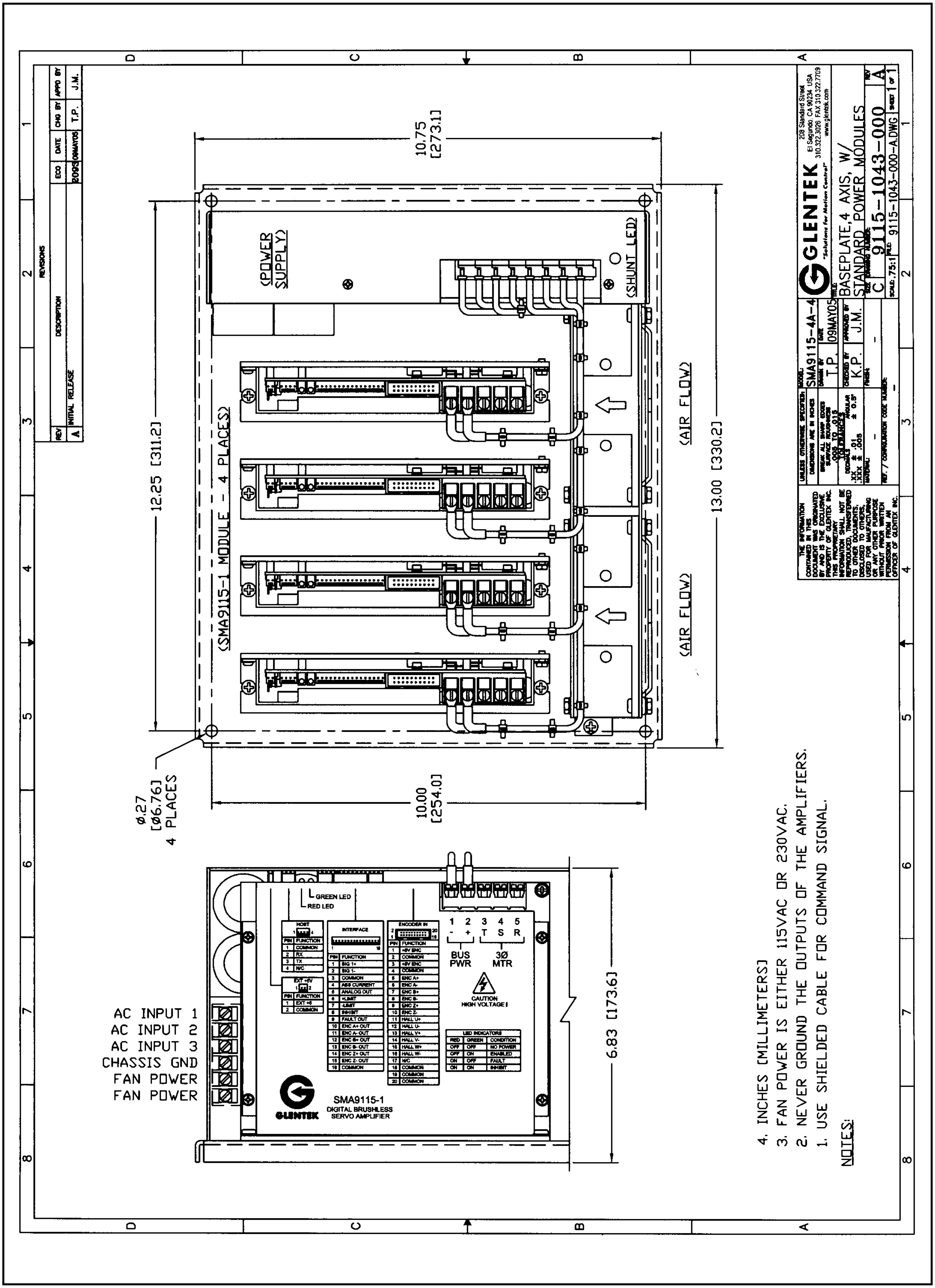


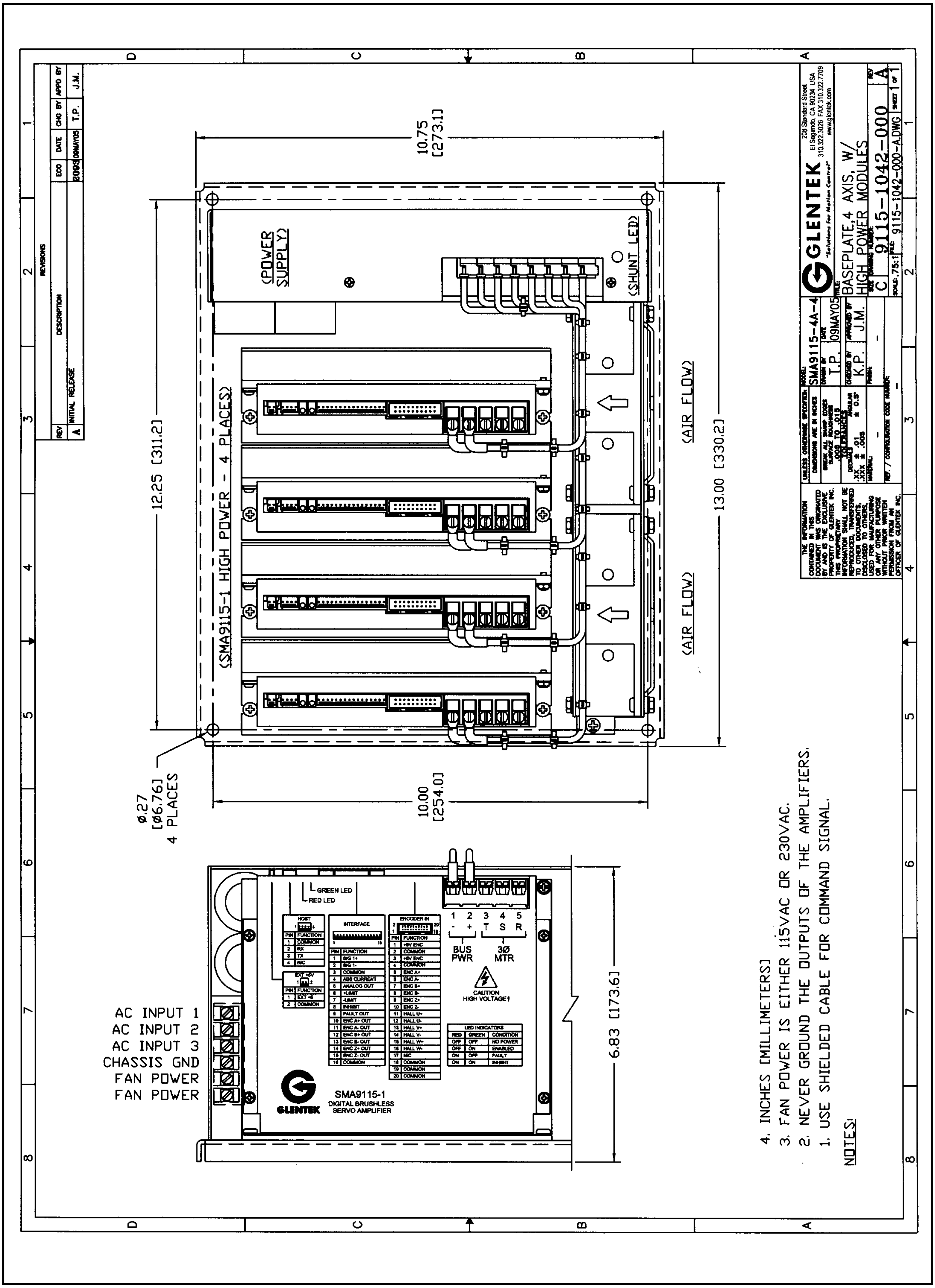
TRANSFORMER COUPLED AC INVERTER FOR ALL ISOLATED PWR
+5 VDC LOGIC PWR
±8 VDC OP_AMP PWR
+3.3 VDC PWR
ISOLATED 3 PHASE PWM OUTPUT CKTS
ISOLATED CURRENT SENSE CKTS
DSP CONTROL LOGIC
PWM CONTROL
CUR. SENSE
HIGH VOLTAGE
BUS INPUT
B-
B+
MOTOR OUTPUT
PHASE T
PHASE S
PHASE R
EXT +5V
EXT +5 VDC
COMMON
INTERFACE (cont.)
ENC_A
ENC_A*
ENC_B
ENC_B*
ENC_Z
ENC_Z*
ENCODER A OUT
ENCODER B OUT
ENCODER Z OUT
HOST
T2_OUT
R2_IN
HALL LINE RECEIVER SN75175N
ENCODER LINE RECEIVER SN75175
12 BIT D/A CONVERTER
PULL UP/DOWN SELECTION
SIG+
SIG-
(±10V MAX.)
ABS I
1V = 7.5A
ANALOG OUT
+LIMIT
-LIMIT
INHIBIT IN
FAULT OUTPUT
INTERFACE
HALL U
HALL U*
HALL V
HALL V*
HALL W
HALL W*
ENC_PWR
ENCODER IN
9115-1044-000
A



