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Electro-Craft

MAX-400

PWM SERVO DRIVE

INSTRUCTION MANUAL

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March 1990

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WARNING

DANGEROUS VOLTAGES ARE PRESENT IN THIS EQUIPMENT!

CONTACT WITH LIVE PARTS COULD CAUSE SERIOUS INJURY OR DEATH!

REFER CONNECTION, INSTALLATION, MAINTENANCE, ADJUSTMENT, SERVICING AND OPERATION TO COMPETENT PERSONNEL.

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SECTION I - INTRODUCTION

1.1 Purpose

This manual describes the function and theory and application of the Robbins & Myers/Electro-Craft MAX-400 servo amplifiers and provides information related to their performance, operation and maintenance. This manual is addressed to the customer engineer or technician involved in the installation and maintenance of the MAX-400 amplifier. It is assumed that the customer personnel are trained in the use of mechanical and electrical test equipment and are familiar with basic servo system maintenance procedures.

1.2 Introduction

Figure 1-1 shows the Robbins & Myers/Electro-Craft MAX-400 amplifier. MAX-400 series amplifiers are designed to drive permanent magnet, brushtype, DC servomotors. The amplifiers and motors are intended for use in a broad range of industrial servo applications, including machine tool and robotic applications, and are used in both velocity and position type servo systems. Each amplifier is a self-contained unit, ready for mechanical installation and electrical interconnections to the AC power transformer, motor-tachometer, and controller.

1.3 Recommended Reference Material

The following handbook is a useful reference source and is available from Robbins & Myers/Electro-Craft:

DC Motors, Speed Controls, Servo Systems, an engineering handbook Robbins & Myers/Electro-Craft 5th edition, 1980.

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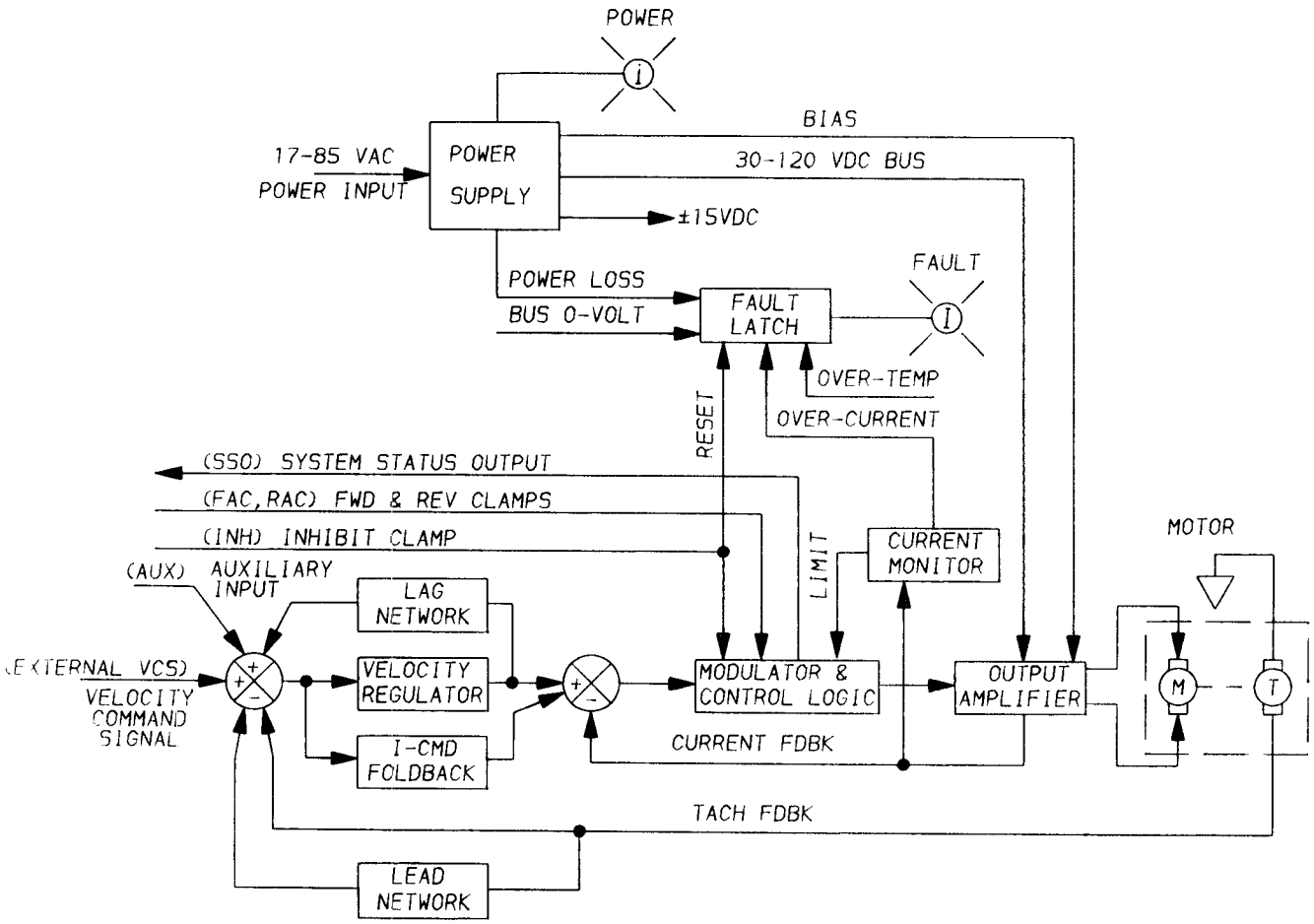


Figure 1-1 System Functional Diagram

1.4 Functional Description

The Robbins & Myers/Electro-Craft MAX-400 is a controllable power source for brushtype, DC servo motors. Usually configured as a controlled velocity system, the amplifier interfaces with a controller which provides an analog voltage signal proportional to the desired motor velocity. Refer to Figure 1-2 for a functional diagram. The MAX-400 amplifier contains circuitry for protection of both motor and amplifier from effects of various overload and short circuit conditions. The MAX-400 is a 20 kHz pulse-width modulation (PWM), switching type amplifier that reduces system power losses. Motor speed is precisely controlled down to a maximum torque, low velocity condition.

The MAX-400 amplifier also contains automatic current foldback if the RMS current exceeds ± 15.0 amp. This feature will protect the amplifier and motor from over-current conditions.

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SECTION II - SPECIFICATIONS

2.1 Performance Specifications

Peak Motor Current	±30.0 Amps
Maximum continuous motor current	±15.0 Amps
Motor supply voltage	30-120 VDC

2.2 Electrical Specifications

Automatic current foldback	Approx. 50%
Foldback time constant	0.05 Sec. at 30.0 Amps
Recovery time constant	1.0 Sec. at 10.0 Amps
Switching frequency	20 kHz nominal
Typical VCS signal input voltage	±10 V (±20 Max.)
VCS input impedance	22 kOhms
Typical input amplifier drift	10 uV/^{o}C
Dead band	Zero
Maximum continuous shunt power dissipation	50 Watts
Motor current output monitor (1 kohm output impedance)	±1.5V=±30 Amps
Auxiliary ±15 VDC supply	15 milliamps

2.3 Input Power Requirements

Isolated AC Input Voltage	20-85 VAC
Frequency	47-63 Hz

2.4 Physical Specifications

Height		10.25 in.(260 mm)
Width		2.95 in.(75 mm)
Length		7.30 in.(185 mm)
Weight		6.6 lbs.(2.90 kg)
Ambient Temperature	- Operating	32^{o} to 122^{o}F (0^{o} to 50^{o}C)
	- Storage/Shipping	-40^{o} to 158^{o}F (-40^{o} to 70^{o}C)
Relative Humidity		5% to 95% non-condensing

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SECTION III - INSTALLATION

3.1 General Information

All wiring and mechanical instructions described in this section should be made with reference to drawing numbers 9097-0608, 9097-0609 and 120 or 240 VAC input power/motor wiring diagrams, Figure 3-1 or 3-2 (whichever is applicable).

3.2 Mounting

The drive must be mounted in the vertical position (heatsink fins must be vertical) away from other heat producing devices. In multiple axis applications, minimum of 1.0" separation between each chassis is recommended.

3.3 AC Input

AC input power to the MAX-400 must be supplied by an isolation transformer with an output of 20-85 VAC. Do not apply greater than 85 VAC to the AC input terminals of P3.

3.4 Grounding Connections

The grounding connections for AC power, chassis and motor must be connected as shown in Figure 3-1 or 3-2 (whichever is applicable).

