JULY 1987

INSTRUCTION MANUAL

PMI AXA SERIES

PWM SERVO AMPLIFIER WITH POWER SUPPLY

MODEL AXA-90-10-20

MODEL AXA-180-10-20

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HOW TO USE THIS MANUAL

This manual is divided into several sections to help you familiarize yourself with the AXA Series amplifiers in an orderly and logical manner.

1. Introduction - Provides a general description of the amplifier and how to apply it.

2. Specifications - Describes the features of the AXA amplifier and lists the electrical and mechanical specifications.

3. Inputs and Outputs - Explains the input and output connections, adjustments and indicators.

4. Wiring Instructions - Covers AC wiring, motor connections and wiring of input and output signals.

5. Setup Instructions - Step-by-step procedure for powering up the amplifier and setting the adjustments.

6. Troubleshooting - A simple checkout procedure in case of difficulties to determine if the AXA is working properly.

***** ! PLEASE TAKE NOTICE ! *****

THE AXA AMPLIFIER FAMILY PRESENTLY CONSISTS OF TWO MODELS, SPECIFICALLY: AXA 90 -10 -20 AND AXA 180 -10 -20. THE EARLY AXA 90 UNITS HAVE CIRCUIT BOARDS WITH LETTER REVISION "A".
THE NEWER ONES HAVE BOARDS WITH LETTER REVISION "B" OR LATER. PLEASE TAKE NOTE OF THE REVISION LETTER ON THE BOARD OF YOUR UNIT(S) BECAUSE THE ADJUSTMENT POT DIRECTIONS DIFFER.

THE REVISION LETTER CAN BE FOUND ON THE UPPER RIGHT-HAND CORNER OF THE CIRCUIT BOARD ADJACENT TO THE LED INDICATORS. YOU MUST OPEN THE DOOR TO READ IT. REFER TO FIGURE 1 FOR GUIDANCE. TAKE NOTE OF STEPS V2 AND T2 IN THE SET-UP PROCEDURE OF THIS MANUAL.

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List of Figures and Drawings

1.0 Introduction

The AXA is a pulse-width modulated servo amplifier specifically designed to drive PMI's low-inductance, high-performance disc-armature dc servo motors. It is a compact, self-contained unit which includes its own power supply and inductor and requires only the addition of a power transformer and, optionally, a regeneration resistor.

Two models of the AXA are available and they are selected on the basis of the maximum voltage required for the application. A matching transformer must also be selected.

These units feature extensive fault-detection circuitry which protects against short circuits, excess currents, logic supply failure and thermal overload. At the same time, an array of front panel LEDs provides a visual indication of amplifier status, and a fault-indicating relay simplifies interfacing with automated controls.

Motor protection is accomplished through the use of peak and continuous current limits, both of which are adjustable.

AXA amplifiers may be operated in both velocity loop and torque modes. Selection is by means of a switch on the circuit board.

The switching frequency in the AXA family can be set to above 20 khz in many applications, providing inaudible operation. This high frequency also delivers very high bandwidth in the current loop, capable of meeting the most demanding servo applications.

Hook-up and operation is accomplished by carrying out the following steps:

1. Wire A.C. connections to amplifier and transformer.
2. Connect motor to amplifier.
3. Connect command and feedback signals to amplifier.
4. Adjust amplifier controls to meet application requirements.

2.0 System Description

2.1 Features

Modular Design

Compact and self-contained design which includes its own power supply, inductor and regeneration circuit.

Four-quadrant PWM Operation

Pulse-width modulated amplifier provides bi-directional motor operation.

20 KHz Switching Frequency

Extremely high switching frequency results in a bandwidth above 2 KHz in the current loop. This will exceed the most demanding application requirement.

Extensive Fault Protection

Includes protection against:

1. short circuits
2. current limit failure
3. power supply failure
4. overtemperature
5. excessive regeneration

Self-Diagnostics

Readily visible LEDs provide information on the following conditions:

1. power on
2. amplifier enabled
3. current limit activated
4. overtravel condition exists
5. over and under voltages
6. overtemperature

Two Operating Modes

Velocity loop or current mode operation, selectable by a pc board switch.

Adjustable Compensation

Adjustable breakpoint laglead network simplifies servo system stabilization.

Adjustable Peak and Continuous Current Limits

Full range current adjustments give maximum flexibility in matching the amplifier to the application.

2.2 Specifications

Input and Output Power

Input Voltage
- Model AXA-90-10-20 ..... 30 to 79 vac, 1 phase, 50/60 Hz
- Model AXA-180-10-20 ..... 66 to 130 vac, 1 phase, 50/60 Hz

Control Voltage ..... 115 vac +/-10% @ 1 amp

Output Voltage ..... 40 to 180 vdc, depending on input voltage
Continuous Output Current ..... 10 amps
Peak Output Current ..... 20 amps

Electrical Characteristics

Switching Frequency ..... 20 KHz nominal
Form Factor ..... 1.01 or less

Gain (velocity mode) ..... 20 amp/mv
Gain (current mode) ..... 2.0 amp/v
Minimum Input Impedance ..... 100 kohms
Offset ..... adjustable to zero
Drift 0.02%/xC

Bandwidth (velocity loop) ..... 0 to 500 Hz
Dead Band 0

Input Voltage Range
- Command Signal ..... +/-10 vdc, differential or single-ended
- Tachometer Signal ... +/-35 vdc, differential or single-ended

Operational Modes

1. Velocity amplifier
2. Current or torque amplifier

Adjustments

1. Tachometer Gain
2. Offset
3. Compensation
4. Continuous Current Limit
5. Peak Current Limit
6. Input Gain

LED Indicators

1. Control Undervoltage
2. Bus Undervoltage
3. Bus Overvoltage
4. Overtemperature
5. Overcurrent
6. Overtravel
7. Current Limit
8. Enable
9. Power ON

Special Inputs

1. Peak Current Limit
2. +/-15vdc Command Input
3. External Vcc to run opto-isolators (optional)

The following inputs are optically isolated.

4. Run Enable
5. CW Disable
6. CCW Disable
7. Fault Reset

Special Outputs

1. Fault Indication Relay
2. DC Current Monitor
3. +/-15 vdc Reference

Fault Protection

1. Output Short
2. Short to Ground
3. Current Limit Failure
4. Overtemperature
5. Motor Power Supply Failure
6. Excessive Regeneration

3.0 Connections, Adjustments and Diagnostics

3.1 User Terminal Connections (See Figure 2)

TB1 Power Connections

TB1 - Terminal 1	Earth Ground Used to ground the amplifier chassis. This is separate from the electronics or circuit ground.
TB1 - Terminals 2 & 3	115 VAC Input Power for the logic supply and the fan. Requires 115 VAC @ 1 amps.
TB1 - Terminals 4 & 5	Motor AC Input The power transformer for the built-in motor power supply is connected here.
TB1 - Terminals 6 & 7	Motor Connections Terminal 6 is for (+) motor lead. Terminal 7 is for (-) motor lead.

TB2 Signal Connections

TB2 - Terminal 1	CCW (counterclockwise) Disable Grounding this point disables CCW drive to the motor.
TB2 - Terminal 2	CW (clockwise) Disable Grounding this point disables CW drive to the motor.
TB2 - Terminal 3	+/- 15v Command Input Accepts a command voltage with a range of +/- 15 volts. Typically used with a manual run potentiometer connected to the +15v and -15v reference outputs at TB2 terminals 15 and 16.
TB2 - Terminal 4	+/- 10v Command Input Accepts a command voltage with a range of +/- 10 volts. This is typical of A/D converters used with position controls and computers.
TB2 - Terminal 5	Command Input Common Differential signal return connection for the Command Inputs. For single-ended inputs, connect this to terminal 6 or 7 (gnd).

TB2 - Terminals 6 & 7	Signal Ground This is the circuit ground. It is electrically isolated from the earth or chassis ground at TB1-1.
TB2 - Terminal 8 & 9	Tachometer Connections Terminal 8 is for (+) tach lead. Terminal 9 is for (-) tach lead.
TB2 - Terminal 10	Enable Grounding this terminal is required for the motor to run.
TB2 - Terminal 11	Reset Grounding this terminal resets the amplifier from a faulted condition if the fault has been corrected.
TB2 - Terminal 12	Peak Current Limit An input of 0 to 7.5 volts limits the peak current from 0 to 20 amps.
TB2 - Terminal 13	DC Amps Out Monitors the current delivered to the motor. The scale factor is 0.375 volts per amp or 2.67 amps per volt.
TB2 - Terminal 14	External Vcc May be used as an alternative to the internal Vcc to power the optical isolators for the Enable, Reset, CCW Disable and CW Disable signals. The voltage range is 15 to 24 volts dc. This is selected with jumper SH1.
TB2 - Terminal 15	+15V Reference Connected to the internal +15 volt logic supply through a 1000 ohm resistor. May be used to power a potentiometer for manual speed control. Maximum current is 5 ma.
TB2 - Terminal 16	-15V Reference Connected to the internal -15 volt logic power supply through a 1000 ohm resistor. Maximum current is 5 ma.
TB2 - Terminals 17, 18 & 19	Fault Relay Indicates when a fault has occurred by de-energizing. It includes both normally open and normally closed contacts. The contacts are rated for 115 vac at 5 amps.

3.2 Adjustments, Switches and Jumpers (See Figure 3)

Adjustment Potentiometers

Offset	Used to eliminate any dc offset voltage in the servo loop from either internal or external sources. It allows the motor speed to be adjusted to zero when the commanded speed is zero.
Compensation	Adjusts the transient response of the servo system to minimize overshoots and undershoots. Clockwise rotation increases compensation.
Input Gain	A gain adjustment for the command input signal. Adjustment range is 10 to 1.
Tach (Gain) Adjust	A gain adjustment which is used to calibrate the motor speed to the command signal. Higher gain gives stiffer zero speed hold but less speed resolution. Lower gain gives better speed resolution but less stiffness. CCW adjustment increases gain and decreases motor speed.
Continuous Current Limit	Sets the maximum continuous current that can be delivered to the motor. Adjustment range is from 0 to 10 amps.
Peak Current Limit	Sets the maximum peak current that can be delivered to the motor for a maximum time of approximately 2 seconds. After this time, the current is electronically reduced to the continuous current setting. Adjustment range is from 0 to 20 Amps.

Switches

Torque/Speed	Selects between amplifier operation in the speed (voltage) or torque (current) mode.
Trip Reset	Unlatches all faulted circuits and restores the amplifier to operational status if no fault conditions still exist.

Jumpers

Int/Ext Vcc	Allows a choice between operating the AXA opto-isolators with the internal power supply or with an external power supply. The Ext Vcc voltage can be in the range of 15 to 24 vdc. Opto-isolators are used for the Enable, Reset, CW Disable and CCW Disable inputs.

3.3 Indicators

3.3.1 Diagnostic Indicators

Power On Green LED	Indicates that 115 VAC power is applied to the amplifier.
Enable Green LED	Indicates that the Enable terminal (TB2-10) is grounded.
Current Limit Yellow LED	Indicates that the amplifier is electronically limiting the current to the motor. This is not necessarily a fault condition and typically occurs during heavy acceleration.
Overtravel Yellow LED	A condition indicating that either CW Disable or CCW Disable has been activated.
Overcurrent Red LED	A fault condition indicating that the amplifier has shut down due to excessive current.
Overtemperature Red LED	A fault condition indicating excessive heatsink temperature.
Bus Overvoltage Red LED	A fault condition indicating excessive motor bus voltage. This is usually due to excessive regeneration.
Bus Undervoltage Red LED	A fault condition indicating that the motor bus voltage is below the minimum acceptable level.
Control Undervoltage Red LED	A fault condition indicating that the 115 VAC input power line has fallen 10% low or has dropped out for more than two cycles.

3.3.2 Fuses

F1	A 10 amp, 250 volt ceramic fuse feeding the main power circuit.
F2	A 1 amp, 250 volt ceramic fuse feeding the controls circuit and cooling fan.

4.0 Wiring Instructions

**** ! WARNING ! ****

DO NOT POWER UP UNTIL ALL MOTOR CONNECTIONS HAVE BEEN MADE AND SETUP INSTRUCTIONS HAVE BEEN FOLLOWED. THIS IS TO AVOID POSSIBLE DAMAGE TO THE UNIT, MOTOR, AND YOUR EQUIPMENT.

Refer to Figure 4 which shows the system wiring diagram. The diagram on the inside of the amplifier cover will also help you.

4.1 Power Wiring

AC Power Wiring — WARNING ! AN ISOLATION TRANSFORMER MUST BE USED BETWEEN AC POWER AND TB1 TERMINALS 4 AND 5. CONSULT PMI FOR THE RECOMMENDED TRANSFORMER.

Connect the external power transformer as shown in Figures 5 or 6. Use 16 gauge wire.

(a) The secondary winding is connected to TB1 terminals 4 & 5. No polarity has to be observed.

(b) The primary winding is connected to a source of 105-125 VAC 50/60 Hz 1 phase (Figure 5) or 208-240 VAC 50/60 Hz 1 phase (Figure 6).

(c) The earth ground can be connected to TB1 terminal 1 (earth or frame ground).

(d) Terminals 2 & 3 of TB1 are connected to a source of 105-125 VAC, and may be derived from the primary of the transformer. The high or "hot" side must connect to terminal 2 since the internal fuse is in this leg. The low or "neutral" side must connect to terminal 3. Again refer to Figures 5 or 6.

