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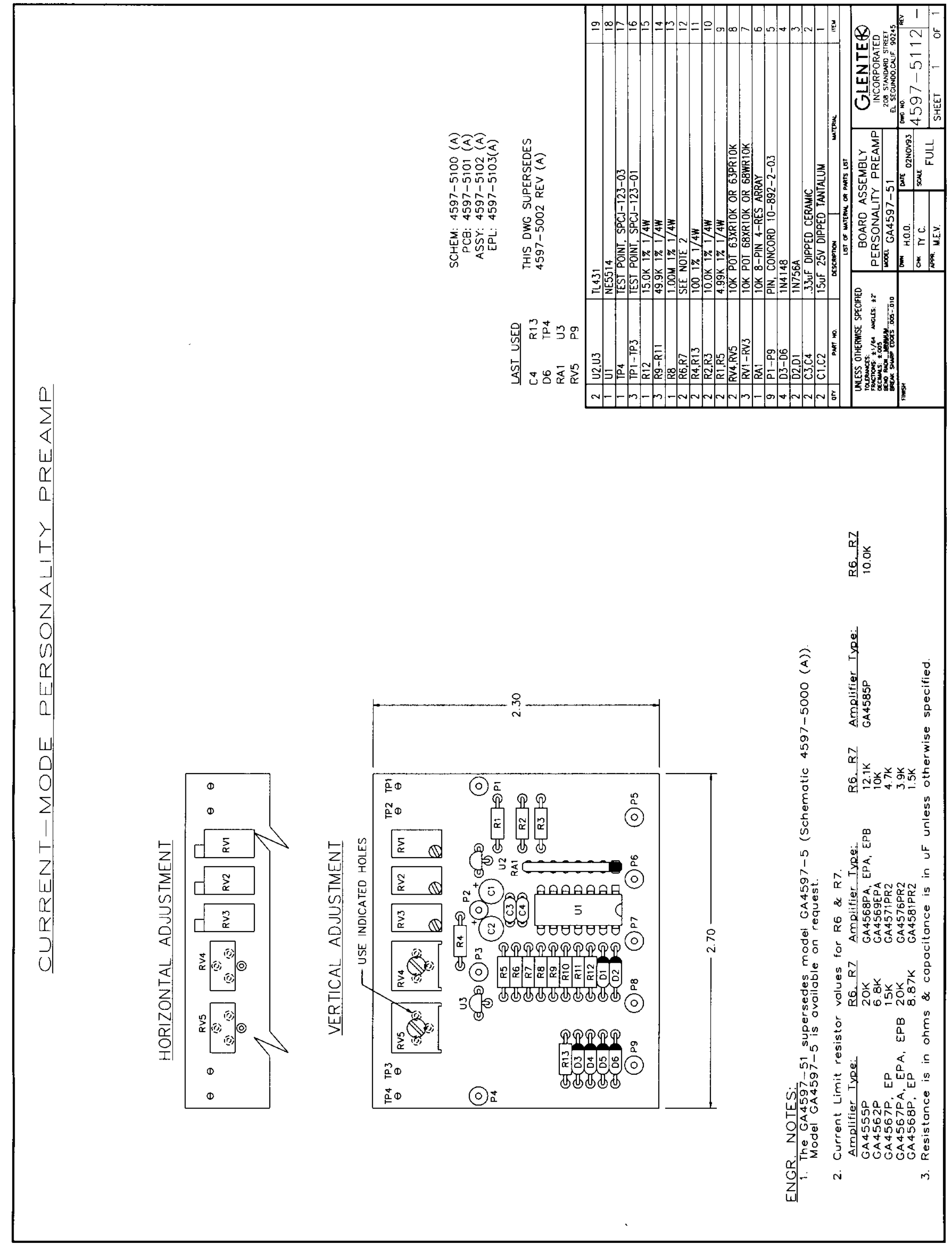
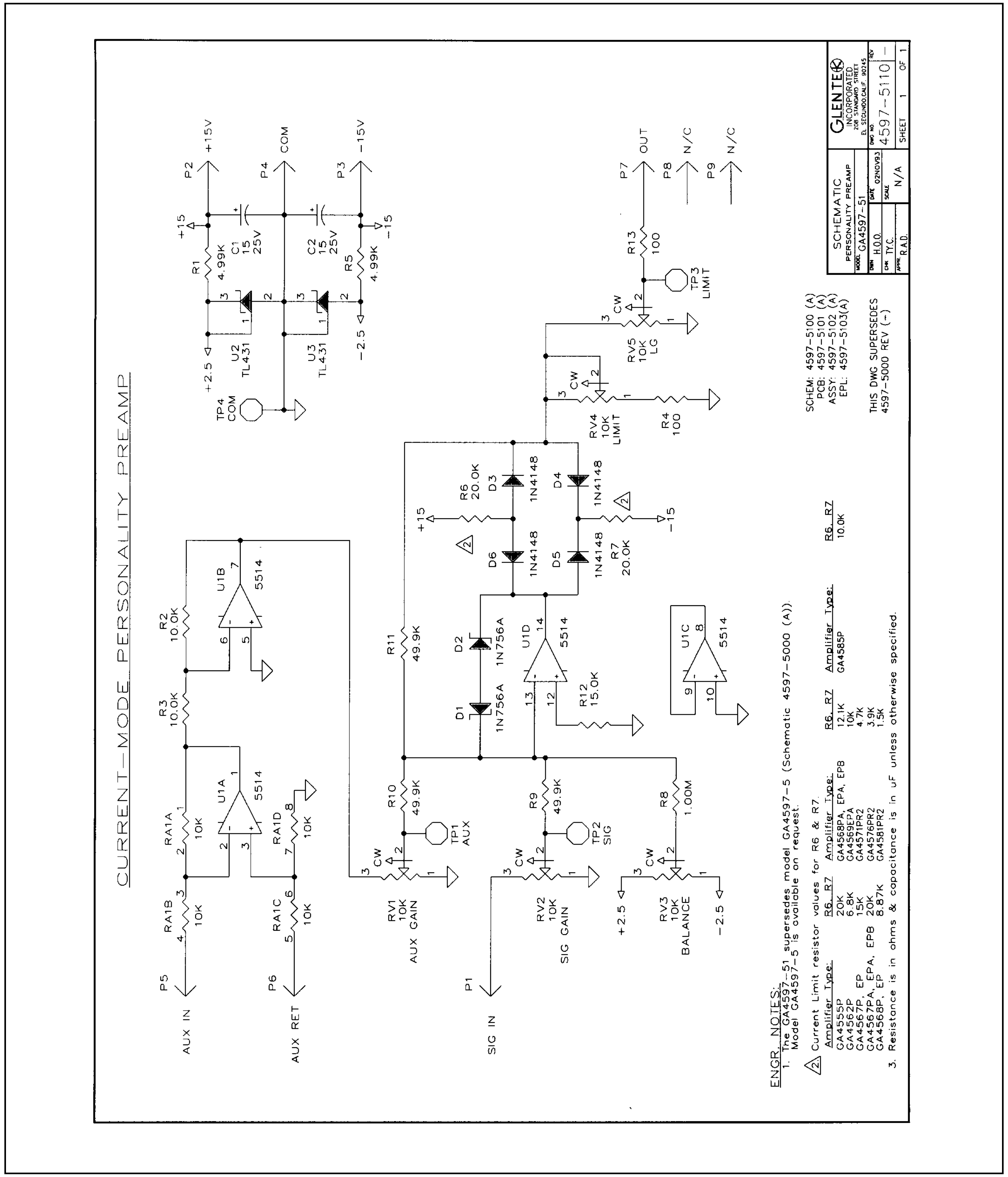
CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION TO THE GA4569EPA MANUAL:

This manual is intended for use with Glentek's TORQUE-SWITCH™ series, model GA4569EPA, pulse-width modulated (PWM), servo amplifiers. It provides all of the information that is required for installation, alignment, and maintenance of the GA4569EPA. We suggest that you take the time to read this manual from cover to cover before trying to work with a GA4569EPA amplifier. If you have any questions that you cannot find the answer to in this manual, please feel free to call and discuss your problem or question with a Glentek applications engineer. Having been in the servo system business for over 35 years, we have a vast pool of applications knowledge waiting to help you.

Thank you for using Glentek's products. It is our goal to save you money, time, and provide you with a superior product.





CHAPTER TWO: DESCRIPTION

2.1 DESCRIPTION OF THE GA4569EPA:

The GA4569EPA is modular, high power, high bandwidth, PWM, servo amplifier designed for use with DC, permanent-magnet, servo motors. The GA4569EPA utilizes today's latest technology in power semiconductors for high efficiency, which in turn makes the amplifiers extremely reliable in today and tomorrow's demanding applications.

2.2 AVAILABLE OPTIONS AND MODEL NUMBERING INFORMATION:

2.2.1 SIGNAL INPUT: The GA4569EPA has two signal inputs: one single-ended and one differential. The differential input is marked Aux., and Aux. Ret., and may be connected single-ended by grounding Aux. Ret. (Refer to Appendix C, drawings 4597-7010 or 4597-5110).

2.2.2 VELOCITY-MODE OR CURRENT-MODE OPTIONS: The GA4569EPA is most often used to close a critically-damped velocity-loop using a DC tachometer for velocity feedback. However, this high-gain, summing amplifier can be bypassed to provide an input directly to the current-loop amplifier. (Refer to Appendix C, drawings 4597-7010 & 4597-7012).

If the amplifier is ordered with the current mode option, the dedicated Current Mode Personality Preamp Card will be used. (Refer to Appendix C, drawings 4597-5110 & 4597-5112)

2.2.3 VELOCITY-TAPER CURRENT-LIMIT OPTION: The Velocity-Taper Current-Limit (VTCL) option limits the maximum available motor current in proportion to the motor RPM. This protects the motor and amplifier from commutator arcing at high RPM. Refer to section 2.3.7 for additional information. Consult a Glentek applications engineer to optimize the VTCL to your application.

2.2.4 + AND - LIMITS: The GA4569EPA may be configured for four different end-of-travel limit circuits (refer to Appendix B, drawing 4569-3400 for implementation):

Type A: Requires grounding of pin 8 or pin 9 to disable amplifier.

Type B: Requires a positive voltage at pin 8 or pin 9 to disable amplifier.

Type C: Requires grounding of pin 8 or pin 9 to enable amplifier.

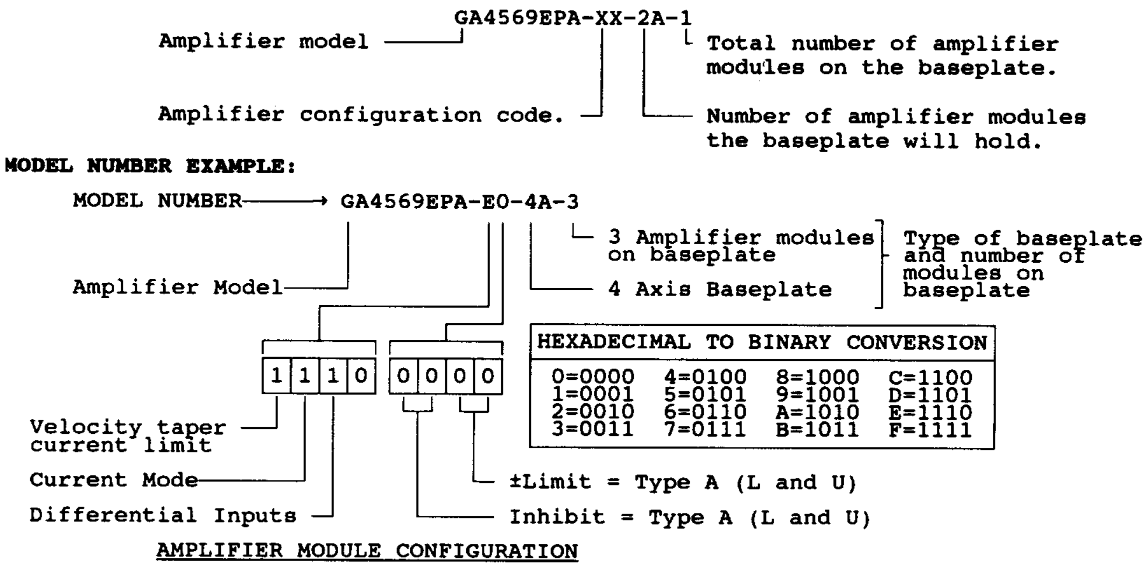
Type D: Requires a positive voltage at pin 8 or pin 9 to enable amplifier.

The amplifier is normally shipped with the type A + and - Limit configuration.

2.2.5 TOTAL INHIBIT: The GA4569EPA may be configured for four different Total Inhibit circuits (See 2.2.3 + AND - LIMITS above, and refer to drawings 4569-3400). The amplifier is normally shipped with type "A" Total Inhibit.

