ANORAD

High Voltage Brushless
Stand Alone Panel Mount

2ϕ/3ϕ CURRENT MODE
D.C. SERVO AMPLIFIER

HARDWARE MAINTENANCE MANUAL
for
73773
73774
73781
73782

September 2004
Revision A
Item No. 74300

Anorad

Rockwell
Automation

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Important User Information

Those responsible for the application and use of this equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, and layout examples shown in this guide are intended solely for purposes of example. Anorad does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

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1. Introduction

1.1 General

This Hardware Maintenance Manual provides a general description and specifications of all the models in the series of **Brushless Pulse Width Modulation (PWM) Stand Alone Panel Mount D.C. Servo Amplifiers.** Then continues with specific instructions for the calibration and use of the **2ϕ/3ϕ Current Mode Model Types** are also included.

1.2 Overview

This series of servo amplifier and power supply combinations may be mounted on any flat surface and used with a variety of Anorad controllers. Their modular construction gives these units the flexibility to meet various configuration requirements. Available in four models each self-contained unit accepts line power and contains all the circuitry to perform motor commutation.

All amplifiers in this series support current mode commutation. The following units also support velocity loop servo control:

- Sinusoidal hall sensor
- Trapezoidal hall effect
- Resolver sinusoidal

These amplifiers provide closed-loop four quadrant PWM velocity or torque control of permanent magnet DC motors. When used with brushless linear or brushless rotary motors, these amplifiers can deliver one amp continuous to 25 amps peak current, with power supply voltages of either 160 VDC or 320 VDC. For complete specifications on all variations of this servo amplifier, see **Section 2: Specifications**.

CAUTION

Use proper grounding. The motor frame should be connected to chassis ground. All other grounds must be properly terminated at the chassis. See Grounding and Shielding diagram, Figure 5-1.

The amplifier provides maximum user flexibility by offering many operating features, which are set by DIP switches. Variable trim potentiometers allow for user adjustment of input command gain, feedback gain, velocity loop gain, peak current, and a derived velocity feedback scale factor. A summary of the servo amplifier features is listed on the next page.

1.2.1 Amplifier Features

- Panel mount package 9.025" L X 4.000" W X 5.660" H (with connectors)
- Line powered AC operation, fused AC input for single-phase input with in rush current protection at turn on. No power isolation transformer is required.
- Single unregulated 160 or 320 volt power supply.
- Output current adjustable one amp continuous to 25 amps peak.
- High efficiency 24kHz PWM drive scheme minimizes EMI in noise sensitive applications and eliminates audible noise.
- Sinusoidal drives provide unsurpassed disturbance free constant velocity performance.
- Fault protection circuits for over temperature, over voltage, current overload.
- Digital inputs command ENABLE/RESET and ± TRAVEL LIMITS.
- Differential amplifier for input command and velocity feedback provides high noise and common-mode voltage rejection.
- High bandwidth current control loop simplifies servo analysis and compensation.
- Variable compensation and gain by trim pots simplify set up of closed loop operation.
- DIP switches set operating configuration.
- Drives three phase delta or wye connected stators.
- Sinewave drives can use linear hall sensors, revolver or 2ϕ/3ϕ input for commutation and current control.
- Complete isolation from input to output.
- Trapezoidal drives use hall effect switches for commutation and current control. and accept three phase commutation sensors with 60 or 120-degree spacing.

1.3 Using This Manual

The procedures in this manual are laid out in a logical sequence to install, test, operate and perform basic troubleshooting procedures on the servo amplifier. Take the time to become acquainted with your new servo amplifier. It is recommended that the entire manual be read before you start handling the equipment

This manual was produced to be an element in a system documentation package. Since the amplifier may be integrated with any one of Anorad controllers, its documentation is available as a modular component. Generally, this manual will accompany controller and encoder documentation, or system manual. If modifications to this servo amplifier have been performed, supporting documentation will be supplied as an **Addendum Sheet labeled: Customer Specifications**.

1.4 Intended Audience

This manual is primarily intended for a technician who has some previous knowledge of Anorad controllers and related servo equipment. This manual is also intended for technicians of a higher skill level who are assigned to perform troubleshooting and maintenance on the servo amplifier.

2. Specifications

2.1 Introduction

This section contains the specifications for all the models of *Stand Alone Panel Mount D.C. Servo Amplifiers* series, including sinusoidal and trapezoidal hall-sensor and software commutation. Use these specifications to verify proper operation of amplifier before initial service and after service repairs have been performed.

2.2 Product Specifications

The following pages list specifications for the all Panel Mount Servo Amplifiers. These charts are divided into segments showing the item number and specification data.

2.3 Trapezoidal Mode Brushless PWM Amplifier Specifications

Item Number	Model	Output	Output Power Continuous*	Output Power Peak**	Motor Inductance	Input Single ϕ
73771	SMA8115-0C54-006-1A-1-00	160VDC,	10A	25A	Low <15mH	120VAC
73772	SMA8115-0C54-007-1A-1-00	160VDC,	10A	25A	High >15mH	120VAC
73779	SMA8115-0C54-008-1A-1-01	320VDC,	10A	25A	Low <15mH	240VAC
73780	SMA8115-0C54-009-1A-1-01	320VDC,	10A	25A	High >15mH	240VAC

* Continuous RMS Current
** Peak Output Current for 3 seconds

Operating Parameters

Operating Temperature:	0 to 50 degrees C
Dual mode operation:	Configurable for velocity control or torque control
Current Gain	0-5 A/V - Adjustable
Velocity Gain	15,000(min.) A/V
Frequency response: (Velocity loop)	750 Hz min.
Frequency response: (Current loop)	2 kHz min.
Commutation:	Trapezoidal using 3 hall sensors
Power Amp switching frequency:	24 kHz
Continuous Output Power:	2000watts
Efficiency	97%
Peak Current Fault	Instantly shuts down the amplifier in case of a short across the motor leads or a ground fault condition. (Current exceeds 80A for 10 microseconds.)
RMS Current Fault	Shuts down the amplifier when operated above max. Continuous rating for a pre-determined period.

