SECTION G

ENGINEERING REFERENCE

PART 2-INSTALLATION NOTES

INDEX

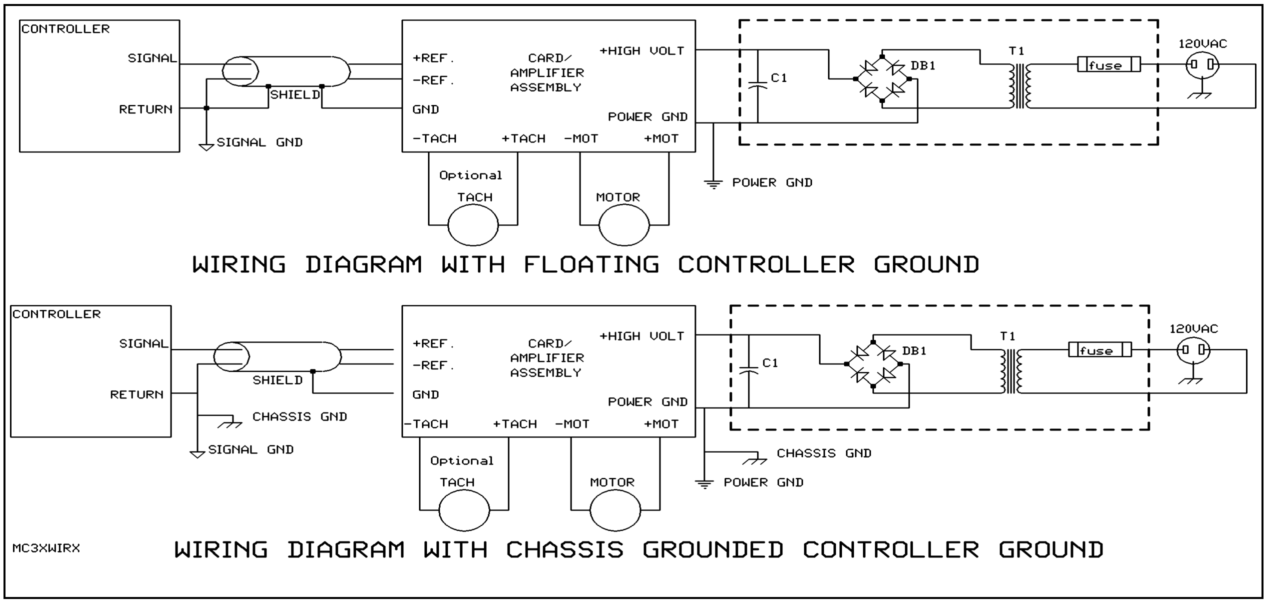
CAUTION: Exercise caution during maintenance and troubleshooting! Potentially lethal voltages exist within the amplifier and auxiliary assemblies. Only qualified technically trained personnel should service this equipment.

3. WIRING INSTRUCTIONS

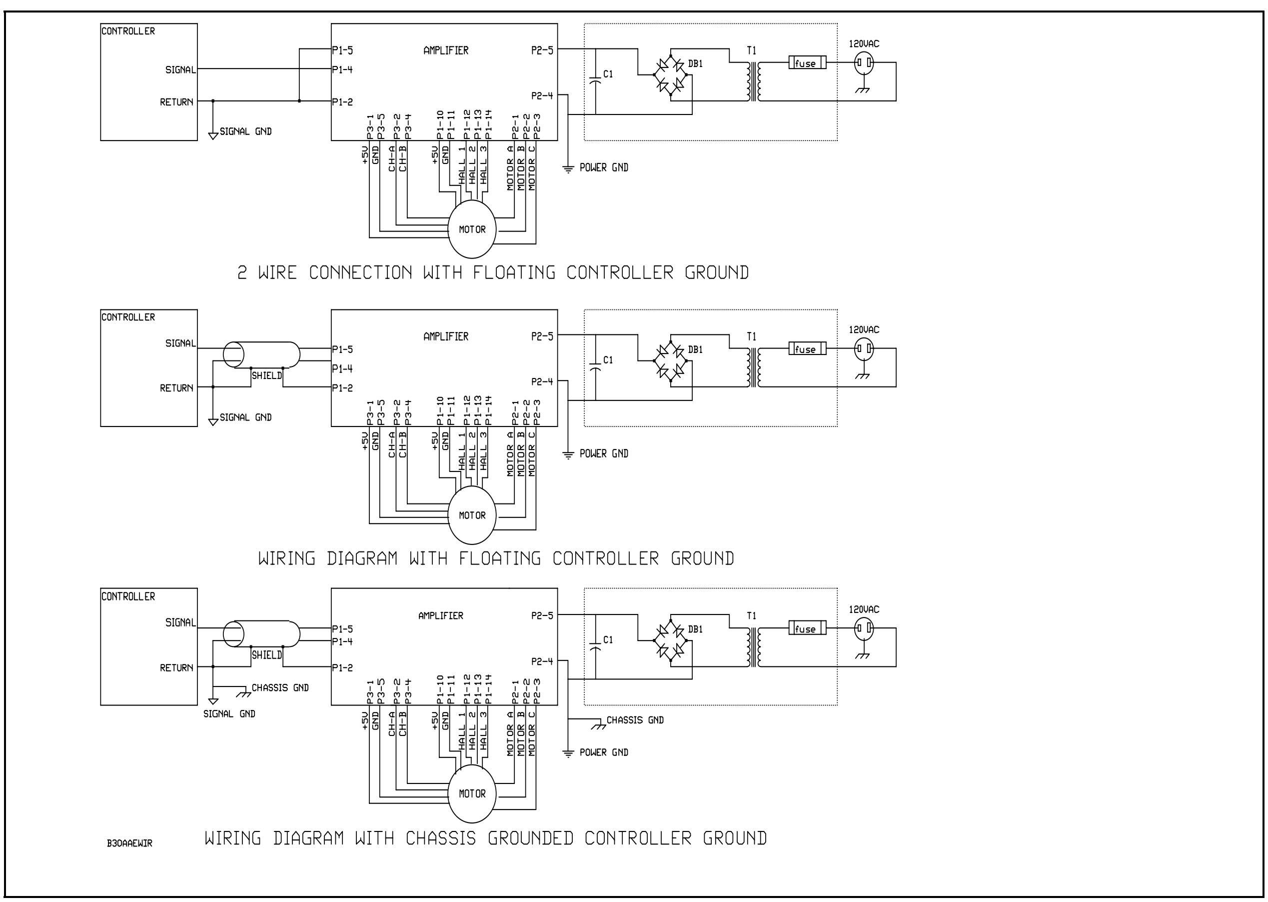
3.1 Typical Wiring Diagrams

The following schematics show typical amplifier wiring configurations:

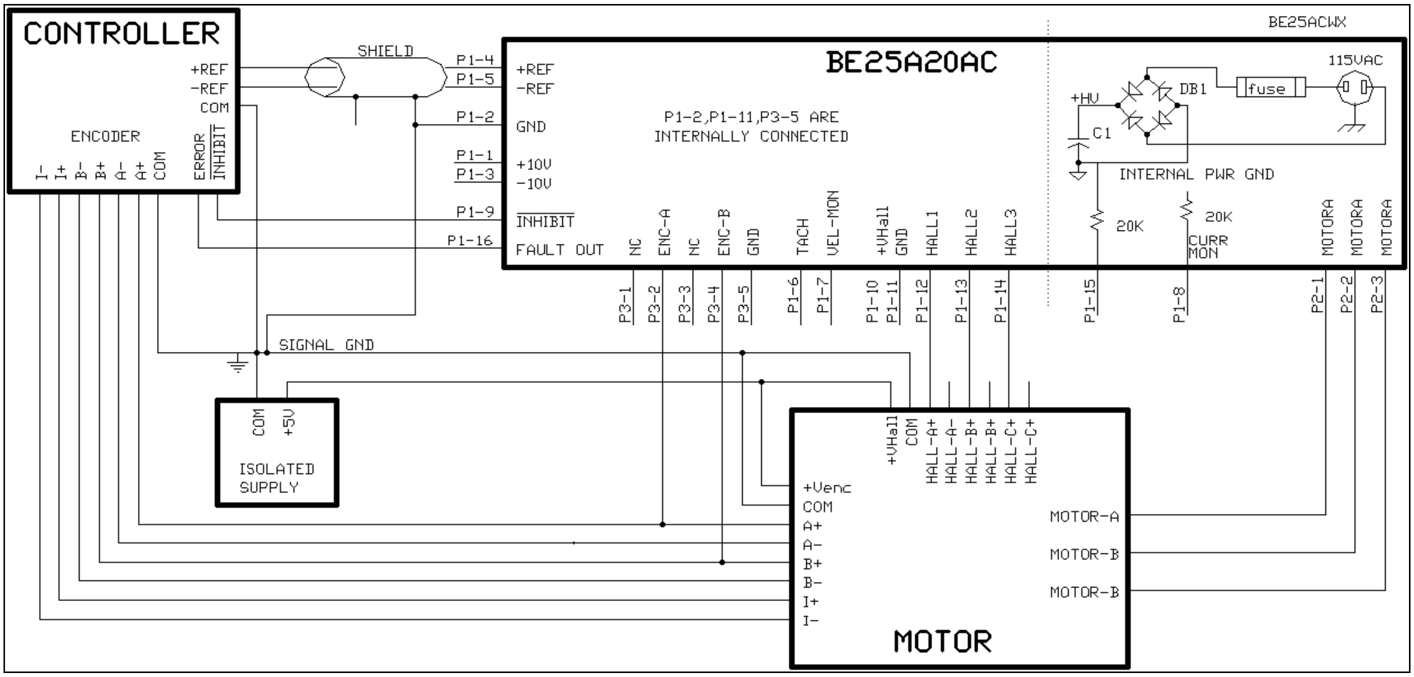
BRUSH TYPE AMPLIFIERS:



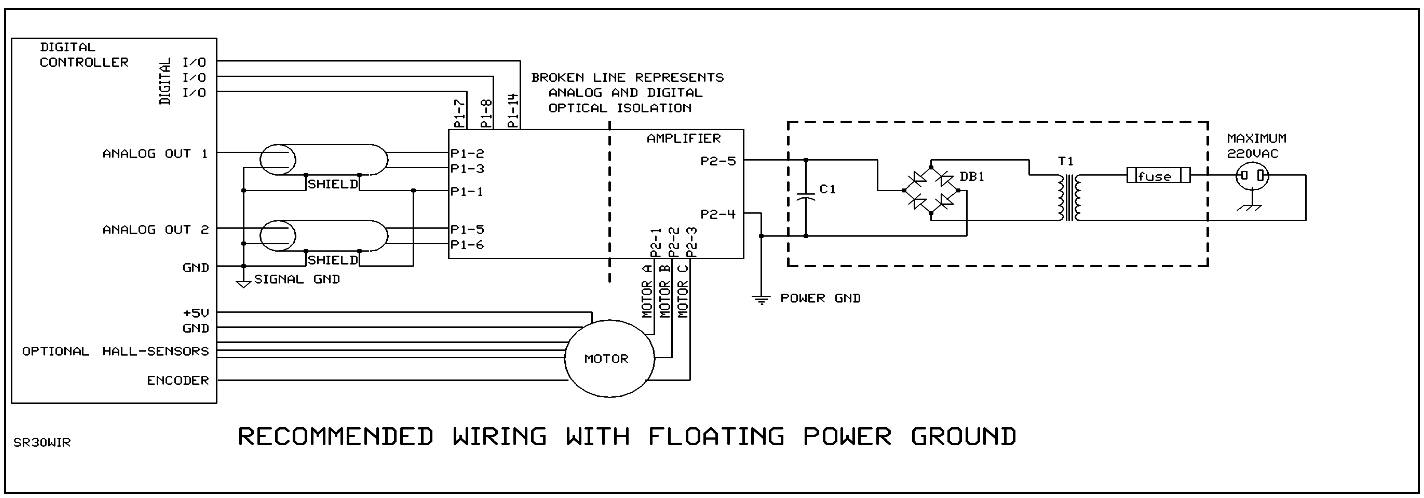
BRUSHLESS AMPLIFIERS:



BRUSHLESS AMPLIFIERS WITH ENCODER:



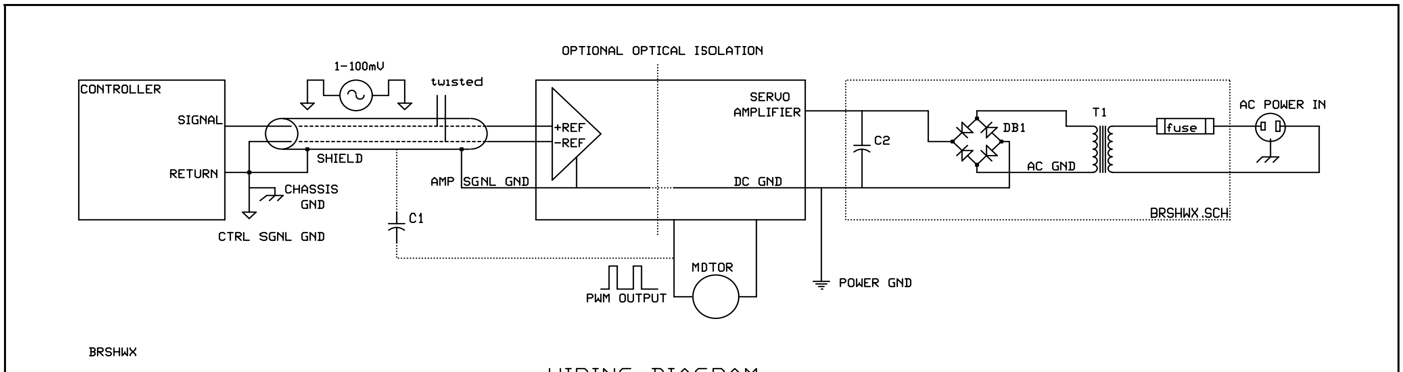
S SERIES BRUSHLESS AMPLIFIERS:



3.2 Noise considerations and system grounding

"Noise" in the form of interfering signals can be coupled:

- Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.



WIRING DIAGRAM

The preceding wiring diagrams show a typical servo system using an *ADVANCED* MOTION CONTROLS servo amplifier.

Experience shows that the main source of noise is the high DV/DT (typically about 1V/nanosecond) of the amplifier's output power stage. This PWM output can couple back to the signal lines through straight capacitance "C1" between output and input wires. The best methods are to reduce capacitance between the offending points (move signal and motor leads apart), add shielding and use differential inputs at the amplifier. For extreme cases use of a filter card is recommended (see section E).

Unfortunately low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

Aside from overall shielding the best way to reduce radio frequency coupling is to keep leads short.

The voltage source shown between the amplifier and controller grounds typically consists of some 60Hz voltage, harmonics of the line frequency, some radio-frequency signals, IR drops and other "ground noise". The differential inputs of the servo amp will ignore the small amount of "ground signal".

Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OPAMP output. Due to the inductance and capacitance of the wire the OPAMP output can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the amplifier with an oscilloscope to make sure that the signal is noise free.

Servo system wiring typically involves wiring a controller (digital or analog), a servo amplifier, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed.

The signal ground of the controller (CTRL SGNL GND) must be connected to the signal ground of the servo amplifier (AMP SGNL GND) either directly or through chassis ground, to avoid noise pick up due to the "floating" differential servo amplifier input.

It is recommended that the signal and power wires are routed in a separate cable harness.

In most servo systems all the grounds are connected to a single chassis ground (normally the same as Earth ground). In the power section there are two grounds "DC GND" and "AC GND" (see wiring diagram). Either of these grounds can be connected to "CHASSIS GND". If the system design requires that "AC GND" is connected to "CHASSIS GND" then the servo amp must have internal optical isolation in order to connect "CTRL SGNL GND" or "AMP SGNL GND" to "CHASSIS GND". This optical isolation is required to avoid a short across the diode-bridge "DB1", through "DC GND".

For servo amplifiers without optical isolation, if "DC GND" and "AMP SGNL GND" are connected to "CHASSIS GND" then it is not necessary to connect the signal wire shield to "AMP SGNL GND" because these grounds are then connected through the chassis.

⚠ **The grounding design is ultimately the responsibility of the user.**

3.3 DC Power Supply Wiring

Most ***ADVANCED*** **MOTION CONTROLS** servo amplifiers operate from a single polarity unregulated DC power supply. Reservoir capacitance of 2,000 μF/ampere of maximum output current will reduce ripple to 4Vp-p at 120 Hz (single phase AC input).

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. If the power supply leads exceed 3 feet then the amplifier must be "by passed" by a capacitor of at least 1000 μF within one foot of the servo amp. Reduce the inductance of the power leads by twisting them.

When multiple amplifiers are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each amplifier directly from the power supply filter capacitor.
2. Use the differential input to the amplifier to avoid common mode noise.
3. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4 Motor Wiring

Use of a twisted, shielded pair for the motor power cables is recommended. Ground the shields to the amplifier's chassis ground and to the motor's frame. The motor power input leads are connected to the amplifier's output.

⚠ **CAUTION: DO NOT use wire shield to carry motor current or power!**

3.5 Tachometer Wiring

Use of a twisted, shielded pair for the tachometer wires is recommended. Ground the shield at one end only to the amplifier's +tach input (tachometer ground).