Motor Connections

By convention connect the plus (+) motor lead to TB1 terminal 6, and the minus (-) motor lead to TB1 terminal 7. The motor will rotate clockwise when a positive signal is imposed on the input. Wire size is to be consistent with the continuous current rating of the motor.

You have now completed the connections to TB1. We will return to TB1 terminals 6 & 7 (the motor connections) later when we set current limits.

4.2 Control Signal Wiring

All control connections will be made on TB2 which is a 19-pin terminal strip located on the upper circuit board of the amplifier. When you open the cover you will see TB2 next to the reset pushbutton. Terminal numbers increase from right to left. (See Figures 2 and 4).

Control connections will consist of Amplifier Inputs and Amplifier Outputs.

Amplifer Inputs:

From	To
TB2 Terminal 10 (Enable)	Signal Ground (TB2-6 or TB2-7) This connection enables the amplifier and permits the motor to run. This can be done through an external contact from a master control or by using a jumper to keep the amplifier enabled at all times.
TB2 Terminal 4 (+/- 10 vdc Command Input)	Command or Controller Signal This is the normal input for commanding the amplifier. See notes below.
TB2 Terminal 3 (+/- 15 vdc Command Input)	Manual Run Potentiometer This connection is used for a manual-run potentiometer which can be connected to the +15v and -15v reference voltages at TB2 15 & 16. Recommended value is 10,000 ohms.
TB2 Terminal 5 (Command Input Common)	Command Signal Return This connects the common side of the command signal. This terminal is also to be grounded to TB2-6 with a jumper. See notes below.
TB2 Terminals 6 & 7 (Signal Ground)	Signal Grounds This is the circuit ground and is isolated from the earth or frame ground.

Notes:
1. The command signal connection must be a twisted pair (22 gauge suitable) with a shield. Ground the shield at TB2-6 if it's not grounded at the signal source. No more than 1.5 inches of signal wires should extend beyond the shield.
2. Grounding TB2-5 to TB2-6 makes the input stage single-ended which is common practice.
3. If a differential mode is absolutely necessary then remove the jumper to TB2-6. But careful shielding will be necessary since the input stage is very susceptible to noise pickup.

TB2 Terminal 8 (Tach +)	Tachometer Positive Connection Ground with jumper to TB2-7. See notes below.
TB2 Terminal 9 (Tach -)	Tachometer Negative Connection See notes below.

Notes: 1. The tach connection must be a shielded twisted pair (22-gauge) with shield connected at TB2-7 on amplifier. No more than 1.5 inches of signal wires should extend beyond the shield.
2. Always connect jumper from TB2-8 (Tach +) to TB2-7 (Gnd).
3. Tachometer voltage must not exceed +/- 35 volts.

TB2 Terminal 2 (CW Disable)	CW Overtravel Signal Ground this input to inhibit CW rotation of the motor. Connect to TB2-6 or TB2-7 to inhibit.
TB2 Terminal 1 (CCW Disable)	CCW Overtravel Signal Connect to TB2-6 or TB2-7 to inhibit CCW rotation of the motor.
TB2 Terminal 12 (Peak Current Limit)	0 to 7.5 Volt Control Voltage This input provides external control of motor current. An input of 0 to 7.5 volts limits the peak current from 0 to 20 Amps. Connect the external voltage to this point and signal ground (TB2-6 or TB2-7).

Note: The peak current limit overrides the continuous current limit if it is set to a lower value.

TB2 Terminal 11 (Reset)	Reset Command Signal Connecting this point to ground (TB2-6 or 7) resets a faulted amplifier if the fault has been corrected. This permits a reset to be performed externally. The reset pushbutton can be used instead.
TB2 Terminal 14 (Ext Vcc)	15 To 24 Volt Power Supply This terminal becomes active when the shorting bar, SH-1 is shifted to "Ext Vcc". (See Figure 2.) You may then connect an external supply voltage of 15 to 24 volts between this point and signal ground for powering the opto-isolators. These are used on the Enable, Reset, CW and CCW Disable inputs.

Note: The shorting jumper is located on the amplifier card (open door) just above TB2.

Amplifier Outputs

From	To
TB2 Terminal 13 (DC Amps Out)	Oscilloscope or Voltmeter The voltage at this terminal is proportional to the motor current. The scale factor is 0.375 volts per amp or 2.67 amps per volt.
TB2 Terminal 15 (+15V Ref)	Manual Run Potentiometer Use this terminal as a voltage reference. It is connected to the internal +15 volt power supply through a 1000-ohm resistor.
TB2 Terminal 16 (-15V Ref)	Manual Run Potentiometer Use as a voltage reference, the same as TB2-15.
TB2 Terminals 17, 18 & 19 (Trip or Fault Relay)	Remote Fault Detector Use this output to activate a remote fault indicator or controller input when a fault occurs.

Note: The contact status of the relay is as follows;

	Fault or Amplifier Off (relay off)	Amplifier functioning (relay energized)
TB2-17	Open	Closed
TB2-18	Closed	Open
TB2-19	Common	Common

The relay contacts are rated at 115 vac and 5 amps.

5.0 Setup Instructions

If you plan to operate in the velocity mode follow the procedures below. If you plan to operate in the torque mode then follow the procedures listed under "Torque Mode Set-up" in the next section.

5.1 Velocity (Speed) Mode Set-up

****** ! WARNING ! ******

IT IS SUGGESTED THAT YOU FOLLOW EACH STEP SEQUENTIALLY.
DO NOT APPLY POWER TO THE WIRED AMPLIFIER UNTIL TOLD TO DO SO.

STEP

V1. Check the Speed/Torque Switch
This is located on the amplifier circuit board. It should be in the Speed position.

V2. Preset the adjustment potentiometers
These are all 25 turn pots and should be set as follows:

Function	Settings (Rev. A)	Settings (Rev. B or higher)	Condition
Current Limit	Fully CCW	Fully CCW	Min. Current
Offset	Fully CCW	Fully CW	Positive Offset
Compensation	Midpoint	Midpoint	Midpoint
Command Gain	Fully CW	Fully CCW	Minimum Gain
Tach Adjust	Midpoint	Midpoint	Medium Gain
Peak Current	Fully CCW	Fully CW	Max. Current

Note: These pots do not have strong end detents. Use of a jeweler's screwdriver or, better yet, a trimmer adjustment tool is recommended. Adjust to one end until you hear and feel a slight click, then stop. For midpoint settings count up (or back) 12.5 turns from a stop. Be careful and attentive when adjusting these pots, now and especially later when the amplifier is powered, since the screwdriver blade can easily slip off and short across adjacent components.
CW means clockwise and CCW means counterclockwise.

V3. Enable the Amplifier
For setting-up purposes, continually enable by putting a jumper wire between TB2-10 and TB2-7.

V4. Connect a DVM (10-volt dc range) or an oscilloscope between terminal TB2-13 and signal ground (TB2-6 or 7). This will be used to monitor and set the output current.

V5. Connect a jumper wire across motor terminals 6 and 7 on TB1. Use 14 or 12 gauge wire.

V6. Turn on the 115 (or 230) VAC power
The amplifier should power up. The fan will operate, the two green LED'S (Power On and Enable) will light.

V7. Current Limit Adjust

Temporarily remove any Command Voltage connections from TB2-3 or TB2-4.

Turn the Current Limit Pot fully CW to deliver maximum current. The yellow Current Limit LED will light after about 2 seconds. The DVM or scope reading should climb to about 3.75 Volts DC. This corresponds to 10 Amps which is the maximum continuous current the AXA delivers. The scope will also show a triangular ripple on the 3.75 volt DC level of about 1.4 volt peak-to-peak and a period of about 55 microseconds. This is normal and is caused by the high-frequency switching action in the amplifier.

Note: The peak-to-peak voltage and frequency will vary with different bus voltages and different motor inductances.

Adjust the current limit to the continuous current or RMS current required for the application. With proper conservative motor sizing this current setting will not exceed 80% of the continuous current rating of the motor. Turn the pot below the desired setting and bring back up as you make your reading.

Consider an example where a setting of 8 amps is desired. To obtain this, turn the current limit pot CW until you read 3.00 Volts on the DVM or scope. (The proportion is 2.67 amps/volt)

V8. Peak Current Adjust

Press, momentarily hold in, then release the Reset pushbutton while observing the DVM or scope. You will note that the reading jumps up to about 7.5 Volts for about 1 to 2 seconds then folds back to a reading corresponding to the Current Limit set in Step V7. This indicates that the maximum peak current of 20 Amps is being delivered by the AXA amplifier.

The adjustment of the peak current requires a few trials since it is allowed to be delivered for only 1 to 2 seconds.

You may approximate the desired peak current by counting turns on the adjustment pot, noting that 25 turns covers the full range from 0 to 20 Amps. For example, if the desired peak current is 16 Amps then your approximate pot setting is 16/20 of 25 turns or 20 turns. So, from the Max. current position turn the pot 5 turns. After doing this, test for the peak current reading by operating the Reset button again (as described above) and noting the reading on your readout. (A scope gives a more accurate reading and is recommended.)

Readjust the Peak Current pot up or down while trial reading using the Reset button until you achieve the desired setting. You will note that 16 amps is represented by 6 volts at the 2.67 amps/volt scale factor.

Check for peak current in the other direction. Turn the Offset pot fully opposite to force the current in the other direction. Check that you get a negative reading of the same value for both peak and continuous current when you use the Reset button. Return the Offset pot to approximately midpoint.

V9. Shut Off The Power
Having completed setting the continuous and peak currents turn off the 115 VAC power to the AXA.

V10. Remove the jumper between TB1 terminals 6 & 7 and see that motor leads are properly reconnected.

V11. Remove the jumper temporarily from TB2-10. This temporarily disables the amplifier.

V12. Restore Power
Turn on the AC power again to the AXA. The Power LED will light but the Enable LED will not.

V13. Safety Check Method Of Enabling Motor.
a. Be sure you have a zero command signal or remove input wire.
b. Touch the enable jumper to TB2-10.

The motor will now be powered. It should be in a locked position or rotating slowly. If it runs away at high speed immediately disable it by pulling away the jumper wire from TB2-10. Reverse the tachometer leads and try again. When you get the motor working properly reconnect the Enable at TB2-10.

V14. Adjust Motor Speed
Determine the maximum command voltage that will be available. Usually it is +/- 10 VDC. When this voltage level is being used, the Input Gain pot remains at minimum. The Input Gain Pot has a range of 10:1 so that the AXA can handle a command signal range as small as +/-1 VDC when the pot is set for maximum gain.

Input the maximum command voltage. The motor will run up to some speed. Determine this speed by using a hand tachometer or measuring the voltage delivered by the motor tach at TB2 terminals 8 and 9. Adjust the motor speed with the Tach Adjust pot. Counterclockwise decreases motor speed (increases tach gain). Set desired motor speed (typically 3000 RPM for 10 V command). Check speed range by applying various command levels. Also check full speed in the opposite direction by commanding a maximum negative voltage.

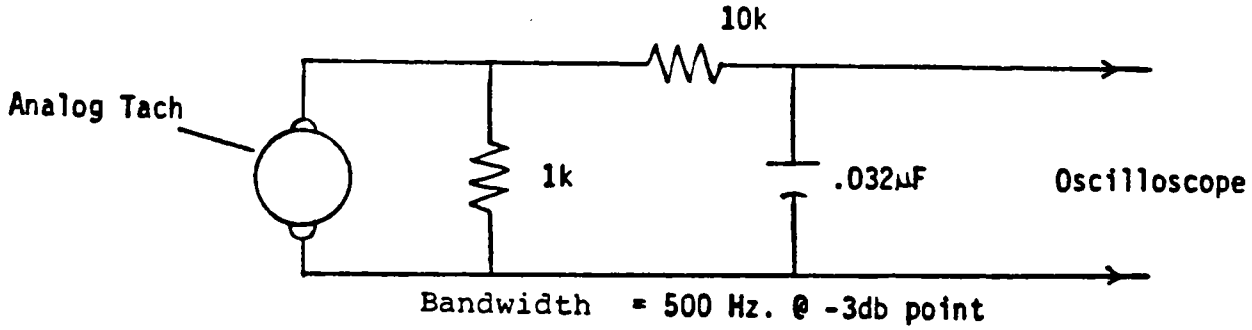
V15. Adjust Offset
Set the command voltage to zero. If the motor is slowly rotating, adjust the Offset pot until it stops.

V16. Adjust Compensation
As a coarse adjustment, the Compensation pot may be left at the midpoint position. This provides satisfactorily performance in a large majority of cases. To optimize the response of the servo loop, the compensation may be adjusted fine adjusted in accordance with the procedure below.

