Copley Controls Corp.

Model 200 Series Servo Controllers

Installation, Operation and Service Manual

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1. INSTALLATION PROCEDURE

> **CAUTION**
>
> Do not install the amplifier assemblies without first determining that all chassis power has been removed for at least 10 seconds. Also, NEVER REMOVE an amplifier from an installation with power applied. The following sections must be reviewed before installing to ensure reliable operation.

1.1 Servo Amplifier Mounting

Each Copley Controls' Series 200 Servoamplifier mounts flush to a metal surface with interfacing connector pins away from the mounting surface. Four 0.150-inch diameter through-holes are located on each amplifies module for this purpose.

If any of the Copley Controls' Series 600 Power Supplies are used, amplifier modules can be mounted directly to the power supply chassis. Otherwise the heatsink option for each amplifier is recommended. Check individual amplifier data sheets for these rating. (When ordering a heat sink, add an H suffix to the amplifier's model number (ie, 210H, 215H, etc.).

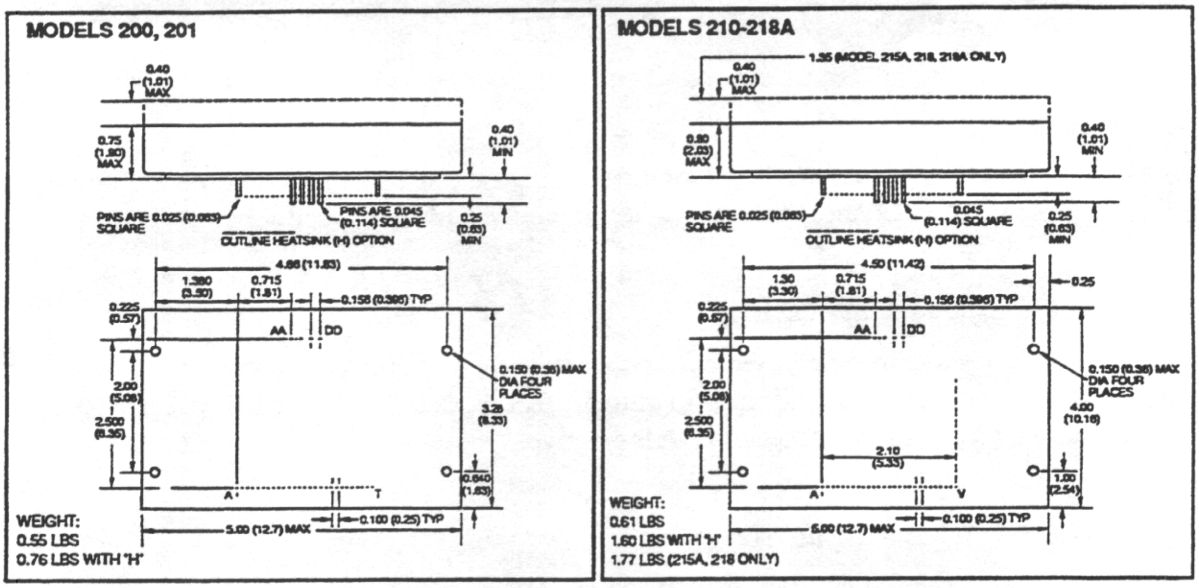


Figure 1: *Mounting dimensions for the Series 200 servoamplifiers*

Figure 1 provides the range of mounting dimensions for the Series 200 amplifiers. Note that overall height may change if Auxiliary Function Cards MB1 through MB9 are incorporated in the application. These cards, which plug into the amplifier's mating pins, provide external components that are accessible to the user. Their purpose is to configure amplifier performance to specific applications. Table 3, following Section 4.2 of the appendix, defines the Mating Card variations.

1.2 Minimum Inductance Requirement

Pulse width modulation (pwm) servoamplifiers deliver a pulsed output that requires a minimum amount of series inductance to reduce motor ripple current and prevent motor instability near voltage saturation. The minimum inductance values for different amplifier types is shown in Table 1 below. If the amplifier is operated below maximum rated voltage, the minimum load inductance can be reduced.

MODEL	MINIMUM INDUCTANCE
200/201	500 µH @ 50V, 250 µH @ 25V
210	500 µH @ 80V, 250 µH @ 40V[1]
215, 215A	250 µH @ 80V, 125 µH @ 40V[1]
216	1.4 mH @ 155V, 700 µH @ 80V[1]
217	700 µH @ 155V, 350 µH @ 80V[1]
218	500 µH @ 155V, 250 µH @ 80V[1]

1. When using these amplifiers with high inductance loads (L>2 mH) order (-1), i.e., Model 210-1.

Table 1: *shows minimum load inductance for Copley Controls Series 200 servoamplifiers*

1.3 Motor Wiring

Use a twisted shielded pair for the motor power cables. Ground the shields at both ends—to the amplifier's power ground pin DD and to the motor's frame. The motor itself is connected to amplifier output pins BB and CC.

1.4 Tachometer Wiring

Use twisted shielded pair. Ground the shield at one end only—to the amplifier's signal ground pin C. Connect the signal wires to pins M and C, respectively.

1.5 Input-Output Polarity

A positive input at the amplifier's reference-input pin A produces a positive output at the motor terminal CC. For proper velocity feedback, the tachometer input at pin M should be negative when the motor output is positive.

1.6 Reference Input Wiring

Use a twisted shielded pair. If the reference source can float (remain ungrounded), connect the cable shield to both the reference source common and the amplifier's ground pin C. It is recommended that the input be connected directly to the servoamplifier's differential input. Connect the reference source (+) to "ref input" pin A and reference source (-) (or ground), to "ref input" pin B. If the reference source is grounded to the master chassis' ground, leave the source-end of the shield unconnected. The servoamplifier's reference input circuit will attenuate the common mode voltage between signal source and amplifier grounds by 250 times, or 48 db, when fed from the low source impedance of a typical operational amplifier.