3.5 Multiple Axis Power Wiring

The isolated AC supply may be common to more than one drive as shown in Figure 3-3. The power leads from each drive should terminate at the transformer terminals as shown on the drawing.

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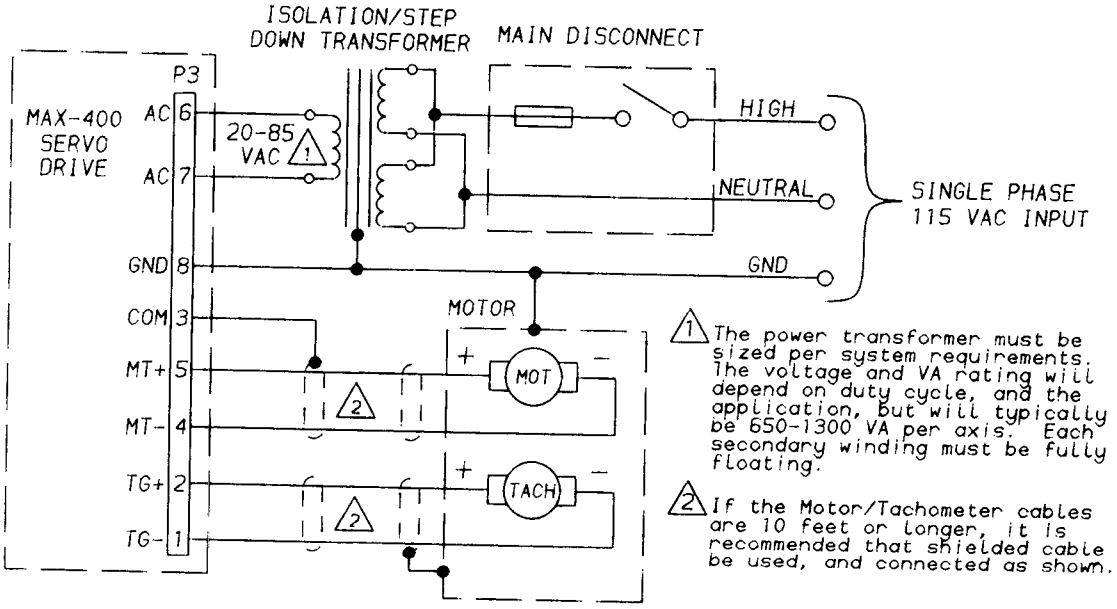


Figure 3-1 115 VAC Input Power/Motor Wiring

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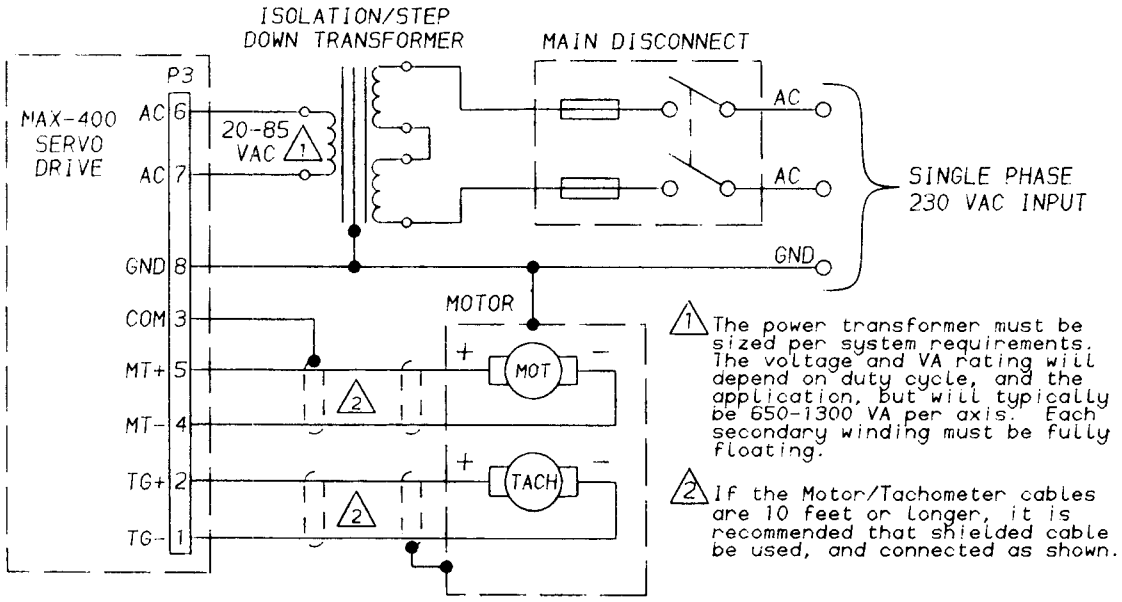


Figure 3-2 230 VAC Input Power/Motor Wiring

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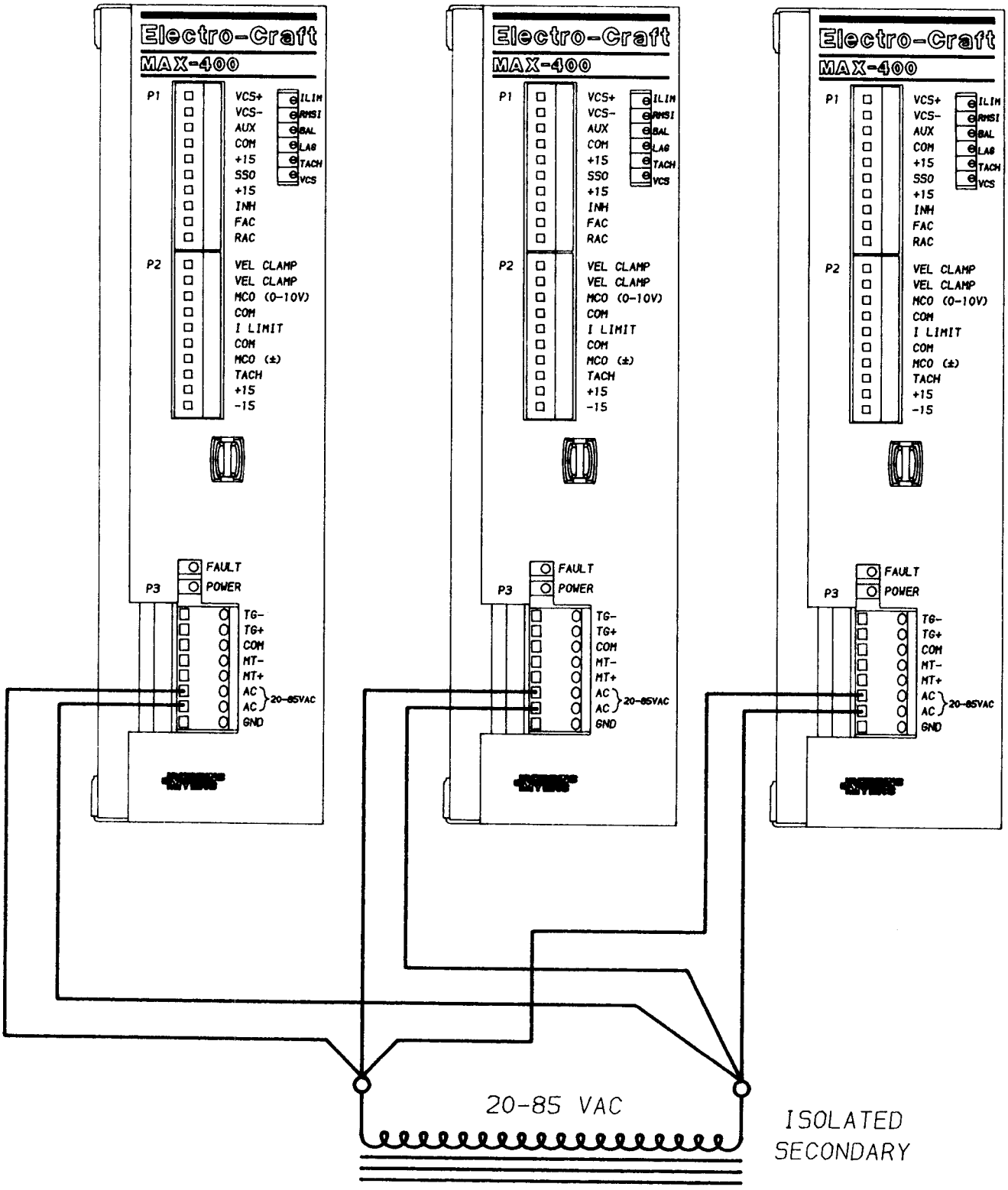


Figure 3-3 Multiple Axis Power Wiring

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SECTION IV - INTERFACE CIRCUITRY

4.1 External Interface

For connection details see Figure 4-1 and 4-2.

