Torque Switch
MODEL GA377

Pulse Width Modulated
Servo Amplifier

OPERATION

and

SERVICE MANUAL

for

MODEL GA377

GLENTEK

Rev (-) 23 Sep 1992

OPERATION and SERVICE MANUAL

FOR MODEL GA377

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INTRODUCTION:

This manual provides all the technical information necessary to install, configure, use, and maintain our TORQUE-SWITCH™ series, servo-motor amplifier, model GA377. There is also an informative theory-of-operation section.

We suggest you take the time to read this manual cover-to-cover before you attempt to use one of these amplifiers for the first time. If at any time you have any questions that you cannot find the answers to in this manual, or if you have any special requirements, please feel free to call and discuss your questions with a Glentek applications engineer. We are happy to provide both off-the-shelf and custom products. With almost three decades in the servo-motor/amplifier business, we have a vast pool of applications knowledge waiting to help you.

Thank you for selecting Glentek for your motion-control needs. It is our goal to save you money, time, and to provide you with a superior product.

CHAPTER ONE: DESCRIPTION and SPECIFICATIONS

1.1 DESCRIPTION:

These amplifiers are of a modular, "open" construction for ease of installation and service. Up to six amplifiers may be ordered on a single baseplate with a common power-supply for maximum packaging density.

Each amplifier accepts a bipolar DC control input. The polarity of this signal determines the direction of rotation. This signal may be used to control either the velocity (RPM) or the current (torque) of the motor (see Configuration, section 2.1). The amplifier provides Pulse-Width Modulated (PWM) power to the motor in proportion to the input signal.

Each amplifier has several special "logic" inputs to stop the motor in one or both directions. These inputs are very useful for connecting to mechanical limit switches or digital equipment.

Each amplifier has several protection circuits to protect the amplifier, motor, and operator from almost any kind of fault. Several LED's show what fault has occurred, and a separate output can be used to signal other equipment.

1.2 FEATURES:

* Ergonomic design:	Easy access to connections, adjustments, and test points.
* Dual signal inputs:	Both inputs may be used simultaneously. One input may be configured for differential operation. Both inputs have up to 15KA/V gain and will withstand $\pm$70V.
* Multi-mode operation:	The amplifier may be configured for velocity-mode or current-mode operation.
* Digital limit inputs:	Separate logic inputs can stop motor in either or both directions. Logic inputs may be configured for active-high or active-low logic, pull-up or pull-down termination, and 0 to 5 or 0 to 15 volt range. See configuration, section 2.1.2.
* Fault input/output:	Open-collector output goes low in the event of a fault. Externally forcing output low will inhibit amplifier. This allows all fault outputs in a multi-axis system to be connected together (wire-ORed) to shut down all amplifiers should any amplifier have a fault.
* External fault reset:	Separate input provided to reset amplifier after a fault.
* Current limit:	Peak motor current is adjustable.
* Built-in Regen Clamp:	Optional Regen Clamp (shunt regulator) bleeds off excess DC Bus voltage when decelerating a large load inertia.

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1.2 FEATURES con't:

* Isolated or off-line AC power operation:	Glentek offers a complete line of power transformers to match any source. An option allows operation directly from the AC line.
* High-Speed Electronic Circuit Breaker:	Instantly shuts-down amplifier in the event of a short across the motor leads or from either lead to DC-Bus return.
* Low-Speed Electronic Circuit Breaker:	Shuts-down amplifier if amplifier is run above maximum continuous current rating for a pre-determined period of time.
* Over / under voltage and over-temp fault:	These circuits constantly monitor motor and amplifier voltages, and amplifier heatsink temperature. They will shut down the amplifier in the event of any out-of-spec condition.
* Multi-axis chassis:	Up to six amplifiers may be ordered on a single baseplate. Multi-axis baseplates include motor (DC Bus) power-supplies and cooling fans. Glentek can design a custom baseplate for more than six amplifiers or to meet any other special requirements.

1.3 MODEL NUMBERING:

A full part number consists of an amplifier model number, an optional amplifier configuration code, a baseplate style number, and an optional baseplate configuration code, e.g:

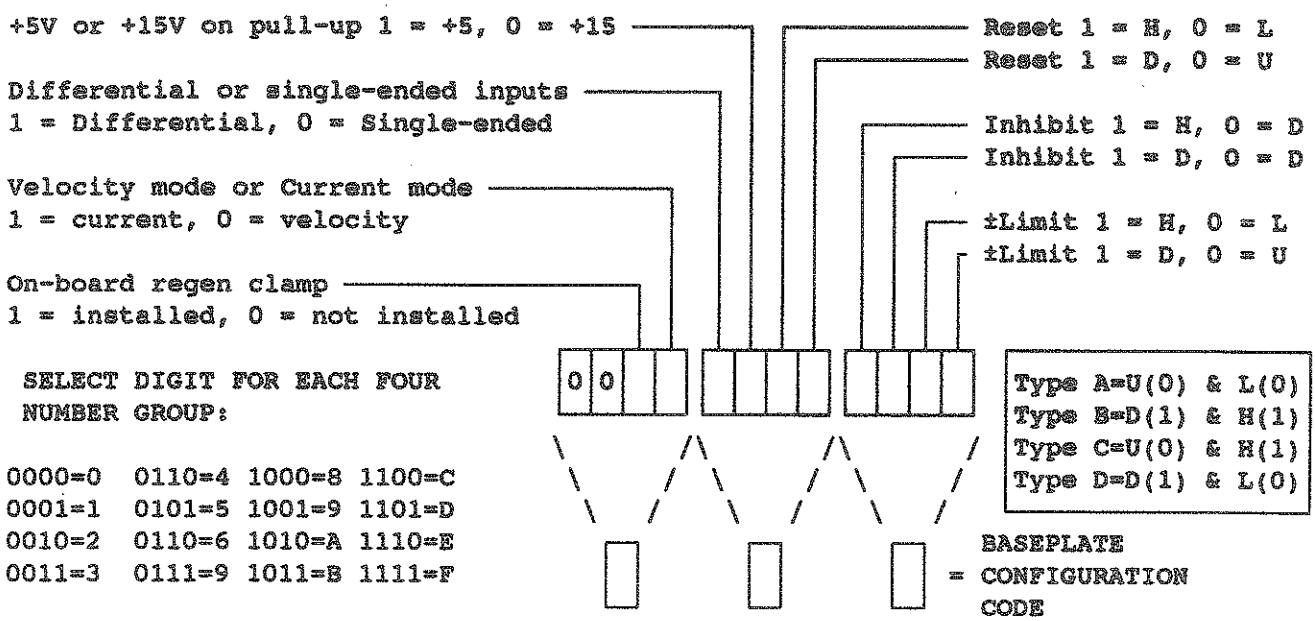
GA377-XXX-6A-5

In this example, the amplifier model is a GA377. The baseplate style is 6A-5 which denotes the number of amplifiers on the baseplate: in this case, a six-axis baseplate with five amplifier modules. Below is a list of standard baseplate styles.

GA377-1	Single amplifier (no baseplate).
GA377-1A-1	1 axis chassis with 1 amplifier.
GA377-2A-1	2 axis chassis with 1 amplifiers.
GA377-2A-2	2 axis chassis with 2 amplifiers.
GA377-4A-3	4 axis chassis with 3 amplifiers.
GA377-4A-4	4 axis chassis with 4 amplifiers.
GA377-6A-5	6 axis chassis with 5 amplifiers.
GA377-6A-6	6 axis chassis with 6 amplifiers.

Most amplifier options, e.g. limits, are user configurable. However, if you would prefer to have Glentek pre-configure your units, a three-digit amplifier configuration code is added to the end of the amplifier model number. The standard amplifier configuration code is 000, and would be omitted from the part number. Refer to Configuration, section 2.1. The chart on the next page shows how to construct a custom configuration suffix.

1.3 MODEL NUMBERING con't:



SELECT DIGIT FOR EACH FOUR NUMBER GROUP:

0000=0	0110=4	1000=8	1100=C
0001=1	0101=5	1001=9	1101=D
0010=2	0110=6	1010=A	1110=E
0011=3	0111=9	1011=B	1111=F

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1.4 SPECIFICATIONS:

1.4.1 INPUT POWER (to baseplate):

Fans:		120VAC, 50/60Hz, single-phase, 1A.
Main power:	Voltage:	45VAC to 120VAC, 50/60Hz, single- or three-phase. See note below.
	Current:	single-axis: 15A RMS.

1.4.2 OUTPUT POWER (per amplifier):

Output current (RMS):	15ADC
Output current (peak):	25ADC
Output voltage (typical):	100VDC
DC Bus voltage (maximum):	250VDC

Note: Bus voltage should be selected to be 10% to 20% above the maximum voltage required at the motor terminals for maximum system efficiency. Higher or lower bus voltages are available, please consult a Glentek applications engineer.

1.4.3 SIGNAL INPUTS:

	VOLTS	IMPEDANCE	GAIN
Single-ended Inputs:	±70V max.	10K ohms min.	15KA/V
Differential Input:	±13V max.	10k ohms min.	15KA/V
Tachometer Input:	±90V max.	10K ohms min.	7KA/V
Drift (ref to input):	.01mV/^{o}C max.		
Frequency response:	750Hz min.		
Dead band:	None.		
Form factor:	1.01.		

1.4 SPECIFICATIONS Con't:

1.4.4 DIGITAL INPUTS:

±Limits, Inhibit, & Reset:	±50V max. Terminated by 10K ohms.
Fault (as input):	+40V/-5V max. Terminated by 10K ohms.
Typical for all digital inputs:	Digital input thresholds are at 1/3 and 2/3 of +5V or +15V depending on range select jumper.

1.4.5 OUTPUTS:

Fault (as output):	Open-collector output can sink 150mA through 10 ohms.
Motor current:	Bipolar output. 1V=10A. 10mA max.

1.4.6 OTHER SPECIFICATIONS:

Carrier frequency: 20KHz

1.4.7 MECHANICAL:

Ambient conditions: 120°F (50°C) max. Built-in fan(s) on baseplate provide forced-air cooling.

MODEL	L x W x H (inches)	WEIGHT (lbs)
GA377-1	7.0 x 1.4 x 6.5	1.5
GA377-1A-1	5.0 x 9.0 x 7.0	5
GA377-2A-2	7.5 x 9.0 x 7.0	7
GA377-4A-4	11.0 x 9.0 x 7.0	11
GA377-6A-6	14.5 x 9.0 x 7.0	14

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CHAPTER TWO: INSTALLATION

2.1 CONFIGURATION:

Each amplifier has several configuration options. This section describes these options and how to implement them. If desired, Glentek will be happy to pre-configure your amplifiers.

2.1.1 ANALOG-INPUT CONFIGURATION:

To configure the Signal input for differential-mode, place shunt on J4, D. To configure for single-ended mode, place shunt on J4, S. Auxiliary is a dedicated single-ended input.

To reconfigure the amplifier for current-mode operation, place shunt on J3.

2.1.2 LOGIC-INPUT CONFIGURATION:

There are five logic inputs: + limit, - limit, Inhibit, Reset, and Fault. The first four may be configured for active-high or active-low signals, and pulled-up or pulled-down termination (type A, B, C, and D). Fault is always active-low and pulled-up (type A). All five have a selectable 0 to +5 or 0 to +15 range.

Type "A": Requires grounding of input to disable amplifier (pull-up, active-low).

Type "B": Requires a positive voltage at input to disable amplifier (pull-down, active-high).

Type "C": Requires grounding of input to enable amplifier (pull-up, active-high).

Type "D": Requires a positive voltage at input to enable amplifier (pull-down, active-low).

