


OPERATOR MANUAL

ATE 3/4 RACK, FULL RACK SERIES

POWER SUPPLY

AUTOMATIC TEST EQUIPMENT

KEPCO INC.
An ISO 9001 Company.

MODELS		
3/4 Rack, 500W		
ATE 6-50, ATE 15-25, ATE 25-20, ATE 36-15, ATE 55-10, ATE 75-8, ATE 100-5, ATE 150-3.5		
Full Rack1000W		
ATE 6-100, ATE 15-50, ATE 25-40, ATE 36-30, ATE 55-20, ATE 75-15, ATE 100-10, ATE 150-7		
<small>ORDER NO.</small>	<small>REV. NO</small>	

IMPORTANT NOTES:

- 1) This manual is valid for the following Model and associated serial numbers:

MODEL	SERIAL NO.	REV. NO.
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- 2) A Change Page may be included at the end of the manual. All applicable changes and revision number changes are documented with reference to the equipment serial numbers. Before using this Instruction Manual, check your equipment serial number to identify your model. If in doubt, contact your nearest Kepco Representative, or the Kepco Documentation Office in New York, (718) 461-7000, requesting the correct revision for your particular model and serial number.
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Conditions of Conformance

When this product is used in applications governed by the requirements of the EEC, the following restrictions and conditions apply:

1. For European applications, requiring compliance to the Low Voltage Directive, 73/23/EEC, this power supply is considered a component product, designed for "built in" applications. Because it is incomplete in construction, the end product enclosure must provide for compliance to any remaining electrical safety requirements and act as a fire enclosure. (EN61010-1:2001, Cl. 6, Cl. 7, Cl.8, and Cl. 9)
2. This power supply is designed for stationary installation, with mains power applied via a detachable power supply cord or via direct wiring to the source power terminal block.
3. This power supply is considered a Class 1 (earthed) product. It is intended for use as part of equipment meant for test, measurement and laboratory use, and is designed to operate from single phase, three wire power systems. This equipment must be installed within a suitably wired equipment rack, utilizing a three wire (grounded) mains connection. See wiring section of this manual for complete electrical wiring instructions. (EN61010-1:2001, Cl.6.10.1)
4. This power supply has secondary output circuits that are considered hazardous, and which exceed 240 VA at a potential of 2V or more.
5. The output wiring terminals of this power supply has not been evaluated for field wiring and, therefore, must be properly configured by the end product manufacturer prior to use.
6. This power supply employs a supplementary circuit protector in the form of a circuit breaker mounted on the front panel. This circuit breaker protects the power supply itself from damage in the event of a fault condition. For complete circuit protection of the end product, as well as the building wiring, it is required that a primary circuit protection device be fitted to the branch circuit wiring. (EN61010-1:2001, Cl. 9.5)
7. Hazardous voltages are present within this power supply during normal operation. All operator adjustments to the product are made via externally accessible switches, controls and signal lines as specified within the product operating instructions. There are no user or operator serviceable parts within the product enclosure. Refer all servicing to qualified and trained Kepco service technicians.

SAFETY INSTRUCTIONS

1. Installation, Operation and Service Precautions

This product is designed for use in accordance with EN 61010-1 and UL 3101 for Installation Category 2, Pollution Degree 2. Hazardous voltages are present within this product during normal operation. The product should never be operated with the cover removed unless equivalent protection of the operator from accidental contact with hazardous internal voltages is provided:



There are no operator serviceable parts or adjustments within the product enclosure. Refer all servicing to trained service technician.



Source power must be removed from the product prior to performing any servicing.



This product is factory-wired for the nominal a-c mains voltage indicated on the rating nameplate located adjacent to the source power connection on the product's rear panel. To reconfigure the product input for other nominal mains voltages as listed herein, the product must be modified by a trained service technician.

2. Grounding

This product is a Class 1 device which utilizes protective earthing to ensure operator safety.



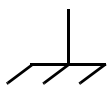
The PROTECTIVE EARTHING CONDUCTOR TERMINAL must be properly connected prior to application of source power to the product (see instructions on installation herein) in order to ensure safety from electric shock.