4.1.1 Velocity Command Signal (VCS)

This input signal on P1 pins 1 and 2 controls motor speed and direction. When a positive voltage is applied to pin 1 with respect to pin 2, the motor shaft will rotate CW facing drive end of motor. A negative voltage applied to pin 1 with respect to pin 2 will command CCW. Input signal range is ± 10 VDC.

This input signal is conditioned through a differential amplifier to reduce noise. Proper shielding is recommended, as shown in Figure 4-1.

4.1.2 System Status Output (SSO)

This output signal on P1 pin 6 provides information on the operational status of the MAX-400 amplifier. This signal is assigned a logic level "1" value to indicate "amplifier ready" status. A logic level "0" value of this signal indicates a detected fault condition (with simultaneously inhibited output stage). This output is an open-collector NPN transistor. P1 pin 5 has been provided with a 1k resistor that may be connected to P1 pin 6, to provide a +15 volt pull-up signal to this transistor.

DS1 (red) on the amplifier also turns on when a fault condition occurs.

4.1.3 Forward and Reverse Clamps (FAC, RAC)

The forward amplifier clamp (FAC) and reverse amplifier clamp (RAC) are directional clamps which when activated stop the operation of the motor in the corresponding direction, allowing operation in the opposite direction.

Forward is defined as CW motor shaft rotation facing drive end of motor. Reverse is defined as CCW motor shaft rotation facing drive end of motor.

To activate or clamp the FAC or RAC, remove the logic "1" level. The input connection for the FAC is P1 pin 9, and the RAC is P1 pin 10.

Figure 4-1 illustrates the suggested method of connecting these inputs to the logic level "1". P1 pin 7 is a common pull-up resistor (1.0 kOhm) for the FAC, RAC and INH, removal of this level will clamp the amplifier.

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Example: 1 (15V) = OK
0 (0V) = Clamped

4.1.4 Inhibit Clamp (INH)

This input signal inhibits or enables the output stage. This signal is also a logic level "0" for the active status, and enters the drive through P1 pin 8. P1 pin 7 is the pull-up resistor for this input also. This input is also used to reset the SSO fault circuit. The (INH) input must be put in the "0" condition to clear the SSO fault.

Example: 1 (15V) = OK
0 (0V) = Clamped

4.1.5 Motor Current Output MCO (±)

The motor current output is a DC voltage which is proportional in size to the motor current output size. The scaling of this DC signal is ± 1.5 volts = ± 30.0 amps. this output signal has a 1.0 kOhm impedance, and is available on P2 pin 7.

4.1.5.1 Motor Current Output MCO (0-10V)

The motor current output is a DC voltage which is proportional to the motor current output. The scaling of this signal is an absolute value of 0-10 volts = ± 30 amps. This output signal is available on P2 pin 3.

4.1.6 Auxiliary DC Power

The output from P2 pins 9 (+15 VDC) and 10 (-15 VDC) may be used to power an external VCS control. The available current from these pins is ± 15 mA.

4.1.7 Optional External Current Limit (ECL)

This input may be used to program the current limit externally. A 2.5 kOhm resistor connected between P2 pins 5 and 6 will reduce the available current by about 50%. The exact degree of reduction is a function of the internal current limit for the motor being used.

4.1.8 Optional Remote Velocity Gain Reduction

A jumper connected between P2 pins 1 and 2 will reduce the gain of the velocity amplifier to approximately 3.0A/volt from the normal 7000A/volt. The amplifier will then function as a torque (current) amplifier.

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4.1.9 Motor Velocity Output (MVO)

The motor velocity output (MVO) signal is an analog voltage signal which is proportional to the actual instantaneous motor speed. In the standard amplifier-motor interconnection, this voltage is positive for CW rotation of the motor facing drive end of motor, and negative for CCW rotation. It's output is P2 pin 8.

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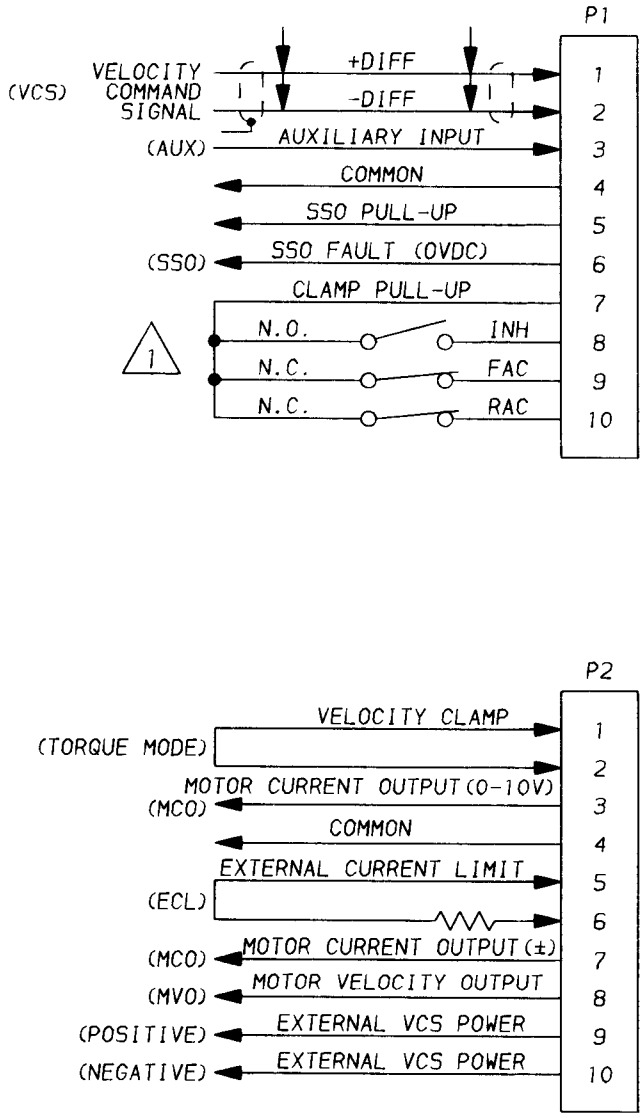


Figure 4-1 External Interface Connections

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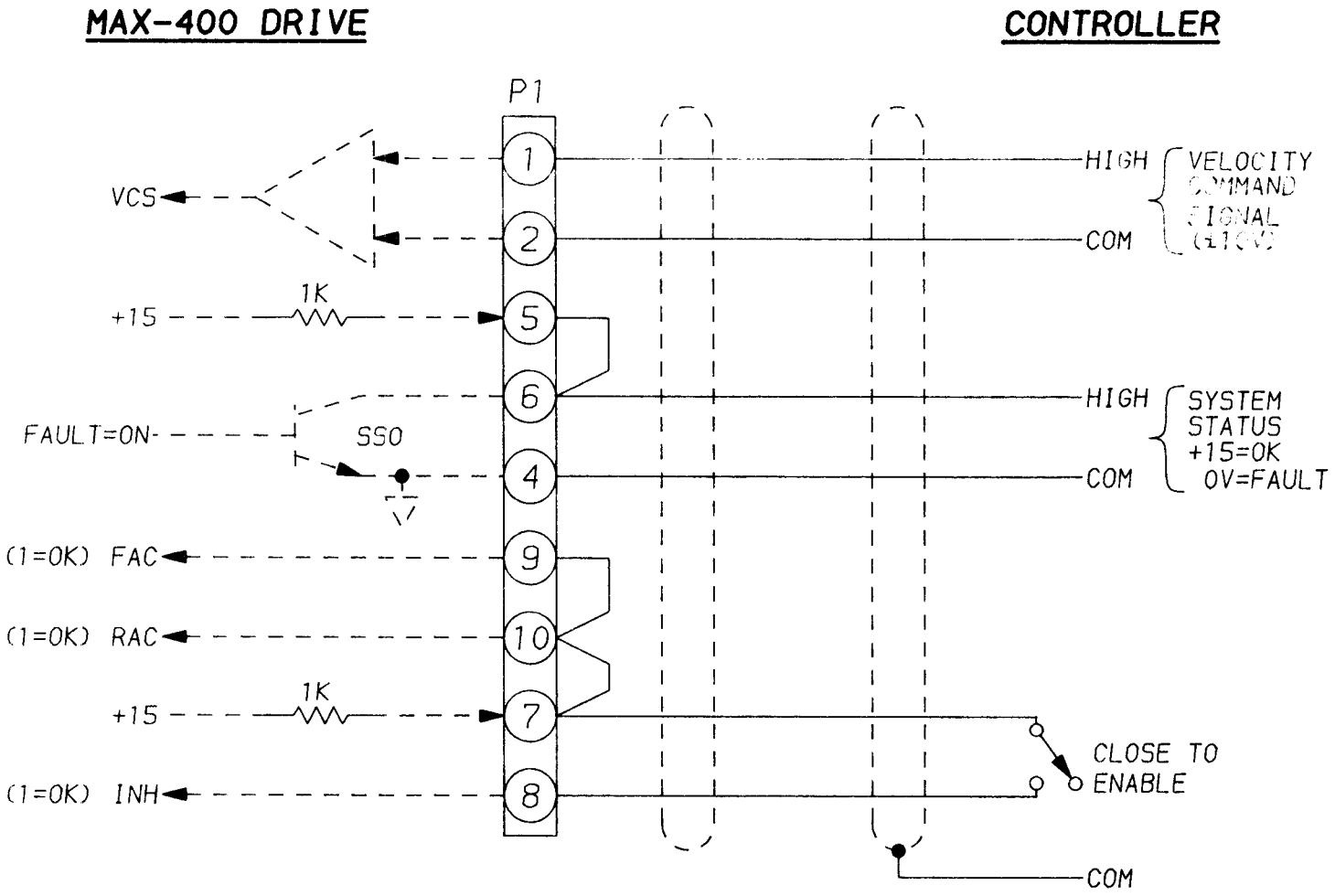