+ limit, - limit, Inhibit, and Reset are shipped factory configured active-low and pulled up (type"A"), and the input range is configured for 0 to +15V. Refer to Model Numbering, section 1.3 for information on ordering other configurations.

The following table shows the jumpers that need to be connected for the Type A, B, C, and D configurations. The as-shipped are shown in bold.

	TYPE A	TYPE B	TYPE C	TYPE D
± Limit	**J9-U, J5-L**	J9-D, J5-H	J9-U, J5-H	J9-D, J5-L
Inhibit	**J10-U, J6-L**	J10-D, J6-H	J10-U, J6-H	J10-D, J6-L
Reset	**J11-U, J7-L**	J11-D, J7-H	J11-U, J7-H	J11-D, J7-L
Fault	**standard**	not available	not available	not available

To reconfigure all inputs for 0 to +5V operation, move J8 from +15 to +5.

2.2 MOUNTING:

Refer to appendix B as you read through the rest of this chapter. Appendix B contains all the wiring diagrams, assembly drawings, and mechanical information necessary to install these amplifiers.

The amplifier package should be mounted in a clean, dry enclosure, free of dust, oil, or other contaminates.

NEVER INSTALL THE AMPLIFIER PACKAGE IN ANY LOCATION WHERE FLAMMABLE OR EXPLOSIVE VAPORS ARE PRESENT.

IMPORTANT: Muffin fan(s) are mounted along one edge of the baseplate to provide cooling. At least 3" must be allowed between the fan side and the side opposite the fans and any other surface. The clearance to any other side of the amplifier package is not critical, although sufficient space should be allowed for ease of wiring and servicing.

2.3 WIRING:

DO NOT APPLY POWER UNTIL INSTRUCTED TO DO SO.

2.3.1 RFI / EMI and WIRING TECHNIQUE:

IMPORTANT: All PWM equipment inherently generates radio-frequency interference (RFI), and wiring acts as antennae to transmit this interference. In addition, motors inherently generate electro-magnetic interference (EMI). Unless the wiring is very short, some sort of shielding on the motor wires is necessary to meet FCC RFI/EMI guidelines and to protect other equipment from the effects of RFI/EMI. We recommend that shielded wire be used, and/or the wires should be run in metallic conduit. The shield or conduit should be tied to the amplifier baseplate, which in turn must be earth grounded. In addition, a conductor of the same gauge as the motor wires must be tied from the motor case to the amplifier baseplate to provide protection from shock hazard. The earth grounding is necessary to meet National Electrical Code (NEC) requirements as well as suppressing RFI/EMI. Additional RFI suppression may be obtained by placing inductors in each motor lead near the amplifier.

IMPORTANT: The signal wiring to the tachometer (if used) and the signal inputs to the amplifier are susceptible to noise pickup. Excessive noise pickup will cause erratic amplifier operation. We urge that each signal input line each be run in separate, twisted-pair, shielded cables. In each case the shield should be terminated at the amplifier end only to the common terminal (see Amplifier Connections, section 2.3.4). We also recommend that the signal lines be kept as far as possible from any power or motor wires.

2.3.2 WIRE SIZE and TYPE:

IMPORTANT: To ensure safe operation, Glentek strongly recommends that all wiring conform to all local and national codes.

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2.3 WIRING con't:

RECOMMENDED WIRE SIZES and TYPES:

MOTOR WIRES:	14AWG two conductor, over-all shielded, or run in metallic conduit.
MOTOR CASE GND:	14AWG or use metallic conduit.
MAIN POWER:	14AWG (single axis) or 12AWG (multi-axis), twisted.
FAN POWER:	16AWG, twisted.
SIGNAL & TACH INPUT:	22AWG, twisted-pair, shielded.
LOGIC INPUTS / OUTPUTS:	22AWG, twisted with its return lead.

2.3.3 BASEPLATE CONNECTIONS:

FAN POWER: Connect 120VAC for fans to TB201,1 and TB201,2.

MAIN POWER: Connect main power from secondary of power transformer to TB201,4, TB201,5 and TB201,6. Any two of the three terminals may be used for single-phase power. If any lead is grounded, I.E., neutral, it should be connected to TB201,4.

Notes: The power transformer is considered a separate part from the amplifier package. Selection is based on the application. Glentek maintains a complete stock of power transformers for virtually every application. See Specifications, section 1.4.1, for input-power requirements.

Please consult a Glentek applications engineer before operating an amplifier without a power transformer.

2.3.4 AMPLIFIER CONNECTIONS (each amplifier):

SIGNAL NAME	TERMINAL	NOTES
REGEN CLAMP:	TB1,1	Regen resistor -. Note that this connection is made on only one amplifier per baseplate.
	TB1,2	Regen resistor +.
MOTOR POWER: (DC Bus)	TB1,2	DC Bus + from filter capacitor(s).
	TB1,3	DC Bus - from filter capacitor(s).
		On multi-axis packages, the above connections have been made at the factory.

2.3 WIRING con't:

MOTOR:	TB1,4	Motor -.
	TB1,5	Motor +.

Sometimes inductors are required in series with each motor lead. See Pulse-Width Modulation, section 5.4, for an explanation of this requirement. The inductors are considered separate parts from the amplifier package. Consult a Glentek applications engineer for inductor recommendations. Glentek stocks a complete line of inductors for virtually every application. Mount inductors as close to each amplifier as possible to minimize RFI.

IMPORTANT: Never ground any motor lead (except the case), and be careful not to use grounded test equipment on the power section of any amplifier.

SIGNAL NAME	TERMINAL	NOTES
DIFF SIGNAL IN:	J1,1	Differential signal input, if selected.
DIFF SIGNAL RET:	J1,2	Differential signal return, if selected.
AUX SIGNAL IN:	J1,3	Dedicated single-ended signal input.
SIGNAL IN:	J1,4	Single-ended signal input, if selected.
TACHOMETER IN:	J1,5	Tachometer input. Not used in current-mode.
COMMON:	J1,6	Common for all signals and shields.
MOTOR CURRENT:	J1,7	Motor current output. 1V = 10A motor current.
+LIMIT:	J1,8	Stops motor rotation in the "+" direction.
-LIMIT:	J1,9	Stops motor rotation in the "-" direction.
INHIBIT:	J1,10	Stops motor rotation in both directions.
COMMON:	J1,11	Common for all signals and shields.
FAULT I/O:	J1,12	Goes low if there is a fault in the amplifier. May be externally forced low to stop motor rotation in both directions.
COMMON:	J1,13	Common for all signals and shields.
RESET:	J1,14	Resets the fault latch. May also be used as an inhibit input.

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CHAPTER THREE: START UP and CALIBRATION

3.1 INTRODUCTION:

All adjustments are made to the pots on the top edge of the amplifier. Refer to Appendix B, drawing 377-1010.

Calibration requires an oscilloscope, a voltmeter, and a "battery box". A battery box is a servo-system calibrator which includes an adjustable bipolar output, a reversing switch, and a pulse switch. A battery box is available from Glentek, part number BB-700. Any battery or floating power-supply with a series switch may be used in place of the battery box.

3.2 SAFETY PRECAUTIONS:

Before starting calibration, the following safety precautions should be observed:

1. Check for any loose or damaged components.
2. Check that all connections are tight.
3. Be sure that the motor mechanism(s) are clear of obstructions. If the mechanism has limited motion, e.g., a lead-screw, set mechanism to mid-position.
4. Disconnect all signal inputs.
5. Turn Loop Gain pots on uncalibrated amplifiers full CCW.
6. Remove input fuses on baseplate and apply main power. Check for the correct AC voltage at fuses. The maximum voltage at this point is usually 170VAC. The DC bus (amplifier supply-voltage) will be 1.4 times this value. Remove power and re-install input fuses.
7. Work on only one amplifier at a time.

3.3.1 CALIBRATION: VELOCITY MODE:

The following potentiometers (pots) will be set during calibration:
Note: All pots except Loop-Gain are 15-turn.

RV2	Loop Gain:	Used to shut down uncalibrated amplifiers.
RV3	Balance:	Used to null any offsets in system.
RV4	Compensation:	Used in conjunction with RV5 to set system bandwidth.
RV5	Tach. Gain:	Sets DC tach gain.
RV6	Current Limit:	Sets maximum motor current.
RV7	Signal Gain:	Sets the input voltage to RPM ratio for Signal Input or Differential input, e.g., 10V = 2000RPM.

3.3.1 CALIBRATION: VELOCITY MODE con't:

RV8 Auxiliary Gain: Sets the input voltage to RPM ratio for the Auxiliary Signal Input, e.g., 10V=2000RPM.

Note: RV1, RV9, RV10, and RV11 are factory set and should not be adjusted.

PROCEDURE:

1. Apply main power and fan power.

2. Slowly turn Loop Gain (RV2) CW. Motor should be stopped or turning slowly. If motor starts running away, remove power, reverse the tach leads, and retest.

3. Set Balance (RV3) for zero motor rotation.

4. Connect oscilloscope to J1,7 and battery box to J1,3. (J1,6 is common for both.) The voltage on J1,7 is a function of motor current: 1V=10A. While applying a step input voltage, adjust Current Limit (RV6) for desired peak current.

The purpose of the following procedure is to set the system bandwidth to obtain a critically-damped response with the maximum possible tach gain. There are many possible settings of Tach Gain and Compensation which will yield a critically damped waveform: The optimum setting will occur when Tach Gain is as CW as possible and Compensation is as CCW as possible. However, the servo-loop may become unstable (the motor oscillates or hunts) with a very low (near CCW) setting of Compensation. In this case, stability is the limiting factor: At no time should the servo-loop be allowed to be unstable.

Amplifiers are normally shipped with Tach Gain (RV5) set at 75%. This is a good place to start. If you are unsure of where Tach Gain is set, turn Tach Gain (RV5) fully CW (up to 15 turns), then CCW 4 turns.

5. Connect oscilloscope to J1,5 (J1,6 is common). Set battery box for steady DC and adjust input voltage or Auxiliary Gain (RV8) to obtain 400RPM. The RPM may be set by measuring the tach voltage at J1,5, e.g., 2.8VDC for a 7V/KRPM tach.

6. Pulse the input and compare the waveform with figure 3.1 (next page).

7. If the waveform is critically-damped or under-damped, increase the bandwidth by adjusting Compensation (RV4) CCW until the waveform becomes slightly over-damped.

8. Adjust Tach Gain (RV5) CW until the waveform becomes slightly under-damped.

9. Repeat steps 7 and 8 until Tach Gain (RV5) is full CW, or Compensation (RV4) is full CCW, or the servo-loop begins to de-stabilize (whichever occurs first).
   If Tach Gain (RV5) is full CW, set Compensation (RV4) for a critically-damped waveform.
   If Compensation (RV4) is full CCW, set Tach Gain (RV5) for a critically-damped waveform.
   If the servo-loop becomes unstable, back-off Tach Gain (RV5) 1 turn CCW and set Compensation (RV4) for a critically-damped waveform.