1.7 Chassis Ground

A single chassis ground point located as close as possible to the amplifier's power ground pin DD should be the only means of grounding the high voltage DC power supply and any other external supplies. If practical, the motor and tachometer should be mounted—hence grounded—to the same chassis.

The amplifier's internal metallic shell is connected to pin DD. If the amplifier is mounted against the chassis for cooling, it is particularly important that the connection between pin DD and chassis ground be very short (less than 4 inches).

Multiple amplifier channels powered by the same high voltage DC supply should be clustered around the chassis' master ground point to minimize ground lead length. Important—run separate wires from the master ground to pins DD on individual amplifiers; also—run separate HV+ power supply wires to each amplifier, do not 'daisy chain' power wires when using multiple amplifiers.

1.8 DC Power Supply

Copley's Series 200 servoamplifiers can operate from single-polarity unregulated DC power supplies. Reservoir capacitance of 4,000 µF per ampere of maximum output current will reduce ripple to 2 volts p-p at 120 Hz. Power supplies should withstand worst-case line voltage transients, and also absorb motor regenerative energy when stopping and reversing.

During braking, the servomotor returns its kinetic energy to the power supply capacitor, and in the process, can charge the capacitor to potentially dangerous voltages. Consequently, power supplies should have sufficient capacitance to absorb this energy without overvoltage and damage to the amplifier.

The Copley Controls' Series 600 Power Supplies are available (see appendix) and are connected according to Figure 2.

1.9 Amplifier—Power Supply Connections

Long inductive power supply leads can store enough energy to damage some amplifiers when the output transistors are switched off. Using parallel bypass capacitors can cause resonant ringing when combined with the lead inductance. All Copley Control's amplifiers incorporate metal film capacitors with a resistor to damp the ringing. Copley also recommends the use of a 580 µF capacitor with a maximum ESR of 0.1 ohms @ 100 KHZ to be physically located within 2" of the amplifier module's power pins. The high frequency energy of a pair of 20" #14 copper wires can be safely absorbed by this electrolytic capacitor, while its internal series resistance will damp out the ringing.

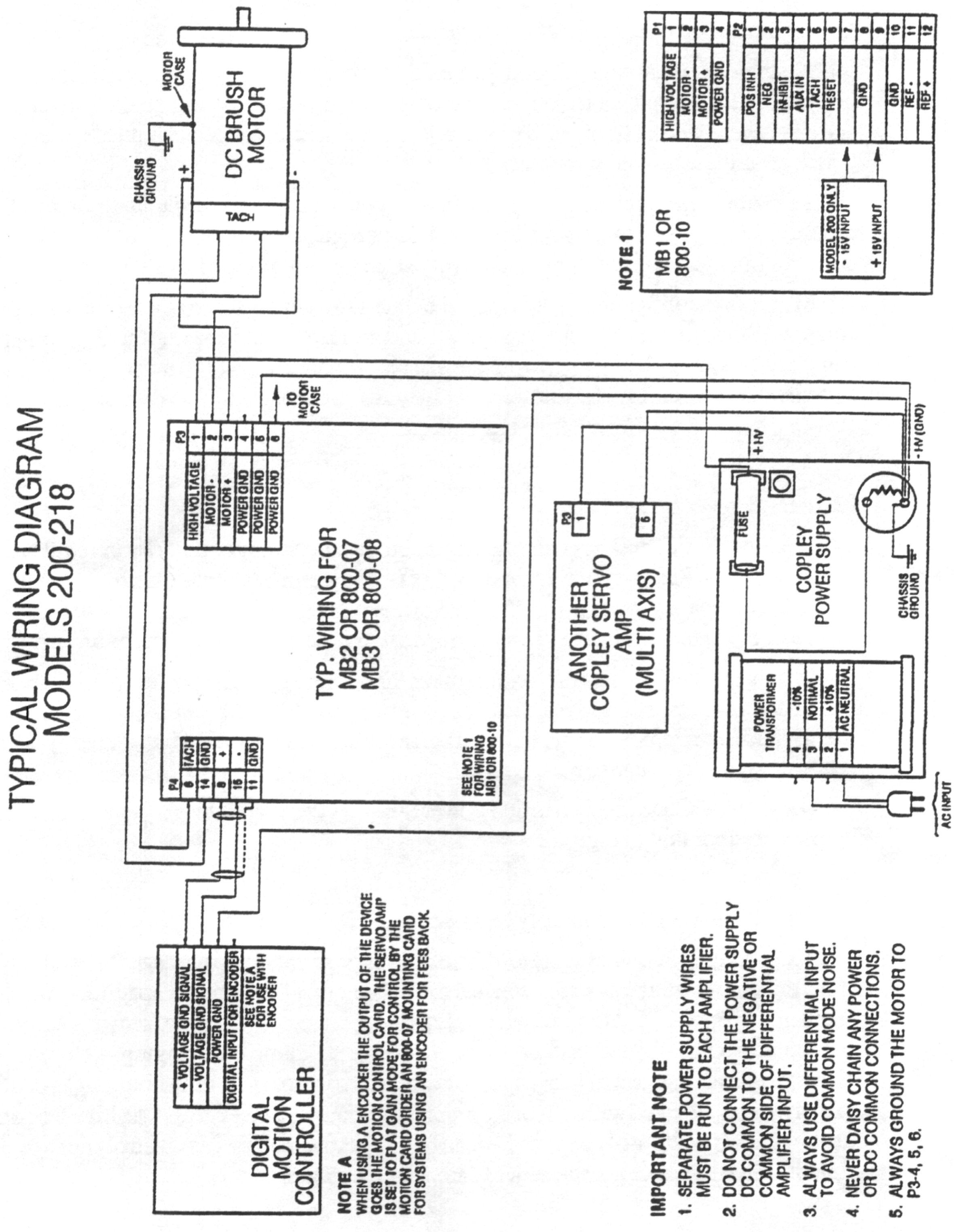


Figure 2: *Overview of connections between Series 200 servoamplifiers and power supply, plus controller and additional equipment.*

1.10 Multiple Amplifier Installations

When multiple amplifiers are installed in a single application, caution regarding ground loops must be heeded. Anytime there are two or more possible current paths to a ground connection, damage could occur. Or, noise can be introduced in the system. The following rules apply to all multiple amplifier installations, regardless of whether more than one power supply is incorporated.