3.6 Input Reference Wiring

Use of a twisted, shielded pair for the input reference wires is recommended. If the reference source can float (remain ungrounded), connect the cable shield to both the reference source common and the amplifier's signal ground. It is recommended that the input be connected directly to the amplifier's differential input (if applicable). Connect the reference source "+" to "+ref input", and the reference source "-" (or common) to "-ref input". If the reference source ground and the amplifier power ground are connected to the master chassis ground, leave the source end of the shield unconnected. The servo amplifier's reference input circuit will attenuate the common mode voltage between signal source and amplifier power grounds. In case of a single ended reference signal, connect the command signal to “+ref” and connect the command return and “-ref” to the signal ground

3.7 Reference Potentiometer Wiring

An external potentiometer can be used in conjunction with the amplifier’s onboard signal voltage (±10 V @ 3 mA or ± 5 V @ 3 mA) to supply a command signal to the amplifier. A 50 KΩ potentiometer is recommended. The potentiometer used should not be less than 20 KΩ. This potentiometer should be wired between the +10V (or +5V) and the -10V (or 5V) output with the wiper wired to the “+ ref” or “- ref” input. The other reference input can remain floating or can be tied to the signal ground. To have a single polarity command source use only the +10V (or +5V) or the -10V (-5V) output and wire the other lead of the potentiometer to the signal ground.

3.8 *Mating Signal Connectors*

The mating connector part number for the 16 pin I/O "Molex" connector part number 22-12-2164 is:

- Molex plastic body : 22-01-3167 Insert terminals : 08-50-0114

The mating connector part number for the 5 pin I/O encoder Connector part number is 22-12-2054 is:

- Molex plastic body: 22-01-3057 Insert terminals: 08-50-0114

Standard crimping hand tool "Molex" part number 11-01-0185.

D-shell connectors: Manufacturer: AMP® (Tel: 1-800-522-6752)

Part numbers:

- 15 Pin plug 748364-1
- 26 Pin plug 748365-1
- Pins 748333-2

Shell Kit (plastic with metal coating):

- 15 Pin 748677-1
- 26 Pin 748677-2

3.9 CE-EMC Wiring Requirements

Additional Installation Instructions Necessary for Meeting EMC Requirements:

General

1. Shielded cables must be used for all interconnect cables to the amplifier and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.

2. The amplifier's metal enclosure must be grounded to the closest ground point with the least amount of resistance.

3. The amplifier must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

Analog Input Amplifiers

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low-level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Amplifiers

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET Switching Amplifiers

6. A Fair Rite model 0443167251 round suppression core must be fitted to the motor cable connector to reduce electromagnetic emissions.

7. An appropriately rated Schaffner 2080 series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply of any MOSFET amplifier system in order to reduce conducted emissions fed back into the supply network.

IGBT Switching Amplifiers

8. An appropriately rated Schaffner 2070 series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply of any IGBT amplifier system in order to reduce conducted emissions fed back into the supply network.

9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the motor cable connector to reduce electromagnetic emissions.

Fitting of AC Power Filters

10. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the two mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power enters the enclosure as possible. Also the AC power cable on the load end of the filter should be routed as far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

For reference purposes, the Technical Construction File Number is TCF No. J97001250.007 (Rev 1).

Below is contact information of filter and torroid suppliers:

Schaffner
Schaffner Elektronik AG
CH-4708 Luterbach
Switzerland
Phone: +41-65-802-626
Fax: +41-65-802-641

Fair Rite
P.O. Box J
One Commercial Row
Wallkill NY 12589
Phone: (914)-895-2055
Fax: (914)-895-2629
E-Mail: ferrites @fair-rite.com

USA (East Coast)
Phone: (201)-379-7778
Fax: (201)-379-1151

USA (West Coast)
Phone: (714)-457-9400
Fax: (714)-457-9510

3.10 CE-LVD Wiring Requirements

Instructions Necessary for Meeting LVD Requirements

The servo amplifiers covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users equipment, the following conditions of acceptability must be met:

A. European approved overload and over current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.

B. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.

C. All amplifiers that do not have a grounding terminal <u>must</u> be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.

D. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.

E. European approved over-current protective devices must be installed in line before the amplifier, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current protection rating value as low as possible, but taking into consideration inrush currents, etc.). Amplifiers that incorporate their own primary fuses do not need to incorporate over current protection in the end users equipment.

These items should be included in your declaration of incorporation as well as the name and address of your company, description of the equipment, a statement that the amplifiers must not be put into service until the machinery into which they are incorporated has been declared in conformity with the provisions of the Machinery Directive, and identification of the person signing.

4. CAUTIONARY NOTES

DO NOT REVERSE THE POWER SUPPLY LEADS! SEVERE DAMAGE WILL RESULT!

- **USE SUFFICIENT CAPACITANCE!**

Pulse width modulation (PWM) amplifiers require a capacitor on the high voltage supply to store energy during the PWM switching process. Therefore, a 1000 μF (minimum value) capacitor is needed within one foot of wire length, in parallel with the high voltage supply of the amplifier module.

Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the amplifier's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the amplifier to further charge the power supply capacitor. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

A 2 mH motor at 20 amperes can charge a 2000 μF capacitor an additional 30 VDC. An appropriate capacitance is typically 2000 μF/A maximum output current for a 50 V supply.

For battery supplied bus voltages, contact factory for capacitance requirements.

- **MAKE SURE MINIMUM INDUCTANCE REQUIREMENTS ARE MET!**

Pulse width modulation (PWM) servo amplifiers deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different amplifier types are shown in the individual data sheet specifications. If the amplifier is operated below maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 μH.

If the motor inductance value is less than the minimum required for the selected amplifier, use of an external filter card is necessary (see section "E").

- **DO NOT ROTATE THE MOTOR SHAFT WITHOUT POWER SUPPLIED TO THE AMPLIFIER!**

The motor acts as a generator and will charge up the power supply capacitors through the amplifier. Excessive speeds may cause over-voltage breakdown in the output power devices. Note that an amplifier having an internal power converter that operates from the high voltage supply will become operative.