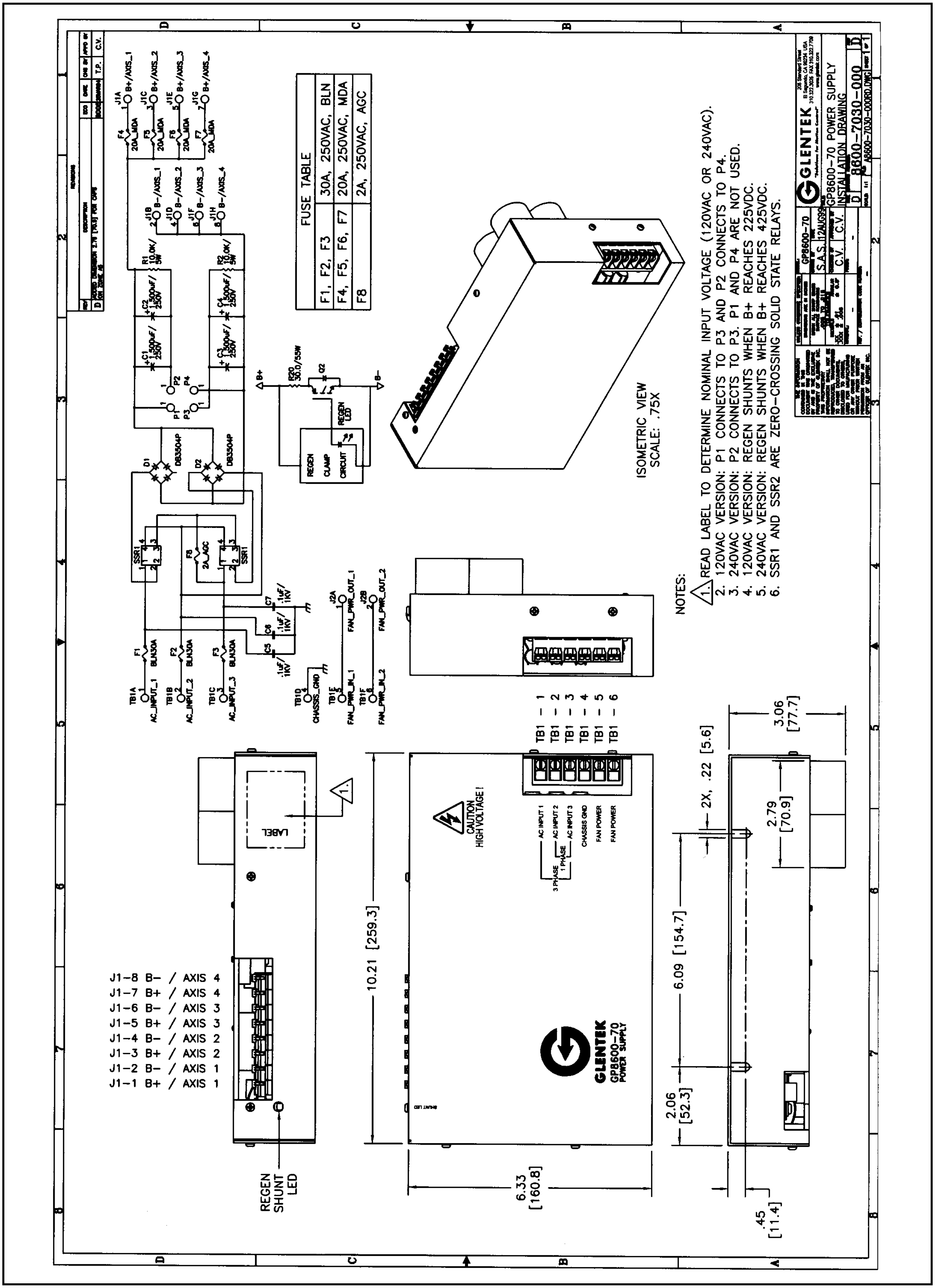
NOTES:
1. USE SHIELDED CABLE FOR COMMAND SIGNAL.
2. NEVER GROUND THE OUTPUTS OF THE AMPLIFIERS.
3. FAN POWER IS 115VAC OR 230VAC.
4. INCHES [MILLIMETERS]
10.75 [273.1]
8.25 [209.6]
9.00 [228.6]
10.00 [254.0]
6.83 [173.6]
Ø.27 [Ø6.76] 4 PLACES
(POWER SUPPLY)
(SHUNT LED)
(AIR FLOW)
(SMA9115-1 MODULE 2 PLACES)
AC INPUT 1
AC INPUT 2
AC INPUT 3
CHASSIS GND
FAN POWER
FAN POWER
GREEN LED
RED LED
BUS PWR
3Ø MTR
CAUTION HIGH VOLTAGE!
SMA9115-1
DIGITAL BRUSHLESS SERVO AMPLIFIER
GLENTEK
BASEPLATE, 2 AXIS, W/ STANDARD POWER MODULES
9115-1041-000
9115-1041-000-A.DWG
SMA9115-2A-2
T.P.
09MAY05
K.P.
J.M.
INITIAL RELEASE


