Brushless Servo Amplifiers

MPA-03/06/09

MTS Systems Corporation
Automation Division

2101 North Broadway

New Ulm, MN 56073

Telephone: 507-354-1616

Fax: 507-354-1611

0101

Part Number 575-00014F

TABLE OF CONTENTS

MPA-03/06/09 BRUSHLESS SERVO AMPLIFIERS

Application

This manual is designed to help you install the MaxPlus™ MPA-03/06/09 amplifier.

Unpacking and Inspection

Carefully unpack the amplifier and inspect it for visible damage. Check items against the packing list. Report any missing or damaged items to your supplier.

Warranty and Service

The amplifier is warranted to be free from defects in workmanship and materials for a period of two years from the original shipment by MTS Automation.

During the warranty period, a defective amplifier unit will be repaired or replaced as outlined below.

Before requesting return authorization, please try to verify that the problem is within the amplifier, and not with external devices.

To arrange for repair or replacement, please contact:

MTS Automation Customer Service
(507) 354-1616
(800) 967-1785
Monday–Friday, 8:00–4:30 Central Time

- You must provide the model and serial number from the labels on the amplifier.
- You must provide an explanation as to why the unit is being returned.
- You will be issued a return authorization number which must be marked on the return shipment and on all correspondence.

Continued on next page

Warranty and Service (continued)

Service Under Warranty

- Return your defective unit, freight prepaid, and it will be repaired and returned within two weeks of receipt via regular UPS, freight prepaid.

- Upon request, a factory-repaired replacement unit will be sent via regular prepaid UPS, within 4 working days. Next day shipment for overnight delivery, freight collect, is available at an expediting charge of $100. The defective unit is to be returned via regular UPS, freight prepaid, upon your receipt of the replacement.

Non-Warranty Service

- Return your defective unit, freight prepaid, and it will be repaired on a time and material basis and returned within three weeks of receipt.

- OR contact your local distributor or MTS Automation Customer Service for a factory-repaired exchange unit, which is available at a flat rate price, assuming the defective unit is in repairable condition and is returned freight prepaid. Next day shipment for overnight delivery, freight collect, is available at an expediting charge of $100.

General Provisions

Except as specifically modified by this warranty statement, all MTS Automation Conditions of Sale and Warranty shall apply.

Introduction

The MPA-03/06/09 amplifier is high performance, reliable, and efficient. The amplifier is designed to be used with high performance brushless servo motors. Extreme care has been taken to assure robust operation. Design consideration for electrical transients have been implemented on the ac inputs and all I/O lines. The amplifier operates over an ac voltage range of 80 to 260 Vac from 45 to 65 Hz. The motor feedback device is a resolver to assure normal operation at elevated motor temperatures of 115° C for the case, and 155° C for the motor windings. The resolver allows for both position and velocity feedback. The motor is further protected by a thermal shutdown thermostat in the motor windings. The amplifier power switching devices are state of the art IGBT modules. The logic supply is a switch mode design reducing undesired heat. LED indicators for diagnostics are provided. Encoder simulated TTL compatible differential quadrature outputs plus an index output are provided for external pulse or position control. The amplifier has inrush current protection to allow for normal turn on. This is especially worthwhile for multiple axis. Consideration for dissipation of regenerative energy is included with internal shunt regulators.

Features

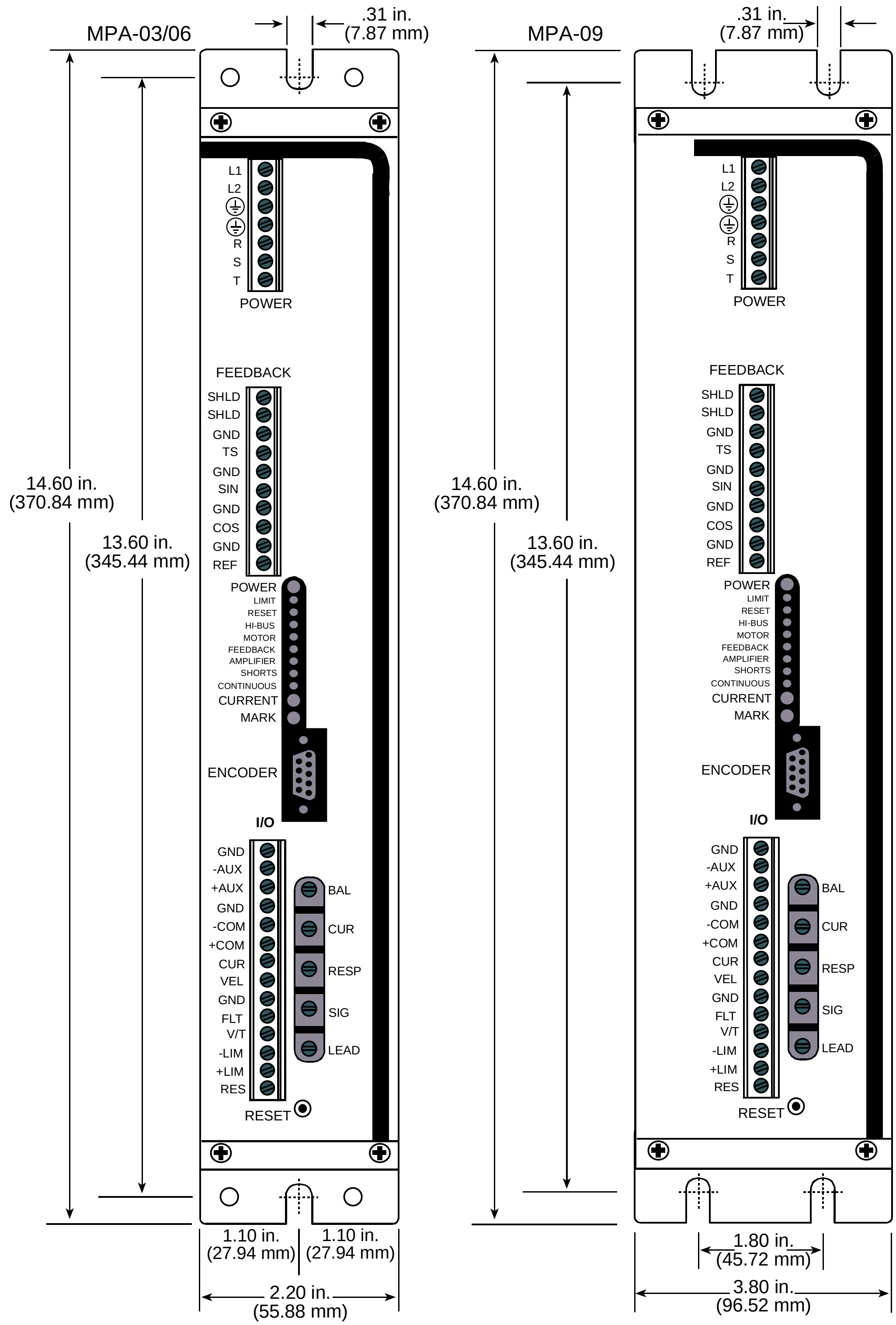
- Efficient power conversion
- High frequency switching
- Resolver feedback
- Simulated encoder signals
- ±10 volts for maximum velocity or torque
- 24 volt I/O for ±LIMIT, RESET, VEL/TORQUE mode
- 2 differential analog channels (command and auxiliary)
- LED diagnostic indicators
- Motor and amplifier thermal protection
- AC, I/O and bridge transient suppression
- Totally self contained space efficient design
- Simple screw terminal interface
- AC inrush protection
- Simple one turn visual adjustments

Specifications

Parameter	Specification
Operating Environment: Temperature Humidity	 0 to 45°C (32 to 113°F) Maximum, Ambient 0 to 95% noncondensing
Input/Output Interface: Analog Signals Velocity Command Input Auxiliary Input Velocity Output Current Output	 Differential input 0 to ±10 Vdc (15 Vdc Max) Differential input 0 to ±10 Vdc (15 Vdc Max) 1.3 volts per 1000 rpm ±10 volts = ± Peak Current
24 Volt Logic:	Reset +Limit -Limit Velocity/Torque Select Fault Output (Open Collector)
Fault Protection:	Continuous Current Shorts (Stator) Amplifier Temperature Feedback Resolver Wiring Motor Thermal HI-BUS
Encoder Simulation:	TTL Differential Output Plus Index, RS422 compatible Phase Quadrature Line Count (select DIP switch); Standard - 250, 360, 400, 500, 720, 1000, 1024, 2000, and 4096
Electrical Characteristics: Input Voltage	 80 to 260 Vac 45 to 65 Hz Single Phase No Isolation Transformer Required
Output Characteristic:	Quasi Trapezoid with Torque Linearization Torque Ripple 5% Maximum
MPA-03: Output: Input:	 3 amps continuous; 6 amps peak; peak ≤ 1 second PWM frequency 18 kHz Single phase; 5 amps continuous max
MPA-06: Output: Input:	 7 amps continuous; 14 amps peak; peak ≤ 1 second PWM frequency 18 kHz Single phase, 10 amps continuous max
MPA-09: Output: Input:	 10 amps continuous; 20 amps peak; peak ≤ 1 second PWM frequency 18 kHz Single phase, 12 amps continuous max

Parameter	Specification
Motor Inductance:	Do not connect motors with less than 2 mH inductance line to line.
Motor/Amplifier Speed and Load Relationship The motors maximum speed is dependent on the bus voltage and motor KE by the following relationships:	(AC Input)/(Motor KE vrms) = Max no load speed. Max no load speed * .75 = Maximum speed at continuous full load.
Adjustments:	0 - Peak Current Limit (CL) Response (RESP) Lead (LEAD) Signal (SIG) Balance (BAL)
Speed/Torque Regulation:	±5% Max Speed 6000 rpm
Encoder Signals: Resolution Accuracy: Resolver Cable Length: 15 foot 25 foot 50 foot 100 foot	 250, 360, 400, 500, 720, 1000, 1024, 2000 and 4096 lines Max. Error: ±20 minutes ±20 minutes ±30 minutes ±40 minutes
Weight: MPA-03/06 MPA-09	 4 lbs. max 6 lbs. max

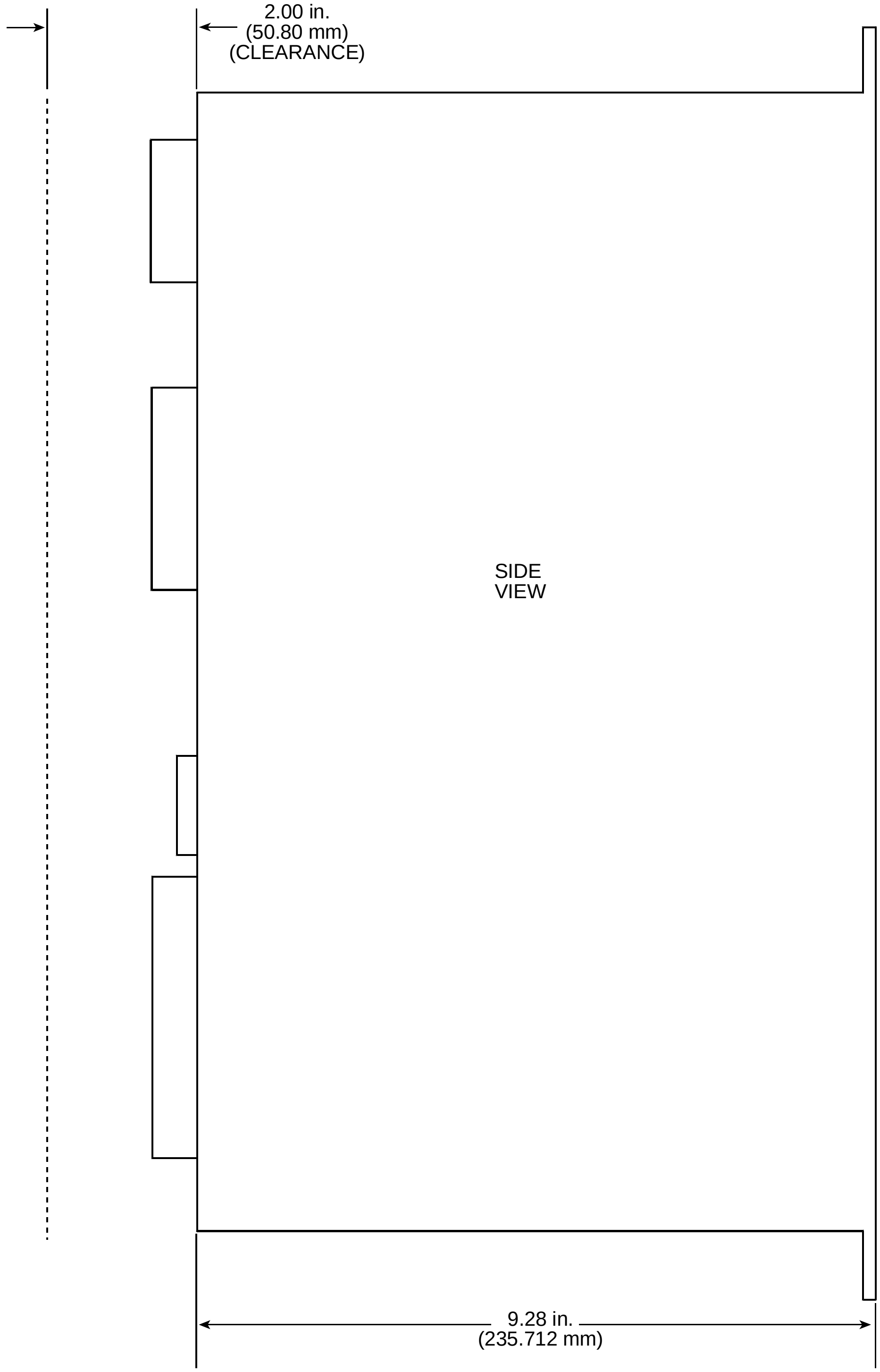
Mounting Dimensions



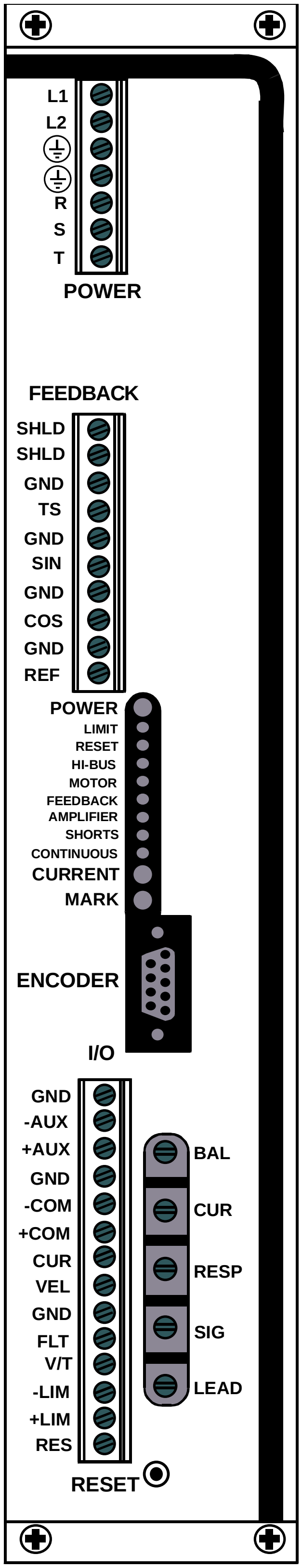
NOTE

Side cover clearances of .2" are required.