- **DO NOT SHORT THE MOTOR LEADS AT HIGH MOTOR SPEED!**

When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the amplifier peak current. The short itself should not damage the amplifier but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the amplifier (due to stored energy in the motor inductance) and may damage the amplifier.

5. SET-UP INSTRUCTIONS

5.1 Precautions

Do not install the amplifier without first determining that all chassis power has been removed for at least 10 seconds. Never remove an amplifier from an installation with power applied.

⚠ **To ensure reliable operation, the wiring and cautionary notes must be reviewed prior to set up.**

5.2 Brush Type Setup Instructions

***ADVANCED* MOTION CONTROLS** amplifiers are designed to operate in a self-test mode, using the "offset" potentiometer to control an on-board signal source.

This test can be used to confirm that the amplifier is functionally operational. Read the setup instructions before applying power:

1. **Review cautionary notes and wiring section before proceeding.**

2. It is recommended to reduce the amplifier output current to avoid motor over heating during the setup procedure.

3. Connect power. Do *not* connect the motor yet!

4. Make sure the amplifier is in an enabled state via all enable inputs. See amplifier data sheets for details.

5. Check that the LED indicates normal operation (green).

6. Set mode according to data sheet for voltage mode.

7. Set offset/test switch ON. Measure the voltage across motor output with a DC voltmeter, turn the "test" potentiometer. Voltage should vary between +/- bus voltage. Set the output voltage with the "test" potentiometer to a low value before connecting the motor leads.

8. Set current limit according to motor specifications. See amplifier data sheets for current limiting options.

9. Verify that the load circuit meets minimum inductance requirements and that the power supply voltage does not exceed amplifier rated voltage or 150% of the nominal motor voltage.

10. Turn the power off. Connect the motor. Turn the power back on. "Tweak" the "test" potentiometer to change motor speed in both directions. Set the offset/test switch OFF.

11. Ground both reference inputs and then using the offset pot, set motor for zero speed.

12. Set mode suitable for your application.

5.3 Brushless Amplifier Setup Instructions (trapezoidal and sinusoidal):

5.3.1 Trapezoidal Amplifiers

Read the setup instructions before applying power:

1. **Review cautionary notes and wiring instructions prior to set up.**

2. It is recommended to reduce the amplifier output current to avoid motor over heating during the setup procedure.

3. According to mode selection table, select *open-loop mode* and set offset/test switch ON.

4. Set current limit according to the motor specifications. See amplifier data sheets for current limiting options.

5. Check power and connect it to the amplifier. Do *not* connect motor lead wires.

6. Make sure the amplifier is in an enabled state via all enable inputs. See amplifier data sheets for details.

7. Set 60/120 degree phase switch. Connect HALL sensor inputs. LED should be green. Manually turn motor shaft one revolution. LED should remain green. If LED turns red or changes color:
    - check 60/120 degree phase switch setting.
    - check power for Hall sensors.
    - check voltage levels of Hall inputs (see commutation sequence table below).
    - with 60 degree phasing interchange Hall1 and Hall2.

8. Remove power. Connect the three motor wires. There are six ways to connect the three wires to the Motor-A, Motor-B, and Motor-C pins. Try all six combinations (remove power prior to changing connection) and choose the best one. The motor should operate and reverse smoothly in both directions. If the motor runs slower in one direction or if you have to move the shaft to start the motor, the combination is incorrect. The speed should be approximately the same in both directions if the combination is correct. Motor speed can be verified by using the velocity monitor or by measuring the frequency of the Hall sensors or the encoder. See below for velocity calculation equations.

9. To verify smooth operation, turn test/offset pot with test/offset switch in ON position. Set offset/test switch OFF, ground both reference inputs and then adjust offset/test potentiometer for zero speed.

10. Select mode suitable for your application.

COMMUTATION SEQUENCE TABLE

60 DEGREE			120 DEGREE			MOTOR		
HALL1	HALL2	HALL3	HALL1	HALL2	HALL3	A	B	C
1	0	0	1	0	0	H	X	L
1	1	0	1	1	0	X	H	L
1	1	1	0	1	0	L	H	X
0	1	1	0	1	1	L	X	H
0	0	1	0	0	1	X	L	H
0	0	0	1	0	1	H	L	X
1	0	1	1	1	1	X	X	X
0	1	0	0	0	0	X	X	X

1 - HIGH LEVEL HALL SENSOR INPUT
0 - LOW LEVEL HALL SENSOR INPUT

H - HIGH OR SWITCHING MOTOR OUTPUT
L - LOW MOTOR OUTPUT
X - MOTOR OUTPUT IS OFF (FLOATING)

THESE LAST TWO LINES ARE INVALID COMMUTATION STATES. IN THESE STATES RED LED INDICATES A DISABLED DRIVE.

To change direction: interchange Hall-1 and Hall-3, then Motor-A and Motor-B.

Calculating motor speed:
Hall sensor cycle / Mechanical revolution = Poles/2
Motor-speed[RPM] = Hall sensor frequency [Hz] * 60 / (Poles/2)
Motor-speed[RPM] = Velocity monitor[V]* Scale factor[Hz/V]*60 / (Poles/2)
Motor-speed[RPM] = encoder frequency [Hz] * 60 / (encoder resolution)
Motor-speed[RPM] = Velocity monitor[V]* Scale factor[Hz/V]*60 / (encoder resolution)

5.3.2 Sinusoidal Amplifiers (SE Series)

Read the setup instructions before applying power:

1. **Review cautionary notes and wiring instructions prior to set up.**

2. According to mode selection table, select *current mode* and set offset/test switch ON.

3. Set current limit to 10% of motor current to avoid high speeds. See amplifier data sheets for current limiting options.

