BURNY ETEK™

SM1 SERVOMATE

OPERATION AND MAINTENANCE MANUAL

AO-73187

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THE SMI SERVOMATE™ OWNER's HANDBOOK AND MAINTENANCE GUIDE

Revised July 1981
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CAUTION

This equipment is at line voltage any time the incoming line is closed whether the power unit is in operation or not. AC power must be disconnected (all AC lines) from the power unit before it is safe to touch any internal parts of this equipment.

RI-00-720B

WARRANTY:

Seller warrants the products furnished hereunder to be free from defects in material and workmanship under normal use and service for the period of one (1) year from date of shipment from Randtronics. Seller's sole obligation under this warranty shall be to repair or replace any defective product or part thereof, which is returned to Seller's factory, transportation charge prepaid, within the period mentioned above, and which upon examination is proven to Seller's satisfaction to be so defective. The warranty shall not apply to any product or part which has been subject to misuse, negligence, or accident. Seller MAKES NO WARRANTY THAT ITS PRODUCTS ARE FIT FOR THE USE OR PURPOSE TO WHICH THEY MAY BE PUT BY THE BUYER whether or not such use or PURPOSE HAS BEEN DISCLOSED TO SELLER IN SPECIFICATIONS OR DRAWINGS PREVIOUSLY OR SUBSEQUENTLY PROVIDED THE SELLER, and whether or not Seller's products ARE SPECIFICALLY DESIGNED AND/OR MANUFACTURED BY SELLER FOR BUYER'S USE OR PURPOSE. SELLER SHALL NOT be responsible for any special or consequential damage, AND THE WARRANTY AS SET FORTH IS IN LIEU OF ALL OTHER WARRANTIES EITHER EXPRESSED OR IMPLIED.

RECEIVING, HANDLING & STORAGE

Receiving

The equipment must be placed under adequate cover immediately upon receipt as packing cases are not suitable for outdoor or unprotected storage.

Examine the shipment carefully upon arrival and check items with the Packing List. Any shortage or damage should be reported promptly to the carrier and to the nearest CMC sales office.

Storage

If equipment is not being installed immediately, it should be stored in a clean, dry location. Precaution should be taken to prevent moisture from accumulating in the equipment. Moisture, dust or dirt is detrimental to the equipment operation.

SAFETY NOTICE

This equipment employs voltages which are dangerous and may be fatal if contacted by operating personnel. Caution should be exercised when working with the equipment. The following rules must be strictly observed:

1) Keep away from live circuits. Voltages up to 240 VAC may be present when power is ON. DO NOT TOUCH any circuit board or chassis components with power applied.

2) Do not make any adjustments inside equipment unless thoroughly familiar with the equipment.

3) Do not service motor unless all power is off. Voltage may be present even though the motor is not rotating.

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1.6 SPECIFICATIONS

		Single Bridge Axis	Double Bridge Axis	Triple Bridge Axis
1.	Continuous Current	12A/15A	24A/30A	36A/45A
2.	Peak Current (5 Sec)	24A/30A	48A/60A	72A/90A
3.	Power Section Gain	4.0 A/V	8.0 A/V	12.0 A/V
4.	Power Rating, Cont.			
	Cont. 100V Units	1.1/1.35KW	2.2/2.7KW	3.3/4.1 KW
	160V Units	2.2/2.7 KW	4.4/4.5 KW	6.4/8.2 KW
5.	Current Limit, Adj	0 to 24/30A	0 to 48/60A	0 to 72/90A
6.	Load Inductance, Min.			
	100V Units	1.0 mH	0.50 mH	0.3 mH
	1 0V Units	4.0 mH	2.0 mH	1.4 mH

The following specifications apply to single, double and triple bridge axes.

7.	Usable Output Voltage	85 VDC or 145 VDC	
8.	DC Bus Voltage (nominal)		
	100V Units	+100 VDC	
	160V Units	+160 VDC	
9.	Preamplifier Gain and Input Impedance		
	Auxiliary	0-2000 V/V	15K Ohm
	Signal (Differential)	0-2100 V/V	15K Ohm
	Tach	0-2000 V/V	15K Ohm
10.	Form Factor	1.002	
11.	Switching Frequency	5KHz, 100V Units; 2KHz, 160V Units	
12.	Gain Linearity	±2%	
13.	Drift (referred to input)	10 uV/°C	
14.	Offset	Adjustable to zero	
15.	Deadband	Zero (Referred to input)	
16.	Frequency Response	DC to 2 KHz	

17.	Input Voltages		
	Bias Supply	115 VAC ±10%, 60/50 Hz, 1Ø	
	Power Bus	100V Units - 70 VAC	
		160V Units - 115 VAC	
		Ungrounded	
		50/60 Hz, 1Ø	
18.	Cooling	Fan-cooled	
19.	Auxiliary Inputs		
		Reset	(RTS)
		External Current Limit	(CLM)
		Positive Current Inhibit	(RDD)
		Negative Current Inhibit	(LDD)
		Auxiliary Speed Command	(AUX)
20.	Auxiliary Outputs	Output current monitor $\pm 10V = \pm I_{PK}$	(ANC)
		Absolute value of motor current (optional)	(ANC)
		Logic level power supply ±12 VDC @ 50 mA ea.	(±12)
		Fault Indication Open Collector Transistor Output	(FLT)
		Excess Continuous Current Open Collector Transistor Output	(ECC)
21.	Temperature Range	Operating: 0 to +50°C	
		Storage: -30 to +65°C	
22.	Terminals	Power: Faston Tabs	
		Signal: Screw-type barrier strip	
23.	Shunt Regulator		
	Peak Power Dissipation	Up to 10 KW	
	Bus Voltage Cut-In Threshold	100V Units - 130 Volts	
		160V Units - 190 Volts	

1.0 GENERAL DESCRIPTION

1.1 MEET THE SERVOMATE TM

The SERVOMATE SMI Series of transistorized controllers are pulse-width-modulated (PWM), fast response, high performance industrial type servo amplifiers. They are designed specifically for use with low inertia DC torque and permanent magnet servomotors in CNC machine tool axis drive applications. The SERVOMATE's compact design requires a minimum of panel space while its modular construction allows straight-forward maintainability. The controllers are supplied chassis-mounted with up to four individual axis drives operated from an integrated DC bus power supply. A wide horsepower range is covered with two output voltage ratings and three output current ratings.

A CMC-developed power transistor switching scheme ("Uni-Switching") is utilized in the drive which has several advantages over other typical PWM controllers. This improved switching concept results in higher frequency response, reduced switching losses, lower motor ripple current and reduced EMI.

Serviceability is assured by status and fault LED indicators with summary fault indications for the CNC. In addition, all circuit boards are plug-in and designed for interchangeability within the system to minimize spares requirements.

Options include a tapered current limit circuit, input signal and tachometer filter circuits and interface terminal strip variations. Also, a shunt regulator option is offered for applications where the inertia of the motor and connected load cause the bus voltage to exceed allowable limits during deceleration.

1.2 PROTECTIVE CIRCUITS

- Adjustable current limit
- Overcurrent
- Armature short to ground
- Positive bus short to ground
- Short circuit across output
- Overvoltage
- Overtemperature
- Bias power fuses
- Over/under bias voltage
- I^2t current limit
- Undervoltage (Optional)
- Shaped current limit(Optional)

1.3 DIAGNOSTIC INDICATORS

<u>Status LEDs</u>

115VAC Power On (XMFR)

Power Bus On (PBU)

+12 VDC (+12)

-12 VDC (-12)

<u>Fault LEDs</u>

Axis Surge Current (SC)

Axis Overtemperature (OH)

System Ground Fault (GFT)

Over/Under Bias Supply Voltage (BIF

Power Bus Overvoltage (PBE)

Excessive I^2t Current (ECC)

1.4 ADJUSTMENTS

Individual axis edge mounted potentiometers for:

Signal Gain (SIG)

Aux Signal Gain (AUX)

Tachometer Scaling (TAC)

Balance (Offset Adjust) (BAL)

Velocity Loop Gain (GAN)

Current Limit (CLM)

1.5 ADDITIONAL FEATURES

Component Size

Plug-In Circuit Boards

Isolated Output Circuit

±12V Ref Voltage (50 MA)

External Current Limiting (CLM)

Right/Left Direction Inhibit (RDD, LDD)

Analog Current Signal (ANC)

External Fault Signal (FLT)

Optional Tachometer Filter

1.7 MODEL INFORMATION

SERVOMATE controllers are specified by model number which designates the output voltage, continuous output current per axis and options required, as indicated below:

SM1-100-4X12A-24A-FPS

- **FPS** — OPTIONS:
  - F - FAULT RELAY DRIVER
  - P - PRESET SPEED CARD OR "PP" (2) 4 PRESET SPEED CARDS
  - S - SPECIALS: DEVIATES FROM STANDARD
  - T - TACHOMETER FILTER
- **24A** — ONE AXIS (AMPS):
  12A, 24A, 36A, 15A, 30A OR 45A
- **4X12A** — MULTI AXIS:
  (QTY) TIMES (AMPS)
  - (AMPS) — 12A, 24A, 36A, 15A, 30A, 45A
  - (QTY) — AS REQUIRED 2 THRU 8
- **100** — 100 (100VDC BUS)/160 (160 VDC BUS)
- **SM1** — PRODUCT LINE

1.8 POWER TRANSFORMERS

The SERVOMATE panel requires an external isolation power transformer which provides an ungrounded source of AC to the internal 1Ø bridge power supply. 100V units require 70 VAC nominal; 160V units require 115 VAC noninal. The chart below lists transformer part numbers for operation from 120 to 240 VAC input power. Transformers for operation from alternate input line voltage (230/460) are also available. Consult the Factory.

Sec, Current Rating, RMS Amps	AC Output Voltage	Nominal Power Rating KVA	CMC Part No.
8	70	0.7	143A07727
12	70	1.0	143A07715
25	70	2.0	143A05615
8	115	0.7	143A08818
12	115	1.0	143A08820
25	115	2.0	143A08844

2.0 INSTALLATION

2.1 MOUNTING

The SERVOMATE Chassis should be mounted in a clean, dry enclosure with a maximum ambient temperature of 50°C (122°F). Locate unit where free air flow is allowed through fan (s) and transistor heatsinks. Do not mount the unit on hot surfaces or above object that radiates heat. Avoid locations subject to steam, oil or chemical vapors. Avoid areas where moisture, dirt, dust or lint prevail. Never install unit where combustible vapors are present.

2.2 WIRING

Figures 2-2 through 2-8 show external wiring connections to the SERO-MATE chassis. Additional wiring diagrams and chassis component layouts are included in the Drawing Section in the back of the manual. Note that these figures are typical and are included for illustrative purposes only. Terminal connections can vary widely between units depending on number of axes, auxiliary bridges and terminal strip options. Always refer to the drawings furnished with the unit.

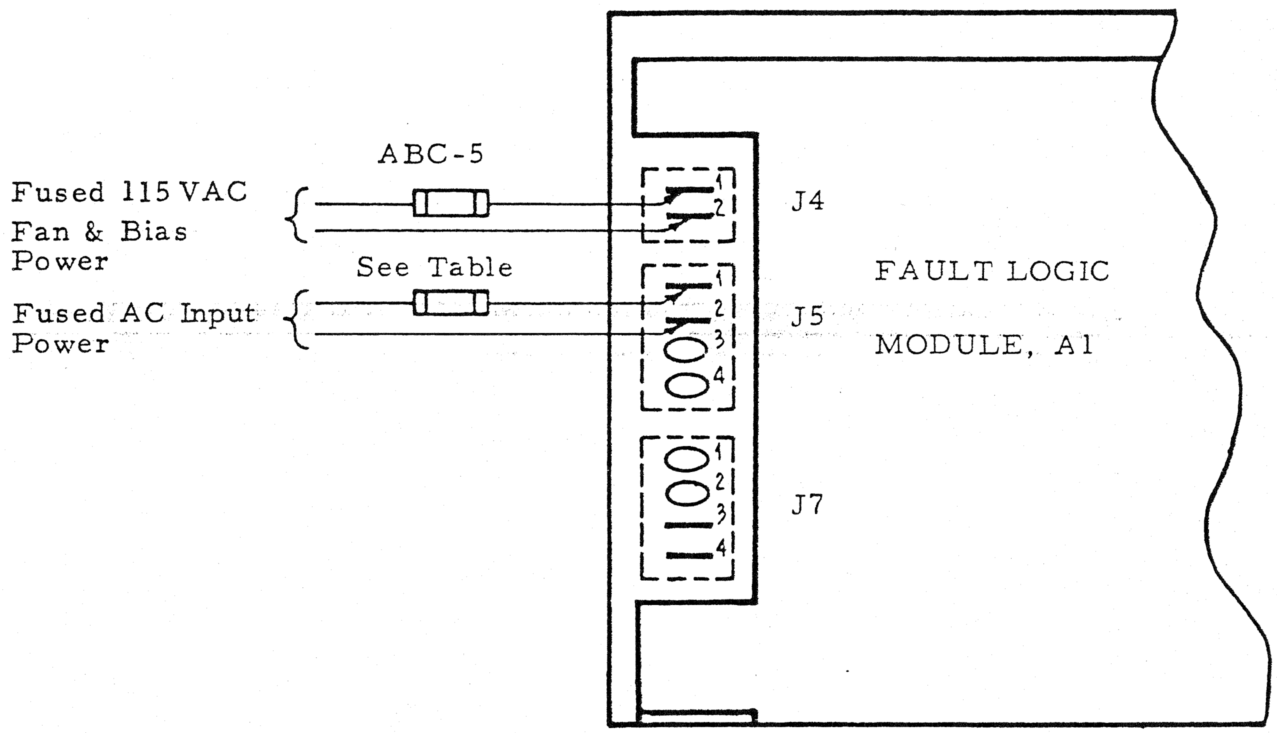
2.2.1 Power Wiring

Wire in accordance with the requirements of the National Electrical Code (NEC) and any local requirements. Size as follows:

Armature Circuit	-	Size for continuous rated motor current (12 AWG minimum)
AC Input Power	-	Size per the transformer KVA rating (12 AWG minimum)
115 VAC Bias & Fan Power	-	16 AWG

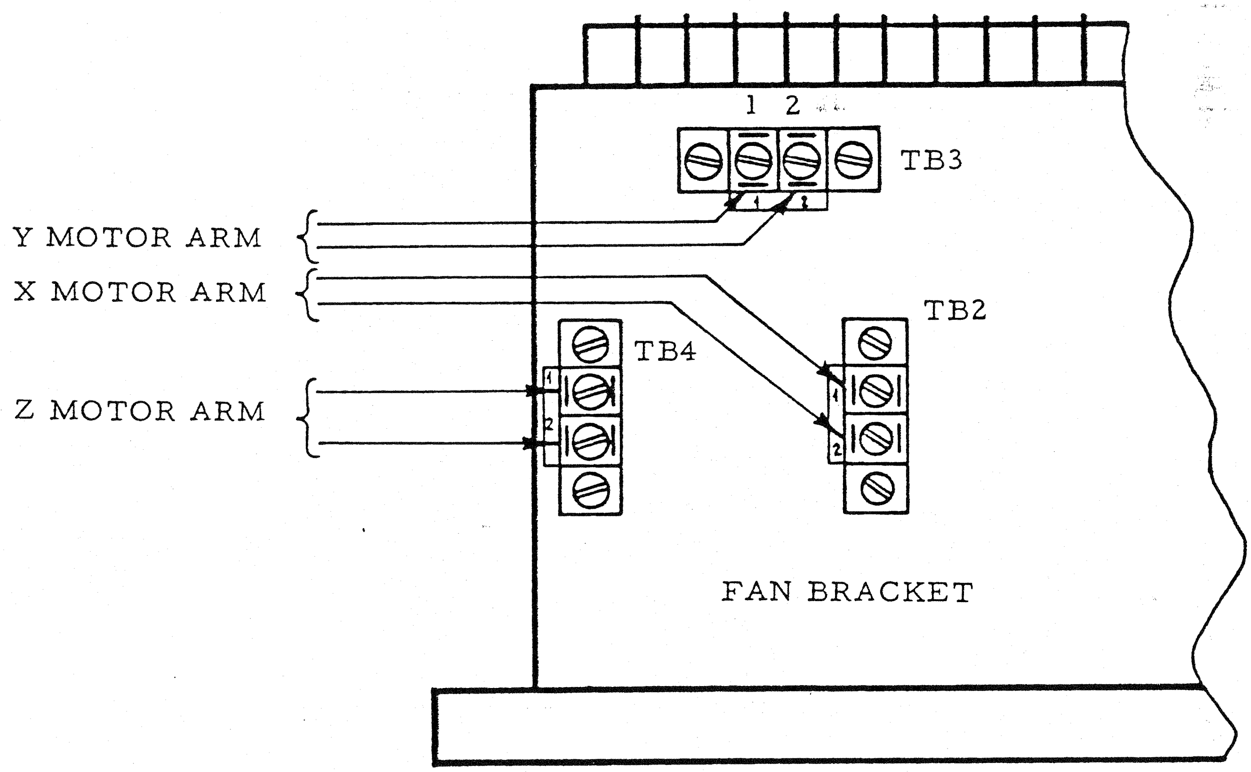
The isolation transformer must be fused. For fuse type, refer to wiring diagram and/or table on following page.

The motor armature leads carry square wave voltages. In order to minimize radiated electrical noise, it is suggested that armature circuit wire be twisted pairs.



Transformer Sec. Current Rating	Suggested Fuse Type
8 Amps	MDA-8
12 Amps	MDA-15
20 Amps	MDA-20
25 Amps	MDA-25
50 Amps	NON-50

FIGURE 2-1. AC INPUT POWER CONNECTIONS

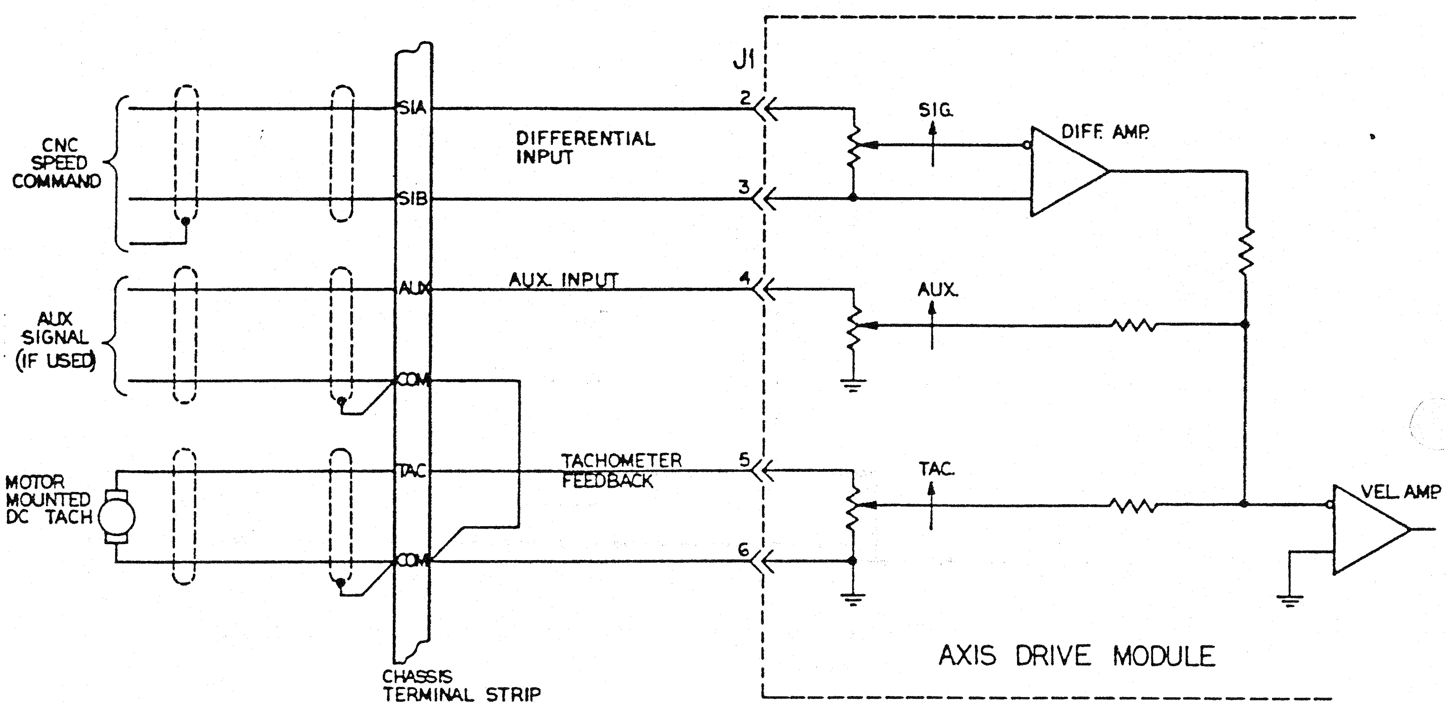


NOTE: Minimum armature circuit inductance for each axis is listed in Section 1.

FIGURE 2-2. MOTOR ARMATURE CONNECTIONS, THREE AXIS SERVOMATE

2.2.2 Signal Wiring

Small gauge wire (18 or 22 AWG) can be used for signal and limit circuits. Command and tachometer wires should be twisted-shielded pairs with the shield grounded at only one end. The tachometer lead shield should be grounded at the SERVOMATE controller. The command lead is most often grounded at the CNC when the differential input (SIA, SIB) is used.



NOTE: For complete schematic, refer to Drawing Section.

FIGURE 2-3. SIGNAL WIRING

2.3 SPECIAL FUNCTIONS

This section shows several special functions and circuits which are available in the SERVOMATE Axis Drive and Fault Logic Module. Note that all chassis configurations do not have these signals brought out to external terminals. Refer to the drawings furnished separately to determine which of these connections is available on your unit.

2.3.1 Left, Right Drive Disable (LDD, RDD)

By connecting LEFT DRIVE DISABLE (LDD) or RIGHT DRIVE DISABLE (RDD) to common, motor operation in that direction is inhibited. This function can be used as an axis overtravel stop to prevent further operation in the inhibited direction, but allows the drive to back out of the limit. Limit switches should be dry circuit type and should be mounted on the machine a sufficient distance from the mechanical end of travel to allow a coast-to-stop.

NOTE: RDD inhibits positive (+) output voltage at ML1 with respect to ML2.

LDD inhibits negative (-) output voltage at ML1 with respect to ML2.

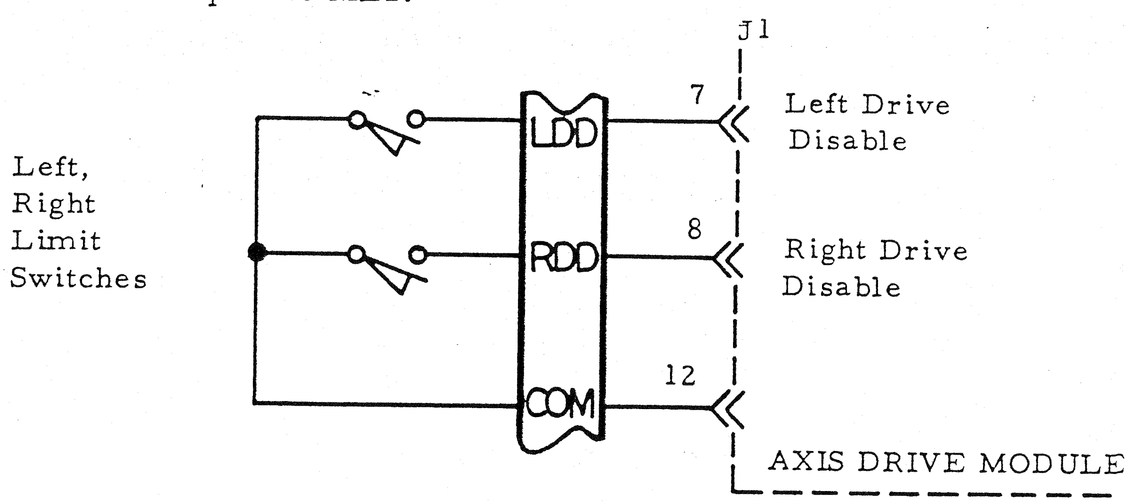


FIGURE 2-4. LEFT, RIGHT INHIBIT CONNECTION

2.3.2 FAULT (FLT) and RETEST (RTS)

The FAULT (FLT) signal is a summary output of all protective circuits on the axis module(s) and the Fault-Logic Module. These protective functions, individually annunciated with LEDs, are:

Overheat (OH) Surge Current (SC)	Individual Axis Drives
Ground Fault (GFT) Bias Voltage Error (BIE) Power Bus Error (PBE) Excessive Continuous Current (ECC)	Fault Logic Module

(A detailed explanation of these fault conditions is included in Section 5.)

In normal operation, the FLT line is internally pulled to +12V through a 10 K ohm resistor. If a fault occurs, all axis drives in the system latch off and the FLT line switches to or below common.

To reset the drive, either:

1) Remove and reapply bias power, or
2) Momentarily connect the RETEST (RTS) line to common as shown in Figure 2-5.

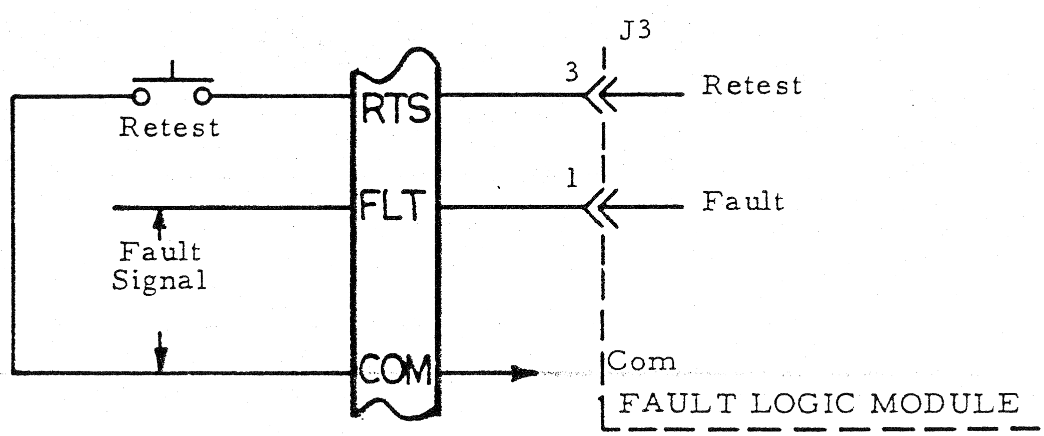


FIGURE 2-5. FAULT SIGNAL & RETEST CONNECTION

2.3.3 Analog Current Signal (ANC) and External Current Limit (CLM)

ANALOG CURRENT SIGNAL (ANC) - This is an output signal which is proportional to armature current. Scaling is ±10 VDC equals peak axis current. The output is op-amp buffered and has a 2 K ohm series resistor so that it can take accidental connection to common without damage.

EXTERNAL CURRENT LIMIT (CLM) - This function is used for external control of armature current. The CLM signal is the output of the velocity control amplifier which is internally clamped to ±5 VDC. By connecting it to common, no output current can flow.

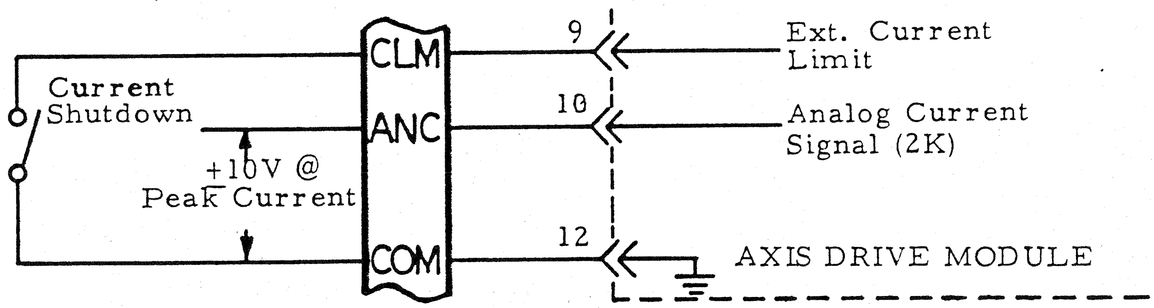


FIGURE 2-6. ANALOG CURRENT SIGNAL & EXTERNAL CURRENT LIMIT

A simple method for limiting current to approximately ±15% is to insert diodes (1N914, typ.) with appropriate direction limit switches. Intermediate limit points can be obtained by substituting a fixed resistor or potentiometer for the diodes. The chart shows typical current limiting versus resistance.

Output Current, %	Resistance Value, R
80%	7.5 K ohm
60%	3.0 K ohm
40%	1.2 K ohm
20%	470 ohm

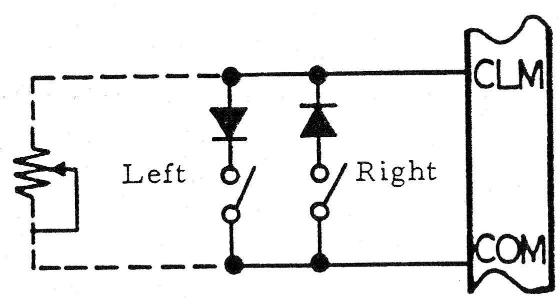


FIGURE 2-7. EXTERNAL DIODE OR RESISTANCE CURRENT LIMIT

2.3.4 Output Contactor

In applications where the motor must be "positively" disconnected from the source in case of emergency stop condition, the addition of an output contactor is recommended. Figure 2-8 below shows this connection.