PROTECTIVE EARTHING CONDUCTOR TERMINAL - This symbol indicates the point on the product to which the protective earthing conductor must be attached.



EARTH (GROUND) TERMINAL - This symbol is used to indicate a point which is connected to the PROTECTIVE EARTHING TERMINAL. The component installer/ assembler must ensure that this point is connected to the PROTECTIVE EARTHING TERMINAL.



CHASSIS TERMINAL - This symbol indicates frame (chassis) connection, which is supplied as a point of convenience for performance purposes (see instructions on grounding herein). This is not to be confused with the protective earthing point, and may not be used in place of it.

3. Electric Shock Hazards

This product outputs hazardous voltage and energy levels as a function of normal operation. Operators must be trained in its use and exercise caution as well as common sense during use to prevent accidental shock.



This symbol appears adjacent to any external terminals at which hazardous voltage levels as high as 500V d-c may exist in the course of normal or single fault conditions.



This symbol appears adjacent to any external terminals at which hazardous voltage levels in excess of 500V d-c may exist in the course of normal or single fault conditions.

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ATE 3/4 RACK SERIES



ATE FULL RACK SERIES

FIGURE 1-1. ATE 3/4 RACK AND FULL RACK SERIES PROGRAMMABLE POWER SUPPLY

SECTION 1- INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains instructions for the installation, operation and maintenance of the ATE Full- Rack and 3/4-Rack series of voltage and current stabilized d-c power supplies, both M suffix (analog meter) and DM suffix (digital meter) manufactured by Kepco, Inc., Flushing, New York, U.S.A.

1.2 GENERAL DESCRIPTION

The Kepco ATE with programmable overvoltage protector is a precision stabilized power supply which can deliver either stabilized output voltage or current. The prevailing operating mode is indicated by LED mode indicators on the front panel. Operating mode crossover is automatic and may be monitored remotely by means of a flag signal, available at the rear programming connector. The power supply features full range output control by means of 10-turn, high resolution front panel potentiometers. A pair of front panel meters constantly monitor the output voltage and output current. This power supply has a linear and fully dissipative NPN pass transistor section driven by high gain integrated circuit amplifiers. The output of the power supply is fully programmable. All necessary input terminals are provided on a programming connector at the rear of the chassis. Terminals are also provided for remote error sensing, as well as for the connection of the output capacitor directly at the load.

The ATE power supply features user-selectable Slow or Fast operating modes. Slow Mode operation is recommended for applications demanding a constant voltage source. Fast Mode operation is best if the output voltage must change rapidly, either in response to an external programming signal or, if the ATE is used as a current stabilizer, as a reaction to changing load resistance.

The ATE power supply is delivered for Slow Mode operation. See Section 2, par. 2.7 for converting the ATE power supply to Fast Mode operation.

A continuously adjustable and remotely programmable overvoltage protection circuit is a built-in feature. The trigger point of the overvoltage protector may be set (or checked) under actual operating conditions by the front panel-accessible setup controls (refer to Section 2 of this manual).

Power transistors and drivers on all ATE designs are mounted onto highly efficient, patented heat sink assemblies which are cooled by low-noise fans. The ATE main chassis assemblies, as well as the wraparound covers, are constructed from cold-rolled steel. The front panels are made from aluminum (refer to "Mechanical Outline Drawings," Figure 1-2 for 3/4 rack models and Figure 1-3 for Full-rack models).

1.3 OPTIONS

ATE options are described below; more than one option may be incorporated into any ATE Power Supply.

1.3.1 DIGITAL METERS (DM SUFFIX): ATE models with DM suffix include two digital meters on the front panel to monitor voltage and current. DM models are now standard. Voltage meter accuracy is $\pm(0.2\% E_{Omax} + 2 \text{ counts})$; current meter accuracy is $\pm(3\% I_{Omax} + 2 \text{ counts})$.

1.3.2 ANALOG METERS (M SUFFIX): ATE models with M suffix include one analog voltage meter and one analog current meter on the front panel to monitor voltage and current.
NOTE: analog meters are no longer available.