1. Run separate power supply wires to each amplifier.
2. Do not connect the power supply DC common to the negative or "common" side of the differential amplifier input.
3. Always use the differential input to the amplifier to avoid common mode noise.
4. Never "daisy-chain" any power or DC common connections.
5. Always ground the motor to pin DD as noted in Section 1.7.

1.11 Auxiliary Connections

Copley Controls Series 200 amplifiers provide auxiliary functions through the various mounting cards (MB cards). These cards carry external components used to shape amplifier response, gain, and other parameters. The MB cards also define whether inhibits are normally-open or normally-closed. Figure 3 shows the outline dimensional for MB1 - MB3 cards.

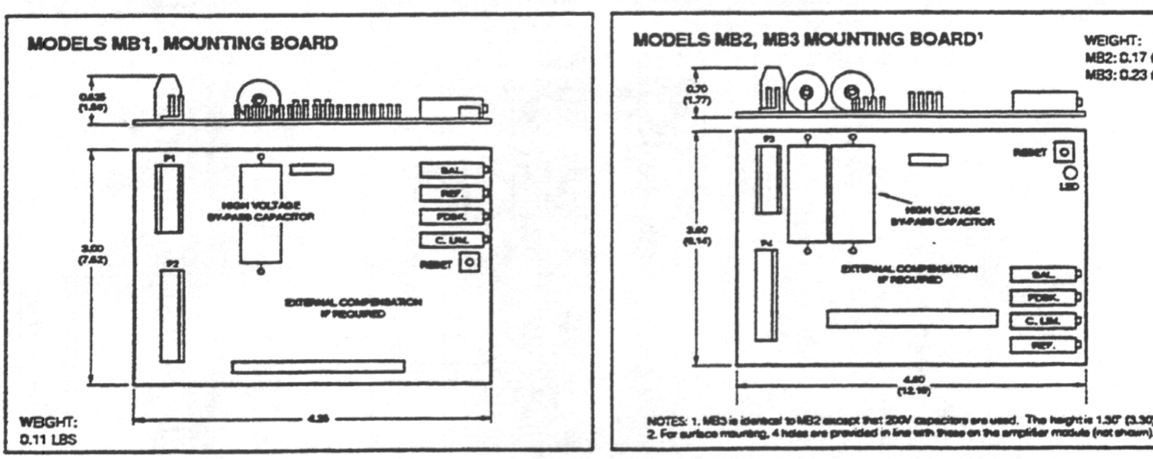


Figure 3: *Shows the component layout of plug-in auxiliary cards MB1 - MB3, which enable user to customize system parameters to their application*

Circuit configurations for the MB cards, along with their associated amplifier circuits, are presented in Figures 4A and 4B. Further information about MB9 use is included in Section 4.3.