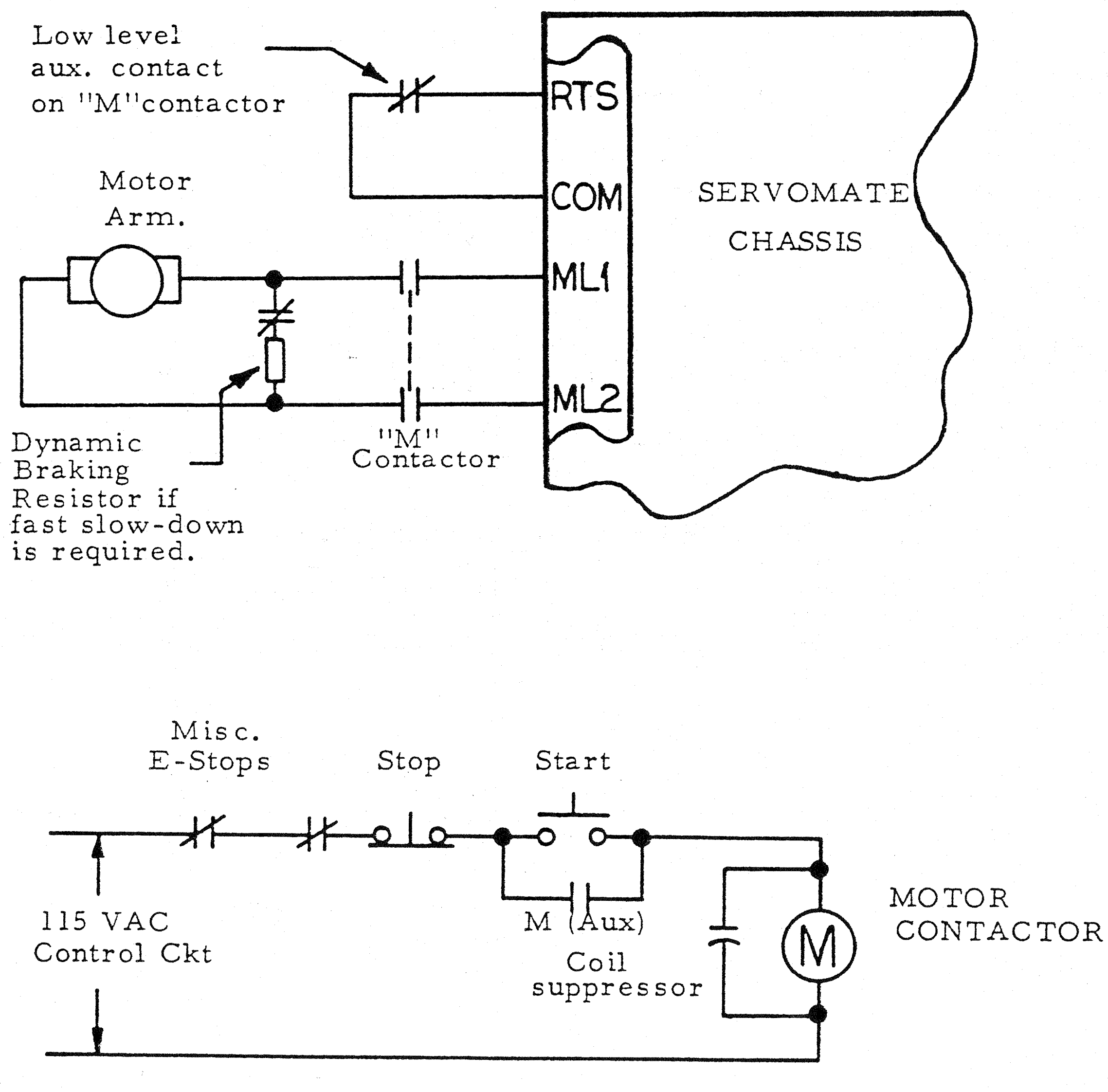


FIGURE 2-8. OUTPUT CONTACTOR CONNECTION

3.0 STARTUP AND ADJUSTMENT

SAFETY PRECAUTIONS

Several important steps should be observed before turn-on of a newly-connected drive system. These rules are itemized below:

- Work on one axis drive at a time. Disconnect the others.
- Verify the bus and bias 115 VAC voltages before connection to the drive.
- Check all power and signal wiring. Verify that the motor mechanism is clear of obstructions. If the motor is connected to an axis lead screw, place the slide at approximately mid-position.
- Turn the CLM adjustment to the full CCW position before applying power.
- Don't touch or short the bus capacitor.
- Be aware of the fact that the motor may run away if the tachometer is disconnected. Be prepared to remove power.

1) Adjustments for each Axis Drive are clearly labelled and are located at the top edge of the circuit board. Refer to the Drawing Section in the back of this manual if any question.

   Initially set adjustments as follows:

Signal (SIG)	Full CCW	Balance (BAL)	As shipped
Auxiliary (AUX)	Full CCW	Gain (GAN)	Full CCW
Tachometer (TAC)	Full CW	Current Limit (CLM)	Full CCW

2) Verify that the input speed command signal reaches the controller terminal strip.

3) Verify the tachometer connection by rotating the motor by hand while monitoring the Servomate TAC connection with a VOM or DVM.

4) Apply 115 VAC to the Servomate chassis. The cooling fans should start and the following Fault-Logic Module LEDs should be on:
   XMFR
   +12V
   -12V

5) Apply the AC input power bus voltage. The Fault-Logic Module LED labelled PBU should come on, but the motor should remain at zero speed.

6) Apply a small speed command (approximately 10%) and rotate the Current Limit (CLM) adjustment three turns clockwise. The motor speed should slowly increase and stabilize at a low speed. If the motor tends to run away, reverse the tachometer connections. If the motor speed stabilizes but the axis moves the wrong direction for a given polarity of speed command, reverse both the tachometer and the armature connections.

7) Check axis travel limit switches, LDD and RDD, if used.

8) Increase the speed command signal to maximum and increase the Signal (SIG) adjustment for full motor speed (Auxiliary adjustment if the AUX input is used).

   NOTE: If a high output (volt/1000 RPM) tachometer is used, it may be necessary to rotate the Tachometer adjustment (TAC) a few turns CCW to achieve the desired speed.

9) Increase the Current Limit adjustment (CLM) to the full CW position.

10) Increase the Gain (GAN) adjustment CW until the system becomes unstable. Then turn the GAN adjustment CCW one turn.

NOTE: This adjustment is best made by abruptly applying and removing the speed command signal so that the axis receives a "step" command.

11) Remove the speed command signal and turn the Balance (BAL) adjustment to eliminate any motor rotation.

12) If the motor overshoots when stopped, turn the tachometer (TAC) adjustment CCW until the overshoot is eliminated.

CAUTION: Do not turn the adjustment (TAC) fully CCW. This would remove the tachometer feedback signal and cause the motor speed to become uncontrollable.

The axis should now be ready for connection into the position control loop.

Repeat the above procedure for each axis on the SERVOMATE Chassis.

4.0 THEORY OF OPERATION

The SERVOMATE PWM axis drive system is basically a multi-channel power amplifier used to control the speed and direction of DC servo motors. Integration of an axis drive into a typical computer controlled system is shown in Figure 4-1. Figure 4-2 shows in block diagram form panel and interface interconnections for a two-axis system. A detailed discussion of all SERVOMATE circuitry follows in this Section.

4.1 AXIS DRIVE MODULE

The axis drive module contains two distinctly separate halves. The left half, Figure 4-3A, consists of the velocity control amplifier, several optional functions, and the analog portion of the pulse-width modulated current source.The analog section of the PWM current source controls the transistor output bridge located on the right half, Figure 4-3B. Only the right half is covered with a heatsink. The left half is exposed on both sides for maximum access to the components.

4.1.1 Switching Configuration

PWM indicates pulse-width modulation which is the operating mode of each axis drive in the system. In a PWM controller, a power transistor bridge switches DC bus supply to the motor load at a fixed frequency but varying on-off ratio for output power control. The Servomate differs from other controllers of its type in that a unique three-state switching technique (uni-switching) is employed which requires that only one output transistor, rather than two, control current from the bus to the load for a given output polarity.

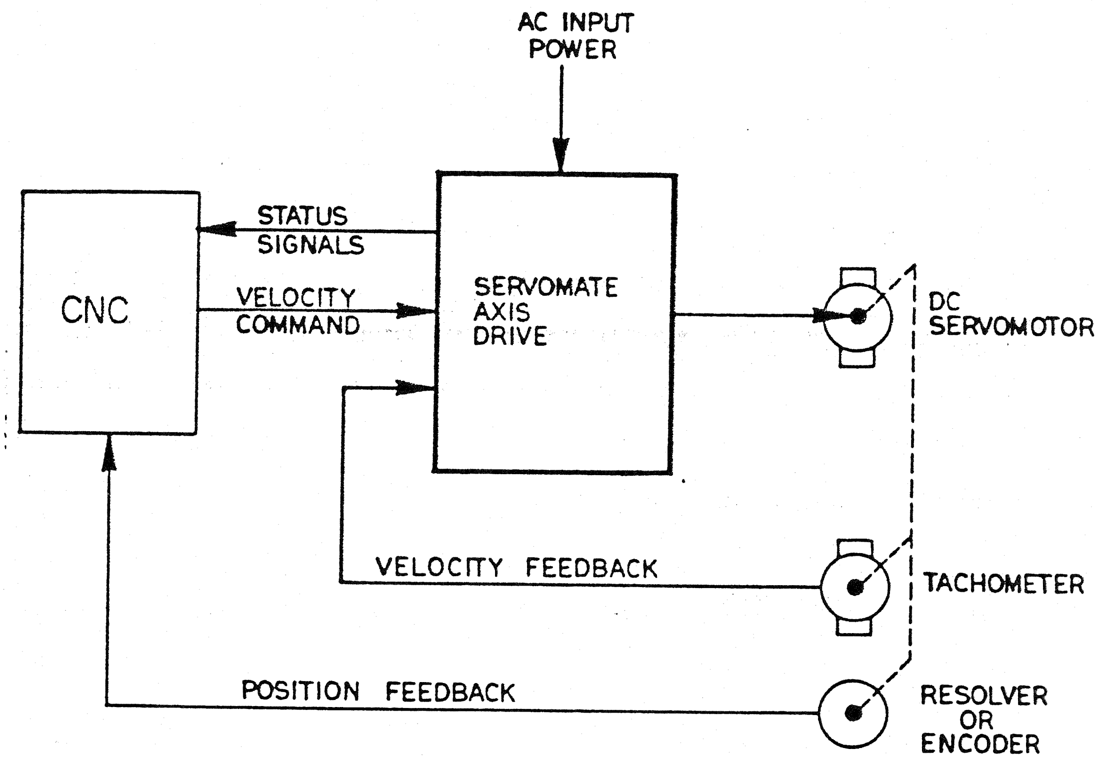


FIGURE 4-1. INTEGRATION OF SERVOMATE AXIS DRIVE IN TYPICAL SYSTEM

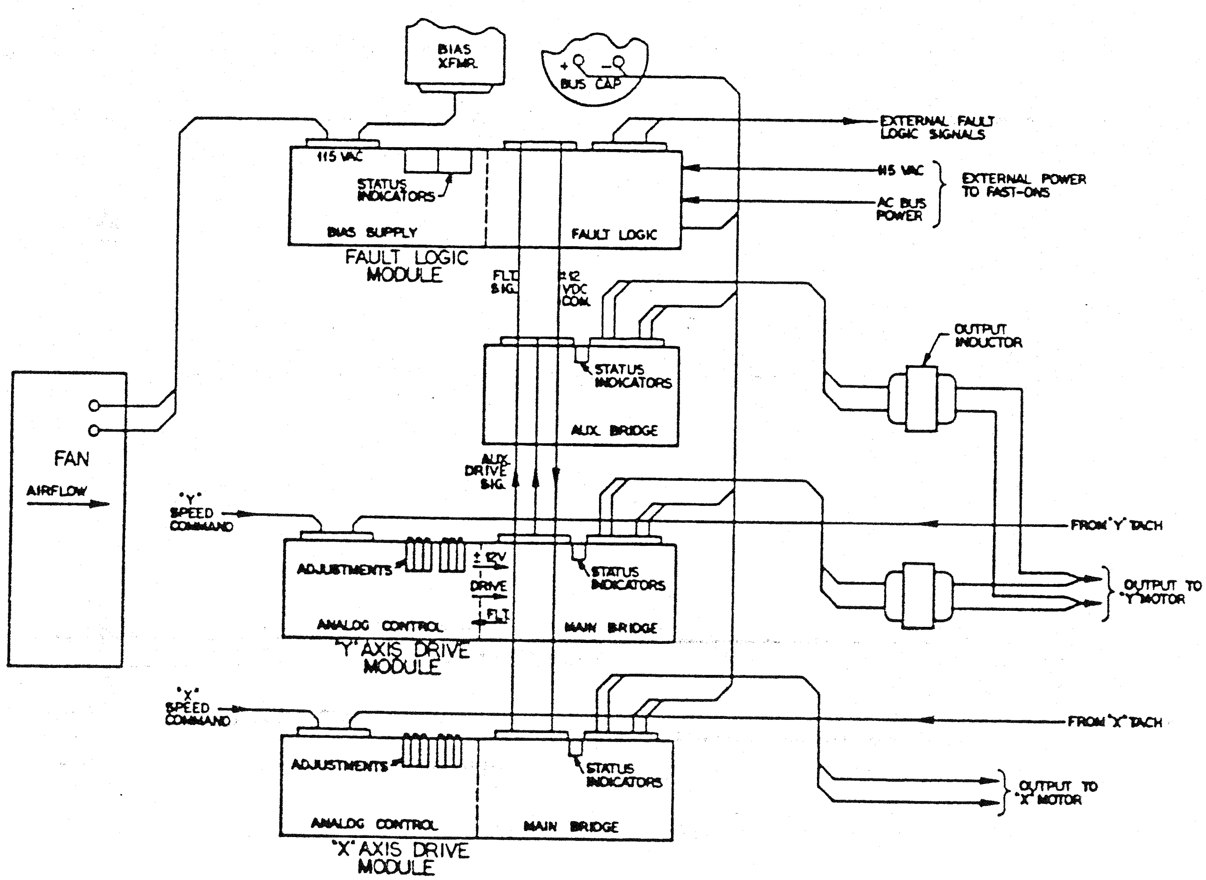


FIGURE 4-2. TYPICAL 2 AXIS MODULE INTERFACE

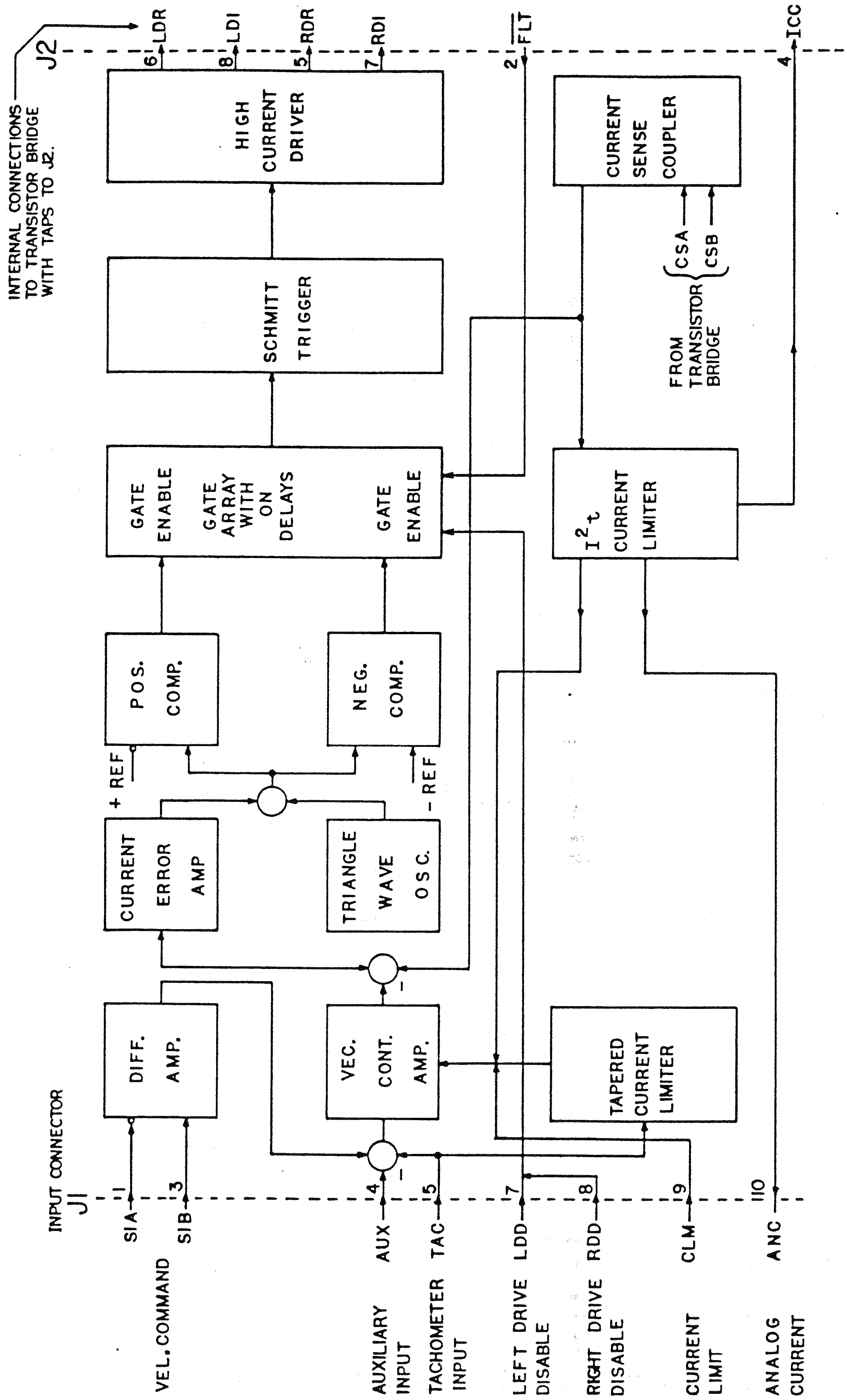


FIGURE 4-3A. ANALOG CONTROL SECTION OF AXIS DRIVE

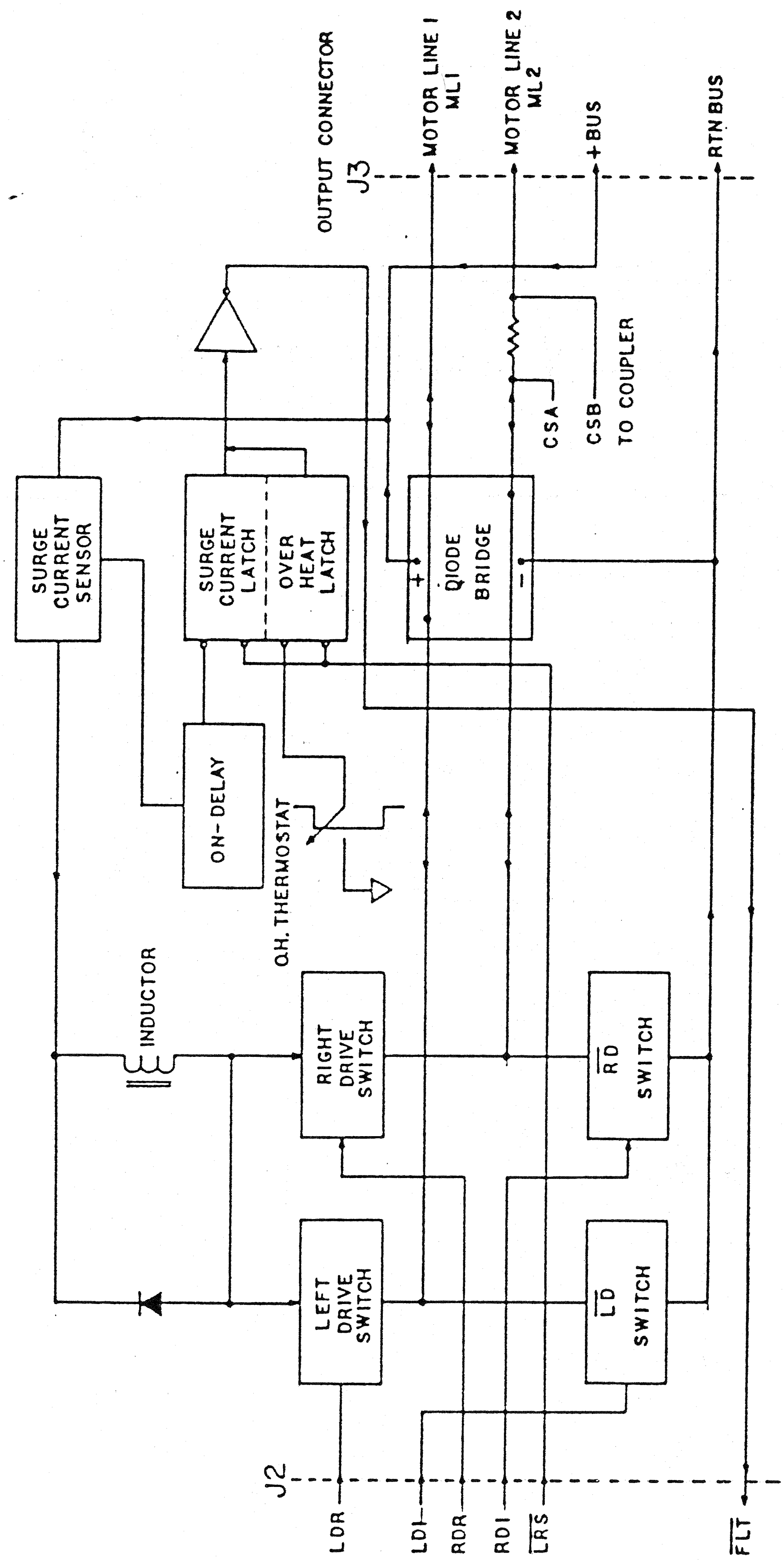


FIGURE 4-3B. TRANSISTOR BRIDGE SECTION OF AXIS DRIVE

This improved switching concept results in:

1) Lower switching losses - less power dissipation.

2) Lower ripple current - less motor heating and lower output inductance required.

3) Lower EMI (Electromagnetic Interference)

4) Higher gain-bandwidth product --better system response.

Controller output lines are switched to the power bus with transistors LDR, RDR, LDI and RDI. Their switching action is determined by a three-state modulator shown in Figure 4-4. It sums the output of the current error amplifier with a triangular waveform and compares it to fixed references --one for each output polarity. A zero voltage signal from the current error amplifier causes only the lower switches to be on; that is, the output voltage is zero and independent of output current (the first state). This is appropriately referred to as the lower circulation method. A positive voltage signal from the current error amplifier causes the left drive, LDR, and right drive inverted, RDI, switches to be on (the second state). The output voltage is then positive. Similarly, a negative voltage signal operates switches RDR and LDI, resulting in a negative output voltage (the third state). Figure 4-4 also illustrates typical output voltages and current as the modulator input is raised.

The three state modulation configuration always allows one of the lower transistor to be on. This fact enables a common DC bias to be developed which reverse-biases the lower transistor which is open. The reverse bias, in turn, reduces the collector-emitter capacitance resulting in significantly less switching losses than a standard two-state diagonal drive.

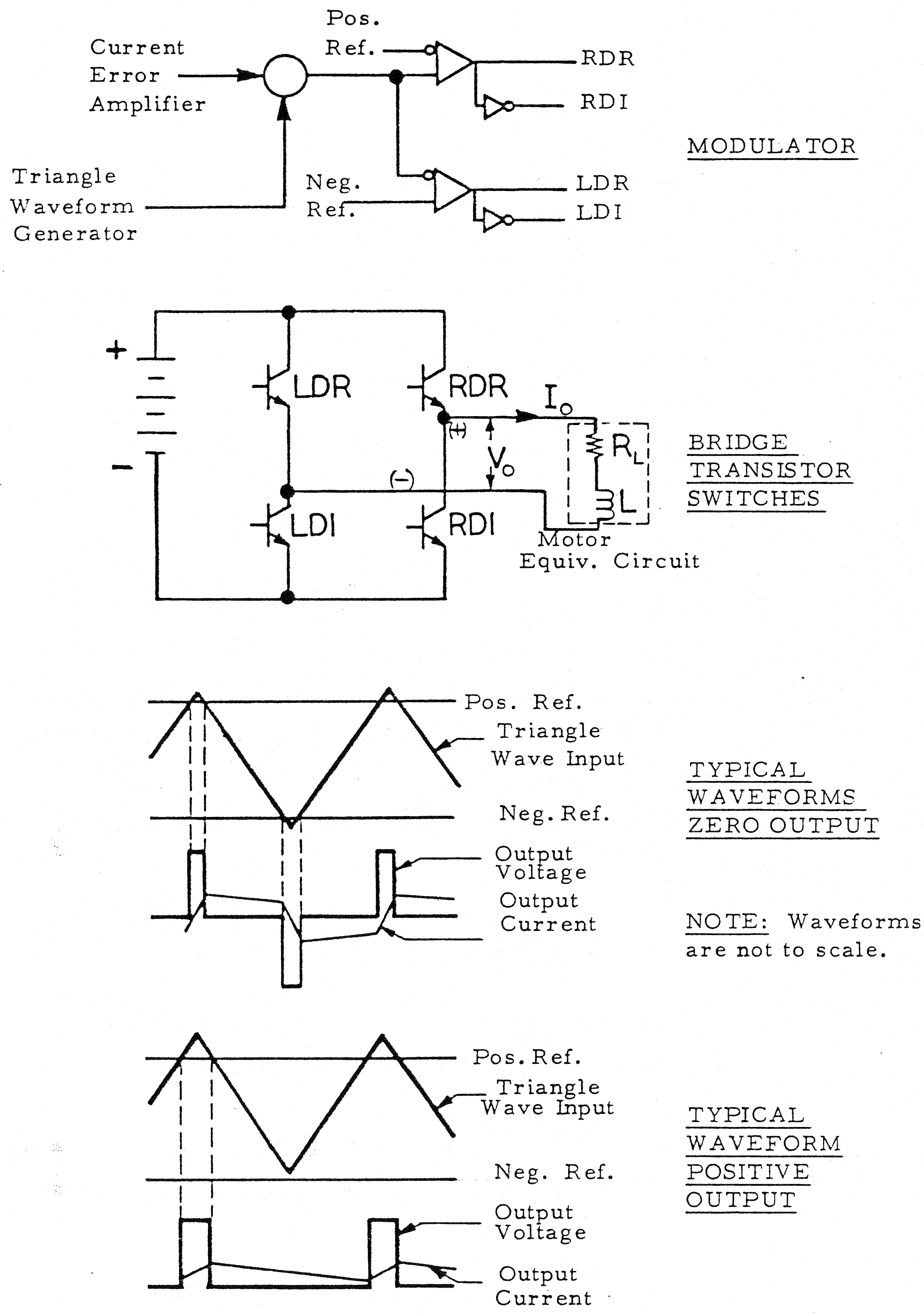


FIGURE 4-4. THE MODULATOR & BRIDGE SWITCHES WITH TYPICAL WAVEFORMS

In addition to the transistor switches, the right half of the axis drive contains a clamped inductor and a fast recovery diode bridge. The diode bridge prevents excessive reverse voltages which could otherwise occur on the transistor switches. The inductor allows the bus to collapse for several microseconds during the switching interval, resulting in short transition times. This inductor also allows the bus to collapse if the output lines are shorted or grounded to the power bus return. This reduces transistor stress in the short circuit condition. The drive lines labelled LDR (Left Drive), LDI (Left Drive Inverted), RDR and RDI are "wire OR'd" to the analog control sections and transistor bridges can be interconnected either for front end redundancy or slaving additional bridges to a master bridge, as described in Section 4.2.