Fine Adjustment of Compensation
(Requires an oscilloscope and a function generator)

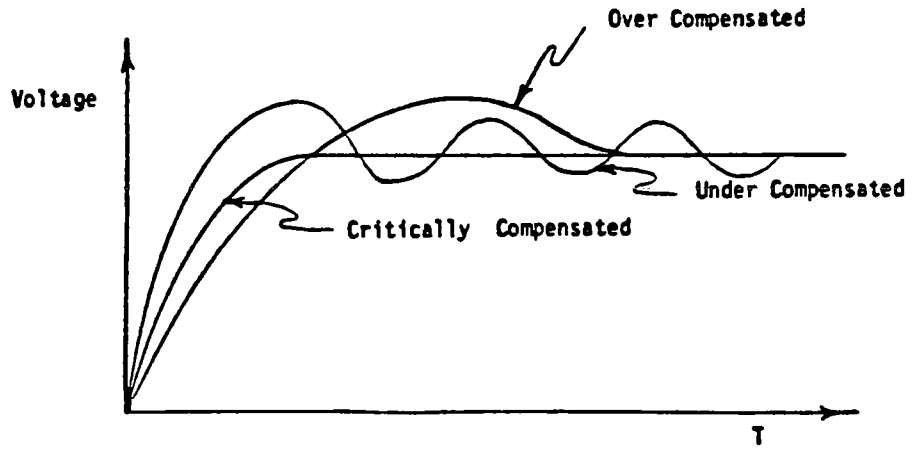
This procedure is used to optimize the transient response of the servo system by minimizing overshoots and undershoots. The response of the servo loop can be observed by using an oscilloscope and a function generator. Connect the oscilloscope to the tach feedback signal which will indicate motor velocity in terms of voltage. Connect the function generator to the Command Input terminal. The output of the function generator should be a low frequency square wave. The frequency must be low enough to enable the motor to reach a steady state speed. The square wave will provide a step input to the system and the tach voltage will show the response.

If your tachometer signal has high ripple content, the following RC filter network is recommended:



If you need a lower cut-off frequency, use a higher value for the capacitor.

The amplitude of the square wave should be adjusted to your desired operating speed. The scope should be triggered on the rising edge of the square wave. If there is a storage scope available, a single trace of the system response can be stored. The scope should display, one of the following wave shapes:



Set the compensation adjustment to obtain a critically compensated response. This will be the fastest response without overshoot. If the system is over-compensated (slow response with overshoot), turn the Compensation pot CCW. If it is under-compensated (overshoot and oscillation), turn the Compensation pot CW.

Readjust the offset as follows. Apply a zero voltage command to the amplifier. If the motor is turning, adjust the Offset pot to bring it to a stop.

This concludes the adjustment and setup procedures for velocity mode applications.

5.1.1 Manual Speed Control

The AXA can be operated as a self-contained speed controller by supplying a command voltage from the wiper of a potentiometer to the +/-15V Input Command terminal at TB2-3. A 10K pot can be powered from the internal +15 Volt and -15 Volt supplies available on the AXA. For one-direction speed control the pot may be connected across the +15V (TB2-15) and ground (TB2-6) for CW running, or across the -15V (TB2-16) and ground (TB2-6) for CCW running. For two-direction control one leg of the pot connects to +15V and the other leg connects to -15V. When the wiper is at centerpoint the potential is zero which therefore commands zero speed. Refer to Figure 7 for the various connection schemes. Shielded wire is recommended if you intend to have a considerable distance between the pot and terminals.

5.2 Torque (Current) Mode Set-up

Note: Normally the torque mode should only be used with a digital positioning controller which also controls motor speed. Before applying this amplifier in the torque mode, we recommend that you contact the PMI Applications Engineering Department.

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STEP

T1. Check the Speed/Torque Switch
This is located on the amplifier circuit board. It should be in the Torque position.

T2. Preset the adjustment potentiometers
These are all 25 turn pots and should be set as follows:

Function	Settings (Rev. A)	Settings (Rev. B or higher)	Condition
Current Limit	Fully CCW	Fully CCW	Min. Current
Offset	Midpoint	Midpoint	Balance
Compensation	Fully CCW	Fully CCW	Min. Comp.
Command Gain	Fully CW	Fully CCW	Minimum Gain
Tach Adjust	Not Used	Not Used	Not Used
Peak Current	Fully CCW	Fully CW	Max. Current

Note: These pots do not have strong end detents. Use of a jeweler's screwdriver, or better yet, a trimmer adjustment tool is recommended. Adjust to one end until you hear and feel a slight click, then stop. For midpoint settings count up (or back) 12.5 turns from a stop. Be careful and attentive when adjusting these pots, now and especially later when the amplifier is powered, since the screwdriver blade can easily slip off and short across adjacent components.
CW means clockwise and CCW means counterclockwise.

T3. Enable the Amplifier
For setting-up purposes continually enable by putting a jumper wire between TB2-10 and TB2-7.

T4. Connect a DVM (10-volt dc range) or an oscilloscope between terminal TB2-13 and signal ground (TB2-6 or 7). This will be used to monitor and set the output current.

T5. Connect a jumper wire across motor terminals 6 and 7 on TB1. Use 14 or 12 gauge wire.

T6. Apply a positive command signal Apply +15 volt command by connecting a jumper from TB2-15 to TB2-3. This will drive the amplifier to maximum positive current.

T7. Turn on the 115 (or 230) VAC power
The amplifier should power up. The fan will operate, the two green LED'S (Power On and Enable) will light.

T8. Current Limit Adjust
Turn the Current Limit Pot fully CW to deliver maximum current. The yellow Current Limit LED will light after about 2 seconds. The DVM or scope reading should climb to about 3.75 Volts DC. This corresponds to 10 Amps which is the maximum continuous current the AXA delivers. The scope will also show a triangular ripple on the 3.75 volt DC level of about 1.4 volt peak-to-peak and a period of about 55 microseconds. This is normal and is caused by the high-frequency switching action in the amplifier.

Note: The peak-to-peak voltage and frequency will vary with different bus voltages and different motor inductances.

Adjust the current limit to the continuous current or RMS current required for the application. With proper conservative motor sizing this current setting will not exceed 80% of the continuous current rating of the motor. Turn the pot below the desired setting and bring back up as you make your reading.

Consider an example where a setting of 8 amps is desired. To obtain this, turn the current limit pot CW until you read 3.00 Volts on the DVM or scope. (The proportion is 2.67 amps/volt)

T9. Peak Current Adjust
Press, momentarily hold in, then release the Reset Pushbutton while observing the DVM or scope. You will note that the reading jumps up to about 7.5 Volts for about 1 to 2 seconds then folds back to a reading corresponding to the Current Limit set in Step T8. This indicates that the maximum peak current of 20 Amps is being delivered by the AXA amplifier.

The adjustment of the peak current requires a few trials since it is allowed to be delivered for only 1 to 2 seconds.

You may approximate the desired peak current by counting turns on the adjustment pot, noting that 25 turns covers the full range from 0 to 20 Amps. For example, if the desired peak current is 16 Amps then your approximate pot setting is 16/20 of 25 turns or 20 turns. So, from the Max. current position turn the pot 5 turns. After doing this, test for the peak current reading by operating the Reset button again (as described above) and noting the reading on your readout. (A scope gives a more accurate reading and is recommended.)

Readjust the Peak Current pot up or down while trial reading using the Reset button until you achieve the desired setting. You will note that 16 amps is represented by 6 volts at the 2.67 amps/volt scale factor.

T10. Apply a negative command signal
Apply a -15 volt command by disconnecting the jumper connection on TB2-15 and moving it to TB2-16. This will drive the output of the amplifier negative, first to the peak current level, then folding back to the continuous current level. Be sure amplifier functions in this manner.

T11. Shut Off The Power
Having completed setting the continuous and peak currents turn off the 115 VAC power to the AXA.

T12. Remove the jumper between TB1 terminals 6 & 7 and see that motor leads are properly reconnected.

T13. Remove the jumper between the +/-15V Command Input (TB2-3) and the -15V supply at TB2-16.

T14. Apply a zero voltage input command
Apply a 0-volt signal from the controller.

T15. Restore power
Turn on the AC power again to the AXA. The Power LED and the Enable LED will light.

T16. Adjust offset.
If the motor is slowly rotating, adjust the Offset pot until it stops.

You have completed setting up the AXA in the torque mode. The amplifier has a gain of 2 amps per volt with the Input Gain pot set to minimum per instructions above. This is the recommended setting.

6.0 Troubleshooting

When problems occur in servo systems any of the components can be suspected. Listed below is a quick-check procedure to follow if you think the problem is with the AXA. The intent and scope of this procedure is to establish whether the AXA amplifier is functioning properly or not.

It is recommended that you go through these quick checks before consulting PMI. If you determine that the amplifier is faulty we recommend that you return it to the factory for repair.

6.1 Indicators

The AXA amplifiers have 9 LED'S and 2 fuses. The LED'S are indicative of many maladies and obviously you should address the problem that the LED indicates before proceeding further.

A lit red LED indicates a problem. An unlit green LED indicates a problem. A lit yellow LED indicates a condition that is not necessarily a problem. You should review the functions of the LED'S on Page 9 of this manual. Also always try to reset the amplifier with the Trip-Reset button first before doing anything else.

If the green LED'S do not go on after checking for power and proper enabling, then check the fuses. The fuses are located behind the power terminal strip TB1. Refer to Page 9 for their values.

If the indicators do not show a fault but the unit is still not working, then proceed to the next section.

6.2 Quick-Check Procedure

1. Remove power from amplifier.
2. Check or replace fuses F1 and F2.
3. Remove all signal inputs to the amplifier.
4. Remove motor leads and put jumper across TB1-6 and TB1-7. Use 16 gauge wire.
5. Put the Speed/Torque switch in the Speed mode.
6. Turn the Offset pot fully CW.
7. Turn the Current-Limit pot to minimum current (fully CCW).
8. Turn the Peak Current pot to maximum (CCW Rev.A, CW others).
9. Apply power to the AXA. The Enable LED will not be lit.

10. Check Voltages.

    A. Check the logic voltages with a DVM. Check for +15V across TB2-6 and TB2-15 and for -15V across TB2-6 and TB2-16. If you read no voltage the AXA needs repair. The 1 amp fuse F2 may or may not be blown. If these readings are not within +/-.75 volt then the AXA needs repair.

    B. Check the bus voltage with a DVM by reading it across pins 1 and 4 of Connector Jack J11 located on the circuit board. See Figure 1. If you read no voltage then the AXA needs repair. The 10 amp fuse F1 may or may not be blown. A voltage reading below 40 volts indicates need for repair.

11. If above voltages check OK then enable the AXA by putting a jumper from TB2-10 and TB2-6. If the Enable LED does not light the AXA needs repair.

12. If Enable is OK then turn Current-Limit pot to maximum current (fully CW).

13. Recheck voltages in Step 9 to be sure they are still proper.

14. Measure continuous current by monitoring the voltage at TB2-13 and ground (TB2-6). If you do not read 3.75 volts +/-.4 volt (corresponds to 10 amps +/-10%) then the AXA needs repair.

15. Check peak current function as follows:
    Press and hold in the Reset button. The DVM will read zero. Release the Reset button while observing the DVM. The reading should climb to a value in the 6 or 7 volt area for a short time (about 1 second) then drop back down to a steady 3.75 volt. If it does not do this then the AXA needs repair.

16. Turn the Offset pot fully CCW. This will reverse current and hence the polarity of the monitor voltage. If you do not read -3.75 volts +/-.4 volt then the AXA needs repair.

17. Check peak current function in the opposite direction by following the procedure of Step 15 and looking for negative readings.

This completes the Quick-Check Procedure. If the AXA passes these steps it is functional and it is reasonably expected it should pass all specifications. If you feel there is a problem in the performance we recommend you consult PMI Applications Engineering for further assistance.