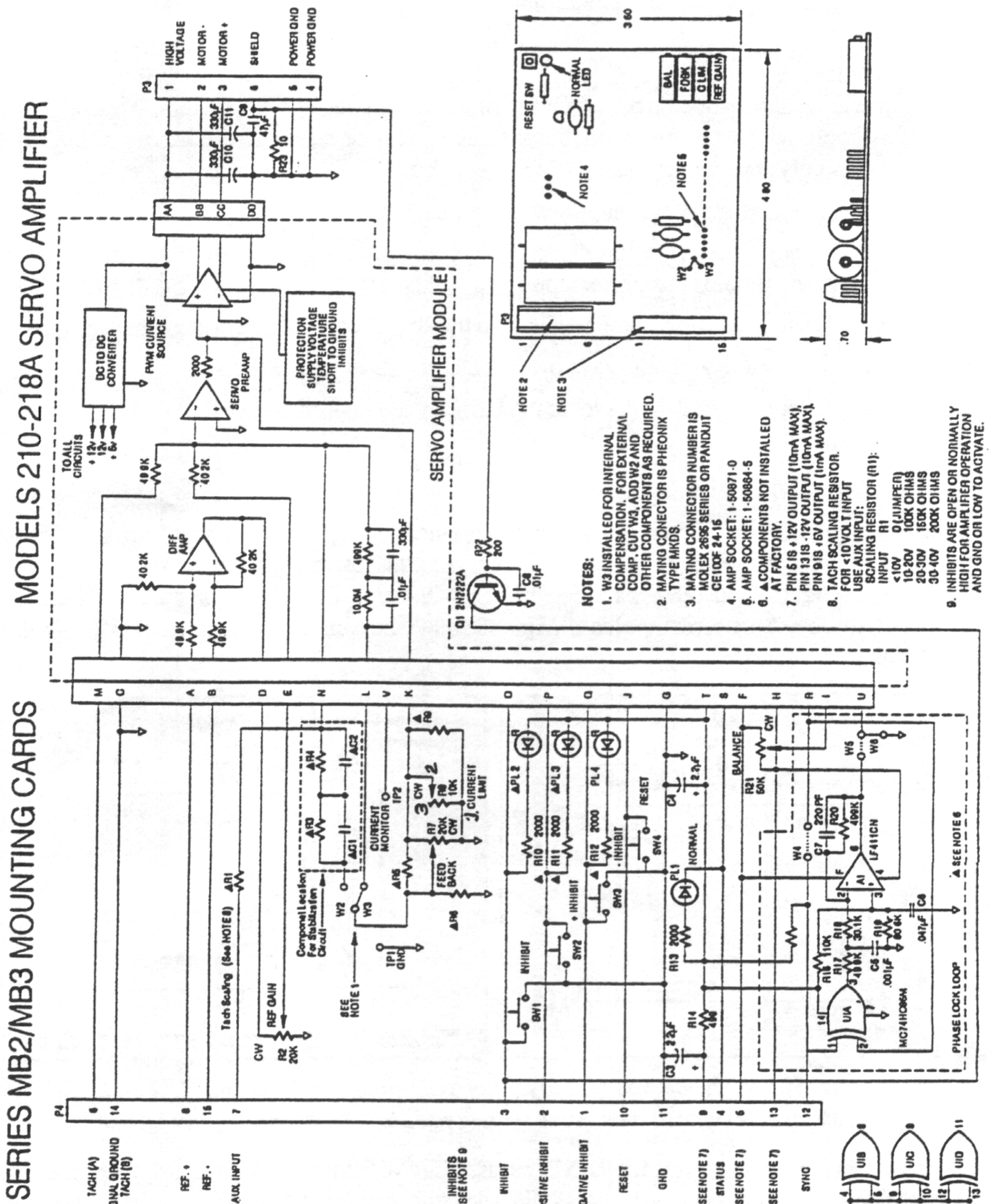


Figure 4A: *Schematic for MB2/MB3 auxiliary function card shows pin-connections between card and Models 210/218 A amplifiers, also the location of jumper and customer-selected amplifier stabilization components.*

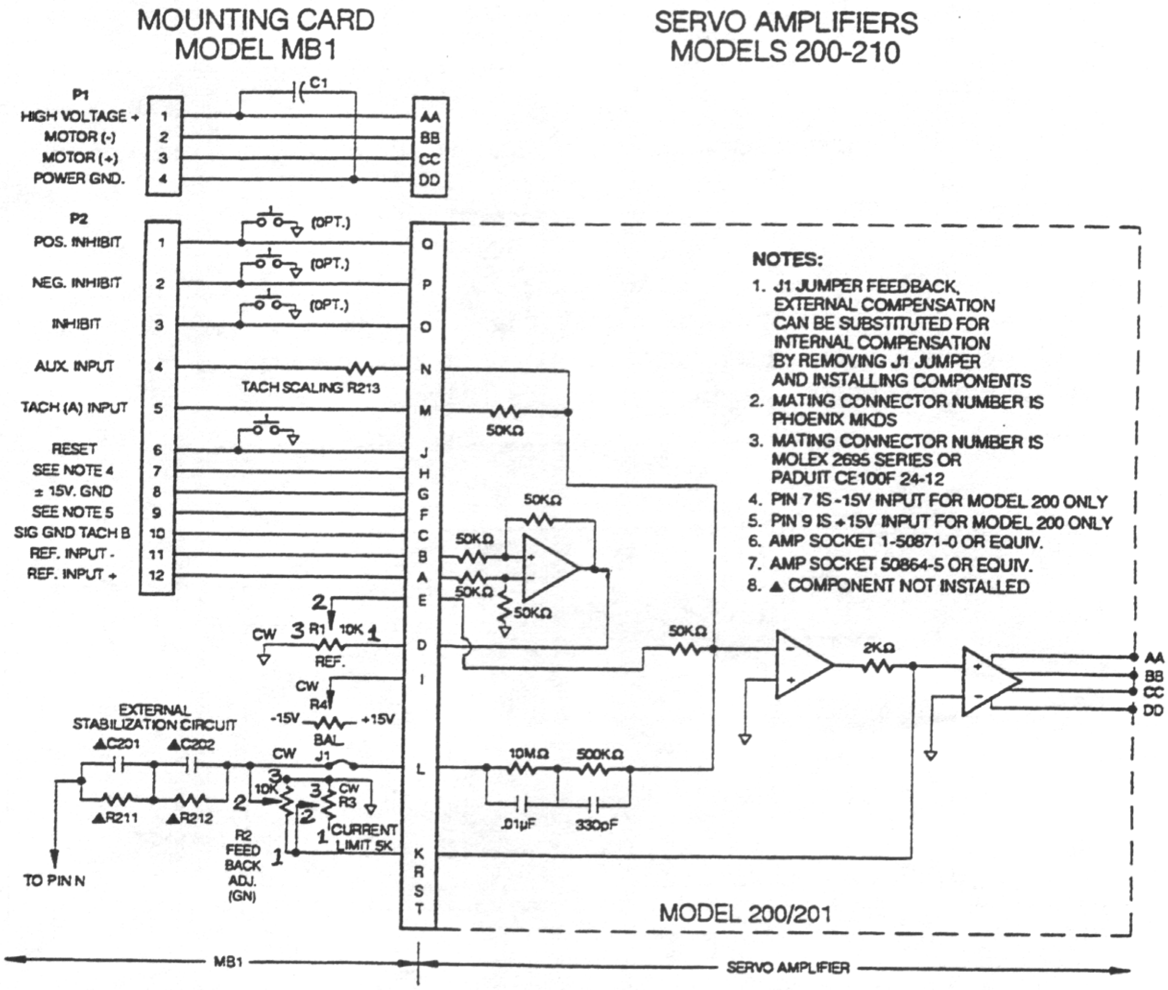
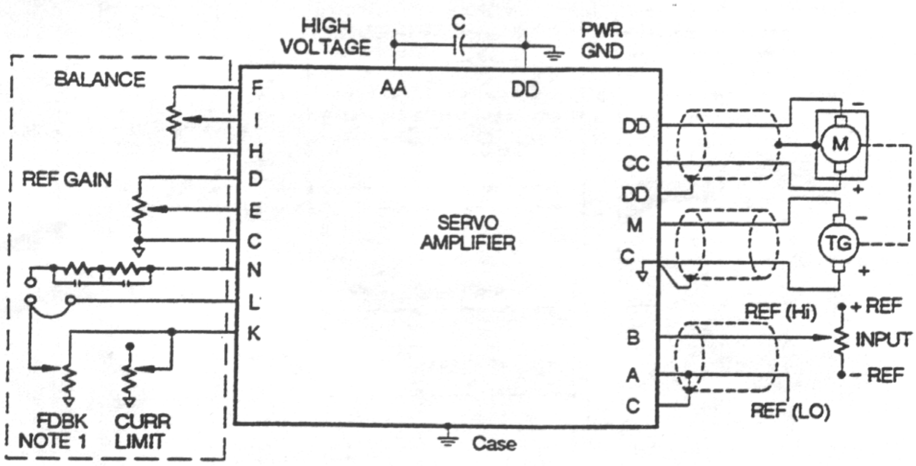