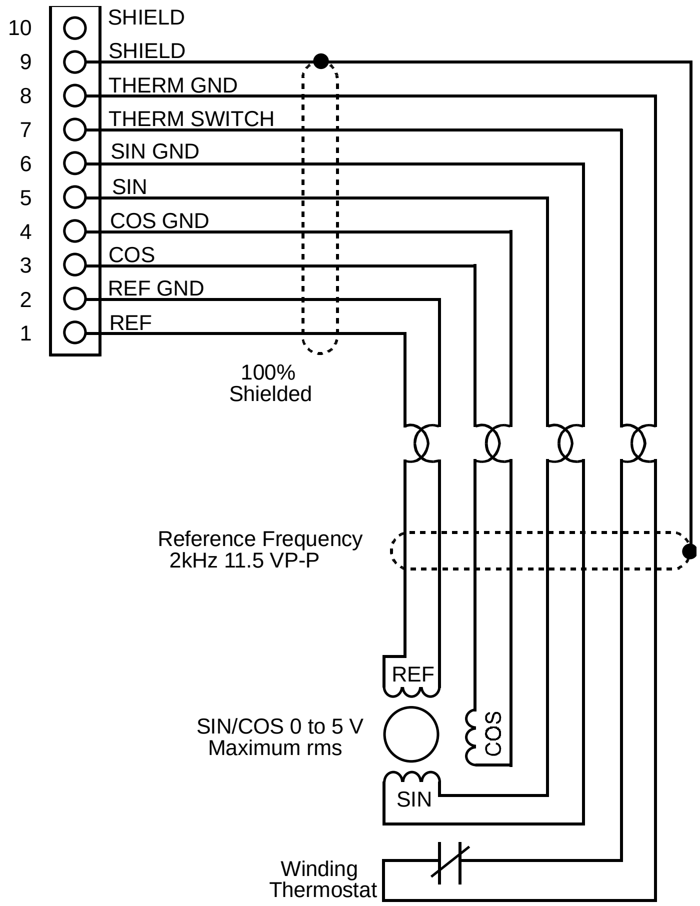
Mounting Dimensions (continued)



Signal/Wiring Overview



Feedback Wiring



NOTE

100% shielded cable is foil and braid. The pairs do not have to be twisted. The resolver wiring should not be run adjacent to any non-shielded high voltage wires, such as the motor wires (RST). If the wiring cannot be separated, the RST motor leads should also be 100% shielded. It is highly recommended that factory cable sets or wiring be used.

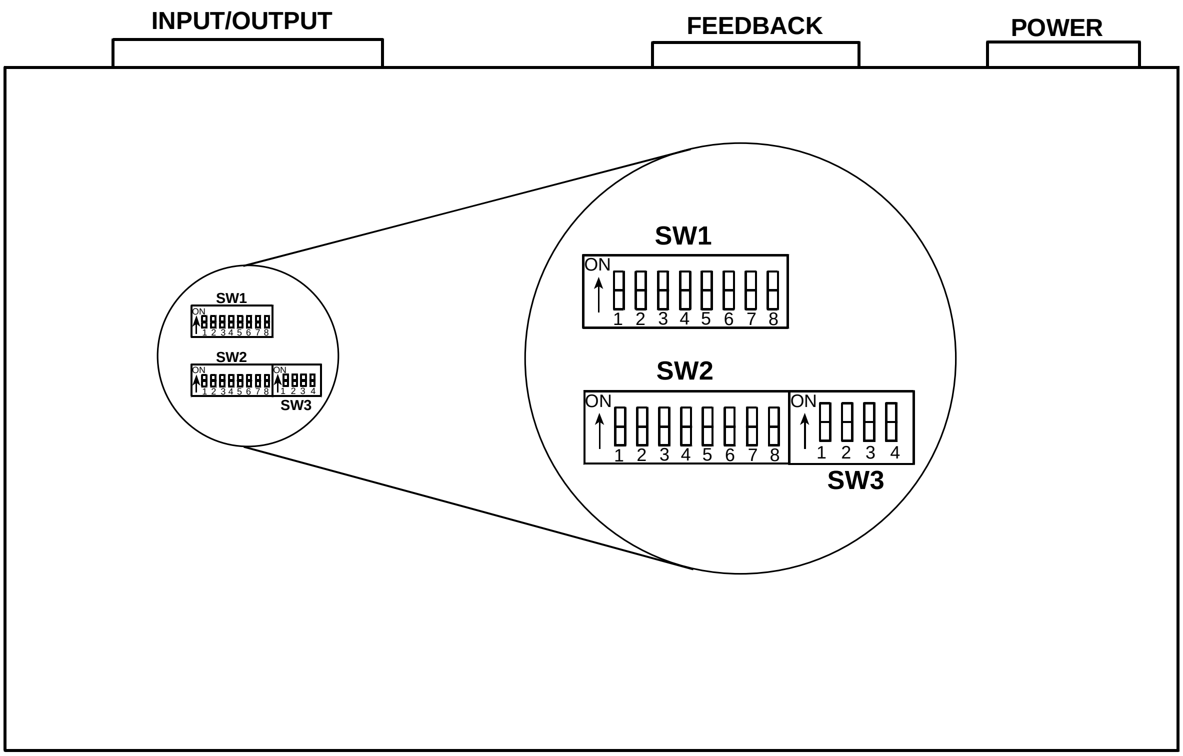
Thermostat

If the motor is equipped with a winding thermostat that is normally closed, it can be connected between terminals 7 and 8 of the feedback wiring connector. If an excess temperature thermal condition exists as indicated by an open thermostat, the amplifier is disabled.

Motors and Commutation

The amplifier can commutate 4-pole, 6-pole, 8-pole, and brush motors in its standard configuration and other factory options are available. DIP switch SW2 allows for configuration changes and switches six, seven, and eight determine the choice. Amplifiers are shipped set for 6-pole operation. Never change the switch settings of S2 with power on.

FEEDBACK AND I/O CONTROL ASSEMBLY



SW2	6	7	8	MOTOR TYPE
	ON	ON	ON	8-POLE
	OFF	ON	ON	6-POLE
	ON	OFF	ON	4-POLE
	OFF	OFF	OFF	BRUSH

All two-inch MTS Automation are 4-pole motors. The three-inch, four-inch, six-inch, and eight-inch motors are 6-pole motors.

For brush motor operation, no resolver alignment is required and the R lead connects to armature (+) and the T lead connects to armature (-). These connections will cause clockwise rotation from the shaft end of the motor.

Diagnostic Indicators

MARK (RED)

This is an output that comes ON at the resolver zero position and can be used in conjunction with alignment procedures. The zero position is about .5 degrees.

CURRENT (BI-COLOR)

This is a bi-color LED that can be either red or green as a function of load. Red indicates positive torque and green indicates negative torque. The intensity increases with load.

There are eight faults that will disable the amplifier.

LED	INDICATION
CONTINUOUS	If a load condition exists that causes the amplifier to produce more than its continuous rating, this fault occurs.
STATOR SHORTS	If stator shorts or most major wiring errors of the stator occur, this fault occurs.
AMPLIFIER THERMAL	An 85° C thermostat is mounted to the amplifiers IGBT heat sink. If an excess temperature is sensed, this fault occurs.
FEEDBACK WIRING	For most resolver wiring errors, defective resolvers or tracking rate errors caused by the resolver, this fault occurs.
MOTOR THERMAL	If an excess thermal condition exists in the motor, this fault occurs.
HI-BUS	If excess DC voltage or a failure of the shunt circuit occurs, this fault occurs.
RESET	During the first second of power up or if the reset input is active, this LED will be ON.
LIMIT	If either of the limit inputs are ON, This LED will be ON.

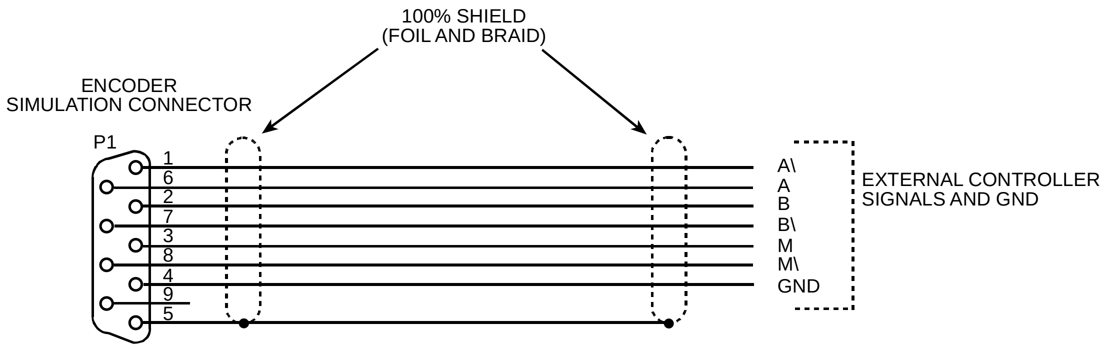
POWER (GREEN)

If logic +5 Vdc is ON, then this LED is ON.

Simulated Encoder Signals

For external counting or position control, a 9-pin D type female connector that has TTL differential outputs is provided. This simulates quadrature encoder channel A and channel B signals. A differential mark signal is also available. These signals are RS422 compatible.

TYPICAL ENCODER CABLE



COMMENTS:

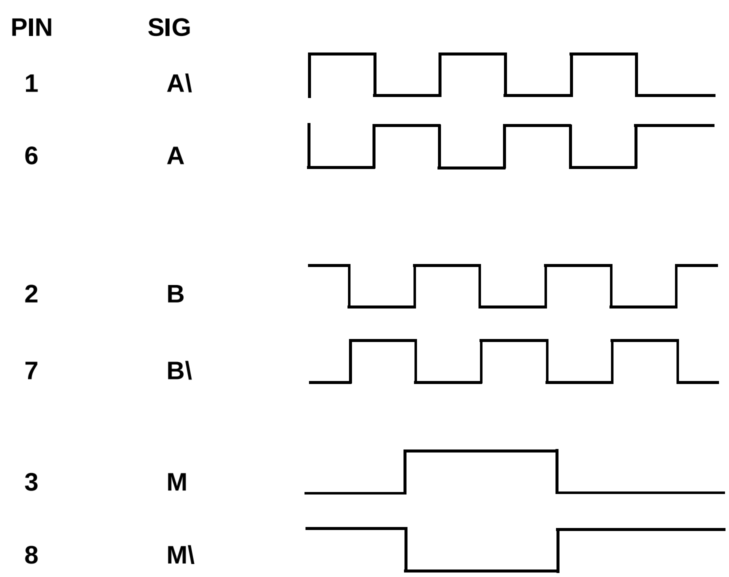
1) THE AMPLIFIER OUTPUTS ARE RS422 DIFFERENTIAL LINE DRIVER COMPATIBLE

2) THEY SHOULD BE CONNECTED TO COMPATIBLE DIFFERENTIAL RECEIVERS

3) THE BEST SHIELDING APPROACH WOULD BE TO CONNECT THE SHIELD AT THE AMPLIFIER END ONLY

4) ALL SIX WIRES AND A GND CONNECTION SHOULD BE CONNECTED AT THE CONTROLLER END

The phase relationship of channels A, B and M are as follows for CW rotation:

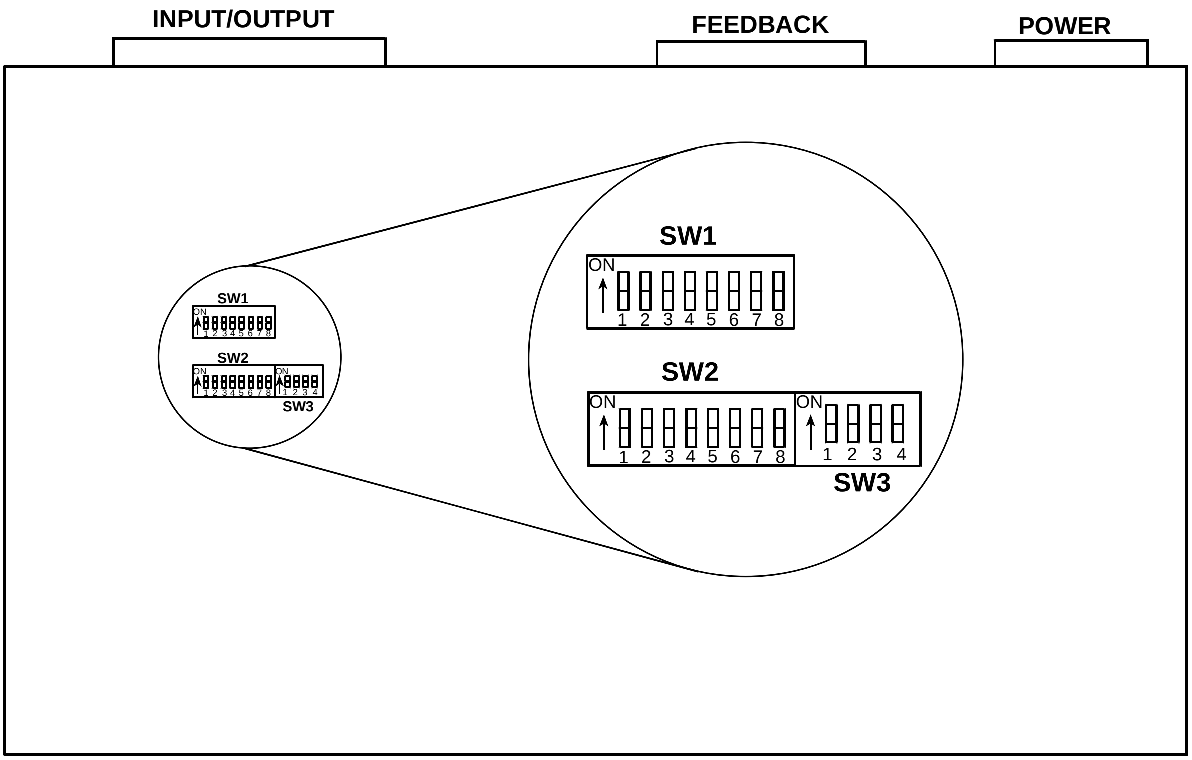


The marker pulse is about .5 degrees in width. The above illustration is for 1024 line condition (default).

The above signals are TTL differential outputs from a DS26LS31 differential driver. The logic 0 is typically between 0 and .5 volts and logic 1's are typically between 3.3 and 4 volts.

SW3 is provided as a means to determine the resolution of the simulated encoder signals.

FEEDBACK AND I/O CONTROL ASSEMBLY



The amplifier is configured from the factory to be 1024 lines.

SW3	1	2	3	4	LINES
	ON	ON	ON	ON	2000
	OFF	ON	ON	ON	500
	ON	OFF	ON	ON	400
	OFF	OFF	ON	ON	1024 (default)
	ON	ON	OFF	ON	250
	OFF	ON	OFF	ON	1000
	ON	OFF	OFF	ON	720
	OFF	OFF	OFF	ON	360
	OFF	OFF	OFF	OFF	4096

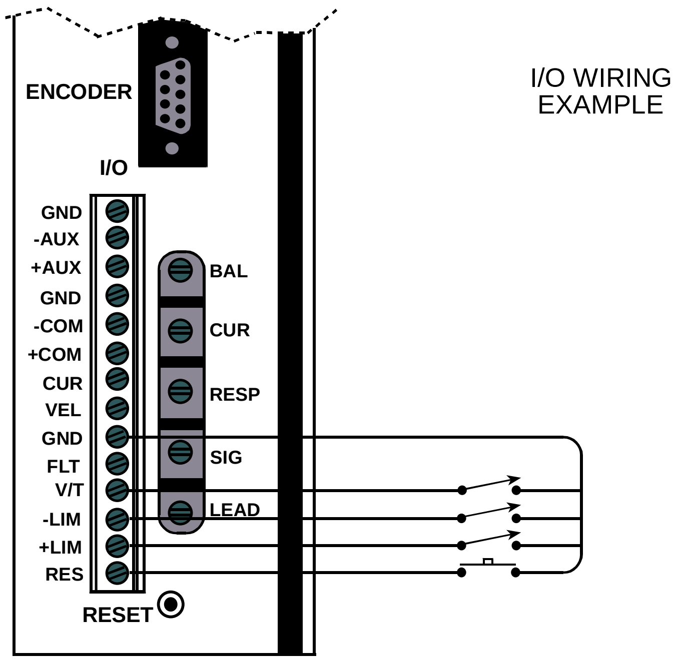
The normal factory configuration of 2-channel quadrature provides for output resolution of 14 bits or 4096 counts per revolution (JP1 - IN, JP2 - OUT). For 12-bit mode, jumpers should be set JP1 - OUT, JP2 - IN.

The maximum tracking rate of the amplifier is limited to 100 rps or 6000 rpm.

I/O Wiring and Descriptions

The amplifier has four inputs and one output. These inputs and output are designed to interface to a 24 volt logic system. The amplifier is shipped so that the operation of the inputs are as follows.

With no wires connected to RESET, +LIMIT, -LIMIT, or VEL/TORQUE, the amplifier is enabled and normal operation will occur in a velocity mode. The inputs are activated by connecting them with a switch closure to any of the provided GND terminals.

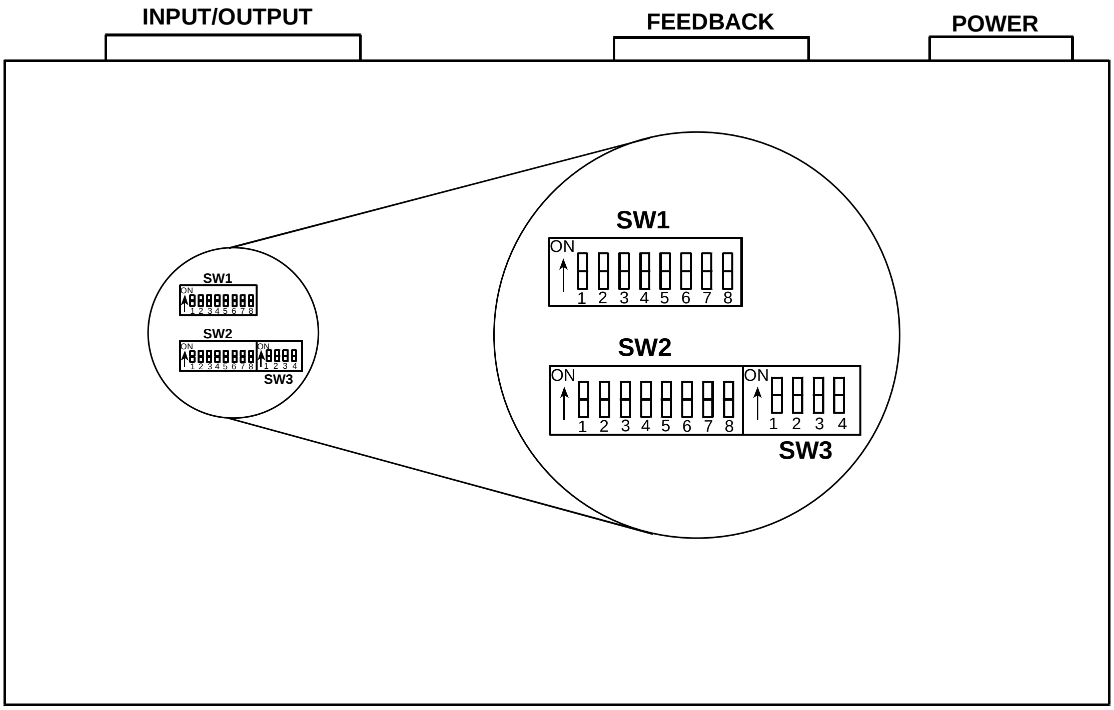


NOTE

The V/T is an input that determines the amplifier mode, Velocity/Torque mode. When the switch is open, the Velocity mode is selected. When the switch is closed, the Torque mode is selected.

As the polarity of the inputs may vary depending on the application, a DIP switch is provided to allow for an inversion of the function.

FEEDBACK AND I/O CONTROL ASSEMBLY



DIP switch SW2 switches 1, 2, 3, and 4, are used for this purpose.

Input	Switch Number	Factory Setting
RESET	1	ON
+ LIMIT	2	ON
- LIMIT	3	ON
VEL/TORQUE	4	OFF

Output	Switch Number	Factory Setting
FAULT	5	ON

By setting switch 2 to the OFF position, the operation of the + LIMIT would change to be closed to run in a plus direction. This reversing characteristic is true for all four switches.

There is a FAULT output. This is equivalent to an open collector NPN transistor with its emitter connected to GND. This transistor can sink 2 amps, and it can withstand 110 volts dc when OFF. When a fault occurs, this output turns ON. This output can also have its polarity inverted by switching the fifth switch on DIP switch SW2. Once this is done, this output will be ON if no fault exists. This output would now be thought of as a READY output instead of a FAULT output. The normal fault operation occurs with SW2-5 ON.

The purpose of inversion of this output is to allow for direct connection to fail safe brakes or other brake interlock circuits.

If this inverted output is used, consideration for the Power-Up Reset Input may be required. For example, during power-up a reset would disable faults. This same reset may then defeat the desired operation of the brake. With no faults and an inverted output selected, the brake output would be ON but power would not be applied to the motor. If SW1 switch eight is set to the ON position, a Reset/Disable condition is allowed to keep the output ON even though there is no fault.

RESET/ENABLE Conversion

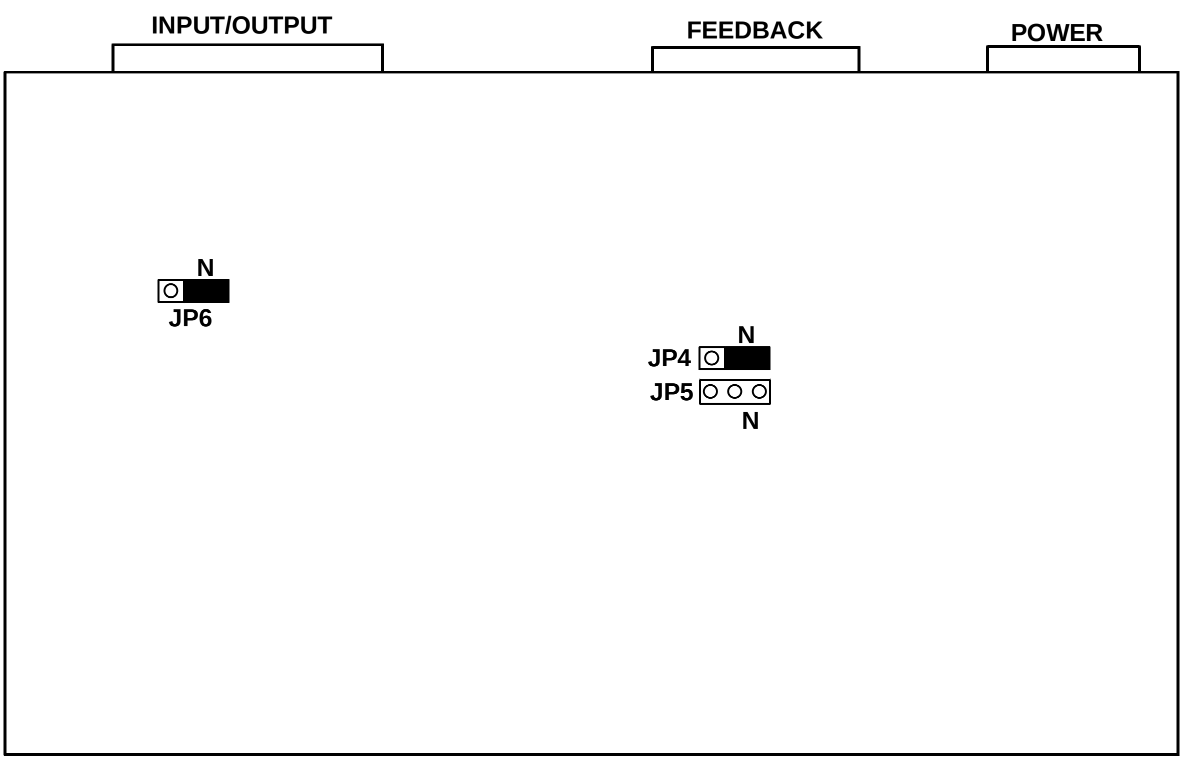
The most common conversion is to change the RESET input to an ENABLE input. If SW2-1 is set to the OFF position, the RESET input must be connected to GND to ENABLE the amplifier.

Although the operation of this input is oriented as an amplifier enable input, during the time the input is not connected to GND, the amplifier is actually in the reset condition. During this time, the fault status indicators are also reset. In some applications, the amplifier fault output is used as a handshake signal to an external controller, and if a fault from the amplifier occurs, the external controller shuts OFF the ENABLE input immediately, and the particular fault that caused the fault is reset.

If the external controller logic cannot be changed and it is desirable to save the fault status indicators, the following header pin jumpers can be changed to reconfigure how the fault status indicators are cleared.

Alternative Fault Reset

MPA-03/06/09 Rev. A5 and higher:



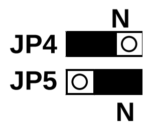
The three header pin jumpers and JP4, JP5, and JP6; shorting pins are all connected as indicated.

Reset if AC Power is Cycled

If the JP4 header is removed, the faults will only clear when the logic supply power is removed and re-applied.