4.2.1 Current Error Amplifier

The current error amplifier, U2-7, is shown in block diagram form in Figure 4-5 and detailed on the schematic diagram included in Section 6. This amplifier sums the current command signal with the current feedback signal from the current sense coupler. It frequency-compensates the resulting signal with feedback components R32 and C12 and applies it to the modulator circuit as described in the preceeding paragraphs. Capacitor C11, normally left off the board, is sometimes used to lower the current amplifier bandwidth for special applications. The current command signal is actually the output of the velocity control amplifier, U1-7. Output current to the motor is therefore directly determined by this signal. Component tolerance errors are trimmed out at factory test with R29A, the CUR CAL potentiometer, so that the maximum current command signal corresponds

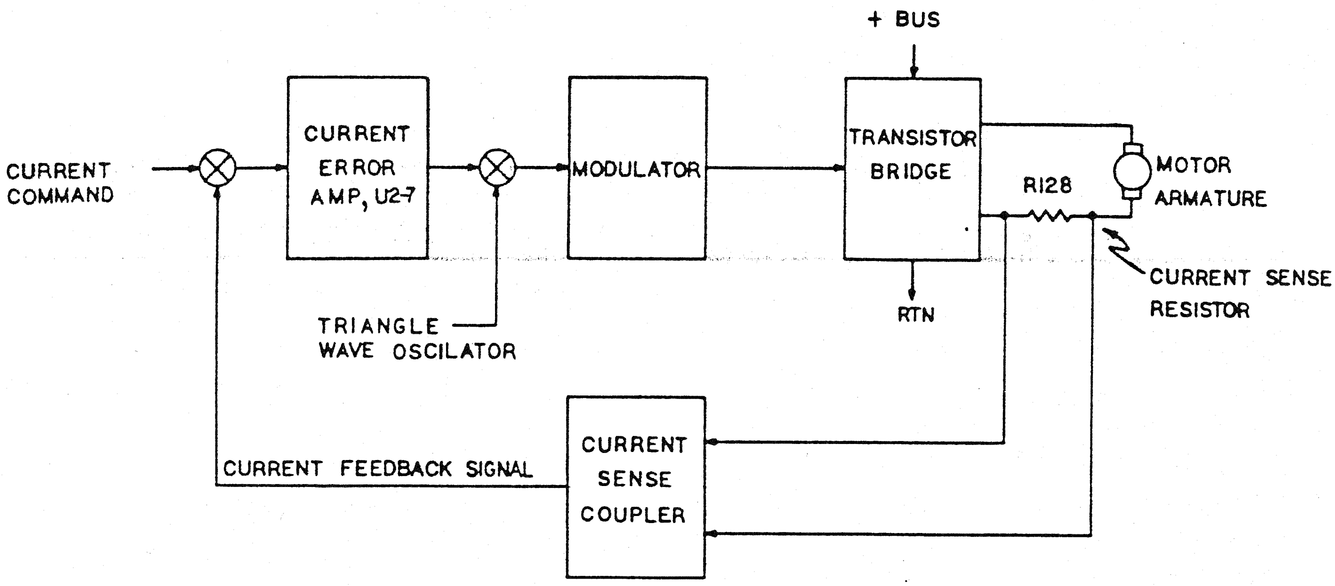


FIGURE 4-5. THE PWM CURRENT LOOP BLOCK DIAGRAM

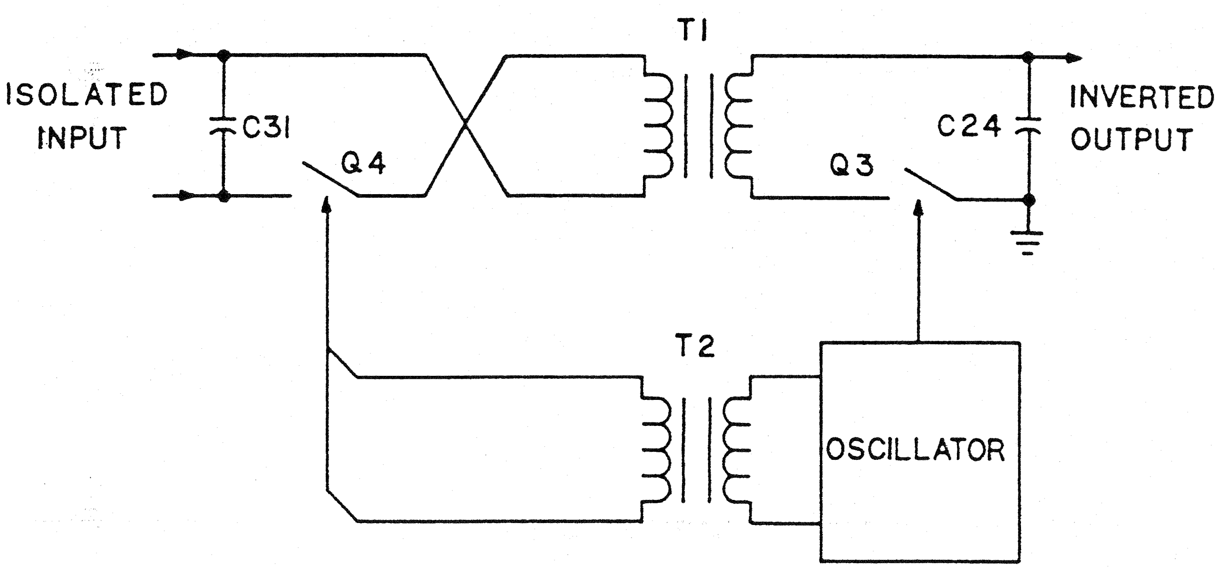


FIGURE 4-6. CURRENT SENSE COUPLER

to the peak rating of the drive. Current can be reduced from peak output down to zero via the Current Limit (CLM) potentiometer, R26.

4.1.3 Current Sense Coupler

The current flowing through the motor lines must be sensed and applied as a feedback signal to the current error amplifier. The motor line voltage, however, is constantly being switched between the positive bus and the bus return. This high voltage must be rejected while the motor current is sensed. The current sense coupler circuit does this job by sensing current through low resistance series resistor, R128. The circuit operates as a modulator-demodulator with an operating carrier frequency of approximatelly 1 MHz. The signal on R128 ($\pm$600 millivolts at peak output current) is transferred through, and isolated by, transformer T1 with transistor switches Q3 and Q4. Figures 4-5 and 4-6 show the current loop block diagram and the current sense coupler configuration.

4.1.4 Velocity Control Amplifier

The velocity control amplifier, U1-7, has three connected inputs: 1) the velocity command from differential amplifier U1-1 through R18; 2) the auxiliary input through R15; and 3) the tachometer feedback signal through R17. The differential amplifier connection is normally used for the velocity command signal in order to minimize the possibility of conducting noise back to the CNC electronics hardware. The auxiliary input can be used for a ground-referenced speed command signal, for a remote speed offset, or for eliminating the hunting tendency about the least significant bit when the drive is connected in a position loop. The tachometer feedback signal is

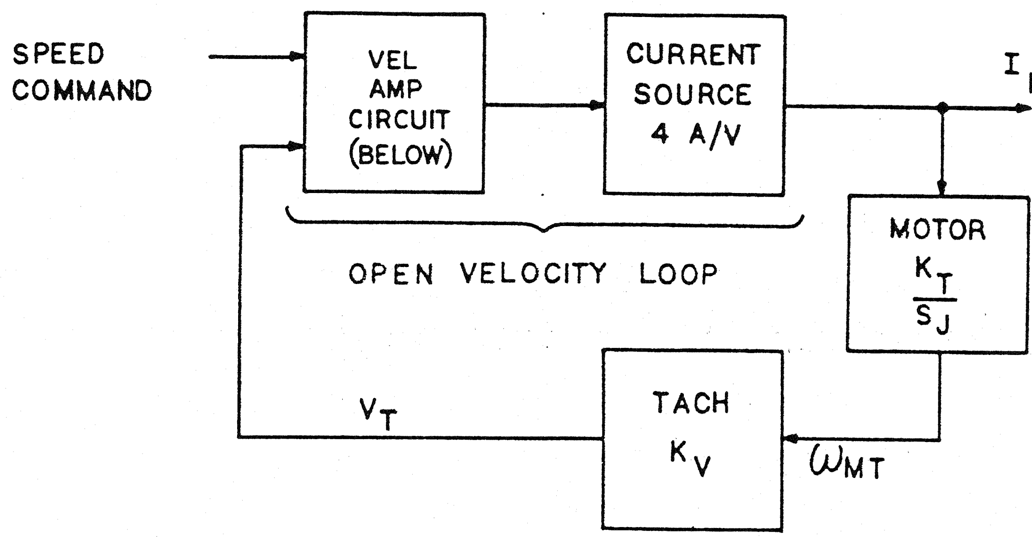


FIGURE 4-7A. OPEN VELOCITY LOOP

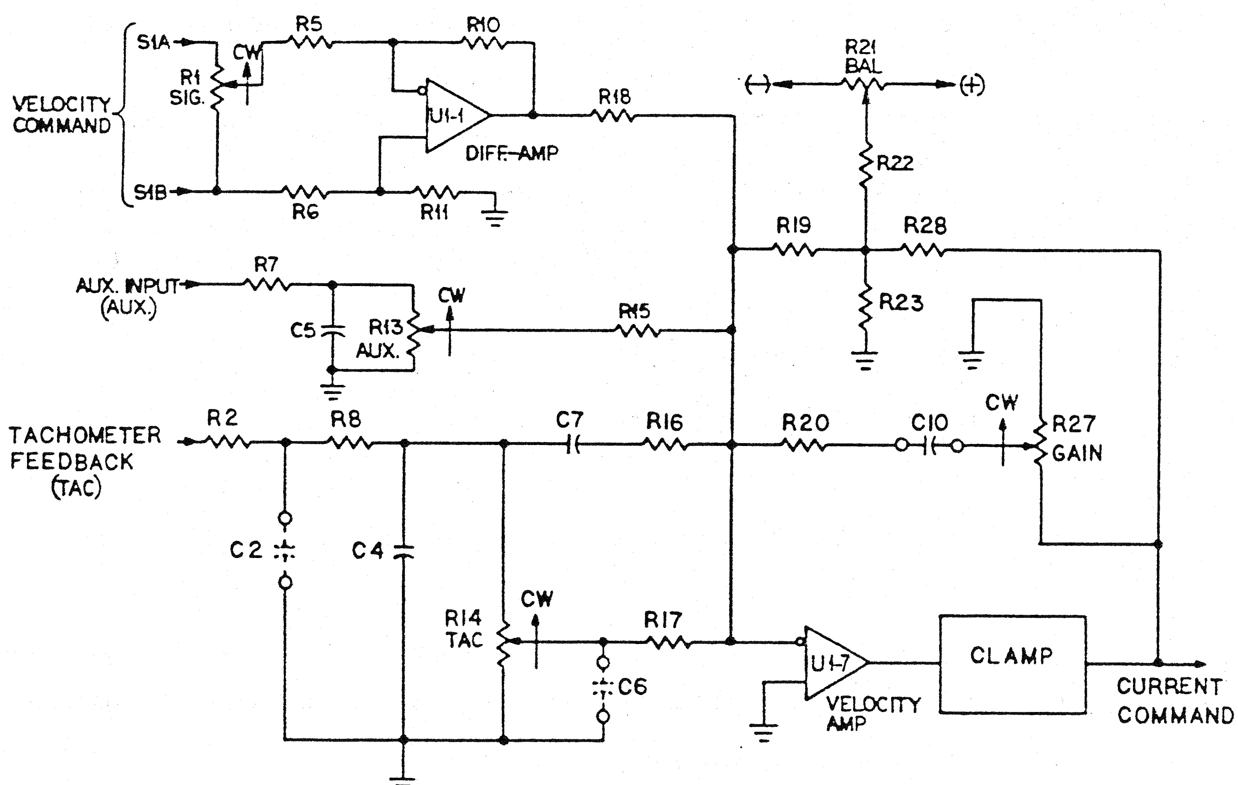


FIGURE 4-7B. VELOCITY AMPLIFIER CIRCUIT

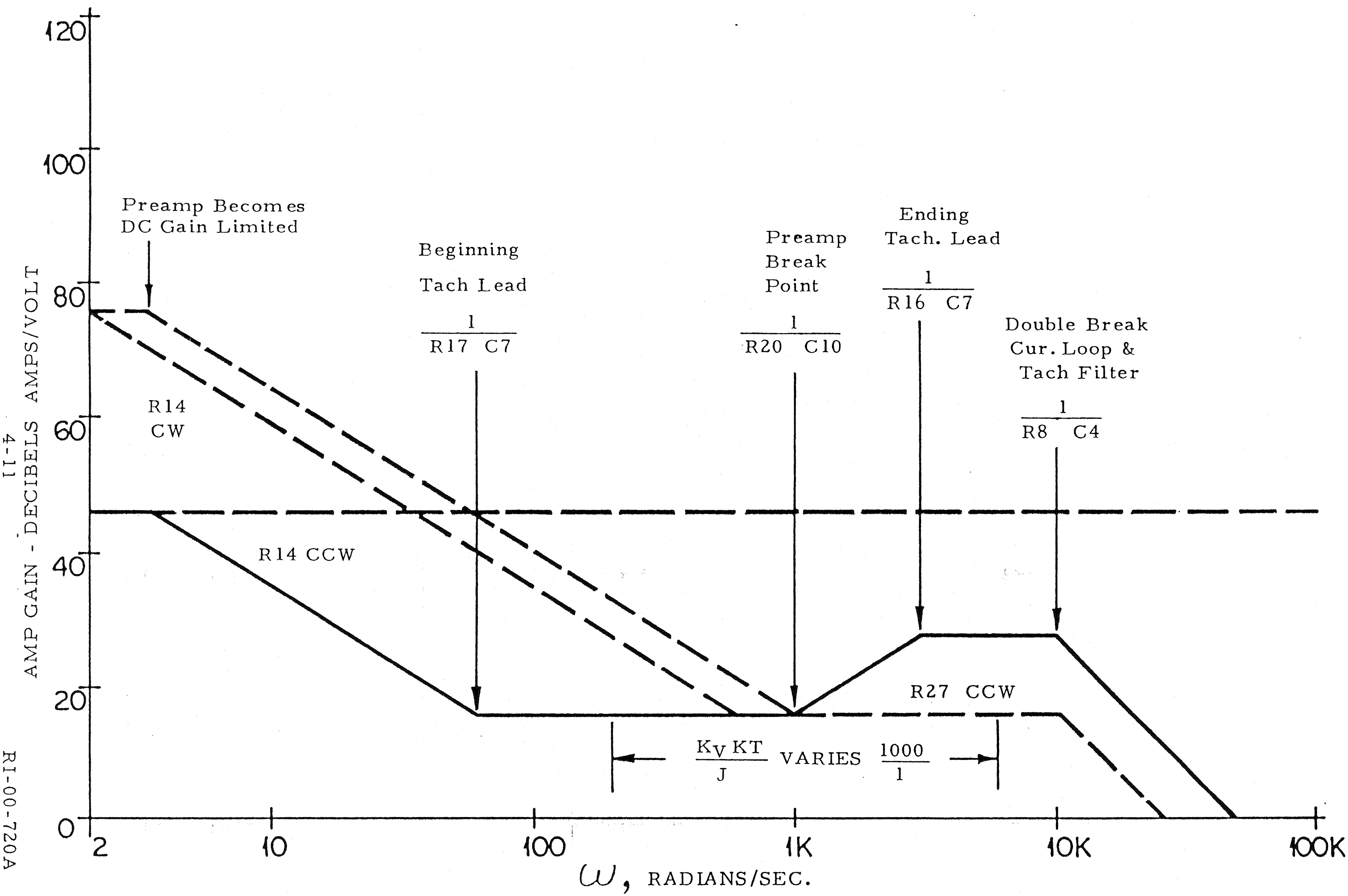


FIGURE 4-8. OPEN VELOCITY LOOP RESPONSE

scaled with potentiometer R14 (TAC) so a wide range of tachometer scale factors can be accomodated without component value changes. Capacitor C4 is normally installed for a filter frequency of approximately 1600 Hz. High response systems may require a heavier filter network (see Section 2.1.12). As described in Para. 4.1.2, the velocity amplifier output is actually the motor current command signal. It is therefore accurately and symmetrically clamped to control peak output current.

The open loop frequency response must vary from one system to the next because of 1), the motor-tach inertia, J; 2) the motor gain, K_T, and 3) the tach gain, K_V. The response curve of Figure 4-8 illustrates how the system conveniently compensates motor-tach combinations with a $K_T K_V / J$ ratio range of 1000:1. This is possible because the gain can be constant over a two-decade range due to the tach lead components C7, R16 and R17. Overall frequency response is tailored by feedback components R20 and C10.

4.1.5 I^2t Limiter

In normal operation, the I^2t circuit is inactive. It senses the axis drive output current and operates only after a given amount of time to protect against excessive and possibly destructive output currents. Current level is sensed by a non-linear comparator which closely follows an I^2t curve above the controller's continuous current rating. See Figure 4-9. If the comparator is tripped, it causes an output clamp to restrict the amplitude of the current command -- thus reducing output current. An I^2t limit output indication is also coupled to connector J2, pin 4. This output, labelled ICC, is normally high (+12 volts) but switches to a low state (com) during limiting. It is "or'd" with the ICC outputs of other axis drives in the system to the Excessive Continuous Current (ECC) circuit and LED indicator on the Fault Logic Module.

Since it is not uncommon for a limit condition to occur during acceleration on axis drives with relatively high connected load inertia, this circuit is normally shipped such that a limit condition does not latch and trip the fault detector to shut down the controller. It can, however, be wired to trip off.

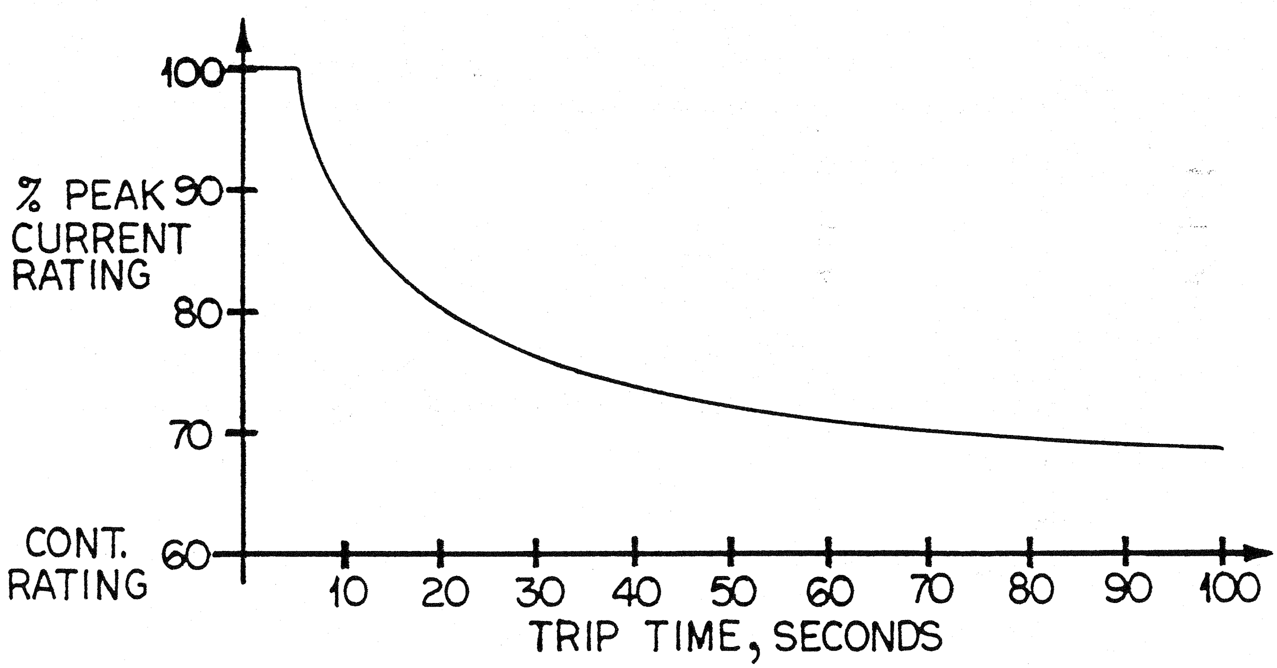


FIGURE 4-9. I^2t LIMITER CIRCUIT OPERATION

4.1.6 Surge Current Sensor

The surge current sensor is incorporated in the axis drive module to shut down the drive if the normal peak output current is exceeded. Surge current sensing is accomplished by means of a low valued resistor in series with the positive bus, Figure 4-3B. A small voltage drop occurs across this resistance each time a surge current occurs. The drop is applied first to a comparator and then to an on-delay timer. The surge causes a latch to be set if the current exceeds a threshold for a predetermined time interval. The axis drive LED labelled "SC" also comes on. To clear the latched-off condition, the drive must be reset by: 1) momentarily connecting the Retest (RTS) line to common; or 2) by removing and reapplying bias power.

4.1.7 Overheat Sensor

A small, normally open thermostat sets the overheat latch, Figure 4-3B, if the heatsink temperature exceeds a predetermined threshold. This condition is annunciated with the axis drive LED labelled "OH". When heatsink temperature reduces to normal, the fault condition can be reset in the same manner as described in the preceding paragraph.

4.1.8 Left, Right Drive Disable

By connecting the Left Drive Disable (LDD) at J1, Pin 7, or Right Drive Disable (RDD) at J1, Pin 8, line to common, Figure 4-3B, drive operation in that direction is inhibited.

RDD inhibits positive (+) output voltage at ML1 with respect to ML2.

LDD inhibits negative (-) output voltage at ML1 with respect to ML2.

These inputs are normally connected to machine-mounted limit switches to allow an axis to back out of an overtravel condition.

4.1.9 External Current Limit

The external current limit, labelled "CLM", at connector J1, Pin 9, can be used to proportionally reduce the axis output current or shut the axis down altogether. See Section 2.3.3 for an explanation of its use in a system.

4.1.10 Analog Current Signal

The analog current signal, labelled "ANC", Figure 4-3A, is available at connector J1, Pin 10. This signal is bi-directional and proportional to the axis drive output current. Scaling is factory set with the MTR CAL potentiometer, R29B, for $\pm$ 10 volts equals peak current.

An optional configuration for this signal is to make it uni-directional; i.e., an absolute value of analog current. This is done by installing diode D19 and removing resistor R63. If done in this manner, the signal can be "diode OR'd" with other axes in the system and used as a common highest current monitor point.

Another possible application is on an axis with a magnetic particle clutch used as a brake. The ANC output could act as a feedback signal to reduce the feed rate as the motor current increases. The circuit board connection for this option is shown in Figure 4-10.

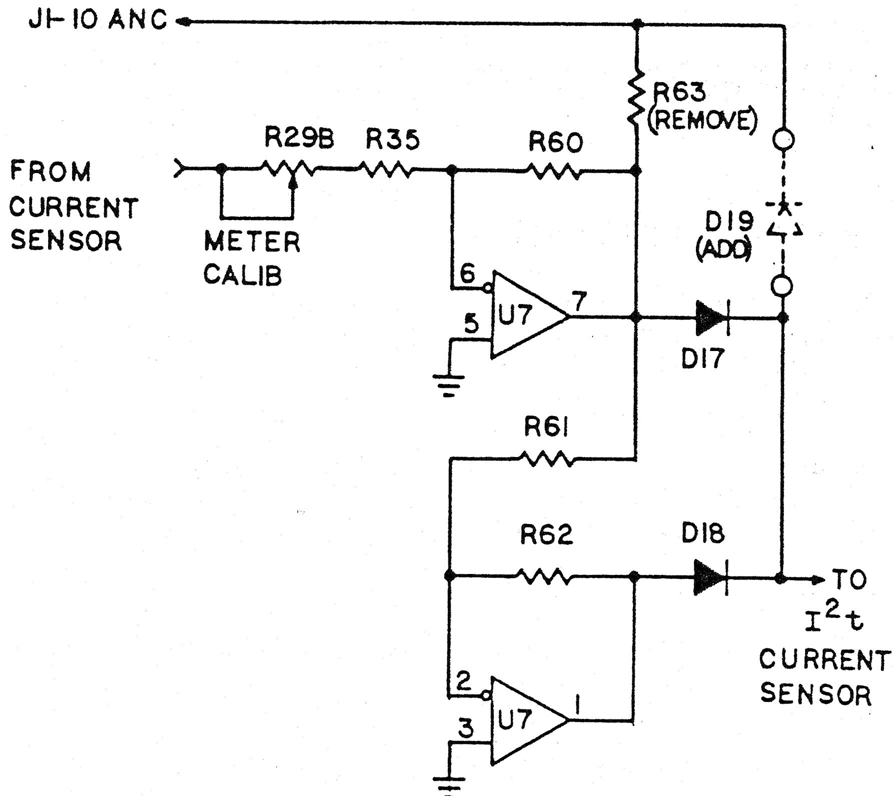


FIGURE 4-10. OPTIONAL ABSOLUTE VALUE CONNECTION FOR ANC SIGNAL

4.1.11 Tapered Current Clamp (Optional)

The purpose of the tapered current clamp, Figure 4-11, is to reduce the available output current linearly as the motor speed increases. This function reduces the high speed motor stress which can cause commutator arcing. The maximum motor current as a function of speed is often specified by the motor manufacturer. An advantage to this connection in a system with large inertia is that it could reduce the size of the shunt regulator by reducing high speed deceleration current.

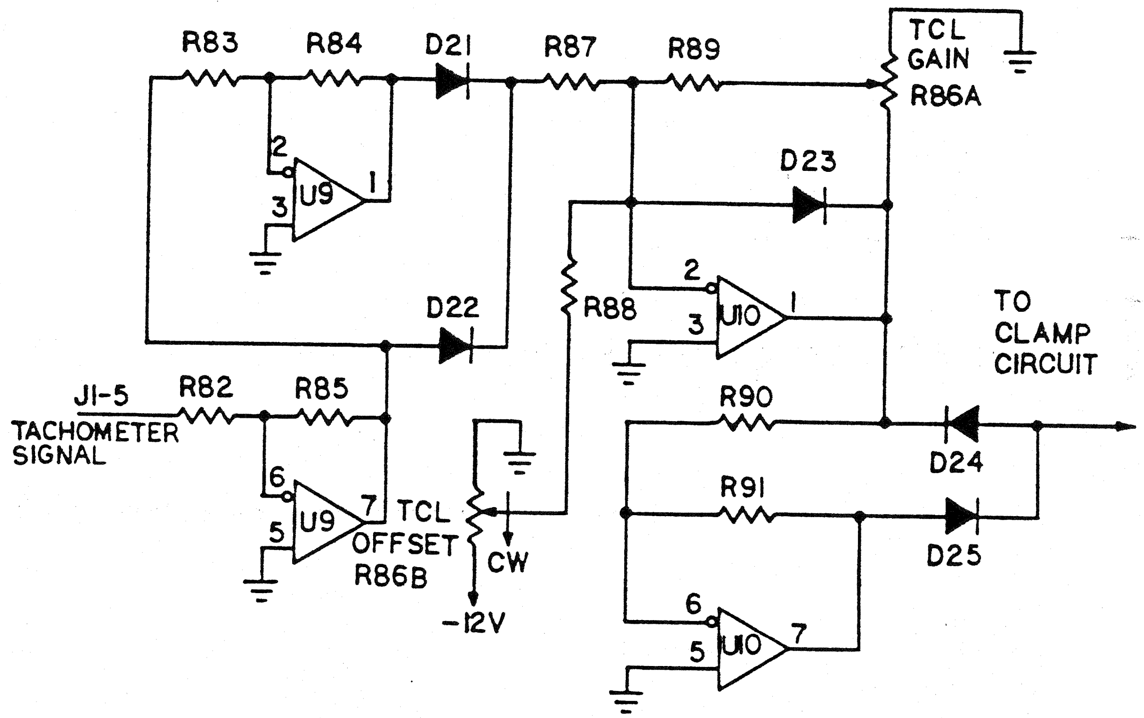


FIGURE 4-11. OPTIONAL TAPERED CURRENT CLAMP

4.1.12 Tachometer Filter (Optional)

The standard tachometer input filter shown in Figure 4-7B, consists of a single section which rolls off at 1600 Hz. If a very high response servo motor is used, it may exhibit a mechanical resonance at 800 to 2000 Hz. This resonance results in an unnecessary phase shift in the velocity control loop and can cause instability. The modified tach filter, Figure 4-12, significantly reduces this resonance condition and open loop velocity gain can be increased.

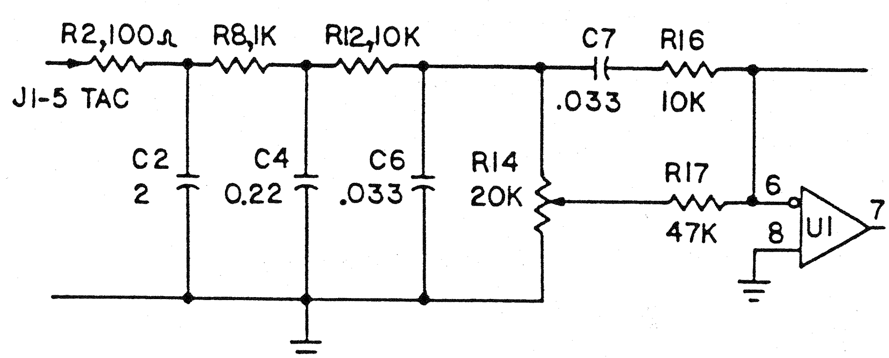


FIGURE 4-12. OPTIONAL 3-SECTION TACH FILTER

4.2 AUXILIARY BRIDGE MODULE

Some machine systems require more current than is available from a single axis drive module. This is accomplished by paralleling or slaving one or more auxiliary bridges to the master axis drive module. For example, a double bridge axis drive requires that one auxiliary bridge be added to the master axis drive. A triple bridge axis drive requires two auxiliary bridges. This connection is shown in Figure 4-13. The circuitry on the auxiliary bridge module is the same as the bridge section (right half) of an axis drive module. See Figure 4-3B.