Operating control signals and indicators:

Input analog control signal:	13 VDC differential	10k ohm Z
	±13 VDC single-ended	10k ohm Z
Current limit:	Adjustable	
± travel limit:	+18V± 0.5V max. 10k ohms termination	
Drive enable/reset:	+18V± 0.5V max. 10k ohms termination	
Fault (input):	+18V± 0.5V max. 10k ohms termination	
Digital inputs:	Hysteresis with thresholds at 1/3 and 2/3 of +5V or +15V depending on range selected jumper	
Fault (output)	Active low. Open-collector can sink 500mA max.	
Motor current monitor (ABS I.):	10A/V Peak Value	
Over Temperature indicator:	Red LED, 70°C for amplifier	
Over Volt	Red LED	
RMS Current Fault:	Red LED	
Peak Current Fault	Red LED	
RUN indicator:	Green LED	
Regen clamp indicator:	Red LED	

Mechanical:	L x W x H (with connectors) (inches)	Weight (lb.)
	9.025 X 4.00 x 5.66	5.25

2.4 2ϕ/3ϕ Current Mode Brushless PWM Amplifier Specifications

Item Number	Model	Output	Output Power Continuous*	Peak**	Motor Inductance	Input Single ϕ
73773	SMA8315-0C4-001-1A-1-00	160VDC	10A	25A	Low <15mH	120VAC
73774	SMA8315-0C4-002-1A-1-00	160VDC	10A	25A	High >15mH	120VAC
73781	SMA8315-1C4-003-1A-1-01	320VDC	10A	25A	Low <15mH	240VAC
73782	SMA8315-1C4-004-1A-1-01	320VDC	10A	25A	High >15mH	240VAC

* Continuous RMS Current
** Peak Output Current for 3 seconds

Operating Parameters

Operating Temperature:	0 to 50 degrees C
Current Gain	0-5 A/V – Adjustable
Frequency response: (Current loop)	2 kHz min.
Commutation:	Software, Two/Three Phase Input Current Mode.
Power Amp switching frequency:	24 kHz
Continuous Output Power:	2000watts
Efficiency	97%
Peak Current Fault	Instantly shuts down the amplifier in case of a short across the motor leads or a ground fault condition. (current exceeds 80A for 10 microseconds.)
RMS Current Fault	Shuts down the amplifier when operated above maximum continuous rating for a pre-determined period.

Operating control signals and indicators:

Input analog control signal:	13 VDC differential	10K ohm Z
	±13 VDC single-ended	10K ohm Z
Current limit:	Adjustable	
± travel limit:	+18V± 0.5V maximum 10k ohms termination	
Drive enable/reset:	+18V± 0.5V maximum 10k ohms termination	
Fault (input):	+18V± 0.5V maximum 10k ohms termination	
Digital inputs:	Hysteresis with thresholds at 1/3 and 2/3 of +5V or +15V depending on range selected jumper	
Fault (output)	Active low. Open-collector can sink 500mA max.	
Motor current monitor (ABS I.):	10A/V Peak Value	
Over Temperature indicator:	Red LED, 70°C for amplifier	
Over Volt:	Red LED	
RMS Current Fault	Red LED	
Peak Current Fault	Red LED	
RUN indicator:	Green LED	
Regen clamp indicator:	Red LED	
Mechanical:	L x W x H (with connectors) (inches)	Weight (lb.)
	9.025 X 4.00 x 5.66	5.25

2.5 Sine Hall Mode Brushless PWM Amplifier Specifications

Part Number	Model	Output	Output Power Continuous*	Output Power Peak**	Motor Inductance	Input Single φ
73769	SMA8415-0C54-001-1A-1-00	160VDC	10A	25A	Low <15mH	120VAC
73770	SMA8415-0C54-002-1A-1-00	160VDC	10A	25A	High >15mH	120VAC
73777	SMA8415-1C54-003-1A-1-01	320VDC	10A	25A	Low <15mH	240VAC
73778	SMA8415-1C54-004-1A-1-01	320VDC	10A	25A	High >15mH	240VAC

* Continuous RMS Current
** Peak Output Current for 3 seconds

Operating Parameters

Operating Temperature:	0 to 50 degrees C
Dual mode operation:	Configurable for velocity control or torque control
Current Gain	0-5 A/V – Adjustable
Velocity Gain	15,000(min.) A/V
Frequency response: (Velocity loop)	750 Hz min.
Frequency response: (Current loop)	2 kHz min.
Commutation:	Sinusoidal using 2 hall sensors, 120 Phase A/Phase B.
Power Amp switching frequency:	24 kHz
Continuous Output Power:	2000watts
Efficiency	97%
Peak Current Fault	Instantly shuts down the amp. in case of a short across the motor leads or a ground fault condition. (amp. Exceeds 80A for 10 microseconds.)
RMS Current Fault	Shuts down the amplifier when operated above max. continuous rating for a pre-determined period.

Operating control signals and indicators:

Input analog control signal:	13VDC differential	10K ohm Z
	±13VDC single-ended	10K ohm Z
Current limit:	Adjustable	
± travel limit:	+5V± 0.5V max. 10k ohm termination	
Drive enable/reset:	+5V± 0.5V max. 10k ohm termination	
Fault (input):	+5V± 0.5V max. 10k ohm termination	
Digital inputs:	Hysteresis with thresholds at 1/3 and 2/3 of +5V	
Fault (output)	Active low. Open-collector can sink 500mA max.	
Motor current monitor (ABS I.):	10A/V Peak Value	
Over Temperature indicator:	Red LED, 70°C for amplifier	
Over Volt:	Red LED	
RMS Current Fault	Red LED	
Peak Current Fault	Red LED	
RUN indicator:	Green LED	
Regen clamp indicator:	Red LED	
Mechanical:	L x W x H (with connectors) (inches)	Weight (lb.)
	9.025 X 4.00 x 5.66	5.25

2.6 Sine/Resolver Mode Brushless PWM Amplifier Specifications

Part Number	Model	Output	Output Power Continuous*	Peak**	Motor Inductance	Input Single ϕ
73775	SMA8215-0AC5F11-006-1A-1-00	160VDC	10A	25A	Low <15mH	120VAC
73776	SMA8215-0AC5F11-007-1A-1-00	160VDC	10A	25A	High >15mH	120VAC
73783	SMA8215-1AC5F11-008-1A-1-01	320VDC	10A	25A	Low <15mH	240VAC
73784	SMA8215-1AC5F11-009-1A-1-01	320VDC	10A	25A	High >15mH	240VAC

* Continuous RMS Current
** Peak Output Current for 3 seconds

Operating Parameters

Operating Temperature:	0 to 50 degrees C
Dual mode operation:	Configurable for velocity control or torque control
Current Gain	0-5 A/V - Adjustable
Velocity Gain	15,000(min.) A/V
Frequency response: (Velocity loop)	750 Hz min.
Frequency response: (Current loop)	2 kHz min.
Commutation:	Resolver sine and cosine signals are converted into position data used to commutate the motor phases.
Power Amp switching frequency:	24 kHz
Continuous Output Power:	2000watts
Efficiency	97%
Peak Current Fault	Instantly shuts down the amp. in case of a short across the motor leads or a ground fault condition. (amp. Exceeds 80A for 10 microseconds.)
RMS Current Fault	Shuts down the amplifier when operated above max. continuous rating for a pre-determined period.