Figure 4B: *Schematic for MB1 function card, along with Models 200/201 servoamplifier internal wiring, shows amplifier stabilization connections.*

2. Amplifier Adjustment (Tuning) Procedure

> **CAUTION**
>
> These initial adjustments should be performed with the motor decoupled from the machine.

The outline drawings of the various Series 200 Auxiliary Function Cards, Figure 3, identifies the locations of all components available for adjustment. These MB function cards typically form an integral part of the amplifier in most applications. Figure 5 shows a typical amplifier, motor, tachometer connection scheme.



NOTES:

1. For external compensation, connect arm of feedback potentiometer in the network (Pin N). As shown, amplifier is connected with internal compensation (Pin L).
2. is signal ground (Pin C.)
3. is power ground (Pin DD, Case).
4. High voltage bypass capacitor (C) use low ESR type mounted close to amplifier. Typically 330 μF for Models 200/201/210 and 660 μF for Model 215, 215A, 216-218.
5. Refer to functional diagram for component values.

Figure 5: *Typical amplifier/motor/tachometer connection scheme.*

2.1 Initial Power-On Test

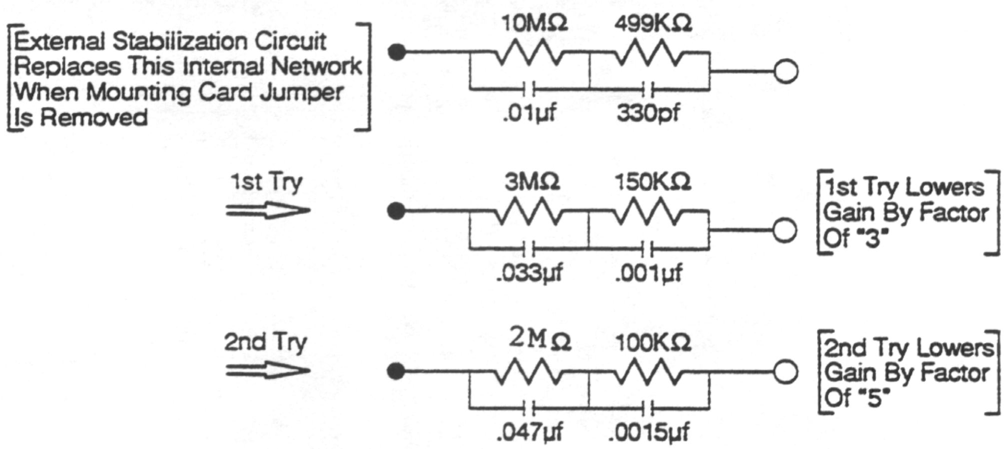
With a zero speed command applied, momentarily apply power to the controller. If upon application of power, the motor rapidly accelerates, a runaway condition exists, due most likely to a reversal of either the motor or tachometer wiring. If the motor and tachometer are properly connected, and the controller is functioning normally, the motor shaft should remain stationary or drift slightly in either direction with power applied.

2.2 Ground the Reference Inputs

Set the current limit potentiometer to approximately one-half maximum setting. Allow time for the amplifier and its power supply to have thermally stabilized. Trim the "balance" potentiometer for minimum amplifier output current by observing motor drift with REF inputs grounded. If the motor does not run away but emits a high-pitched squeal, turn the feedback potentiometer CW until it stops. If the squeal persists, the internal gain is too high and can be lowered by adjusting external component values on the appropriate MB card as follows:

The following steps apply to the MB1 and MB2/MB3 component cards:-

1. Ground the motor's case
2. Ground the input pins P4 - 11 for MB2/MB3, or P2 - 11 for MB1
3. First remove jumper W3 on MB2/MB3 or cut jumper W2 on MB1, to introduce customer-selected component values. Now try the following values for R3, C1, R4, C2 (for MB2/MB3) or R211, C201, R212, C201 (for MB1).



2.3 Alternative Method: Loop Response

Many variables are present in servo system designs, so it is desirable to have access to the components that adjust servo loop response. In many cases, the internal compensation network available at pin L, used in conjunction with an external potentiometer, will provide good stabilization. (See Figure 6 for amplifier response with "internal" compensation). If this method is inadequate, and full knowledge of the motor parameters is unavailable, use the following simple procedure to determine near-optimum RC network for servo stabilization. For this purpose, it is necessary to be able to feed in a small step at the reference input, and observe the error signal on an oscilloscope at pin K. Motor current is proportional to pin K voltage.

1. Connect an external compensation network consisting of a 499 kΩ resistor in parallel with a 330 pF capacitor from the arm of the feedback potentiometer to pin N. Adjust the feedback potentiometer to the point where the system oscillates—then back off slightly. If oscillation occurs at a frequency above 1000 Hz, it may be necessary to slightly increase the 330 pF capacitor value to better filter out any high peak due to shaft resonance. Otherwise, simply set the feedback potentiometer to produce suitable transient response consisting typically of a single overshoot without additional ringing.