2.2.6 MODEL NUMBERING: The following example of a GA4569EPA part number is provided to help you better understand Glentek's part-numbering system:

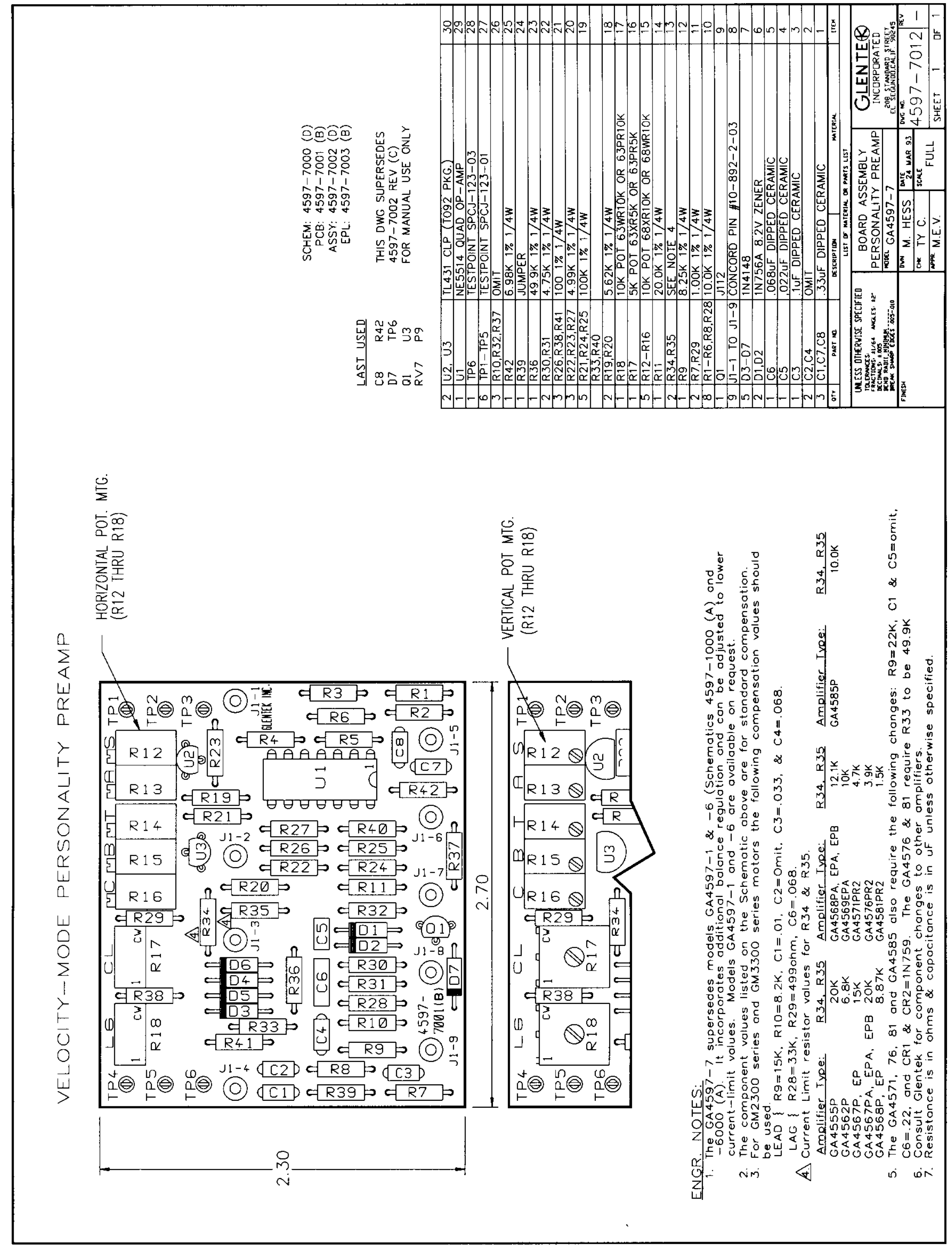
The following is a list of the standard baseplate amplifier combinations.

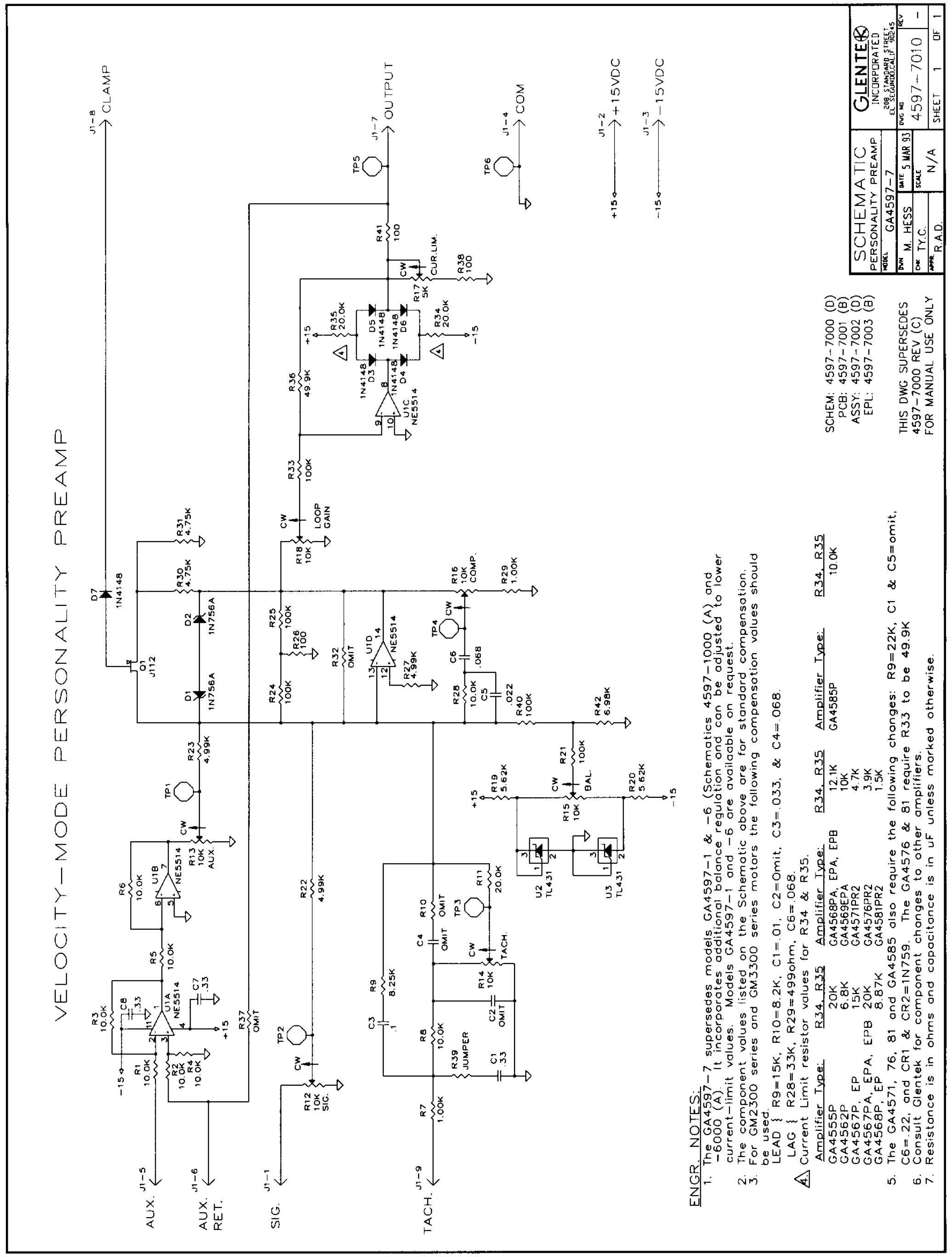


GA4569EPA-1	Single amplifier module.
GA4569EPA-2A-1	Two axis chassis with one amplifier module.
GA4569EPA-2A-2	Two axis chassis with two amplifier modules.
GA4569EPA-4A-3	Four axis chassis with three amplifier modules.
GA4569EPA-4A-4	Four axis chassis with four amplifier modules.
GA4569EPA-6A-5	Six axis chassis with five amplifier modules.
GA4569EPA-6A-6	Six axis chassis with six amplifier modules.

LOGIC-INPUT CONFIGURATION:

There are four logic inputs: + Limit, - Limit, Inhibit, and Fault. The first three may be configured for active-high or active-low signals, and pulled-up or pulled-down termination (type A, B, C, and D). The fault is always active-low and pulled-up (type A). All the logic inputs on the GA4569EPA have a + 15 range only.

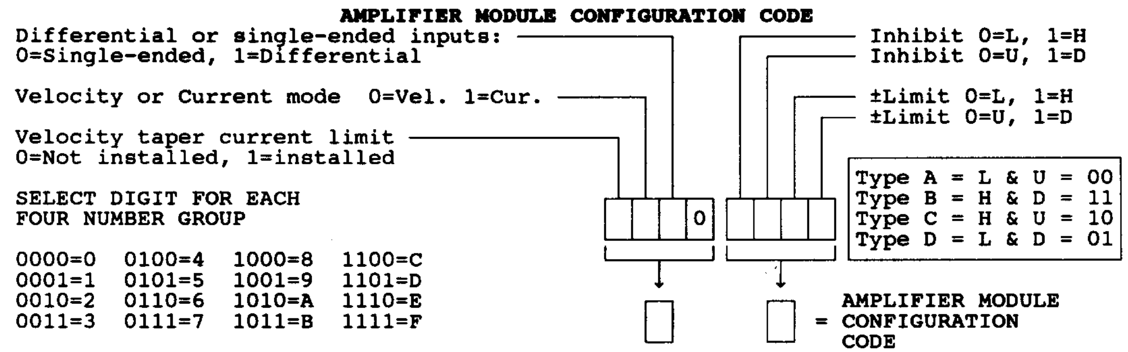




Type A: Requires grounding of input to disable the amplifier (pull-up, active-low).
Type B: Requires a positive voltage at input to disable the amplifier (pull-down, active-high).
Type C: Requires grounding of input to enable the amplifier (pull-up, active-high).
Type D: Requires a positive voltage at input to enable the amplifier (pull-down, active-low).

The two digits of the configuration code set amplifier options, such as the inhibit configuration. Most of these options are user-configurable. If you desire Glentek to pre-configure your amplifier, a configuration code may be constructed as shown below.

When constructing the configuration code, choose the desired configuration for each option and enter a "0" or a "1" in the box provided. When all the boxes are filled, convert the 8-digit number to a 2-digit number using the table provided.



2.3 PROTECTION CIRCUITS:

The following protection circuits are integral to the GA4569EPA amplifier to prevent damage to the amplifier or your equipment. Again, Glentek is anxious to work with you in helping to implement any circuit functions your system might require. Note: For sections 2.3.1 to 2.3.6, refer to Appendix B, drawing 4569-3400.

2.3.1 DRIVE INHIBIT INDICATOR OPERATION (RED LED): The Drive Inhibit LED indicator light (D21) will turn ON and latch for any of the following conditions:

1. Transistor heatsink temperature in excess of 170^0F (77^0C)
2. Low-Speed Electronic Circuit Breaker (LS/ECB) triggered.
3. High-Speed Electronic Circuit Breaker (HS/ECB) triggered.

The Drive-Inhibit indicator light will also turn ON and OFF with the Total-Inhibit input signal (TB1-10). This is a non-latched condition.

2.3.2 LOW-SPEED ELECTRONIC CIRCUIT BREAKER (RED LED): The LS/ECB LED indicator light (D24) will turn ON and latch indicating that the Low-Speed Electronic Circuit Breaker (LS/ECB) has fired. This circuit protects the motor, amplifier, and mechanical system from damage due to excessive mechanical bind in the system or possibly driving into a hard mechanical stop. Circuit operation is as follows:

When the motor current exceeds the value set at TP16, typically 2 VDC (scale factor 1 VOLT= 15 AMPS), U9C switches positive and the voltage on C35 begins integrating up. If the current remains above the set point, typically 1.5 seconds, U9D will trigger the LS/ECB latch and the Drive Inhibited indicator.

2.3.3 HIGH-SPEED ELECTRONIC CIRCUIT BREAKER (RED LED): The HS/ECB LED indicator light (D23) will turn ON and latch, indicating that the High-Speed Electronic Circuit Breaker (HS/ECB) has fired. This circuit protects the amplifier from dead shorts across the amplifier output terminals. The HS/ECB is always factory set and can not be adjusted. The typical factory setting is 121 amps for 10 micro-seconds. Again, this circuit triggers the HS/ECB latch and the Drive-Inhibited indicator.

2.3.4 TEMP INDICATOR OPERATION (RED LED): The Temperature LED indicator light (D22) will turn ON and latch when the transistor heatsink temperature exceeds 170^{0}F (77^{0}C). This condition will also latch the Drive Inhibited indicator.