APPENDIX

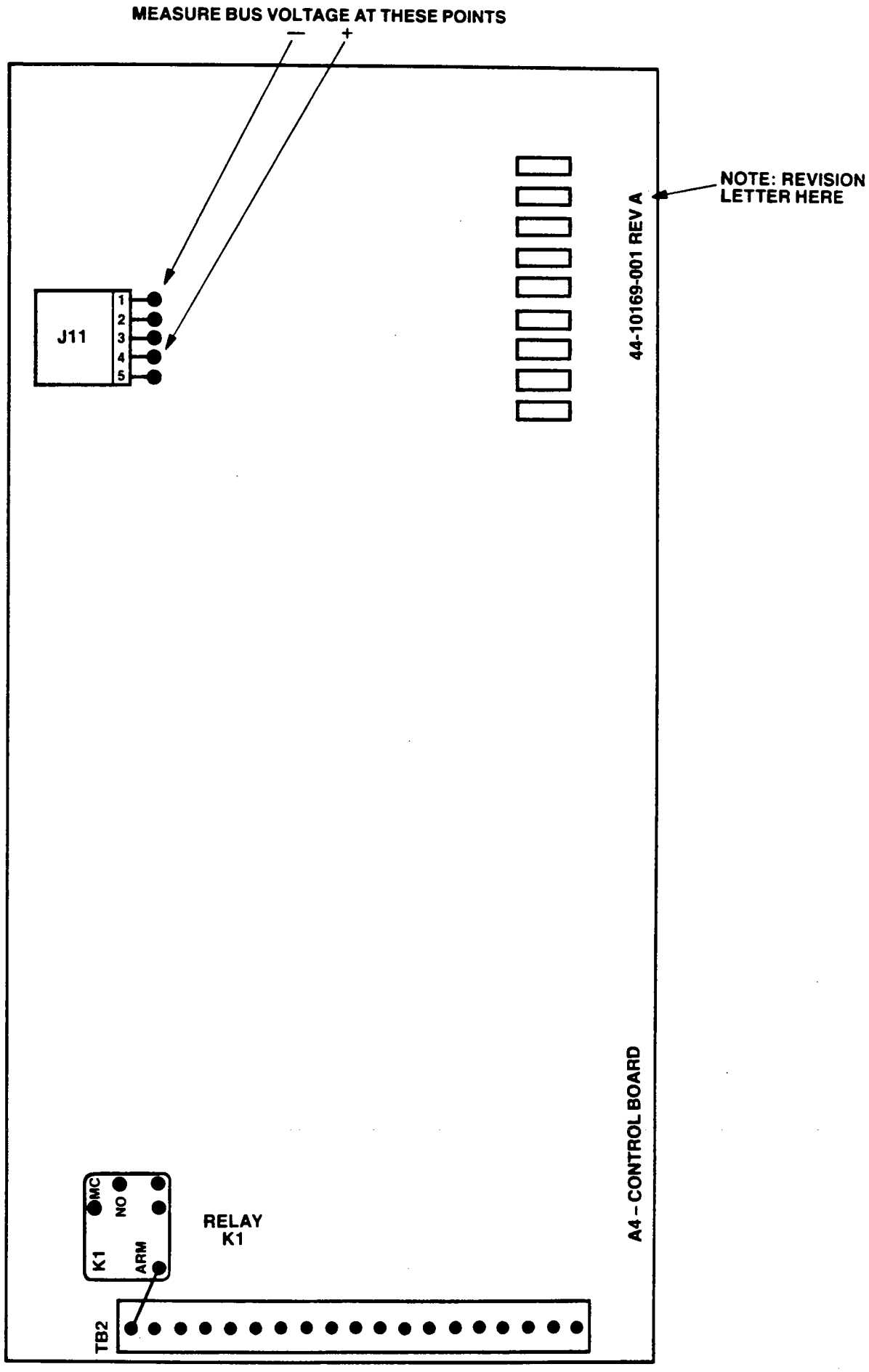
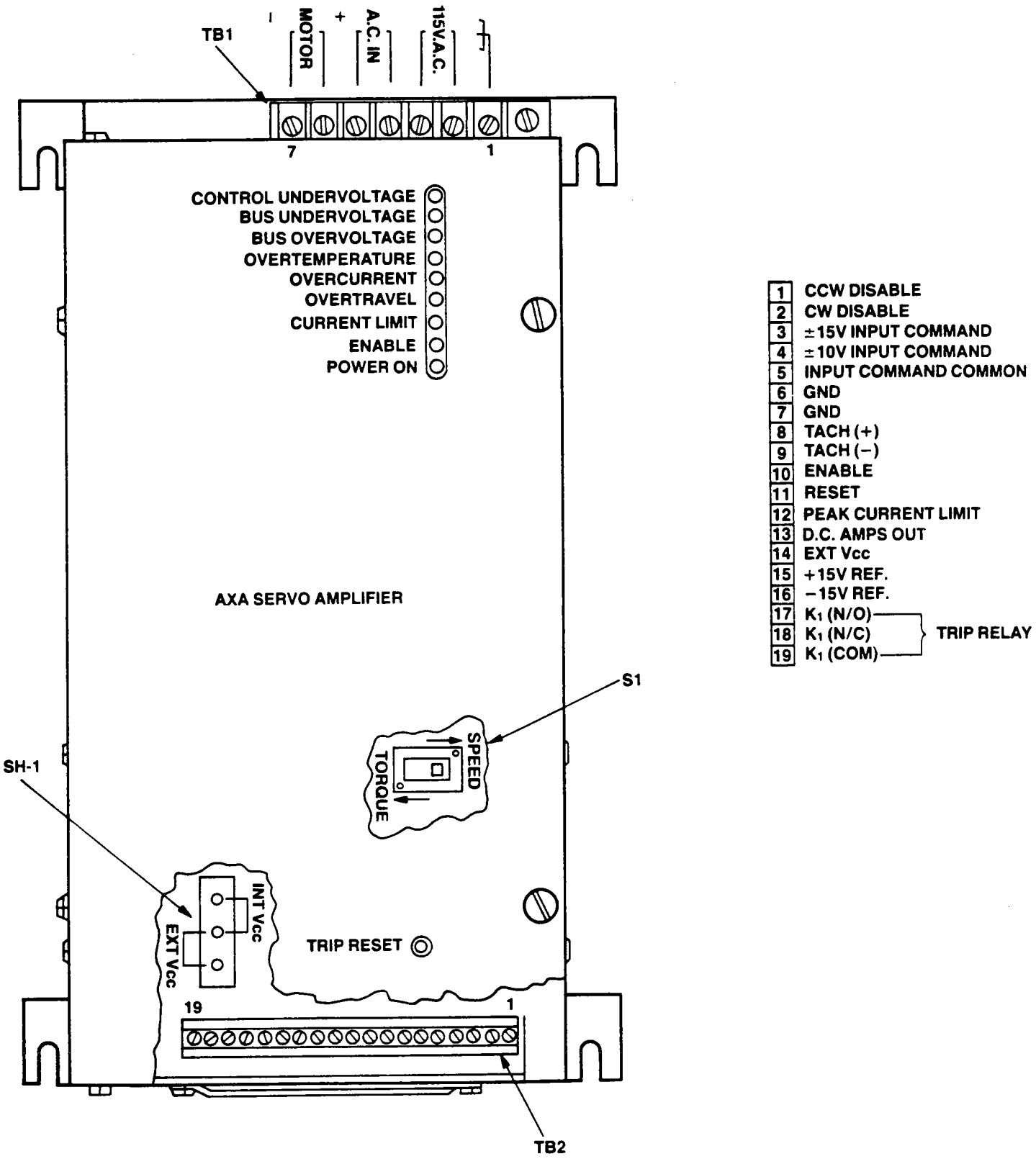


FIG. 1 LOCATION OF REVISION LETTER AND BUS VOLTAGE TEST POINTS



1	CCW DISABLE
2	CW DISABLE
3	±15V INPUT COMMAND
4	±10V INPUT COMMAND
5	INPUT COMMAND COMMON
6	GND
7	GND
8	TACH (+)
9	TACH (−)
10	ENABLE
11	RESET
12	PEAK CURRENT LIMIT
13	D.C. AMPS OUT
14	EXT Vcc
15	+15V REF.
16	−15V REF.
17	K_1 (N/O) — TRIP RELAY
18	K_1 (N/C) — TRIP RELAY
19	K_1 (COM) — TRIP RELAY