Input drive lines, LDR, LDI, RDR and RDI of each slave bridge are wired to those of the master at connector J2. Output lines (ML1 and ML2) of each bridge are then connected to individual chassis mounted current-sharing inductors, the output of which are paralleled and connected to the motor. Current in each of the slave bridges is scaled to that of the master axis module. Dynamic current sharing occurs because the current in each bridge cannot change quickly during a transition interval. Static current sharing occurs due to 1) the DC resistance present in each current-sharing inductor, and 2) the storage time characteristic of each power transistor switch. It should be noted that the transistors used in a multi-bridge axis drive are selected for storage time and therefore are not interchangeable with those in a non-parallel unit.

Each of the auxiliary bridge modules has its own LED indicators for surge current (SC) and overheat (OH) -- the same as the master axis drive module. This provides ready identification of the faulty bridge module should a transistor failure occur.

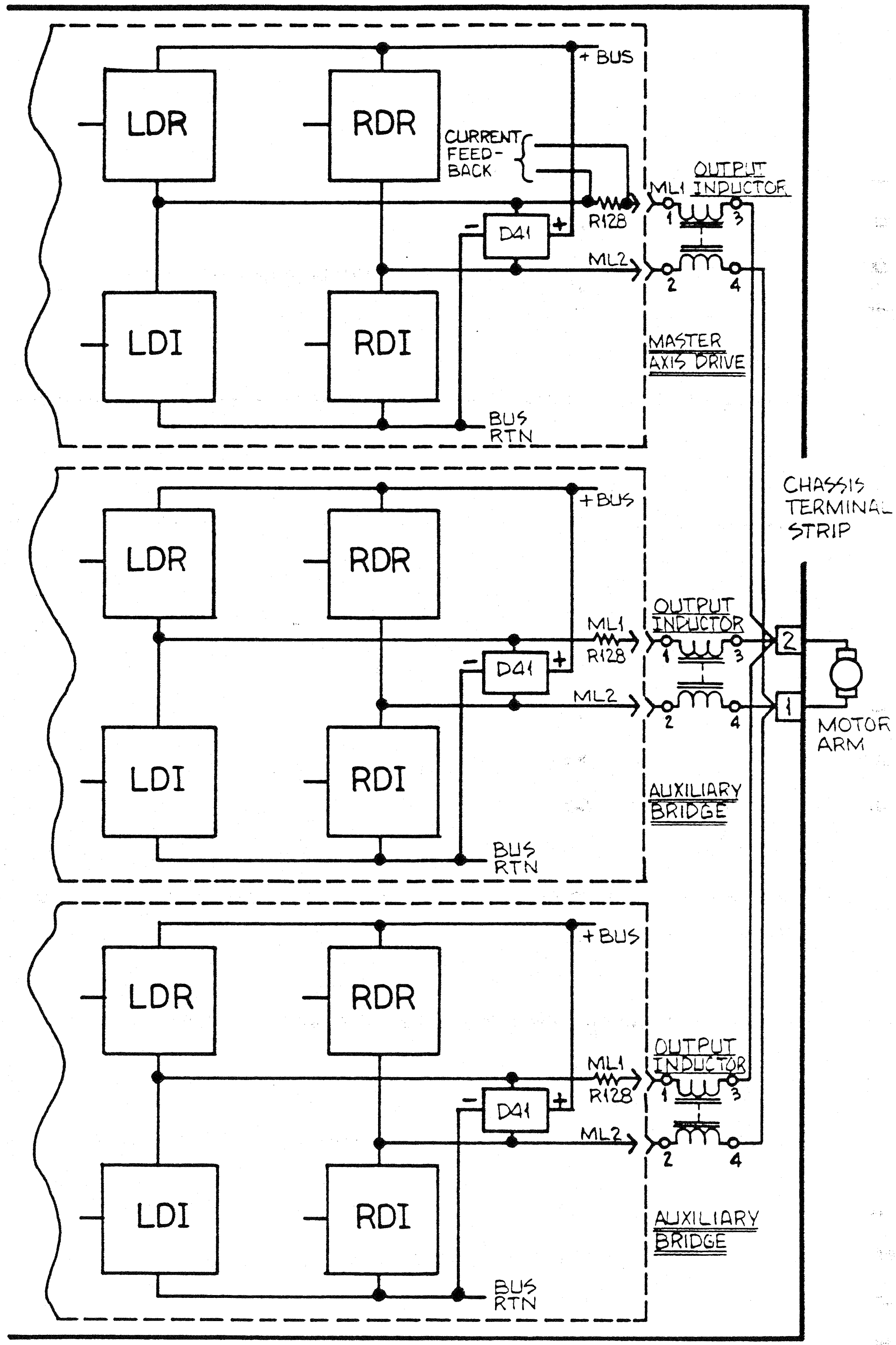


FIGURE 4-13. TRIPLE BRIDGE AXIS DRIVE

4.3 FAULT LOGIC MODULE

The fault logic module, Figure 4-14, is common to all drives in the system. It contains the following circuits:

1) 12 volt bias power supplies
2) High current diode bridge for the DC bias voltage
3) Fault latch circuitry and LED indicators for axis drives

AC bias power for the 12 volt regulators comes from chassis-mounted transformer, T1. It supplies 28 volts center-tapped to connector J-1, Pins 9, 10 and 12. When this power is on(from the 115 VAC input) the XMFR LED indicator is on. The plus and minus 12 volt regulators, each with LED indicators, are tracking type with foldback current limiting to prevent failure if accidentally shorted to common. Their outputs are connected to J2, Pins 9 and 12, for interconnection to axis drives in the system, and are also available at connector J3, Pins 6 and 8, for customer use (50 ma maximum load each). The 115 VAC incoming power to the bias supply transformer and cooling fan(s) at J4 is protected on the fault logic module with fuse F1. High power AC input voltage from the isolation transformer connects to faston terminals at J5. This single-phase voltage is rectified with diode bridge CR4 which is heatsink mounted. The bus capacitor(s) connect to the DC bridge output at faston terminals J7. When this voltage is on, the PBU (Power Bus Up) LED indicates.

The fault latches -- each with LED indicators -- are:

ECC	-	Excessive Continuous Current
PBE	-	Power Bus Error
BIE	-	Bias Voltage Error
GFT	-	Ground Fault

If any of the above faults except ECC occur, it latches the corresponding LED and turns off the system. The FLT line at J3, Pin 1, normally pulled to +12 volts, is switched to or below common. This line is brought out to the external terminal strip for customer use*. If an ECC fault occurs, it normally does not latch, but simply reduces the individual axis output current to a safe level to allow self-clearing "ride through" operation. The ECC fault circuit can be factory-connected to latch the system off.

Inputs to the ECC circuit are from the I^2t output of each axis drive in the system. These outputs, labelled ICC, are open collector comparators and are "wire OR'd" to the fault logic module at connector J2, Pin 4.

The PBE latch is set if the power bus comparator on the fault logic board detects an excessively high voltage.

BIE fault occurs if the sum of the plus and minus 12 volt supplies falls below 22 volts.

A GFT fault is detected if either motor line or the positive bus line becomes connected to the chassis, resulting in 1 amp or more of current flow. Fault logic board fuse F3 protects the ground fault sensing circuit if the positive line is permanently grounded.

Each of the above latches is initially cleared at bias voltage power up with a one second RC timer. They can also be cleared externally by momentarily connecting the RTS (Retest) line to common. If a system fault still exists, it will immediately trip its latch circuit and inhibit drive operation.

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* The FLT line can be used to externally inhibit drive operation by connecting it to common.

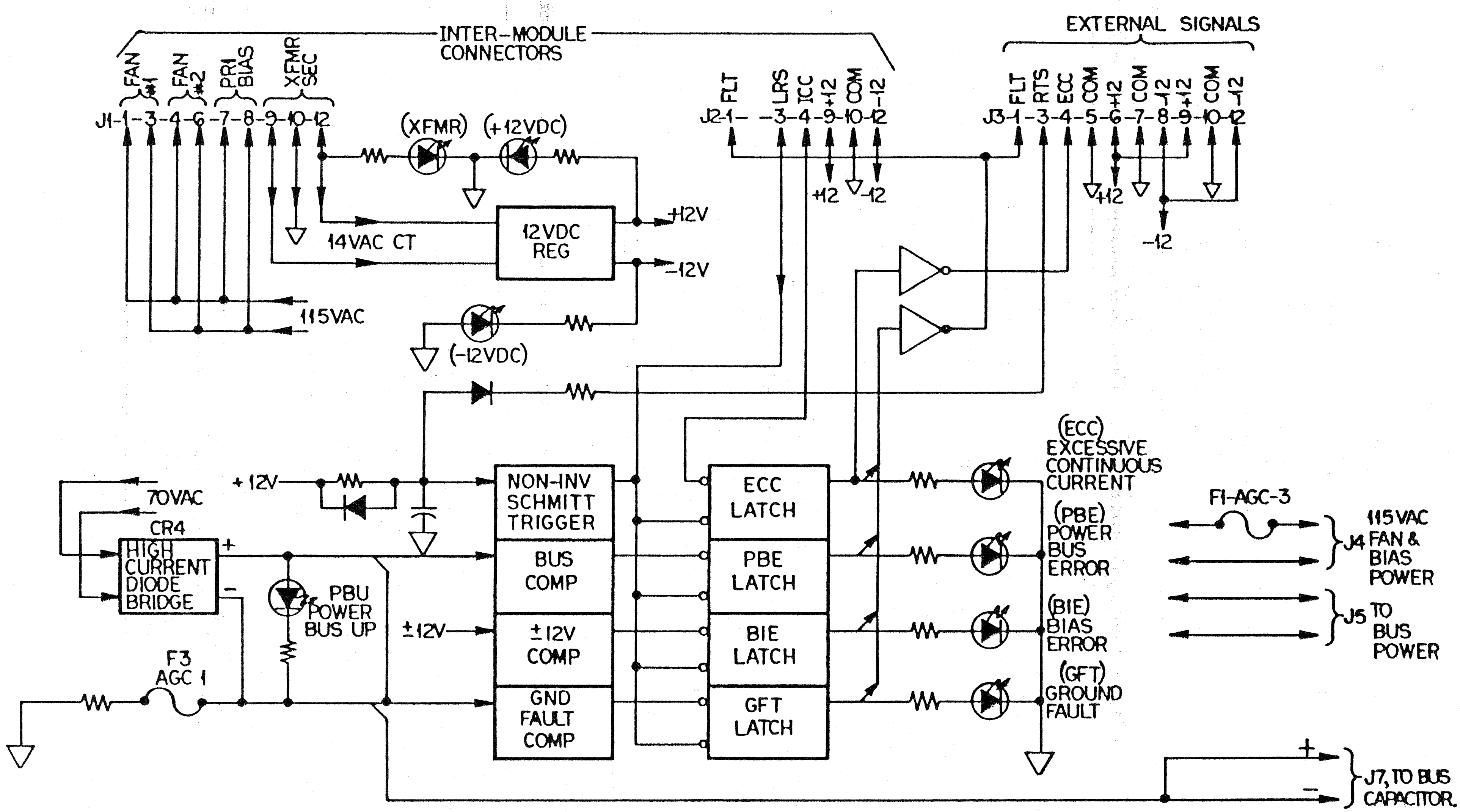


FIGURE 4-14. FAULT LOGIC MODULE

4.4 SHUNT REGULATOR

The armature in a running motor contains kinetic energy. If the motor is decelerated, this energy is dissipated in 1) the armature total loop resistance, and 2) the bus capacitor. At high current levels, the motor energy is often dissipated in the armature resistance only. However, at low current levels during deceleration the energy cannot be dissipated resistively. The motor energy is then transferred to the bus capacitor by pumping up or increasing the bus capacitor voltage. If the voltage becomes too high, the PBE indicator operates, turning off the drive. To eliminate this condition, a shunt regulator is used to clamp the bus voltage to a point below the PBE threshold.

The Shunt Regulator, Figure 4-15, consists of a voltage comparator and a set of load resistors (up to four) which are each driven by a separate power transistor. The comparator operates to turn on the transistors only if the bus voltage exceeds the trip level. The excessive motor-load energy is then dissipated in the resistor(s). Sections of the load group can be added as the application requires. The last three sections, Q2, Q3 and Q4, are driven from the first section, Q1. Separate fuses are in series with each load resistor to open in the unlikely event that a transistor shorts or if the connected load has so much inertia that the resistors cannot dissipate the energy without overheating.

The clamp voltage is factory-adjusted to the specified clamp level. (Approximately 130 volts, 100V units; 190 volts, 160V units.) The reference is controlled by a double zener clamp which is stable as ambient temperature changes. The unit uses remote sensing at the bus capacitor to eliminate noise which would otherwise occur on the bus power lines. All connections are through a single connection, J1.

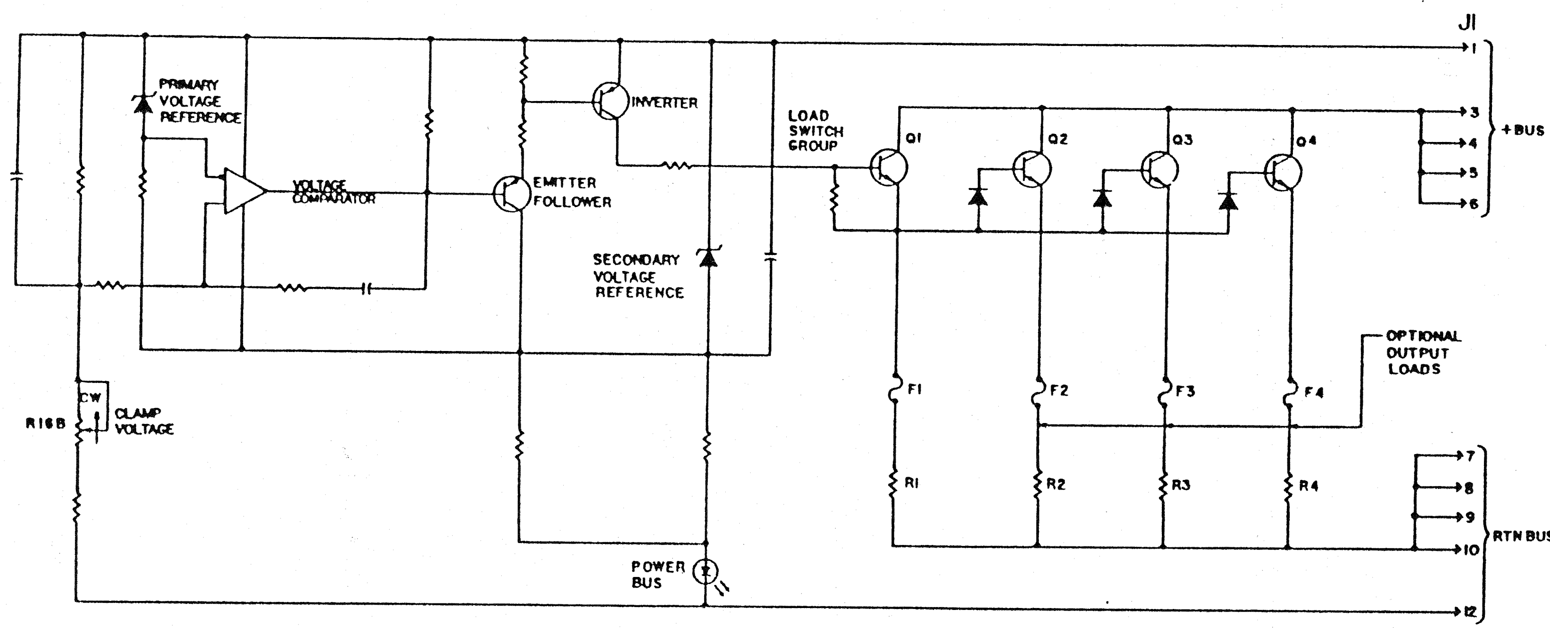


FIGURE 4-15. SHUNT REGULATOR

5.0 SERVICE & MAINTENANCE

SAFETY NOTICE

This equipment employs voltages which are dangerous and could cause injury to personnel or equipment. Caution should be exercised and the following rules observed:

1) Remove power --both the 115 VAC bias and fan voltage and the high power AC bus voltage --before performing any maintenance work on controller or motor. Allow bus capacitor voltage time to bleed down.

2) Do not make any adjustments unless thoroughly familiar with the equipment.

5.1 PERIODIC MAINTENANCE

The only periodic maintenance for the Randtronics SERVOMATE SMI Series Controller is an occasional inspection for accumulated dust or dirt on heatsinks and circuit boards. For maximum efficiency heatsinks must be kept clean. Also, shop dust in some environments tends to be electrically conductive and can cause controller malfunction. If cleaning is needed, carefully vacuum loose dirt or use dry compressed air.

5.2 SERVICING

The SERVOMATE Controller is designed for easy and straight-forward servicing. Modules are connectorized and mount to the chassis with only two or three screws. Adjustments are readily accessible at the top edge of the circuit boards. LED's provide immediate indication of controller status and fault condition.

5.2.1 Module Replacement

Module Removal:

1) Remove all power. Make certain bus capacitor voltage has bled down. DO NOT SHORT CAPACITOR WITH SCREWDRIVER OR CLIP LEAD. Measure with voltmeter or wait 60 seconds.

2) Disconnect module top edge connectors. Use a wide blade screwdriver if necessary per Figure 5-1.

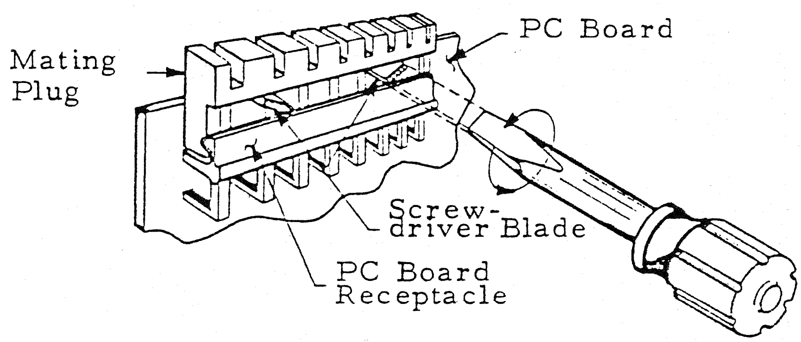


FIGURE 5-1. MODULE CONNECTOR REMOVAL

3) Loosen the module's chassis mounting screws (mounting brackets are slotted) and slide module out from chassis.

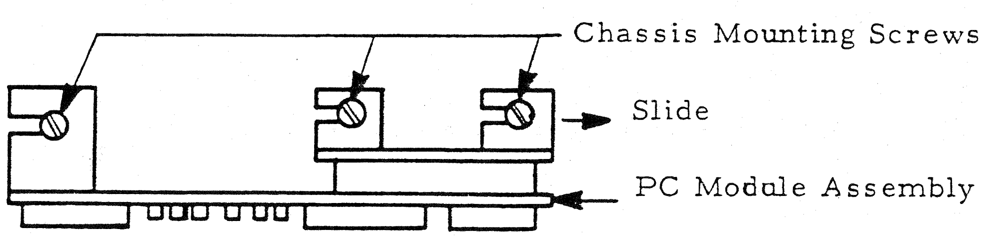


FIGURE 5-2. CHASSIS MODULE MOUNTING

Module Replacement:

Reverse above procedure. Take care to observe connector polarization when re-installing.

5.2.2 Circuit Abbreviations and Terminology

The module interface signal points and adjustments are identified on the diagram and silk-screened on the circuit board with a three-letter symbol. The description of designations is as follows:

1) Potentiometer Adjustments Located on Each Axis Drive Board

SIG - Designates signal or velocity command sensitivity. This is in front of a differential amplifier used to minimize ground currents which might otherwise send noise impulses to the CNC system.

AUX - Designates auxiliary input gain, similar to the velocity input, but single-ended.

TAC - Designates the DC gain control connected to the tachometer circuit. Typically, the TAC pot is initially turned fully clockwise.

BAL - Designates balance or input offset adjustment. This is used to stop the motor from drifting in a velocity control loop.

GAN - Designates internal velocity loop gain. This is normally turned clockwise until the system oscillates. Then the adjustment is backed off one turn.

CLM - Designates the output current limit or the maximum peak current allowed to the motor armature.

2) Customer Interface Signals Located on Each Individual Axis Drive Board - Connector

SIA
SIB - Designates a differential input speed command which is then applied to the velocity control amplifier.

AUX - Designates the auxiliary input connection (single ended).

TAC - Designates the tachometer connection.

COM - Designates common or the tachometer and auxiliary input return connections.

LDD - Designates left drive disable. This line, when grounded, inhibits negative (-) output voltage at ML1 with respect to ML2.

RDD - Designates right drive disable. This line, when grounded, inhibits positive (+) output voltage at ML1 with respect to ML2.

CLM - Designates current limit control. This is the velocity control amplifier output clamped to ± 5 VDC with a source impedance of 4K ohms. When grounded, no motor current can be commanded.

ANC - Designates analog current. The line is buffered and scaled to ± 10 VDC to indicate peak motor armature current. The buffered line has a 2K ohm resistor in series with it. It can be grounded.

COM - An additional common connection is provided as return for the two drive disable lines.

3) Customer Interface Signals Located on the Fault Logic Board, Connector

FLT - Designates a fault function. The line is pulled to or below ground if a fault condition occurs. Also, the drive will become disabled if the line is pulled to ground externally.

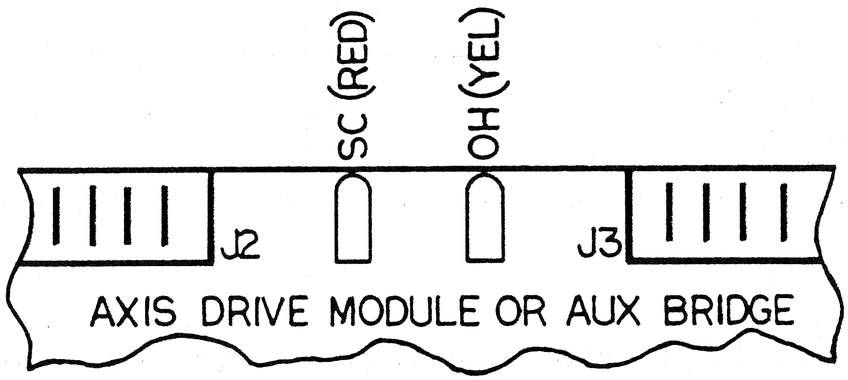
RTS - Designates a retest signal. Normally, the line is pulled to ground and then released. Pulling the line to ground disables a running drive.

ECC - Designates an excessive continuous current signal. This signal does not latch unless wired specifically for that purpose.

+12V
-12V - For customer use, 50 ma maximum.

5.2.3 Status and Fault LED Indicators

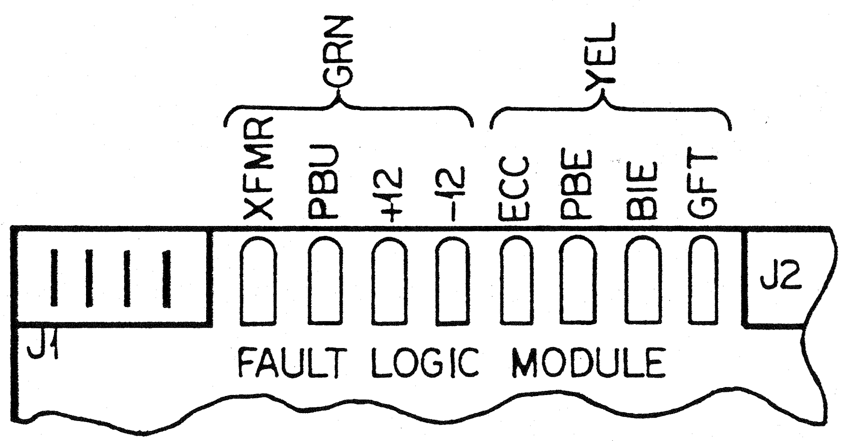
1) Axis Drive Module or Auxiliary Bridge



SC - Surge Current on power bus
OH - Transistor heatsink overheat

FIGURE 5-3. FAULT LED INDICATORS, AXIS DRIVE OR AUXILIARY BRIDGE

2) Fault Logic Module



Status LEDs

XFMR	-	115 VAC to bias transformer
PBU	-	Power bus up or energized
+12	-	+12 volt bias energized
-12	-	-12 volt bias energized

Fault LEDs

ECC	-	Excessive I^2t (armature current)
PBE	-	Power bus error (usually overvoltage)
BIE	-	±12 volt bias voltages out of tolerance
GFT	-	Ground Fault

FIGURE 5-4. STATUS & FAULT INDICATORS, FAULT LOGIC MODULE

5.2.4 TROUBLESHOOTING CHART

The troubleshooting charts included here list symptoms of possible malfunctions along with areas to check when troubleshooting. (Most of these checks can be made by observing the diagnostic LED's and using a VOM.)

To minimize the equipment "downtime", it is strongly recommended that any repairs be made on a module substitution basis. DO NOT ATTEMPT TO REPLACE COMPONENTS PARTS ON THE CIRCUIT BOARDS. This could cause further problems and void the equipment warranty.

Troubleshooting should begin with a systematic check of command signals and power to the controller:

- o Check input speed command signals - do they reach controller terminal strip?
- o Check external limit switches.
- o Check 115 VAC bias power and AC bus voltage

Make a physical inspection, looking for the following:

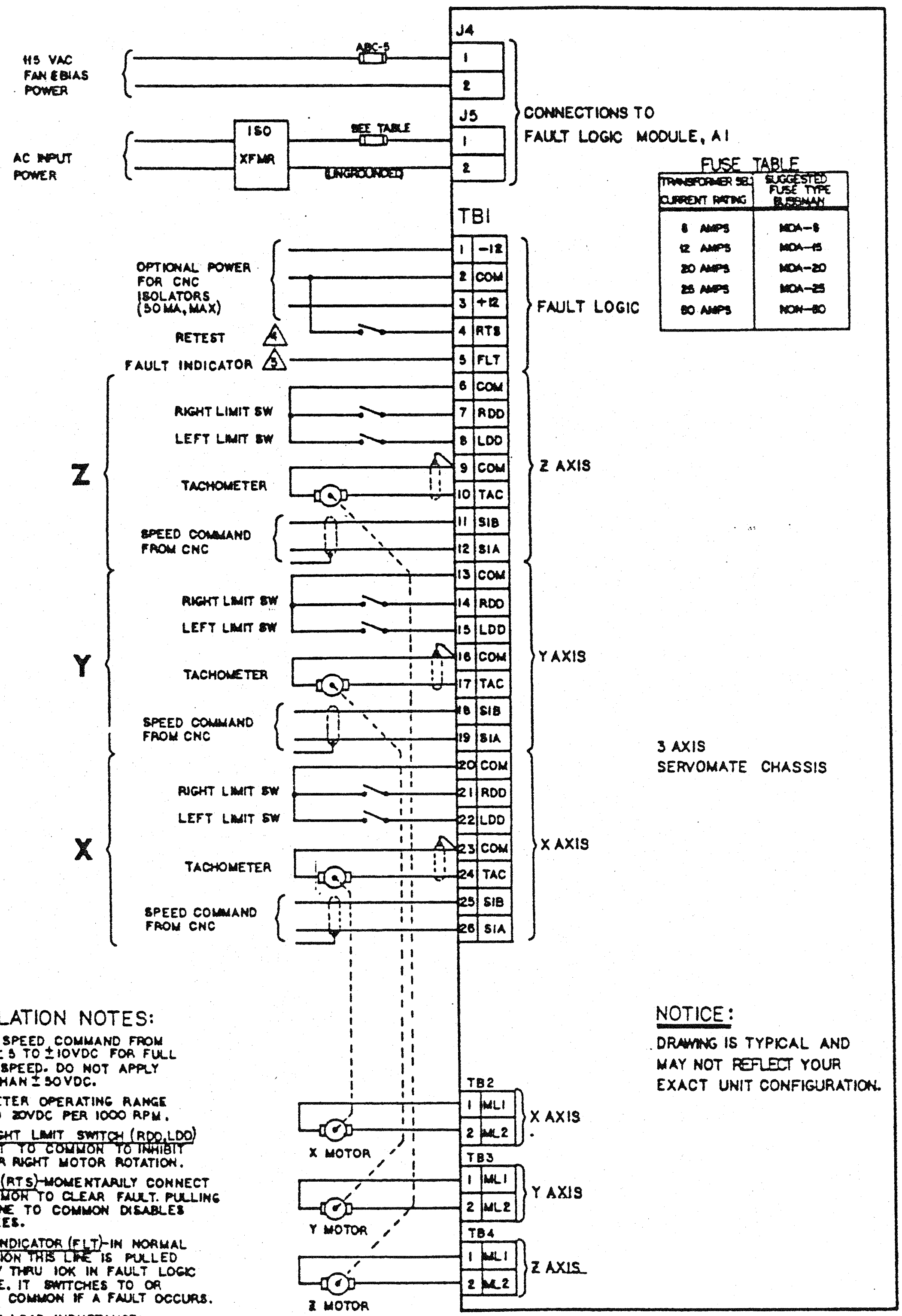
- o Abnormally hot components
- o Loose terminals
- o Open fuses or circuit breakers
- o Burned parts or insulation

NOTE: If a fault develops on a system which was working properly, DO NOT MAKE ANY ADJUSTMENTS. The problem must be properly diagnosed by observing the LED indicators and using troubleshooting charts.