2. Add a capacitor in parallel with 10MΩ in series with the parallel network of 499KΩ and 330 pF. Start with a large capacitor and then select the smallest value that does not materially increase servo system ringing.

   If there is any noticeable vibration or instability, reduce feedback for 1/2 turn or more.

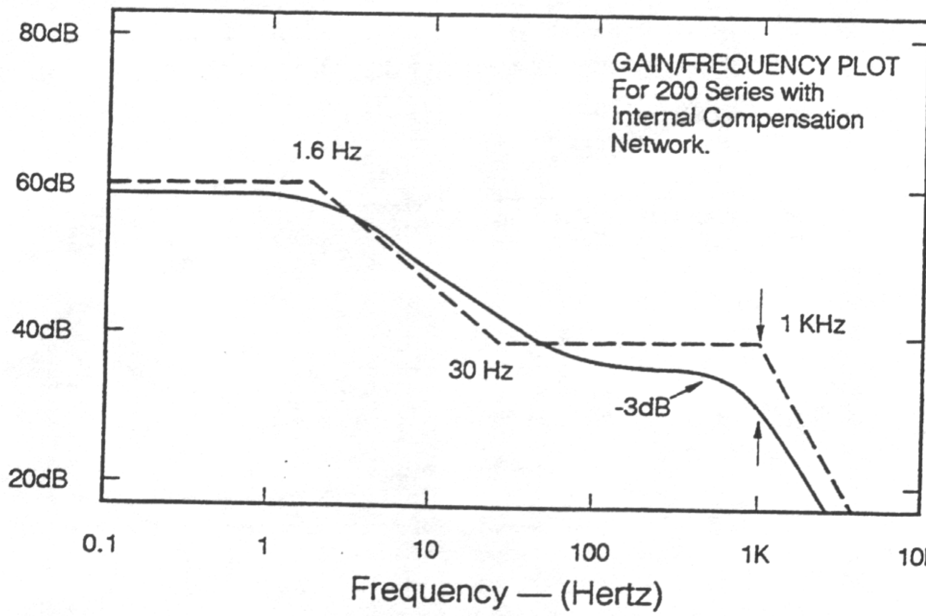


Figure 6: *Amplifier loop response with internal compensation—which can be application configured by changing components on auxiliary mounting board MB1*

2.4 Tachometer Scaling

Many industrial servo motors have high voltage tachometer outputs for operating speeds of 3000 rpm or more. Tachometer gradients of 31volts/1000 rpm are not uncommon.

Because the Series 200 amplifiers have high gain input preamplifiers, tachometer gradients of 10 volts/1000 rpm or greater may cause saturation. Scaling the tachometer input is recommended when gradients exceed 10V/1K rpm. Caution is necessary in choosing scaling resistors if extreme low velocity is also required in the application. Figures 4A and 4B show typical location for the additional tach gradient resistors.

Scaling resistors should be selected so as to not load the tachometer (approximate 10k minimum load), keeping the applied voltage to less 9 volts between pins M & E.

3. TROUBLESHOOTING

CAUTION

Exercise caution during maintenance and troubleshooting. Potentially lethal voltages exist within the amplifier and auxiliary assemblies. Only qualified personnel should work on this equipment.

3.1 Fault Determination Procedures

Table 2 summarizes the 200 Series protection circuits and the protective actions taken.

To aid troubleshooting, the Series 200 amplifiers provide a green LED indicator on all Auxiliary Function Cards. When the LED is illuminated the amplifier is active (no fault or inhibit conditions exist). If the LED is not illuminated either a fault condition per Table 2 has occurred, or an inhibit input is active. A manual RESET pushbutton is located adjacent the LED on all Auxiliary Function Cards. Actuation of this pushbutton should clear the fault if the fault condition has corrected itself. If not, then a step-by-step fault-diagnosis check is necessary per Table 2.

REMOTE SHUTDOWN[1]	
INHIBIT	SWITCH CLOSURE INHIBITS OUTPUT.
POSITIVE INHIBIT	SWITCH CLOSURE INHIBITS POSITIVE OUTPUT.
NEGATIVE INHIBIT	SWITCH CLOSURE INHIBITS NEGATIVE OUTPUT.
AMPLIFIER PROTECTION	
OVERLOAD	CURRENT LIMITER.
HEAT SINK TEMP.	SHUTDOWN 95°C.
LATCH OFF	UNTIL REAPPLICATION OF POWER OR DEPRESSION OF RESET BUTTON.
OVER VOLTAGE SHUTDOWN	TEMPORARY, ABOUT HV
UNDER VOLTAGE SHUTDOWN	WHEN ANY SUPPLY IS BELOW MINIMUM.
SHORTS	ACROSS OUTPUTS OR EITHER OUTPUT TO GROUND.
CURRENT MONITOR	±6V/FS
STATUS	TTL LOW INDICATES NORMAL OPERATION. TTL HIGH INDICATES AMPLIFIER FAULT.

1. When Using MB9 User May Select Inhibit Or $\overline{\text{Inhibit}}$ Option.

Table 2: *Protection Circuit*

3.2 Overload Fault

1. Check to see if the motor shaft freely rotates with no power applied. The load on the motor must be free of jams.
2. Reset the fault and monitor current during motion. If loads have increased beyond the controller's continuous rating, then the condition must be corrected before continuing the operation.
3. Check the duty-cycle. Frequent peak current commands will cause an overload condition. Reducing duty-cycle or current-limit value will correct the condition.

3.3 Heat Sink Temperature

1. Check that the ambient temperature of the installation does not exceed rated specifications. A thermistor internal to the amplifier will cause inhibit for excessive case temperature.

3.4 Overvoltage Shutdown

1. Check the power input voltage for a value in excess of those listed in data sheet. If larger than listed, then 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 power supply voltage. If the supply voltage increases above specified values, then additional power supply capacitance is necessary. Systems taking longer than 50 ms to decelerate to zero velocity at maximum current limit setting usually require proportionately more capacitance than supplied with the Series 600 Power Supplies. Additional capacitors must be electrolytic type and located as close to the controller as possible. An active regenerative circuit (dumper) can be used. Copley Model 121 or equivalent.