Operating control signals and indicators:

Input analog control signal:	13 VDC differential	10k ohm Z
	±13 VDC single-ended	10k ohm Z
Current limit:	Adjustable	
± travel limit:	+18V± 0.5V max. 10k ohm termination	
Drive enable/reset:	+18V± 0.5V max. 10k ohm termination	
Fault (input):	+18V± 0.5V max. 10k ohm termination	
Digital inputs:	Hysteresis with thresholds at 1/3 and 2/3 of +5V or +15V depending on range selected jumper	
Fault (output)	Active low. Open-collector can sink 500mA max.	
Motor current monitor(ABS I):	10 A/V Peak Value	
Over Temperature indicator:	Red LED, 70°C for amplifier	
Over Volt:	Red LED	
RMS Current Fault:	Red LED	
Peak Current Fault:	Red LED	
RUN indicator:	Green LED	
Regen clamp indicator:	Red LED	

Mechanical:	L x W x H (with connectors) (inches)	Weight (lb.)
	9.025 X 4.00 x 5.66	5.25

3. 2ϕ/3ϕ Current Mode Amplifier Features

3.1 Introduction

This section describes the features on the Brushless D.C. Servo Amplifier circuit board. The descriptions will break down the boards functional elements. The servo amplifier is designed to provide current and commutation control for ANORAD's three-phase Brushless Sinewave Linear Motors. This model servo amplifier is configured for torque (current) mode.

3.2 PWM Drive Scheme

The amplifier contains a high efficiency, switch mode power output stage that utilizes a unique PWM drive scheme to minimize EMI in noise sensitive applications. The amplifier also improves motor efficiency by reducing copper and iron losses in the motor. A switching frequency of 24KHz removes audible noise, allowing a wide control bandwidth in the current feedback loop.

The core of the Brushless DC Servo Amplifier is a three-phase PWM transconductance amplifier. A high bandwidth current feedback loop is used to transform the input voltage command to a motor drive current. A proprietary control scheme is utilized to provide current modulation as a function of motor coil position relative to the magnets and the input current command.

3.3 Fault Protection

Fault protection circuits detect and shutdown the power output stage when over temperature, over voltage, or over current condition exists. Logic output signals and LED indicators provide fault indication. The amplifier incorporates a latching circuit that locks the power output stage in a shutdown mode until the fault condition is cleared. Clearing is done by either asserting an external enable command or by pushing the Reset button.

- Manual and external fault resets — Push button and a separate input are provided to reset the amplifier after a fault.
- Fault input/output — Open collector output goes low in the event of a fault. This input is configured so that externally forcing this output low will inhibit the amplifier. This allows all fault outputs in a multi-axis system to be connected together (wired) to shut down all amplifiers should any amplifier have a fault.
- Peak Current Fault — Instantly shuts down the amplifier in the event of a short across the motor leads or a ground fault condition. (i.e. amplifier exceeds 80A for 10 microseconds)

- RMS Current Fault — Shuts down the amplifier if the amplifier is operated above the maximum continuous current rating (i.e. 10A for standard 120VAC and 240 VAC for predetermined period (i.e. 3 seconds).
- Over voltage — This circuit constantly monitors power supply voltages. It will shut down the amplifier in the event any of any out of specification condition. The overvoltage protection circuit is set to turn on at +250VDC for 120 VAC line input and +450VDC for 240VAC-line input.
- Over temperature — This circuits constantly monitors the motor and amplifier-heatsink temperatures. They will shut down the amplifier in the event equipment operating temperature exceeds maximum specification. The amplifier over temperature protection circuit is set to trigger at 70°C. The motor has a separate input.

3.4 Power Supply

This series of stand-alone panel mount amplifiers incorporates either a 160 VDC or a 320 VDC self-contained power supply. Input AC voltages are respectively 105-120VAC and 205-250VAC in these configurations.

3.5 Regen Circuit

Fused regeneration clamp circuit (shunt regulator) with LED indicator and 50W internal load resistor bank bleeds off excess DC Buss voltages when decelerating a large load inertia. The regen clamp circuit is set to turn on at +215VDC for 120VAC operation and +400VDC for 240VAC operation.

3.6 Modes of Operation

In two-phase current mode, the amplifier generates three sinewave currents that are proportional to two input signals. The third command is generated on the personality module as the negative sum of the other two signals. In the three-phase current mode, the amplifier generates three sine wave currents that are proportional to the three input signals.

WARNING

Dangerous voltages, temperatures, forces and energy levels exist in servo controlled systems. Extreme care must be exercised when operating, maintaining or servicing this amplifier to prevent harm to personnel or equipment.

CAUTION

Due to the CMOS devices present on the circuit cards, extreme care must be taken when handling the cards to avoid electrical static discharge. The user must wear a ground strap when handling cards to eliminate any static electric charge.

4. INSTALLATION

4.1 Introduction

This chapter provides the necessary information to make all the wiring connections for the amplifiers to operate properly.

4.2 Mounting

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

IMPORTANT

A Muffin fan is mounted along one edge of the baseplate to provide cooling. At least 3 inches 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 easy wiring and servicing.

4.3 Wiring

4.3.1 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 electromagnetic 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 is used, or the wires should be run in metallic conduit. The shield or conduit should be connected 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 connected 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. Consult a Anorad applications engineer for inductor recommendations. Anorad stocks a complete line of inductors for virtually every application.

IMPORTANT

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 be run in a twisted-pair, shielded cable. The hall-sensor signal lines should be run in a three twisted-pair, shielded cable. In each case, the shield should be terminated at the amplifier end only to a common terminal. We also recommend that the signal lines be kept as far as possible from any power or motor wires.

4.3.2 Wire Size and Type

IMPORTANT

*To ensure safe operation, Anorad strongly recommends that all **wiring** conform to all local and national codes.*

Recommended Wire Size and Type

Motor Wires	14AWG, shielded - Standard. 12AWG, shielded - High Power.
Motor Case Ground	Same as motor wires, or use metallic conduit.
Main Power	Same as motor wires.
Signal Input	22AWG, twisted-pair, shielded.
Logic Inputs/Outputs	22AWG, shielded with its return lead.

4.4 The Signal Connector

The signal connectors are supported by the Molex® KK .100" (2.54mm) Centerline Connector System

- J1 of the Main Amplifier:
  Mating Connector: Molex® 2695 Series .100 (2.54mm) Center Crimp Terminal Housing(P/N: 22-01-3157):
  - red nylon housing.
  - 15 positions.
  - with polarizing rib.