FAULT	TROUBLE SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1	GFT (DS8) Ground fault indicator on Fault Logic Module	The GFT indicator operates if 1 ampere flows from either output line or from the positive bus to chassis. This typically occurs if, 1) an output line is shorted to the chassis, 2) a ground fault occurs in the motor, or 3) the positive bus is shorted to chassis.	Typical remedies consist of, 1) Checking the output lines for shorts to chassis with ohmmeter, 2) checking the motor for excess capacitance to ground, or 3) motor arcing and 4) checking the Axis Drive Module for a short from the output sections to chassis.
2	BIE (DS7) Bias Error Indicator on Fault Logic Module	The bias error indication operates if the sum of the plus and minus 12V supplies falls below 22 volts. Peak output current on each bias supply is approximately 2 amperes. However, if either supply is overloaded, it decreases significantly because of the current foldback capability. Also, the plus supply tracks the minus supply. The most common bias error fault occurs because one of the supplies is shorted to ground.	The drive should be reset and retried after external ± 12 volt bias loads are removed.
3	PBE (DS6) Power Bus Error Indicator On Fault Logic Module	The PBE indicator operates if the bus voltage exceeds 130 volts on 90 volt controller, 190 volts on 150 volt controller. This occurs if the motor energy causes the bus capacitor voltage to rise or if the transformer taps are incorrect. Also, an open or loosely connected bus capacitor will result in bus voltage noise. This, in turn, will operate the PBE indicator and disable the drive.	Measure AC bus voltage to the controller to verify that it corresponds to nameplate rating. Check bus capacitor voltage during deceleration with voltmeter or oscilloscope. The addition of a Shunt Regulator Module may be required. If Shunt Regulator Module is already included in the system, check it's fuses, F1 thru F4.
4	ECC (DS5) Excessive Continuous Current Indicator On Fault Logic Module	The ECC indicator operates if the RMS current exceeds controller rating. This occurs if, 1) the system gain is too high, 2) excessive tach noise is present, 3) system oscillation occurs, 4) the motor loading is excessive.	The problem is corrected by reducing the system gain, using a quieter tach, reducing the load, or increasing the size of the drive by adding an auxiliary bridge. The connection to J1-10, ANC on the Axis Drive Module, is convenient to monitor the motor current with an oscilloscope, ±10 volts corresponds to motor peak current.
5	SC (DSI) Surge Current Indicator On Axis Drive Module or Auxiliary Bridge Module	The surge current indicator operates if a 30 ampere bus surge current occurs for more than 8 microseconds on any output bridge. The surge current is often caused by shorting the axis drive output lines. The surge can also occur if an output transistor is shorted.	Check the bridge output lines and the collector/emitter junction of the output bridge transistors for the shorted condition with an ohmmeter. Replace Module if shorted transistor is found.
6	OH (DS2) Overheat Indicator On Axis Drive Module or Auxiliary Bridge Module	The overheat indicator operates if the heatsink temperature rises to 75°C. The heat transducer is a normally-open thermostat which opens at about 12 Centigrade degrees below the closing temperature. However, the fault indication is latched to eliminate the possibility of an accidental restart. After the thermostat clears, the system is cleared by momentarily grounding the RTS or Retest Line.	Check cooling fan for normal operation. Check for excessive dirt accumulation on heatsink. Check for heat producing components in the enclosure which may cause the maximum ambient temperature rating of the controller to be exceeded.

FAULT	TROUBLE SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
7	Fuse F1 Open Fault Logic Module	Fuse F1 protects the fan and bias supply against over-heating due to shorts. If either becomes defective, the other will turn off. Each device can be disconnected, temporarily, separately.	Replace fan or Axis Drive Module as required.
8	Fuse F3 Open Fault Logic Module	Fuse F3 protects a 10 ohm, 10 watt ground fault sensing resistor on the fault logic module. The fuse can be blown only by grounding the bus power system with the power on for at least one second.	Check motor lines and plus power bus for shorts to ground (chassis) with ohmmeter. Problem should be found before fuse is replaced and controller retried.
9	Fuse F1 thru F4 Open Shunt Regulator	Each of four loads in the shunt regulator consists of a 6.5 ohm, 100 watt resistor. At 120 volts, the resistor current becomes 18.5 amperes. The shunt regulator fuses are rated at 5 amperes. They will open, (1) if the shunt regulator is undersized, (2) if the bus voltage is over 120V or (3) if the shunt regulator switches become shorted.	Correct the problem by verifying that (1) the shunt regulator operates, (2) the transformer taps are correct, and (3) that the average shunt regulator current is not being exceeded.
10	Squealing or Unstable Motor Operation	The instability usually occurs if the gain adjustment is too far CW. However, it can also happen if the gain of the tachometer is too high.	Solutions to this problem consist of: (1) turning the gain adjustment (GAN) or tach adjustment (TAC) CCW.
11	Motor rotates against external torque disturbance with zero velocity command.	This is a positive feedback problem in the tachometer loop. Unshielded or improperly grounded shield wires can pick up motor switching pulses and cause the motor rotation.	Use twisted-shielded pairs for tachometer signal wiring. Connect shield to common at controller end only.
12	No Output, One Direction	The LDD, RDD or FLT lines, when grounded, will cause this to happen. However, an open bridge transistor produces the same effect. An open transistor can occur if the emitter bonding within the TO-3 package is defective.	Check interface connections to CNC. If found not grounded, verify that the base-emitter junction of each output transistor exhibits the same forward resistance as the others.
13	Motor Runs at Uncontrolled High Speed	The runaway motor condition is caused either by a reversed tachometer connection, or by the tachometer connection not being complete.	Retry the system with tachometer leads reversed. If this does not correct the problem, verify that the tachometer signal occurs at J1-5. Lastly, verify that R14, the tach lead adjustment, is not fully CCW.
14	Motor Exhibits a Dead Zone	The dead zone condition appears if the current loop gain is too low. This can be caused by the output inductance being too large. A low bus voltage can also reduce the current loop gain.	Check armature loop output inductance. (Consult Randtronics factory for assistance.) Check bus voltage.
15	Unsymmetrical Output Current	In a multibridge drive, this condition can occur as a result of poor output or intermodule connections.	Check all output connections and module connectors.

6.0 DRAWINGS



FUSE TABLE

TRANSFORMER SEL CURRENT RATING	SUGGESTED FUSE TYPE BUSSMAN
8 AMPS	MDA-8
12 AMPS	MDA-15
20 AMPS	MDA-20
25 AMPS	MDA-25
50 AMPS	NON-50

INSTALLATION NOTES:

1. TYPICAL SPEED COMMAND FROM CNC IS ±5 TO ±10VDC FOR FULL MOTOR SPEED. DO NOT APPLY MORE THAN ±50VDC.
2. TACHOMETER OPERATING RANGE IS 3 TO 20VDC PER 1000 RPM.
3. LEFT, RIGHT LIMIT SWITCH (RDD, LDD) CONNECT TO COMMON TO INHIBIT LEFT OR RIGHT MOTOR ROTATION.

△4 RETEST (RTS)-MOMENTARILY CONNECT TO COMMON TO CLEAR FAULT. PULLING THIS LINE TO COMMON DISABLES ALL AXES.

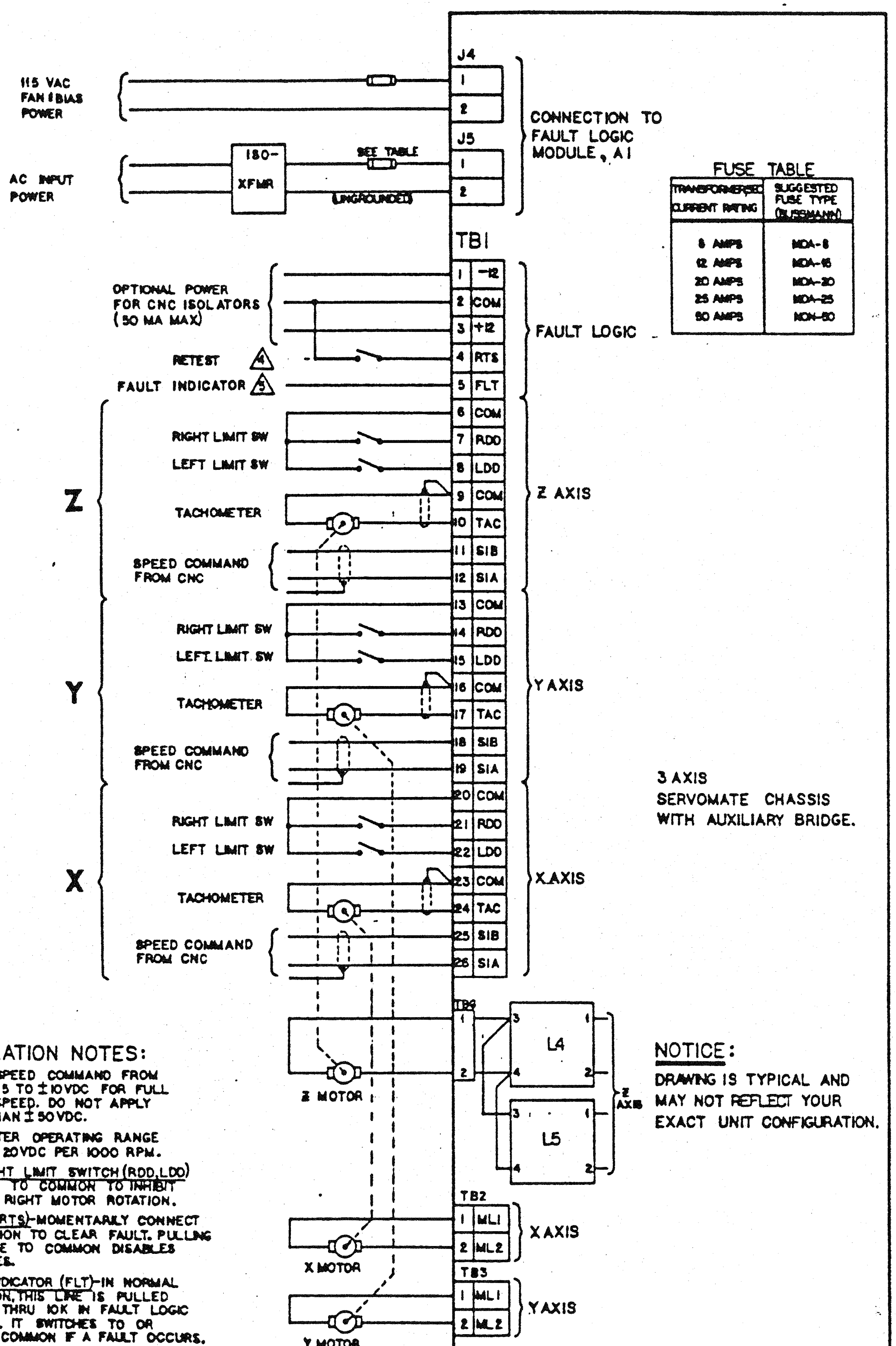
△5 FAULT INDICATOR (FLT)-IN NORMAL OPERATION THIS LINE IS PULLED TO +12V THRU 10K IN FAULT LOGIC MODULE. IT SWITCHES TO OR BELOW COMMON IF A FAULT OCCURS.

6. MINIMUM LOAD INDUCTANCE: IS 1.5MHY PER AXIS.

NOTICE:

DRAWING IS TYPICAL AND MAY NOT REFLECT YOUR EXACT UNIT CONFIGURATION.

FIGURE 6-1. EXTERNAL WIRING DIAGRAM - THREE-AXIS SERVOMATE



FUSE TABLE

TRANSFORMER SEC CURRENT RATING	SUGGESTED FUSE TYPE (BUSSMANN)
8 AMPS	MDA-8
12 AMPS	MDA-15
20 AMPS	MDA-20
25 AMPS	MDA-25
50 AMPS	NON-50

NOTICE:
DRAWING IS TYPICAL AND MAY NOT REFLECT YOUR EXACT UNIT CONFIGURATION.

INSTALLATION NOTES:

1. TYPICAL SPEED COMMAND FROM CNC IS ±5 TO ±10VDC FOR FULL MOTOR SPEED. DO NOT APPLY MORE THAN ±50VDC.
2. TACHOMETER OPERATING RANGE IS 3 TO 20VDC PER 1000 RPM.
3. LEFT, RIGHT LIMIT SWITCH (RDD, LDD) CONNECT TO COMMON TO INHIBIT LEFT OR RIGHT MOTOR ROTATION.
4. RETEST (RTS) - MOMENTARILY CONNECT TO COMMON TO CLEAR FAULT. PULLING THIS LINE TO COMMON DISABLES ALL AXES.
5. FAULT INDICATOR (FLT) - IN NORMAL OPERATION, THIS LINE IS PULLED TO +12V THRU 10K IN FAULT LOGIC MODULE. IT SWITCHES TO OR BELOW COMMON IF A FAULT OCCURS.
6. MINIMUM LOAD INDUCTANCE:
   X, Y AXIS 1.5 MHY EACH.
   Z AXIS .75 MHY

FIGURE 6-2. EXTERNAL WIRING DIAGRAM - THREE-AXIS SERVOMATE WITH AUXILIARY BRIDGE

NOTE: Drawing is typical and may not reflect your exact drive configuration.

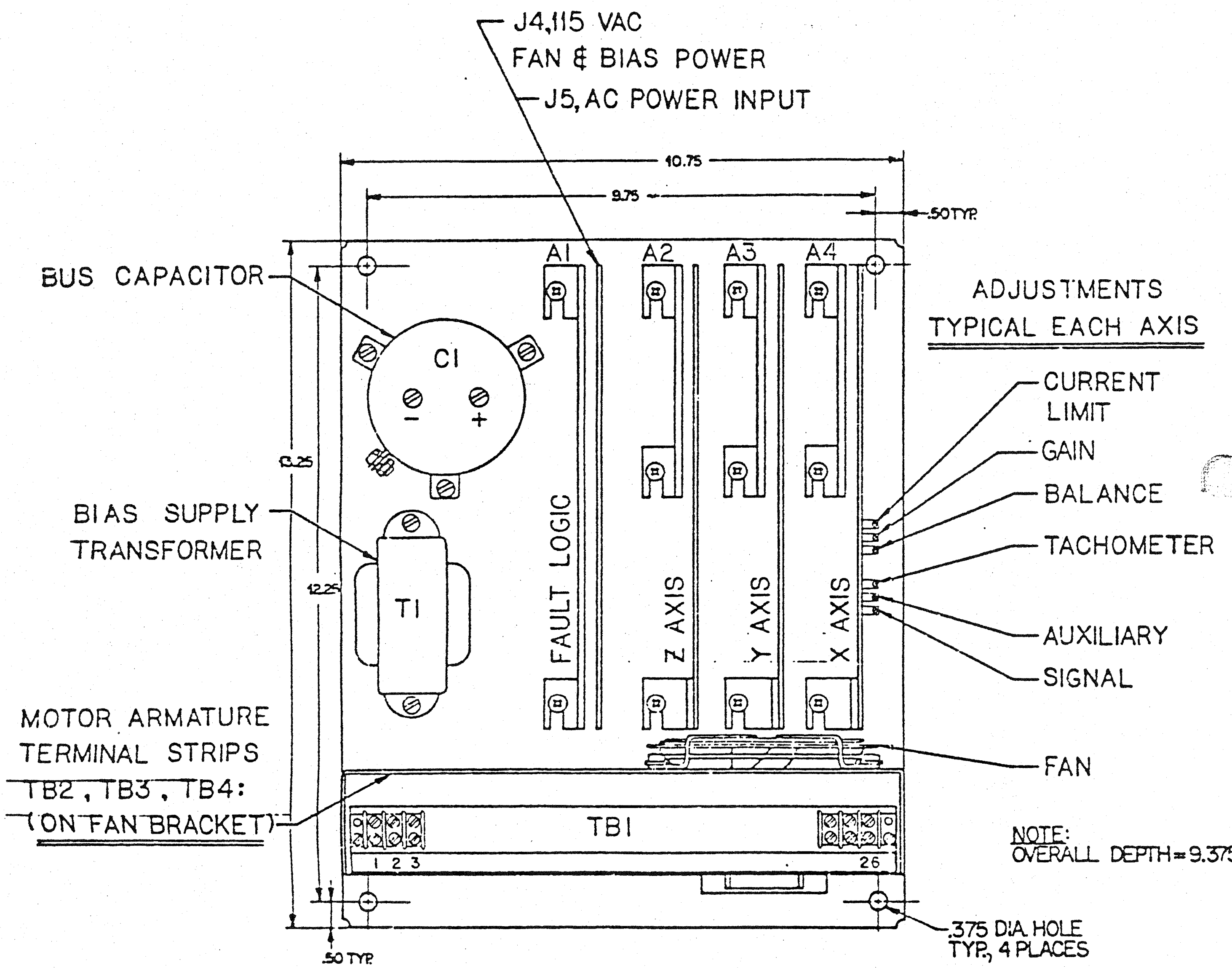


FIGURE 6-3. THREE-AXIS SERVOMATE CHASSIS

NOTE: Drawing is typical and may not reflect your exact drive configuration.

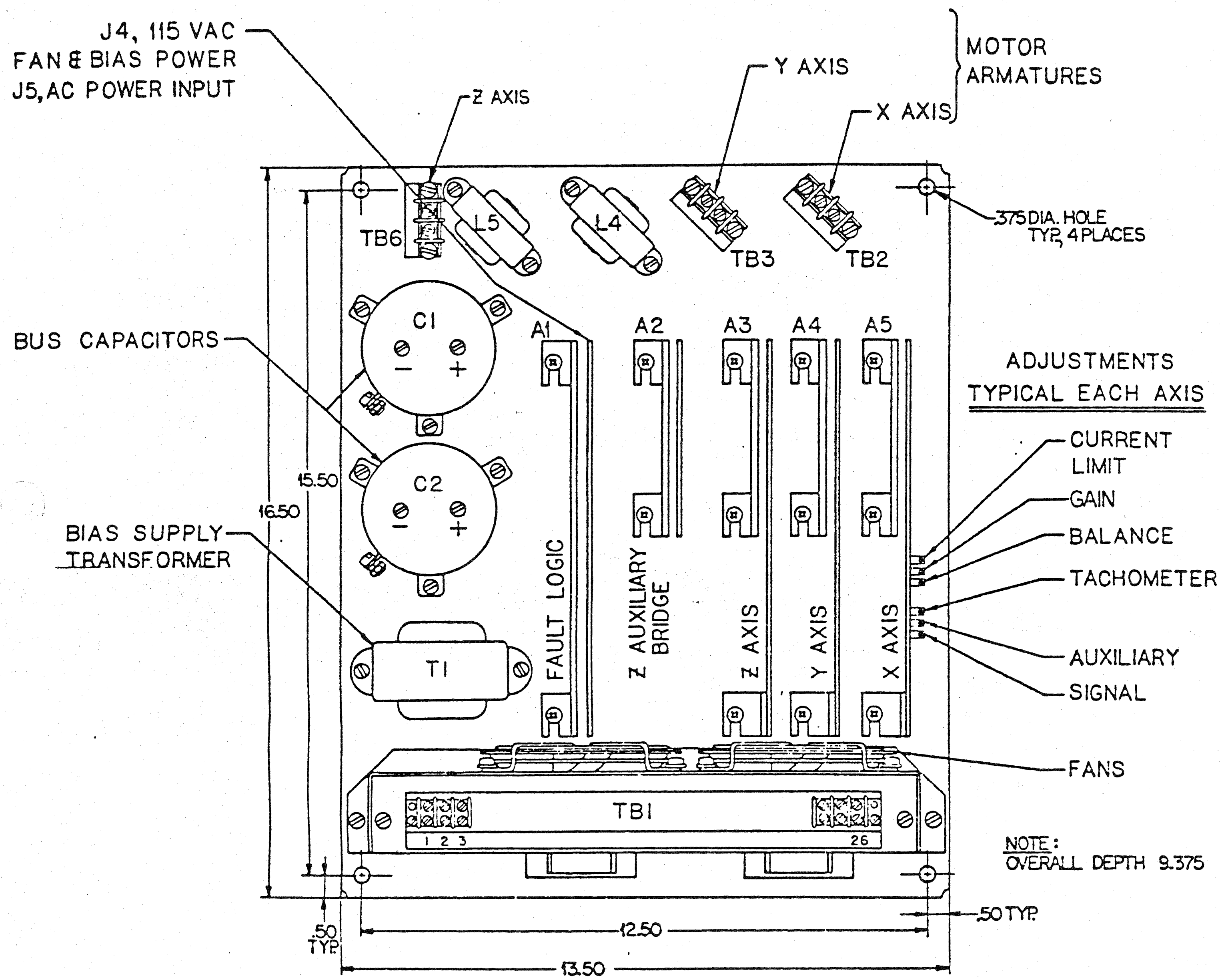
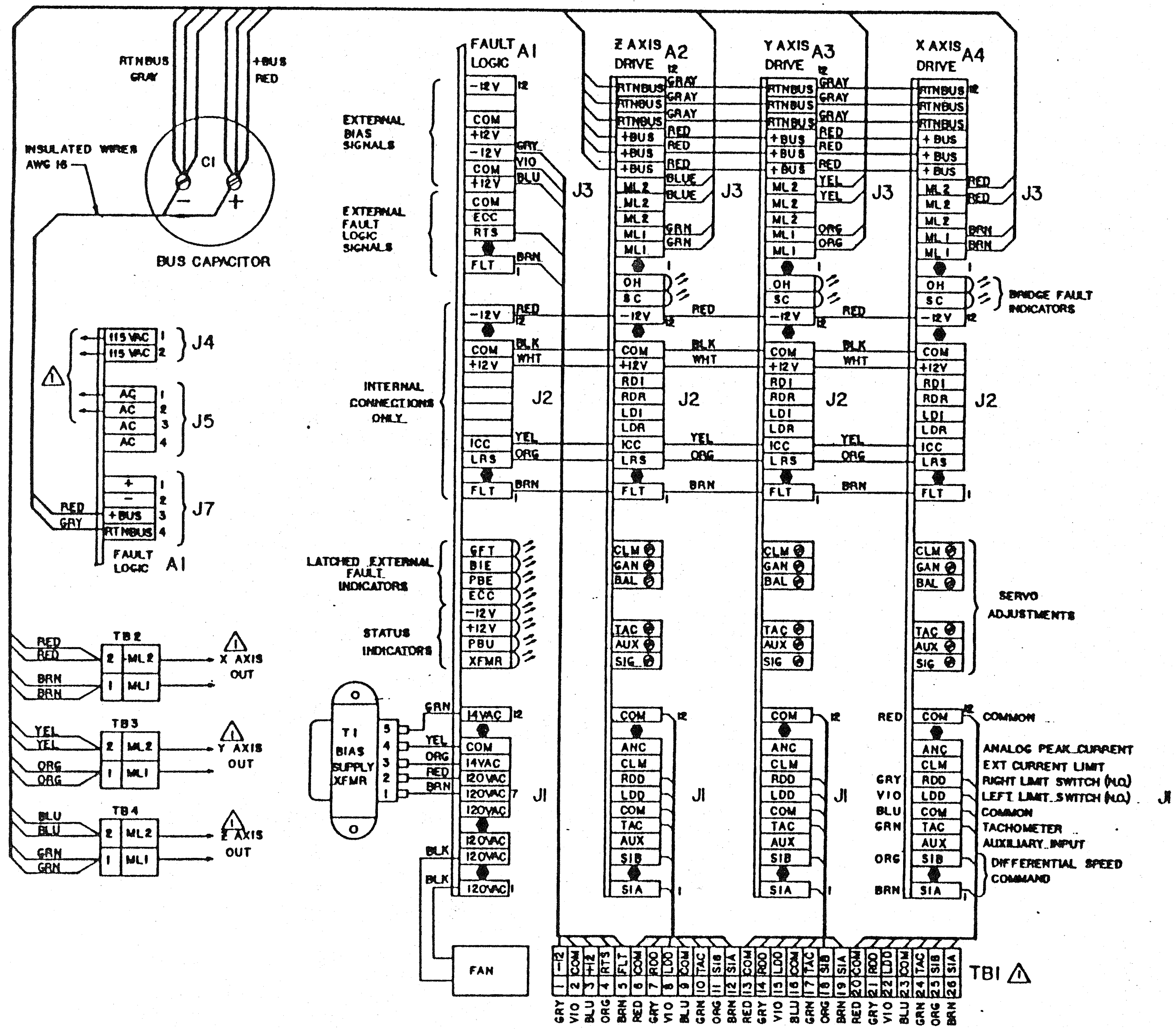


FIGURE 6-4. MODEL SM1090-1120G THREE-AXIS SERVOMATE CHASSIS WITH AUXILIARY BRIDGE



NOTES:

1. CUSTOMER CONNECTION.
2. SYMBOL INDICATES CONNECTOR POSITIONING PLUG
3. ALL WIRING NO.18 AWG STRANDED UNLESS OTHERWISE SPECIFIED.

FIGURE 6-5. INTERNAL WIRING DIAGRAM, THREE-AXIS SERVOMATE

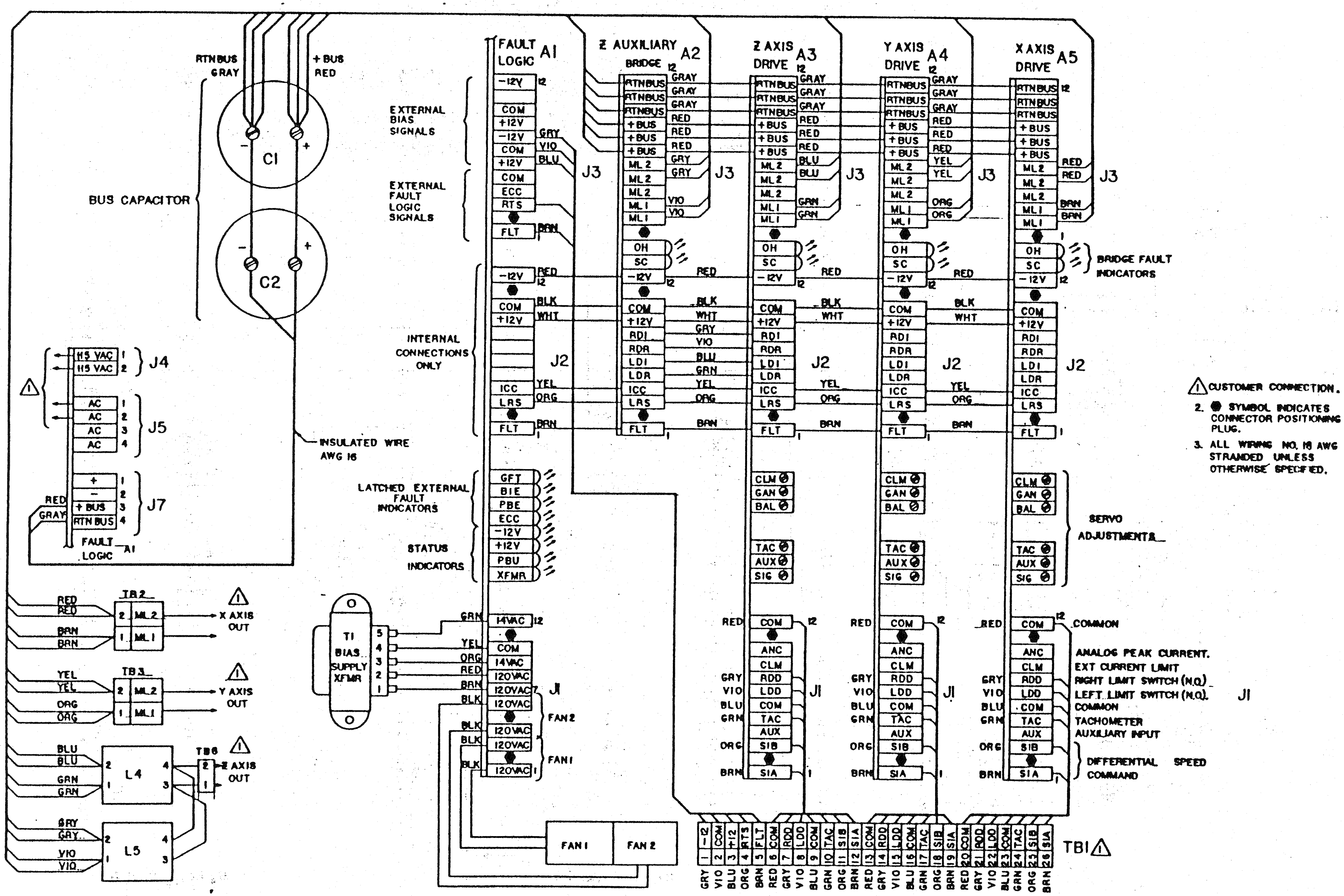
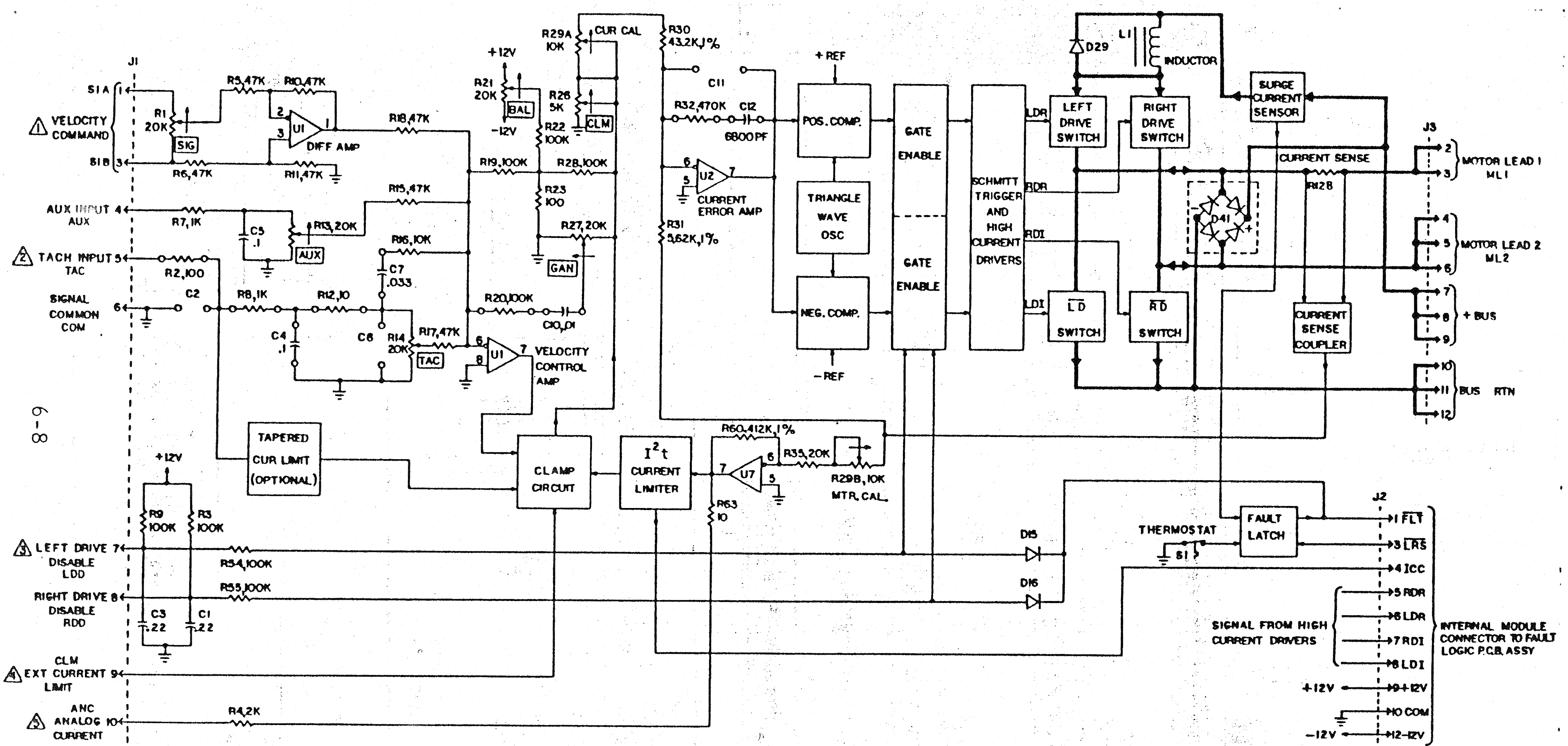


FIGURE 6-6. INTERNAL WIRING DIAGRAM, THREE-AXIS SERVOMATE WITH AUXILIARY BRIDGE



NOTES:

1. TYPICAL VELOCITY COMMAND IS ± 10V FOR FULL MOTOR SPEED. DO NOT APPLY MORE THAN ± 50 VDC.
2. TACHOMETER OPERATING RANGE IS 3 TO 20 VDC PER 1000 RPM.
3. LEFT, RIGHT DRIVE DISABLE-CONNECT TO SIGNAL COMMON (J1-6,12) TO INHIBIT LEFT OR RIGHT MOTOR ROTATION.
4. EXT CURRENT LIMIT-CLAMP TO SIGNAL COMMON FOR ZERO MOTOR CURRENT. SEE MANUAL FOR REDUCED OR UNSYMMETRICAL CURRENT LIMIT CONNECTION.
5. ANALOG CURRENT-SCALED TO ± 10VDC EQUALS PEAK MOTOR CURRENT.