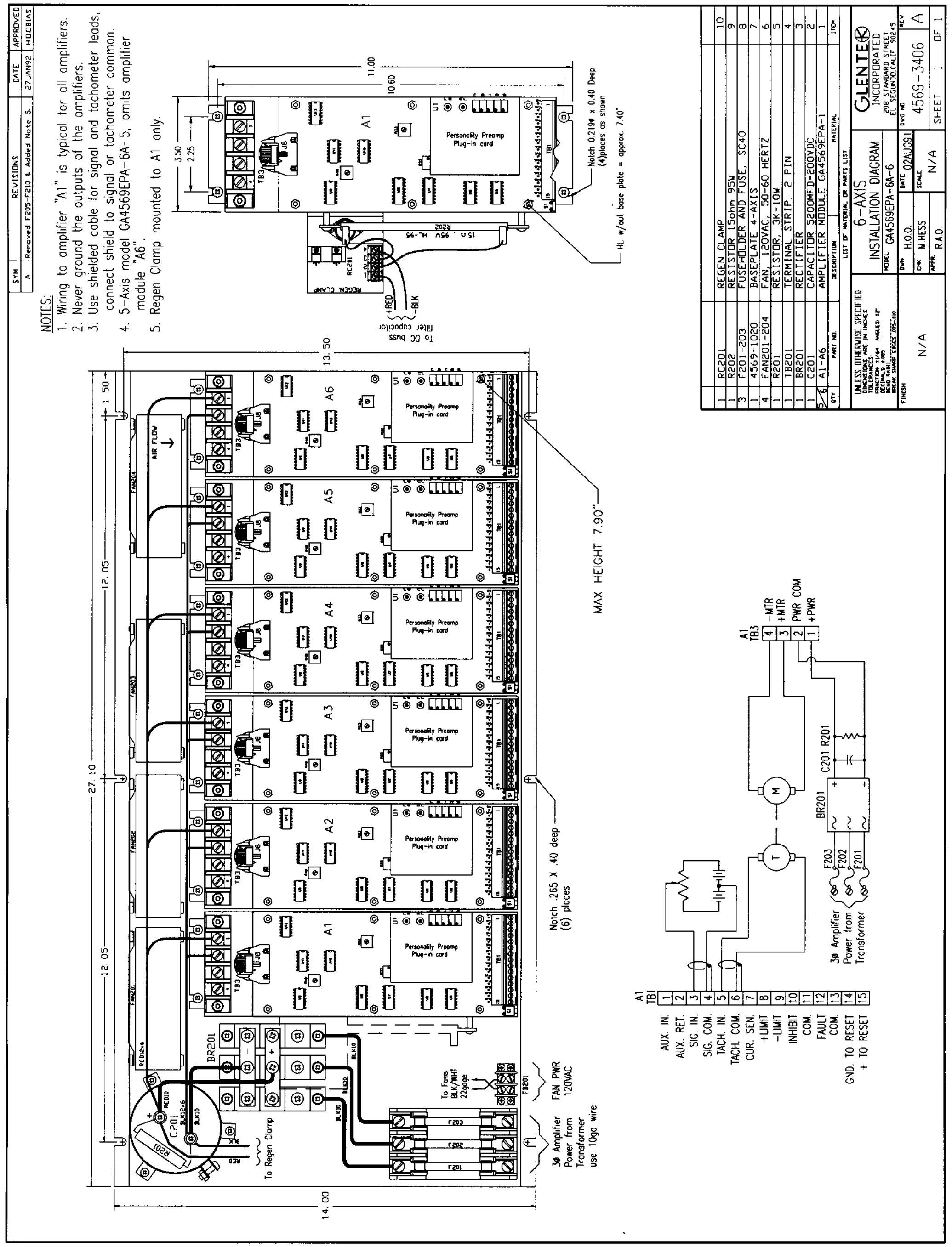
2.3.5 POWER SUPPLY MONITOR: The amplifier will automatically shut-down if the on-board, low-voltage power supplies cannot maintain proper operating voltages. This is a non-latched condition.

2.3.6 DC BUSS VOLTAGE REGEN' CLAMP & RESISTOR: These components are mounted on amplifier module A1. They function to keep DC Buss voltage surges below 170 VDC, protecting the amplifier and DC Buss capacitor from over-voltage.

2.3.7 VELOCITY-TAPER CURRENT-LIMIT: Motor specifications often include a SOA (Safe Operating Area) curve which is maximum motor current as a function of RPM (See figure 2.3.7). The optional VTCL (Velocity-Taper Current-Limit) ensures that the maximum available motor current is within SOA limits. Below maximum, the motor current is still controlled by the velocity-error (or current-command) signal. The VTCL may decrease the rate of acceleration and deceleration. Consult a Glentek applications engineer before ordering.

APPENDIX C

PERSONALITY PREAMP



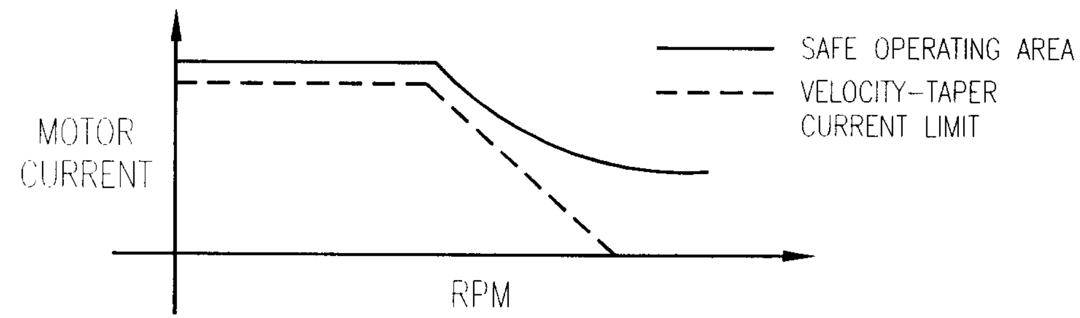


Figure 2.3.7

2.4 SPECIFICATIONS

The specifications for each GA4569EPA amplifier module are as follows:

2.4.1 OUTPUT POWER

PEAK OUTPUT CURRENT:	+/- 60ADC
RMS OUTPUT CURRENT:	+/- 30ADC
OUTPUT VOLTAGE (Typical):	+/- 60VDC to +/- 150VDC

Note: Off-line operation and/or buss voltages to 350VDC are available. Consult Glentek. Buss voltage should be selected to be 10% to 20% above the maximum voltage required at the motor terminals for maximum system efficiency.

2.4.2 INPUT POWER:

DC BUSS (Typical):	65VDC to 170VDC
DC BUSS (Maximum):	200VDC (See note above)

A fused, single- or three-phase, full-wave rectifier and filter capacitor are provided on the baseplate to supply the DC BUSS voltage. The AC input to this circuit is usually supplied by a separately mounted power transformer unique to the application. The power transformer and motor output inductors are not standard parts of the amplifier package. Glentek has power transformers and inductors in stock to meet your system requirements.

INPUT POWER FOR FANS:	120 VAC, 50/60 Hz @ 1 AMP

2.4.3 SIGNAL INPUTS:

VOLTAGE, MAXIMUM

Aux. Input:	± 13 volts.
Sig. Input and Tach. input:	± 70 volts.
Input impedance, minimum:	10K ohms.

GAIN, MAXIMUM

Sig., and Aux., Inputs:	15,000 amps/volt.
Tachometer:	7,000 amps/volt.
Drift (ref., to input), maximum:	0.01 mV/°C.
Frequency response, minimum:	750 Hz.
Dead band:	none.
Form factor:	1.01.

2.4.4 OTHER INPUTS AND OUTPUTS

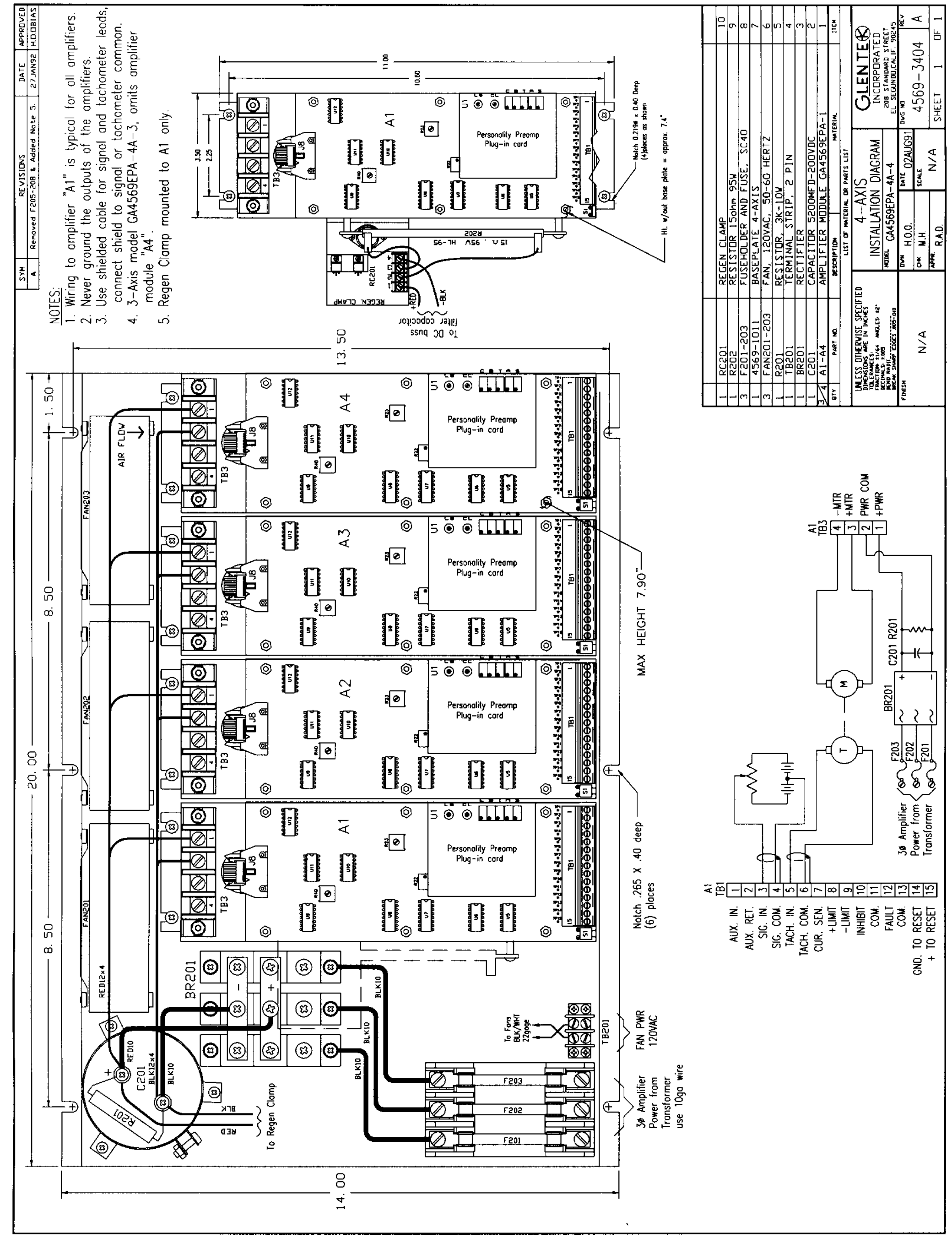
+ and - Limits (type “A”):	Activated by a 2mA contact closure to common.
Total Inhibit (Type “A”):	Activated by a 2mA contact closure to common.
Fault Monitor:	Ground on fault. Open collector transistor can sink 500mA max. Output is pulled up to 15V by 5K ohms.
Ground to Reset	Activated by a 15mA contact closure to common.
+ to Reset	Activated by 10 to 15VDC, 1 mA max.