10. Do not adjust Tach Gain or Compensation for the rest of the calibration procedure.

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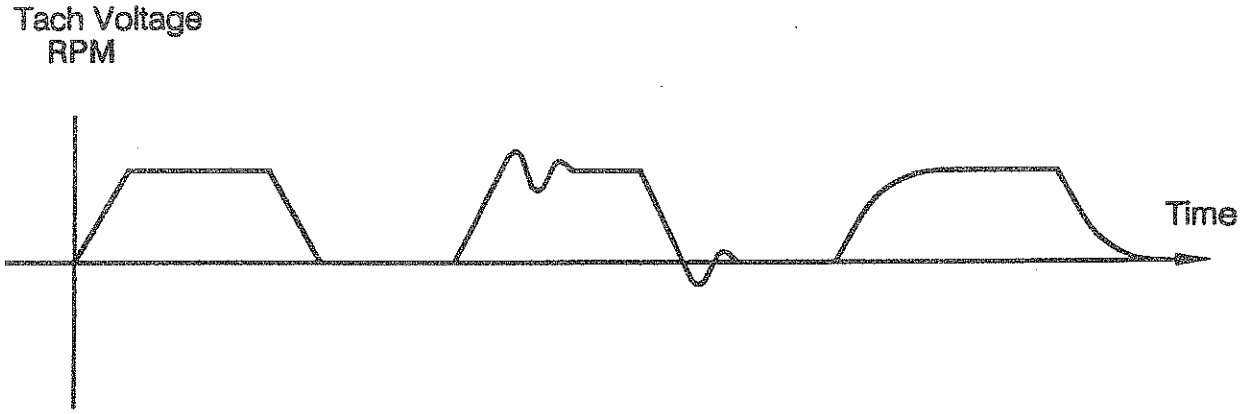
3.3.1 CALIBRATION: VELOCITY MODE con't:



Critically damped.

Under damped: Too much Tach or not enough Bandwidth.

Over damped: Not enough Tach or too much Bandwidth.

Figure 3.1

11. Set battery box for a known DC voltage, typically the maximum input voltage you will be using. Monitor the motor RPM or the tach voltage on J1,5. (The battery box should still be connected to J1,3 and J1,6.)

12. If your system uses only one signal input, turn Auxiliary Gain (RV8) full CCW (up to 15 turns) and proceed to step 14. If your system uses both inputs, perform both steps 13 and 14.

13. Adjust Auxiliary Gain (RV8) to obtain the desired RPM for the input voltage being applied.

14. Turn off battery box. Move battery box from J1,3 to J1,4. (If your system uses the Differential input, move battery box to J1,1 and J1,2) Set battery box for a known DC voltage, typically the maximum input voltage you will be using. Adjust Signal Gain (RV7) to obtain the desired RPM for the input voltage being applied.

15. If the motor is rotating the wrong way for the polarity of input being applied, remove power and reverse both the motor leads and the tach leads.

16. Remove battery box, and repeat step 4.

17. Calibration complete. Reconnect signal wires.

3.3.2 CALIBRATION: CURRENT MODE:

RV2 Loop Gain: Not used (Must be full CW).

RV3 Balance: Used to null any offsets in system.

RV4 Compensation: Not used.

3.3.2 CALIBRATION: CURRENT MODE con't:

RV5 Tach. Gain: Not used.

RV6 Current Limit: Sets peak motor current.

RV7 Signal Gain: Sets the input voltage to motor-current ratio for Signal Input or Differential input, e.g., 10V=10A.

RV8 Auxiliary Gain: Sets the input voltage to motor-current ratio for the Auxiliary Signal Input, e.g., 10V=10A.

Note: RV1, RV9, RV10, and RV11 are factory set and should not be adjusted. Adjusting these pots voids warranty.

PROCEDURE:

1. Apply main power and fan power.
2. Be sure Loop Gain (RV2) is full CW. Motor should be stopped or turning slowly. Set Balance (RV3) for 0V at J1,7.
3. Connect oscilloscope to J1,7 and battery box to J1,3. (J1,6 is common for both.) The voltage on J1,7 is a function of motor current: 1V=10A. While applying a step input voltage, adjust Current Limit (RV6) for desired peak current. If desired peak current cannot be achieved with pot full CW, increase input voltage or increase Auxiliary Gain (RV8) CW.
4. Set battery box for a known DC voltage, typically the maximum input voltage you will be using, but see note. Monitor motor current on J1,7. Scale factor is 1V=10A.
5. If your system uses only one signal input, turn Auxiliary Gain (RV8) full CCW and proceed to step 7. If your system uses both inputs, perform both steps 6 and 7.
6. Adjust Auxiliary Gain (RV8) to obtain the desired motor current for the input voltage being applied.

Note: If the maximum input command voltage causes the amplifier output to exceed its continuous current rating, the LS/ECB will trip. To avoid this, use a step input voltage with an on-time of less than 1.5 seconds, or use a fraction of the maximum input to do the calibration: e.g. set the input to 1/2 of maximum and adjust gain pot(s) for 1/2 of maximum output current.

7. Turn off battery box. Move battery box from J1,3 to J1,4. (If your system uses the Differential input, move battery box to J1,1 and J1,2) Set battery box for a known DC voltage, typically the maximum input voltage you will be using. Adjust Signal Gain (RV7) to obtain the desired motor current for the input voltage being applied.
8. If the motor is rotating the wrong way for the polarity of input being applied, remove power, reverse motor leads, and retest.
9. Remove battery box and repeat step 3.
10. Calibration complete. Reconnect signal wires.

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3.4 CALIBRATION LOG:

It is good practice to keep a record of all pot settings. Doing so will facilitate calibration on future units and repair on this unit. Although not a substitute for the above procedure, it will at least get you "in the ballpark." Remove power and allow all capacitors to discharge before taking measurements. Refer to Appendix B, drawing 377-1010 for the location of the test points to take the measurements.

	AMP 1	AMP 2	AMP 3	AMP 4	AMP 5	AMP 6
1. Auxiliary-Gain pot wiper J2,2 to common (ohms):	_____	_____	_____	_____	_____	_____
2. Signal-Gain pot wiper J2,3 to common (ohms):	_____	_____	_____	_____	_____	_____
3. Tach-Gain pot wiper J2,4 to common (ohms):	_____	_____	_____	_____	_____	_____
4. Compensation pot wiper J2,5 to common (ohms):	_____	_____	_____	_____	_____	_____
5. Current limit pot wiper J2,6 to common (ohms):	_____	_____	_____	_____	_____	_____
6. Signal input to Tach input voltage ratio: _____ volts Signal / volts Tach	_____	_____	_____	_____	_____	_____

Note: Tach voltage is measured at J1,5. Common for all measurements is at J2,1.

Note: Balance pot should not be measured in this fashion, but should always be set per step 3 in the calibration procedure.

Date data taken: ___ ___ ___

Model & serial number GA377-_____-____-_____ S/N: _____

Note any changes to components or any special features in the space below:

CHAPTER FOUR: MAINTENANCE, REPAIR, and WARRANTY

4.1 MAINTENANCE:

Glentek amplifiers do not require any scheduled maintenance, although it is a good idea to occasionally check for dust build-up or other contamination.

4.2 AMPLIFIER FAULTS:

If an amplifier should cease to operate and a fault LED is lit, review the sections which follow for information and possible causes.

A FAULT CAN ONLY BE CAUSED BY ABNORMAL CONDITIONS. LOCATE AND CORRECT THE CAUSE OF THE FAULT BEFORE REPEATED RE-CYCLING OF THE AMPLIFIER TO PREVENT POSSIBLE DAMAGE.

4.2.1 OVER-TEMP FAULT:

When the heatsink temperature reaches a level that, if exceeded, would damage the output transistors, the Over-Temp indicator LED is latched ON and the amplifier is inhibited.

The following is a list of possible causes:

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 tach signal (if tach used). A noisy tach signal 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 tachometer noise.
6. Mis-adjusted amplifier. See Calibration, section 3.3.

4.2.2 LOW-SPEED ELECTRONIC CIRCUIT BREAKER (LS/ECB) FAULT:

When the RMS output of the amplifier exceeds 15A for 1.5 seconds, the LS/ECB fault LED is latched ON, and the amplifier is inhibited.

The following is a list of possible causes:

1. Binding or stalling of motor shaft due to excessive mechanical overload.
2. Large reflected load inertia.

4.2 AMPLIFIER FAULTS con't:

4.2.3 HIGH-SPEED ELECTRONIC CIRCUIT BREAKER (HS/ECB) FAULT:

When the peak output of the amplifier exceeds 35A for 10 micro-seconds, the HS/ECB fault LED is latched ON, and the amplifier is inhibited.

The following is a list of possible causes:

1. Shorted motor leads.
2. Short from a motor lead to ground.
3. Motor inductance too low.

4.2.4 OVER-VOLTAGE FAULT:

When the DC-Bus voltage has reached a level that, if exceeded, would damage the output transistors, the Over-Volt indicator LED is latched ON and the amplifier is inhibited.

The following is a list of possible causes:

1. Main AC line voltage is too high.
2. Incorrect power transformer.
3. Decelerating a large load inertia. When decelerating, a DC motor acts as a generator. If the load inertia is large, the generated voltage can pump-up the DC-Bus. As an option, the GA377 can include a Regen Clamp to bleed off this voltage. If this fault occurs, consult Glentek.

4.2.5 UNDER-VOLTAGE FAULT:

The GA377 uses a DC-DC converter to generate operating voltages from the DC-Bus. If the DC-Bus voltage falls below the level that the amplifier can maintain its operating voltages the amplifier will shut down. This is a non-latched fault. Normal operation will resume when the DC-Bus voltage returns to normal.

4.2.6 RESETTING A FAULT:

The fault latch may be reset by applying an appropriate voltage to the Reset input (J1,14); by pressing the Reset pushbutton; or by removing power, allowing the filter capacitor(s) to discharge, and re-applying. Note that the fault latch will not reset unless the fault has been cleared.

4.3 AMPLIFIER FAILURE:

If an amplifier should fail, that is, if it should cease to operate with no apparent fault, the fault-tracing charts in appendix A may be used to isolate the problem to the lowest module which Glentek recommends as replaceable. In an emergency, the drawings in appendix B will enable a skilled technician to trouble-shoot an amplifier to even lower levels.

The fault-tracing charts in appendix A are as follows:

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

The lowest-level parts or modules which Glentek recommends for field replacement are:

1. Fuses F201 and F202 on baseplate, and F1 on each amplifier.
2. Rectifier bridges BR201 and BR202.
3. DC-Bus filter capacitor C201.
4. Fans 201 and 202

4.4 FACTORY REPAIR:

Should it become necessary to return an amplifier 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 and representative returning the unit, along with a telephone number.
   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 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.

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4.5 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, provided that you promptly send to us notice of the defect and establish that the product has been properly installed, maintained, 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 hold us harmless from any and all such claims or damages that may be initiated against us by third parties.

CHAPTER FIVE: THEORY of OPERATION

5.1 INTRODUCTION to THEORY of OPERATION:

A velocity-mode servo amplifier is essentially comprised of two control loops (see fig. 5.1).

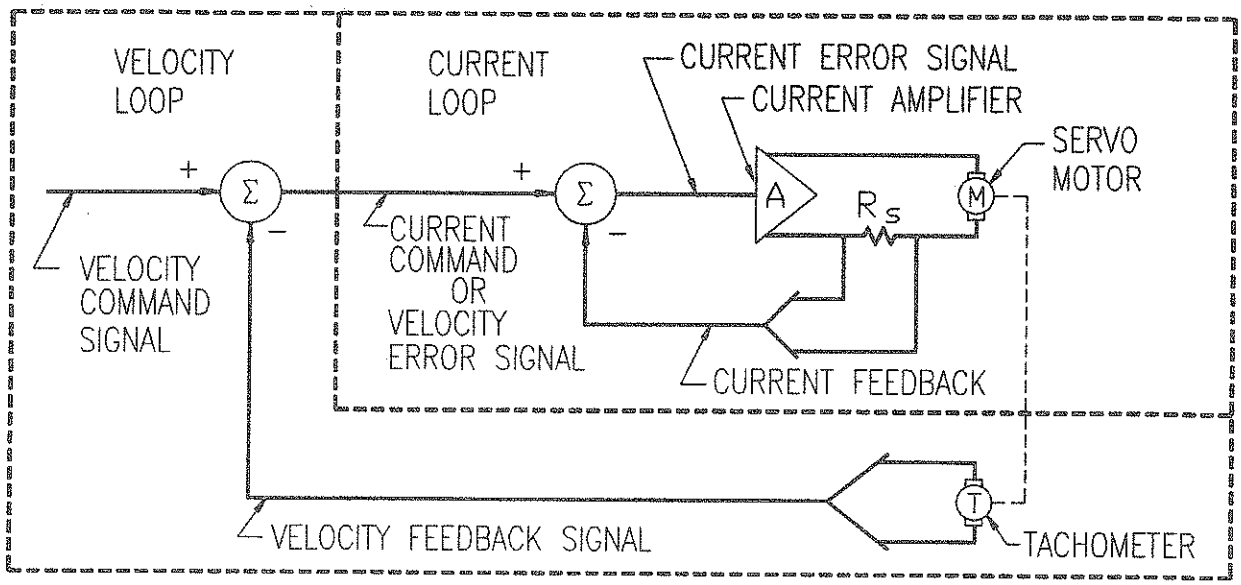

Figure 5.1

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.