Figure 4-2 Typical MAX-400/Controller Interface Wiring

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SECTION V - OPERATION

5.1 Steps For Set-Up

AC power must be turned off until step 5.3.3. The following steps must be performed in the specified order.

5.2 Motor/Tachometer Connections

Reference Figure 3-1 and Figure 3-2.

5.2.1 Motor Leads

Connect the motor leads to P3. Pin 5 is MT+ and pin 4 is MT- for CW motor shaft rotation facing drive end of motor. To reduce the effect of radiated electrical noise it is suggested that the motor leads and the supply leads be run as twisted pairs, or as shielded cable. It is also advisable to keep the motor and power leads away from the signal leads.

5.2.2 Tachometer Leads

Connect the tachometer leads to P3. Pin 2 is TG+ and pin 1 is TG- for CW motor shaft rotation facing drive end of motor.

5.2.3 Interface Connections

Install the required interface connections to P1 and P2 as outlined in Section IV.

5.3 Adjustments

Reference drawing 9077-0609.

5.3.1 Initial Setting

Rotate all adjustments at least 16 turns CCW (to full CCW position). Check that VCS input (from external controller) is approximately 0 volts DC. Rotate the RMSI approximately 5 turns CW.

5.3.2 Tach Gain (TAC. GAIN)

Turn the TACH GAIN approximately 6 turns CW from full CCW position.

5.3.3 Apply AC Power

Check that the MAX-400 sheet metal cover is in place. Apply AC power, if the drive is enabled when power is applied, there will be an approximate 1 second delay before the output stage is enabled.

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5.3.4 Internal Current Limit (I LIMIT)

Slowly turn the CURRENT LIMIT control CW until the motor starts to rotate. If it accelerates toward full speed, switch off the AC power and reverse the tachometer leads. Apply AC power again and the motor should rotate slowly.

5.3.5 Balance Control (BALANCE)

Adjust the BALANCE control until the motor shaft remains stationary.

5.3.6 Setting the Internal Current Limit Control (I LIMIT)

Set the CURRENT LIMIT control at a suitable point:

4 turns CW = approximately 50% peak current
8 turns CW = approximately 70% peak current
16 turns CW = 100% peak current

5.3.7 RMS Current Limit (RMSI)

The RMS current Limit control adjusts the foldback level from approximately zero to 50% of the peak current value. Set for the desired level:

4 turns CW = approximately 12.5% peak current
8 turns CW = approximately 25% peak current
16 turns CW = 50% peak current

5.3.8 LAG Control (LAG)

Turn the LAG Control CW until the motor shaft starts to oscillate, then turn back sufficiently to stop the oscillation.

5.4 **VCS Signal and Scaling (VCS)**

Reference Figure 5-1.

5.4.1 Equipment Needed

Use a signal generator and an oscilloscope to perform the following steps.

5.4.2 VCS Signal Input

Connect the output of the function generator to the VCS+ and VCS- inputs (P1 pin 1 and pin 2), and connect the oscilloscope to the tachometer signal. Set the function generator for a frequency of 0.5 Hz, with an amplitude of ±0.5 volts (square wave).

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5.4.3 VCS Gain Setting

Turn the VCS GAIN CW until a ±0.5 volt tachometer signal is observed on the oscilloscope. Make adjustments as required to obtain optimum system response as shown in Figure 5-1.

5.4.4 VCS Signal Scaling

After the desired system response is obtained by appropriate adjustment of the LAG Control and/or the TACH GAIN, adjust the VCS GAIN for desired scaling of VCS volts to motor RPM. After adjusting, if the motor is rotating slowly, bring the VCS to zero and readjust the BALANCE until the motor shaft remains stationary.

5.4.5 Torque Mode Operation

For use as a torque amplifier, a jumper must be installed from P2 pin 1 to P2 pin 2. With the VCS control fully clockwise, a 10 volt VCS signal applied to the drive will yield a 30 amp output to the motor.

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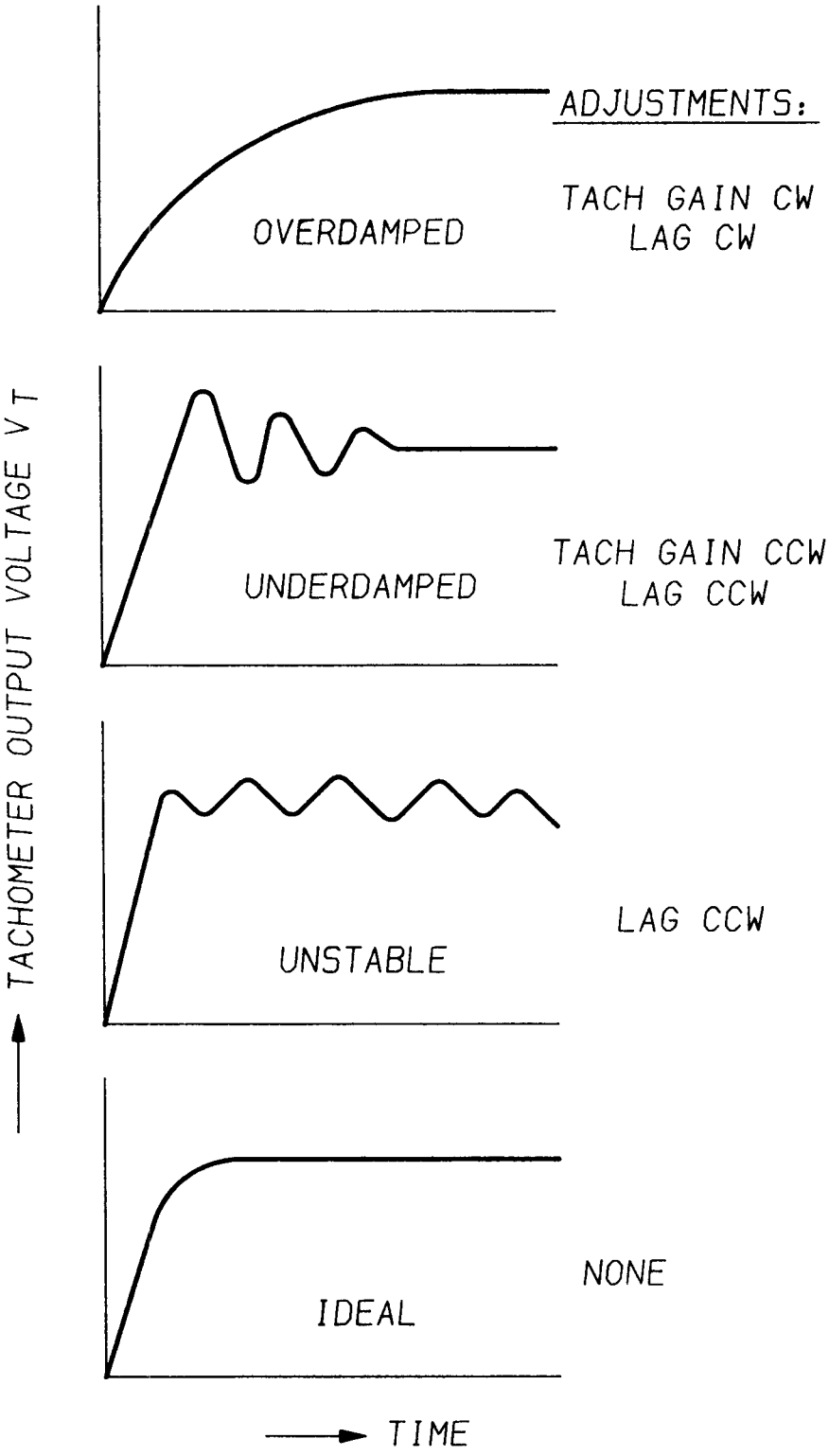


Figure 5-1 System Response To a Step VCS Input

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SECTION VI - MAINTENANCE

6.1 Scheduled Maintenance

The MAX-400 Series amplifiers have been designed to require minimum maintenance.