FIGURE 6-7. SCHEMATIC DIAGRAM, AXIS DRIVE

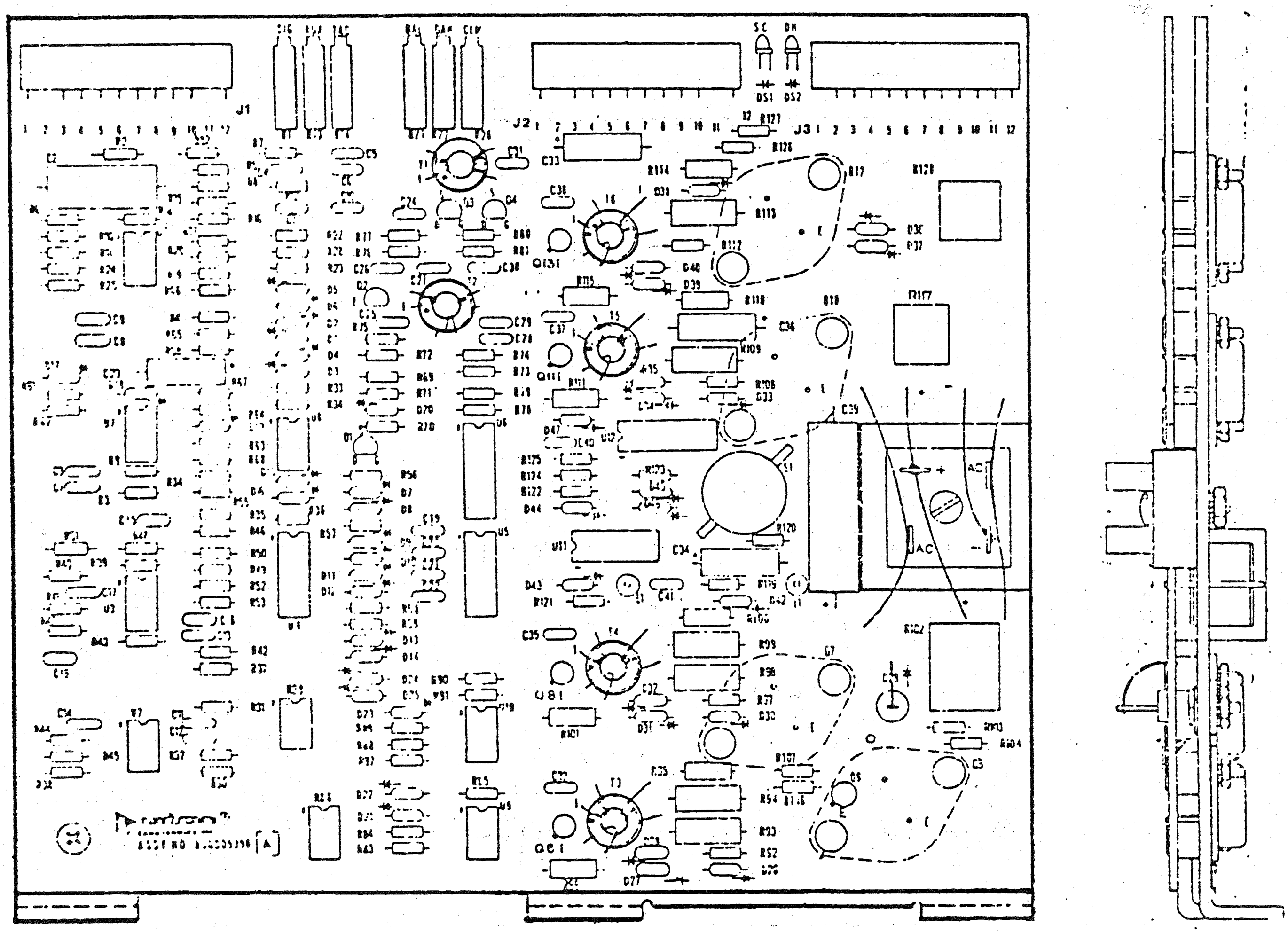


FIGURE 6-8. AXIS DRIVE COMPONENT LOCATION

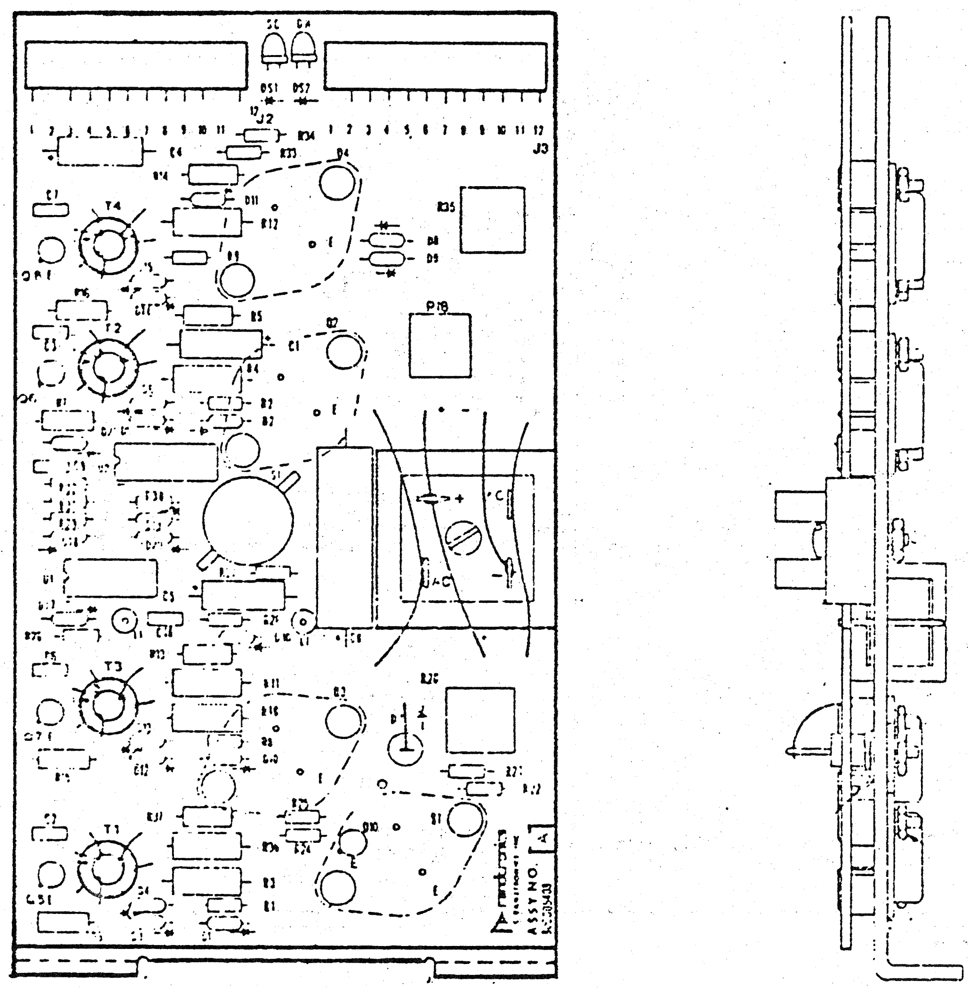


FIGURE 6-9. AUXILIARY BRIDGE COMPONENT LOCATION

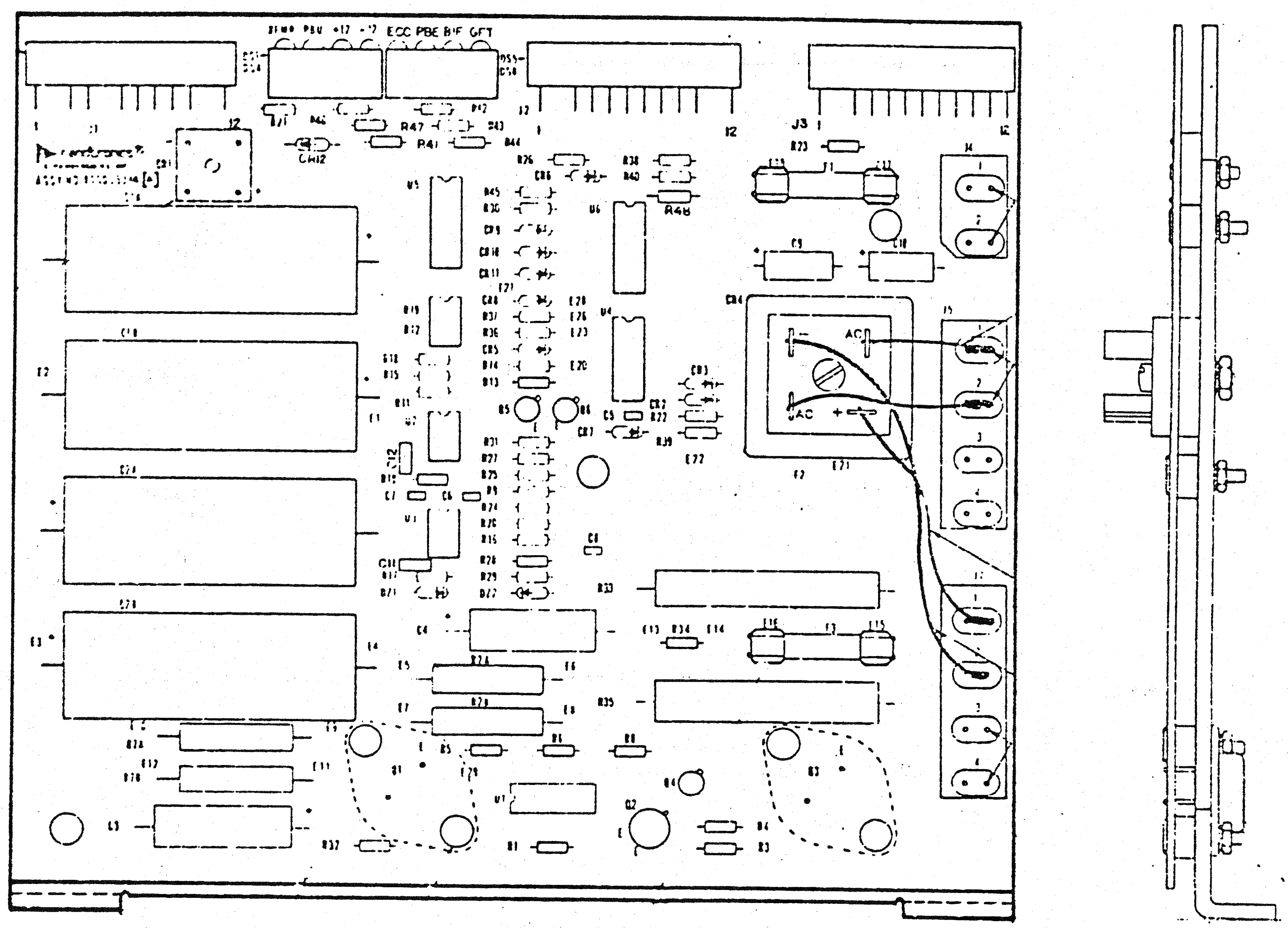


FIGURE 6-10. FAULT LOGIC COMPONENT LOCATION

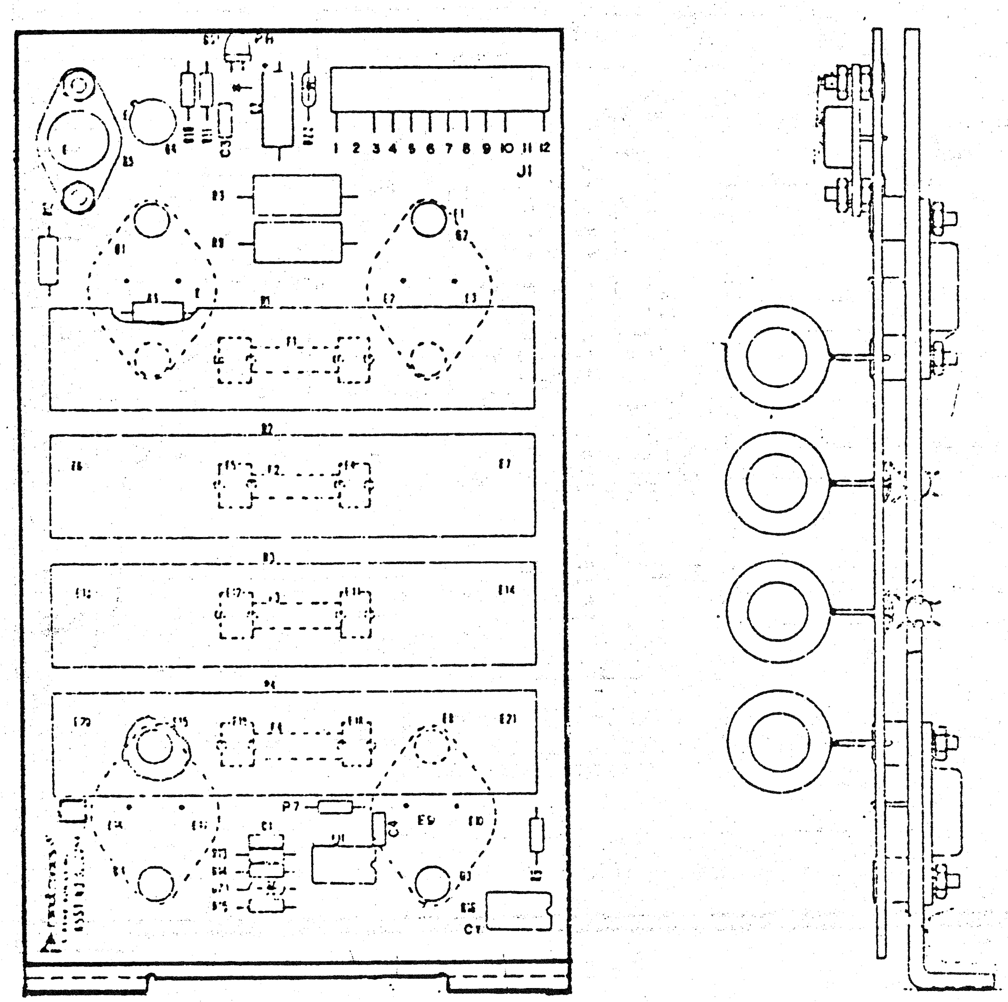
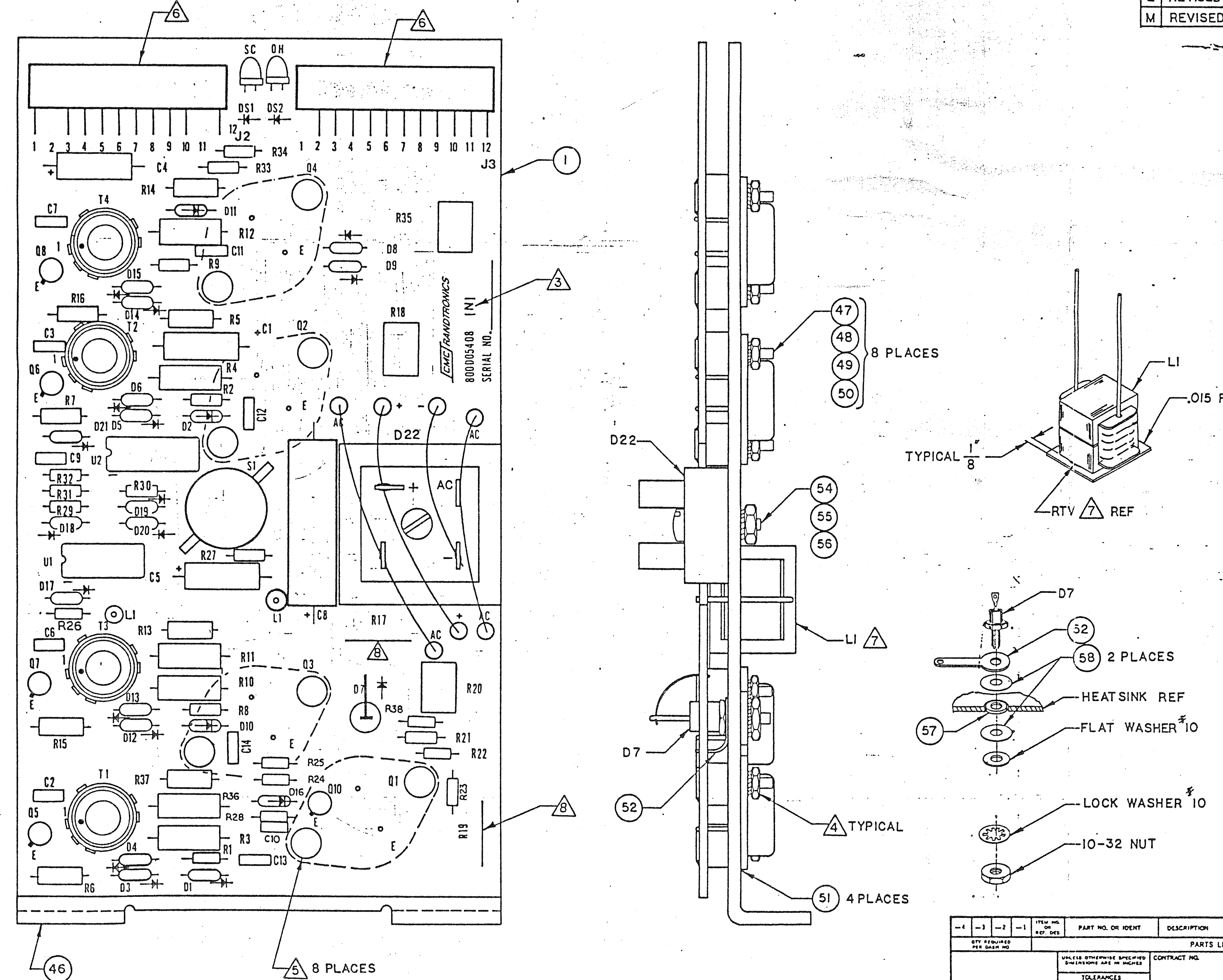


FIGURE 6-11. SHUNT REGULATOR COMPONENT LOCATION

LTR	REVISIONS DESCRIPTION	DATE	APPROVED
L	REVISED AND REDRAWN PER ECO #495	10-11-83	
M	REVISED ARTWORK REV E ARTWORK	11-29-83	



NOTES: UNLESS OTHERWISE SPECIFIED.

1. SYMBOLS AND ABBREVIATIONS PER MIL-STD-100.
2. REMOVE BURRS AND BREAK SHARP EDGES.
3. RUBBER STAMP CURRENT REVISION LETTER.
4. ALL TRANSISTORS TO BE TORQUED TO 10 POUND INCHES.
5. SOLDER STUD TO P.C.B..
6. BEFORE ASSY REMOVE PINS AS FOLLOWS.

J2	J3
2, 11	1

7. RTV L1 TO PC BOARD.
8. #16 AWG JUMPER R17 AND R19: "C" ISSUE BOARDS.

-4	-3	-2	-1	ITEM NO. OR REF. DES.	PART NO. OR IDENT	DESCRIPTION	CODE IDENT	SPEC/MFG
QTY REQUIRED PER DASH NO.					PARTS LIST			

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±
DECIMALS
2 PLACES ±
3 PLACES ±
MATERIAL: SEE PARTS LIST

CONTRACT NO.
PREPARED: IEC — DATE: 10-11-83
CHECKED
APPROVED — 12/1/83
APPROVED

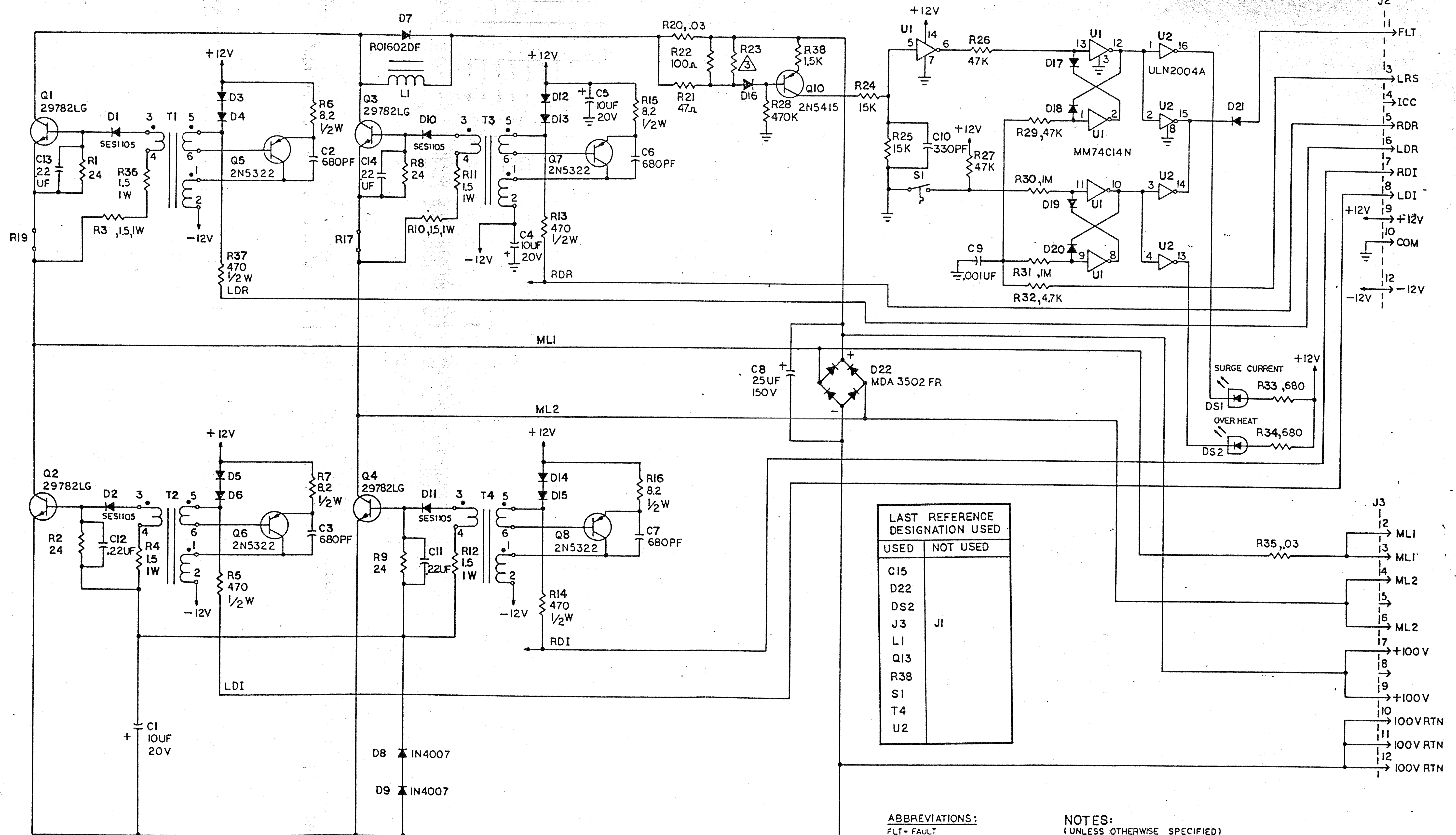
randtronics® a company

PRINTED CIRCUIT BOARD ASSY
AUXILIARY BRIDGE

SIZE: D | CODE IDENT: 33831 | 800D05408 | REV: M
SCALE 2=1 | SHEET 1 OF 2

DASH NO. | SIZE | NEXT ASSY: 800D05408

800D05408



LAST REFERENCE DESIGNATION USED	
USED	NOT USED
C15	
D22	
DS2	
J3	J1
L1	
Q13	
R38	
S1	
T4	
U2	

ABBREVIATIONS:

FLT = FAULT
LRS = LATCH RESET
RDR = RIGHT DRIVE
LDR = LEFT DRIVE
RDI = RIGHT DRIVE INVERTED
LDI = LEFT DRIVE INVERTED.
ML1, ML2 = MOTOR LINE 1 & 2.
CSA, CSB = CURRENT SENSE A & B.
ICC = INTERNAL CONTINUOUS CURRENT.