Reset on Enable Transition

By moving the JP4 pin to the non-N position and the JP5 pin to the N position, the faults will clear on the transition of the ENABLE. The fault output will shut off if the condition that caused it is removed at this time. This allows the fault to be displayed when the ENABLE is removed. Faults will clear on the transition of the ENABLE or when AC power is cycled.



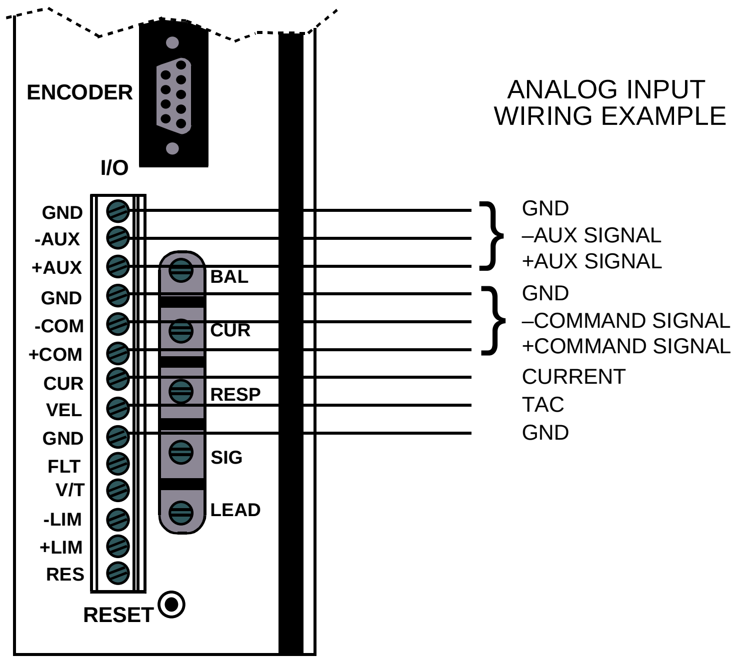
Reset via Unused +LIM Input

By moving the JP4, JP5 and JP6 pins to the non-N positions, the operation of the +LIM input is changed so that it becomes CLEAR FAULT STATUS input. Assuming that SW2-2 is still on the CLEAR FAULT STATUS would clear by connecting the +LIM input to GND. The fault output would clear at this time if the fault condition was removed. The +LIM and -LIM inputs cannot be used as limits, they are disabled in favor of using the +LIM as a fault status clear. SW2-2 can be switched to the OFF position and this would invert the operation of the fault clear so that it would have to be normally connected to GND and then be disconnected to clear the fault indicators.

Analog Inputs, Outputs, and Adjustments

Inputs

There are two analog input channels; one for command and one for auxiliary. Both of these channels are differential inputs and both are summed with a TAC feedback differential amplifier that controls velocity.



Normal operation of the command signal is to apply a + voltage (pin #9) with respect to GND (pin #11) and get clockwise rotation of the shaft. Negative voltage causes counterclockwise rotation. ±10 volts is then used to control velocity, and the SIG pot is used for velocity adjustments. If the + COMMAND voltage is applied to the - COMMAND signal input, then an opposite shaft rotation occurs.

The operation of the AUXILIARY ± inputs is the same as the COMMAND inputs. The normal purpose of the AUXILIARY inputs is to provide a second summing voltage to compensate/modify normal COMMAND voltage.

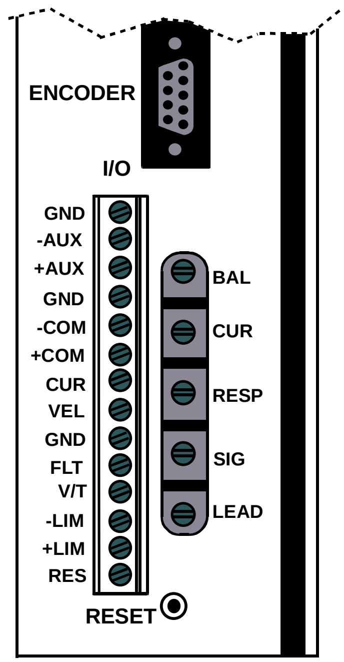
If the input for VEL/TORQUE is set up so the torque mode is chosen, voltages applied to the COMMAND ± inputs control motor current. The SIG pot can now be used to adjust the current. Normal operation in this mode assumes that 10 volts represents peak current and 5 volts represents the continuous current rating of the amplifier.

The current limit of the amplifier can be adjusted with the CUR pot from 0 (full CCW) to 100% (peak full CW). It is a good idea during start-up to adjust the CUR pot to its full CCW position and increase it slowly CW to assure normal operation.

During start-up the BAL adjustment can be used to reduce/stop any low speed CW/CCW drift caused by imbalance between the external command voltage and the amplifier.

Once connected to loads, the crispness of motion (step response) and stability can be optimized with the RESP and LEAD pots. Full CW is maximum response and full CCW is minimum LEAD.

The location of these adjustments is next to the I/O wiring.

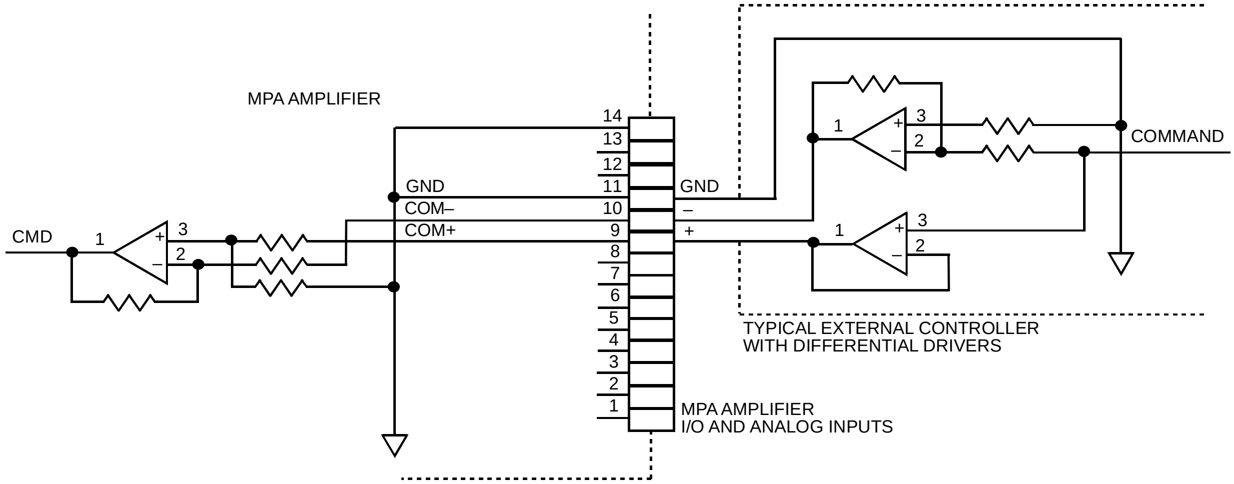


Outputs

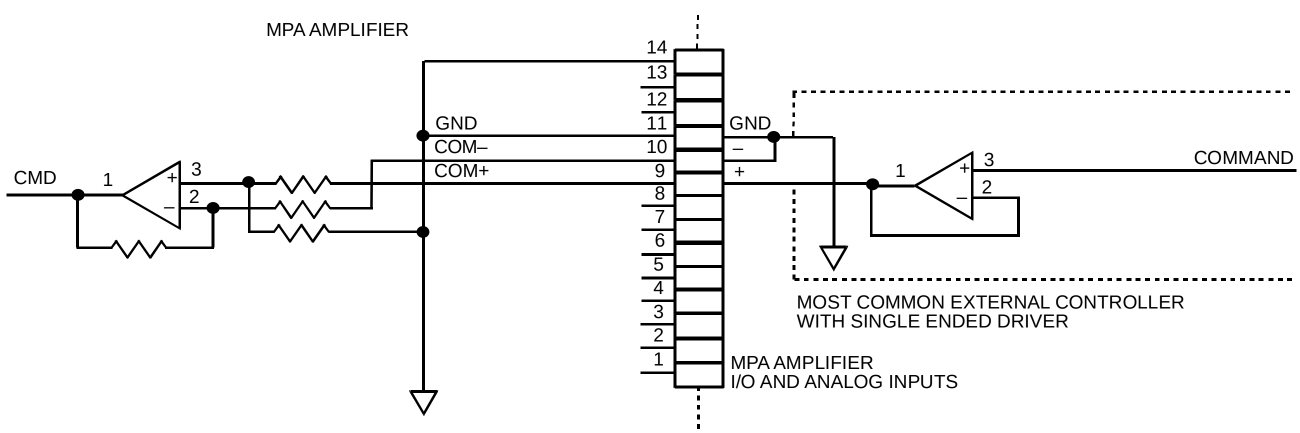
Two diagnostic outputs are the dc voltage proportional to velocity and the dc output proportional to current/torque. The nominal TAC gradient is 1.3 volts per thousand rpm. The current gradient is 10 volts equal peak.

Analog Inputs (Specific Interface Requirements)

The analog input channels consist of differential input amplifiers to allow controllers that have differential output drivers a three wire connection that excludes potential ground loops. When differential modes of operation are used, the command or auxiliary input is based on 5 volts equaling maximum input, and the analog ground from the external controller must be connected to the amplifiers GND connection. A +5 volt connection to the COM+ terminal and a -5 volt connection to the COM- terminal is equal to a +10 volts command voltage. The rotational direction of the motor will be CW viewed from the shaft end of the motor. To change directional rotation, the COM+ and COM- connections must be reversed.



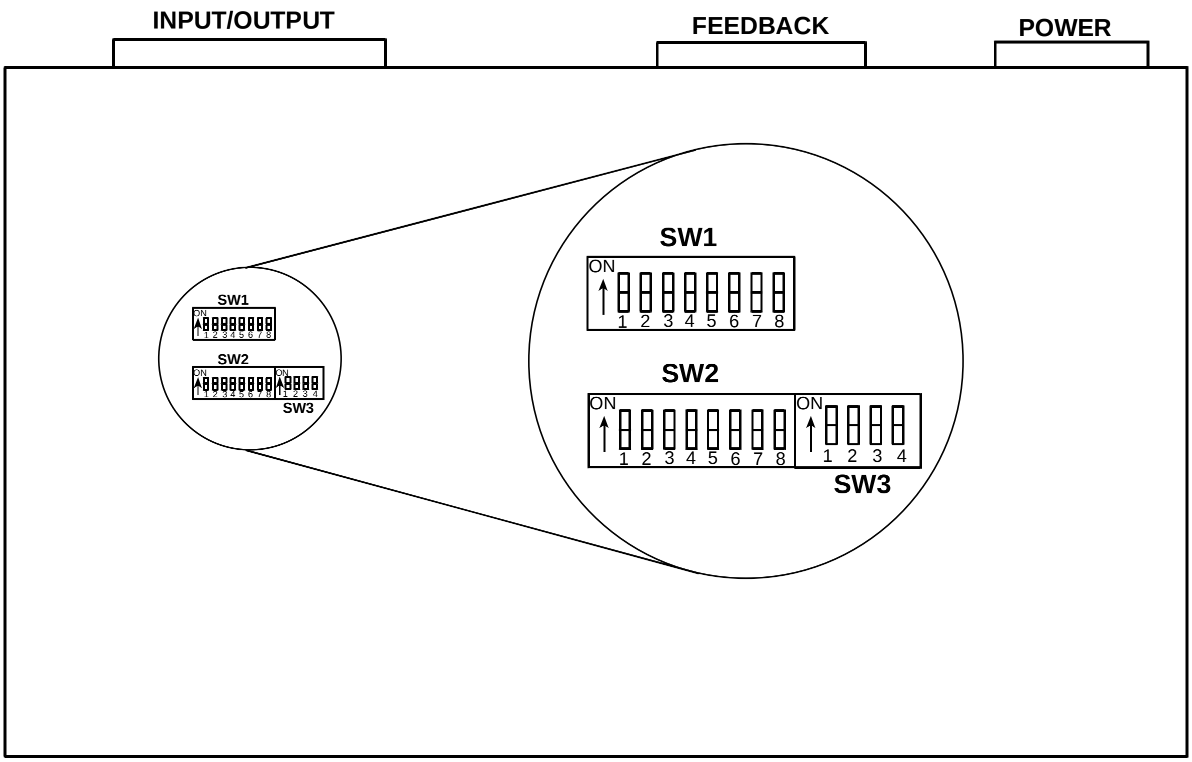
The most typical input to the command and auxiliary inputs is a simple two wire interface consisting of a command voltage with respect to a GND. The ground wire of this pair must be connected to the MPA GND terminal associated with the analog channel and the command wire can be connected to either the COM+ or COM– input to determine the rotational characteristic required. A positive command voltage with respect to GND connected to the COM+ terminal will cause CW rotation as viewed from the shaft end of the motor. The unused input, COM+ or COM-, should be connected to GND.



TAC Gradient, Response, Lead

SW1 is provided as a means to alter the amplifiers normal default conditions.