4.4.1 The Power and Motor Connector of the Stand Alone Amplifier

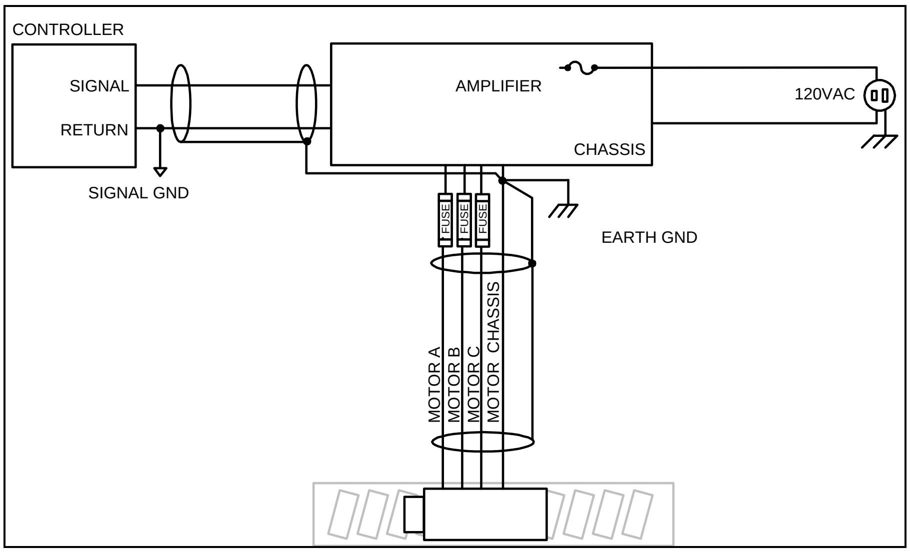
- Motor - J2 of the Stand Alone Amplifier:
  Mating Connector: PHOENIX CONTACT, COMBICON Plugs in 7.62mm Pitch (P/N: GMVSTBR 2.5/3-ST-7.62):
  - with vertical plug-in direction to the conductor axis.
  - 3 positions.
  - Color: green.
- Power Input - J6 of the Stand Alone Amplifier:
  Mating Connector: PHOENIX CONTACT, COMBICON Plugs in 7.62mm Pitch (P/N: GMVSTBW 2.5/4-ST-7.62):
  - with vertical plug-in direction to the conductor axis.
  - 4 positions.
  - Color: green.

5. Installation Considerations

5.1 Basic Installation Checks

Before operating the system controller, the technician must verify that all external connections are in agreement with sections 5.2 through 5.4. The user must also verify that amplifier input AC power is in the correct voltage range (120 VAC or 240 VAC).

Figure 5-1 Suggested External Connection Diagram



5.2 External Signals and Interconnections

Suggestions for External Connections are shown in Figure 5-1. Use them as a guide for grounding and shielding techniques. Shields for the command signal, feedback, commutation position sensor, optical sensor, and motor phases should be insulated from each other. Shields should be terminated to recommended termination points with the shortest possible lead length. Motor leads should be shielded, twisted, and routed separately from sensitive signal lines. Finally, the motor frame should be connected to chassis ground.

Care must be taken to avoid ground loops. There should be only one ground return point in a power distribution system. Power distribution consists of the primary power supply, all its loads, and all other power supplies connected to the same loads.

Due to the diversity of applications and systems, no single method of wiring is completely applicable. Therefore, to verify proper operation of the servo amplifier under operating conditions, it is highly recommended that the sensitive signal lines be monitored for excessive noise levels. Sensitive signal lines are the analog command and feedback signals, commutation position sensor, optical sensor, enable/reset, and other 5VDC logic signals.

Wire gauge sizes should match the power and motor requirements as defined in the specifications, Section 2. Since ambient conditions are varied on certain applications, a derating factor should be considered. In addition, wiring to the amplifier or motor exceeding 30 feet in length may cause excessive voltage drops. Consult wire gauge tables for factors on ambient conditions, current capacity, length, and resistance.

5.3 Motor and Commutation Position Sensor Connections

The phase relationship between the three motor phases and three commutation position sensor outputs are shown in section 6.4.5.

5.4 System Wiring Guidelines

All PWM equipment inherently generates radio-frequency interference (RFI) and wiring acts as an antenna to transmit this interference. In addition, motors inherently generate electromagnetic interference (EMI). To minimize the effects of the high noise output in these systems, employ the following techniques.

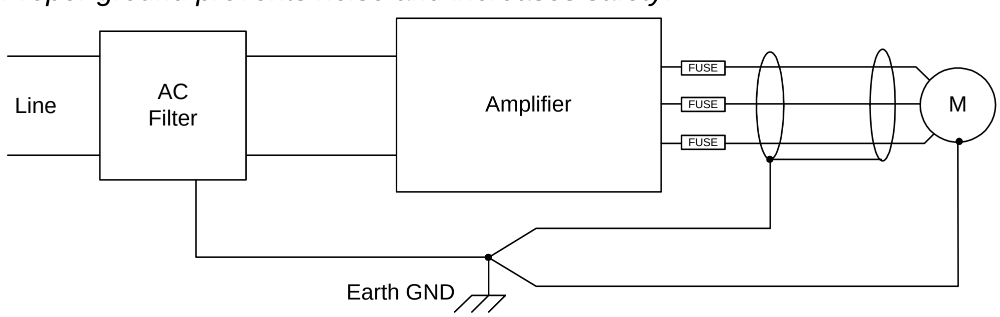
5.4.1 Protecting Power Source

In some cases, a line filter can be added to prevent switching noise form transmitting back onto the power source.

5.4.2 Grounding

To achieve optimum grounding, tie the motor ground and motor shield to a star connection with the base plate and earth ground. In addition, connect a conductor of the same gauge as the motor wires 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 suppress RFI/EMI. See Figure 5-2.

Figure 5-2 Proper ground prevents noise and increases safety.



5.4.3 Fuses on Phases

Select Slo-Blo fuses that are equal to the continuous current of the motor. See motor manual or specification sheet for specific values. The peak current should be set to the lower of two values, either the peak current rating of the motor or the maximum anticipated current for acceleration. See Section 6.6.5 to set peak current.

5.4.4 Chokes on phases

Isolated Gate Bipolar Transistor (IGBT) type amplifier's PWM switching is very fast and has an increased potential to cause EMI problems. To minimize the effects place a ferrite core inductor between the motor and amplifier. This slows the switching edges, which in turn decreases noise levels. This also introduces a small amount of additional inductance but has minimal effect on the performance of the system. Call Anorad for the availability of inductor modules for your application.

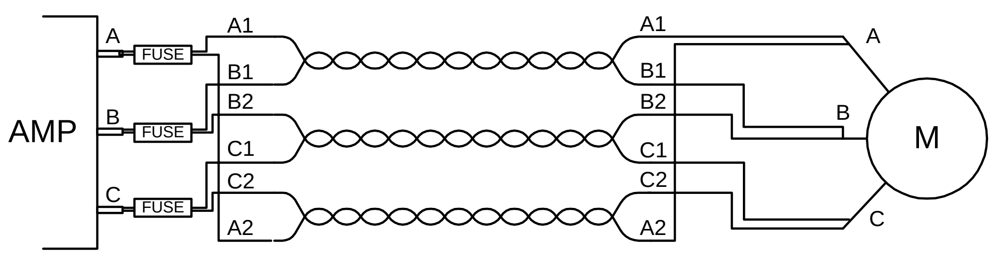
5.4.5 Choice of Motor Cables

Typical cable composition is three motor conductors and a fourth ground wire surrounded by a good quality braided ground shield with at least 85% coverage. The proper cable choice matches the continuous current of the motor being driven.

When your design requires extremely tight bend radius, a high flex flat cable will provide the solution. In your design, allow for the smaller gauge conductors by running multiple conductors for each phase of motor current.

Anorad recommends using twisted pairs to carry alternate phases of power to the motor. See Figure 5-3. This design will help in electrical noise reduction as well as safely deliver the proper current.