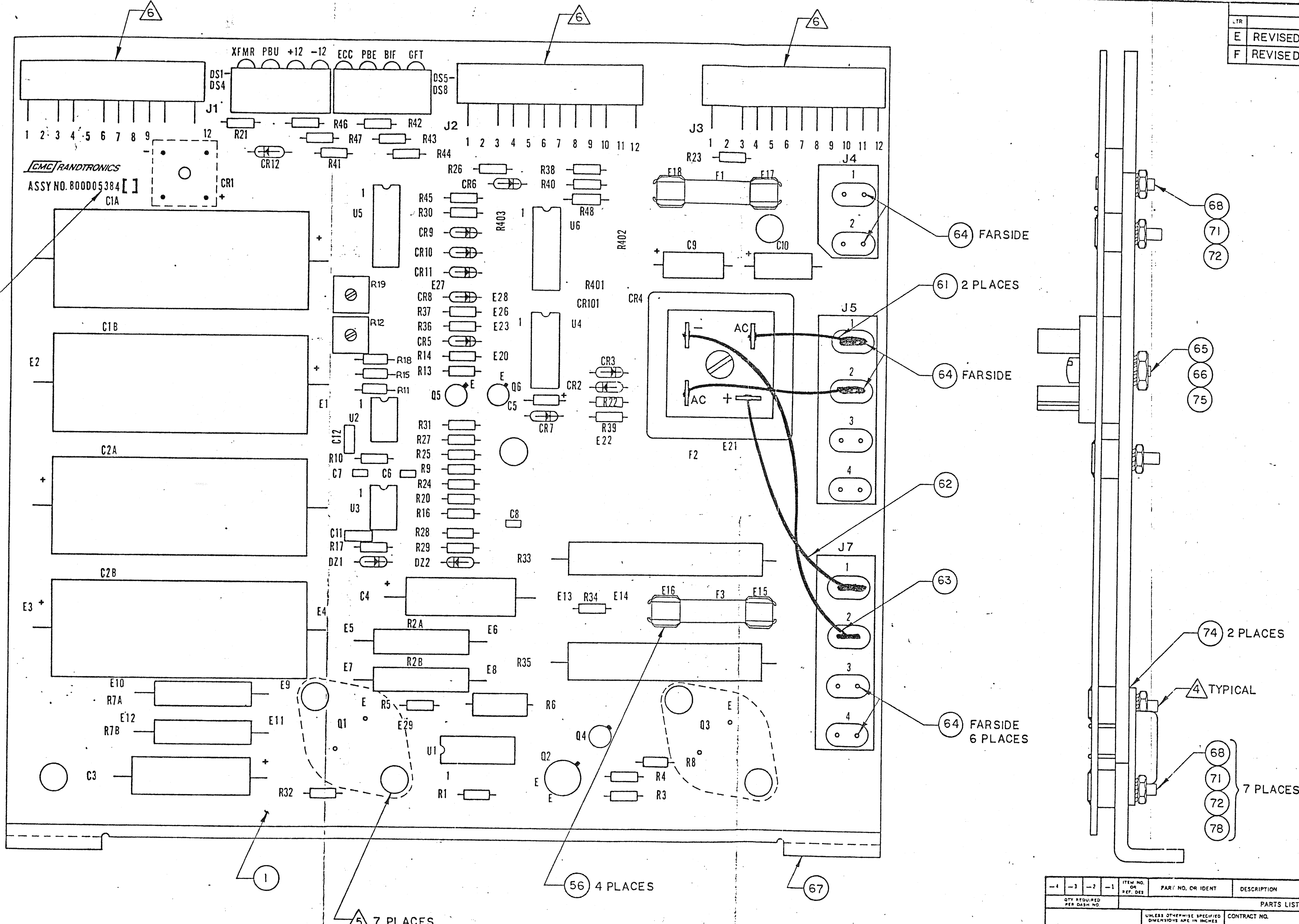
NOTES:
(UNLESS OTHERWISE SPECIFIED)
1. RESISTORS ARE 1/4 W C.C.
2. DIODES ARE 1N914.
3. SELECT VALUE AT TEST.
4. SYMBOL ⏚ DENOTES SIGNAL GROUND.

AUXILIARY BRIDGE SCHEMATIC

SIZE	CODE IDENT		
D	33831	800D05408	
SCALE NONE	9505	SHEET 2 OF 2	

800D05408

LTR	DESCRIPTION	DATE	APPROVED
E	REVISED AND REDRAWN	10-25-83	
F	REVISED PER ECO. 543	3-25-85	



NOTES: UNLESS OTHERWISE SPECIFIED.

1. SYMBOLS AND ABBREVIATIONS PER MIL-STD-100.
2. REMOVE BURRS AND BREAK SHARP EDGES.
3. RUBBER STAMP CURRENT REVISION LETTER.
4. ALL TRANSISTORS TO BE TORQUED TO 10 POUND INCHES.
5. SOLDER STUD TO PRINTED CIRCUIT BOARD.
6. BEFORE ASSEMBLY, REMOVE PINS AS FOLLOWS:

J1	J2	J3
2,5,11	2,11	2

7. NOTES CONTINUED ON SHEET 2.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

TOLERANCES: FRACTIONS ± DECIMALS 2 PLACES ± 3 PLACES ±

MATERIAL: SEE PARTS LIST

800D05384

PREPARED: IEC DATE: 10-25-83

randtronics®

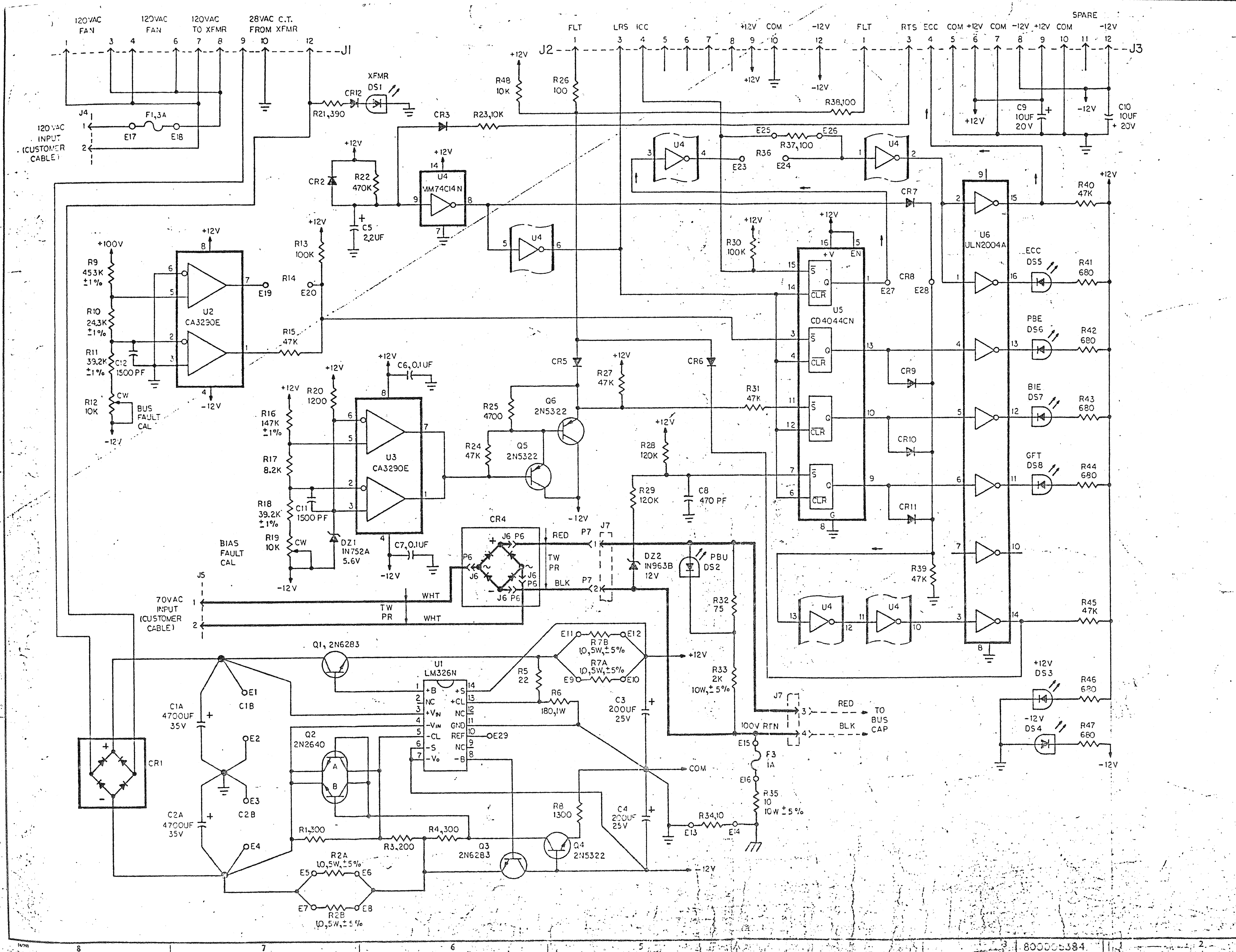
PRINTED CIRCUIT BOARD ASSY FAULT LOGIC

SIZE D CODE IDENT 33831 800D05384 REV F

SCALE 2=1 SHEET 1 OF 2

800D05384

©RANDTRONICS INC.



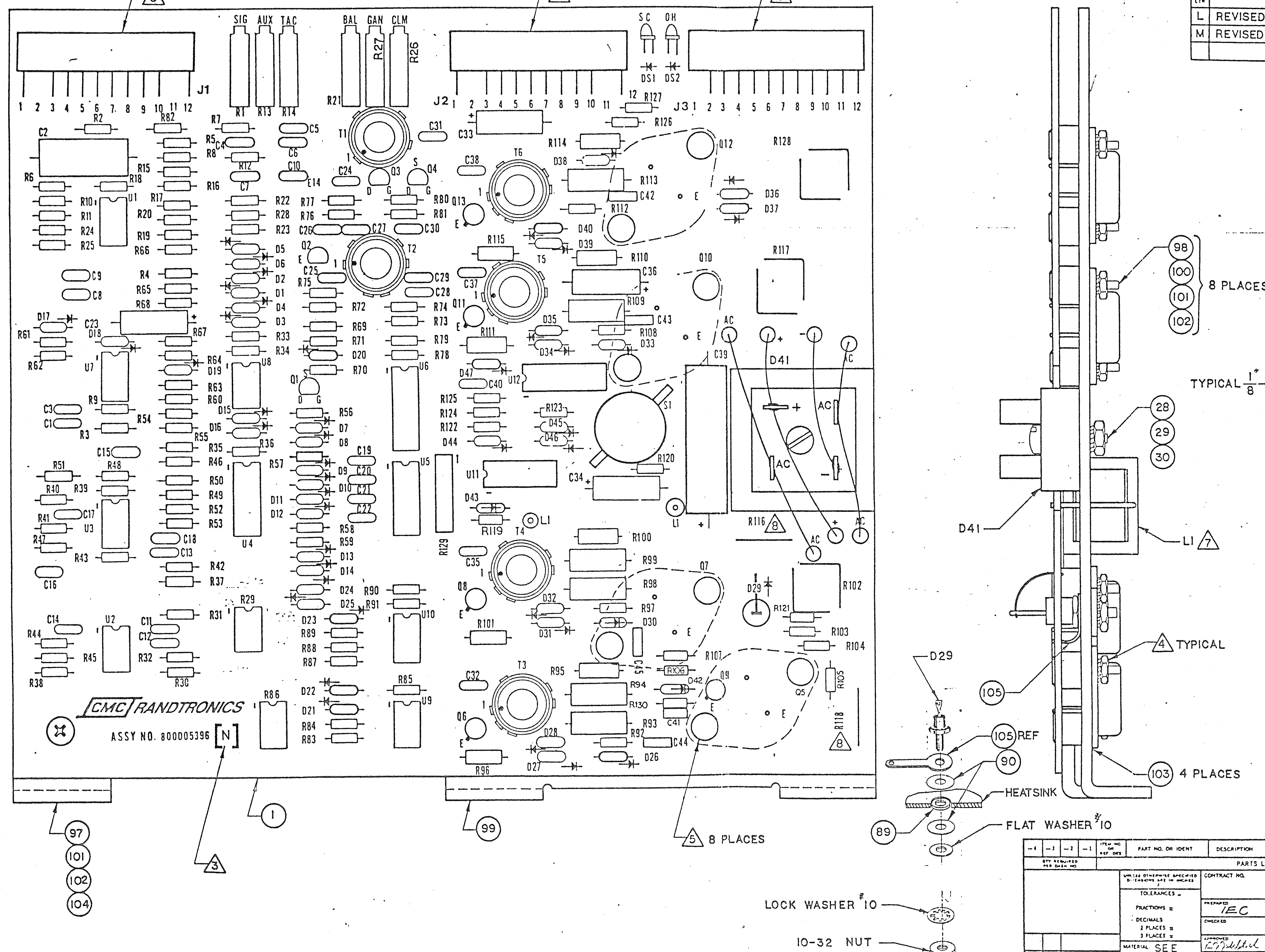
NOTES:

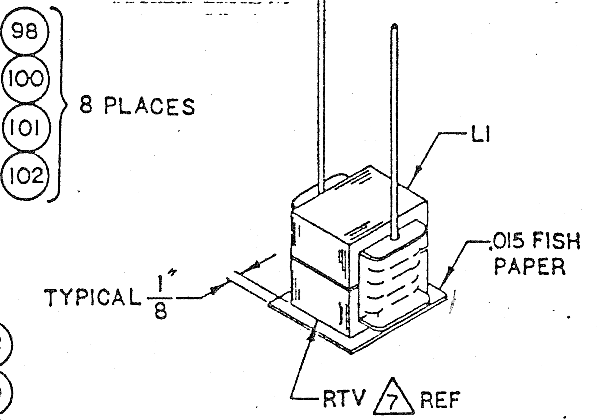
1. SYMBOLS AND ABBREVIATION PER MIL-STD-100.
2. REMOVE BURRS AND BREAK SHARP EDGES.
3. RESISTANCE IN OHMS, 1/4 W, ±5%. CAPACITANCE IN MICROFARADS.
4. SIGNAL NOMENCLATURE:
   - BIE = BIAS ERROR
   - COM = COMMON
   - ECC = EXTERNAL CONTINUOUS CURRENT
   - FLT = FAULT
   - GFT = GROUND FAULT
   - ICC = INTERNAL CONTINUOUS CURRENT
   - LRS = LATCH RESET
   - PBE = POWER BUS ERROR
   - PBU = POWER BUS UP
   - RTS = RESET
5. ALL CR'S ARE 1N914.
6. SYMBOL ⏚ DENOTES SIGNAL GND. SYMBOL ⫽ DENOTES CHASSIS GND.

SIZE	CODE IDENT		REV
D	33831	800D05384	F
SCALE NONE	9505	SHEET 2 of 2	

800D05384

LTR	DESCRIPTION	DATE	APPROVED
L	REVISED AND REDRAWN PER ECO #494	10-10-83	
M	REVISED ARTWORK - REV "E"	11-29-83	





NOTES: UNLESS OTHERWISE SPECIFIED.

1. SYMBOLS AND ABBREVIATIONS PER MIL STD-100.
2. REMOVE BURRS AND BREAK SHARP EDGES.
3. RUBBER STAMP CURRENT REVISION LETTER.
4. ALL TRANSISTORS TO BE TORQUED TO 10 POUND INCHES.
5. SOLDER STUD TO P.C.B.
6. BEFORE ASSY REMOVE PINS AS FOLLOW

J1	J2	J3
2 & 11	2 & 11	PIN 1

7. RTV L1 TO BOARD.
8. 16 AWG JUMPERS R116 AND R118: "C" ISSUE BOARDS.

PARTS LIST

MATERIAL: SEE PARTS LIST 800D05396

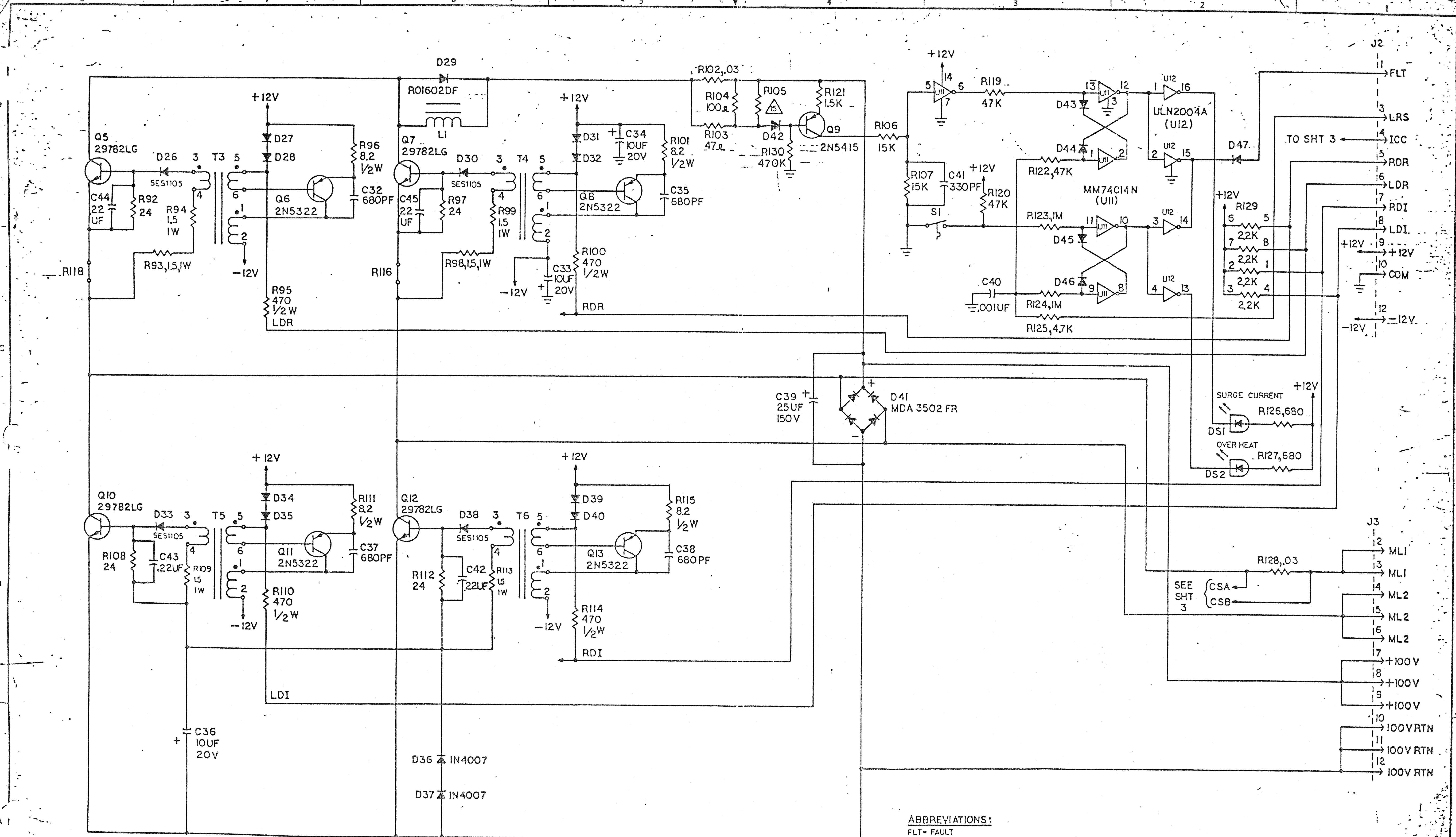
randtronics®

PREPARED: IEC 10-10-83

PRINTED CIRCUIT BOARD ASSY
AXIS DRIVE

SIZE D | CODE IDENT 33831 | 800D05396 | REV M

SCALE 2 = 1 | SHEET 1 OF 3

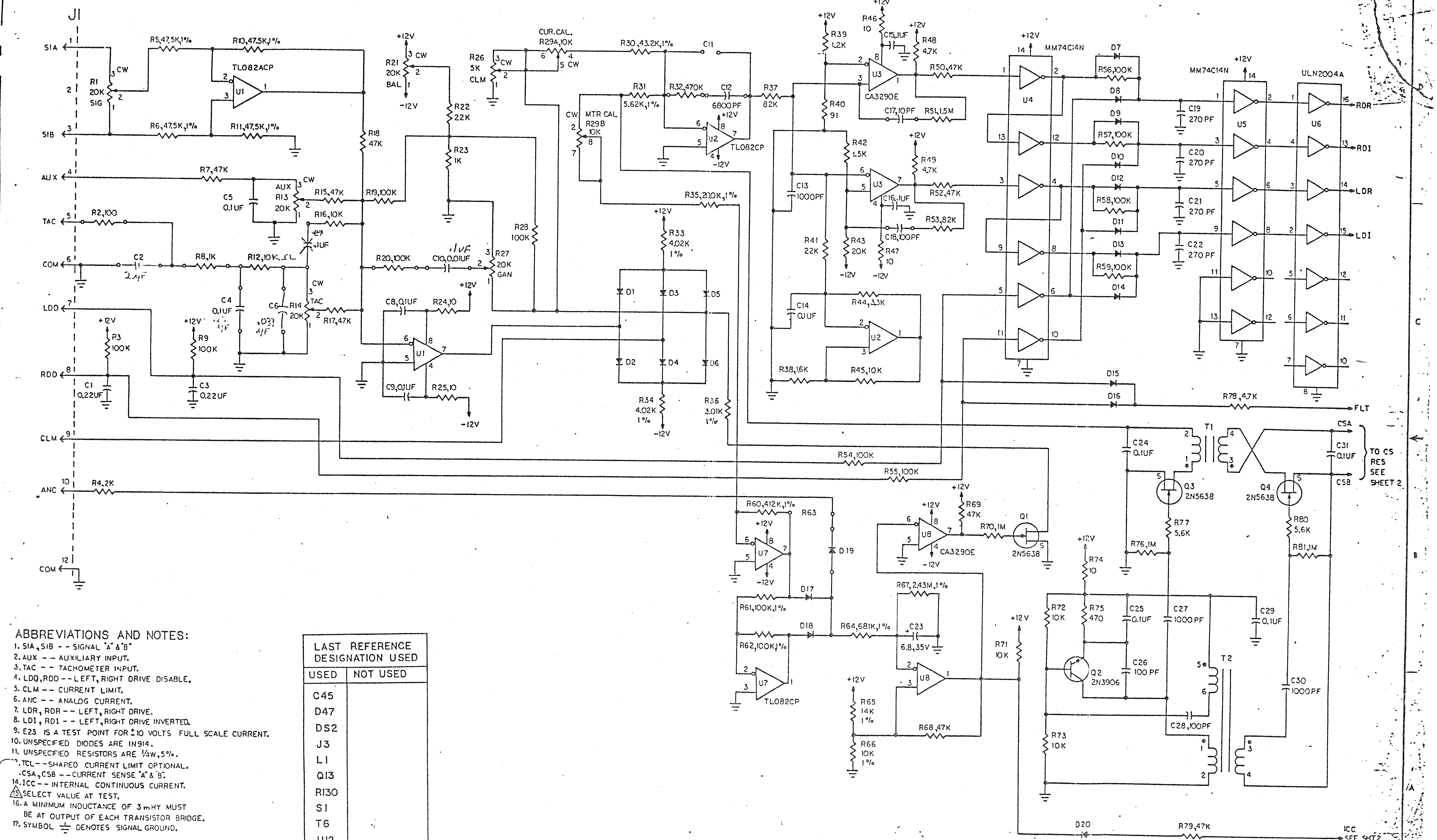


ABBREVIATIONS:

FLT= FAULT
LRS= LATCH RESET
RDR= RIGHT DRIVE
LDR= LEFT DRIVE
RDI= RIGHT DRIVE INVERTED
LDI= LEFT DRIVE INVERTED.
ML1, ML2= MOTOR LINE 1 & 2.
CSA, CSB= CURRENT SENSE, A & B.
ICC= INTERNAL CONTINUOUS CURRENT.

SIZE	CODE IDENT	
D	33831	800D05396
SCALE NONE		SHEET 2 OF 3

800D05396



ABBREVIATIONS AND NOTES:

1. SIA, SIB - - SIGNAL "A" & "B"
2. AUX - - AUXILIARY INPUT.
3. TAC - - TACHOMETER INPUT.
4. LDD, RDD - - LEFT, RIGHT DRIVE DISABLE.
5. CLM - - CURRENT LIMIT.
6. ANC - - ANALOG CURRENT.
7. LDR, RDR - - LEFT, RIGHT DRIVE.
8. LDI, RDI - - LEFT, RIGHT DRIVE INVERTED.
9. E23 IS A TEST POINT FOR ±10 VOLTS FULL SCALE CURRENT.
10. UNSPECIFIED DIODES ARE IN914.
11. UNSPECIFIED RESISTORS ARE 1/4W, 5%.
12. TCL - - SHAPED CURRENT LIMIT OPTIONAL.
13. CSA, CSB - - CURRENT SENSE "A" & "B".
14. ICC - - INTERNAL CONTINUOUS CURRENT.
15. SELECT VALUE AT TEST.
16. A MINIMUM INDUCTANCE OF 3 mHY MUST BE AT OUTPUT OF EACH TRANSISTOR BRIDGE.
17. SYMBOL ⏚ DENOTES SIGNAL GROUND.

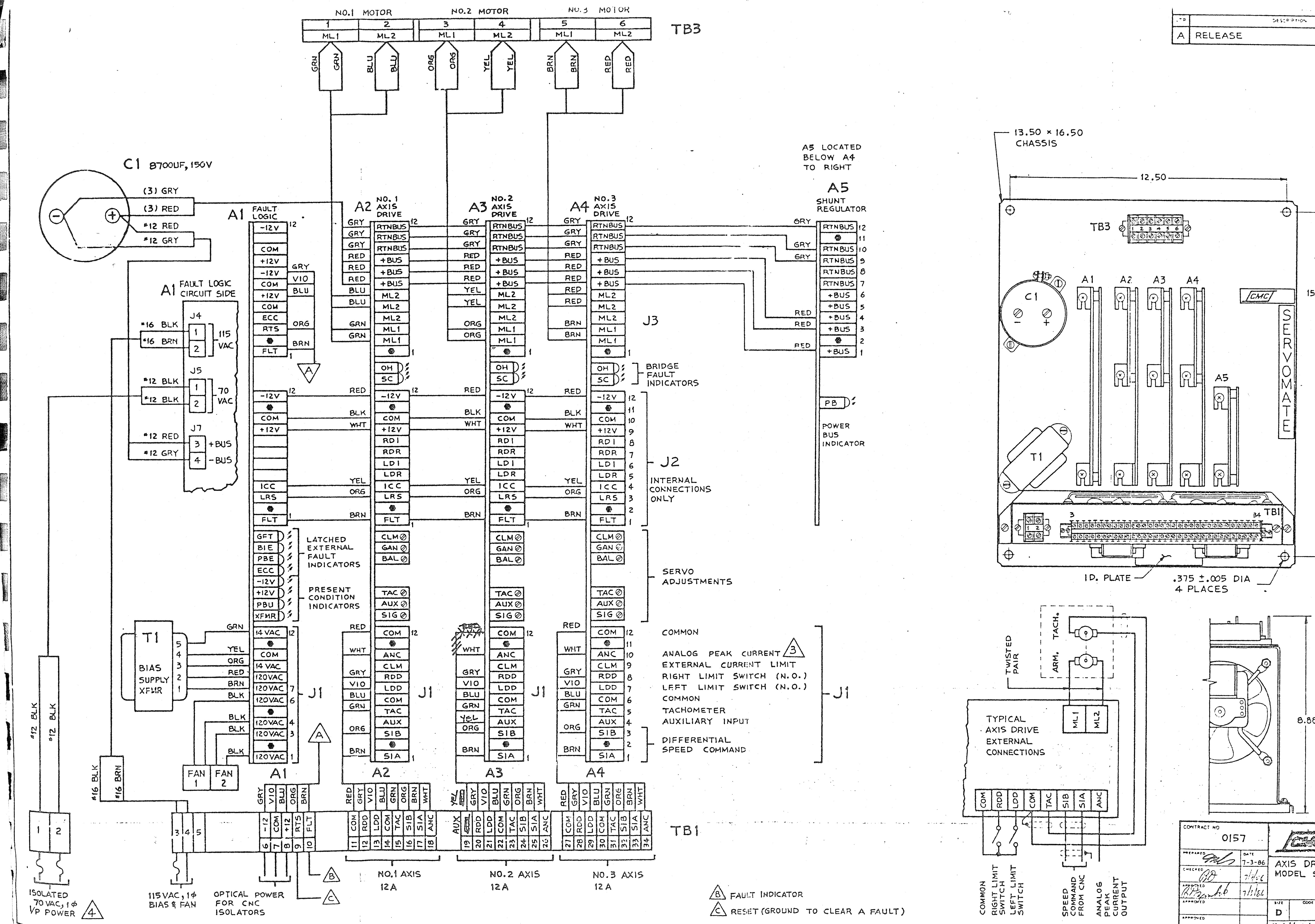
SYMBOL ⏚ DENOTES CHASSIS GROUND.

LAST REFERENCE DESIGNATION USED	
USED	NOT USED
C45	
D47	
DS2	
J3	
L1	
Q13	
R130	
S1	
T6	
U12	

SIZE	CODE IDENT		
D	33331	800D05396	N
SCALE NONE	9505	SHEET 3 OF 3	

800D05396

LTR	DESCRIPTION	DATE	APPROVED
A	RELEASE	7-3-86	



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL WIRES NO. 18 STRANDED IRRADIATED PVC.
2. ● INDICATES POLARIZING KEY.
3. PEAK CURRENT IS SCALED TO ±10V.
4. 70 VAC INPUT POWER MUST NOT BE GROUNDED.
5. WIRE IN ACCORDANCE WITH THE REQUIREMENTS OF THE NATIONAL ELECTRICAL CODE (NEC) AND ANY LOCAL REQUIREMENTS.
6. MATERIALS SEE PARTS LIST 540D2340X.