4. Check power and connect it to the amplifier. Do *not* connect motor leads.

5. Make sure the amplifier is in an enabled state via all enable inputs. See amplifier data sheets for details.

6. Set 60/120 degree phase switch. Connect HALL sensor inputs (the encoder can be connected as well without affecting correct set-up). The LED should be green. Turn the motor shaft manually one revolution. The LED should remain green. If the LED turns red or changes color:
    - check 60/120 degree phase switch setting.
    - check power for Hall sensors.
    - check voltage levels of Hall inputs.
    - with 60 degree phasing interchange Hall1 and Hall2.

7. Remove power. Connect the three motor wires. There are six ways to connect the three wires to the Motor-A, Motor-B, and Motor-C pins. Try all six combinations (remove power prior to changing connection) and choose the best one. The motor should operate and reverse smoothly in both directions. If the motor runs slower in one direction or if you have to move the shaft to start the motor, the combination is incorrect. The speed should be approximately the same in both directions if the combination is correct. Motor speed can be verified by using the velocity monitor or by measuring the frequency of the Hall sensors or the encoder. See above for velocity calculation equations.

8. When the Hall sensor phasing is correct the amplifier will automatically switch to sinusoidal commutation. This can be verified by monitoring the "Phase" output.

9. To verify smooth operation, turn test/offset pot with test/offset switch in ON position. Set the offset/test switch OFF, and then adjust offset/test potentiometer for zero speed.

10. Select mode suitable for your application.

5.4 Brushless amplifier with brush type motor (trapezoidal only).

To drive a brush-type motor disconnect all Hall sensor inputs, set phase setting switch to 60 degrees, and use the Motor-A and Motor-B terminals. See brush-type set up instructions. For step number five configure the amplifier for open loop mode instead of voltage mode.

6. AMPLIFIER ADJUSTMENT (TUNING) PROCEDURE

6.1 Command Signal

The command signal is a reference voltage, which is applied to the amplifier to adjust motor current or voltage. Depending on the amplifier mode, this command signal controls motor current, voltage or speed.

6.2 Feedback Elements

The feedback element can be any device capable of generating a voltage signal proportional to current, velocity, position or any parameter of interest. Such signals can be provided directly by a tachometer or potentiometer or indirectly by other feedback devices such as resolvers, Hall sensors or encoders. These latter devices must have their signals converted to a DC voltage (by an external converting circuit or by the amplifier).

The feedback element must be connected for negative feedback. This negative feedback will cause a difference between the command signal and the feedback signal. This difference is called the error signal. The amplifier compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero.

6.3 Current Loop Adjustments

The following procedure is intended for advanced users and high performance applications only. It is recommended to contact the factory to discuss application requirements and proper amplifier tuning prior to making any adjustments.

⚠ **CAUTION: INPROPER CURRENT LOOP TUNING MAY RESULT IN PERMANENT AMPLIFIER AND MOTOR DAMAGE REGARDLESS OF AMPLIFIER CURRENT LIMITS!**

The resistors and capacitors shown under the current control block on the functional block diagram for the amplifier determine the frequency response of the current loop. It is important to tune the current loop appropriately for the motor inductance and resistance, as well as the bus voltage to obtain optimum performance. Brushed-type amplifiers and brushless DC (or trapezoidal) amplifiers have a single current loop. Sinusoidal amplifiers have three current loops. All three loops must be tuned the same or the amplifier will not operate properly. The loop gain and the integrator capacitance of the current loop must both be adjusted for the tuning to be complete.

⚠ **CAUTION: ALWAYS REMOVE THE BUS VOLTAGE BEFORE MAKING ANY RESISTOR OR CAPACITOR MODIFICATIONS!**

CAUTION: THE FOLLOWING ADJUSTMENTS MUST BE MADE WITH THE MOTOR UNCOUPLED FROM THE LOAD! ALSO SECURE THE MOTOR AS SUDDEN MOTOR SHAFT MOVEMENT MAY OCCUR!

Current Loop Gain Adjustment

1) Use the DIP-switches and current limit potentiometer to select current mode, the input range (if applicable) and to set appropriate current for the motor you are using (note: S-series amplifiers are automatically in current mode).

2) Connect only the motor power leads to the amplifier. No other connections should be made at this point.

3) Using a function generator, apply a +/- .5 V, 100 Hz square wave reference signal.

4) Short out the current loop integrator capacitor(s) using the appropriate DIP-switch or a jumper (see functional block diagram and data sheets).

5) Apply power to the amplifier. Approximate application bus voltage should be used or the current loop compensation will not be correct.

HINTS:
- Make sure the amplifier is enabled (green LED).
- Trapezoidal and SE amplifiers: configure for 60 degree phasing in order to get output current and measure current through phase B.
- S series amplifiers: connect function generator to +REF-IN-A and signal ground, and measure phase-A current.
- SR-series amplifiers: connect the resolver to the amplifier for proper operation.

6) Observe the motor current using a current probe or shunt resistor (<10% of motor resistance). This observation should be done for both the high and low current loop gain (see amplifier switch functions for current loop gain settings if available). If neither position gives a proper square wave response, then the current loop gain resistor(s) will need to be changed to optimize response. See amplifier functional block diagram for default current loop values. The best response will be a critically damped output waveform.

Current Loop Integrator Adjustment

1) Enable the current loop integrator through DIP-switch or remove previously installed jumper.

2) Using a function generator, apply a +/- .5 V, 100 Hz square wave reference signal.

3) Apply power to the amplifier. Approximate application bus voltage should be used or the current loop compensation will not be correct.

4) Observe the motor current using a current probe or shunt resistor (<10% of motor resistance). The default value for the current loop capacitance can be found on the functional block diagram of the amplifier. If the square wave output overshoots, the current loop integrator will need to be increased by utilizing the through-hole or SMT capacitor locations. Use non-polarized capacitors. If the square wave response is over-damped (sluggish), the current loop capacitance value will need to be decreased. When the current loop integrator is chosen properly, there can be some overshoot but it should be less than 10%. However, the output should settle to a flat top with minimal current following error (difference between commanded current and actual current).

Please contact the factory for further assistance with current loop tuning.