1.3.3 LOCKING FRONT CONTROLS (L SUFFIX) ATE Power Supplies with L suffix are equipped with locking-type screw-driver-adjustable controls in place of the front panel control knobs. For L option models, changing front panel settings require that the controls be unlocked first.

1.4 SPECIFICATIONS

Table 1-1 lists the output parameters applicable to individual models. Table 1-2 lists general specifications applicable to all full-rack and 3/4 rack models except where otherwise noted. Table 1-3 lists dynamic specifications and Table 1-4 lists static specifications. Mechanical specifications are presented in the mechanical outline drawings, Figures 1-3 (full rack) and 1-2 (3/4 rack)..

TABLE 1-1. ATE D-C OUTPUT RATINGS AND OUTPUT IMPEDANCE

MODEL	d-c OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES R	SERIES L ⁽¹⁾		SHUNT R ⁽²⁾	SHUNT C ⁽³⁾	
				SLOW	FAST		SLOW	FAST
SIZE "D" 3/4-RACK (500 Watt)								
ATE 6-50DM	0-6	0-50	2.4μΩ	0.5μH	5μH	12kΩ	12000μF	10μF
ATE 15-25DM	0-15	0-25	12μΩ	0.5μH	5μH	30kΩ	8000μF	4μF
ATE 25-20DM	0-25	0-20	25μΩ	1μH	10μH	50kΩ	5800μF	2.5μF
ATE 36-15DM	0-36	0-15	48μΩ	1μH	10μH	72kΩ	5900μF ⁽⁴⁾	2μF
ATE 55-10DM	0-55	0-20	0.11mΩ	2μH	20μH	110kΩ	2600μF ⁽⁵⁾	1.5μF
ATE 75-8DM	0-75	0-8	0.19mΩ	2μH	20μH	150kΩ	1200μF	1μF
ATE 100-5DM	0-100	0-5	0.4mΩ	4μH	40μH	200kΩ	680μF	0.5μF
ATE 150-3.5DM	0-150	0-3.5	0.86mΩ	4μH	40μH	300kΩ	440μF	0.2μF
SIZE "E" FULL-RACK (1000 Watt)								
ATE 6-100DM	0-6	0-100	1.2μΩ	0.5μH	5μH	12kΩ	26000μF ⁽⁶⁾	15μF
ATE 15-50DM	0-15	0-50	6μΩ	0.5μH	5μH	30kΩ	12000μF	6μF
ATE 25-40DM	0-25	0-40	12.5μΩ	1μH	10μH	50kΩ	12000μF ⁽⁷⁾	4μF
ATE 36-30DM	0-36	0-30	24μΩ	1μH	10μH	72kΩ	12000μF ⁽⁷⁾	3μF
ATE 55-20DM	0-55	0-20	55μΩ	2μH	20μH	110kΩ	5200μF	2.25μF
ATE 75-15DM	0-75	0-15	0.1mΩ	2μH	20μH	150kΩ	3100μF ⁽⁸⁾	1.5μF
ATE 100-10DM	0-100	0-10	0.2mΩ	4μH	40μH	200kΩ	1700μF ⁽⁹⁾	0.75μF
ATE 150-7DM	0-150	0-7	0.42mΩ	4μH	40μH	300kΩ	1700μF ⁽⁹⁾	0.3μF
<p>(1) For determining dynamic impedance in voltage mode. (6) 33000μF is also valid for ATE 6-100.</p> <p>(2) Based on 0.5mA load effect in FAST mode. (7) 14000μF is also valid for ATE 25-40 and ATE 36-10.</p> <p>(3) For determining dynamic impedance in current mode. (8) 3900μF and 5000μF are also valid for ATE 75-15.</p> <p>(4) 6800μF and 8200μF are also valid for ATE 36-15. (9) 2200μF and 2300μF are also valid for ATE 100-10 and ATE 150-7.</p> <p>(5) 3300μF is also valid for ATE 55-10.</p>								

TABLE 1-2. ATE SERIES SPECIFICATIONS

SPECIFICATION	RATING/DESCRIPTION	CONDITION
INPUT CHARACTERISTICS		
A-C Voltage	nominal: 104, 115, 208, 230Va-c	User selectable, See PAR. 2.3
	Tolerance: ± 8.7%	
Frequency	range: 47 - 63 Hz	
Current	Full rack	Max load, 115V a-c
	3/4 rack	