Figure 5-3 Alternating phases when using twisted pairs prevents noise.



5.4.6 Choice of Signal Cables

Excessive noise pickup will cause erratic amplifier operation. Anorad suggests that each input signal be run in a shielded twisted pair cable. The hall sensor and encoder signal lines, when run in twisted pairs, also help to limit noise. In each case, terminate the shield to the amplifier end and only to a common terminal.

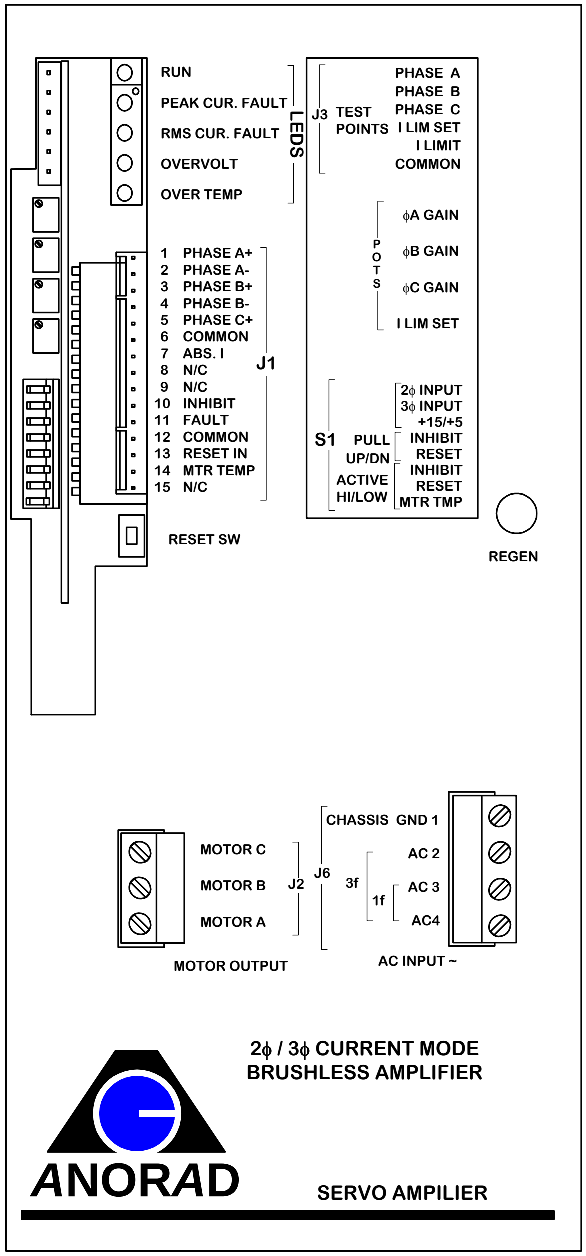
5.4.7 Cable Placement

The signal wires to encoder and amplifier are susceptible to noise pickup. Motor cable and encoder cables should be located as far away from each other as possible. The distance will help to minimize noise. A design tip: even a separation of an inch is better then having the motor and encoder cable packaged on top of each other.

6. 2ϕ/3ϕ Current Mode Brushless PWM Amplifier

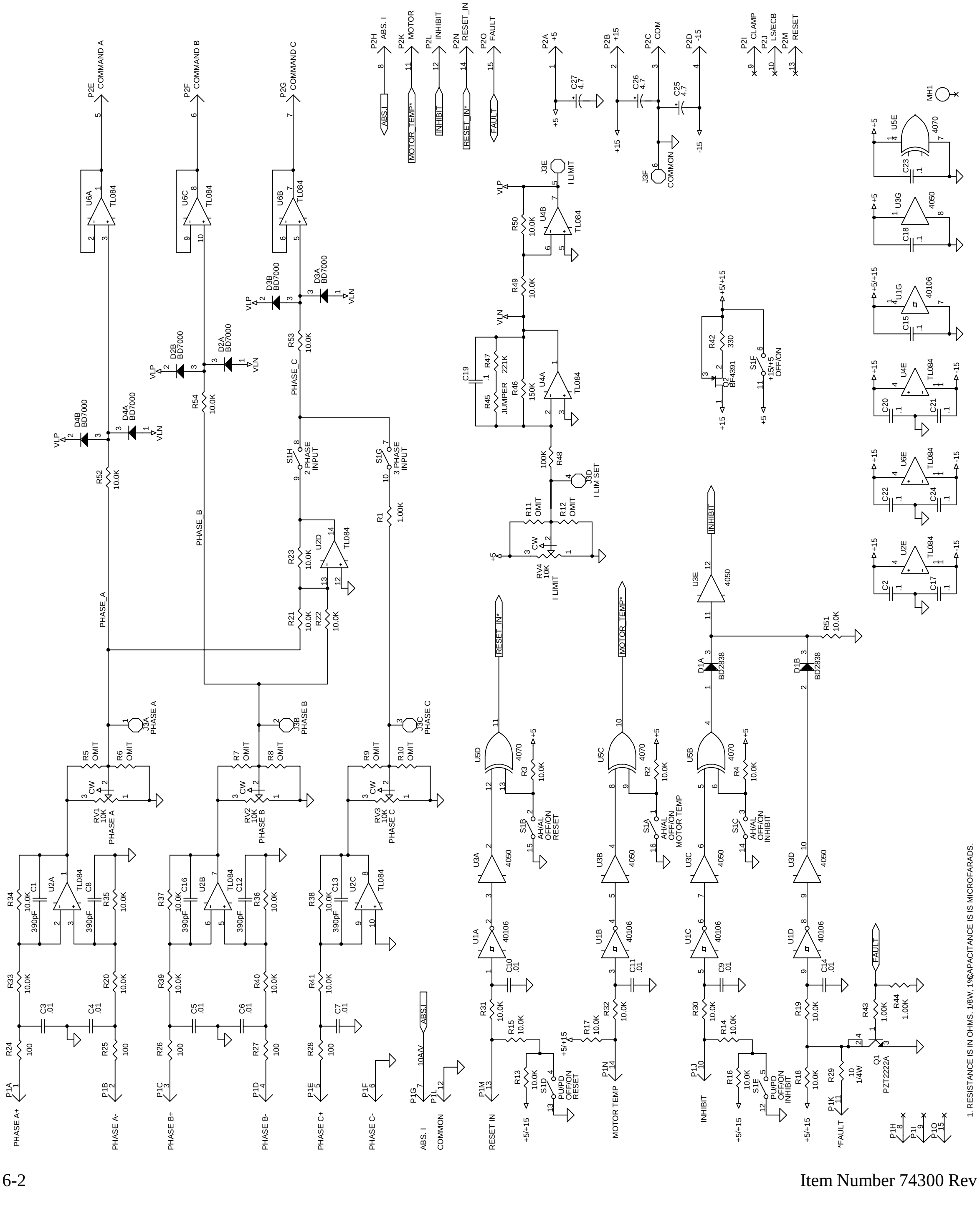
6.1 Stand Alone Amplifier Dimensions and Connector Layout