6.4 Voltage or Velocity Loop Adjustments

CAUTION: These adjustments should initially be performed with the motor uncoupled from its mechanical load!

Configure the amplifier for the desired operation mode using the DIP-switches (see amplifier block diagram and data sheets).

- Voltage loop:

Compensating the voltage loop requires the least amount of effort. Turn POT1 CW and back off if oscillation occurs.

- Velocity loop:

The velocity loop response is determined by the loop gain potentiometer P1. A larger resistor value (CW) results in a faster response. The velocity integrator capacitor can be used to compensate for large load inertia. A large load inertia requires a larger capacitor value. This may be accomplished by either switching in the extra capacitor with the DIP-switch or installing a through-hole capacitor. The need for an extra capacitor can be verified by shorting out the velocity integrator capacitor with the DIP-switch. If the velocity loop is stable with the capacitor shorted out and unstable with the capacitor in the circuit then a larger capacitor value is needed.

- IR feedback:

Start with a very high (or open) IR feedback resistor with an unloaded motor shaft. Command a low motor speed (about 20-200 RPM). Without the IR feedback the motor shaft can be stalled easily. Decreasing the IR feedback resistor will make the motor shaft more difficult to stop. Too much IR feedback, i.e. too low resistor value, will cause motor run-away when torque is applied to the motor shaft.

- Analog position loop:

Use of a tachometer is recommended to obtain a responsive position loop because the position loop is closed around the velocity loop. First the velocity loop must be stabilized (or voltage loop for undemanding applications). The position loop gain is determined by the fixed gain of the input differential amplifier of the servo amplifier. For best results the servo amplifier can be ordered with a higher differential amplifier gain. Extension ANP must be specified e.g. 25A8-ANP.

6.5 Potentiometer Adjustments

- *Offset adjustment*

Before offset adjustment is made, reference inputs must be grounded or commanded to 0 volts. Put the test/offset switch in the OFF position (offset mode), and trim the "offset" potentiometer for minimum amplifier output current by observing motor drift. Offset adjustment is complete.

- *Loop gain adjustment*

This potentiometer adjusts the gain in the forward portion of the closed loop (velocity or voltage mode). Starting from the CCW position, turn CW until motor shaft oscillates. Then back off one turn.

Note: This potentiometer should be set completely CCW in current mode. Use the reference gain potentiometer for scaling.

- *Reference gain adjustment*

This potentiometer adjusts the ratio between the input signal and the output variable (voltage, current, or velocity). Turn this potentiometer clockwise until the required output is obtained for a given input signal.

- *Current limit adjustments*

It is critical to set the current limit such that the instantaneous motor current does not exceed the specified motor peak current rating. Should this occur, the motor permanent magnets may be demagnetized. This would reduce both torque constant and torque rating of the motor and seriously affect system performance.

Most ***ADVANCED*** **MOTION CONTROLS** servo amplifiers feature peak and continuous current limit adjustments. The maximum peak current is needed for fast acceleration and deceleration. Most amplifiers are capable of supplying the maximum peak current for 2 sec. and then the current limit is reduced gradually to the continuous value. The purpose of this is to protect the motor in stalled condition by reducing the current limit to the maximum continuous value. Current limiting is implemented in the amplifier by reducing the output voltage.

The current limit adjustment potentiometer (50kΩ) has 12 active turns plus 1 inactive turn at each end and is approximately linear. Thus, to adjust the current limit, turn the potentiometer counter-clockwise to zero (using ohmmeter between appropriate ground and potentiometer wiper, see amplifier block diagram), then turn clockwise to the appropriate value. If the peak current reference does not reach the set peak current limit, the time for peak current will be longer than 2 sec. The actual time will be a function of RMS current.

A selection of amplifiers feature separate peak and continuous current limit adjustments. This can be achieved by connecting an external resistor between the continuous current limiting pin and the signal ground. In addition, many amplifiers have the option of current limiting using the DIP-switches. If this is an option, it will be indicated in the switch function section of the particular amplifier.

6.6 TEST POINTS FOR POTENTIOMETERS

After the potentiometer adjustments in the compensation section are complete, the resistance values can be measured for future adjustments or duplication on other amplifiers. Test points for the potentiometer wipers are provided and are located under all four potentiometers. **Make sure the power is off,** then measure the resistance between the test point and the outer leg of the potentiometer or between the test point and an appropriate ground. See the amplifier's functional block diagram to determine which ground should be used for each potentiometer. The potentiometers are all approximately 50K. Resistance measurements are only to be used to duplicate amplifier settings since some potentiometers have other resistors in series or parallel.

7. INVERTED INHIBIT INPUTS

Inputs INH and +/-INH can be inverted by removing "J1" jumper (0 ohm SMT resistor marked on PCB). Removing J1 jumper requires that all inhibit lines be brought to ground to enable amplifier. Most amplifiers except the 10A8 can be ordered with this option. Part number example would be B30A8X-INV. INV stands for inverted inhibit inputs. Some amplifiers such as the B30A40 have a dip switch to invert the inhibits. This option will be listed on the amplifier data sheets if it is available.

8. TROUBLE SHOOTING/FAULT CONDITIONS

A red LED can indicate any of the following fault conditions: over-temperature, over-voltage, under-voltage, short-circuits, invalid commutation, status and power on reset. All fault conditions are self-reset by the amplifier. Once the fault condition is removed the amplifier will become operative again without cycling power. Please see amplifier data sheets for protection features included.

- *Heat-sink Temperature*

  Verify that the heat-sink temperature is less than 65^{o} C. If this temperature is exceeded the amplifier will remain disabled until the temperature at the base plate falls below 65^{o} C.

- *Over-Voltage Shutdown*

  1. Check the power supply voltage for a value in excess of those listed in the data sheets. If a larger than listed value is observed, check the AC power line connected to the power supply for proper value.

  2. Check the regenerative energy absorbed during deceleration. This is done with a voltmeter or scope monitor of the amplifier bus voltage. If the bus voltage increases above specified values, additional bus capacitance is necessary. Additional capacitors must be electrolytic type and located within a one foot lead distance from the amplifier. See also regenerative operation section.