FEEDBACK AND I/O CONTROL ASSEMBLY



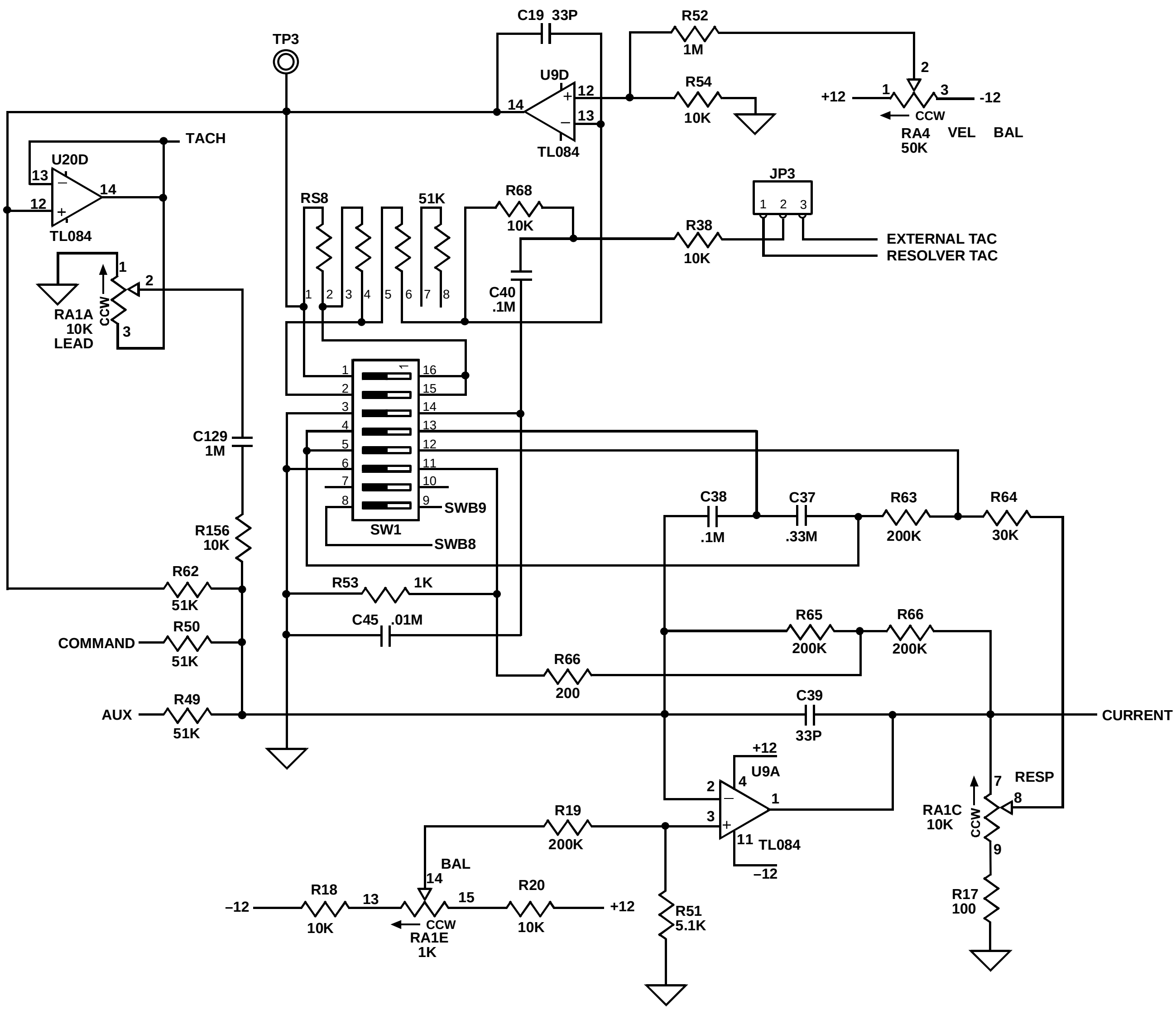
TAC Gradient

SW1	1	2	TAC Gradient
	ON	ON	1.3
	OFF	ON	2.6
	ON	OFF	2.6
	OFF	OFF	3.9

Default Normal Settings - Lead/Lag

SW1	1	2	3	4	5	6	7	8
	X	X	OFF	OFF	OFF	ON	X	OFF

Response/Lead Compensation and TAC



Set-Up

This procedure assumes that the amplifier is being used in the velocity mode otherwise the external controller would resolve PID gains for the amplifier and the amplifier would be in the TORQUE mode.

The USER adjustments are set as follows for shipping.

LEAD	CCW	(no lead)
SIG	MID	
RESP	MID	
CUR	MID	
BAL	MID	

The procedure that is used to determine the actual SWITCH settings and USER adjustments is load and application dependent.

The best method to determine these is based on testing with Voltmeters and Oscilloscope for observing the TAC and command signal. P (proportional gain) is determined by the TAC and signal gains. An oscilloscope can be used to monitor the TAC signal for over or under damping. The I (integral gain) is controlled by the RESP pot and the switch settings of SW1, 4 and 5. The D (derivative gain) is determined by the adjustment of the LEAD pot.

An abbreviated method that allows for reasonable success is:

1. Determine the TAC gain for the application and set the SW1-1,2 SWITCHES accordingly. Amplifier saturation is based on 10 volts of either signal or TAC. With the TAC switches set for normal operation, the TAC gradient is 1.3 volts per thousand and saturation will occur at 10 volts max / 1.3 volts per Krpm = 7.7 Krpm. The motor's KE, and the amplifier's bus voltage will also limit the maximum speed.

   The amount of TAC gain alters the drive's proportional gain, and under most conditions higher TAC gains allow control of larger inertia. Since TAC gain compared to signal gain also controls velocity, the external controllers dc voltage proportional to velocity is an issue to consider. In some controllers a KF (feedforward term) is available. This term is a pre-computed voltage that is the velocity component. The controller's KP term adds or subtracts from this existing KF term, based on encoder count error, a voltage that forces correction. For this type of controller, the best possible performance can be achieved by having high TAC gain and minimum KP. Following errors are adjusted out with the drive's SIG adjustment when running at a known speed, and the BAL adjustment can be used to zero following error at zero velocity.

   Some controllers have no KF term and run error loops. Motion occurs as a result of the error over time, and for each time interval more error occurs causing higher speed. For this type of control, high TAC gains would generally deteriorate performance as the key to running is to make the same following errors at the same times. This type of control is very common. In several instances the difficulty in setup is that the external controller has no KP or KF term and the drive's KP is the only way of achieving stability. The drive's KP is determined by the TAC gain, SIG/AUX pot, LEAD pot. The best process would be to start out with the lowest TAC gain. Adjustment of the SIG/AUX input, RESP, and LEAD should cause normal operation.

Continued on next page

Set-Up (continued)

2. The TAC filter SWITCH SW1-3 is usually OFF (minimum filter), but for larger (3-4" motors) and applications where load inertia is minimal, the best performance is achieved by having maximum filtering, SW1-3 ON. SW1-4,5 should be switched ON for maximum integration and the lowest gain. When the RESP is full CCW Integration (I) is maximum. CW adjustment of the RESP pot moves towards less integration.

3. We would next set the RESP and CUR pots full CCW and assure that the LEAD pot is full CCW. The BAL pot and SIG pot are in the MID.

4. Power up the amplifier.

5. Slowly turn the CUR pot towards the middle position while observing the following.

    a. it may be necessary to increase the RESP adjustment CW to achieve stability or to minimize oscillation or vibration. If the RESP is full CCW, a low frequency oscillation is possible. As the adjustment is increased CW to the maximum, a high frequency, audible oscillation is common. The RESP should be set to just below this high frequency if instability occurs.

    b. if the instability is substantially improved but not good enough, the LEAD adjustment can be increased. The LEAD pot dampens motion. It can be used to reduce overshoot.

6. If operation is improved but not good enough, the process can be repeated from Step 3 after turning OFF SW1-4. This causes a decrease in Integration (I).

7. If operation is again improved but still not good enough, the process can be repeated from Step 3 after turning OFF SW1-5. This causes an increase in gain.

8. If you are unable to achieve the speed you want, you may have to increase the SIG pot to have an 8-10 volt command signal equal the amplifiers maximum velocity.

9. You can also continue to increase the CUR adjust as operation is improved.

AC Input and Internal Protection

A branch circuit disconnect must be provided in front of the amplifier.

Model	Single Phase
MPA-03	5 amps
MPA-06	10 amps
MPA-09	12 amps

AC power wiring must be consistent with any local codes, national electric codes, and be able to withstand the voltage/current ratings applied.

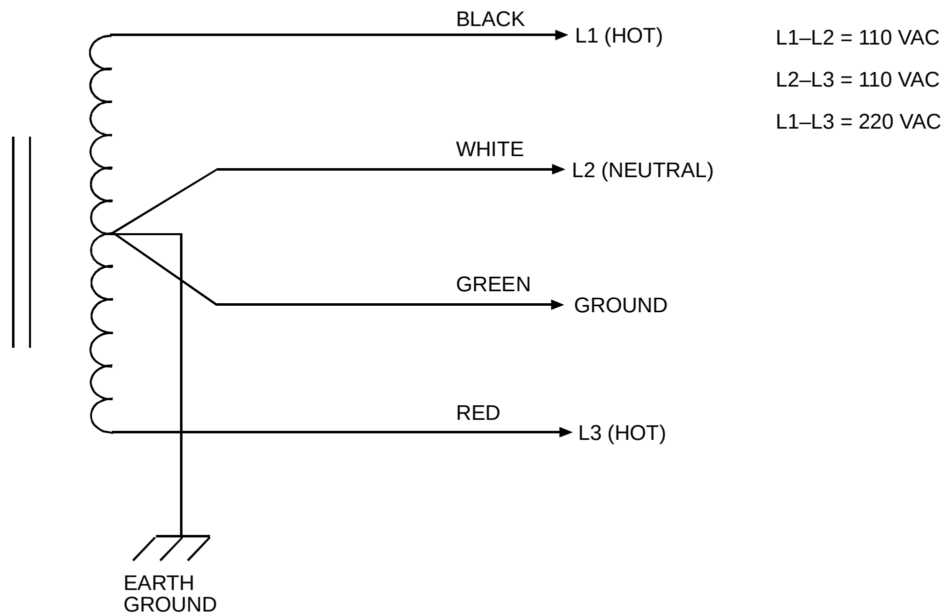
A ⏚ (ground) terminal is supplied and should be connected to earth ground.

Internal Protection

The MPA-06/09 has two AC Input fuses and a shunt fuse on the circuit board as a means of protection from catastrophic failures. The MPA-03 does not require a shunt fuse. In the event that any of these fuses becomes defective, the amplifier must be repaired by a factory technician.

Grounding – Single Phase

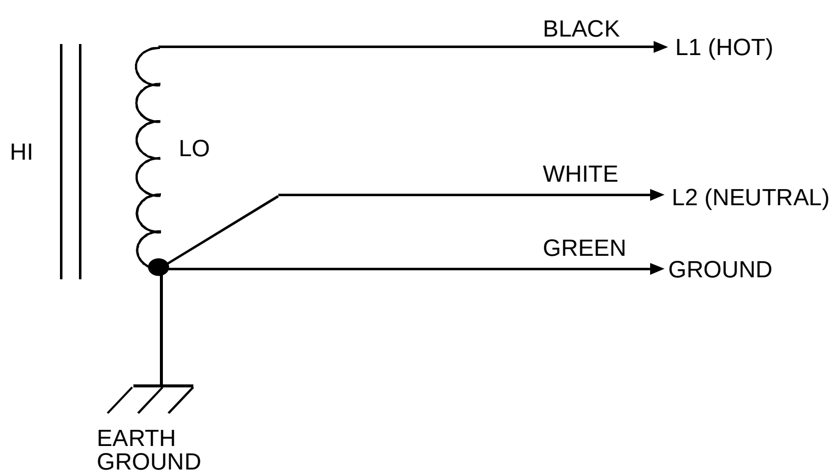
Typical 220 VAC Single Phase



In the United States, the neutral connection is L2 and is a white wire. The green wire is ground. L1 and L3 can be almost any other color but white or green.

Step Down Transformer

Single Phase



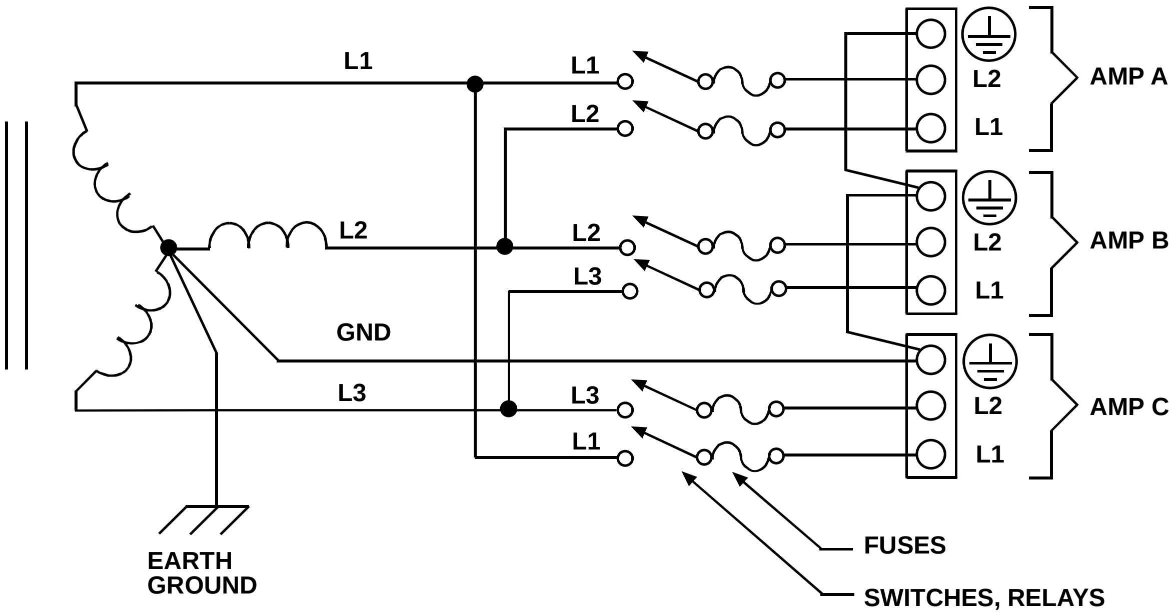
In the United States, the neutral connection is a white wire and the green wire is ground.