The following are suggestions for preventive maintenance:

1. Keep the amplifiers as clean as possible. This will result in cooler operation and more reliable performance.

2. Periodically check all connections and fasteners for tightness.

3. Check the incoming AC line occasionally for high or low voltage condition. If the line is persistently high or low, change transformer taps as necessary.

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6.2 **Malfunction Diagnosis**

Table 6-1 MAX-400 System Problem Symptoms and Possible Causes

Symptoms	Possible Causes
Motor Inoperative	1. No AC power to the amplifier 2. Faulty wiring to motor
No ±15 VDC at P2	1. Power supply Defective 2. ±15 VDC regulators defective
No voltage between MT+, MT- terminals	1. INH clamp activated 2. Defective amplifier
Motor responds to commands only in one direction	1. FAC or RAC clamp activated 2. Defective output stage or amplifier board
Voltage measured between motor terminals but motor does not rotate	1. Motor or load mechanically jammed 2. Motor brushes worn or improperly seated 3. Open motor winding
Motor runs only at a a high, constant speed	1. Faulty wiring to the tachometer 2. Tachometer brushes worn or improperly seated 3. Open tachometer winding 4. Tachometer leads reversed

6.3 **LED Indicators**

6.3.1 Power LED (Green)

The main bus supply is monitored by this LED. Whenever power is applied to the drive, this indicator will be on.

6.3.2 Fault LED (Red)

This LED is turned on by any of the following conditions:

A. Heatsink over-temp (above 85°C)

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B. Bus over-voltage (above 140 VDC)

C. Over-current on the output stage.

D. AC Power Loss

If any of these conditions occur, the output stage is disabled also. To clear the fault, the inhibit line must be switched to the disable condition to reset the fault latch.

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SECTION VII - TRANSFORMERS

7.1 Listing of Transformers

The following is a list of transformers for the MAX-400. Use the part numbers listed below when contacting Robbins & Myers/Electro-Craft concerning replacement or purchase of:

Transformers	Part Numbers	Description
0.65 kVA	0020-5071-003	115/230 VAC input - 2 secondary windings each with 14, 28 VAC outputs, 12 amps total.
1.8 kVA	0020-5083	115/230 VAC input - 2 secondary windings each with 20, 40, 60 VAC outputs, 15 amps each secondary.
3.6 kVA	0020-5082	115/230 VAC input - 2 secondary windings each with 20, 40, 60 VAC outputs, 30 amps each secondary.

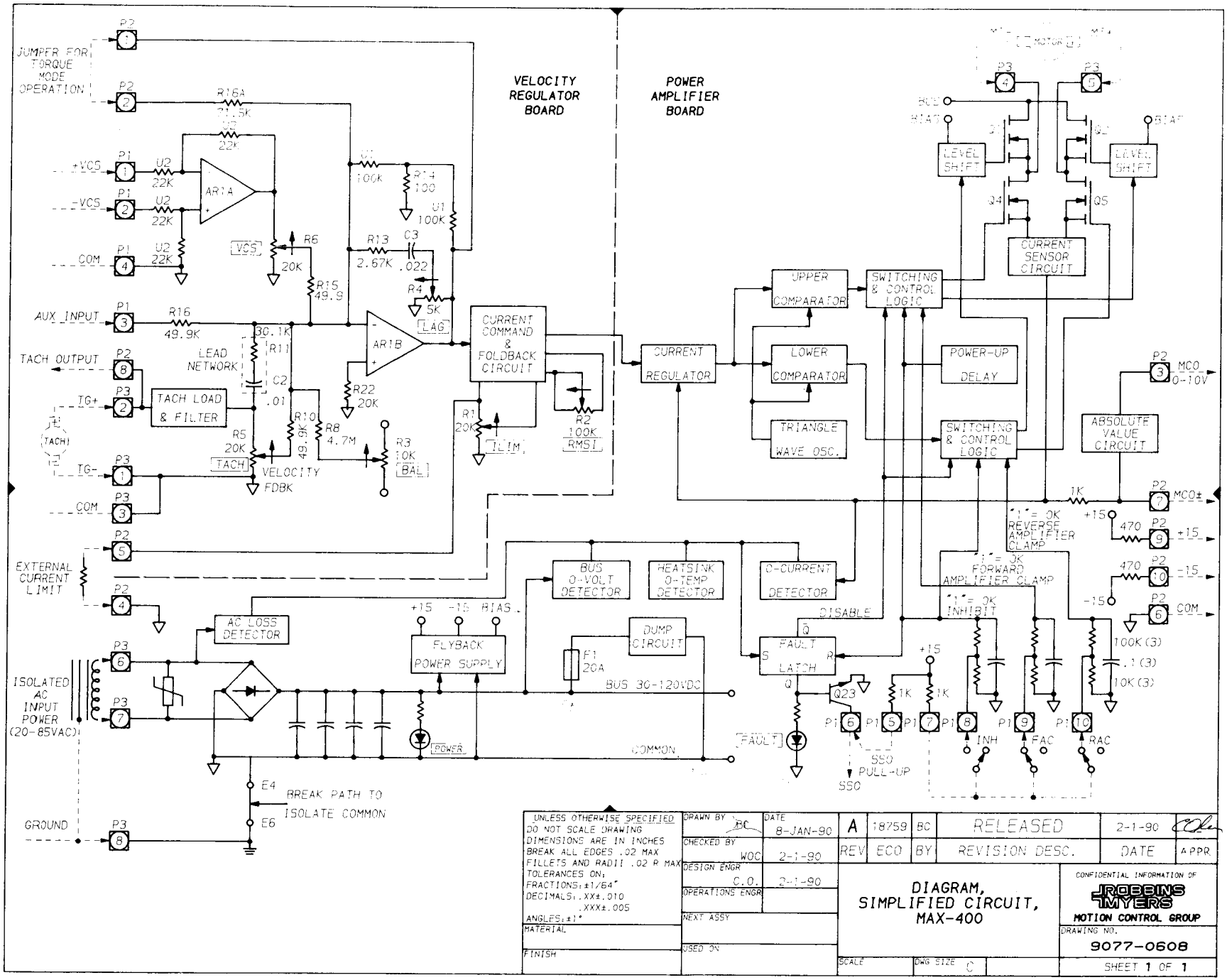
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SECTION VIII - CUSTOMER REFERENCE DRAWINGS

8.1 Listing of Drawings

Drawing Number	Description
9077-0608	Simplified Circuit
9077-0609	Outline Mounting and Adjustment Locations

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UNLESS OTHERWISE SPECIFIED	DRAWN BY	DATE					
DO NOT SCALE DRAWING	BC	8-JAN-90	A	18759	BC	RELEASED	2-1-90
DIMENSIONS ARE IN INCHES	CHECKED BY		REV	ECO	BY	REVISION DESC.	DATE
BREAK ALL EDGES .02 MAX	WOC	2-1-90					APPR
FILLETS AND RADII .02 R MAX	DESIGN ENGR						
TOLERANCES ON:	C.O.	2-1-90					
FRACTIONS: ±1/64"	OPERATIONS ENGR						
DECIMALS: .XX ± .010							
.XXX ± .005	NEXT ASSY						
ANGLES: ±1°							
MATERIAL	USED ON						
FINISH							