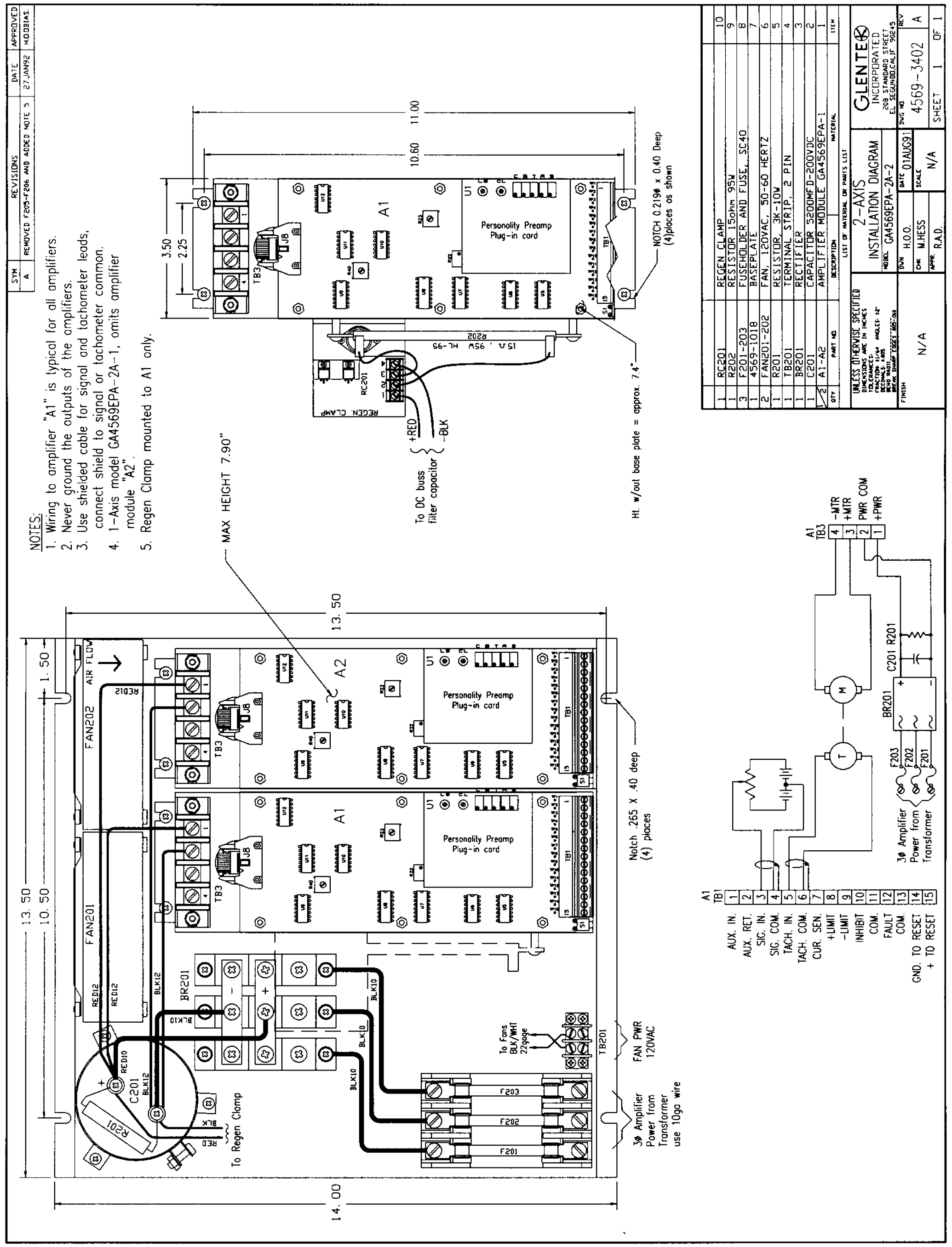
2.4.6 MECHANICAL (SEE APPENDIX B4-B6)

Mounting:	Any Position.	
Cooling:	122^{0}F (50°C) ambient max.	
Baseplate:	GA4569EPA-1	6 lbs.
	GA4569EPA-2A-210.5 in. x 14.0 in. x 8in.	26lbs.
	GA4569EPA-4A-420.0 in. x 14.0 in. x 8in.	421lbs.
	GA4569EPA-6A-627.1 in. x 14.0 in. x 8in.	58lbs.

2.4.6 TYPICAL FACTORY SETTINGS

Sig. and Aux. Gain:	5V(Sig.)/7V(Tach)	Comp:	CW (mm. bandwidth).
Tach. Gain:	50%	LS/ECB:	30A @ 1.5 sec.
Loop Gain:	CCW (OFF)	HS/ECB:	121A @ 10 micro-sec.





CHAPTER THREE: PERSONALITY PREAMP CARD

3.1 INTRODUCTION TO THE PERSONALITY PREAMP CARD:

The Personality Preamp card is a modular plug-in card that comes in two versions: velocity mode and current mode. Schematic and board-assembly prints for these cards are found in Appendix C, drawing numbers 4597-7010, 4597-7012, 4597-5110, 4597-5112 and will be referred to in the following description.

The Personality card contains the main high-gain preamp with all associated system alignment adjustments. This card greatly enhances system trouble shooting and repair. If an amplifier should fail, simply remove the Personality card (which has all of the original system constants adjusted in) and replace it on a spare amplifier. This eliminates system realignment when changing out amplifiers. Also, a motor-tach-load may be aligned at the factory and then just the Personality card sent to the field for system test.

3.1.1 VELOCITY-MODE PERSONALITY PREAMP CARD: The Velocity-Mode Preamp card contains the main high-gain preamp with all the associated system alignment adjustments to close a velocity loop using a D.C. tachometer for velocity feedback (Refer to Appendix C, drawings 4597-70 10 and 4597-7012).

3.1.2 CURRENT-MODE PERSONALITY PREAMP CARD: The Current-Mode Personality card contains all the system alignment adjustments to control a current-mode amplifier (Refer to Appendix C, drawings 4597-5110 and 4597-5112).

3.2 DESCRIPTION OF OPTIONS AND ADJUSTMENTS:

The Personality Preamp card is a small printed-circuit card (2.7" x 2.3") standing on nine pins (0.6" long) that mate with appropriate sockets on the amplifier control board.

The Personality card is most often used to close a velocity loop by using a DC tachometer for velocity feedback. However, the high-gain, summing amplifier can be bypassed providing an input directly to the current-loop amplifier (Current-Mode option). If the Current-Mode (CM) option is specified, the committed Current-Mode Personality Preamp card will be supplied.

3.2.1 POTENTIOMETER ADJUSTMENTS: The following is a description of the potentiometer adjustments used for the two modes of operation. Please refer to Chapter Six on Start Up and Adjustment Procedures for a detailed description of how to set these potentiometers.

VELOCITY MODE: (Refer to Appendix C, drawings 4597-7010 and 4597-7012)

R12 - **Signal-Gain** potentiometer sets the input voltage to output RPM required by your system for the single-ended input (e.g. 10 volt input = 2000 RPM).

R13 - **Auxiliary Signal-Gain** potentiometer sets the input voltage to output RPM required by your system for the differential signal input (e.g. 10 volt input 2000 RPM).

R14 - **Tachometer-Gain** potentiometer sets the amount of tach' signal required by your system. Use in conjunction with the Compensation potentiometer, R16, to adjust the system bandwidth.

R15 - **Balance** potentiometer is used to null out any DC offset in the amplifier (e.g. 0 volt input = 0 RPM).

R16 - **Compensation** potentiometer sets the amount of bandwidth (frequency response) required by your system. Use in conjunction with the Tachometer-Gain potentiometer, R14, to adjust the system bandwidth.

R17 - **Current-Limit** potentiometer sets the maximum acceleration and deceleration current.

R18 - **Loop-Gain** potentiometer is used to reduce the velocity-loop gain to zero when the system is first turned on to prevent run away operation. Before turning the system on for the first time, this potentiometer is set fully CCW to command zero current to the motor. Once the system is correctly phased this potentiometer is set fully CW for all further system adjustments.

CURRENT MODE: (Refer to Appendix C, drawings 4597-5110 and 4597-5112)

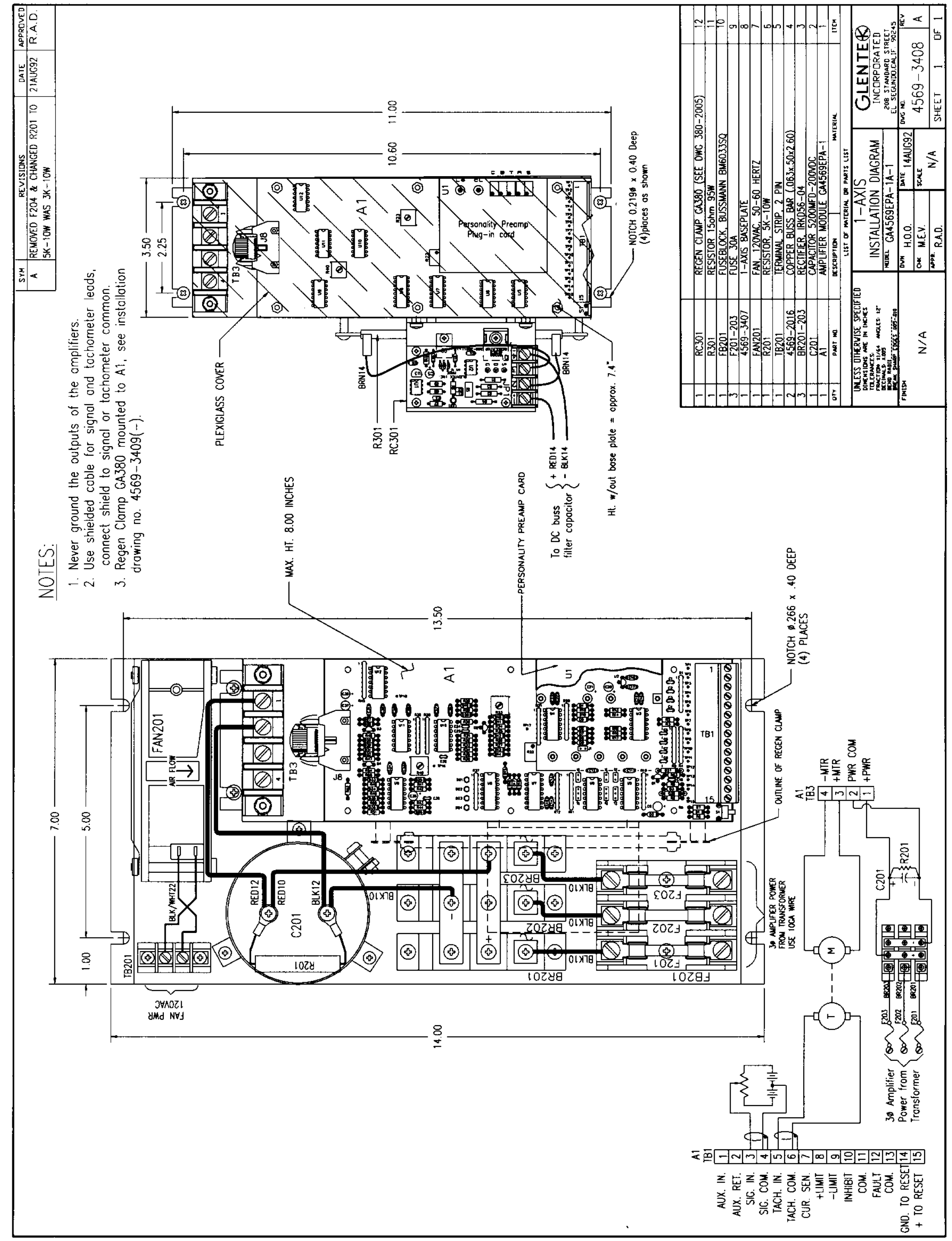
R14 - **Signal-Gain** potentiometer sets the input voltage to output current required by your system for the single-ended input (e.g. 5 volt input = 20 amp output current).

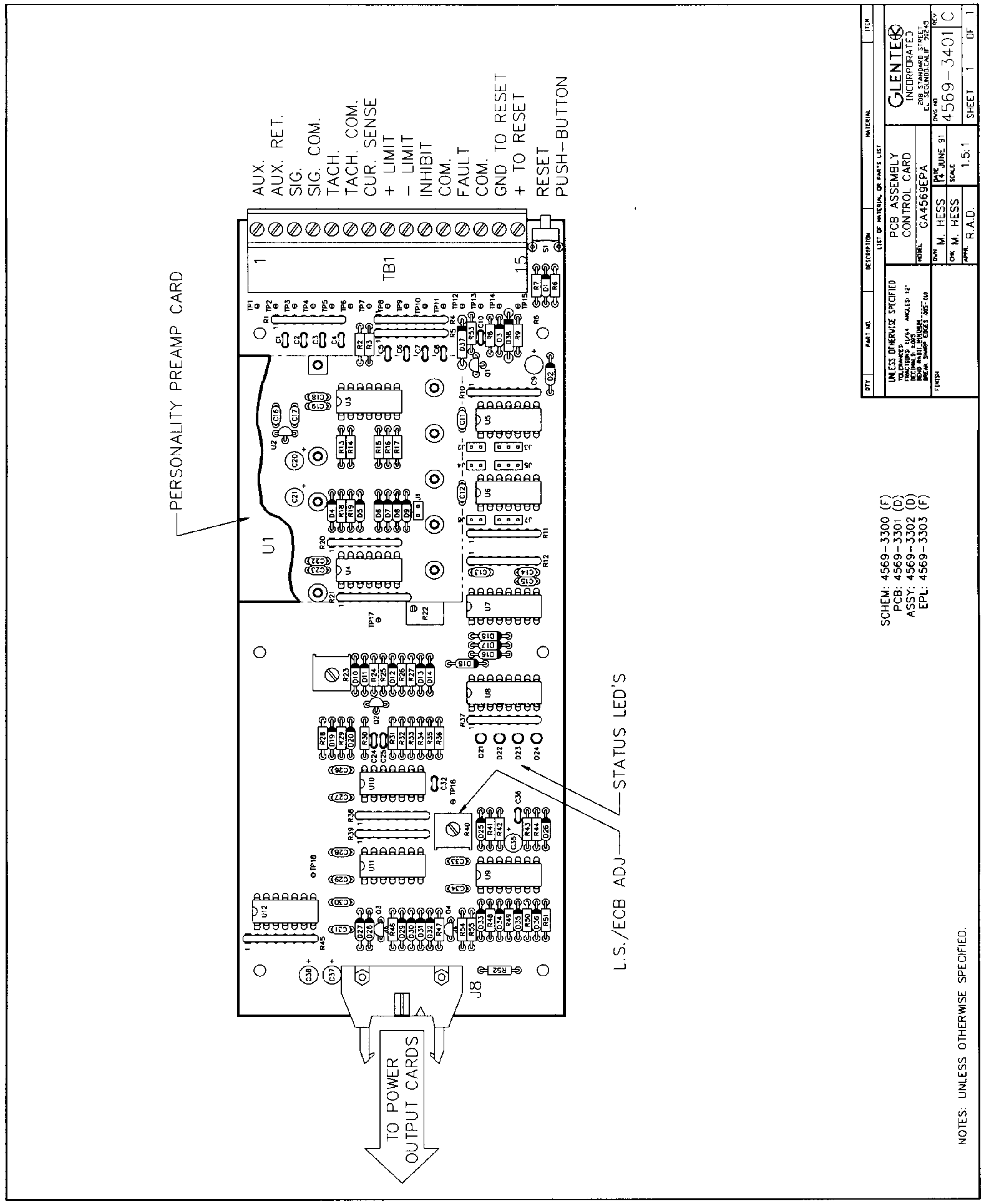
R15 - **Auxiliary Signal-Gain** potentiometer sets the input voltage to output RPM required by your system for the differential signal input (e.g. 5 volts input = 20 amps current).