For single phase amplifiers, or three phase amplifiers that use a neutral (L2) connection, this connection does not require a switch, fuse, or other means to disconnect. The disconnects and fuses go in the hot leads.

Single Phase Amplifiers on Three Phase Power

In certain multiple single phase amplifier applications, a three phase power source exists. An assumption that the single phase amplifiers can be applied on a three phase transformer and balanced operation can be achieved, by connecting as follows, is incorrect.

NOT ACCEPTABLE:



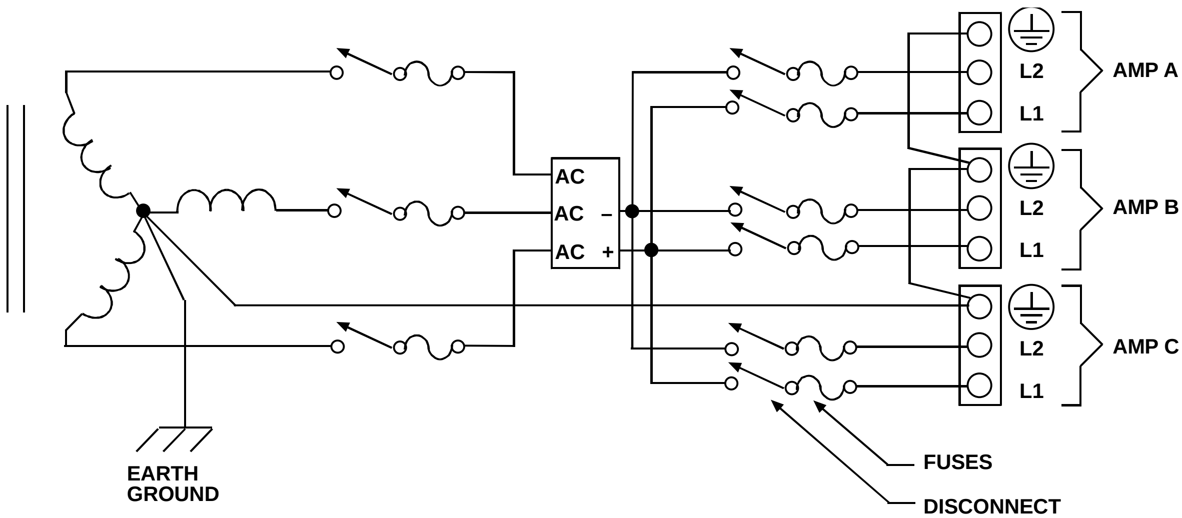
This is not acceptable and can become a major cause of amplifier failures when the transformer is undersized. The most common failure occurs as a result of inrush current at the time power is applied. There are no relays or switches that close at the same time. Therefore, the results are that imbalanced lines cause excess voltages that are destructive. Similar destruction can occur as a result of excessive loads on one axis imbalancing the lines.

Single phase amplifiers should be connected, in parallel, to a single phase line. The line must have sufficient power to drive as many amplifiers connected based on the sum of their continuous ratings.

Three Phase Line to Multiple Single Phase Amplifiers

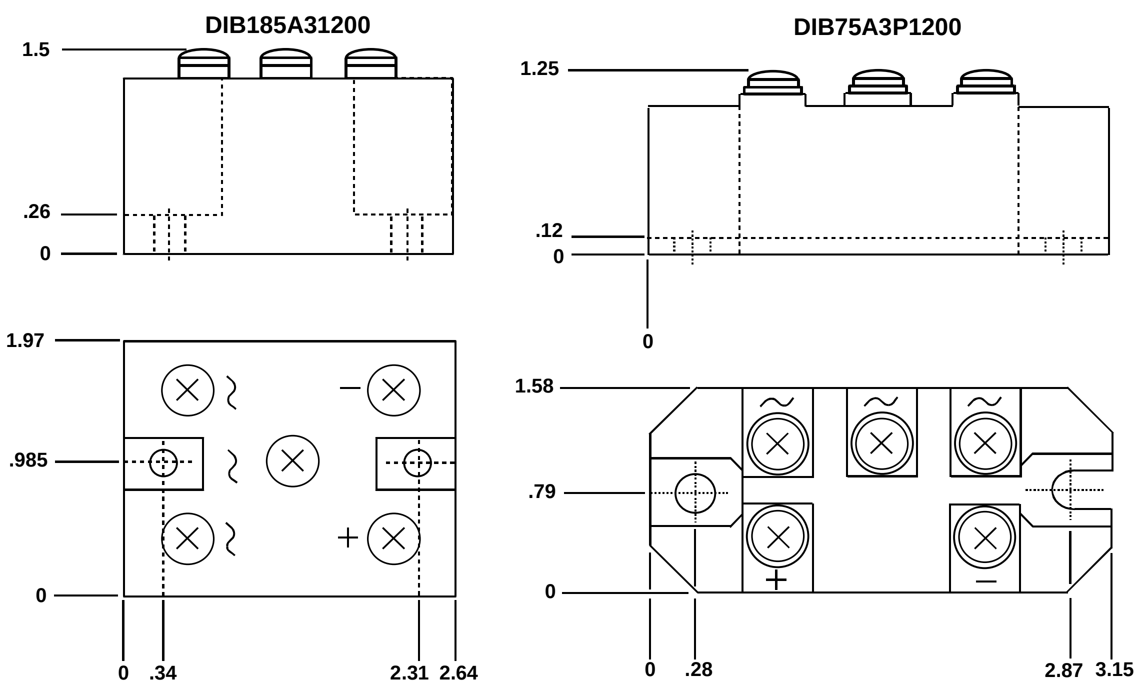
Since all MPA amplifier designs are based on switch mode techniques, they will operate on dc or pulsating dc voltages.

To balance the three phase transformer, a three phase rectifier can be placed between the amplifiers and the transformer.



There are multiple acceptable ideas based on this concept. A three phase rectifier for each amplifier is also acceptable.

For multiple amplifiers, there are two choices of three phase rectifiers available:

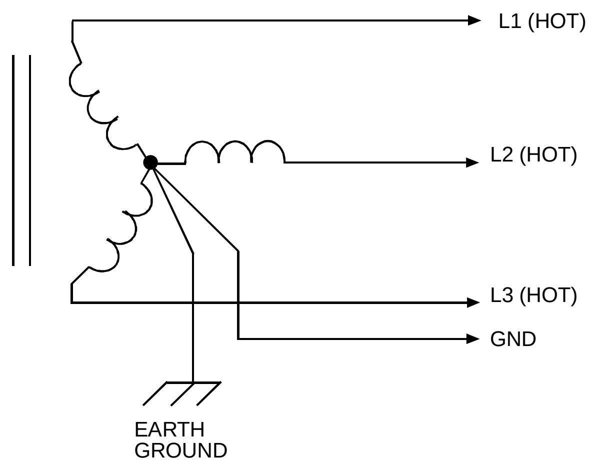


The DIB185A31200 is rated for 90 amps continuous, and the DIB75A3P1200 is rated for 40 amps continuous. The sum of the continuous ratings of the amplifiers should not exceed the rating of the rectifier.

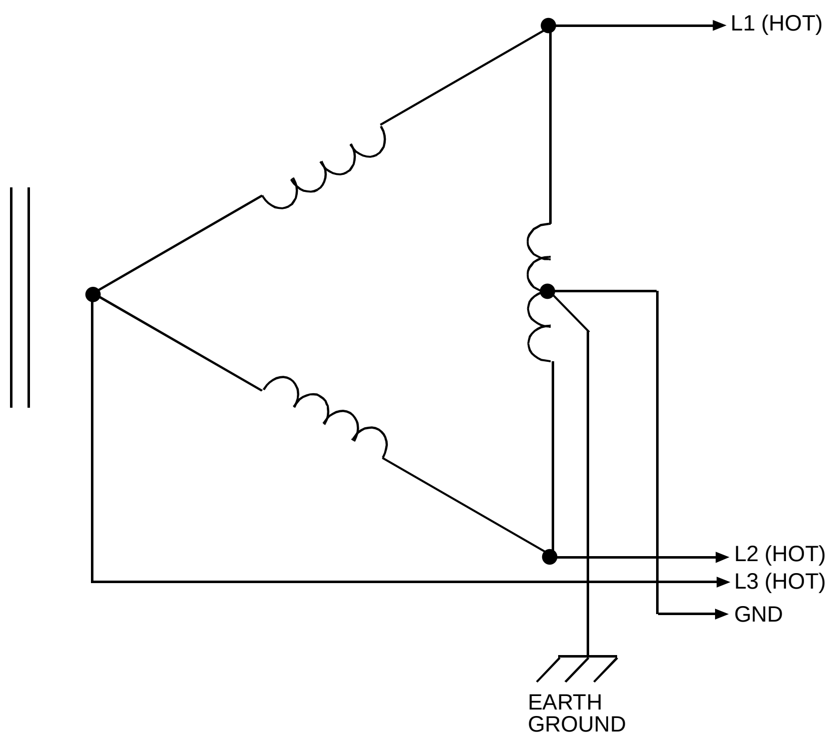
Grounding – Three Phase

The ac supply source for the amplifier is supposed to be bonded to earth ground.

Typical WYE Secondary



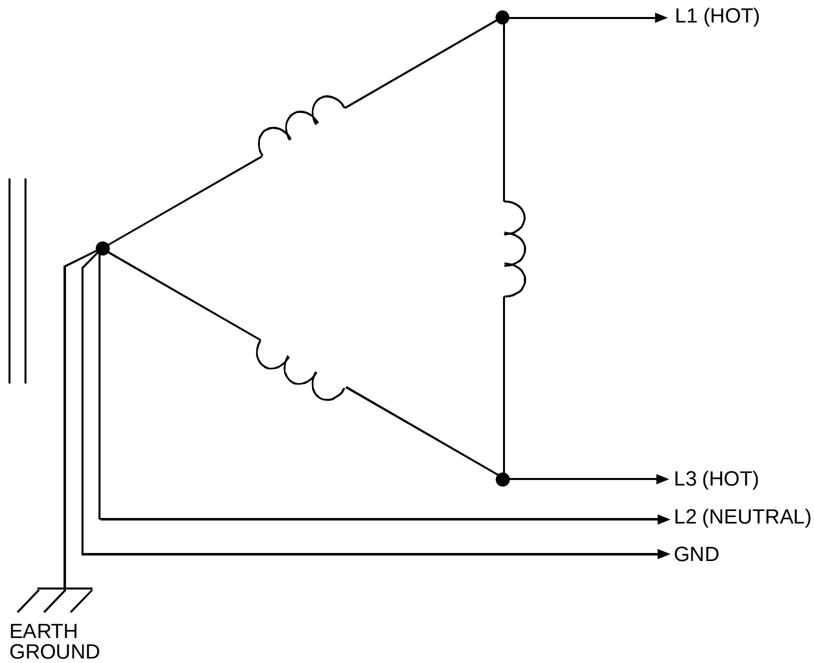
Typical Delta Secondary



These are the two most typical transformer configurations, and failure to ground these properly could void warranty.

The MPA amplifier does not care where the earth ground is. This example is a delta secondary.

Delta Secondary



In this example L2 became ground.

Power/Grounding Requirements

The following information covers the grounding requirements of 3-phase servo amplifiers manufactured by MTS Automation. It has been found when an amplifier has been connected to a transformer with an ungrounded secondary, premature amplifier failure will occur.

The 3-phase MPA amplifiers require the AC power (L1, L2, L3, and Ground) be derived from a transformer which has it's secondary intentionally bonded to earth ground. This means that some point on the secondary must be connected to an earth ground with no exceptions (see examples A1, A2, A3). Do not assume just because there are three power leads with a ground available at an installation, that this is a valid configuration. Some facilities are supplied with 13,200 volts AC which is reduced to 460 volts AC via a transformer. However, the secondary of this transformer usually is not grounded as in an ungrounded delta secondary (Example U3). Each installation or facility is unique and the power distribution must be inspected or measured to make sure the transformer secondary is, in fact, tied to earth ground. A machine or system built and tested at one facility, may fail at another site due to incorrect transformer configurations.

There are two common transformer secondary configurations. They are the Wye and the Delta secondary. Most problems are found with an ungrounded Delta secondary connection. The examples show acceptable (A1, A2, and A3) and unacceptable (U1, U2, U3) configurations.

If it is not possible to visually inspect the transformer configuration, you can electrically measure the line voltages to verify a correctly grounded transformer secondary.

A properly grounded secondary (wye or delta) will have certain voltage characteristics when measured with an AC volt meter:

- A properly grounded wye secondary will read the same voltages when measuring all three legs, phase to ground (A1).
- A properly grounded wye or delta secondary will read the same voltage when measuring all three legs phase to phase (A1, A2, A3).

A properly grounded delta with high leg (A2) and delta with grounded leg (A3) show different characteristics when measuring phase to ground.

- In example A2 (Delta with high leg), the two low legs (L1 and L2) must be the same voltage when measured phase to ground.
- In example A2 (Delta with high leg), the high leg (L3), when measured phase to ground, will read twice the value of L1 or L2 to ground.
- In example A3 (Delta with grounded leg), L1 and L2 must be the same voltage when measured phase to ground.

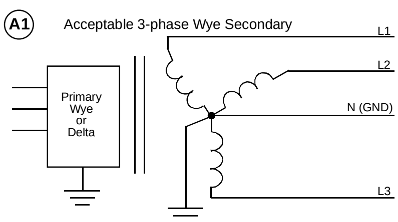
If the measured voltages at the installation do not correspond with the above, or the transformer secondary is, in fact, ungrounded, one of the following steps must be done:

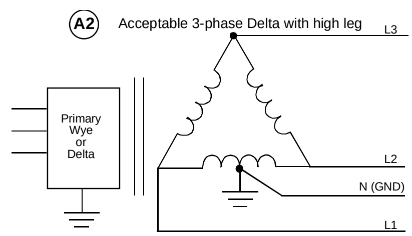
A) Ground the secondary of the transformer if it is electrically and mechanically possible.
B) Add an isolation transformer and ground the secondary per acceptable connection.