FIG. 2 TERMINALS, JUMPERS AND SWITCHES

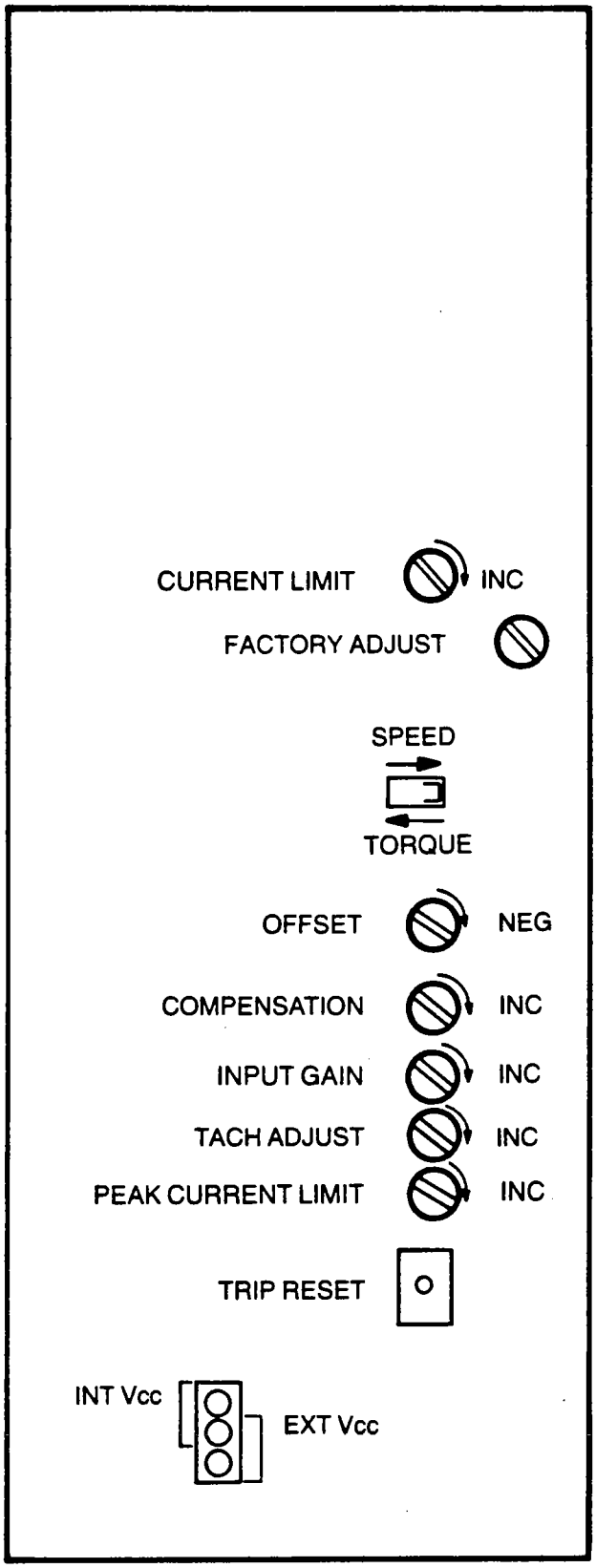


FIG. 3 ADJUSTMENT LOCATIONS

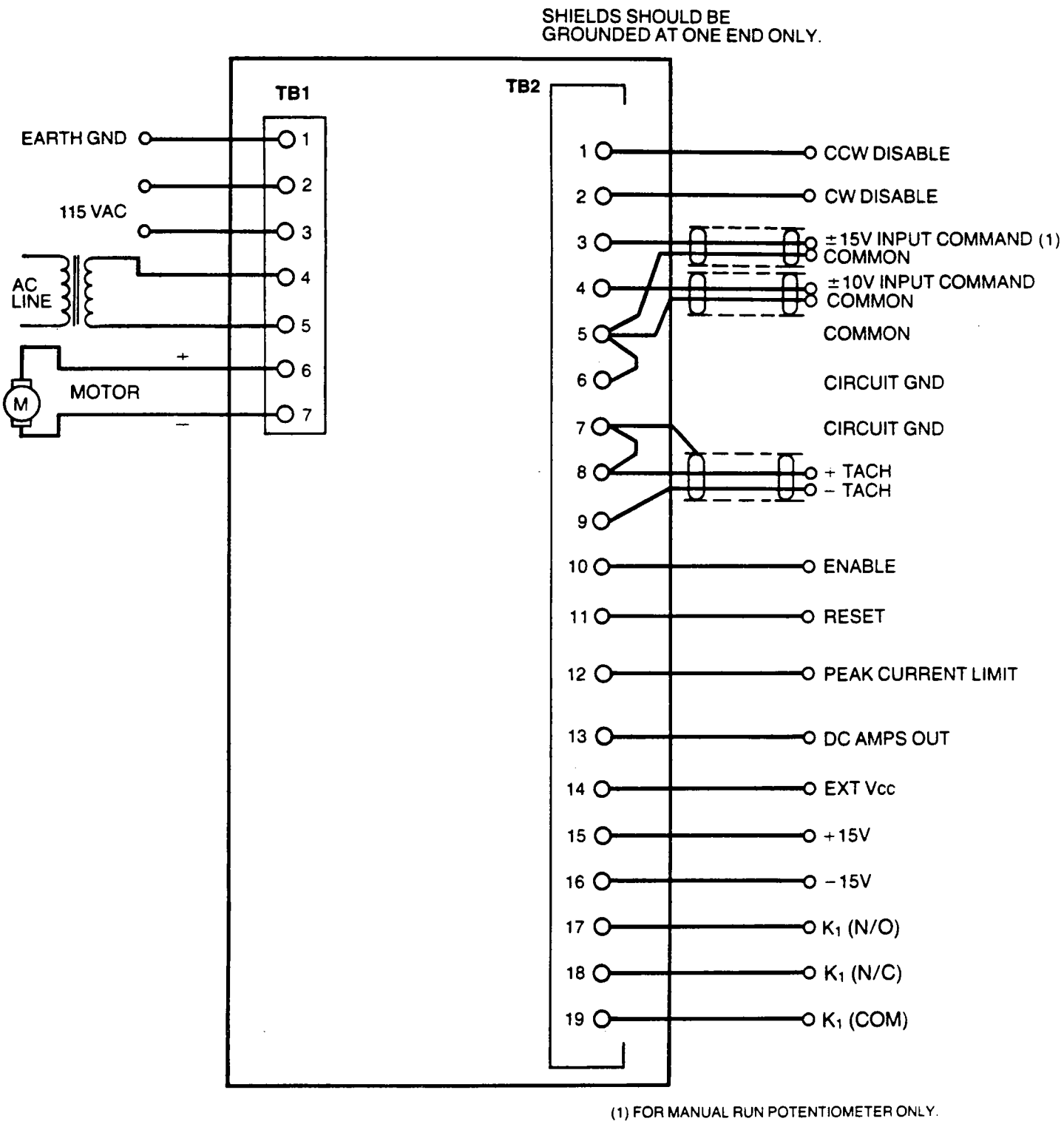


FIG. 4 WIRING DIAGRAM

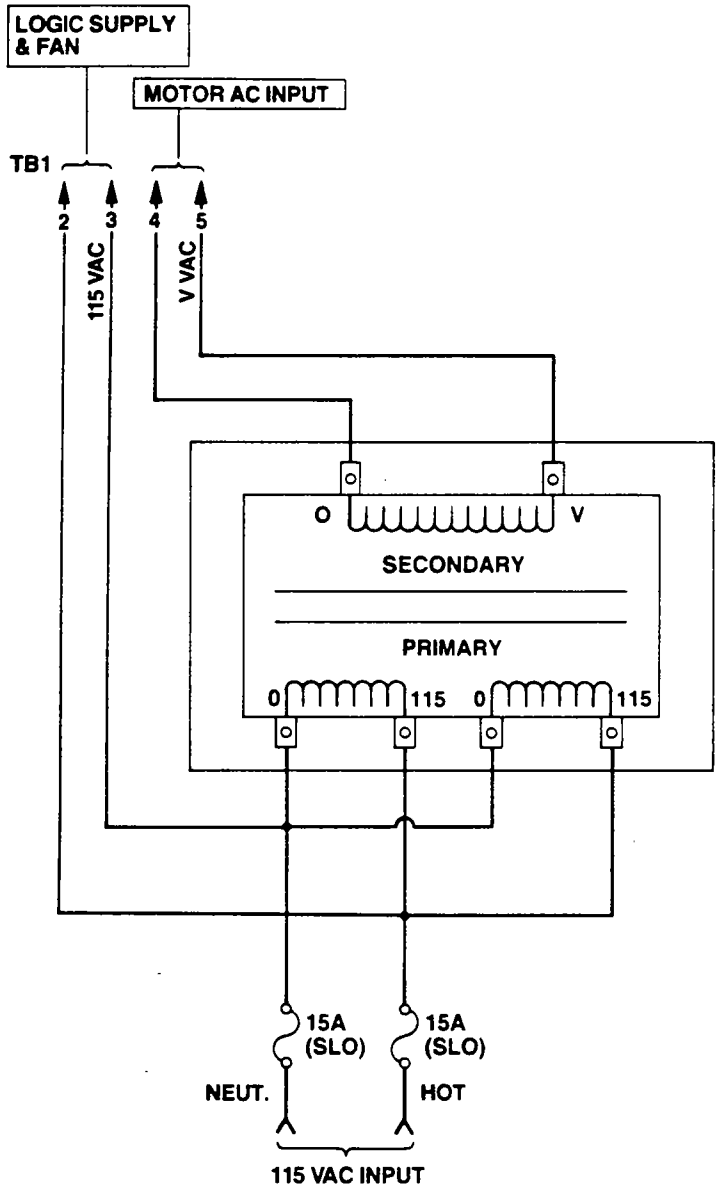


FIG. 5 105-125 VAC TRANSFORMER WIRING DIAGRAM

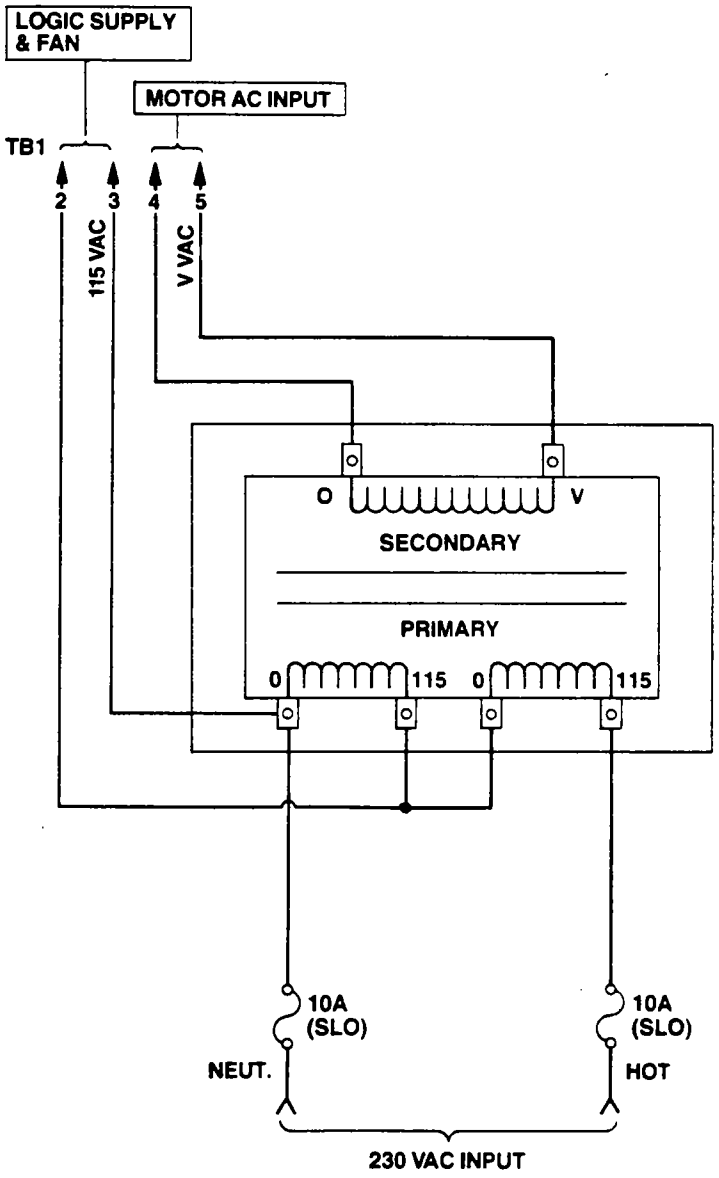


FIG. 6 208-240 VAC TRANSFORMER WIRING DIAGRAM

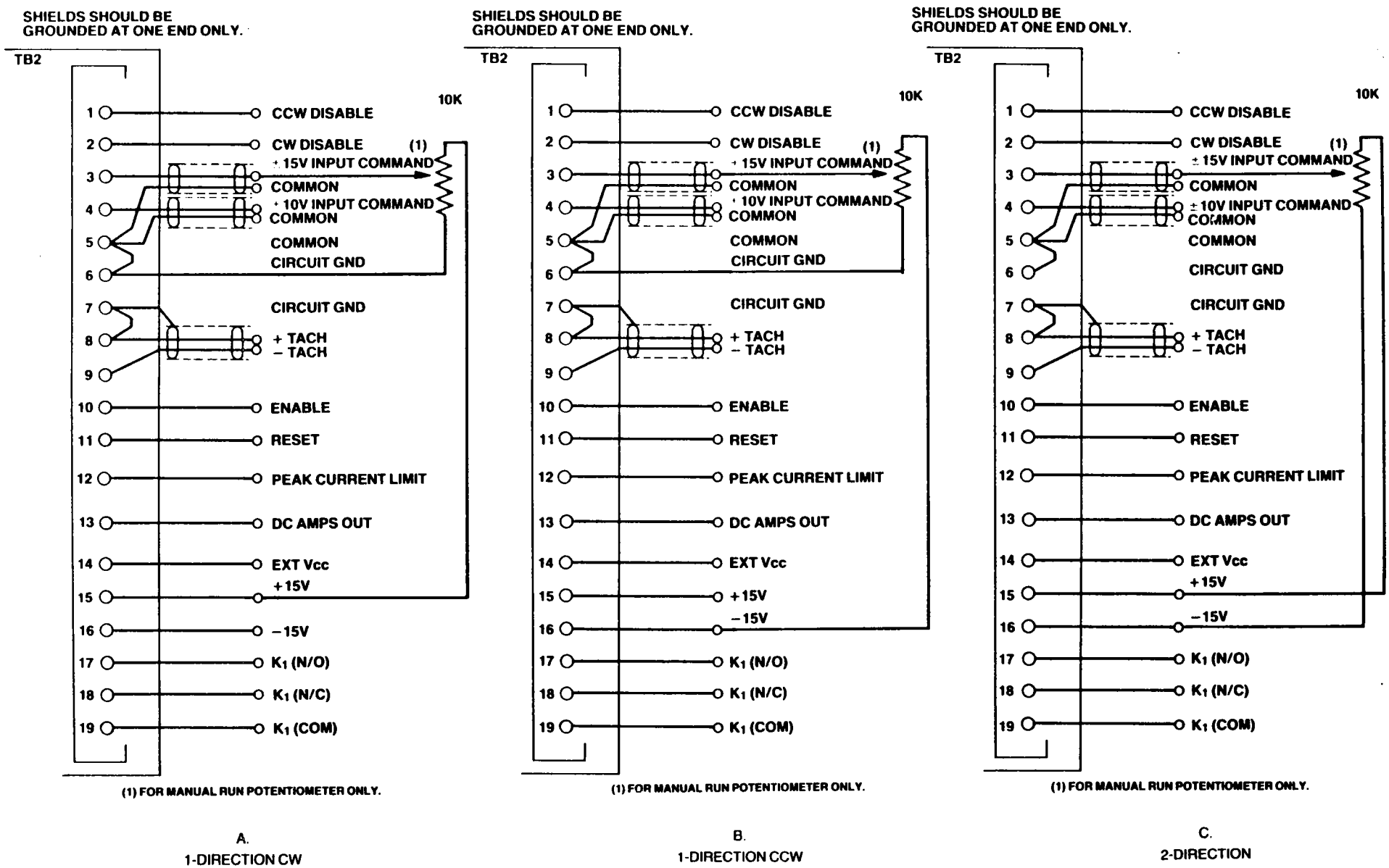
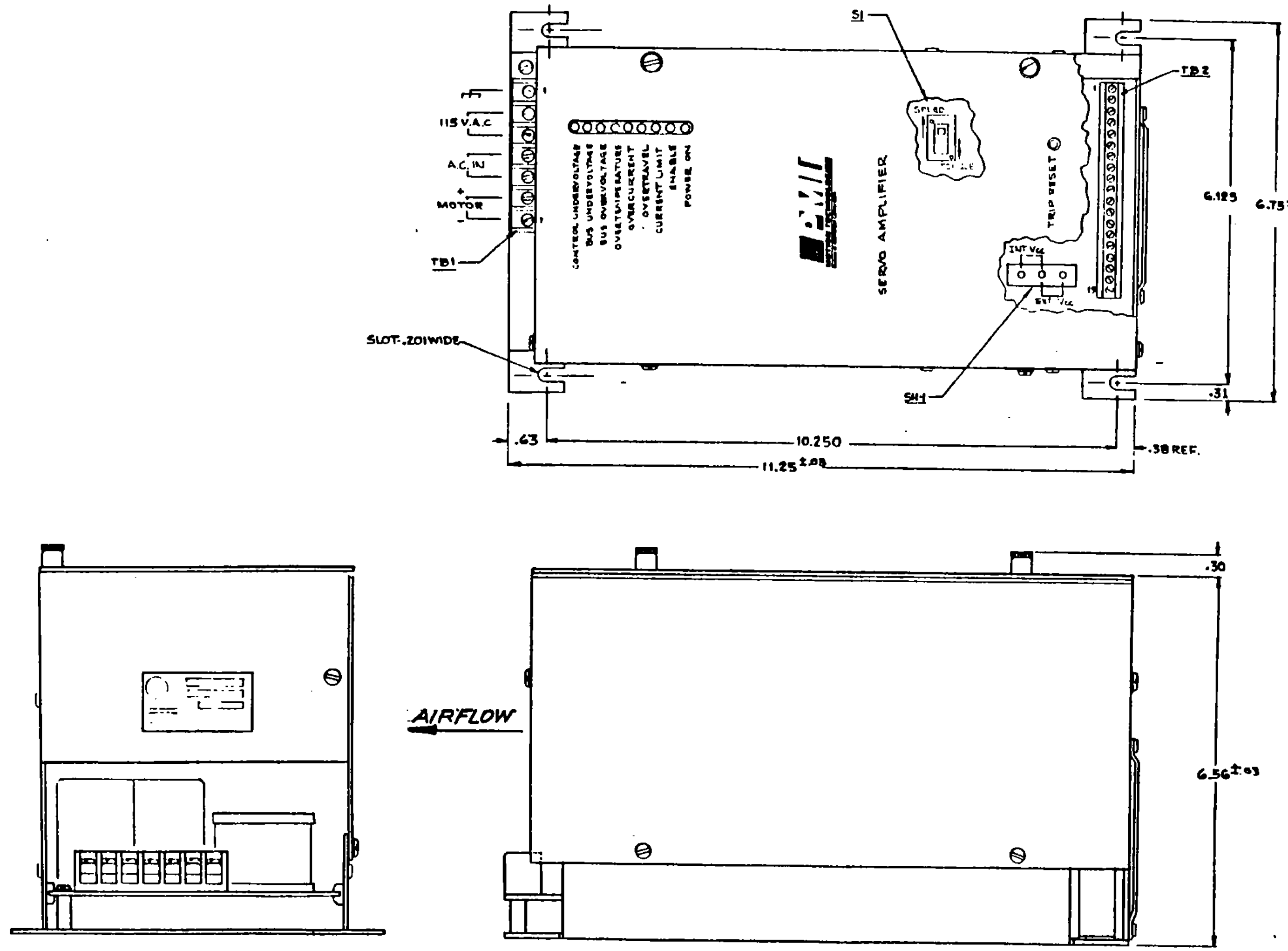