5.2 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.

5.3 "H TYPE" OUTPUT BRIDGE CONFIGURATION:

The output configuration of the amplifier is an "H TYPE" bridge (see fig. 5.2 for schematic representation of an output bridge with a motor connected).

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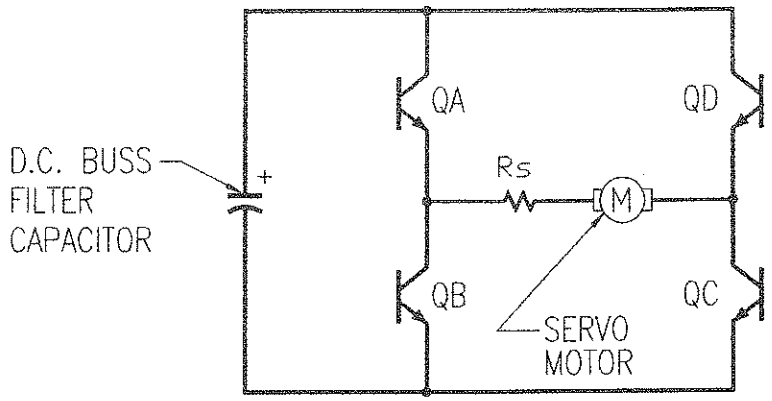

Figure 5.2

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.

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.

5.4 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 5.3. Note that since the pulse widths are equal, the net DC current in the motor is equal to zero.

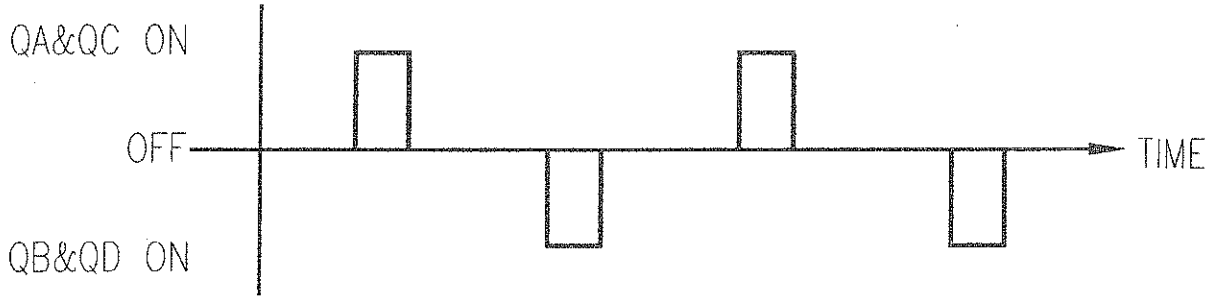

Figure 5.3

When a non-zero current is commanded to the current loop, the transistor switching waveform is as shown in figure 5.3A. 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.

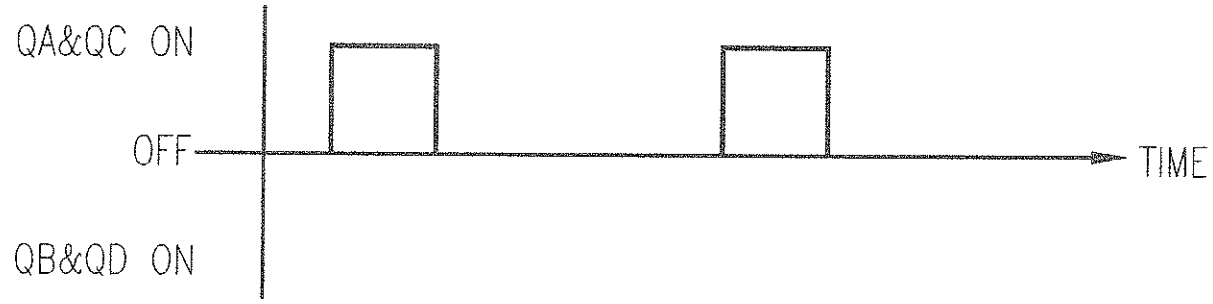

Figure 5.3A

If the input to the current loop had been changed in polarity, the output transistor switching waveform would be as shown in figure 5.3B.

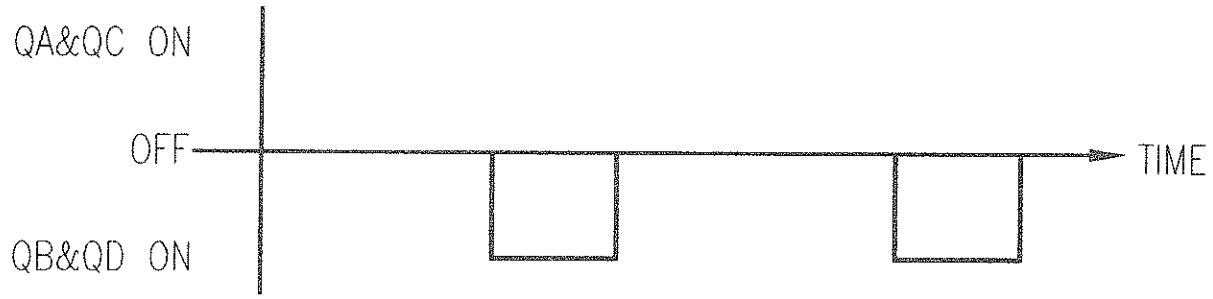

Figure 5.3B

If a larger current of the same polarity was commanded to the output transistors (see fig. 5.3B) 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".

A coil of wire, such as the windings of a motor, forms an inductor. Inductors resist changes in current. This resistance to change, known as reactance, acts to dampen or average the high-current spikes that would otherwise occur when the output devices are on. In fact, if motor inductance is low, external inductors may have to be added in series with each motor lead to ensure proper operation.

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.

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5.5 CURRENT-LOOP OPERATION:

Please refer to figure 5.1 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. 5.1) 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.

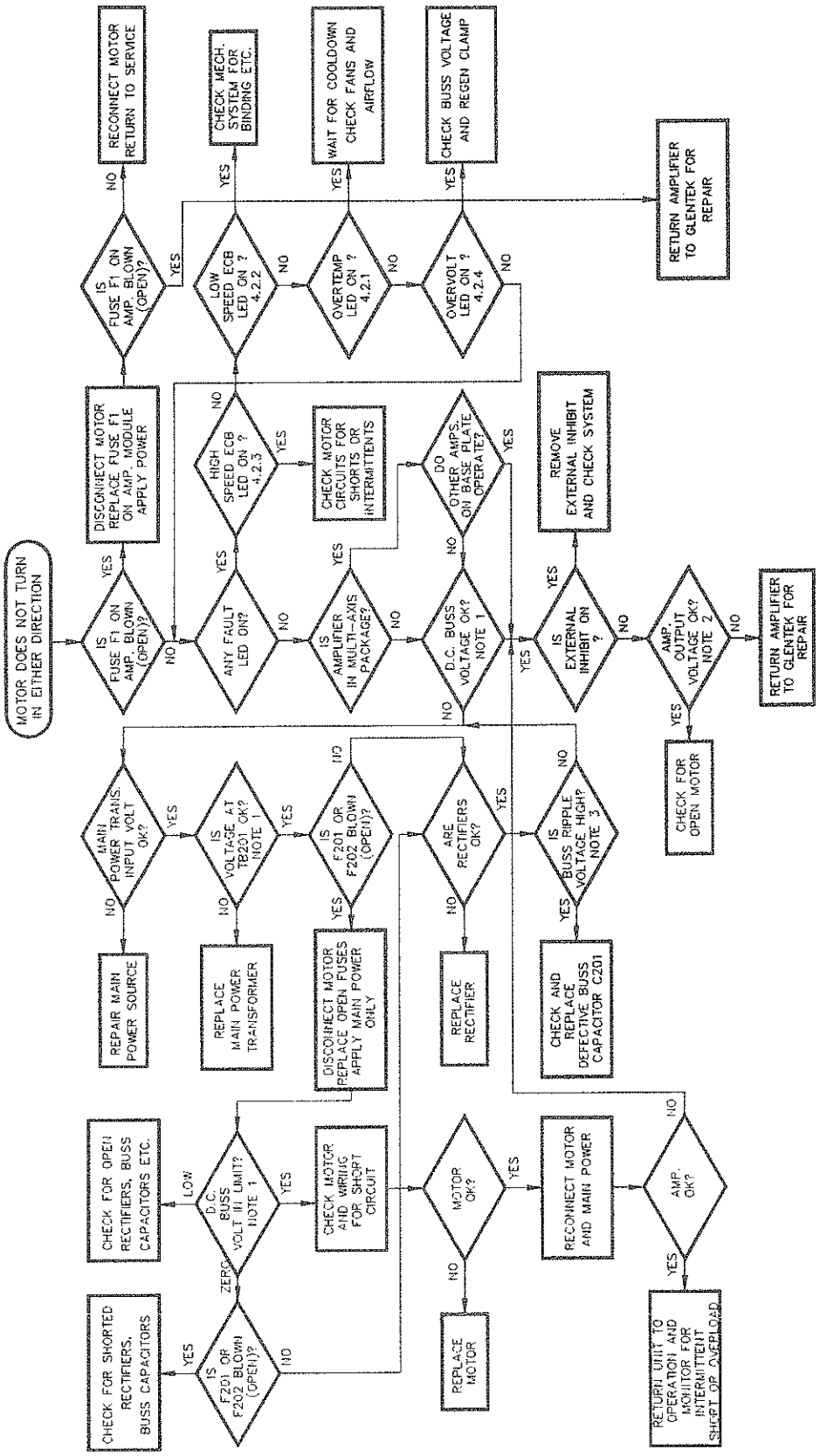
5.6 VELOCITY-LOOP OPERATION:

Please refer to figure 5.1 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.