10.75
[273.1]
8.63 [219.1]
9.00 [228.6]
10.00
[254.0]
6.83 [173.6]
Ø.27
[Ø6.76]
4 PLACES
(SMA9115-1 HIGH POWER
2 PLACES)
(POWER
SUPPLY)
(SHUNT LED)
(AIR FLOW)
AC INPUT 1
AC INPUT 2
AC INPUT 3
CHASSIS GND
FAN POWER
FAN POWER
GREEN LED
RED LED
BUS
PWR
3Ø
MTR
CAUTION
HIGH VOLTAGE!
SMA9115-1
DIGITAL BRUSHLESS
SERVO AMPLIFIER
GLENTEK
NOTES:
1. USE SHIELDED CABLE FOR COMMAND SIGNAL.
2. NEVER GROUND THE OUTPUTS OF THE AMPLIFIERS.
3. FAN POWER IS 115VAC OR 230VAC.
4. INCHES [MILLIMETERS]
GLENTEK
"Solutions for Motion Control"
208 Standard Street
El Segundo, CA 90234 USA
310.322.3026 FAX 310.322.7709
www.glentek.com
SMA9115-2A-2
T.P.
09MAY05
K.P.
J.M.
BASEPLATE, 2 AXIS, W/
HIGH POWER MODULES
C
9115-1040-000
A
9115-1040-000-A.DWG
REVISIONS
A
INITIAL RELEASE
2093
09MAY05
T.P.
J.M.


REVISIONS
REV
DESCRIPTION
ECO
DATE
CHG BY
APPD BY
A
INITIAL RELEASE
09MAY05
T.P.
J.M.
10.75
[273.1]
12.25 [311.2]
13.00 [330.2]
10.00
[254.0]
6.83 [173.6]
Ø.27
[Ø6.76]
4 PLACES
(POWER SUPPLY)
(SHUNT LED)
(SMA9115-1 MODULE - 4 PLACES)
(AIR FLOW)
(AIR FLOW)
AC INPUT 1
AC INPUT 2
AC INPUT 3
CHASSIS GND
FAN POWER
FAN POWER
GREEN LED
RED LED
HOST
INTERFACE
ENCODER IN
EXT +5V
BUS
PWR
3Ø
MTR
CAUTION
HIGH VOLTAGE!
LED INDICATORS
SMA9115-1
DIGITAL BRUSHLESS
SERVO AMPLIFIER
GLENTEK
NOTES:
1. USE SHIELDED CABLE FOR COMMAND SIGNAL.
2. NEVER GROUND THE OUTPUTS OF THE AMPLIFIERS.
3. FAN POWER IS EITHER 115VAC OR 230VAC.
4. INCHES [MILLIMETERS]
GLENTEK
"Solutions for Motion Control"
208 Standard Street
El Segundo, CA 90245 USA
BASEPLATE,4 AXIS, W/
STANDARD POWER MODULES
SMA9115-4A-4
T.P.
09MAY05
K.P.
J.M.
C
9115-1043-000
A
9115-1043-000-A.DWG