- *Under-Voltage Shutdown*

  Verify power supply voltages for minimum conditions per specifications. Also note that the amplifier will pull the power supply voltage down if the power supply cannot provide the required current for the amplifier. This could result in a flickering LED when high current is demanded and the power supply is pulled below the minimum operating voltage required by the amplifier.

- *Short Circuit Fault*

  1. Check each motor lead for shorts with respect to motor housing and power ground. If the motor is shorted, it will not rotate freely when no power is applied while it is uncoupled from the load.

  2. Measure motor armature resistance between motor leads with the amplifier disconnected.

- *Invalid Hall Sensor State (Brushless Amplifiers only)*

  See the "Commutation Sequence" table for valid commutation states. If the LED is red or if it is changing between red and green as the shaft rotates check the following:

1. Make sure that the 60 or 120 degree phasing switch is in the correct position per motor data sheets. When driving a brush type motor with a brushless amplifier, use the 60 degree phase setting.

2. Check the voltage levels for all the Hall sensor inputs.

3. Make sure all Hall lines are connected properly.

- *Status*

  Check ALL inhibit inputs for correct polarity (i.e. pull to ground to inhibit or pull to ground to enable). Inhibit configuration depends on weather J1 is installed or on the position of the inhibit/enable switch if this is a feature on the particular drive you are using. Please note that the master inhibit will cause a red LED but the plus and minus inhibits (+INH and –INH) featured on some amplifiers will disable the amplifier in the plus or minus direction without causing a red LED. Also, keep in mind that noise on the inhibit lines could be a cause for false inhibit signals being given to the amplifier.

- *Power-on Reset*

  All amplifiers will have a brief flicker of a red LED during power up. This is the power-on reset and is built into the amplifier to ensure that all circuitry on the board is functional prior to enabling the amplifier.

- *Overload*

  Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the amplifier and thus it might cause the short circuit fault to trip. Excessive heating of the amplifier and motor is also characteristic of the minimum inductance requirement not being met. See amplifier data sheets for minimum inductance requirements

- *Over-current*

  All ***ADVANCED*** **MOTION CONTROLS** amplifiers incorporate a "fold-back" circuit that protects them against over-current (except for PWM and sinusoidal input amplifiers, which have different protection features). This "fold-back" circuit uses an approximate "I^2t" algorithm to protect the amplifier. All amplifiers can run at peak current for maximum 1 second (each direction). Currents below this peak current but above the continuous current can be sustained during a time period of approximately (peak current/current)^2 seconds. If such a current is commanded for a longer time period, the amplifier will automatically fold back to the continuous current. An over-current condition will not cause the LED to be red.

⚠ ***Caution:*** ***Sustained maximum current demand, when switching between positive and negative maximum current without fold-back, will result in amplifier damage. Amplifier RMS current should be below the continuous current setting!***

Causes of Erratic Operation

1. Improper grounding (e.g. amplifier signal ground is not connected to source signal ground).

2. Noisy command signal. Check for system ground loops.

3. Mechanical backlash, dead-band, slippage, etc.

4. Excessive tachometer noise.

5. Noisy inhibit input lines.

6. Excessive voltage spikes on bus.

9. PRODUCT LABEL DESCRIPTION

The following is a typical example of a product label as it is found on the amplifier:

1. EIA Date Code: The date code is a 4-digit number signifying the year and week that the amplifier was manufactured. The first two digits designate the year and the second two digits designate the week. For example, the above part would have been built during the ninth week of 1999.

2. Serial number: The serial number is a 5-digit number followed by a 4-digit number. Some of the older amplifiers have a 6-digit serial number. Present serial number configuration started in June of 1997.

3. Part number: Refer to the amplifier data sheets for typical part numbers. The last letter refers to the revision (in the above example T). The part number can be proceeded by an X, which signifies a prototype unit. The part number can also have a suffix (e.g. 50A20T-AM1), which designates a special version of the standard amplifier (50A20T is the standard amplifier, -AM1 designates the special version).

10. FACTORY HELP

FAX service: (805) 389-1165
E-mail: techsupport@a-m-c.com

For aid in trouble shooting with amplifier set-up or operating problems please gather the following information and FAX or e-mail directly to ***ADVANCED*** **MOTION CONTROLS:**

A. DC bus voltage and range.

B. Motor type, including inductance, torque constant, and winding resistance.

C. Position of all DIP-switches.

D. Position of all potentiometers.

E. Length and make-up of all wiring and cables.

F. If brushless, include HALL sensor information.

G. Type of controller, plus full description of feed back devices.

H. Description of problem, i.e. instability, run-away, noise, over/under shoot, etc.

I. Complete part number and serial number of ***ADVANCED*** **MOTION CONTROLS** product. Original purchase order is helpful, but not necessary.

11. WARRANTY

ALL RETURNS (WARRANTY OR NON-WARRANTY) REQUIRE THAT THE CUSTOMER FIRST OBTAINS AN RMA NUMBER FROM THE FACTORY.

RMA number requests may be made by telephone at (805) 389-1935 or by fax at (805) 389-1165.

***ADVANCED* MOTION CONTROLS** warrants its products to be free from defects in workmanship and materials under normal use and is limited to replacing or repairing at its factory any of its products which within one year after shipment are returned to the factory of origin, transportation charges prepaid, and which are determined to be defective. This warranty supersedes all other warranties, expressed or implied, including any implied warranty or fitness for a particular purpose, and all other obligations or liabilities on ***ADVANCED* MOTION CONTROLS'** part and it neither assumes nor authorizes any other person to assume for the seller any other liabilities in connection with the sale of the said articles.

The original warranty period is not extended by the above-mentioned provisions for any replaced or repaired articles. This warranty shall not apply to any of ***ADVANCED* MOTION CONTROLS'** products that have been subjected to misuse, negligence, accident, or modification by the user.