Figure 6-1 Amplifier Dimensions and Connector Layout



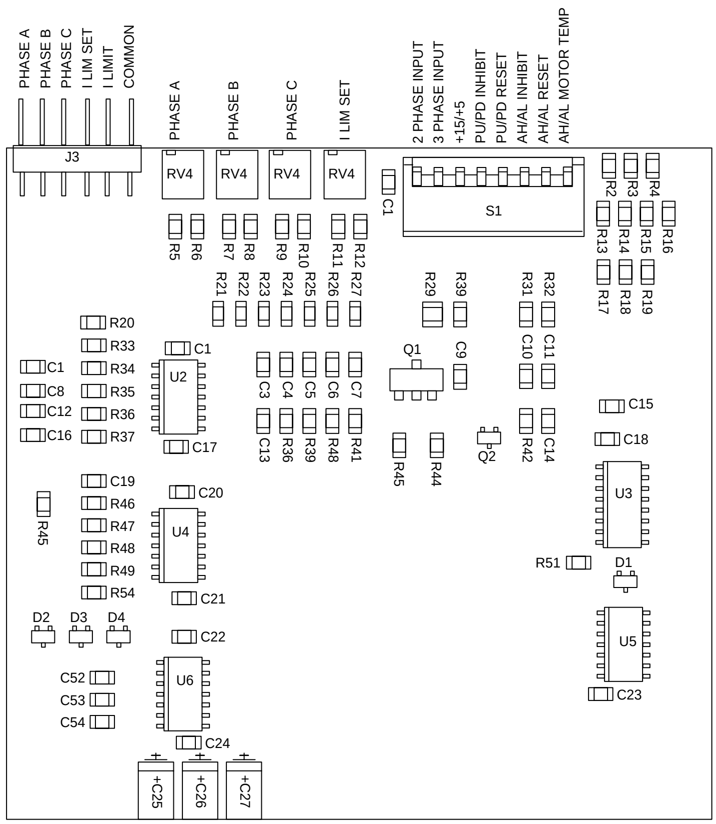
6.2 Installation Schematic

Figure 6-2 Installation Schematic



6.3 2ϕ/3ϕ Current Pre-Amp

Figure 6-3 2ϕ/3ϕ Pre-Amp



6.4 Stand Alone 2ϕ/3ϕ Current Amplifier Connections

6.4.1 Signal Connections at Amplifier - Jl

Signal Name	SMA8115/ SMA8215 Terminal	Notes
PHASE A+	J1-l	Sinusoidal input phase A.
PHASE A-	J1-2	Sinusoidal input phase A return.
PHASE B+	J1-3	Sinusoidal input phase B.
PHASE B-	J1-4	Sinusoidal input phase B return.
PHASE C+	J1-5	Sinusoidal input phase C.
COMMON	J1-6	Signal common.
ABS I	J1-7	Absolute value of the motor current (10A/V).
N/C	J1-8	No connection.
N/C	J1-9	No connection.
INHIBIT	J1-10	Inhibits the motor in both directions.
FAULT	J1-11	Goes low for a fault on this amplifier, or inhibits the amplifier when forced low.
COMMON	J1-12	Digital common.
RESET IN	J1-13	Resets fault latch.
MTR TEMP	J1-14	Motor over temperature switch input.
N/C	J1-15	No connection.

6.4.2 Motor Connections - J2

Signal Name	Terminal	Notes
MOTOR C	J2-1	See Figure 6-1
MOTOR B	J2-2	See Figure 6-1
MOTOR A	J2-3	See Figure 6-1

6.4.3 Power Connections - J6

Signal Name	Terminal	Notes
GND	J6-1	Chassis ground.
AC	J6-2	AC power input. (Omit for single-phase input)
AC	J6-3	AC power input.
AC	J6-4	AC power input.

6.4.4 Hall Sensor and Motor Phase Alignment

Connect scope to BEMF per Figure 6-4

Phase A will align with Motor A,
Phase B will align with Motor B and
Phase C will align with Motor C.

Figure 6-4 Oscilloscope connections to motor for phase alignment

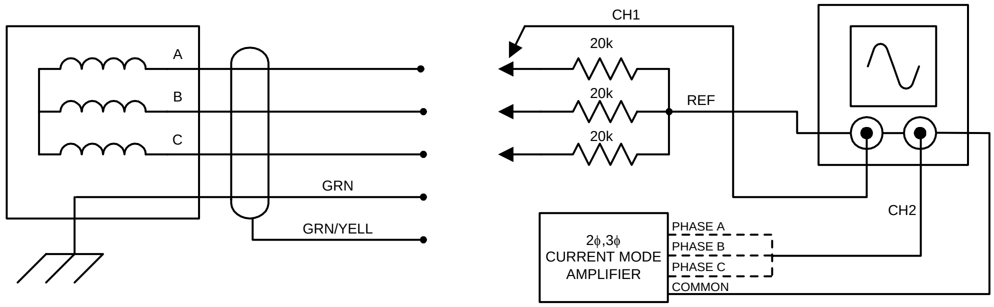
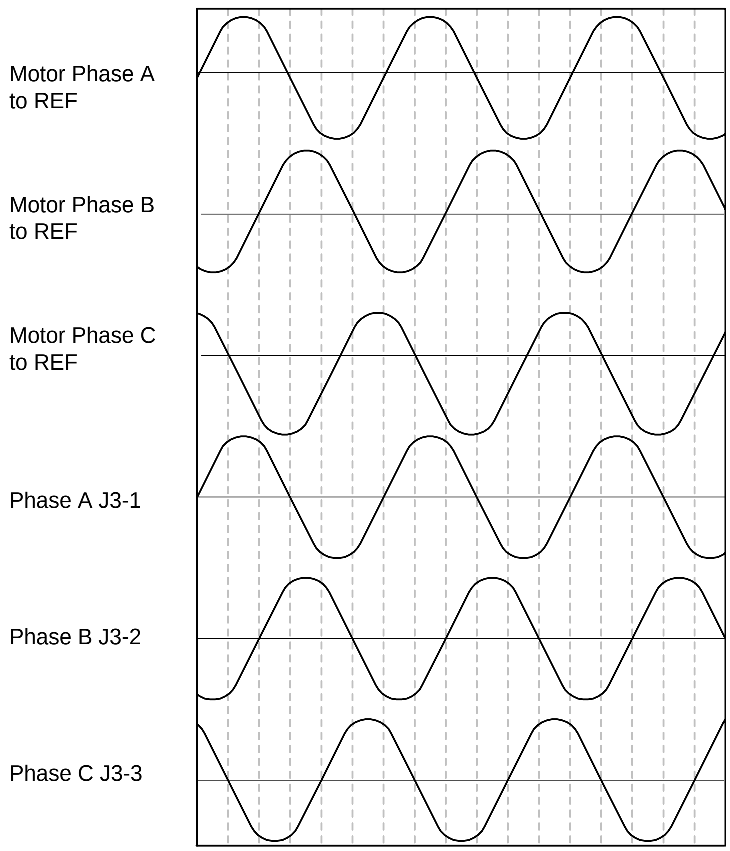


Figure 6-5 Hall to BEMF Timing Alignment in the (+) Positive Direction



6.5 Configuration

6.5.1 Introduction

Each amplifier has several configuration options. This chapter describes these options and how to implement them. If desired, Anorad will be happy to pre-configure your amplifiers. Standard configuration is Type A.