NOTES:
1. USE SHIELDED CABLE FOR COMMAND SIGNAL.
2. NEVER GROUND THE OUTPUTS OF THE AMPLIFIERS.
3. FAN POWER IS EITHER 115VAC OR 230VAC.
4. INCHES [MILLIMETERS]
GLENTEK
BASEPLATE, 4 AXIS, W/ HIGH POWER MODULES
9115-1042-000
SMA9115-4A-4
(SMA9115-1 HIGH POWER - 4 PLACES)
(POWER SUPPLY)
(SHUNT LED)
(AIR FLOW)
10.75 [273.1]
12.25 [311.2]
13.00 [330.2]
10.00 [254.0]
6.83 [173.6]
ø.27 [ø6.76] 4 PLACES
AC INPUT 1
AC INPUT 2
AC INPUT 3
CHASSIS GND
FAN POWER
FAN POWER
SMA9115-1
DIGITAL BRUSHLESS SERVO AMPLIFIER


FUSE TABLE
F1, F2, F3 30A, 250VAC, BLN
F4, F5, F6, F7 20A, 250VAC, MDA
F8 2A, 250VAC, AGC
NOTES:
1. READ LABEL TO DETERMINE NOMINAL INPUT VOLTAGE (120VAC OR 240VAC).
2. 120VAC VERSION: P1 CONNECTS TO P3 AND P2 CONNECTS TO P4.
3. 240VAC VERSION: P2 CONNECTS TO P3. P1 AND P4 ARE NOT USED.
4. 120VAC VERSION: REGEN SHUNTS WHEN B+ REACHES 225VDC.
5. 240VAC VERSION: REGEN SHUNTS WHEN B+ REACHES 425VDC.
6. SSR1 AND SSR2 ARE ZERO-CROSSING SOLID STATE RELAYS.
ISOMETRIC VIEW
SCALE: .75X
J1-8 B- / AXIS 4
J1-7 B+ / AXIS 4
J1-6 B- / AXIS 3
J1-5 B+ / AXIS 3
J1-4 B- / AXIS 2
J1-3 B+ / AXIS 2
J1-2 B- / AXIS 1
J1-1 B+ / AXIS 1
REGEN SHUNT LED
LABEL
CAUTION HIGH VOLTAGE!
GLENTEK GP8600-70 POWER SUPPLY
TB1 - 1
TB1 - 2
TB1 - 3
TB1 - 4
TB1 - 5
TB1 - 6
10.21 [259.3]
6.33 [160.8]
6.09 [154.7]
2.06 [52.3]
2X, .22 [5.6]
2.79 [70.9]
3.06 [77.7]
.45 [11.4]
REGEN CLAMP CIRCUIT
GP8600-70 POWER SUPPLY INSTALLATION DRAWING
B8600-7030-000

NOTES

Omega Series Digital PWM Brushless Servo Amplifiers

- PWM (Pulse-Width-Modulated) Brushless servo amplifiers to 20KW

Analog Brush Type Servo Amplifiers

- Linear Brush type servo amplifiers to 2.6KW
- PWM (Pulse-Width-Modulated) Brush type servo amplifiers to 28KW

Analog Brushless Servo Amplifiers

- Linear Brushless servo amplifiers to 3.5KW
- PWM (Pulse-Width-Modulated) Brushless servo amplifiers to 51KW

Permanent Magnet DC Brush Type Servo Motors

- Continuous Torques to 335 in. lb.
- Peak Torques to 2100 in. lb.

Permanent Magnet DC Brushless Servo Motors

- Continuous Torques to 1100 in. lb.
- Peak Torques to 2200 in. lb.

GLENTEK
"Solutions for Motion Control"

MANUAL#: 9115-3040-000
REVISION: (A)
DATE: 1 July 2005

208 Standard Street, El Segundo, California 90245, USA.
Telephone: (310) 322-3026; Fax: (310) 322-7709
www.glentek.com e-mail sales@glentek.com

CE