R16 - **Current-Limit** potentiometer sets the maximum acceleration and deceleration current.

R17 - **Loop-Gain** potentiometer is factory set to prevent amplifier maximum rated current from being exceeded when the current-limit potentiometer is fully CW.

R21 - **Balance** potentiometer is used to null out any DC offset in the amplifier (e.g. 0 volts input = 0 current output)





3.2.2 INPUT AND OUTPUT SIGNALS ON PERSONALITY CARD:

Pin No.		
1	SIGNAL:	Single-ended signal input.
2	+ 15 VDC:	+ 15 VDC power.
3	- 15 VDC:	- 15 VDC power.
4	COMMON:	+/- 15 VDC and signal common.
5	AUXILIARY:	+ differential signal input.
6	AUXILIARY RETURN:	- differential signal input.
7	OUTPUT:	Velocity-error or current-command output.
8	CLAMP:	Reduces gain of the summing amplifier when drive is inhibited.
9	TACHOMETER:	Tachometer signal input.

3.3 REMOVAL AND INSTALLATION:

When removing or installing the Personality Preamp card, **care must be taken not to damage any of the components** under the card on the Amplifier Controller board or on the Personality card.

Removal: Hold the Personality card by its edges and pull straight away from the Amplifier Controller board **(Do not pull on the components).** For amplifiers with the Personality card mounted vertically, remove amplifier module first before unplugging Personality card.

Installation: Hold the Personality card by its edges and carefully align the nine pins with their mating sockets and push straight toward the amplifier controller board until it is firmly seated **(Do not press on any of the components).**

3.4 TROUBLE SHOOTING WITH THE PERSONALITY CARD:

If your system exhibits a problem and a working amplifier module is available, fault tracing can be expedited by removing the Personality Preamp card from the malfunctioning amplifier, plugging it into the replacement amplifier, and testing the system. If the system does not work with the new amplifier module, refer to Chapter Seven on Maintenance and Repair for a more detailed fault tracing procedure. However, If the system does work with the new amplifier module, check the malfunctioning unit for loose connections arid retest the suspected unit in the system to verify the malfunction.

CHAPTER FOUR: THEORY OF OPERATION

4.1 INTRODUCTION TO THEORY OF OPERATION:

A velocity-mode servo amplifier is essentially comprised of two control loops (see fig. 4.1).

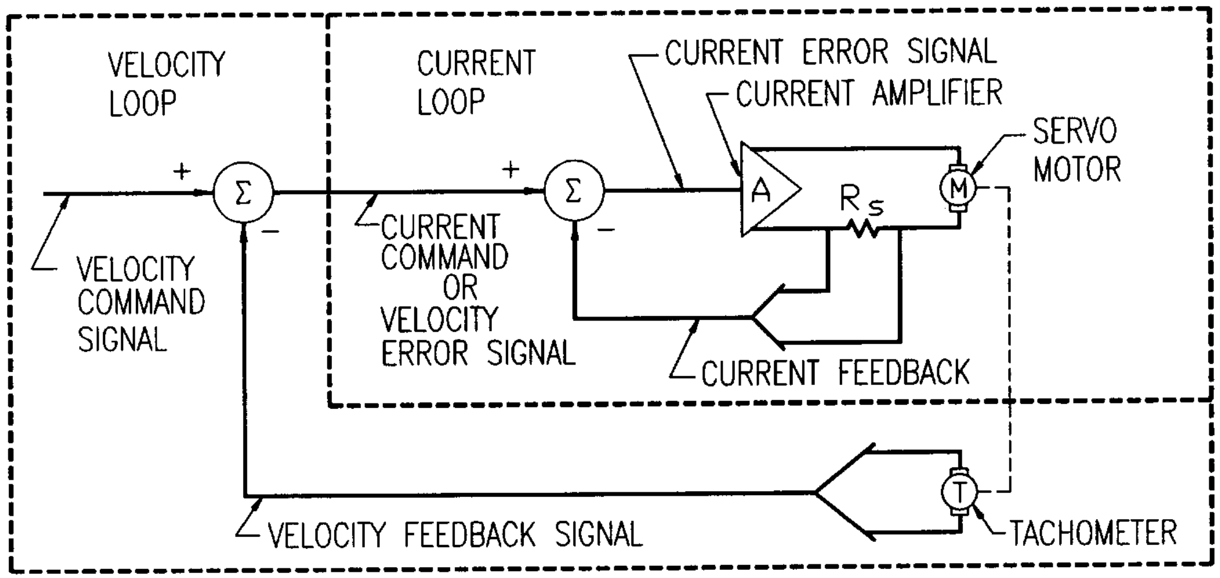
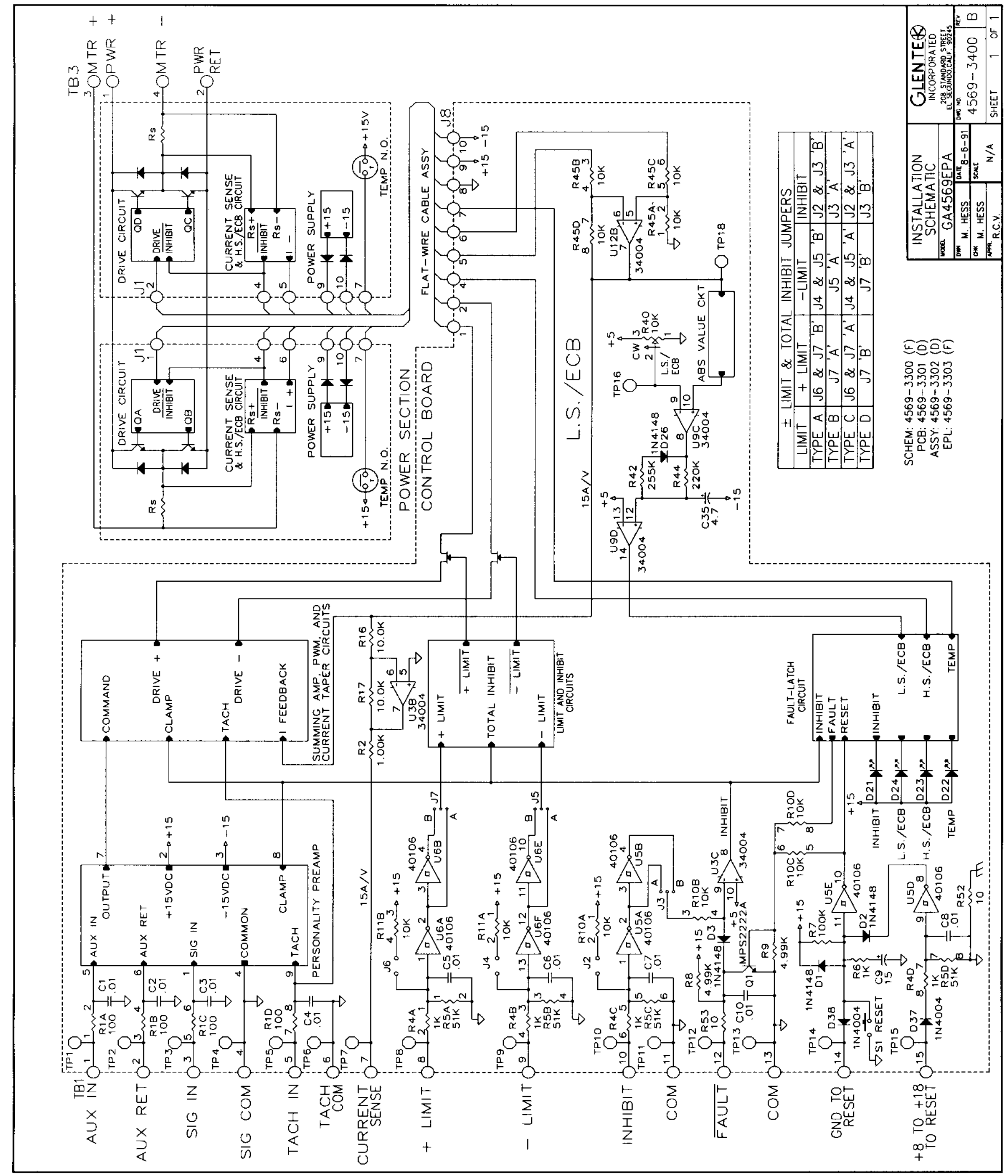


Figure 4.1

The inside control loop is referred to as the "current loop" and the outside loop is referred to as the "velocity loop". Before we begin our analysis of the current loop, let us review some basic concepts which will help you to better understand the amplifier's operation.

4.2 OPERATION OF OUTPUT SWITCHING TRANSISTORS:

The output transistors, for all intents and purposes, operate in only two states. They are analogous to ON/OFF switches. When an output transistor is OFF, there is no current flowing through it (its resistance is~infinite). When an output transistor is ON, current flows through it (its resistance is near zero). When the transistor is ON, it is technically referred to as being in saturation.



APPENDIX B

AMPLIFIER DRAWINGS

4.3 "H TYPE" OUTPUT BRIDGE CONFIGURATION:

The output configuration of the amplifier is an "H TYPE" bridge (see fig. 4.2 for schematic representation of output bridge with motor connected).

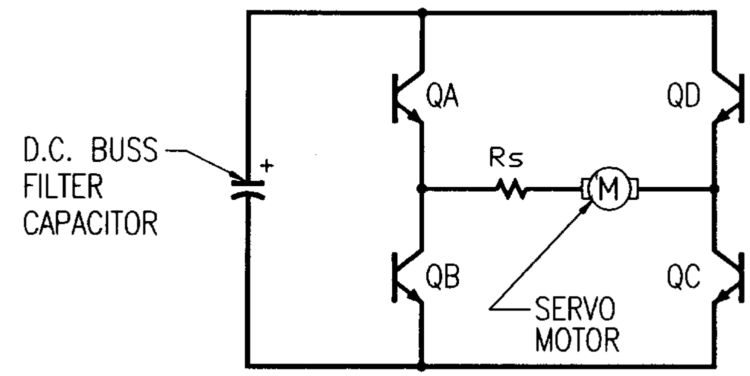


Figure 4.2

The advantage of an "H TYPE" output bridge configuration is that by controlling the switching of the opposite pairs of transistors, current can be made to flow through the motor in either direction using a single-polarity power supply as shown in figure 4.2.

To provide motor current in one direction, transistors A and C are turned ON, while B and D remain in the OFF state. To provide motor current in the other direction, B and D are turned ON, while A and C remain in the OFF state.

4.4 PULSE-WIDTH-MODULATION (PWM):

"Pulse-width modulation" is the technique used for switching opposite pairs of output transistors ON and OFF to control the motor drive current. When zero current is commanded to the current loop, the opposite pairs of transistors are turned ON and OFF as shown in figure 4.3. Note that since the pulse widths are equal, the net DC current in the motor is equal to zero.

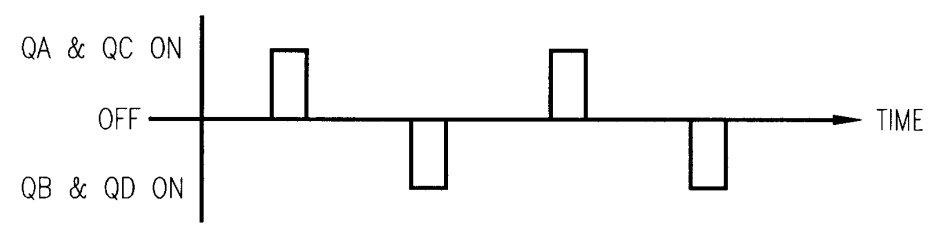


Figure 4.3

When a non-zero current is commanded to the current loop, the transistor switching waveform is as shown in figure 4.3A. Since there is a non-zero current command, the output transistor pulse widths will change and the motor will see a net DC current flowing from A through C.