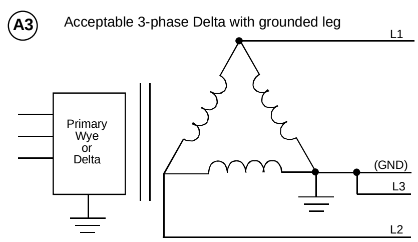
If unsure, ask a licensed electrician to perform the above steps.

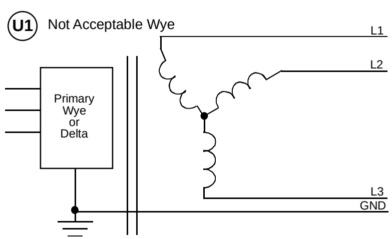
Example 1 shows a typical factory configuration. It shows a ungrounded delta secondary and there is existing equipment already running. on line. This equipment could be simple 3-phase induction motors where an ungrounded secondary is not an issue. However, before a 3-phase MPA amplifier, or a machine utilizing 3-phase amplifiers, can be connected, an isolation transformer, with a grounded secondary must be installed.

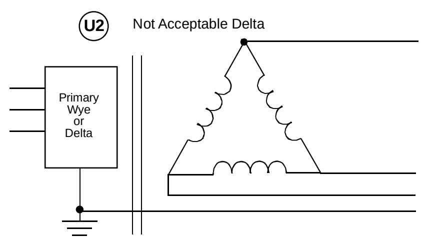
Everyone, (OEM's, End users, etc.) must be made aware of this possible situation when a machine is installed at a customer's site. The power distribution needs to be known and a transformer, with a grounded secondary, may need to be added to the system before power is applied.

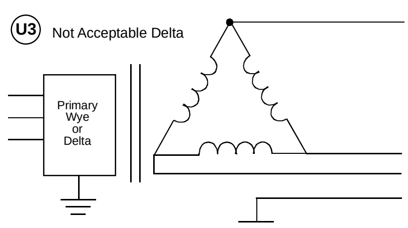






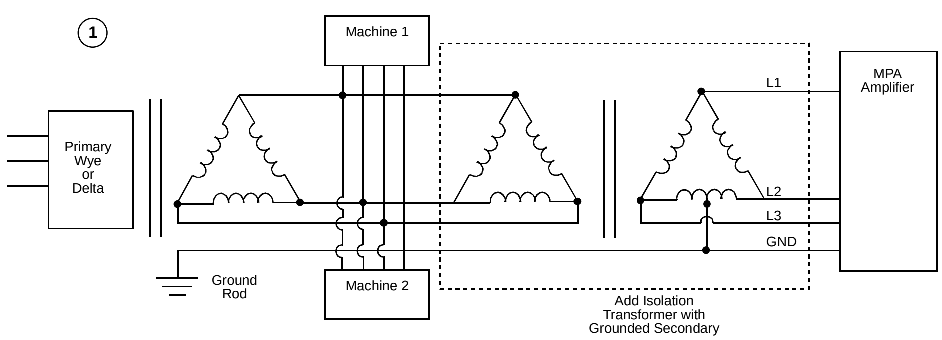






If you find one of the unacceptable connections above, you must:

A. Ground the secondary if possible
B. Add an isolation transformer per acceptable connection (See example 1 below)

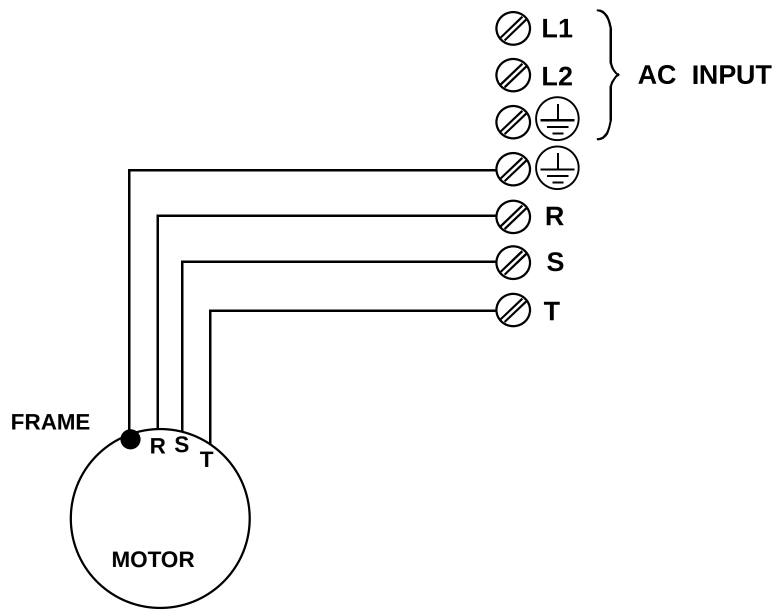


Stator Wiring

The locked rotor stator current is equal to the amplifier's continuous rating, and for either low speed or locked rotor conditions the stator must withstand this continuous rating.

Model	Locked Rotor
MPA-03	3 amps
MPA-06	7 amps
MPA-09	10 amps

For operation at 230 Vac, it is recommended that the stator wiring insulation withstand 600 volts.



A GND connection is supplied as a means to ground the motor frame to earth ground.

If shielded cable is not used, it is recommended that the RST and GND wires be twisted.

NOTE

If the resolver feedback wiring is to be run adjacent to the RST motor wiring, the motor wiring should be 100% shielded (foil and braid).

Shunt Loads and the "-ES" Option

Regenerative energy during deceleration causes the normal voltage on the amplifier's bus to increase. The amount of energy is application dependent and relates to total inertia. In general the amplifier's internal shunt load can dissipate this energy within the constraint that the load inertia is not more than 20 times that of the rotor, but this is a guideline. The deceleration rate of the load determines the rate that voltage rises in the bus capacitors.

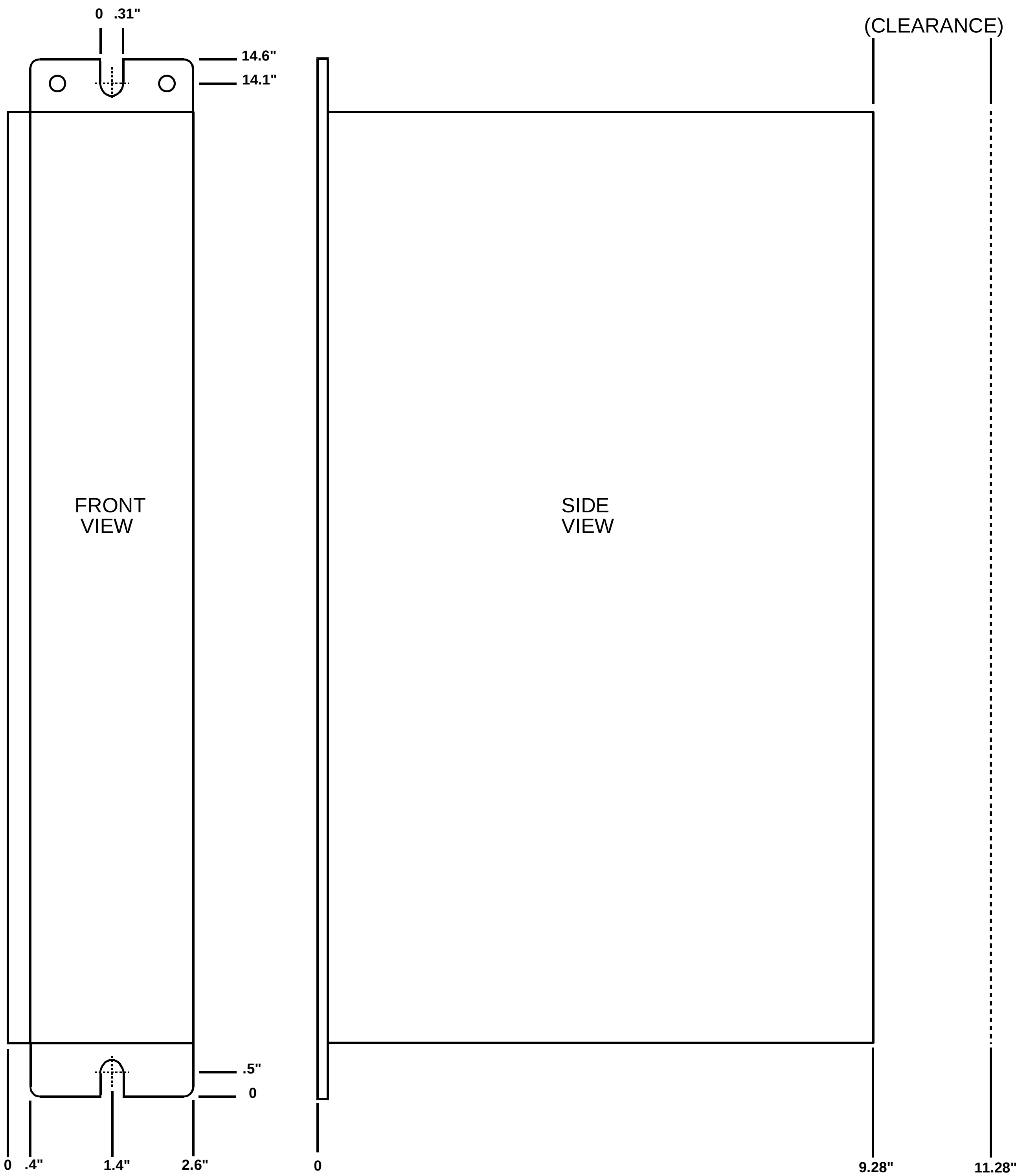
The voltage on the bus is sensed, and when it becomes too high, a solid state device turns on that causes a load to be placed in parallel with the bus. There are three protection devices that are used to protect the amplifier from this application dependent loading. The shunt loads are thermally protected to 85° C maximum, and there is a fuse in series with the shunt load to limit average power in the shunt. If this fuse blows, another circuit measures the bus for an even higher voltage, and a HI-BUS fault occurs and disables the amplifier.

For 230 volt amplifier products, the shunt is turned on at 400 Vdc and turns off at 360 Vdc. A HI-BUS fault occurs if the bus goes over 440 Vdc.

The MPA-03 does not have a shunt load. Regenerative energy is dissipated in mov's that turn on at 390 Vdc.

Model	Load ohms	Fuse amps ABC	Fuse amps MDL	Peak amps	Bus Cap (min) MFD
MPA-06	48	2	1	8.3	540
MPA-09	24	6	3	16.7	1170
MPA-06-ES	24	6	3	16.7	540

Mechanical Footprint - MPA-06-ES



NOTE

Side cover clearances of .2" are required.

Thermal Characteristics

The amplifiers are specified to operate at a 45° C ambient. This is not a maximum safe operating specification. There are no parts in the amplifier that cannot operate at a 60° C temperature. The absolute maximum temperatures that the amplifier can operate at are determined by thermal switches on the bridge switch power devices (IGBTs) and on the shunt loads. These thermal switches open and disable the amplifier at 85° C.

At temperatures above 45° C, the amplifier's ability to produce its continuous rating is impaired by the heat rise from the ambient temperature. The amplifier will thermally shut down once the 85° C condition is sensed at either the bridge or the shunt load.

A guideline for enclosures would be to assume that the amplifier's thermal rise caused by the bridge is 16 times the continuous current rating of the amplifier plus 30 watts. The 30 watts is required for the logic supplies.

If the application is causing bus pumping, and the shunts are being used, the thermal rise from the shunts is restricted to 85° C. The thermal rise of the shunt would be equal to the bridge, and as a guideline, the shunt thermal rise could equal the bridge.

The amplifiers can be supplied with different shunt loads as options.

Example for a MPA-06 in a highly regenerative application:

MPA-06 = 7 amps continuous

7 x 16 = (bridge rise)		112 watts
plus 30 watts	+	30 watts
plus 112 watts regenerative	+	112 watts
Total		254 watts

"-S" Separated Supply Option

The -S option amplifier allows for the removal of the dc voltages from the power devices within the amplifier that form the outputs RST. This is accomplished by removing the Main AC (bridge) input. The amplifier should be disabled prior to the removal of power and should not be enabled until this power is restored. Unless this process is followed, an erratic start up (jerking) of the motor shaft can occur because if the logic and amplifier are enabled with no available power for the bridge power device, the logic states produce maximum outputs to null the current and velocity loops. If the power to the bridge is restored during this condition, the motor may jerk. The reset/enable input of the MPA amplifier forces the logic states to minimal levels.