DIAGRAM, SIMPLIFIED CIRCUIT, MAX-400

CONFIDENTIAL INFORMATION OF ROBBINS MYERS MOTION CONTROL GROUP

DRAWING NO. 9077-0608

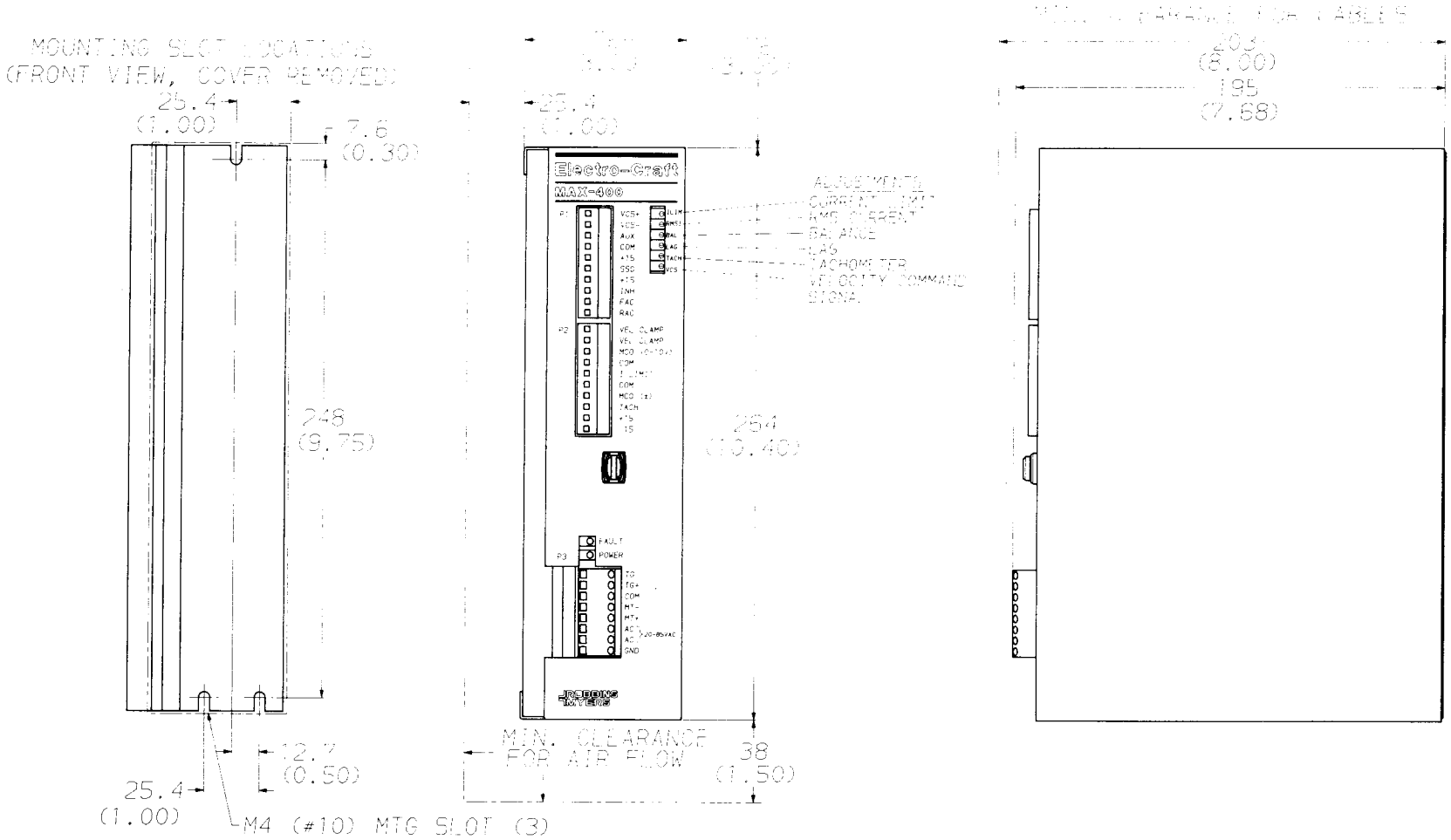
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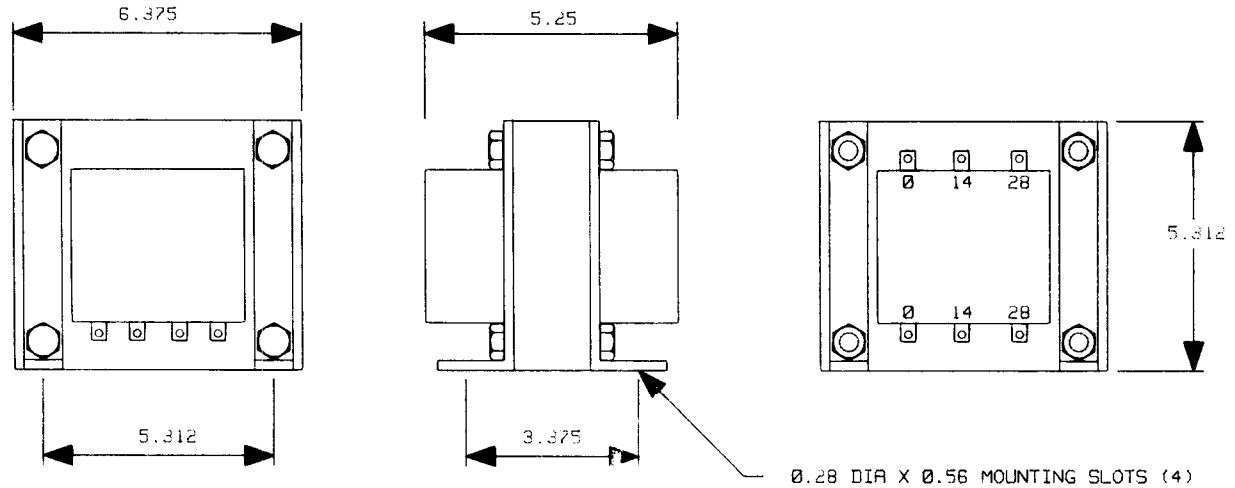
PART NO. 9077-0609

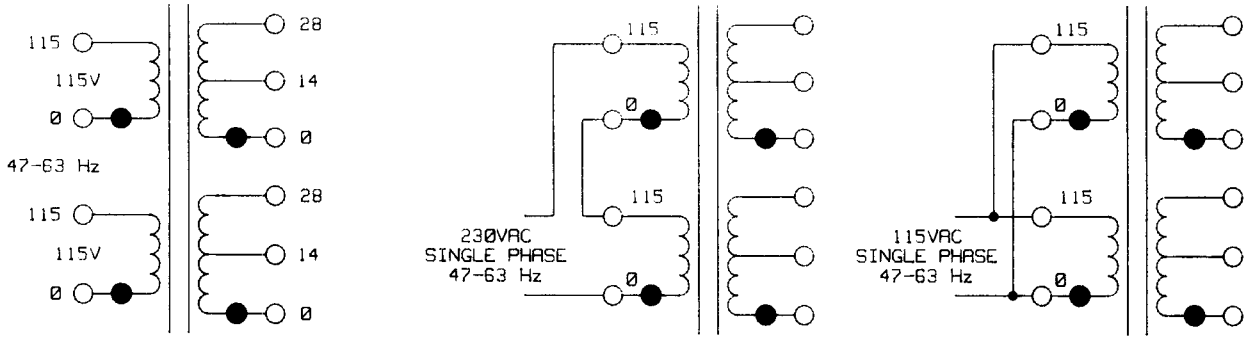


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(INCHES)

UNLESS OTHERWISE SPECIFIED DO NOT SCALE DRAWING DIMENSIONS ARE IN INCHES BREAK ALL EDGES .02 MAX FILLETS AND RADII .02 R MAX TOLERANCES ON: FRACTIONS: ±1/64" DECIMALS: .XX ±.010 .XXX ±.005 ANGLES: ±1°	DRAWN BY BC	DATE 5-JAN-90	A	18759	BC	RELEASED	2-1-90	
	CHECKED BY WOC	5-JAN-90	REV	ECO	BY	REVISION DESC.	DATE	APPR
	DESIGN ENGR	7-1-90	DIAGRAM, OUTLINE MOUNTING AND ADJUSTMENT LOCATION, MAX-400				CONFIDENTIAL INFORMATION OF ROBBINS MYERS MOTION CONTROL GROUP	
	OPERATIONS ENGR							
MATERIAL N/A	NEXT ASSY N/A						DRAWING NO. 9077-0609	
FINISH N/A	USED ON --		SCALE FULL		DWG SIZE D		SHEET 1 OF 1	