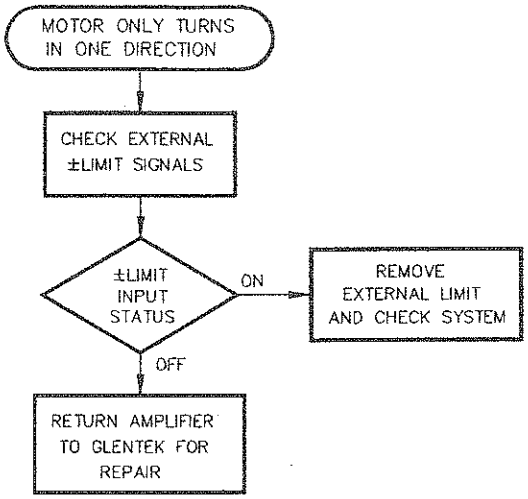
APPENDIX A

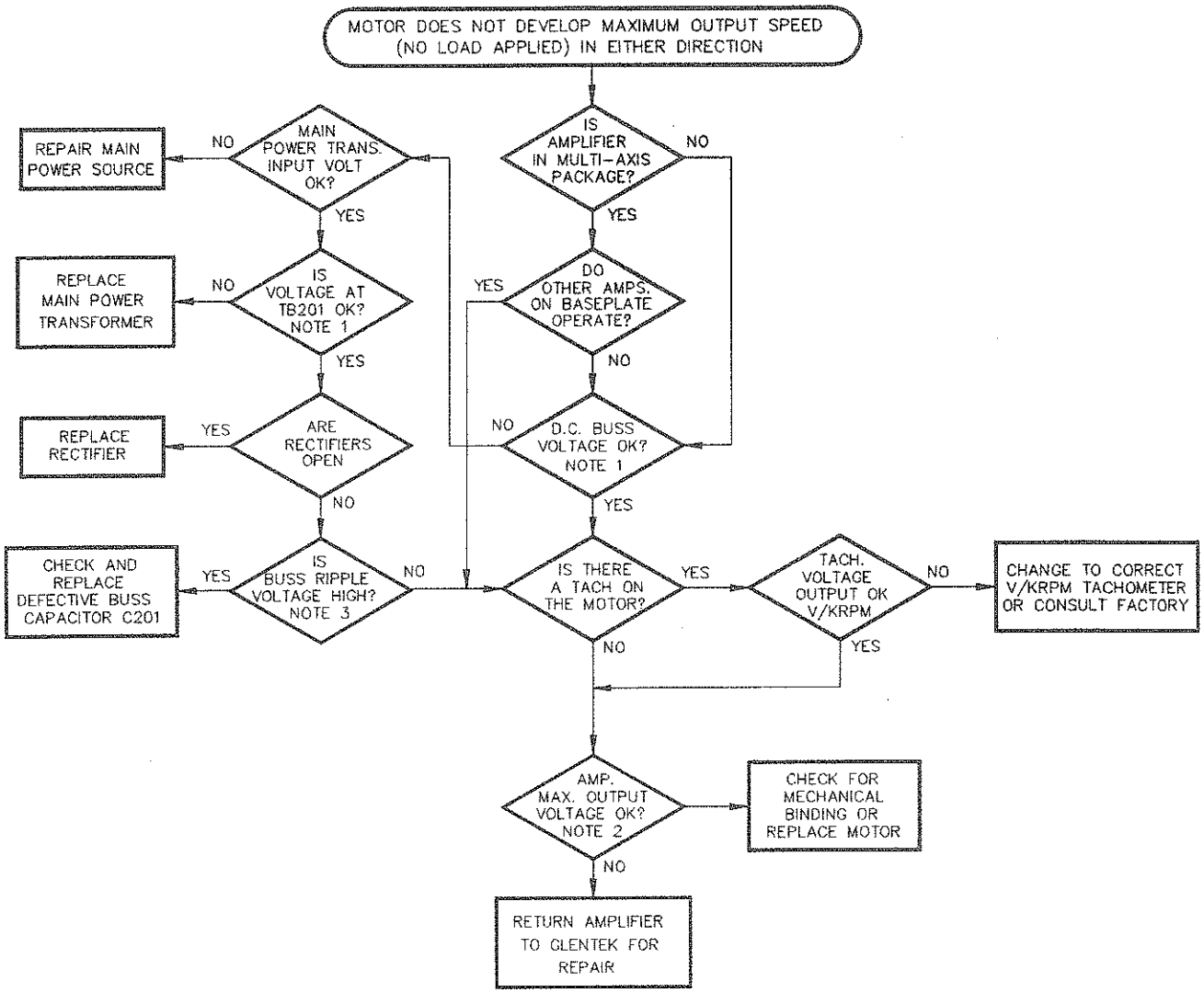
FAULT TRACING CHARTS

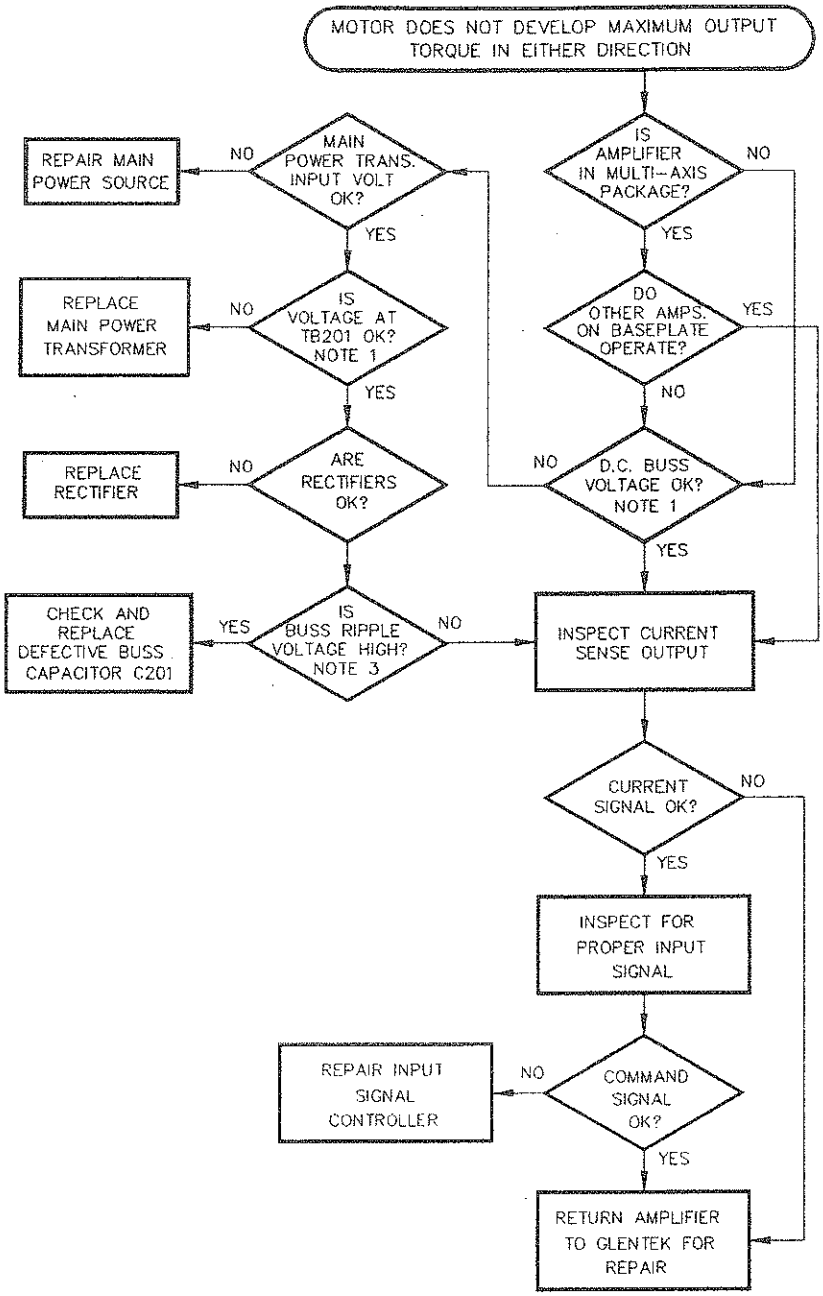
GA377 MANUAL
APPENDIX A



GA377 MANUAL
APPENDIX A




MOTOR DOES NOT DEVELOP MAXIMUM OUTPUT SPEED (NO LOAD APPLIED) IN EITHER DIRECTION
IS AMPLIFIER IN MULTI-AXIS PACKAGE?
NO
YES
MAIN POWER TRANS. INPUT VOLT OK?
NO
REPAIR MAIN POWER SOURCE
YES
DO OTHER AMPS. ON BASEPLATE OPERATE?
YES
NO
IS VOLTAGE AT TB201 OK? NOTE 1
NO
REPLACE MAIN POWER TRANSFORMER
YES
D.C. BUSS VOLTAGE OK? NOTE 1
NO
YES
ARE RECTIFIERS OPEN
YES
REPLACE RECTIFIER
NO
IS BUSS RIPPLE VOLTAGE HIGH? NOTE 3
YES
CHECK AND REPLACE DEFECTIVE BUSS CAPACITOR C201
NO
IS THERE A TACH ON THE MOTOR?
YES
TACH. VOLTAGE OUTPUT OK V/KRPM
NO
CHANGE TO CORRECT V/KRPM TACHOMETER OR CONSULT FACTORY
YES
NO
AMP. MAX. OUTPUT VOLTAGE OK? NOTE 2
CHECK FOR MECHANICAL BINDING OR REPLACE MOTOR
NO
RETURN AMPLIFIER TO GLENTEK FOR REPAIR


MOTOR DOES NOT DEVELOP MAXIMUM OUTPUT TORQUE IN EITHER DIRECTION
IS AMPLIFIER IN MULTI-AXIS PACKAGE?
NO
YES
MAIN POWER TRANS. INPUT VOLT OK?
NO
REPAIR MAIN POWER SOURCE
YES
DO OTHER AMPS. ON BASEPLATE OPERATE?
YES
NO
IS VOLTAGE AT TB201 OK? NOTE 1
NO
REPLACE MAIN POWER TRANSFORMER
YES
D.C. BUSS VOLTAGE OK? NOTE 1
NO
YES
ARE RECTIFIERS OK?
NO
REPLACE RECTIFIER
YES
IS BUSS RIPPLE VOLTAGE HIGH? NOTE 3
YES
NO
CHECK AND REPLACE DEFECTIVE BUSS CAPACITOR C201
INSPECT CURRENT SENSE OUTPUT
CURRENT SIGNAL OK?
NO
YES
INSPECT FOR PROPER INPUT SIGNAL
COMMAND SIGNAL OK?
NO
REPAIR INPUT SIGNAL CONTROLLER
YES
RETURN AMPLIFIER TO GLENTEK FOR REPAIR

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.