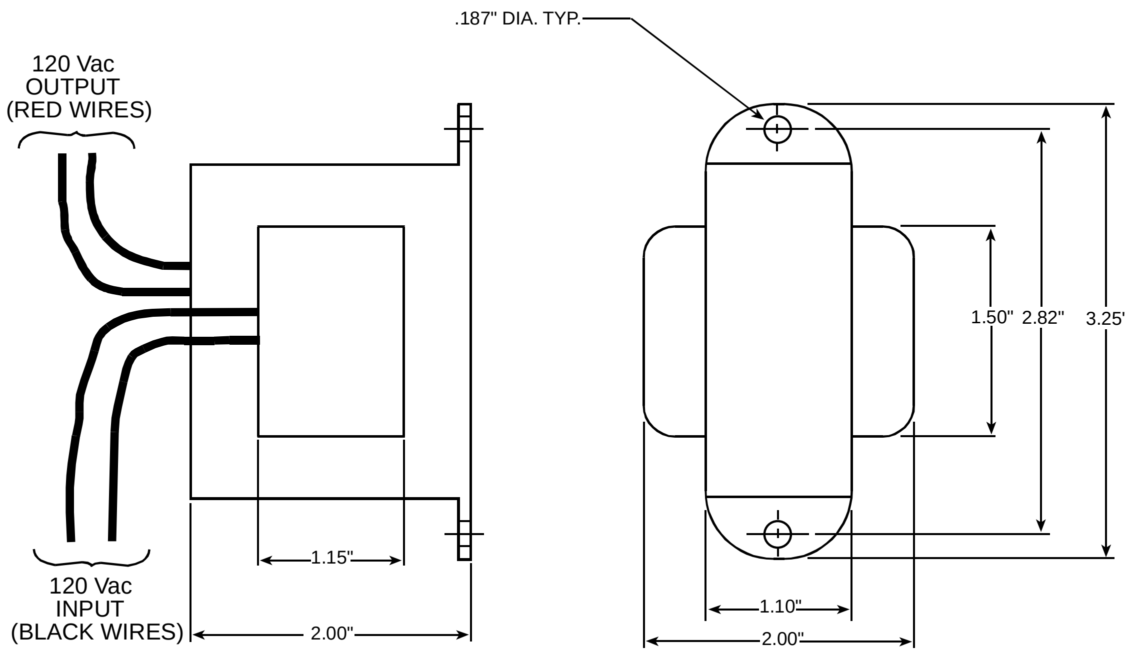
The MPA amplifier that has this option will have two additional terminals identified with an isolated AC input sticker. This is a low power (50-100 V-A) 120 volt input that cannot be connected to earth ground. Each MPA amplifier should have an isolation transformer to supply the isolated 120 Vac source. A 50 to 100 V-A rated transformer that operates from either a 240 or 480 Vac input would be sufficient.

A. The separated supply is returned to ground through the amplifier's internal connection. The ac line source for the amplifier should be bonded to earth ground.

B. This is a class 2 circuit that can only supply 100 V-A max.

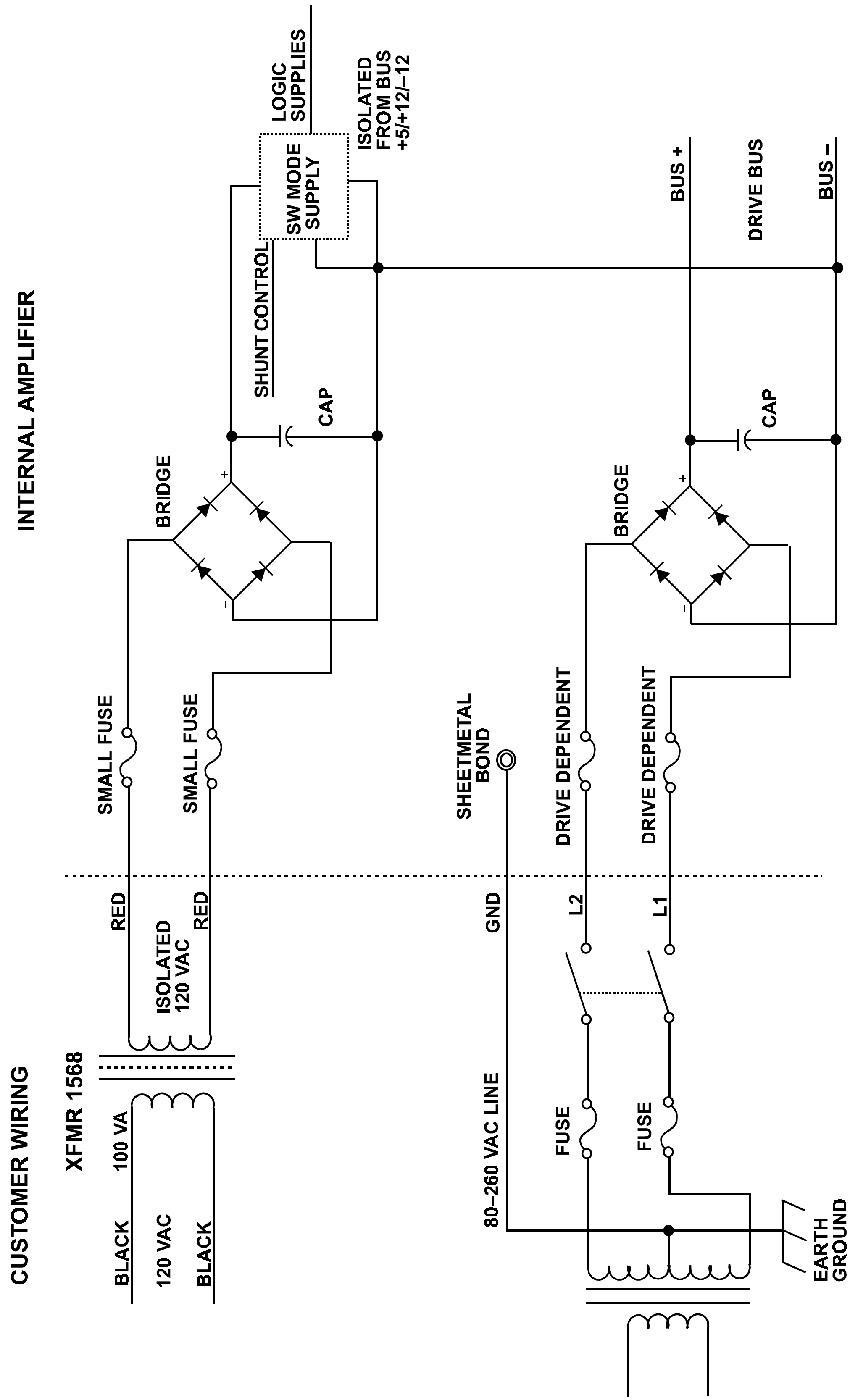
C. The wiring for this circuit is internal to the enclosure.

MTS Automation can supply the isolation transformer. The part number is 119719-97.



This transformer is for 120 Vac single-phase operation only.

Typical "-S" Single Phase Amplifiers



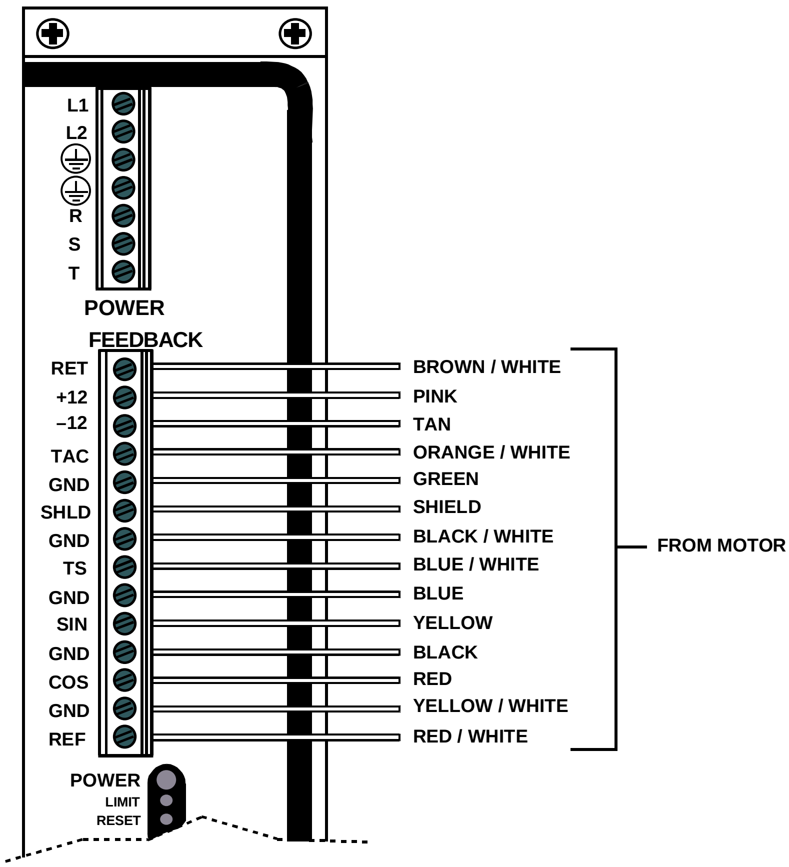
"-T" Brushless TAC Option

The MPA amplifiers use resolver feedback. The resolver provides positional information for commutation of the motor, simulated encoder signals and a velocity signal for the amplifier when the velocity mode is selected.

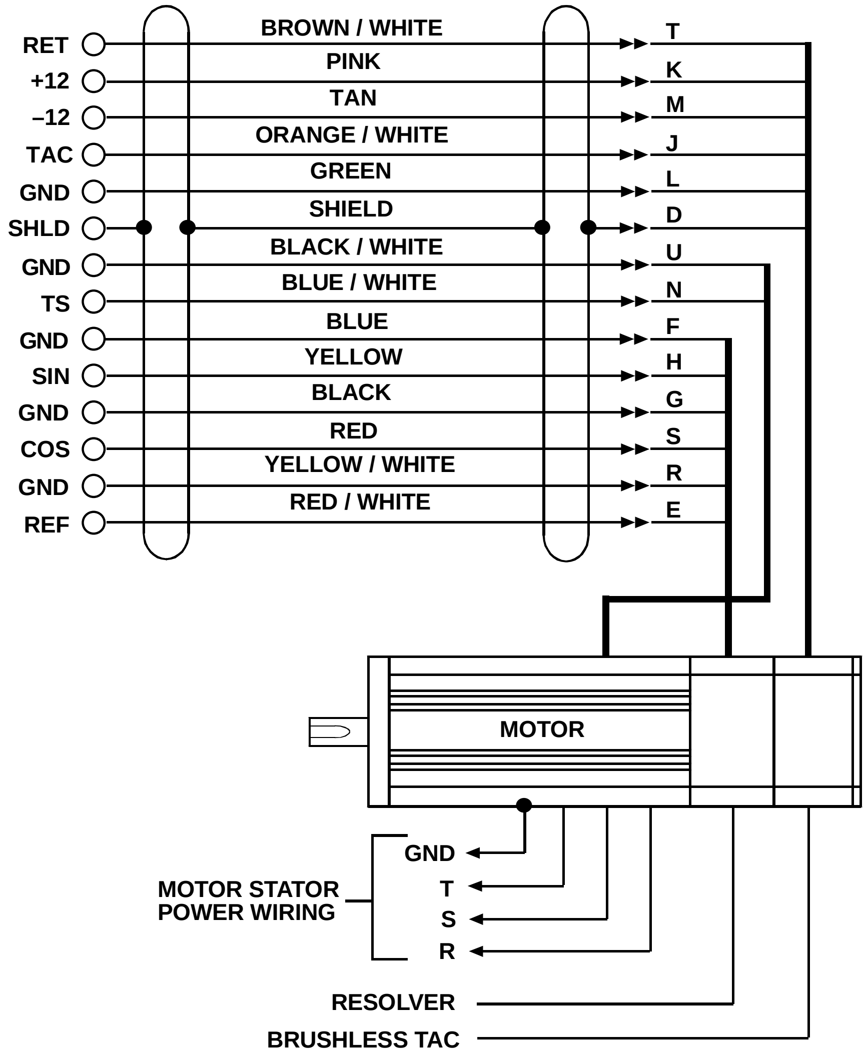
In some instances, the quality of the velocity signal derived from the resolver to digital converter compromises performance because of 2-Pole cyclic position ripple. The 2kHz excitation frequency used for the resolver reference may also be effected.

For the most demanding applications, the motors can be instrumented with a brushless tachometer to improve the quality of the velocity signal when the MPA amplifier is provided with the "-T" option. The feedback wiring is extended to facilitate the additional signals.

Typical Feedback Wiring



Typical Motor Connector



The amplifier is further changed so that the brushless TAC signal is processed through the amplifier's normal velocity paths. The difference is that TAC gain constants are now a function of the brushless TAC's gradient.

The brushless TAC gradient can be measured at the feedback connector between (TAC) and (TAC RET).

This voltage is processed through the amplifier's circuits that otherwise would have used the internal R-D circuits and as a result the DIP switch settings of SW1- 1 and 2 affect the gain.

If a brushless TAC with a gradient of 1 Vdc per thousand rpm is used, the TAC gradient found at the I/O connector, TAC, and GND would be as follows:

SW1	1	2	(TAC)
	ON	ON	2.06
	OFF	ON	4.12
	ON	OFF	4.12
	OFF	OFF	6.18

All normal amplifier adjustments remain the same.

Startup

Once normal wiring is verified, power can be applied to the amplifier.

Assure the DIP switch is set as required. Default settings are for 6-pole motors. Inputs Reset, +Limit, and -Limit are not going to disable the amplifier if they are not connected.

The CUR, RESP, and LEAD adjustments are turned down (CCW). Once power is applied, CUR can be slowly increased in a CW direction to achieve shaft torque. Crispness can be increased by a CW adjustment of RESP. Overshooting can be reduced with increased LEAD.

For start-up verification of wiring with external position controls, the following simple test can be used to verify the phase relationship.

To check the phasing of an external position controller, the following test can be done.

With the current limit turned full CCW or with the RST wiring disconnected, a CW rotation of the motor shaft will produce a negative command voltage at pin #9 (SIG) to pin #11 (GND) on the I/O (J1) connector. For a CCW rotation, a positive command must occur. The rotation is started from a null, or a close to zero shaft position. If the relationship is wrong, there are two choices:

1. interchange the A, A\ and B, B\ signals at the simulated encoder.

2. use the command - input for signal and pin #11 is still ground.

Either method works, but the first method still assures that positive command voltages cause CW rotation of the motor shaft as viewed from the shaft end of the motor.

Typical Wiring