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SCHEMATIC

TYPICAL AC INPUT POWER WIRING

SPECIFICATIONS

INPUT: 115/230VAC 47-63 Hz

OUTPUT: 14, 28, 42, 56 VRMS @ 12A

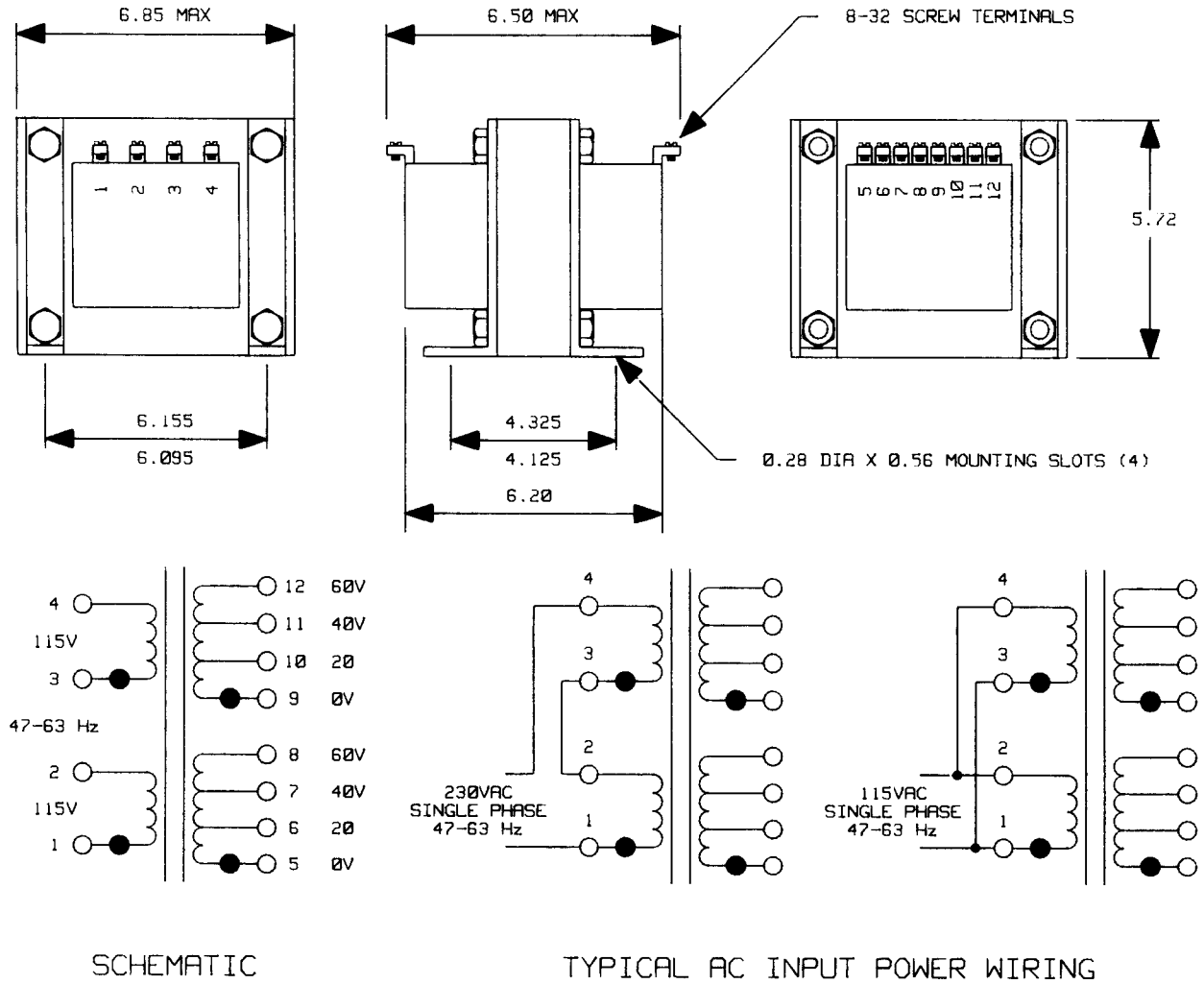
BREAKDOWN TEST: SHALL WITHSTAND 1500VRMS @ 60 Hz FOR 1 SECOND

AMBIENT TEMPERATURE: 122° F (50° C) OPERATING

WEIGHT: APPROX 22 LBS (10 kg)

Figure 8-1 0.625 kVA Transformer, Part Number 0020-5071-003

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SCHEMATIC

TYPICAL AC INPUT POWER WIRING

SPECIFICATIONS

INPUT: 115/230ØVAC 47-63 Hz

OUTPUT: 20, 40, 60VRMS @ 15A EACH SECONDARY

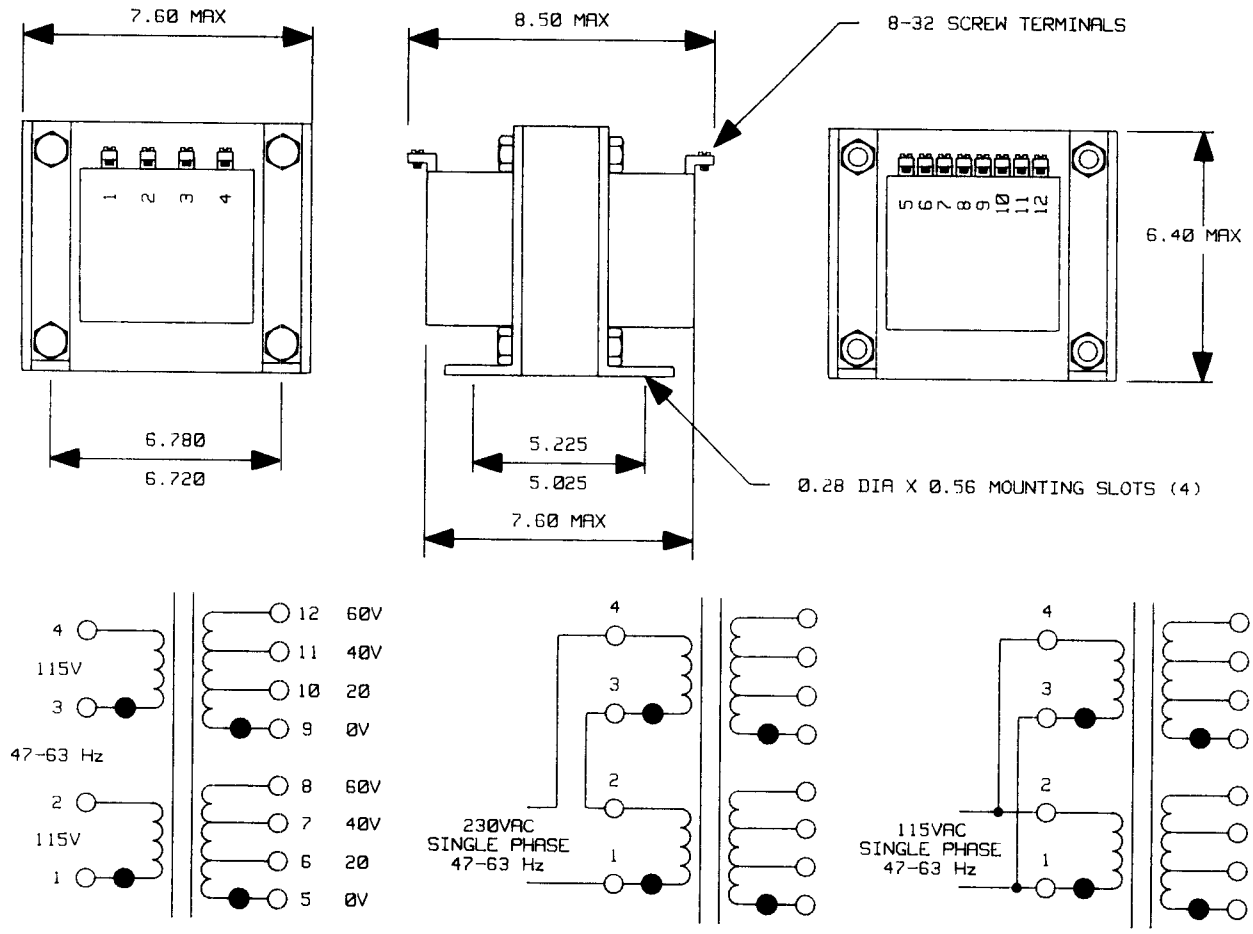
BREAKDOWN TEST: SHALL WITHSTAND 1500VRMS @ 60 Hz FOR 1 SECOND

AMBIENT TEMPERATURE: 122° F (50° C) OPERATING

WEIGHT: APPROX 35 lbs (16 kg)