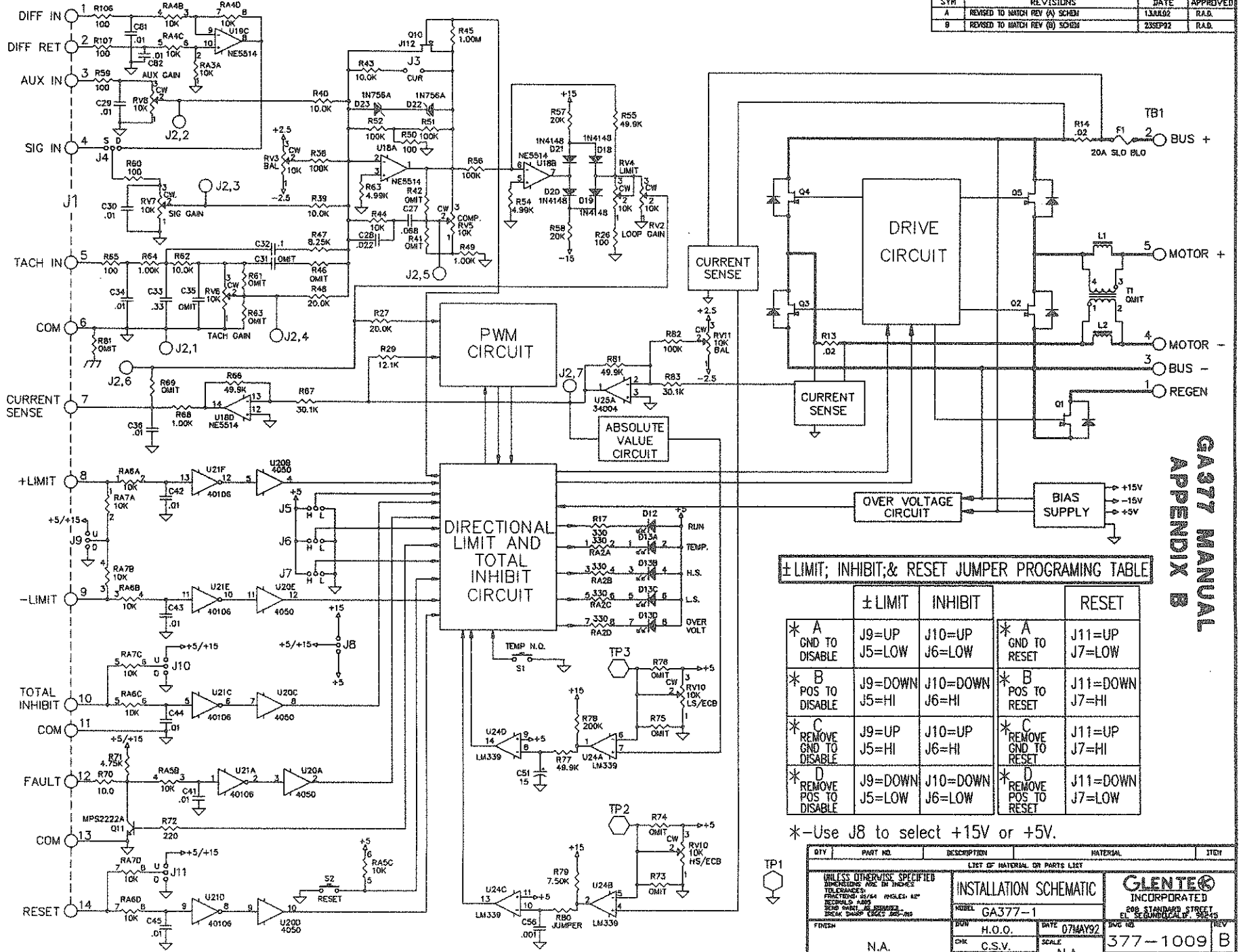
NOTE 2: The output voltage to the motor can be checked by alternately applying a positive and then negative voltage to the signal input and observing the voltage swing at the amplifier motor output terminals. Keep in mind that the Signal potentiometer must be set at least somewhat CW. This test can be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

APPENDIX B

AMPLIFIER DRAWINGS

SYM	REVISIONS	DATE	APPROVED
A	REVISED TO MATCH REV (A) SCHEM	13JUL92	R.A.D.
B	REVISED TO MATCH REV (B) SCHEM	23SEP92	R.A.D.



±LIMIT; INHIBIT;& RESET JUMPER PROGRAMING TABLE

	±LIMIT	INHIBIT		RESET
* A GND TO DISABLE	J9=UP J5=LOW	J10=UP J6=LOW	* A GND TO RESET	J11=UP J7=LOW
* B POS TO DISABLE	J9=DOWN J5=HI	J10=DOWN J6=HI	* B POS TO RESET	J11=DOWN J7=HI
* C REMOVE GND TO DISABLE	J9=UP J5=HI	J10=UP J6=HI	* C REMOVE GND TO RESET	J11=UP J7=HI
* D REMOVE POS TO DISABLE	J9=DOWN J5=LOW	J10=DOWN J6=LOW	* D REMOVE POS TO RESET	J11=DOWN J7=LOW

*-Use J8 to select +15V or +5V.

QTY	PART NO.	DESCRIPTION	MATERIAL	ITEM
		LIST OF MATERIAL OR PARTS LIST		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS± 32/64 ANGLES± 2°
DECIMALS .XXX
BREAK SHARP EDGES .005-.015

FINISH: N.A.

INSTALLATION SCHEMATIC

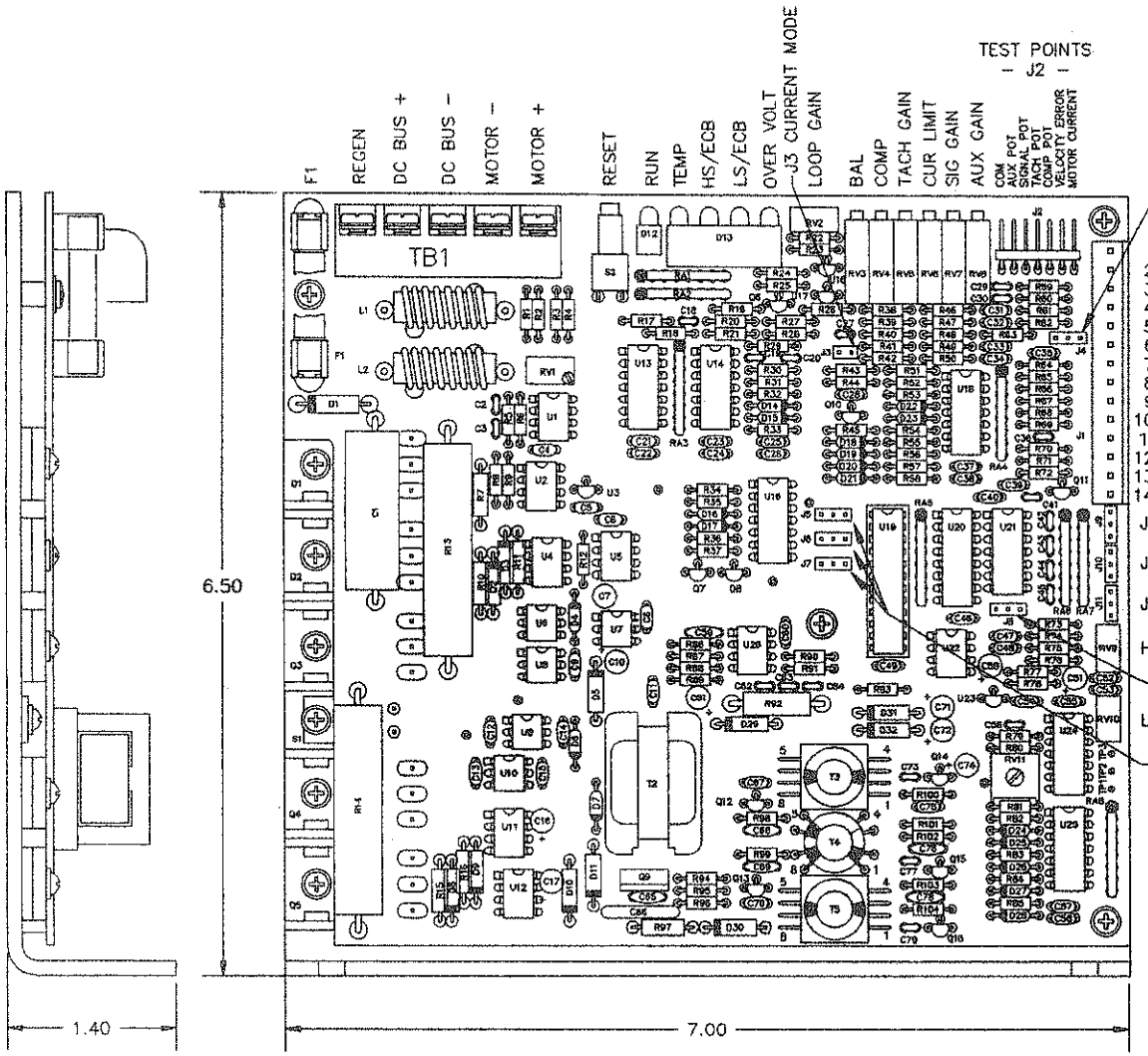
MODEL GA377-1

DWN H.O.O. DATE 07MAY92
CHK C.S.V. SCALE N.A.
APPR. R.A.D.

GLENTEK INCORPORATED
208 STANDARD STREET
EL SEGUNDO,CALIF. 90245

DWG NO 377-1009 REV B
SHEET 1 OF 1

SYM	REVISIONS	DATE	APPROVED
A	Production Release	07MAY92	R.A.D.
B	REVISED TO MATCH REV (A) PCB	13JUL92	R.A.D.
C	REVISED TO MATCH REV (B) PCB	23SEP92	R.A.D.



J4 – SINGLE–ENDED / DIFFERENTIAL
S = SINGLE ENDED
D = DIFFERENTIAL

J1

1	DIFF IN
2	DIFF RET
3	AUX IN
4	SIG IN
5	TACH IN
6	COM
7	MOTOR CUR
8	+ LIMIT
9	– LIMIT
10	INHIBIT
11	COM
12	FAULT
13	COM
14	RESET

RECOMMENDED MATING CONNECTOR:
HOUSING – MOLEX 09–50–7141
PINS – MOLEX 08–50–0106

J9 – ±LIMITS TERMINATION: U=PULL UP, D=PULL DOWN

J10 – INHIBIT TERMINATION: U=PULL UP, D=PULL DOWN

J11 – RESET TERMINATION: U=PULL UP, D=PULL DOWN

HS/ECB

J8 – LOGIC LEVEL: +5 OR +15

LS/ECB

J5 – ±LIMITS ACTIVITY: H=ACTIVE HIGH, L=ACTIVE LOW
J6 – INHIBIT ACTIVITY: H=ACTIVE HIGH, L=ACTIVE LOW
J7 – RESET ACTIVITY: H=ACTIVE HIGH, L=ACTIVE LOW

GA377 MANUAL
APPENDIX B

SCHEM: 377–1000 (B)
PCB: 377–1001 (B)
ASSY: 377–1002 (B)
EPL: 377–1003 (B)

QTY	PART NO.	DESCRIPTION	MATERIAL	ITEM
		LIST OF MATERIAL OR PARTS LIST		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±1/64 ANGLES ±2°
DECIMALS ±.005
BEND RADII AS REQUIRED
BREAK SHARP EDGES .005–.010

INSTALLATION DRAWING
MODEL GA377–1

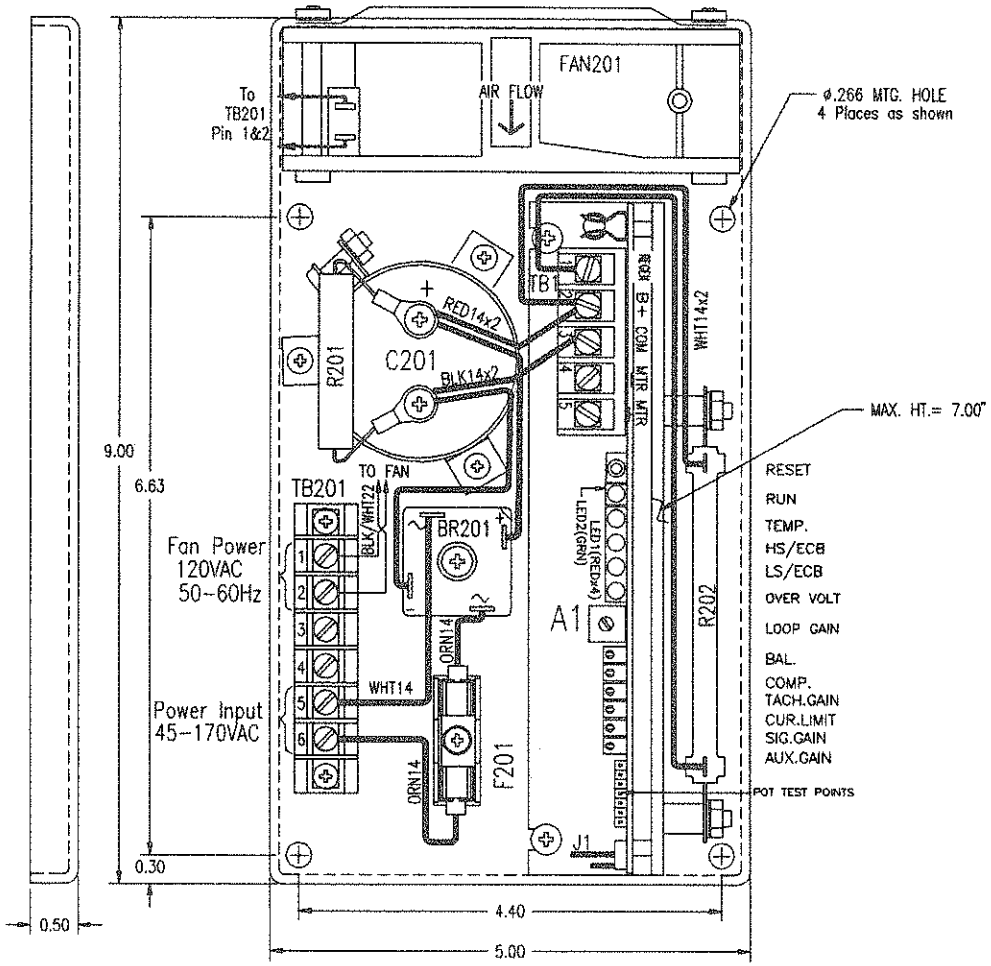
GLENTEK INCORPORATED
208 STANDARD STREET
EL SEGUNDO, CA. 90245

FINISH: N.A.