6.5.2 Logic Input Configuration

Table 6-1 Switch State Definitions

S1 DIP Switch	Name	On Position	Off Position
S1-1	Motor Temp. Polarity	Pull down to disable Amp	Pull down to enable amplifier
S1-2	Reset Polarity	If S2 ON -S6 has to be in the off position. Resets on rising edge Pull Low than release	If S1-2 OFF –S1-4 has to be in the on position. Resets on a falling edge Pulled High than Low for reset.
S1-3	Inhibit polarity	High to enable Amp	Low to enable Amp
S1-4	Reset Pull-up/Pull down	Input pulled Low	Input pulled High
S1-5	Inhibit Pull up/pull down	Input pulled Low	Input pulled High
S1-6	+15V/+5V Logic Level Configuration	+5Volt Logic	+15V logic

There are five logic inputs: Limit +, Limit -, Inhibit, Reset In, Motor Temp. 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). The motor-temp may be configured for active-high or active low signals, and is always pulled-up (type A, and C). All five logic inputs have a selectable 0 to +5VDC or 0 to +15VDC range.

- Type "A": Requires grounding of input to enable the amplifier.
- Type "B": Requires a positive voltage at input to disable the amplifier.
- Type "C": Requires grounding of input to disable the amplifier.
- Type "D": Requires a positive voltage at input to enable the amplifier.

6.5.3 2ϕ/3ϕ Input Current Mode Amplifier Configuration

The following tables shows the DIP switches that need to be configured for the Type A, B, C, and D configurations. The standard configuration is shown in bold.

	Type A	Type B	Type C	Type D
INHIBIT	**S1-5 - OFF** **S1-3 - OFF**	S1-5 - ON S1-3 - OFF	S1-5 - OFF S1-3 - ON	S1-5 - ON S1-3 - ON
RESET IN	**S1-4 - OFF** **S1-2 - OFF**	S1-4 - ON S1-2 - ON	S1-4 - OFF S1-2 - ON	S1-4 - ON S1-2 - ON
MTR TEMP	**S1-1 - OFF**	not available	S1-1 - ON	not available

6.5.4 +15V/+5V Logic Level Configuration

- +15V: S1-6 - OFF.
- + 5V: S1-6 - ON

6.5.5 Standard Configuration for 2ϕ/3ϕ Input Current Mode

DIP-switch	Switch Name	2ϕ current mode	3ϕ current mode
S1-8	2 phase input	ON	OFF
S1-7	3 phase input	OFF	ON

6.6 Start up and Calibration

6.6.1 Introduction

This chapter contains the procedure required for initial start up and amplifier calibration. The 2ϕ/3ϕ Current Mode Amplifier can be configured to run in either velocity mode or current mode.

Required Equipment: Oscilloscope and voltmeter

6.6.2 Initial Start Up

When applying power to start up your amplifier system for the first time, we recommend you follow this procedure. If you have already gone through this procedure, you can skip to the appropriate calibration procedure.

1) Check for any loose or damaged components.
2) Check that all connections are tight.
3) Be sure that the motor mechanism is clear of obstructions. If the mechanism has limited motion, e.g.: a lead-screw set the mechanism to mid-position.
4) Disconnect the signal and auxiliary inputs.
5) Work on only one amplifier at a time.

6.6.3 Pre-Amp Board Potentiometers

The following pots will be set during calibration:
Note: RV1 to RV4 are 12-turn pots.

Table 6-2 Pre-Amp Board Potentiometers

Pots	Name of Pot	Note
RV1	PHASE A	Signal gain for phase A input current.
RV2	PHASE B	Signal gain for phase B input current.
RV3	PHASE C	Signal gain for phase C input current.
RV4	I LIMIT (Current Limit)	Sets maximum peak motor current. Shipped set CW (maximum current limit).

6.6.4 Pre-Amp Board Test Points

The following test points will be use during calibration:

Table 6-3 Pre-Amp Board Test Points

Signals monitored from wiper arm of potentiometers.

Test Point	Signal	Note
J3-1	Phase A	RV1
J3-2	Phase B	RV2
J3-3	Phase C	RV3
J3-4	I Limit Set	RV4
J3-5	I Limit	5A/V Scale
J3-6	Common	

6.6.5 2ϕ/3ϕ Current Mode Amplifier Calibration

The amplifier in this configuration receives either two or three bi-polar phase current command signals input. The amplifier generates three sine wave currents that are proportional to the input signals. Use appropriate procedure to calibrate the amplifier for your system configuration.

6.6.5.1 Two Phase Input Current Mode Amplifier Calibration Procedure

1) The motor is not needed to perform the following calibration. **Ensure it is disconnected from the amplifier.**

2) Reference manual for the motor that will be used with the amplifier being calibrated. Locate the Motor Specifications Table, and make a note of the *Peak Current (Ip 0.25)*[1] specification.

3) If the application of your linear motor system dictates a lower peak current rating than that found via Step 2, tailor the peak current specification to your requirements. **Under no circumstances exceed the specification found via Step 2, during the calibration process.**

4) Reference Figure 6-1. Adjust current limit pot RV4 (I Lim Set) to its full CCW[2] position.

5) Ensure DIP switch SIG (S1 - 3ϕ Input) is in the open (off) position, and SIG (S1 - 2ϕ Input) is in the closed (on) position.

6) Turn Phase A (ϕA Gain - RV1), Phase B (ϕB Gain - RV2) and Phase C (ϕC Gain - RV3) pots full CCW.

7) Apply main power and fan power.

NOTE:

The current limit measurement at the current limit test point (I Limit - J3-5) is scaled to five amps per volt (5A/V).

8) Based on the current limit requirement noted in Step 3, calculate the signal necessary to meet the required current limit specification e.g., if a motor were rated at 10 amps peak current, it would require 2 volts scaling to generate this amperage.

CAUTION:

Proceed slowly with the next step.

9) Connect one channel of an oscilloscope to the Phase A Voltage Gain Signal at J3-1. Connect the other channel of the oscilloscope to the current limit test point at J3-5. Inject a command-input signal into Phase A (J1-l/Phase A+, Jl-2/Phase A-), slowly increasing it from 0 to +10V. Monitoring the signals at J3-1 and J3-4, slowly turn the Phase A signal gain pot (RV1) CW until the voltage calculated in Step 8 is obtained at TP J3-1.