Figure 8-2 1.8 kVA Transformer, Part Number 0020-5083

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SCHEMATIC

TYPICAL AC INPUT POWER WIRING

SPECIFICATIONS

INPUT: 115/230VAC 47-63 Hz

OUTPUT: 20, 40, 60VRMS @ 30A EACH SECONDARY

BREAKDOWN TEST: SHALL WITHSTAND 1500VRMS @ 60 Hz FOR 1 SECOND

AMBIENT TEMPERATURE: 122° F (50° C) OPERATING

WEIGHT: APPROX 59 lbs (27 kg)

Figure 8-3 3.6 kVA Transformer, Part Number 0020-5082

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SECTION IX - APPLICATION INFORMATION

9.1 Application Information

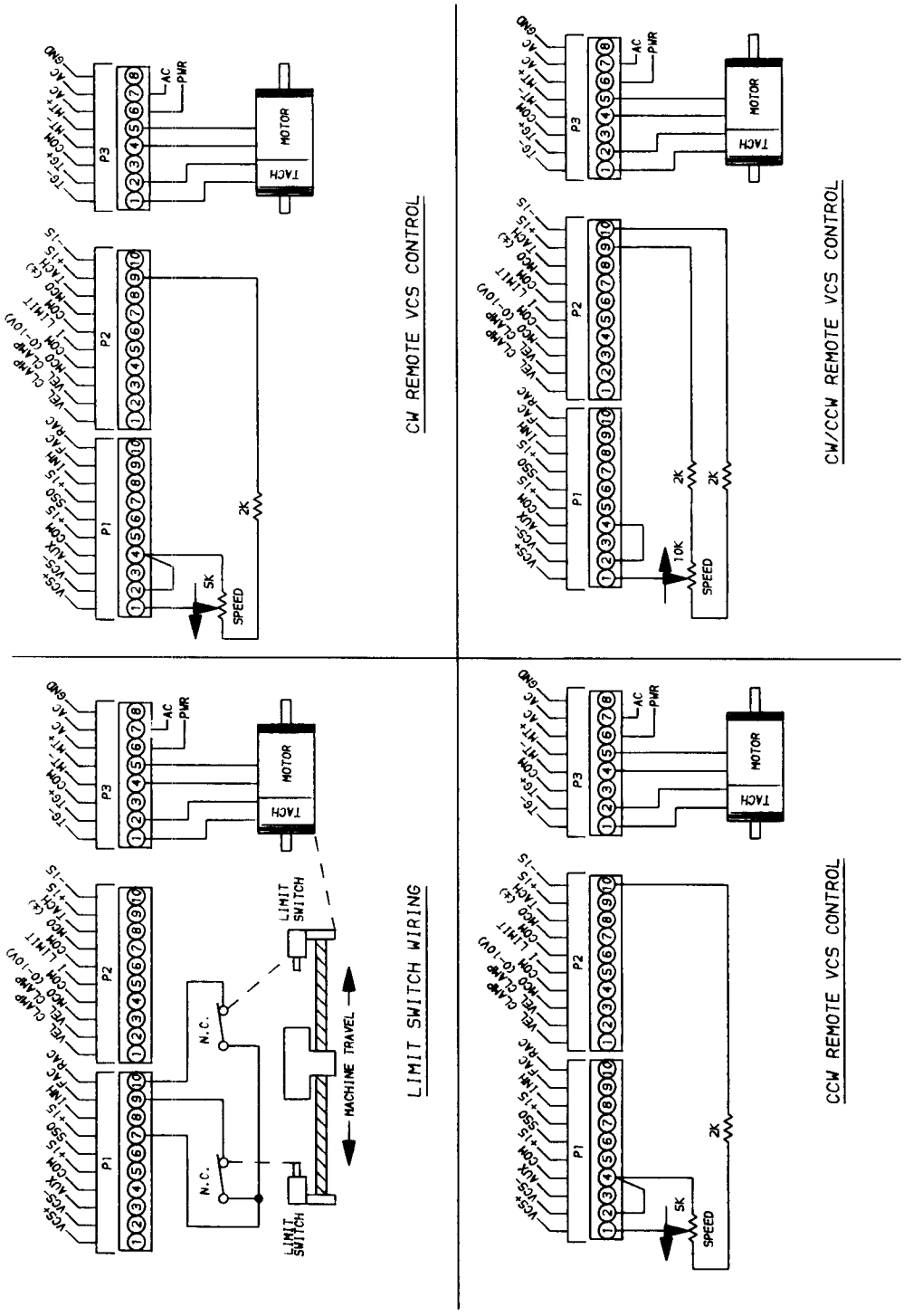


Figure 9-1 Application Information

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9.2 Application Information

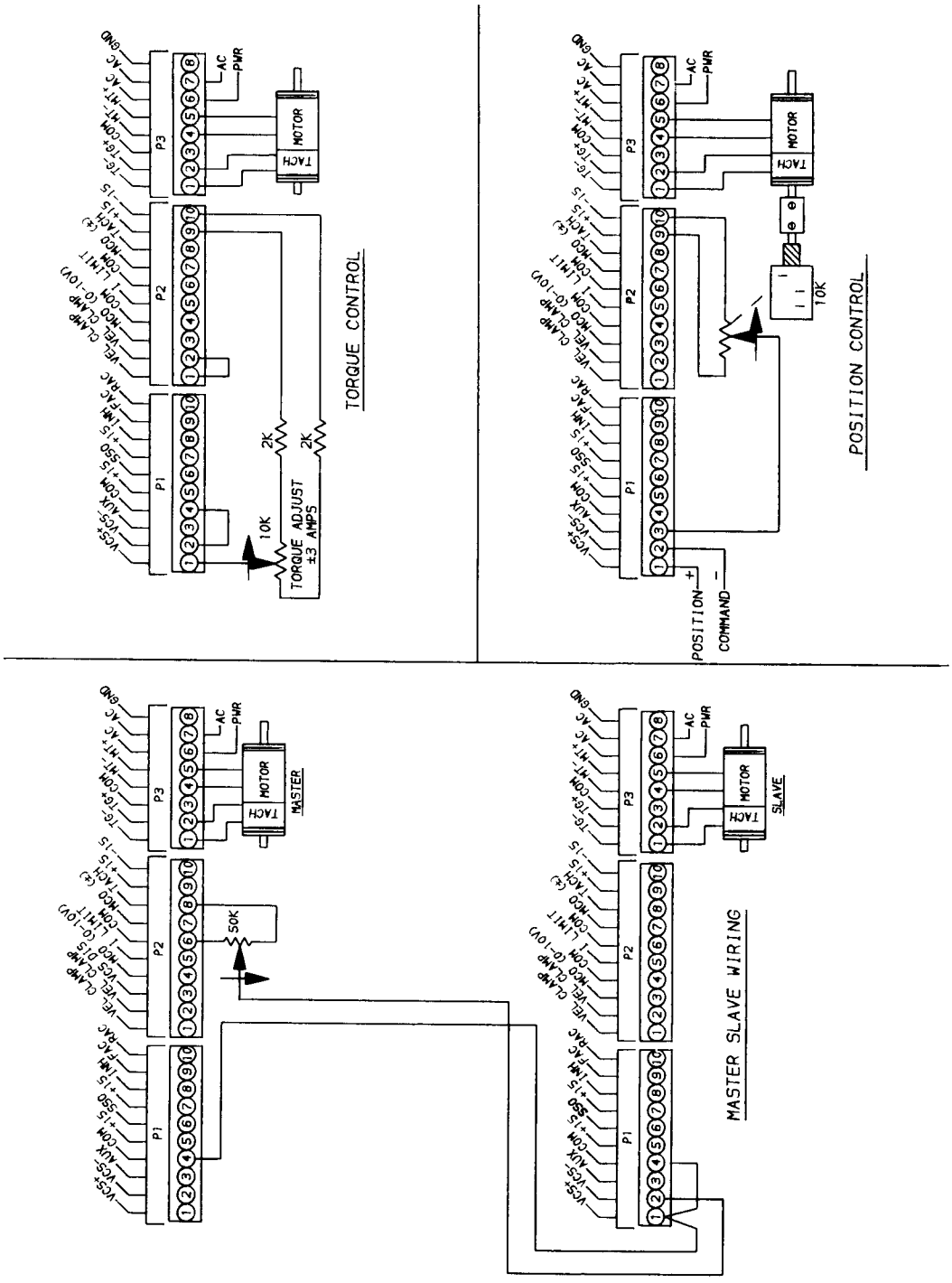


Figure 9-2 Application Information

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