3.5 Under Voltage Shutdown

Check power supply voltages for minimum conditions per specifications.

3.6 Short Circuit Fault

1. A short circuit causes an overload fault.
2. Measure the output of amplifier for short condition with motor disconnected. Also check each output with respect to ground for shorts to ground.
3. Measure motor armature resistance with the amplifier disconnected.

3.7 Status

Check positive inhibit, negative inhibit and full inhibit inputs for proper input in accordance with the Mounting Card incorporated.

3.8 Other Concerns

1. Erratic Operation
   - A. Improper grounding. Refer to Section 1.9 (also Fig. 3).
   - B. Noisy command signal. Check for system ground loops.
   - C. Mechanical backlash, deadband, slippage, etc. Always check loads frequently for positive mechanical coupling.
   - D. Excessive tachometer noise causes high ripple currents or, in many cases, motor oscillations (in the form of shaft vibration). A typical 1000Hz band-pass filter can be added to the Auxiliary Function Card in series with the tach input. Typical values are to 5kμΩ resistors and 0.1μF capacitor in a "T" filter configuration.
2. Always make sure the installation is properly grounded to "earth". It may be necessary for a ground rod installation at the machine in extremely noisy conditions.

3.9 Factory Repair Service

Copley Controls does not advise field repair of the Model 200 Series. Defective assemblies should be returned to the original equipment manufacturer, or with his advice to Copley Controls.

1. Collect the following information when returning a defective assembly:
   - A. Model number (from serial tag on side of amplifier)
   - B. Serial number (from serial tag on side of amplifier)
   - C. Reason for return/description of problem
2. Call the Copley Controls authorized repair agent and give the above information and request a Return Material Authorization (RMA) number.

4. APPENDIX

4.1 Series 600 Unregulated DC Power Supplies

The Series 600 power supplies have been designed to complement Copley Controls' Series 200 servo controllers and to provide the user with a complete solution to single- and multi-axis DC drive applications. The Series 600 unregulated DC power source is an acceptable solution for most applications where output variations and AC ripple components can be tolerated. These unregulated power supplies are designed to provide the best cost-per-watt value. Their output varies with different loading conditions as well as changes in the AC line input. To minimize the effect of load variations, a bleeder resistor has been added to keep a minimum load on the supply, and thereby, move the operating point away from the zero load point. Copley Controls' unregulated power supplies have tapped primary windings to optimize the output voltage under actual load conditions. Ripple is a maximum of 3% of the output voltage at full rated load, and the output is fuse protected. Because of the requirement of peak load currents in most servo applications, the Series 600 power supplies have been designed to provide 1 second peak currents at 2.5 times nominal rating with a 20% duty cycle.

4.2 Position Loop Applications

When connecting the amplifiers to any position control, the type of command from the position control must be known, i.e., velocity command or current command.

If the position control commands velocity, then normal adjustment procedures apply; however, if the position control commands current, then the servo controller can only be used as a current amplifier. In these cases, the velocity loop compensation is negated by incorporating a flat gain option (pure DC gain with no frequency compensation) on the Auxiliary Function Cards (Table 3.)

MOUNTING CARDS DESCRIPTION	
PART NO.	**DESCRIPTION**
MB1 800-10	Mounting card for 200, 201 amplifiers. MB1, factory set for 'Flat Gain'.
MB2 800-07	Mounting card for 210, 211, 215, 215A amplifiers. MB2, factory set for 'Flat Gain'.
MB3 800-08	Mounting card for 216, 217, 218, 218A amplifiers. MB3, factory set for 'Flat Gain'.
MB9 MB10	Multifunction card, user set 'Flat Gain'. MB9 with 200V Capacitors for 216-218A series.

Table 3: *Defining MB Cards*

4.3 MB-9/10 Board Application Notes: General Description

The MB-9/10 board is a platform for a multitude of motor control applications using the Series 200-218A PWM servo-amplifiers.

The MB-9 mounting board attaches to a Series 200-218A amplifier, and provides a number of standard features, as with our other MB boards:

1. High-voltage by-pass capacitors on the board provide filtering and reduce ripple on the high-voltage supply.
2. A six-position, screw-terminal connector provides quick connection to the high-voltage supply, motor, and cable shields.
3. Potentiometers are provided for input-balance, amplifier current limit, and compensation.
4. Reset switch and status LED aids in fault diagnosis.

In addition, the MB-9 provides:

Easy selection of flat-gain, voltage-control (armature-feedback), current, and servo feedback loops.

Easy selection between active-high and active-low inhibits.

P3, POWER AND LOAD

-1 HIGH-VOLTAGE
-2 LOAD+ (BB)
-3 LOAD- (CC)
-4 HIGH-VOLTAGE RETURN
-5 HIGH-VOLTAGE RETURN
-6 SHIELD

P2, SIGNAL-MATING CONNECTOR IS MOLEX 2695

-1 INHIBIT-	-6 TACH	11 GROUND
-2 INHIBIT+	-7 AUX INPUT	12 SYNC
-3 INHIBIT	-8 REF+	13 -12V
-4 STATUS	-9 +5V	14 SIG GROUND
-5 +12V	10 RESET	15 REF-

NOTE: 10mA MAX, ±12V
1mA MAX, 5V

MB-9 INHIBIT LOGIC SELECTION

FUNCTION	LOW TO ACTIVATE	HIGH TO ACTIVATE
NEG. INHIBIT	JUMPER 6-7	JUMPER 5-6
POS. INHIBIT	JUMPER 9-10	JUMPER 8-9
INHIBIT	JUMPER 12-13	JUMPER 11-12