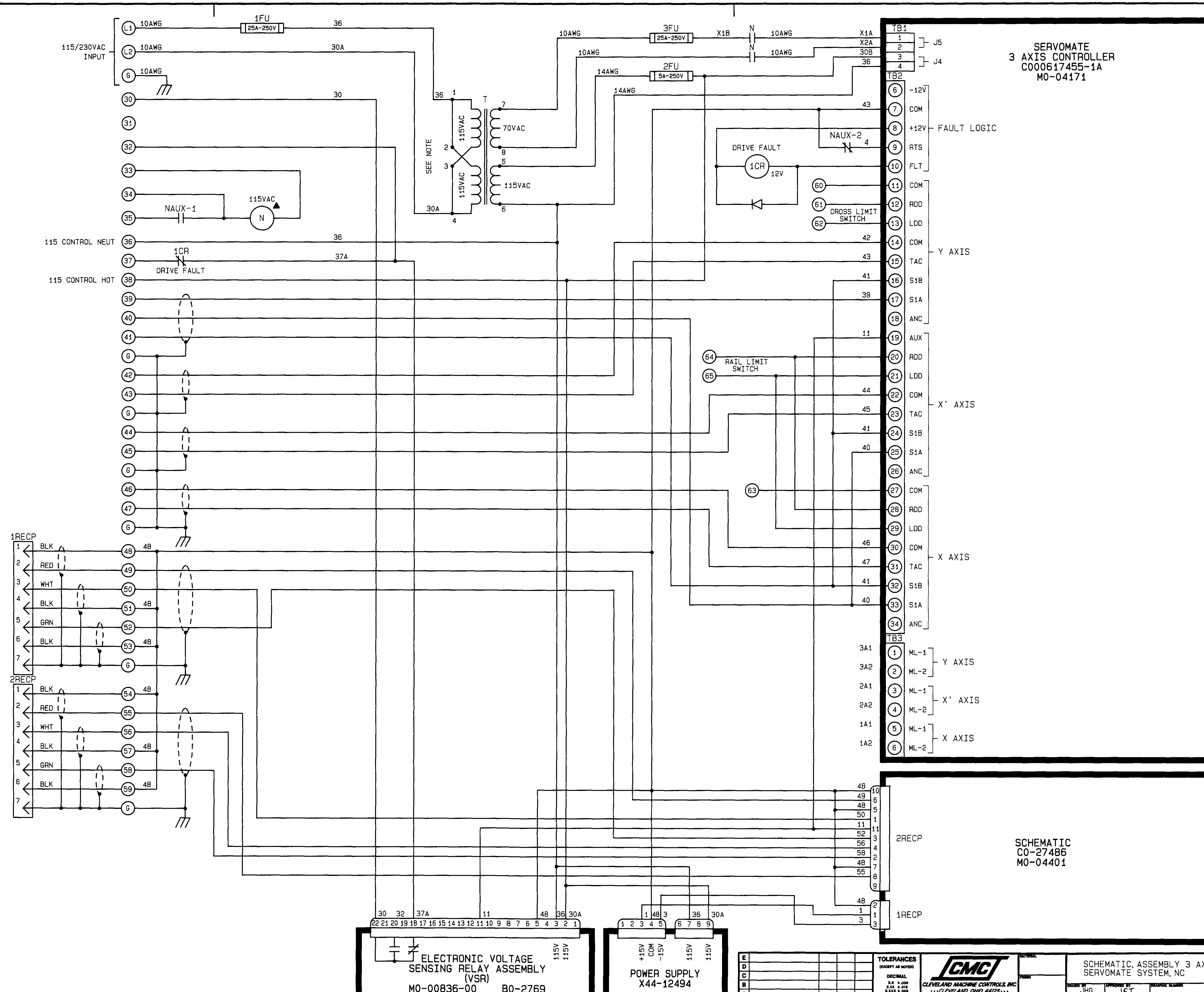
CONTRACT NO	0157
	CLEVELAND MACHINE CONTROLS, INC. WESTERN OPERATIONS
PREPARED / DATE	7-3-86
TITLE	AXIS DRIVE SYSTEM ASSY MODEL SM1-100-3×12A
SIZE	D
DRAWING NO.	540D2340X
REV	A
SCALE	1/2 : 1
SHEET	1 OF 1

540D2340X

NOTE:
1.) ▲ DENOTES SUPPRESSED COIL.
2.) TRANSFORMER "T" PRIMARY FOR
115VAC JUMPER 1-2, 3-4.
230VAC JUMPER 2-3.
3.) UNLESS SPECIFIED WIRE IS 18AWG.

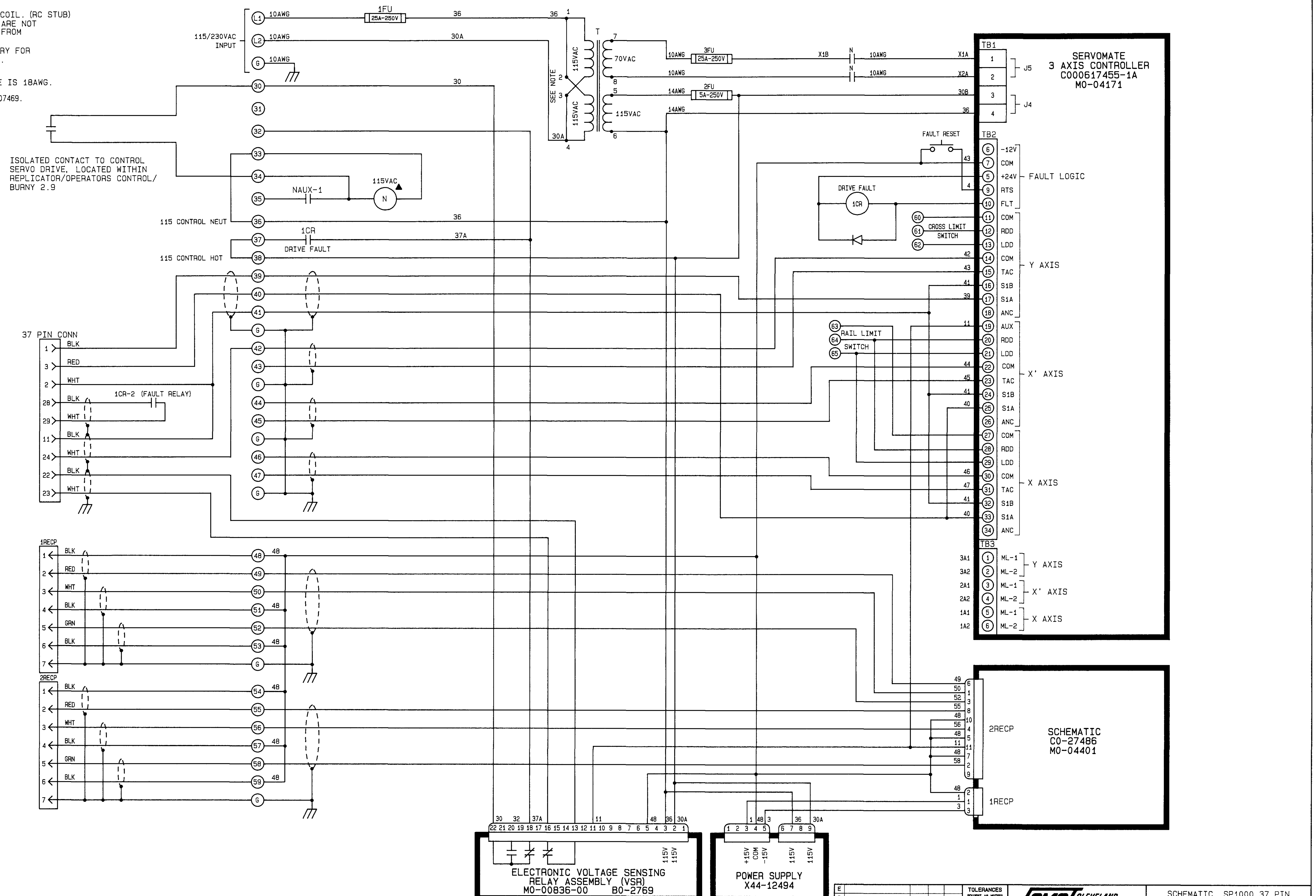
E				TOLERANCES (EXCEPT AS NOTED) DECIMAL ANGULAR	CMC CLEVELAND MACHINE CONTROLS, INC. • • • CLEVELAND, OHIO 44125 • • •	SCHEMATIC, 2 AXIS SERVOMATE SYSTEM, NC
D					DO NOT SCALE DRAWING	
C					MND-06453	DRAWN BY JHG
B					DATE 06-11-90	APPROVED BY MP
A						DO-24748
SYM	REVISION	ECO	BY	DATE		

NOTE:
1.) ▲ DENOTES SUPPRESSED COIL. (RC STUB)
2.) IF MOTOR THERMOSTATS ARE NOT USED ADD JUMPER WIRE FROM 30 TO 33.
3.) TRANSFORMER "T" PRIMARY FOR 115VAC JUMPER 1-2, 3-4. 230VAC JUMPER 2-3.
4.) UNLESS SPECIFIED WIRE IS 18AWG.



TOLERANCES (EXCEPT AS NOTED) DECIMAL .XX ±.030 .XXX ±.010 .XXXX ±.005 ANGULAR ±.5°	CMC CLEVELAND MACHINE CONTROLS, INC. ...CLEVELAND, OHIO 44125...		SCHEMATIC, ASSEMBLY 3 AXIS SERVOMATE SYSTEM, NC	
	DO NOT SCALE DRAWING	REF M0-04172	DRAWN BY JHG DATE 12-08-89	APPROVED BY JFT DATE 01-08-90	D0-27597

NOTE:
1.) ▲ DENOTES SUPPRESSED COIL. (RC STUB)
2.) IF MOTOR THERMOSTATS ARE NOT USED ADD JUMPER WIRE FROM 30 TO 33.
3.) TRANSFORMER "T" PRIMARY FOR 115VAC JUMPER 1-2, 3-4. 230VAC JUMPER 2-3.
4.) UNLESS SPECIFIED WIRE IS 18AWG.
5.) REFERENCES: MO-08057, MND-07469.



E					
D					
C					
B					
A	FAULT TO +24V	8273	JJS	10-92	
SYM	REVISION	ECO	BY	DATE	

TOLERANCES (EXCEPT AS NOTED) DECIMAL X.X ± .030 X.XX ± .015 X.XXX ± .005 ANGULAR ±0.5° DO NOT SCALE DRAWING

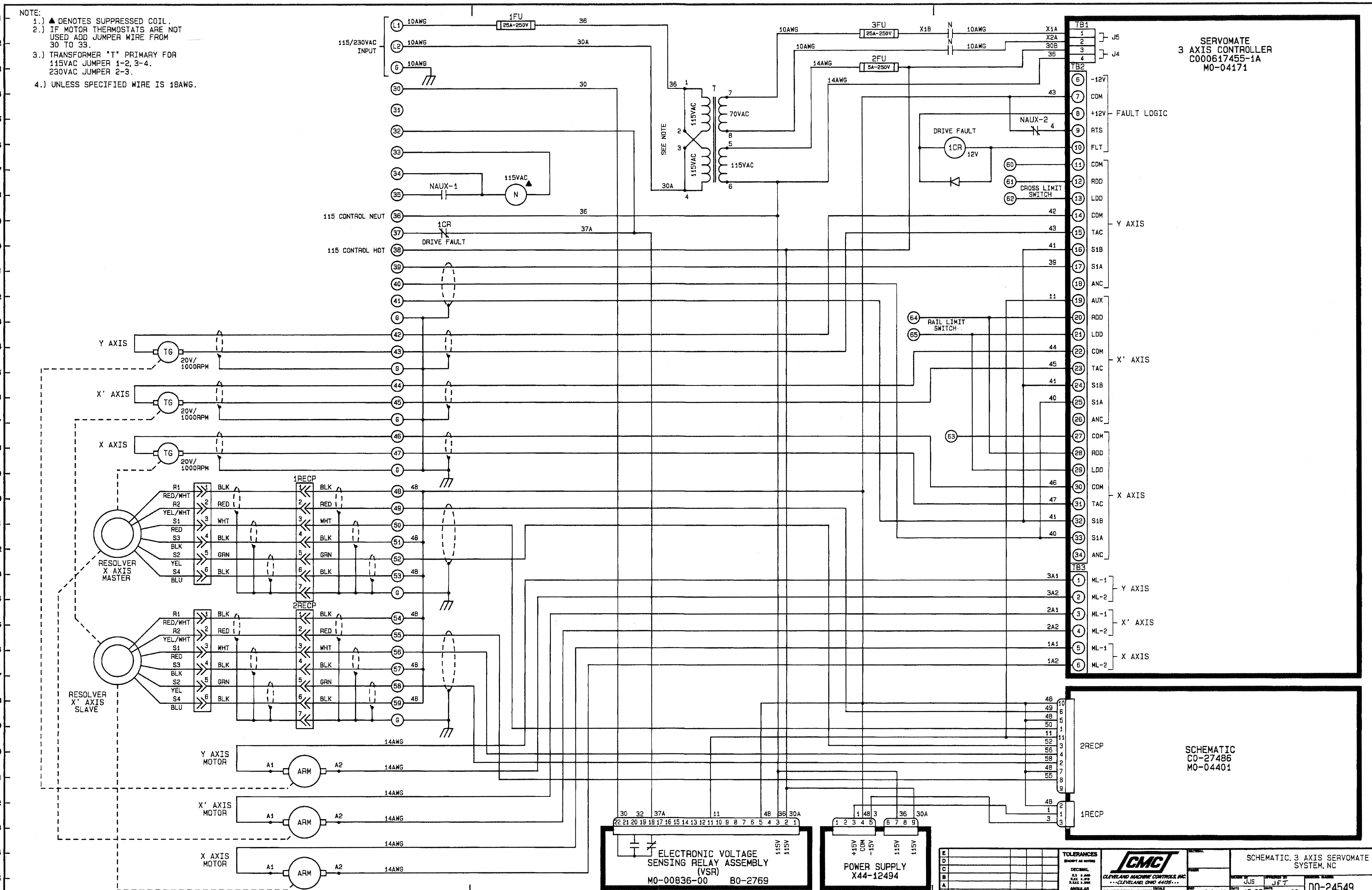
CMC CLEVELAND MACHINE CONTROLS

MATERIAL | FINISH | SCALE | REF NOTE 5

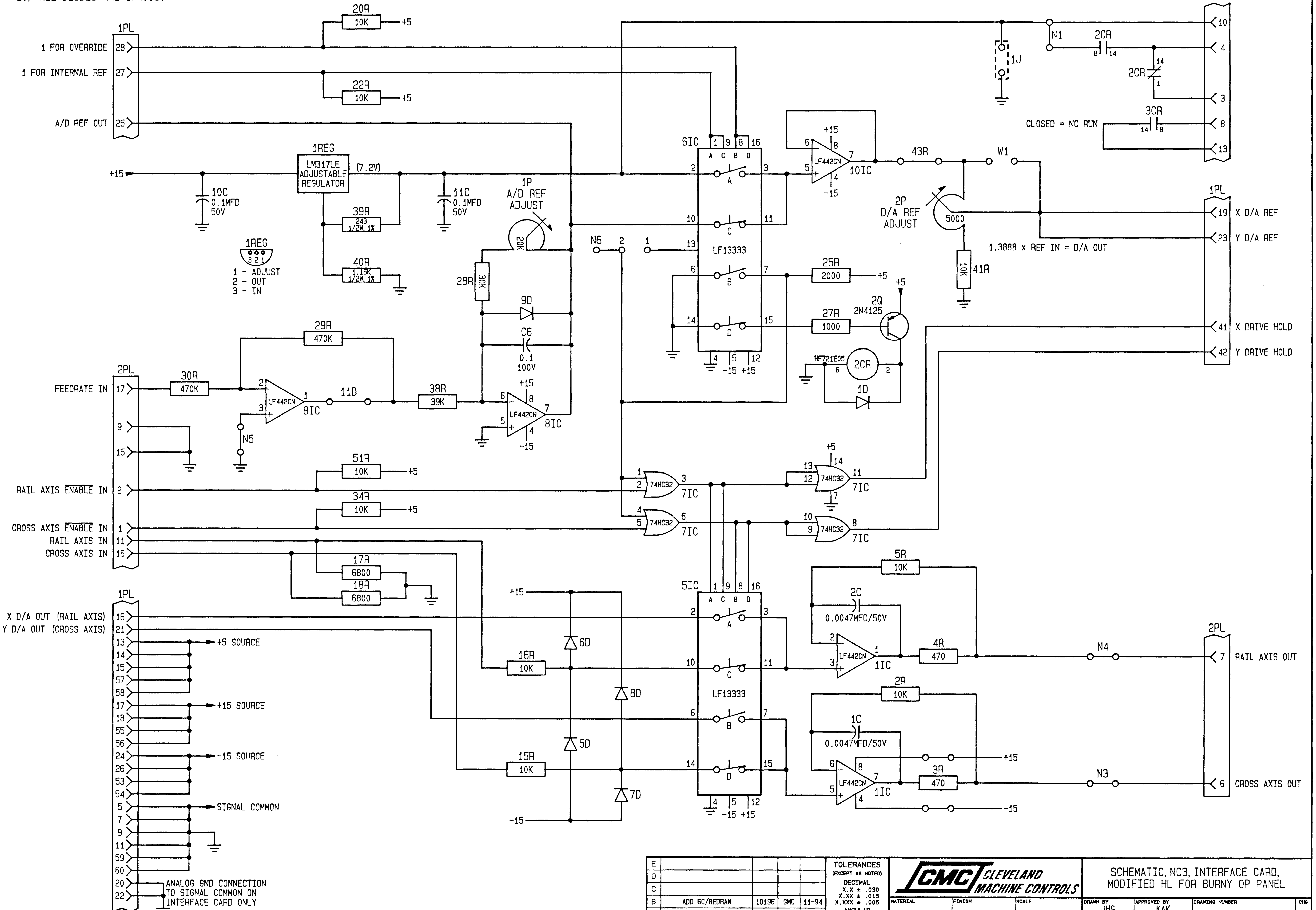
DRAWN BY JHG/JJS | DATE 04-30-92 | APPROVED BY

SCHEMATIC, SP1000 37 PIN DRIVE REFERENCE INPUT

DRAWING NUMBER D0-27748 | CHG A


NOTE:
1.) ▲ DENOTES SUPPRESSED COIL.
2.) IF MOTOR THERMOSTATS ARE NOT USED ADD JUMPER WIRE FROM 30 TO 33.
3.) TRANSFORMER "T" PRIMARY FOR 115VAC JUMPER 1-2, 3-4. 230VAC JUMPER 2-3.
4.) UNLESS SPECIFIED WIRE IS 18AWG.
115/230VAC INPUT
10AWG
1FU
25A-250V
3FU
25A-250V
2FU
5A-250V
14AWG
70VAC
115VAC
SEE NOTE
NAUX-1
NAUX-2
115VAC
115 CONTROL NEUT
1CR
DRIVE FAULT
115 CONTROL HOT
12V
CROSS LIMIT SWITCH
RAIL LIMIT SWITCH
SERVOMATE
3 AXIS CONTROLLER
C000617455-1A
MO-04171
TB1
J5
J4
TB2
FAULT LOGIC
Y AXIS
X' AXIS
X AXIS
TB3
Y AXIS
20V/ 1000RPM
X' AXIS
X AXIS
RESOLVER X AXIS MASTER
RESOLVER X' AXIS SLAVE
1RECP
2RECP
Y AXIS MOTOR
X' AXIS MOTOR
X AXIS MOTOR
ARM
SCHEMATIC
CO-27486
MO-04401
ELECTRONIC VOLTAGE SENSING RELAY ASSEMBLY (VSR)
MO-00836-00 BO-2769
POWER SUPPLY
X44-12494
CMC
CLEVELAND MACHINE CONTROLS, INC.
CLEVELAND, OHIO 44125
DO NOT SCALE DRAWING
SCHEMATIC, 3 AXIS SERVOMATE SYSTEM, NC
MO-04172
JJS
JFT
11-17-89
12-8-89
DO-24549

NOTE: UNLESS OTHERWISE SPECIFIED.
1.) ALL RESISTORS ARE 1/4W, 5%.
2.) ALL DIODES ARE 1N4005.



SYM	REVISION	ECO	BY	DATE
E				
D				
C				
B	ADD 6C/REDRAW	10196	GMC	11-94
A	SCHEMATIC CHANGE	6695	JJS	9-89

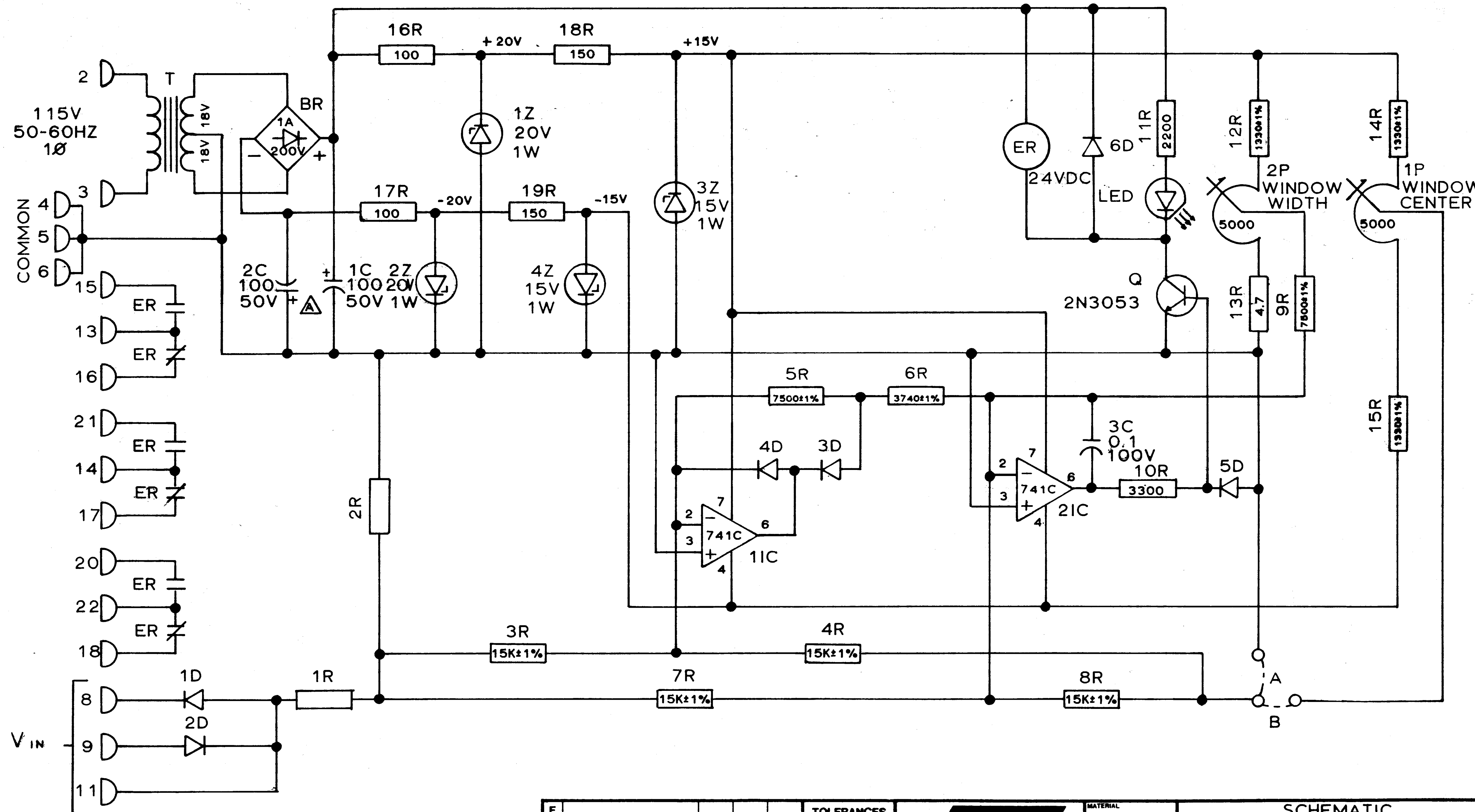
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
X.X ± .030
X.XX ± .015
X.XXX ± .005
ANGULAR ±0.5°
DO NOT SCALE DRAWING

CMC CLEVELAND MACHINE CONTROLS

SCHEMATIC, NC3, INTERFACE CARD, MODIFIED HL FOR BURNY OP PANEL

MATERIAL | FINISH | SCALE | REF MD-05529

DRAWN BY JHG | DATE 23 OCT 89
APPROVED BY KAK | DATE 26 SEPT 89
DRAWING NUMBER CO-24364 | CHG B

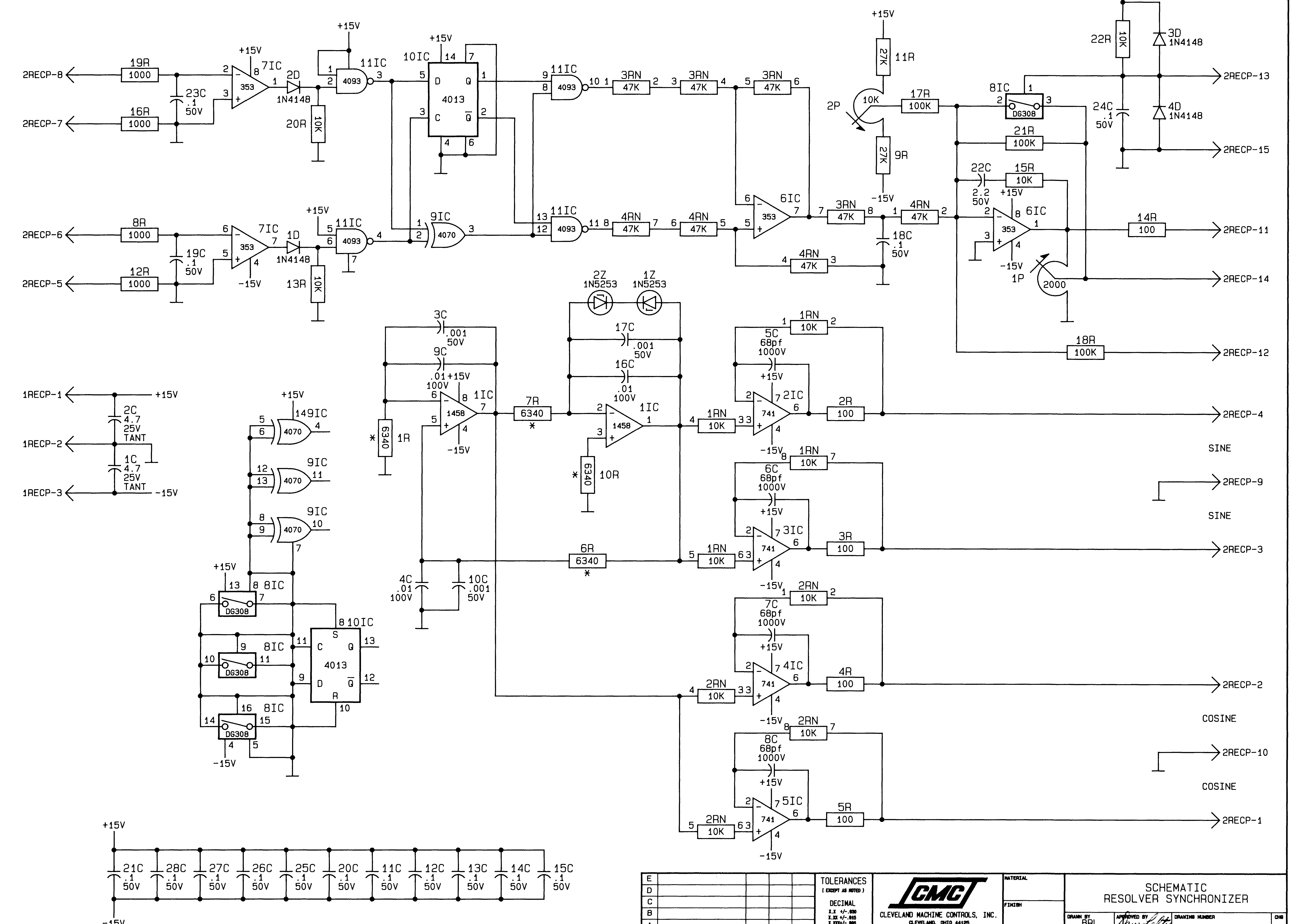


E					TOLERANCES (EXCEPT AS NOTED) DECIMAL X.X ±.030 X.XX ±.015 X.XXX ±.005 ANGULAR ±.5°	CMC CLEVELAND MACHINE CONTROLS, INC. ···CLEVELAND, OHIO 44125···	MATERIAL
D							FINISH
C							
B							
A						DO NOT SCALE DRAWING / SCALE	REF
SYM	REVISION	ECO	BY	DATE			

SCHEMATIC ELECTRONIC VOLTAGE SENSING RELAY

DRAWN BY	APPROVED BY	DRAWING NUMBER	CHG
ELK	DH	BO-2769	
DATE 11-1-84	DATE 11-84		

NOTE:
1.) ALL RESISTORS ARE 1/4W, 5% UNLESS DESIGNATED BY AN ASTERISK (*) WHITCH INDICATES 1/4W, 1%.



SYM	REVISION	ECO	BY	DATE
E				
D				
C				
B				
A				

TOLERANCES (EXCEPT AS NOTED)
DECIMAL X.X +/-.030 X.XX +/-.015 X.XXX+/-.005
ANGULAR +/-.5 DEG

CMC
CLEVELAND MACHINE CONTROLS, INC.
CLEVELAND, OHIO 44125

DO NOT SCALE DRAWING | SCALE

MATERIAL | FINISH | REF

SCHEMATIC
RESOLVER SYNCHRONIZER

DRAWN BY BRL | DATE 7-22-87 | APPROVED BY Dave Letts | DATE 7/23/87 | DRAWING NUMBER C0-27486 | CHG