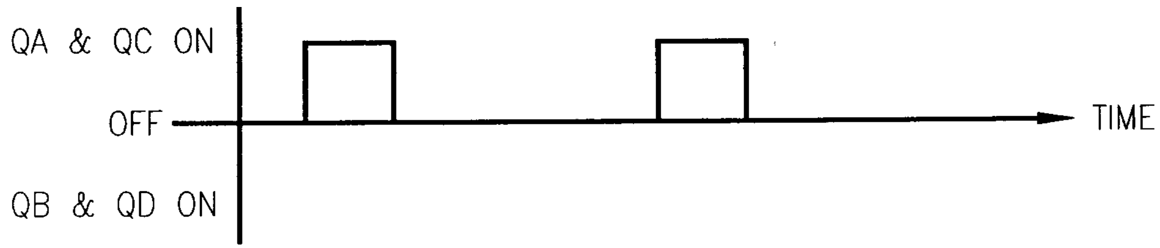


Figure 4.3A

If the input to the current loop had been changed in polarity, the output transistor switching waveform would be as shown in figure 4.3B.

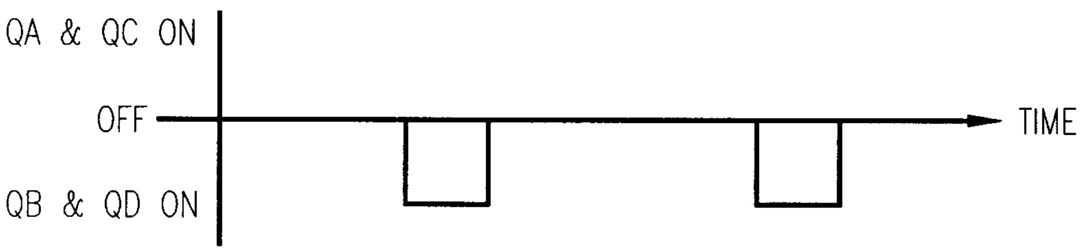


Figure 4.3B

If a larger current of the same polarity was commanded to the output transistors (see fig. 4.3B) the ON-time widths of B and D would automatically increase to provide more current.

From the previous examples it is easy to understand why this output transistor switching technique is referred to as pulse-width modulation.

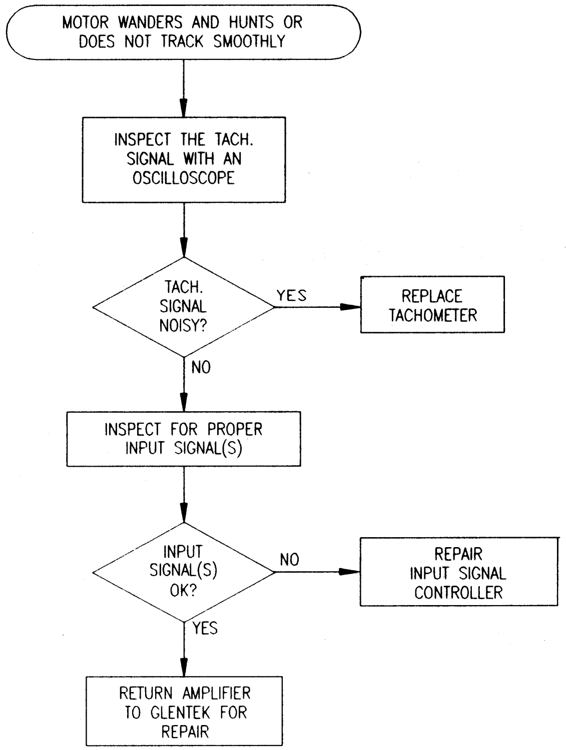
To change the magnitude and polarity of the current flow in the motor, the pulse widths of the opposite pairs of transistors are modulated. The frequency at which these output transistors are switched ON and OFF is referred to as the ‘carrier frequency’.

ENGINEERING NOTES FOR FAULT TRACING CHARTS:

NOTE 1: To measure the DC buss voltage, carefully connect a voltmeter across the bleeder resistor attached to the DC buss filter capacitor. The proper DC buss voltage for your amplifier is calculated by multiplying the AC power input voltage on the main DC buss transformer by 1.4 (e.g. For 70 VAC input you should read 70 x 1.4 or approx. 100 VDC buss voltage). The DC buss voltage will vary depending on if the motor is under a heavy or light load. The DC buss voltage will sag under heavy loads. This is normal for unregulated DC power supplies.

NOTE 2: The output voltage to the motor can be checked by alternately applying a positive and then negative voltage to the signal input and observing the voltage swing at the amplifier motor output terminals. Keep in mind that the Loop Gain and Signal potentiometers must be set at least somewhat CW. This test can be made with motor disconnected from amplifier.

NOTE 3: A low, but not zero, DC buss voltage could indicate an open or defective DC buss filter capacitor. To check capacitor, remove from circuit and check with an ohmmeter. A visual check of the capacitor port seal could show a blown pressure seal caused by a failed, overheated capacitor.



After realizing how the PWM amplifier output works, it becomes apparent that some inductance must be added to the motor circuit to prevent excessively high AC ripple current and heating in the servomotor. Consult a Glentek applications engineer for recommended inductance.

Now that we have a good understanding of how the current is provided from an “H TYPE” pulse-width modulated (PWM) bridge, let’s analyze the operation of the current loop.

4.5 CURRENT-LOOP OPERATION:

Please refer to figure 4.1 for a diagram of the current loop. In control electronics the symbol Sigma (with the circle around it) is referred to as a “summing junction”. The manner in which this summing junction operates is as follows:

The current-command signal (also referred to as the velocity-error signal when received from the output of the velocity loop, as shown in fig. 4.1) is added to the current-feedback signal. The signal resulting from this addition, is referred to as the “current-error” signal. This current-error signal is fed into the current amplifier, which in turn produces a current in the motor. A voltage which is proportional to the motor current is developed across Rs (shunt resistor). This voltage is referred to as the “current-feedback” signal. The current in the motor increases until the current-feedback signal is exactly equal in magnitude, but opposite in polarity, to the current-command signal. At this point the current-error signal drops to zero, and the actual current is equal to the commanded current. If anything happens to disturb either the current-command signal, or the current-feedback signal, the same process occurs again until the current-feedback signal is equal in magnitude to the current-command signal, but opposite in polarity.

The type of loop described above is referred to as a “servo loop” because the current servos about a commanded value.

We are surrounded in our everyday lives by a multitude of servo loops. For example, many of today’s luxury cars have what is called “automatic climate control”. To operate this servo loop, you set the climate control to the temperature that you wish to be maintained in the interior of the car (current-command signal). The selected temperature is then summed with the actual temperature from a thermometer (current-feedback), and the output (current-error signal) activates either the heater or the air-conditioner until the actual temperature as measured by the thermometer (current-feedback signal) is equal in magnitude, but opposite in polarity, to the set temperature.

4.6 VELOCITY-LOOP OPERATION:

Please refer to figure 4.1 for a diagram of a typical velocity loop. The velocity-loop’s operational description is analogous to the current-loop description, except for the fact that the input signal is called the Velocity Command and the feedback signal from the DC tachometer is called the Velocity Feedback.

CHAPTER FIVE: INSTALLATION PROCEDURE

5.1 MOUNTING:

The installation diagrams in Appendix B show the bolt hole mounting pattern to support the amplifier. The mounting holes will accept 1/4 inch bolts. The base material is cadmium plated, .060-inch-thick steel.

THE MOUNTING BOLTS SHOULD PROVIDE AN ELECTRICAL GROUND FOR THE CHASSIS TO MINIMIZE SHOCK HAZARD.

The surface that the amplifier package will be mounted on must be able to support its weight, but does not need to provide "cold plate" cooling for the amplifier.

Standard 100 CFM muffin fans are mounted on the baseplate to cool the amplifiers. **It is IMPORTANT to allow a minimum of three inches** between both the **fan side and the module side (opposite fans) of the amplifier baseplate and the cabinet wall.** The distance between the other two sides and top of the amplifier and the cabinet walls are not critical. However, some space should be provided for wire routing and terminal strip access.

The amplifier package should be mounted in a clean, dry enclosure with a maximum ambient temperature of 122°F (50°C). To ensure maximum reliability, keep the amplifier cabinet cool and free from dust, oil and other contaminates.

NEVER INSTALL THE AMPLIFIER PACKAGE IN ANY LOCATION

WHERE FLAMMABLE OR EXPLOSIVE VAPORS ARE PRESENT

5.2 WIRING SIZE AND PROPER TECHNIQUE:

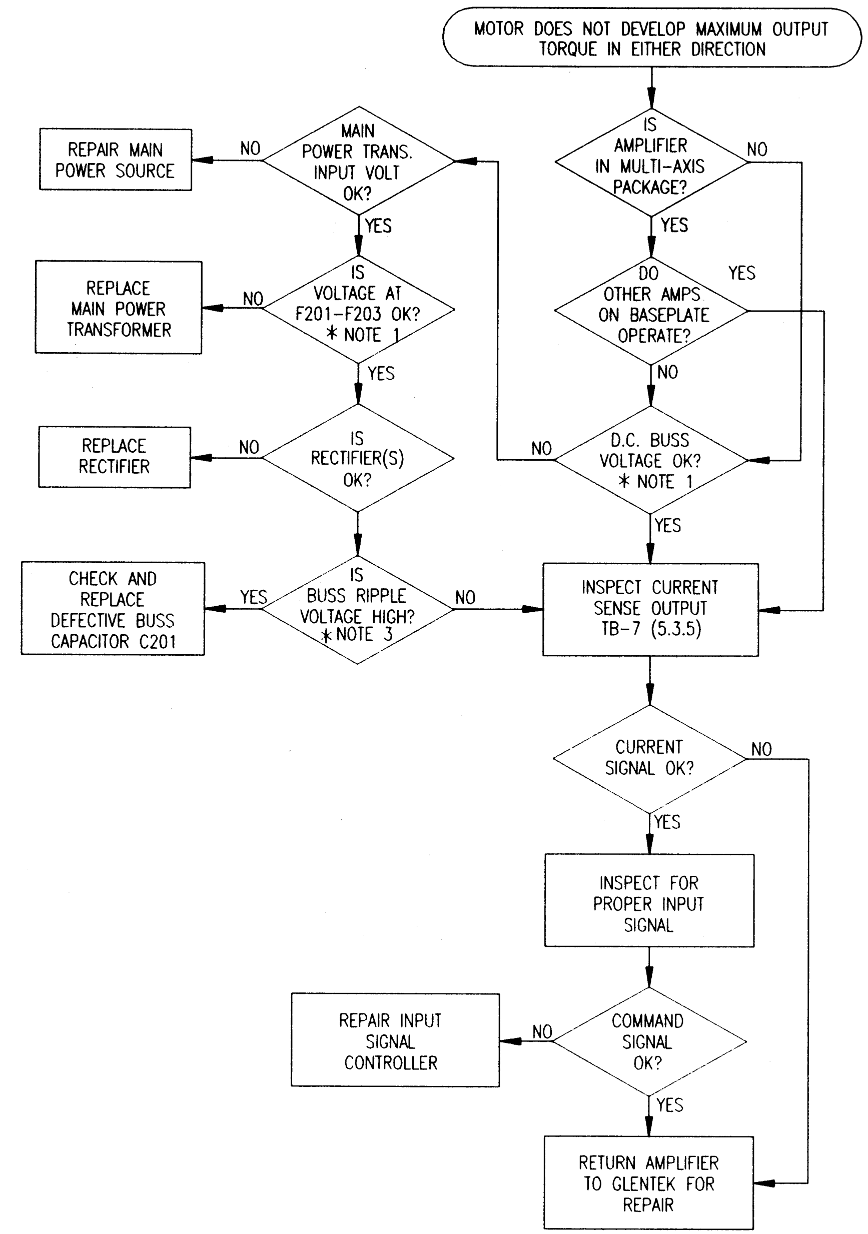
Please refer to Appendix B, GA4569EPA installation diagrams. These installation diagrams show the necessary external connections to ensure proper amplifier operation.