DWN H.O.O. | DATE 07APR92 | DWG NO. 377–1010 | REV C
CHK TY C. | SCALE 5:8
APPR. R.A.D.
SHEET 1 OF 1

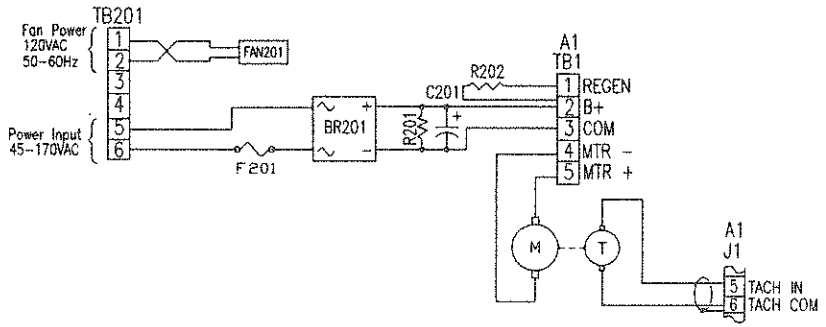
SIZE B

SYM	REVISIONS	DATE	APPROVED



NOTES:

1. Never ground the outputs of the amplifier.
2. Use shielded cable for Signal and Tach. leads, connect shield to Signal or Tach. common.
3. Package shown with Optional Regen-Clamp and shunt resistor R202.
4. For Lower/Higher D.C. Buss Voltage, Please consult with Glentek.



QTY	PART NO.	DESCRIPTION	MATERIAL	ITEM
1	R202	RESISTOR DALE HL-55, 15ohm (Optional)		9
1	TB201	TERMINAL BLOCK 6-PIN, MAGNUM		8
1	F201	FUSEHOLDER AND FUSE 20A MDA		7
1	BR201	RECTIFIER, 25A		6
1	R201	RESISTOR 10K-10W		5
1	C201	CAPACITOR, 2500MFD-250VDC		4
1	FAN201	FAN, 120VAC, 50-60Hz		3
1	377-1012	1-AXIS BASEPLATE		2
1	A1	GA377-1 AMPLIFIER MODULE		1

LIST OF MATERIAL OR PARTS LIST

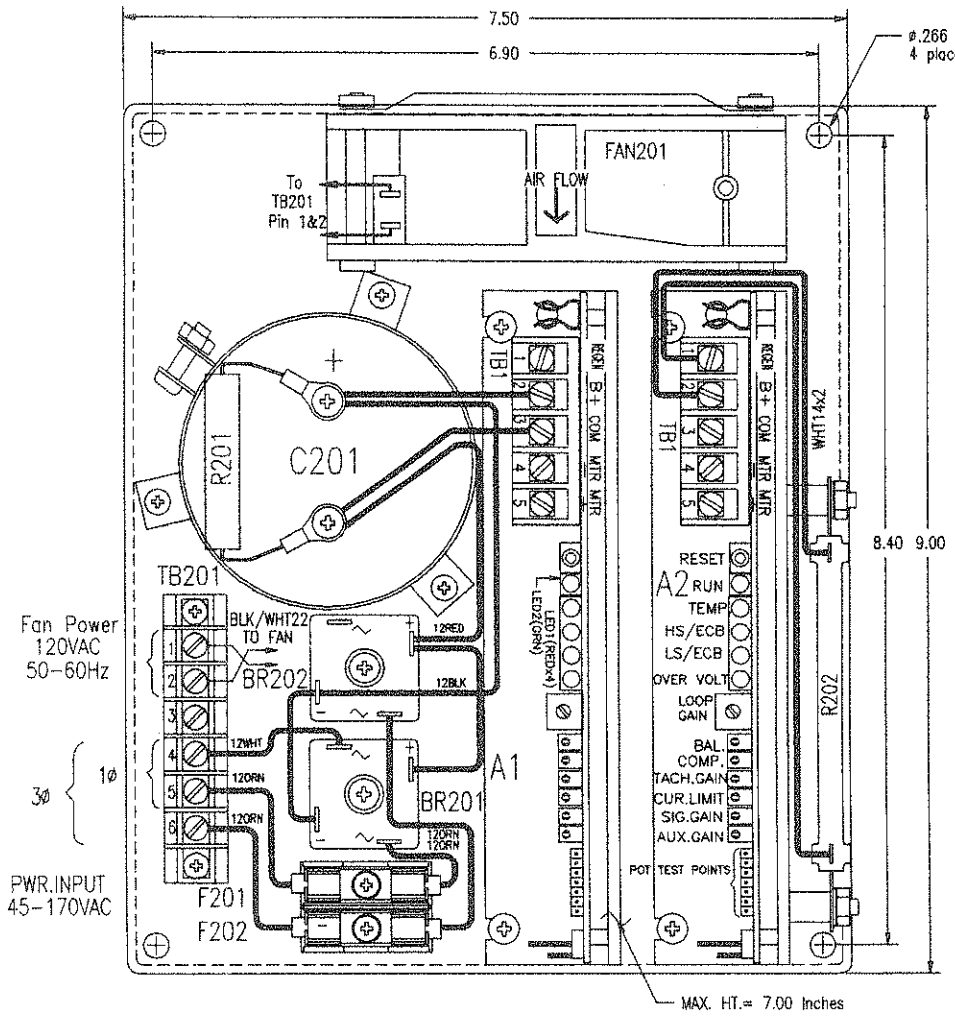
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±1/64 ANGLES: ±2°
DECIMAL ± .005
REMOVE BURRS AND BREAK SHARP EDGES .005-.010

1-AXIS INSTALLATION DRAWING
MODEL GA377-1A-1

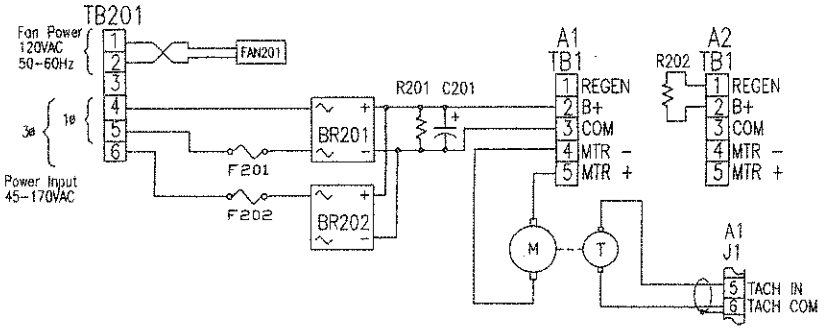
GLENTEK INCORPORATED
208 STANDARD STREET
EL SEGUNDO, CALIF. 90245

FINISH: N.A.
DWN: H.O.O.
CHK: TY C.
APPR: R.A.D.
DATE: 15MAY92
SCALE: N.A.
DWG NO. 377-1017
REV: -
SHEET 1 OF 1

SYM	REVISIONS	DATE	APPROVED



NOTES:
1. Wiring to Amplifier "A1" is typical for all amplifiers.
2. Never ground the outputs of the amplifiers.
3. Use shielded cable for Signal and Tach. leads, connect shield to Signal or Tach. common.
4. 2-Axis package shown with optional Regen-Clamp and R202 shunt resistor.
5. For Lower/Higher D.C. Buss Voltage, Please consult with Glentek.



QTY	PART NO.	DESCRIPTION	MATERIAL	ITEM
1	R202	RESISTOR DALE HL-55, 15ohm(Optional)		9
2	F201,F202	FUSE HOLDER AND FUSE 20AMP MDA		8
1	TB201	TERMINAL BLOCK 6-PIN, MAGNUM		7
2	BR201,BR202	RECTIFIER, 35A, 400V		6
1	R201	RESISTOR 10K-10W		5
1	C201	CAPACITOR 6000MFD-250VDC , MAX. SURGE 300VDC		4
1	FAN201	FAN, 120VAC, 50-60Hz		3
1	377-1014	2-AXIS BASEPLATE		2
2	A1-A2	GA377-1 AMPLIFIER MODULE		1

LIST OF MATERIAL OR PARTS LIST

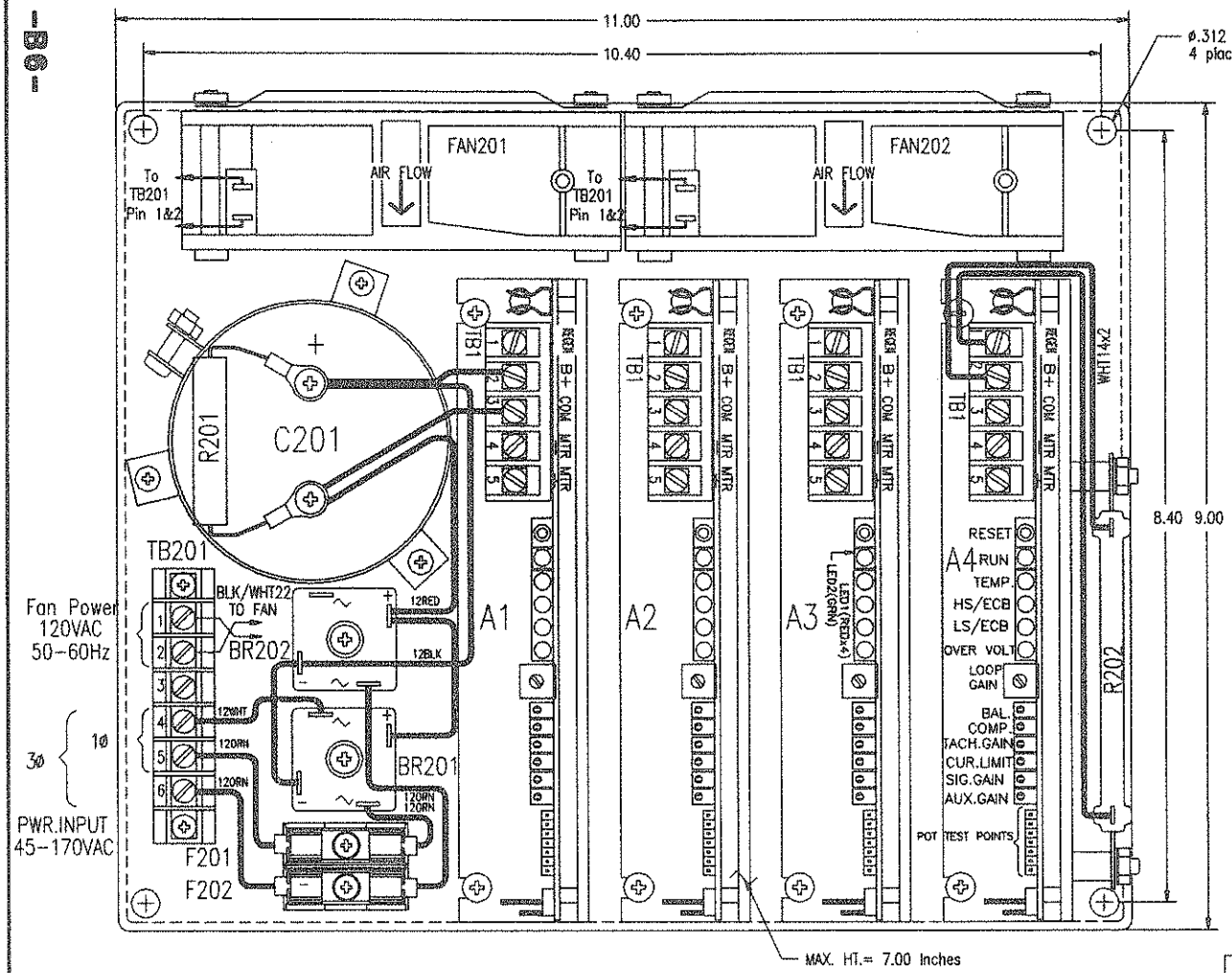
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/64 ANGULAR ±0°
DECIMALS ±.005
BEND RADII AS REQUIRED
BREAK SHARP EDGES .005-.010