FIG. 7 MANUAL SPEED CONTROL CONNECTION SCHEMES

LTR	DESCRIPTION	DATE	APPROVED
A	REL FOR PROD. ECN 6200		
B	ECN 6989: ADD TB1 TO OVERALL DWG. TITLE WAS AXA		



TB2

1	CCW DISABLE
2	CW DISABLE
3	±15V INPUT COMMAND
4	±10V INPUT COMMAND
5	INPUT COMMAND COMMON
6	GND
7	GND
8	TACH (+)
9	TACH (-)
10	ENABLE
11	RESET
12	PEAK CURRENT LIMIT
13	D.C. AMPS OUT
14	EXT Vcc
15	+15V REF.
16	-15V REF.
17	K_1(N/O) — TRIP RELAY
18	K_1(N/C) — TRIP RELAY
19	K_1(COM) — TRIP RELAY

NOTES:

1- OPEN HINGED COVER FOR ACCESS TO TB2.
2- REFER TO OPERATIONS MANUAL FOR INSTALLATION & OPERATIONS PROCEDURES.
3- ALL CONTROL WIRING MUST BE RUN SEPARATELY FROM ALL POWER WIRING.
4- ALL CUSTOMER CONTROL WIRES SHALL BE SHIELDED 22 AWG OR BETTER WIRE AND SHIELD SHALL TERMINATE AT TB2-6 OR TB2-7.
5- TO AVOID SAFETY HAZARDS, CHASSIS SHALL BE TIED TO EARTH GROUND AT TB1-1.
6- TB2, S1, AND SH-1 ARE MOUNTED ON CONTROL BOARD OF AMPLIFIER. (SEE DATA FOR SWITCH AND SHUNT BLOCK FUNCTIONS)

MATERIAL:

FINISH:

THIRD ANGLE PROJECTION

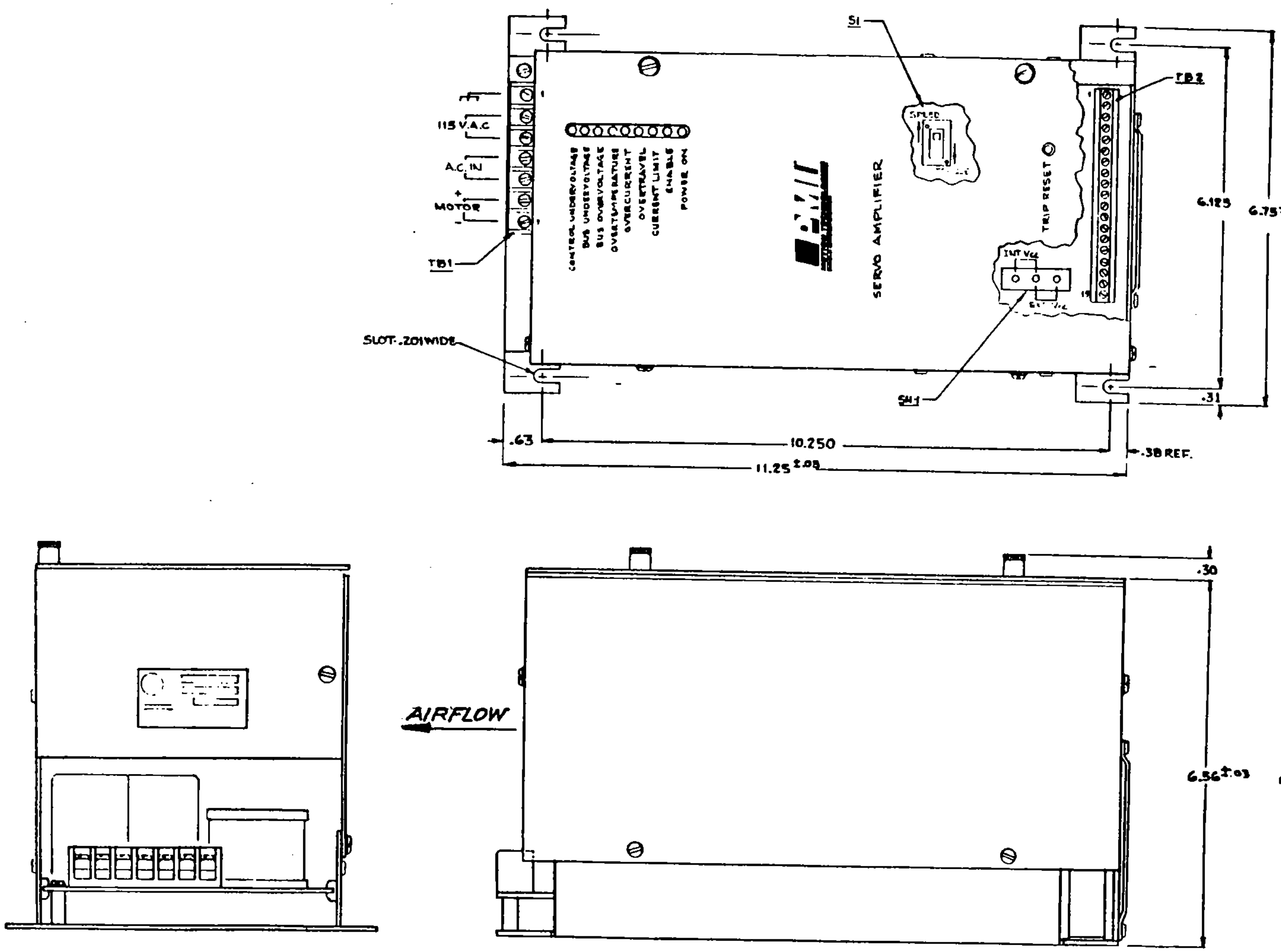
DR BY G. HAUPT

CHECKED

PMI

OUTLINE DWG
AXA SERVO AMPL.

D | 57271 | 00-88051-001



TB2	
1	CCW DISABLE
2	CW DISABLE
3	±15V INPUT COMMAND
4	±10V INPUT COMMAND
5	INPUT COMMAND COMMON
6	GND
7	GND
8	TACH (+)
9	TACH (-)
10	ENABLE
11	RESET
12	PEAK CURRENT LIMIT
13	D.C. AMPS OUT
14	EXT Vcc
15	+15V REF.
16	-15V REF.
17	K_1 (N/O) — TRIP RELAY
18	K_1 (N/C) — TRIP RELAY
19	K_1 (COM) — TRIP RELAY

NOTES:

1 - OPEN HINGED COVER FOR ACCESS TO TB2
2 - REFER TO OPERATING MANUAL FOR INSTALLATION & OPERATING PROCEDURES
3 - ALL CONTROL WIRING MUST BE RUN SEPARATELY FROM ALL POWER WIRING.
4 - ALL CUSTOMER CONTROL WIRES SHALL BE SHIELDED 22 AWG OR BETTER WIRE AND SHIELD SHALL TERMINATE AT TB2-6 OR TB2-7.
5 - TO AVOID SAFETY HAZARDS, CHASSIS SHALL BE TIED TO EARTH GROUND AT TB1-1.
6 - TB2, S1 AND SW1 ARE MOUNTED ON CONTROL BOARD OF AXA. SEE [illegible] FOR SWITCH AND SHUNT [illegible] POSITIONS.)

LTR	DESCRIPTION	DATE	APPROVED
A	REL'D FOR PROD. ECN 6200	[illegible]	[illegible]
B	ECN 4989 [illegible]	[illegible]	[illegible]

MATERIAL:

FINISH:

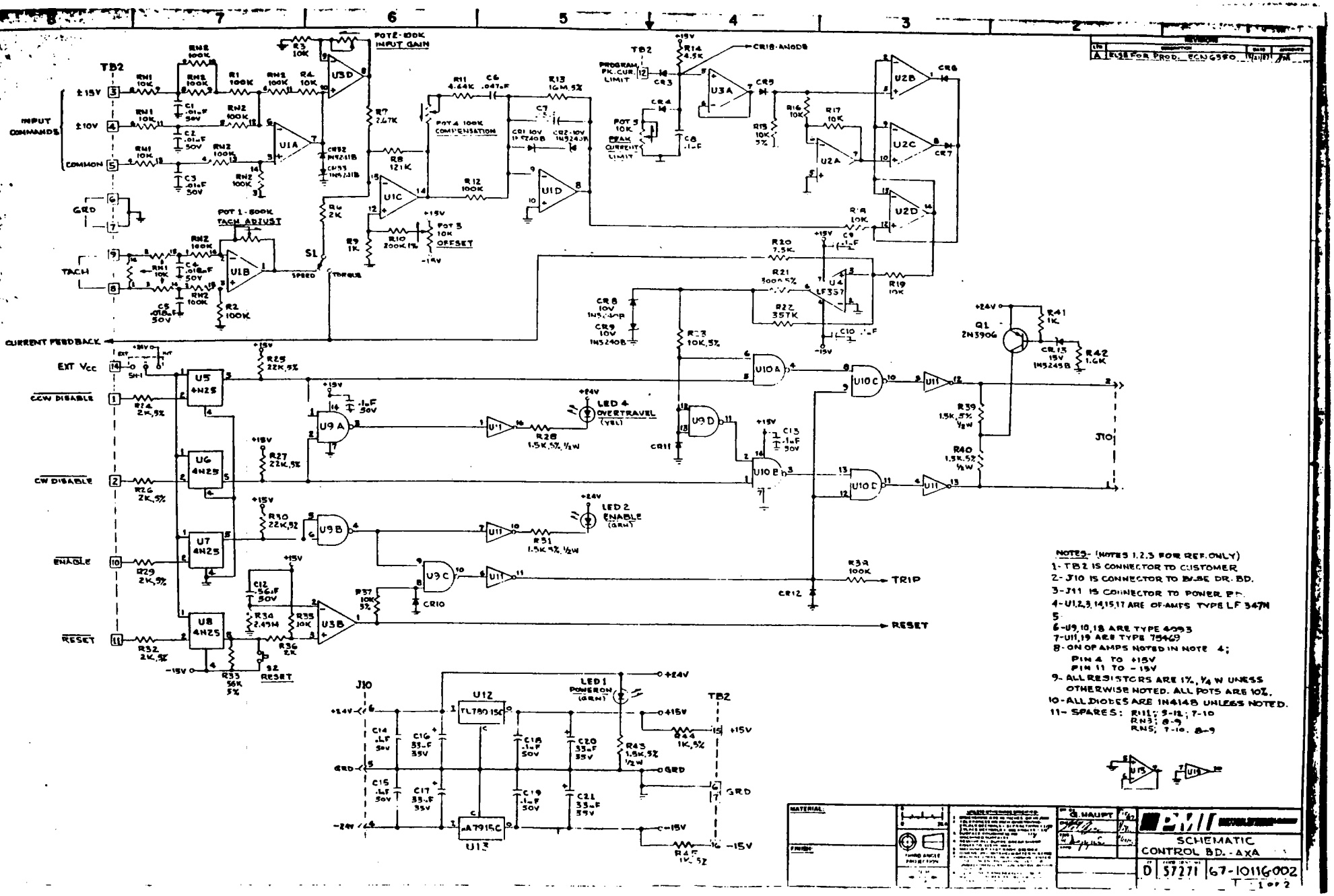
THIRD ANGLE PROJECTION

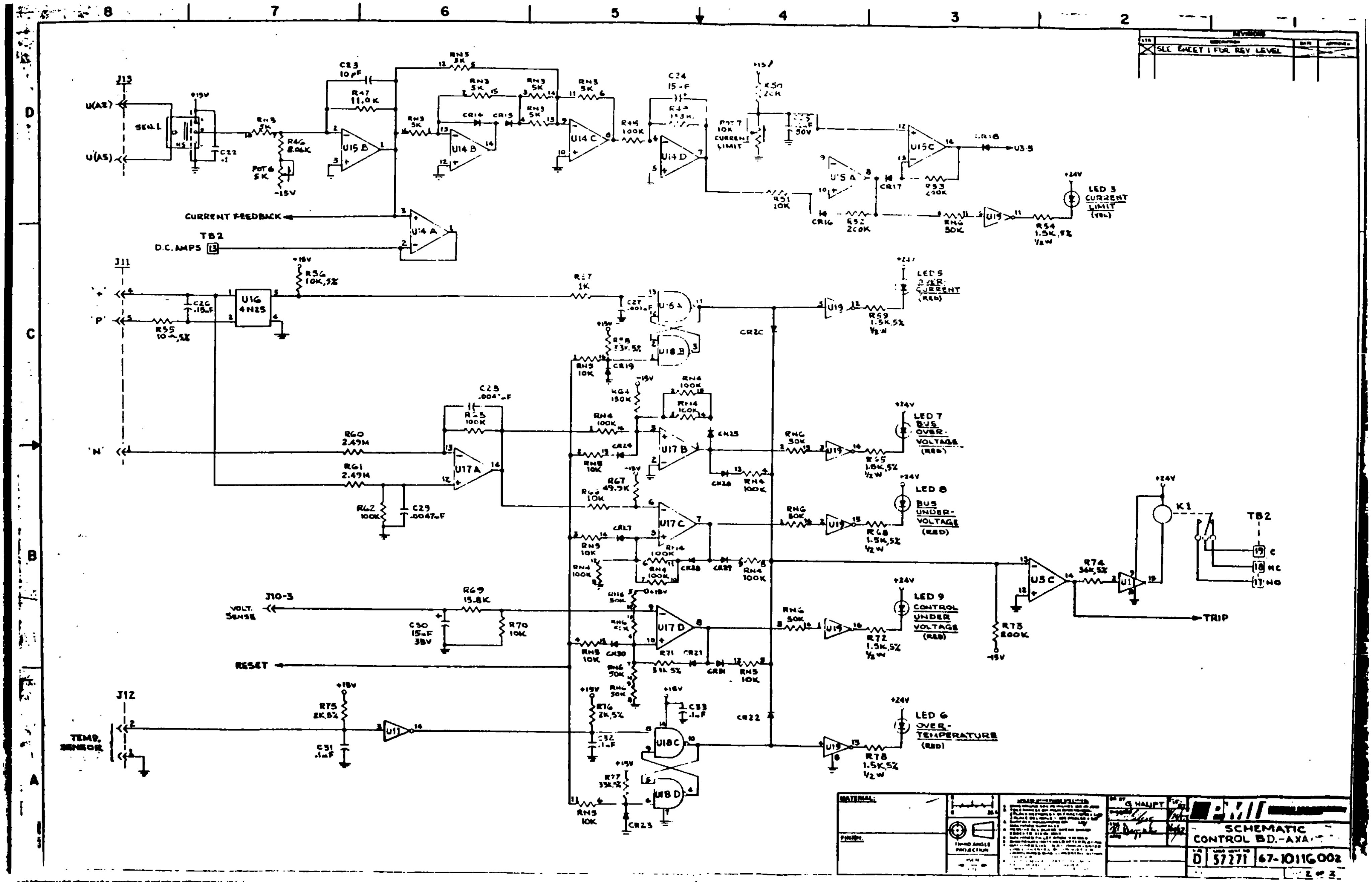
DR BY G. HAUPT

PMI

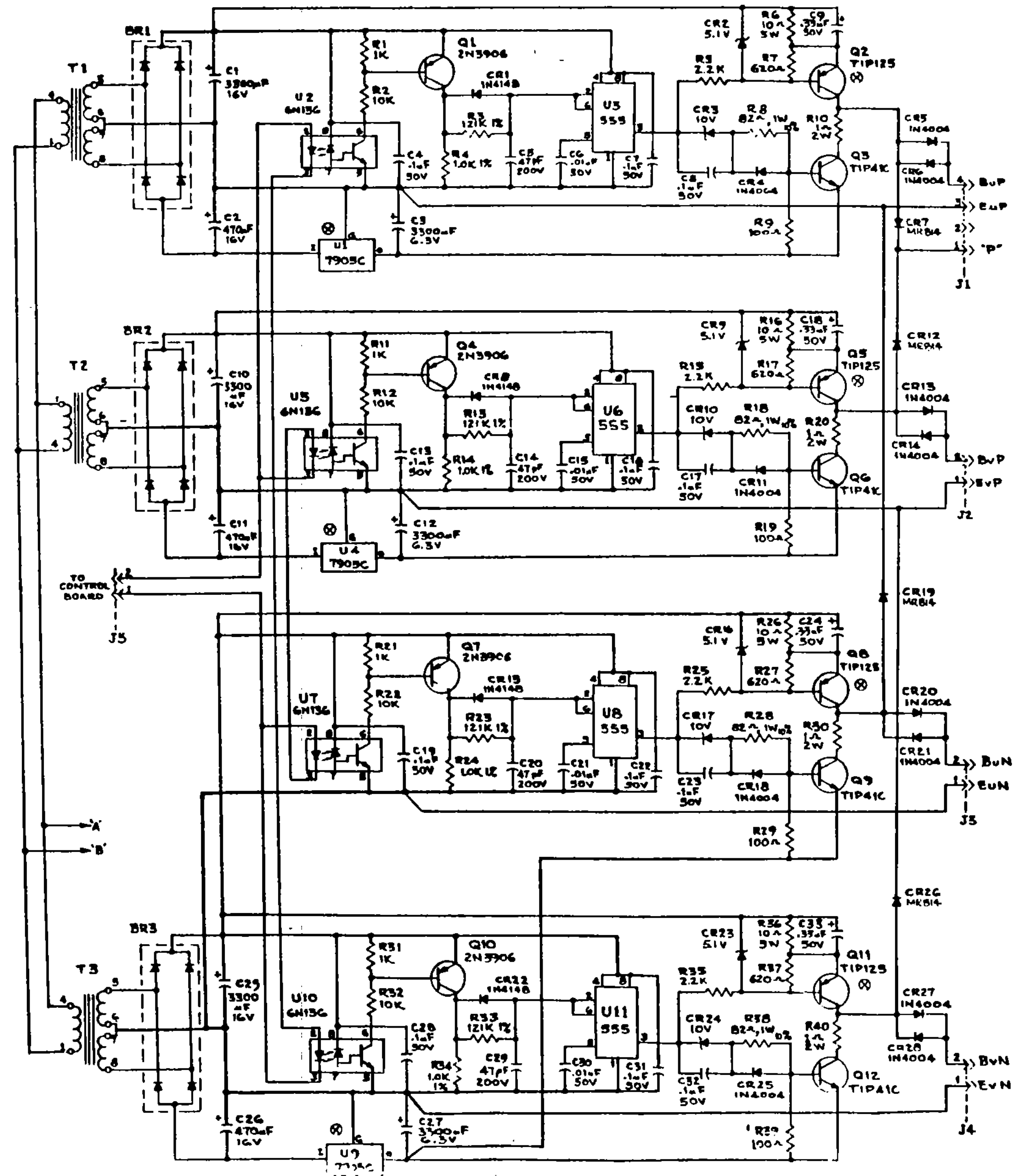
OUTLINE DWG
AXA SERVO AMPL.

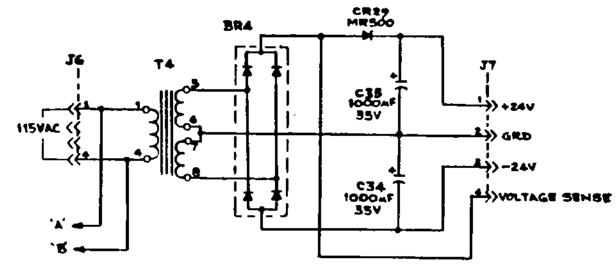
D 57271 00-88051-001


INPUT COMMANDS
±15V
±10V
COMMON
GRD
TACH
TB2
POT2-100K INPUT GAIN
POT 1-500K TACH ADJUST
POT 4 100K COMPENSATION
POT 5 10K PEAK CURRENT LIMIT
POT 3 10K OFFSET
PROGRAM PK. CUR. LIMIT
CR1 10V 1N5240B
CR2-10V 1N5240B
CR3 1N914B
CR4 1N914B
CR5 1N914B
CR6 1N914B
CR7 1N914B
CR8 10V 1N5240B
CR9 10V 1N5240B
CR10 1N914B
CR11 1N914B
CR12 1N914B
CR13 15V 1N5245B
CR18-ANODE
SPEED
THROUGH
S1
S2 RESET
CURRENT FEEDBACK
EXT Vcc
CCW DISABLE
CW DISABLE
ENABLE
RESET
U1A
U1B
U1C
U1D
U2A
U2B
U2C
U2D
U3A
U4 LF357
U5 4N25
U6 4N25
U7 4N25
U8 4N25
U9A
U9B
U9C
U9D
U10A
U10B
U10C
U10D
U11
U12 TL780 15C
U13 μA7915C
Q1 2N3906
LED 4 OVERTRAVEL (YEL)
LED 2 ENABLE (GRN)
LED 1 POWERON (GRN)
TRIP
RESET
J10
TB2
NOTES- (NOTES 1,2,3 FOR REF. ONLY)
1- TB2 IS CONNECTOR TO CUSTOMER.
2- J10 IS CONNECTOR TO BASE DR. BD.
3- J11 IS CONNECTOR TO POWER P.S.
4- U1,2,3,14,15,17 ARE OP-AMPS TYPE LF 347N
5-
6- U9,10,18 ARE TYPE 4093
7- U11,19 ARE TYPE 75469
8- ON OP AMPS NOTED IN NOTE 4;
PIN 4 TO +15V
PIN 11 TO -15V
9- ALL RESISTORS ARE 1%, ¼ W UNLESS OTHERWISE NOTED. ALL POTS ARE 10%.
10- ALL DIODES ARE IN4148 UNLESS NOTED.
11- SPARES: R111; 9-12, 7-10
RN3; 8-9
RN5; 7-10, 8-9
SCHEMATIC
CONTROL BD. - AXA
D 57271 67-10116002
T - 1 of 2



SEE SHEET 1 FOR REV LEVEL
J13
U(A2)
U(A5)
+15V
-15V
CURRENT FEEDBACK
TB2
D.C. AMPS
J11
'+'
'P'
'N'
U16 4N25
R55 10Ω,5%
R56 10K,5%
R57 1K
R60 2.49M
R61 2.49M
R62 100K
C29 .0047μF
U17A
U17B
U17C
U17D
U14A
U14B
U14C
U14D
U15A
U15B
U15C
U18A
U18B
U18C
U18D
U19
U3C
U11
C23 10pF
R47 11.0K
R45 100K
C24 15μF
POT 7 10K CURRENT LIMIT
POT 6 5K
R46 8.06K
R51 10K
R52 200K
R53 200K
R54 1.5K,5% 1/2W
LED 3 CURRENT LIMIT (YEL)
LED 5 OVER-CURRENT (RED)
R59 1.5K,5% 1/2W
LED 7 BUS OVER-VOLTAGE (RED)
LED 8 BUS UNDER-VOLTAGE (RED)
LED 9 CONTROL UNDER VOLTAGE (RED)
LED 6 OVER-TEMPERATURE (RED)
R68 1.5K,5% 1/2W
R72 1.5K,5% 1/2W
R78 1.5K,5% 1/2W
R67 49.9K
R64 150K
R69 15.8K
R70 10K
C30 15μF 35V
J10-3
VOLT. SENSE
RESET
J12
TEMP. SENSOR
R75 2K,5%
C31 .1μF
R76 2K,5%
C32 .1μF
C33 .1μF
R77 33K,5%
R71 33K,5%
R73 800K
R74 56K,5%
K1
+24V
TRIP
TB2
C
NC
NO
SCHEMATIC
CONTROL BD.-AXA
D 57271 67-10116002
G HAUPT
THIRD ANGLE PROJECTION
MATERIAL
FINISH
2 of 2





NOTES:
1. ⊗ = HEAT SINK.
2. BR1,2,3,4 = 2KPD05
3. T1,2,3 = 5T5-20
   T4 = 5T5-36
4. RES = 5%, ¼W UNLESS NOTED.

LTR	DESCRIPTION	DATE	APPROVED
A	RLSE FOR PROD. [illegible]	[illegible]	[illegible]
B	ECN 6309 [illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]

MATERIAL:

FINISH:

THIRD ANGLE PROJECTION

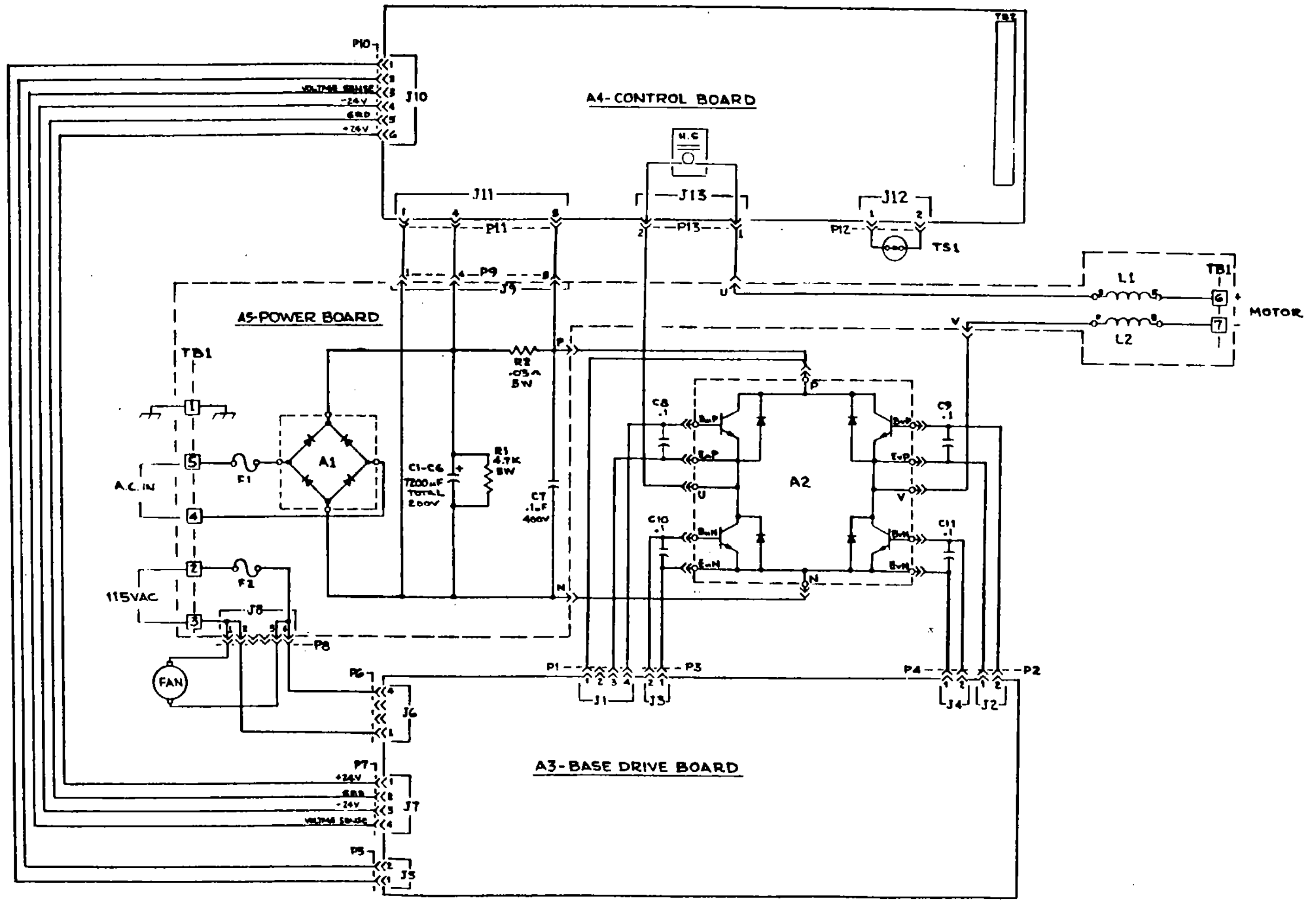
DR BY G. HAUPT

PMI

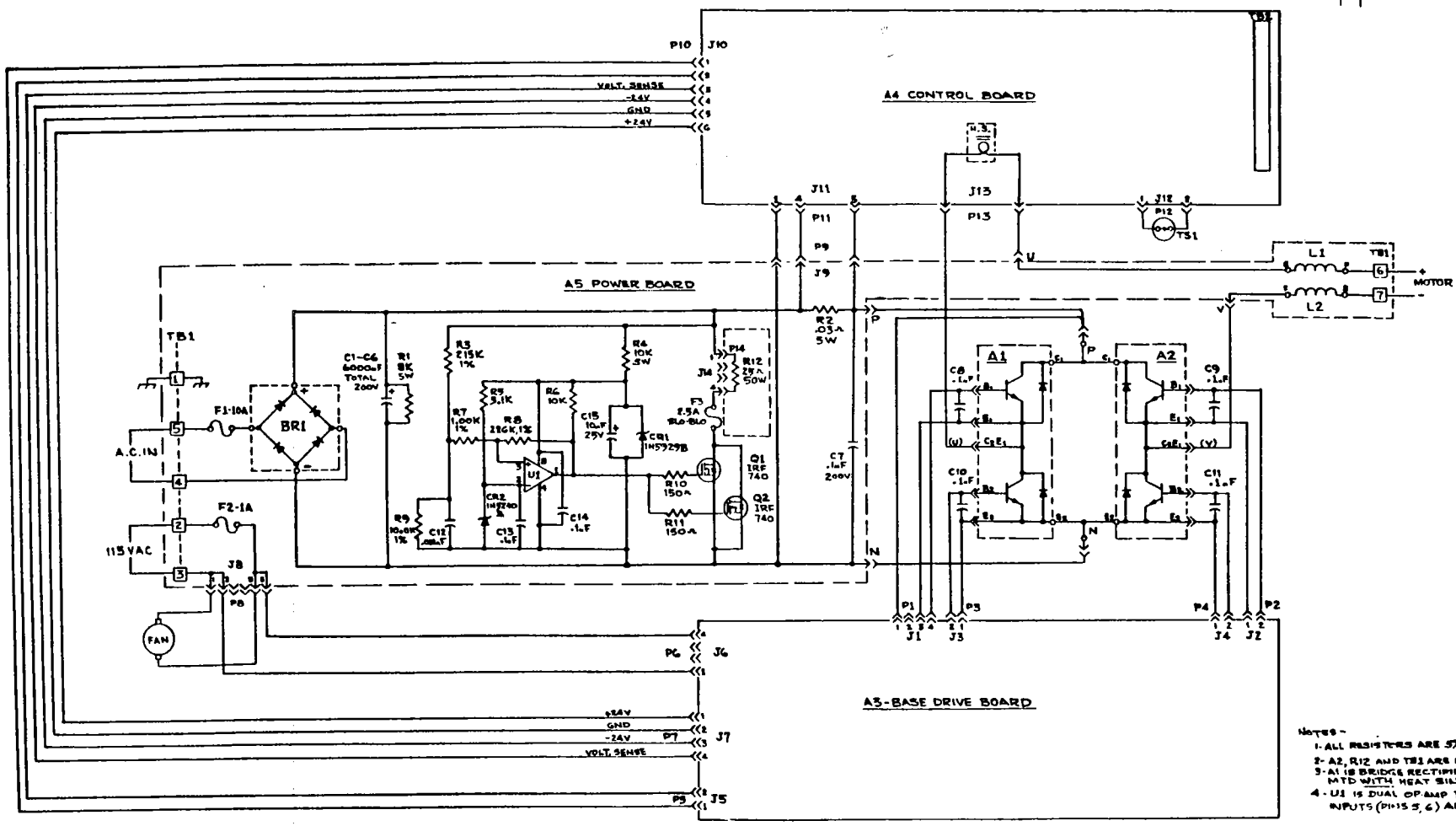
SCHEMATIC
BASE DRIVE - AXA

D 57271 67-10117-001

LTR	DESCRIPTION	DATE	APPROVED
A	REL FOR PROD. XF67-9035 ECN 6200		
B	ECN 6385		



MATERIAL:	
FINISH:	
THIRD ANGLE PROJECTION	
DR BY	G HAUPT
	SCHEMATIC
	AXA-90 AMPLIFIER
D	57271
	G7 10118 001



Notes -
1. ALL RESISTORS ARE 5%, ¼W UNLESS NOTED.
2. A2, R12 AND TB1 ARE MOUNTED ON HEAT SINK.
3. A1 IS BRIDGE RECTIFIER 40A TYPE FP1404W3, MTD WITH HEAT SINK.
4. U1 IS DUAL OP-AMP TYPE LM393N. UNUSED INPUTS (PINS 5, 6) ARE TO BE GROUNDED.

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	RLSE FOR PROTO		
B	RLSE FOR PROD. ECN 6350	4/1/91	

DO NOT SCALE DRAWING - WORK TO DIMENSIONS SHOWN

MATERIAL:
FINISH:
THIRD ANGLE PROJECTION

DR BY G. HAUPT
CHECKED
APPD

SCHEMATIC DIAGRAM
AXA-180-10 SERVO AMPL

SIZE D | 57271 | 67-10124 001
SHT 1 OF 1

DASH NO	"L" DIM	"W" DIM	"H" DIM	"X" DIM	"Y" DIM	"T" DIM	SLOT SIZE	PRIMARY	SECONDARY (X) RMS RATINGS	TERMINAL SCREW SIZE	TYPE NO	MTG SCREW
-001	4 7/8	3 1/4	3 9/16	3 7/16	2 5/8	1/2	13/64 x 3/8	115/230VAC,50/60Hz	16V, 12A	#6-32	T-20-8	NO 8
-002	4 1/2	3 9/16	3 1/4	3 1/4	2 1/2	1/2	13/64 x 3/8	115/230VAC,50/60Hz	20V, 12A	#8-32	T-26-8	NO. 8
-003	4 1/8	3 1/4	3 7/16	3 7/16	2 5/8	1/2	13/64 x 3/8	115/230VAC,50/60Hz	36V, 5.5A	#6-32	T-48-4	NO 8
-004	4 1/2	3 1/2	3 1/4	3 1/4	2 1/2	1/2	13/64 x 3/8	115/230VAC,50/60Hz	56V, 5.4A	#8-32	T-75-4	NO 8
-005	5 1/4	4 3/4	4 1/8	4 3/8	3 5/8	3/4	9/32 x 15/32	115/230VAC,50/60Hz	80V, 9A	#8-32	T-110-6	1/4
-006	4 1/2	3 1/2	3 1/4	3 1/4	2 1/2	1/2	13/64 x 3/8	115/230VAC,50/60Hz	115V, 2.6A	#8-32	T-160-2	NO 8
-007	5 1/4	4 3/4	4 1/8	4 3/8	3 5/8	3/4	9/32 x 15/32	115/230VAC,50/60Hz	115V, 6.5A	#8-32	T-160-4	1/4
-008	6 1/4	4 7/8	5 7/16	5 7/16	3 1/4	3/4	9/32 x 9/16	115/230VAC,50/60Hz	115V, 9A	#8-32	T-160-6	1/4
-009	4 1/2	4 1/2	3 3/4	3 3/4	3 1/2	1/2	13/64 x 3/8	115/230VAC,50/60Hz	20V, 24A	#8-32	T-26-16	NO 8
-010	4 1/2	4 1/2	3 3/4	3 3/4	3 1/2	1/2	13/64 x 3/8	115/230VAC,50/60Hz	36V, 12A	#8-32	T-48-8	NO. 8
-011	7 1/2	5 5/8	6 1/4	6 3/4	3 5/8	3/4	9/32 x 9/16	115/230VAC,50/60Hz	80V, 18A	#8-32	T-110-12	1/4
-012	7 1/2	5 5/8	6 1/4	6 3/4	3 5/8	3/4	9/32 x 9/16	115/230VAC,50/60Hz	115V, 13A	#8-32	T-160-8	1/4
-013	7 1/2	5 5/8	6 1/4	6 3/4	3 5/8	3/4	9/32 x 9/16	115/230VAC,50/60Hz	130V, 13A	#8-32	T-180-8	1/4

LTR	DESCRIPTION	DATE	APPROVED
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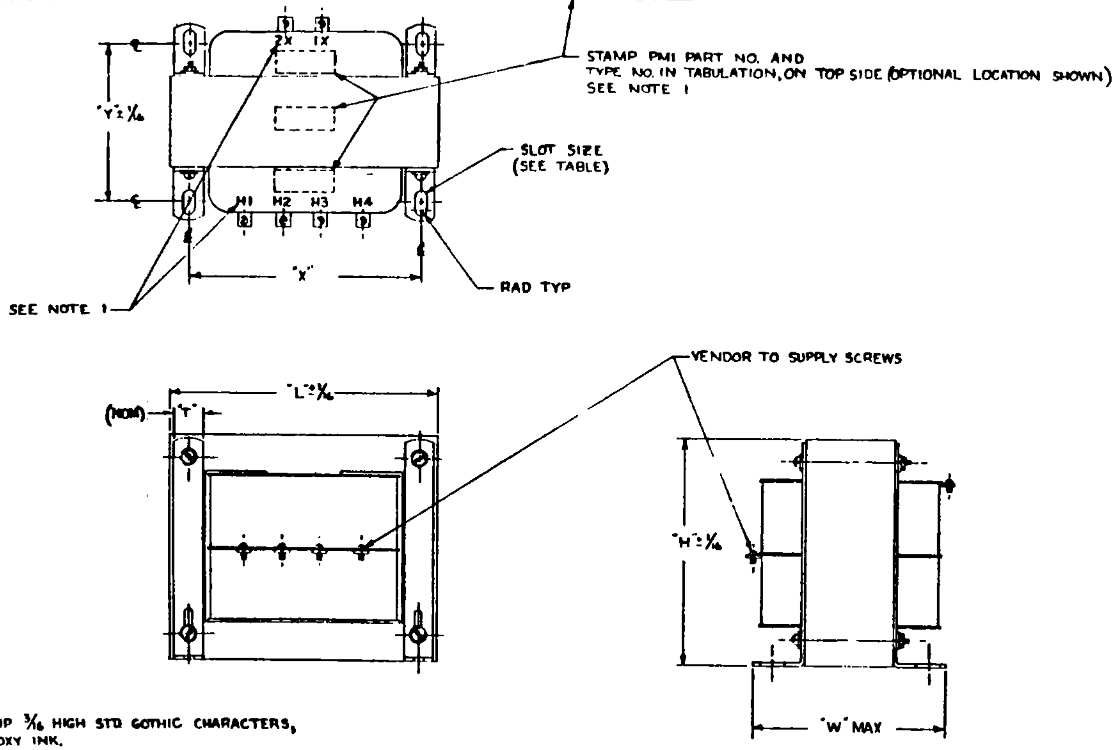
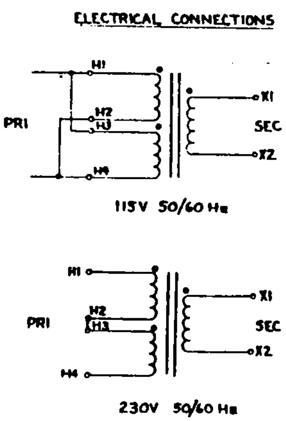
B	ADDED -009 TO -012 TO TAB, CHNGD NOTE 3, ECN NO. 6419		
C	ADDED -013 TO TAB, ECN 6596		





NOTES:
1. STENCIL OR RUBBER STAMP 3/16 HIGH STD GOTHIC CHARACTERS, USING CONTRASTING EPOXY INK.
2. FOR PURCHASE INFORMATION SEE QVL 77.
3. TOP SIDE OF TERMINAL AND HOLE THREADS SHALL BE FREE OF SOLDER AND VARNISH.

DO NOT SCALE DRAWING – WORK TO DIMENSIONS SHOWN

PURCHASED PART DRAWING

MATERIAL:

FINISH: BLACK PAINT AND/OR VARNISH

THIRD ANGLE PROJECTION

B. CLEARY

PMI

TRANSFORMER - SCREW LUG TERMINALS

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All specifications subject to change without notice

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