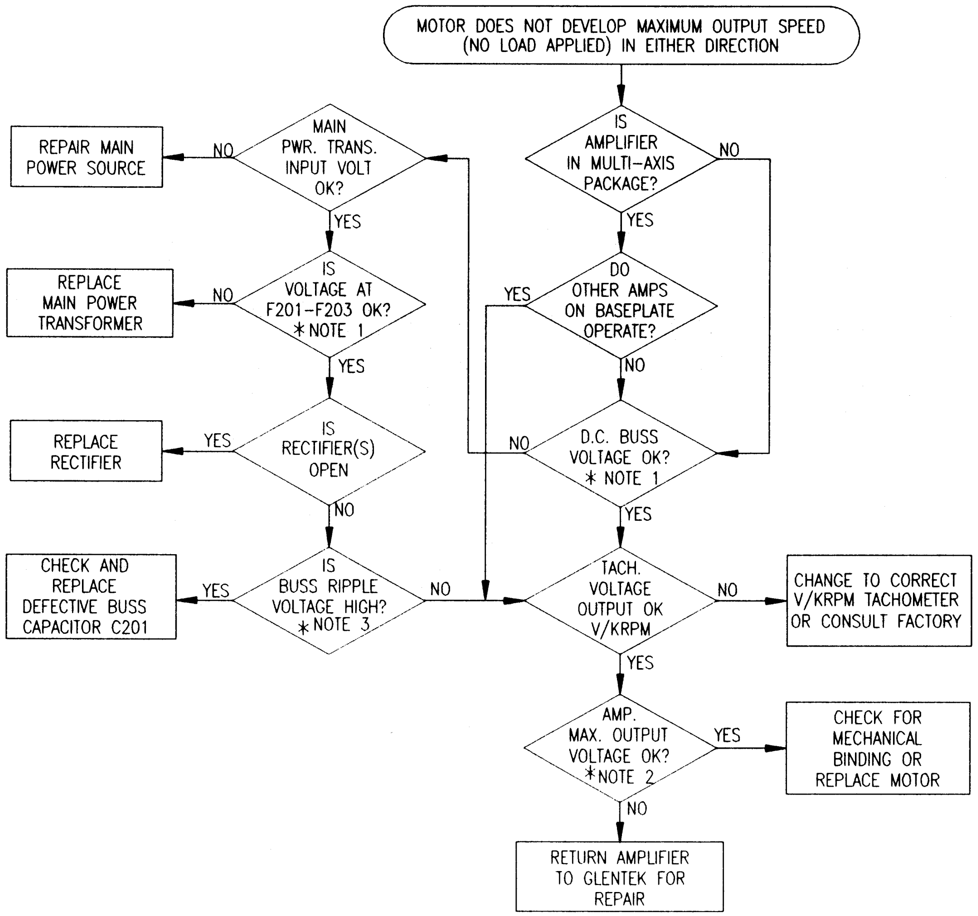
Glentek recommends that your wiring be in accordance with all national and local codes that are applicable to your system. Wire size must be sufficient to accommodate the maximum continuous current that will be run through it.

Recommended wire sizes for the GA4569EPA are as follows:

MOTOR ARMATURE - 12 AWG.

0-105 VAC POWER INPUT (from secondary of power transformer) - 10 AWG.





120 VAC FOR FANS - 16 AWG twisted pair.

SIGNAL INPUT - 22 AWG mm., 2-conductor, shielded.

TACHOMETER INPUT - 22 AWG mm. 2-conductor, shielded. Terminate shield at amplifier end only, to Tachometer Common, TB1 terminal-strip.

When wiring to-and-from the drive cabinet, it is considered good technique to route the power lines (16 AWG and larger) along different paths than the signal and tachometer lines. This minimizes the amount of stray noise pick-up that is injected into the amplifier.

5.3 BASEPLATE CONNECTIONS:

5.3.1 120 VAC 50/60 Hz FOR FAN(S): Connect the 120 VAC to terminals 1 and 2 of terminal barrier-strip TB201 located on the baseplate.

DO NOT APPLY ANY POWER YET.

5.3.2 INPUT FROM SECONDARY OF POWER TRANSFORMER: The AC voltage that is used to form the DC buss of the amplifier package, is supplied from a separately mounted transformer that has been selected by Glentek for your application. Connect the secondary of the power transformer to input terminals of fuses F201, F202, and F203.

DO NOT APPLY ANY POWER YET.

5.4 AMPLIFIER CONNECTIONS AND FUNCTIONS:

5.4.1 DC BUSS: The DC buss from the filter capacitor is connected to terminals 1 (+) and 2 (-) of terminal strip TB3. This connection is already made for you on our multi-axis packages. The power transformer for the DC buss is not a standard part of the amplifier package. Glentek can advise on transformer specifications required. Most styles and sizes are in stock at Glentek.

5.4.2 MOTOR: The motor is connected to terminals 3 (-) and 4 (+) of terminal strip TB3 of the amplifier module. In most cases, if the motor inductance is less than 1 millihenry, an inductor should be connected in series with the motor leads. The inductor is considered to be a separate part from the amplifier package. Glentek can advise on the inductor specifications, and most styles and sizes are in stock at Glentek.

IT IS IMPERATIVE THAT YOU DO NOT USE GROUNDED TEST EQUIPMENT ON THE MOTOR ARMATURE NOR CONNECT EITHER END OF THE MOTOR ARMATURE TO SIGNAL GROUND OR DC BUSS RETURN.

5.4.3 SIGNAL INPUT: The amplifier has two Signal Inputs, one single-ended (Signal Input TB1-3) and one differential (Auxiliary Signal Input TB1-1 and Auxiliary Return TB1-2). Please refer to Chapter 2.2 for options and model numbering information. Typically, when operating in the velocity mode, the input signal range is + or - 10 VDC. The input voltage is summed with a precision DC tachometer to provide accurate velocity control at the servomotor shaft (see fig. 4.1). The Signal Gain potentiometer R12, and Auxiliary Gain potentiometer, R13, adjust the motor velocity desired for a given input voltage velocity command.

5.4.4 TACHOMETER INPUT: The Tachometer is connected to terminals 5 and 6 of terminal strip TB1 of the amplifier module (see 5.2 for recommended wire type & size).

5.4.5 CURRENT SENSE: The Current Sense output signal can be monitored at terminal 7 of terminal strip TB1 of the amplifier module. It is an isolated output signal that is proportional to motor current. The scale factor is 1 volt = 15 amps.

5.4.6 + AND - LIMITS: The + and - Limits are located respectively at terminals 8 and 9 of terminal strip TB1 of the amplifier module. Please refer to 2.2.3 for a description of the different configurations of limits that are available. Amplifier modules are normally shipped with type “A” limits which means that when terminal TB1-8 or TB1-9 is pulled to ground (TB1-11) by some external circuit, the amplifier is inhibited in the + or - direction.

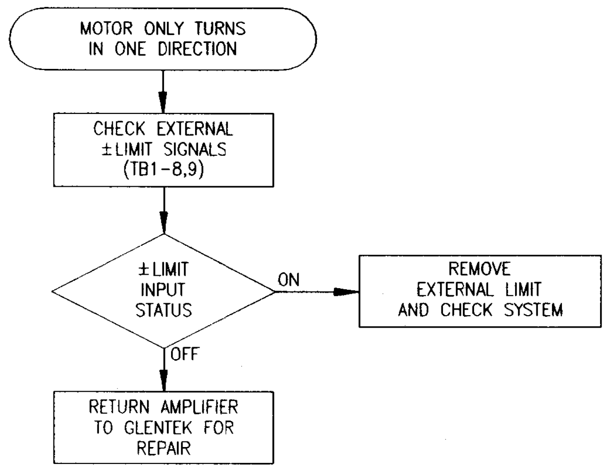
5.4.7 TOTAL INHIBIT: The Total Inhibit is located at terminal 10 of terminal strip TB1 of the amplifier module. Please refer to 2.2.3 for a description of the different configurations of limits that are available. Amplifier modules are normally shipped with type “A” limits which means that when terminal TB1-10 is pulled to ground (TB1-11) by some external circuit the amplifier is totally inhibited.

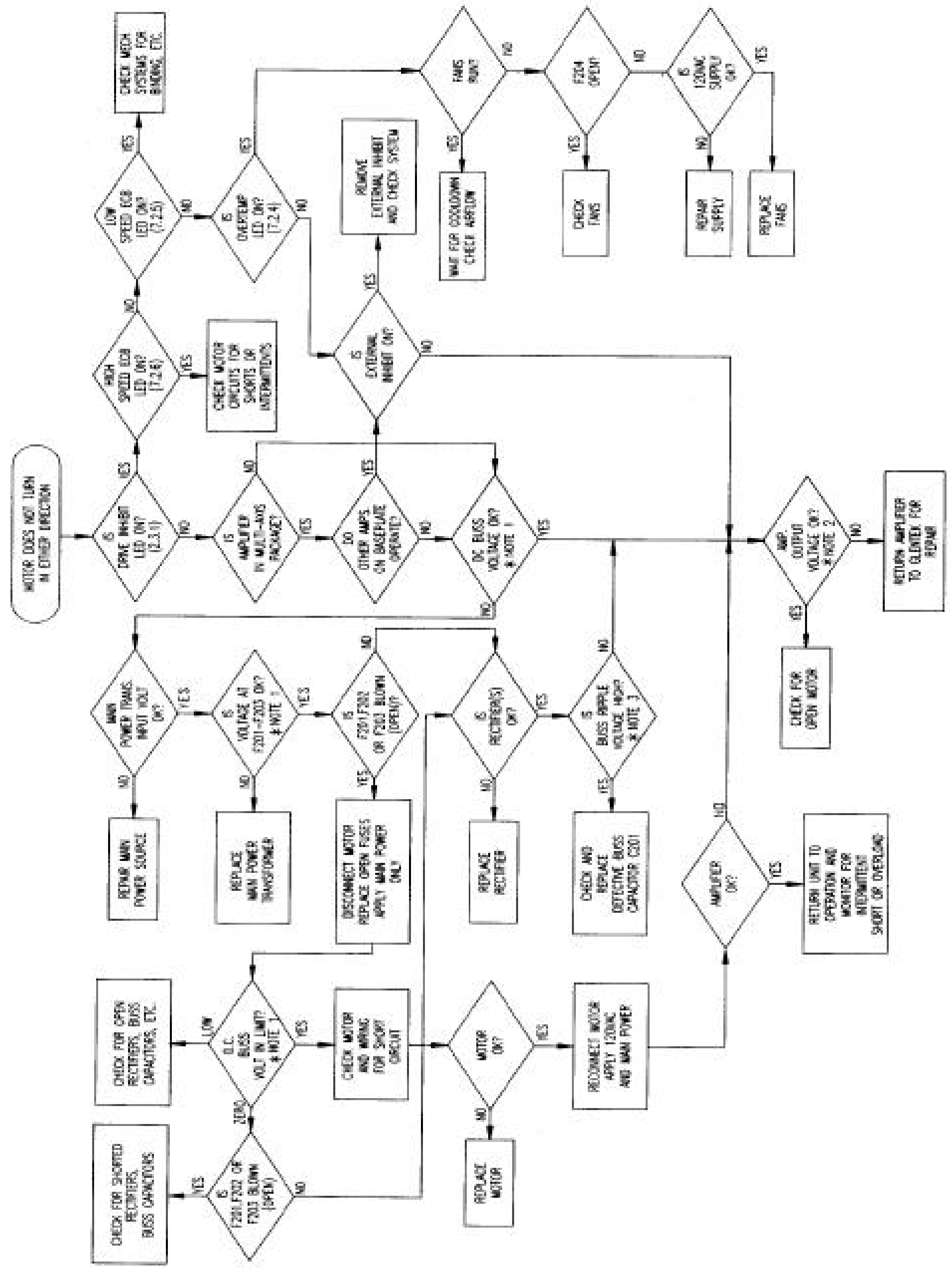
5.4.8 FAULT MONITOR: The Fault Monitor is located at terminal 12 of terminal strip TB1 of the amplifier module. The amplifier will pull this terminal to ground by turning ON Q1 for any of the following fault conditions:

1. Transistor heatsink temperature in excess of 170^{0}F (77^{0}C).
2. Low-Speed Electronic Circuit Breaker (LS/ECB) triggered.
3. High-Speed Electronic Circuit Breaker (HS/ECB) triggered.

NOTE: Please refer to Chapter 2.3 on Protection Circuits for a more detailed description of the possible conditions that will cause the above faults to occur.

This is an open-collector output which may be externally pulled down to force a fault condition. If the Fault output of all amplifiers is tied together, a fault on one amplifier will shut down all other amplifiers.





5.4.9 EXTERNAL FAULT-LATCH RESET:

Ground to Reset: Grounding terminal-strip TB1-14 will reset the fault latch.

+ to Reset: Applying 10 - 15VDC to terminal-strip TB1-15 will reset the fault latch.

Note: The fault latch will not reset unless the fault has been removed.

CHAPTER SIX: START UP AND ADJUSTMENT PROCEDURE

6.1 SAFETY PRECAUTIONS:

Before starting the adjustment and alignment procedure please be sure to observe the following precautions:

1. Be certain that there are no visibly loose or damaged components.
2. Check that all connections are tight.
3. Check all power and signal wiring. Remove power input fuses, apply power and measure that correct power voltage is being applied. Your DC buss voltage will be 1.4 times the AC voltage applied (Refer to Appendix A, note 1).
4. Be sure that the motor mechanism is clear of all obstructions. If motor is connected to an axis lead screw or other device with limited motion, place at midposition.
5. Work on only one amplifier at a time.
6. Make sure all Loop-Gain pot's are turned fully CCW before applying power.
7. **DO NOT** use grounded test equipment.

6.2 AMPLIFIER ALIGNMENT INTRODUCTION:

When adjusting an amplifier for optimum velocity-loop operation it is desirable to achieve a critically damped, stable-step velocity response with maximum Tach Gain. The following discussion will describe how to best achieve this result:

Your amplifier has been run at the factory with a known motor, tachometer and inertial load. In testing at the factory, we try to simulate the same conditions you will have in your system. For this reason it is a good idea to start with the initial settings as shipped from the factory.

NOTE: All of the following adjustments are to be made on the personality Preamp card (Refer to Appendix C, drawings 4597-7010 & 4597-7012).