1- or 2-AXIS
INSTALLATION DRAWING
MODEL GA377-2A-1 or -2

GLENTEK
INCORPORATED
208 STANDARD STREET
EL SEGUNDO,CALIF. 90245

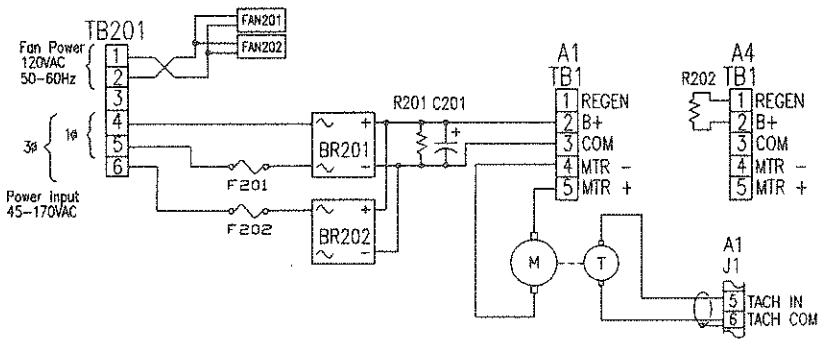
FINISH	DSN	DATE	DWG NO.	REV
N.A.	H.O.O.	21MAY92	377-1018	-
	CHK C.S.V.	SCALE N.A.		
	APPR. R.A.D.		SHEET 1 OF 1	

SYM	REVISIONS	DATE	APPROVED



NOTES:
1. Wiring to Amplifier "A1" is typical for all amplifiers.
2. Never ground the outputs of the amplifiers.
3. Use shielded cable for Signal and Tach. leads, connect shield to Signal or Tach. common.
4. 3-Axis Model GA377-4A-3, omits amplifier "A4".
5. 4-Axis package shown with Optional Regen-Clamp and shunt resistor R202 installed on "A4", For 3-Axis model, Regen-Clamp is installed on "A3".
6. For Lower/Higher D.C. Buss Voltage, Please consult with Glentek.

GA377 MANUAL
APPENDIX B



ITEM	DESCRIPTION	MATERIAL	QTY
1	R202	RESISTOR, DALE HL-55 15ohm(Optional)	9
2	F201,F202	FUSE HOLDER AND FUSE 20AMP MDA	8
1	TB201	TERMINAL BLOCK 6-PIN, MAGNUM	7
2	BR201,BR202	RECTIFIER, 35A, 400V	6
1	R201	RESISTOR 10K-10W	5
1	C201	CAPACITOR 6000MFD-250VDC, MAX. SURGE 300VDC	4
2	FAN201-202	FAN, 120VAC, 50-60Hz	3
1	377-1013	4-AXIS BASEPLATE	2
3/4	A1-A4	GA377-1 AMPLIFIER MODULE	1

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ±1/64 ANGLES ±2° DECIMALS ±.005 SEND RADII AS REQUIRED BREAK SHARP EDGES .005-.010

3- or 4-AXIS INSTALLATION DRAWING

MODEL GA377-4A-3 or -4

GLENTEK INCORPORATED
900 STANDARD STREET
EL SEGUNDO, CALIF. 90245

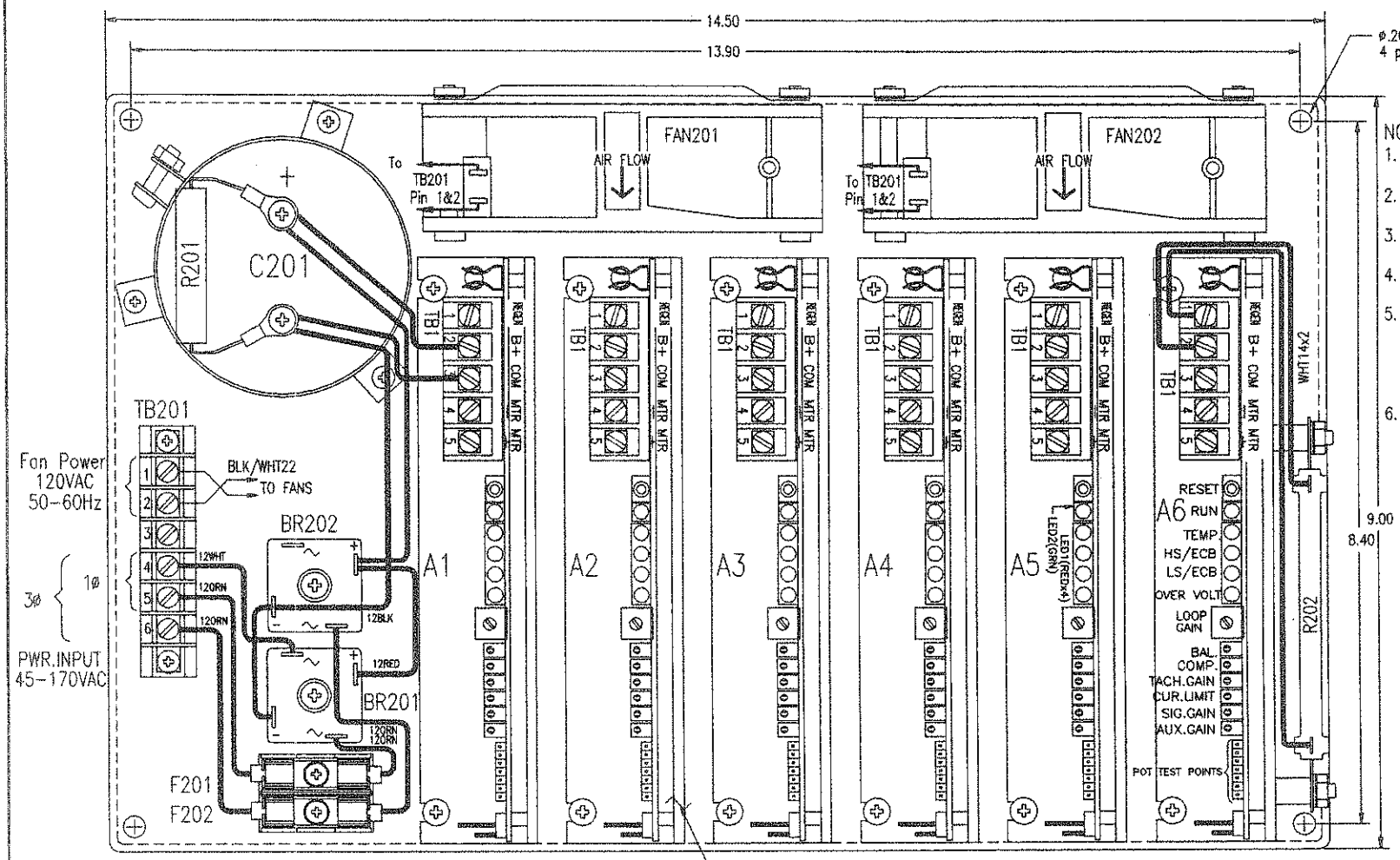
FINISH: N.A.

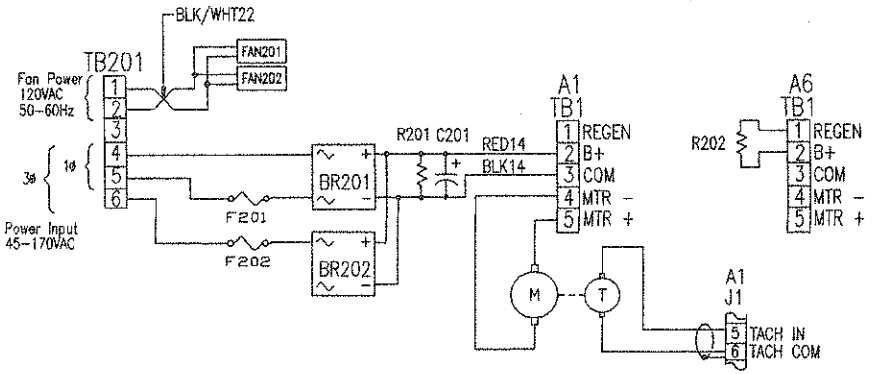
DWN H.O.O. | DATE 18MAY92
CHK C.S.V.
APPR. R.A.D.
SCALE N.A.

DWG NO. 377-1020 REV ---

SHEET 1 OF 1

SYM	REVISIONS	DATE	APPROVED





QTY	PART NO.	DESCRIPTION	MATERIAL	ITEM
1	R202	RESISTOR, DALE HL-55 15ohm(Optional)		9
2	F201,F202	FUSE HOLDER AND FUSE 20AMP MDA		8
1	TB201	TERMINAL BLOCK 6-PIN, MAGNUM		7
2	BR201,BR202	RECTIFIER, 35A, 400V		6
1	R201	RESISTOR 10K-10W		5
1	C201	CAPACITOR 6000MFD-250VDC , MAX. SURGE 300VDC		4
2	FAN201-202	FAN, 120VAC, 50-60Hz		3
1	377-1016	6-AXIS BASEPLATE		2
5/6	A1-A6	GA377-1 AMPLIFIER MODULE		1

LIST OF MATERIAL OR PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONS ±1/64 ANGLES ±2° DECIMALS X.XXX ±.010 REMOVE ALL BURRS BREAK SHARP EDGES .005-.010

FINISH: N.A.

5- or 6-AXIS INSTALLATION DRAWING

MODEL GA377-6A-5 or -6

DWN H.O.O. | DATE 22MAY92

CHK C.S.V.

APPR. R.A.D. | SCALE N.A.

GLENTEK INCORPORATED
208 STANDARD STREET
EL SEGUNDO,CALIF. 90245

DWG NO. 377-1021 REV -

SHEET 1 OF 1

GA377 MANUAL
APPENDIX B