10) Repeat Step 9 for the Phase B signal. Connections/adjustments for this signal are respectively:

Signal Gain Pot: RV2
Signal Gain Testpoint: J3-2
Input (injected) J1-3, J1-4

[1] Motor current specifications are rated in amps/rms. Current (pk) = Current (rms) * 1.4144
[2] Potentiometers RVI - 4 are 12 turn pots

6.6.5.2 Three Phase Input Current Mode Amplifier Calibration Procedure

1) The motor is not needed to perform the following calibration. **Ensure it is disconnected from the amplifier.**

2) Reference the manual for the motor that will be used with the amplifier undergoing calibration. Locate the Motor Specifications Table(s), and make a note of the *Peak Current (Ip 0.25)*[1] specification.

3) If the application of your linear motor system dictates a lower peak current rating than that found via Step 2, tailor the peak current specification to your requirements. **Under no circumstances exceed the specification found via Step 2, during the calibration process.**

4) Reference Figure 6-1. Adjust current limit pot RV4 (I Lim Set) to its full CCW[2] position.

5) Ensure DIP switch SIG (S1 - 2ϕ Input) is in the open (off) position, and SIG (S1 - 3ϕ Input) is in the closed (on) position.

6) Turn Phase A (ϕA Gain - RV1), Phase B (ϕB Gain - RV2) and Phase C (ϕC Gain - RV3) pots full CCW.

7) Apply main power and fan power.

NOTE:

The current limit measurement at the current limit test point (I Limit - J3-5) is scaled to five amps per volt (5A/V).

8) Based on the current limit requirement noted in Step 3, calculate the signal necessary to meet the required current limit specification e.g., if a motor were rated at 10 amps peak current, it would require 2 volts scaling to generate this amperage.

CAUTION:

Proceed slowly with the next step.

9) Connect one channel of an oscilloscope to the Phase A Voltage Gain Signal at J3-1. Connect the other channel of the oscilloscope to the current limit test point at J3-5. Inject a command-input signal into Phase A (J1-l/Phase A+, Jl-2/Phase A-), slowly increasing it from 0 to +10V. Monitoring the signals at J3-1 and J3-4, slowly turn the Phase A signal gain pot (RV1) CW until the voltage calculated in Step 8 is obtained at TP J3-1.

10) Repeat Step 9 for the Phase B and Phase C signals. Connections/adjustments for these two signals are respectively:

Signal Gain Pots: RV2/RV3
Signal Gain Testpoint: J3-2/J3-3
Input (injected)   J1-3, J1-4/J1-5, J1-6

[1] Motor current specifications are rated in amps/rms. Current (pk) = Current (rms) * 1.4144
[2] Potentiometers RV1 - 4 are 12 turn pots

7. Maintenance and Repair

7.1 Maintenance

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

7.2 Amplifier Faults

If an amplifier should cease to operate and one or more of the fault LED's are lit, review the sections that follow on the fault in question for information and possible causes.

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

7.2.1 Table of Fault LED Conditions

Table 7-1 Fault LED Conditions

Input or Fault Condition	RUN LED	Peak Over I LED	RMS Over I LED	OVER VOLT LED	OVERTEMP LED	FAULT OUTPUT
Normal Operation	ON	OFF	OFF	OFF	OFF	NO
Inhibit (ON)	OFF	OFF	OFF	OFF	OFF	NO
Reset In (ON)	OFF	OFF	OFF	OFF	OFF	NO
Ext. Fault (ON)	OFF	OFF	OFF	OFF	OFF	YES
Undervoltage (+15V)	OFF	OFF	OFF	OFF	OFF	YES
Over Peak I (Latched)	OFF	ON	OFF	OFF	OFF	YES
Over RMS I (Latched)	OFF	OFF	ON	OFF	OFF	YES
Over-Voltage (Latched)	OFF	OFF	OFF	ON	OFF	YES
Over Temp (Latched)	OFF	OFF	OFF	OFF	ON	YES

7.2.2 Under Voltage Fault

When the +15VDC is below +12VDC, a level that would cause unreliable operation, the Run LED will turn off, a Fault Output is generated, and the amplifier is inhibited. This is not a latched condition: that is, if the problem is resolved the amplifier will resume operation.

The following is a list of possible causes:

1) Main AC line voltage is too low.
2) Bad rectifier bridge.
3) Bad DC bus filter capacitor.

7.2.3 Motor Over Temperature Fault

When the motor temperature has reached a level that, if exceeded, would damage the motor, the Run LED will turn off, the OVER TEMP LED will turn on, a Fault Output will generated, and the amplifier is inhibited. Note: This is a latched condition.

The following is a list of possible causes:

1) The continuous motor current is too high.
2) Binding or stalling of motor shaft due to excessive mechanical overload.
3) Motor rating too small for the load.

7.2.4 Peak Over Current Fault

When the peak output of the amplifier exceeds 80A for 10 micro-seconds, the Run LED will turn off, the Peak Over Current will turn on, a Fault Output is generated, and the amplifier is inhibited. Note: This is a latched condition.

The following is a list of possible causes:

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

7.2.5 RMS Over Current Fault

When the RMS output of the amplifier exceeds 15/10A for standard 120/240VAC for 3 seconds, the Run LED will turn off, the RMS Over Current will turn on, a Fault Output is generated, and the amplifier is inhibited. Note: This is a latched condition.

The following is a list of possible causes:

1) Binding or stalling of motor shaft due to excessive mechanical overload.
2) Overload of amplifier output to motor.
3) Large reflected load inertia.

7.2.6 Over Temperature Fault

When the heatsink and or motor temperature has reached a level that, if exceeded, would damage the output transistors or the motor, the Run LED will turn off, the OVER TEMP LED is latched on, a Fault Output is generated, 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) The motor’s thermal switch has been tripped due to excessive overloading.

7.2.7 Over Voltage Fault

When the DC-Buss voltage reaches a level that, if exceeded, would harm the amplifier or motor (i.e. +250VDC for standard), the Run LED will turn off, the Over-voltage LED's are latched on, a Fault Output is generated, and the amplifier is inhibited.

The following is a list of possible causes:

1) Main AC line voltage is too high.
2) Decelerating a large inertial load. When decelerating, a DC motor acts as a generator. If the inertial load is large, the generated voltage can pump-up the DC-Bus. If this fault occurs, you may need a Regen Clamp. Consult Anorad.

7.2.8 Resetting a Fault

The fault latch may be reset by pushing the Reset button, activating the Reset input J1-13, or by removing power and allowing the filter capacitor(s) to discharge. Note that the fault latch will not reset unless the fault has been cleared.

7.3 Amplifier Failure

If an amplifier should fail, that is, if it should cease to operate with no apparent fault, Figures 6-2 and 6-3 will enable a skilled technician to trouble-shoot an amplifier to even lower levels.

If the Amplifier is not serviceable call
Anorad's Technical Support @ 631.344.6600

Report failure to a technician and request a RMW #.

Pack amplifier to be returned in keeping with good commercial shipping practice.

Clearly display the RMW # on shipping container. Items shipped without RMW # will take longer to process and may be returned without being serviced.

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