6.3 VELOCITY-LOOP PHASING:

For proper servo operation it is necessary for the amplifier to receive negative feedback from the tachometer. If the tachometer leads are reversed (positive feedback), the amplifier will run away. To check the phasing of the motor and tachometer proceed as follows:

1. Make sure Loop-Gain potentiometer, R18, is full CCW (as shipped from factory).

2. Make sure that nothing is connected to the Signal Input (TB1-3) or the Auxiliary Signal Input (TB1-1 or TB1-2).

APPENDIX A

FAULT TRACING CHARTS

7.4 WARRANTY:

Any product or part thereof manufactured by Glentek, Inc. described in the manual which, under normal operation 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 replaced free of charge FOB our factory, El Segundo, California 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. 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 electric motors 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. 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 including power transistors.

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 claims or damages that may be initiated against us by third parties.

3. Apply the main power and the 120 volt fan power.

4. Slowly turn the Loop-Gain potentiometer, R18, CW. If the motor starts to run away, turn the Loop-Gain potentiometer full CCW and reverse the tachometer leads (do not move the shield lead). Again, slowly turn the Loop-Gain potentiometer CW. The motor should be stopped or rotating slowly.

5. Leave the Loop-Gain potentiometer, R18, full CW for all remaining adjustments and operations.

6.4 TACH-GAIN ADJUSTMENT:

1. At this point the motor will be stopped or rotating slowly. Adjust the Balance potentiometer, R15, until the motor rotation is stopped.

2. While observing the tachometer output voltage with an oscilloscope, apply a step voltage at the Signal Input terminal of the amplifier. A step voltage can be simulated by applying and removing a flashlight battery to the Signal Input. For this purpose, the battery is usually mounted inside of a small box with a switch. Common names used to describe this DC signal voltage source are Battery Box or DC Simulator. Elaborate signal sources made for this purpose often include bipolar output, potentiometer output adjust and polarity reversing switches, etc. You often hear the phrase "DC Box the velocity loop servo" used by people working on servo systems.

   (This Signal Box may be purchased from Glentek Inc., Part Number BB700)

3. At this point the motor should be running smoothly. While applying and removing the DC input signal, adjust the Current-Limit potentiometer, R17, for desired maximum acceleration and deceleration. Motor current should be observed by using an oscilloscope at TB1 -7. Scale factor of voltage at this point is 1 volt = 15 amps. Leave the Current-Limit potentiometer at this setting for all remaining adjustments. Note that the optional Velocity-Taper Current-Limit may affect this adjustment (see section 2.3.7).

4. Adjust the Signal-Gain potentiometer, R12 or R13, (depending on the input you are using) so that when you apply the DC signal the motor rotates at approximately 400 RPM.

5. Observe the tachometer voltage with an oscilloscope while applying and removing the DC input signal. You will observe one of three possible waveforms: critically damped, under damped, or over damped (see figure 6.4).

6. The optimum waveform for most systems is the critically-damped waveform. If the waveform that you are observing is critically damped, proceed to step 9.

7. If your waveform is under damped, make the following adjustments:

   Turn the Compensation potentiometer, R16, CCW until the waveform becomes critically damped. Note here that the limiting factor will be motor oscillation or "hunting". You must always leave the Compensation potentiometer far enough CW so that the velocity loop remains stable.

   If the waveform is still under damped after adjusting the Compensation potentiometer for maximum bandwidth, turn the Tachometer-Gain potentiometer, R14, 2 turns CCW and then adjust Compensation potentiometer, R16, CCW until waveform becomes critically damped. Repeat procedure if necessary. Again, the servo velocity-loop must at all times remain stable. Consult the factory if necessary.

8. If the waveform is over damped, make the following adjustments:

   Turn the Tachometer-Gain potentiometer, R14, CW until a slight overshoot appears on the waveform; then turn the Compensation potentiometer, R16, CCW until a critically damped waveform is observed.

9. Now that the waveform is critically damped, leave the Compensation, R16, and Tachometer Gain, R14, at these settings for all remaining adjustments and operations.

10. Next, set the Signal potentiometer, R12 or R13, to the gain required by your system (e.g. 10 volts = 2000RPM).

11. Adjust Balance potentiometer, R15, one more time to null out any offset (with 0 volt input).

12. For all remaining adjustments when placing the amplifier in your system only the Signal potentiometer, R12 or R13, and Balance potentiometer, R15, should be adjusted.

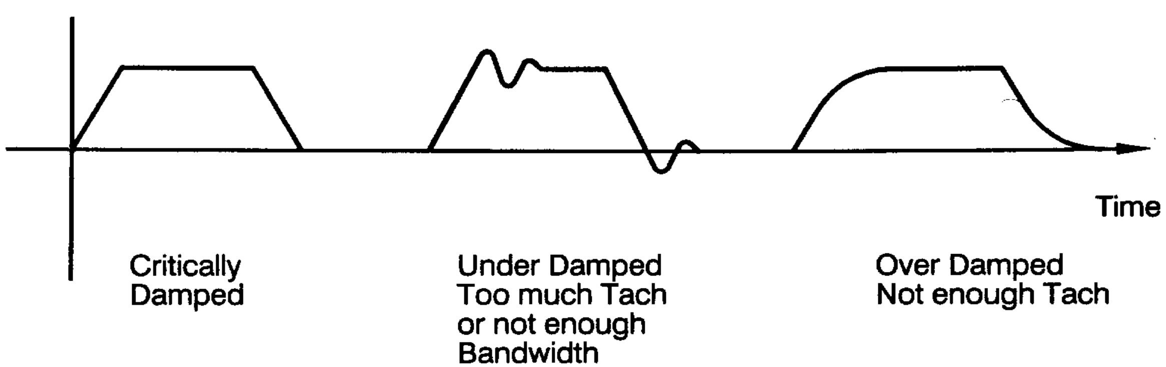


Figure 6.4

7.2.5 LOW-SPEED ELECTRONIC CIRCUIT BREAKER (LS/ECB) SHUTDOWN: The LS/ECB is tripped when a preset current threshold is exceeded for a preset length of time, typically 30 Amps for 1.5 seconds.

List of possible causes:
1. Binding or stalling of motor shaft.
2. Overload of amplifier output to motor.
3. Large reflected load inertia.

The time delay is typically set at factory to your system requirements.

Reset is accomplished the same way as for OVER TEMP above.

7.2.6 HIGH-SPEED ELECTRONIC CIRCUIT BREAKER (HS/ECB) SHUTDOWN: The HS/ECB is tripped by 121 amps or more of output current for 10 micro-seconds.

List of possible causes: 1. Shorted motor leads. 2. Motor inductance too low. 3 . Intermittent motor short. 4. Motor Commutator flash over.

Reset is accomplished the same way as for OVER TEMP above.

7.3 FACTORY REPAIR:

Should it become necessary to return the GA4569EPA 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 assembly unit.
   B. Company name and 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 handling stickers (e.g. FRAGILE: HANDLE WITH CARE).

4. Contact a Glentek representative, confirm the unit is being returned to the factory and obtain an RMA (Return Material Authorization) number.

5. Return the unit by the best means possible. The method of freight chosen will directly affect the timeliness of its return.

7.2.3 PART REPLACEMENT: The removal and replacement of the defective assembly can be accomplished with standard shop procedures. The assemblies that may be easily removed are as follows:

1. Fuses F201-F210.
2. Rectifier BR201
3. Capacitor C201
4. Fan 201 -204.
5. Amplifier Module A1-A6.
6. Transformer T201

After reviewing the fault tracing charts you may conclude that the complete amplifier should be returned to Glentek for failure analysis, repair and retesting to specifications. This is particularly true with failure modes in the amplifier module sections A1 thru A6.

7.2.4 OVER TEMPERATURE SHUTDOWN: When the heatsink temperature has reached a level that, if exceeded, would damage the output transistors, the Temp indicator LED is latched ON and the Drive Inhibit indicator LED is latched ON inhibiting the amplifier.

THE OVERTEMP CONDITION CAN ONLY BE CAUSED BY ABNORMAL CONDITIONS. THE CAUSE SHOULD BE INVESTIGATED BEFORE REPEATED RECYCLING OF THE MOTOR DRIVE TO PREVENT POSSIBLE DAMAGE TO THE AMPLIFIER

The following is a list of possible causes of excessive temperature rise:

1. Loss of cooling air - Fans are defective or airflow is blocked.
2. Excessive rise in cooling air temperature due to cabinet ports being blocked or excessive hot air being ingested.
3. Extended operational-duty cycle due to mechanical overload of motor or defective motor.
4. Defective power output section due to component failure (Return to Glentek for repair).
5. Noisy Tachometer - Signal - A noisy tachometer causes a considerable amount of random switching of the power output transistors, thus increasing the amount of heat developed in the output section. The higher the bandwidth, the more the heating due to a noisy tachometer. A noise tachometer can be identified by a large amount of rumbling and twitching of the motor at low or zero shaft speeds.

RESETTING: After a fault latched, it may be cleared by pressing the reset pushbutton located on the amplifier control board, next to terminal strip TB1; by grounding TB1-14; or by applying 10 - 15VDC to TB1-15.

Note: The fault latch will not reset unless the fault has been removed.

6.5 CONNECTING AMPLIFIER TO A DIGITAL POSITION LOOP:

Before connecting the amplifier to a digital position loop, be sure the adjustments of section 6.4 have been made. Start out with the Loop-Gain potentiometer, R18, fully CCW and activate the digital position loop. Slowly turn the Loop-Gain potentiometer CW. If servo runs away, immediately adjust Loop Gain fully CCW and turn power OFF.

1. It is possible, at this time, that the digital loop is reverse phased. An example of this would be if a positive voltage from the velocity DAC (digital to analog converter) required the motor to turn CW. However, it turned CCW instead causing the encoder feedback signal to count up instead of down. This would cause a run away condition.

   If you are out of phase as described, be sure power is OFF and reverse the motor leads at the amplifier. This will cause the motor to rotate in the opposite direction than it did before, properly phasing the digital loop.

2. With the Digital Loop operating, turn the Loop-Gain potentiometer, R18, fully CW and command a small move. Slowly increase or decrease the Signal-Gain potentiometer, R12 or R13, until the servo is operating as required. It should be noted here that too much Signal Gain can cause instability (oscillation). Do not stay in this oscillating condition long, as it may result in system mechanical or electrical damage. Be sure when all signal adjustments are made that the Balance is re-checked and adjusted for zero rotation for zero signal input.

3. It should also be noted here that the GA4569EPA is designed to operate with many different systems and if, after reading this manual, you have further questions, do not hesitate to call a Glentek applications engineer.

ENGINEERING NOTE:

After all systems are aligned and functioning, it is good practice to remove power from the amplifier and, using a digital ohm-meter, measure the impedance value of the following potentiometer wiper settings with respect to signal ground. These values may be useful for the next machine you align or for maintenance of this system at a later date. Make these measurements on each amplifier on a multi-axis baseplate.

Record resistance measurements:	AMP 1	AMP 2	AMP 3	AMP 4	AMP 5	AMP 6
1 - Tach. potentiometer wiper to signal ground (ohms).	_____	_____	_____	_____	_____	_____
2 - Signal potentiometer wiper to signal ground (ohms).	_____	_____	_____	_____	_____	_____
3 - Comp. potentiometer wiper to signal ground (ohms).	_____	_____	_____	_____	_____	_____
4 - Current Limit potentiometer wiper to signal ground (ohms).	_____	_____	_____	_____	_____	_____
Also record signal voltage to Tachometer voltage ratio: Volts Signal / Volts Tachometer	_____	_____	_____	_____	_____	_____

Date data taken ____

Also, note any changes to compensation components, etc.

CHAPTER SEVEN: MAINTENANCE, REPAIR AND WARRANTY

7.1 MAINTENANCE:

The GA4569EPA amplifiers do not require any scheduled maintenance. The only wear-out items are the cooling fans which are specified to have in excess of 15,000 hours MTBF by their manufacturer.

7.2 REPAIR:

If your system exhibits a problem, this manual should assist you to identity the fault and to replace the defective component or sub-assembly. The GA4569EPA amplifiers are modular assemblies and each individual amplifier section is designed to be easily removed and replaced in the field. It is Glentek's recommendation that a failed amplifier module be replaced in the field and returned to Glentek for failure analysis and repair. However, Appendices B and C contain complete system schematics that, in case of extreme emergency, should permit a skilled electronic technician to trouble shoot the circuit boards to levels lower than those recommended as replaceable.

7.2.1 FAULT TRACING: This section will aid in the location of defective replaceable components and assemblies. A list of the fault tracing charts in Appendix A, along with the observable fault follows:

Fault Chart 1 Motor does not turn in either direction.
Fault Chart 2 Motor only turns in one direction.
Fault Chart 3 Motor does not develop maximum output speed (no load applied) in either direction.
Fault Chart 4 Motor does not develop maximum output torque in either direction.
Fault Chart 5 Motor wanders and hunts or does not track smoothly.

7.2.2 FAULT TRACING CHARTS: The fault tracing charts in Appendix A start with an observable fault listed at the top of each chart. Follow the line connections between blocks by your answers to the questions noted in the diamond shape blocks until the defective part is isolated. The charts are to be used only as a guide to identify the parts or assemblies that Glentek recommends as the lowest level of repair.

The fault tracing procedures assume that only a single failure mode exists.