MB-9 GAIN SELECTION

FLAT GAIN	JUMPER 16-17; INSTALL: C1 = 680 pF R3 = 34.8 K Ω R4 = JUMPER C2 = OPEN
INTERNAL COMPENSATION	JUMPER 17-18
ARMATURE FEEDBACK (VOLTAGE MODE)	JUMPER 1-2 JUMPER 3-4; INSTALL: C1 = 470 pF C2 = 0.01 µF R3 = 49.9 K Ω R4 = OPEN INPUT VIA P2-6, (TACH), or P2-7

Table 4: *Signal Assignment For MB-9 Board*

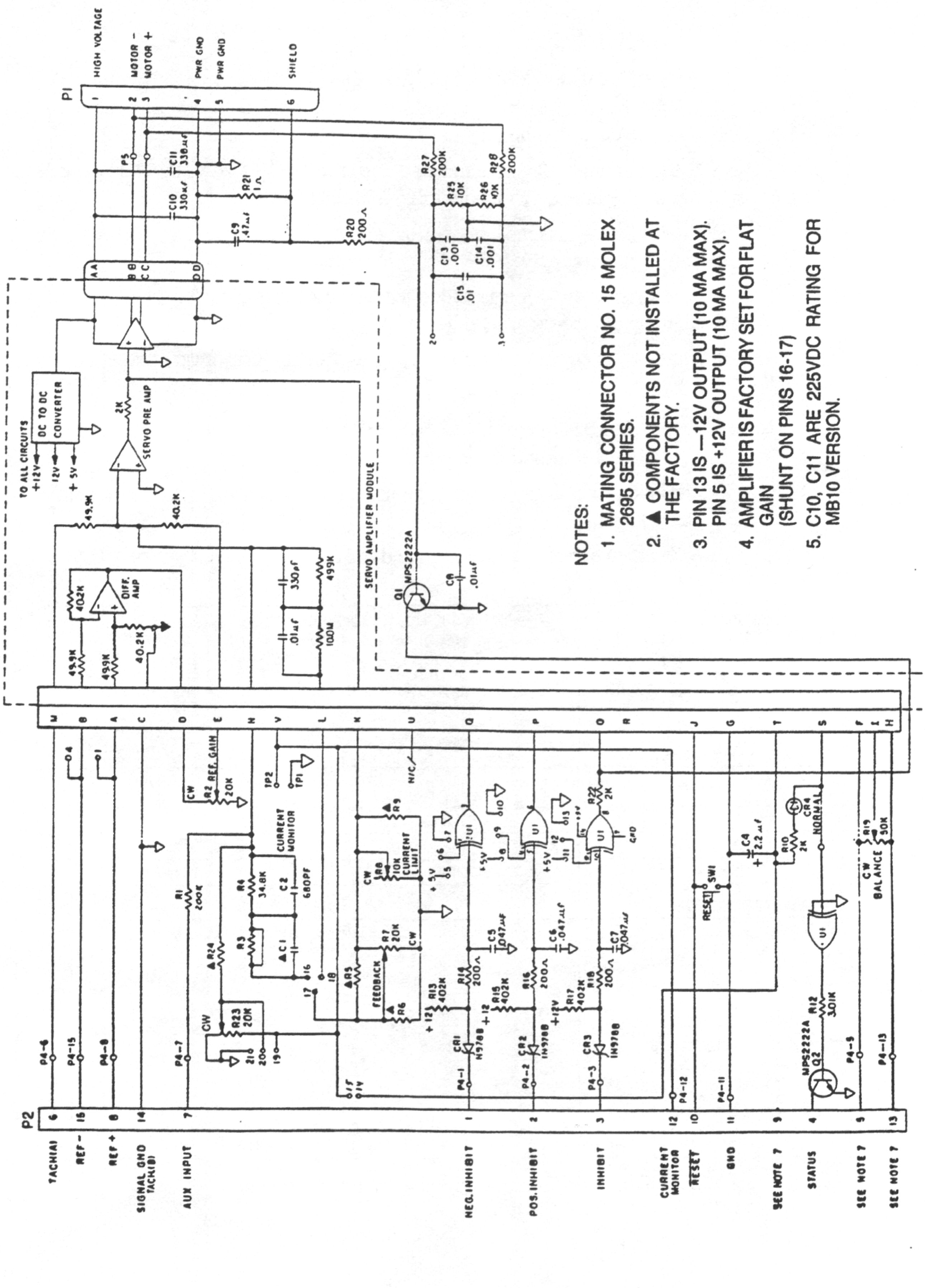


Figure 8: *Schematic For The MB9/MB10*

How To Destroy A DC Servo Amplifier (General cautions from our engineering department.)

Use Insufficient Power Supply Capacitance

This problem occurs particulary 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 500 µH motor at 20 amperes can charge 2000 µF up to 10 V. However, a 10 mH motor can charge 2000 µF as much as 45 V, causing output transistor failure.

An appropriate capacitance is typically 2000 µF/A maximum output current for a 60 V supply. Systems that take longer than 50 ms to decelerate to zero at maximum current may require proportionately more capacitance or an electronic energy absorber.

Always use a local electrolytic bypass capacitor as recommended in the application notes. In Addition, locate much of the main power supply capacitance close to the amplifier so as to relieve the carrier ripple current load on the local capacitors.

Spin The Motor Without Power

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

Short The Motor At High 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 be bad for the motor. If the connection arcs or opens while the motor is spinning rapidly this high current flows back into the amplifier due to stored energy in the motor's inductance and may damage the amplifier.

Reverse The Power Supply

Enough Said.

Causes of Erratic Operation

Improper Grounding

Failure to ground each amplifier, its signal source, and the power supply at a single master chassis ground point within a few inches of all amplifiers may cause common mode noise voltages and crosstalk between axes. Use a shielded twisted pair of reference input wires to reference the negative amplifier input to the source common. Connect as outlined in the application notes.

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