TABLE 1-2. ATE SERIES SPECIFICATIONS (Continued)

SPECIFICATION	RATING/DESCRIPTION	CONDITION	
OUTPUT CHARACTERISTICS			
d-c Output	Series Pass Transistor		
Type of Stabilizer	Automatic crossover	Voltage/Current	
Voltage	0 to 100% of rating	Adjustment range for temp 0 to +50°C	
Current	0-100% of rating	Usable range limited to approximately 1% to 100%. Adjustment range for temp 0 to +50°C.	
Static Specifications		See Table 1-4	
Dynamic Specifications		See Table 1-3	
Error sense	0.5V per load wire (0.25V for 6V model)	Voltage allowance	
Isolation Voltage	500Vd-c or peak plus E _O nominal	Between each output terminal and chassis ground	
Leakage current Output to Ground	<5 microamperes max.	rms at 115V a-c	
	<50 microamperes max.	p-p at 115V a-c	
Parallel Connection	Automatic	Use current mode limiting	
	Current Sharing	Use master/slave connection	
	Redundancy type	Use external OR-ing diodes	
Series Connection	Automatic	Use OVP	
	Voltage Sharing	Use master/slave connection	
Overvoltage Protection (OVP)	Type	Crowbar	
	Control range	Min: greater of 1.6% E _O max or 3V Max: 110% E _O max	Local (manual)
	Trigger Time:	Normal: 50 microseconds	Slow mode
		Delayed: 500 microseconds	Fast mode
	Threshold:	Min: greater of 0.5V or 2% E _O max.	
	Temperature Coefficient:	Max: 0.02% E _O max per °C	
CONTROL			
Type	Voltage	Inverting fix gain configuration	
	Current	Differential comparison configuration	
Voltage	Local	10-turn precision potentiometer	
	Remote Analog	Voltage control: 0 to 10V d-c Resistive control: 0 to 10k Ohms	Use PREAMP "A" to enable control using High impedance voltage source, Negative voltage or Resistance.
	Remote Digital	Use SN or SNR interface	12 bit, listen only
Current	Local	10-turn precision potentiometer	
	Remote Analog	Voltage control: 0 to 1V d-c Resistive control: 0 to 1k Ohms	Use PREAMP "B" and/or the External Current Comparison Amplifier (internally located) to enable control using High impedance voltage source, Negative voltage, Resistance or External loop.
	Remote Digital	Use SN or SNR interface	12 bit, listen only
Dynamics	Normal (slow mode)	dv/dt - I _{lim} /C _O	I _{lim} is the preset current limit value C _O is the output capacitor value (see Table 1-1)
	Fast mode	See Table 1-3	

TABLE 1-2. ATE SERIES SPECIFICATIONS (Continued)

SPECIFICATION	RATING/DESCRIPTION	CONDITION
GENERAL (ENVIRONMENTAL) CHARACTERISTICS		
Operating Temperature	DM suffix	0 to +50°C
	M Suffix	0 to +65°C
Storage Temperature	DM suffix	-20 to +70°C
	M Suffix	-40 to +85°C
Humidity		0 to 95% RH
Shock		20g, 11msec ±50% half sine
Vibration		5-10Hz 10mm, double amplitude
Cooling		Forced air
		High efficiency, single bearing fans, permanently lubricated with special low-noise non-metallic blades. Exhaust to rear.
PHYSICAL CHARACTERISTICS		
Weight		3/4 rack: 57lbs (25.9Kg) Full rack: 96 lbs. 43.6Kg
Dimensions	inches	3/4 rack: 5-7/32 x 12-17/32 x 18-1/16
		Full rack: 6-31/32 x 19 x 20-1/64
	mm	3/4 rack: 318.6 x 132.6 x 159
		Full rack: 177 x 482.6 x 506.8
a-c source connections		Terminal block
d-c output connections	Rear panel	Binding post
	Rear panel	compression studs
User port		50-terminal connector
Indicators		Three LED's
Meters		Analog (2)
		Digital (2)
		M suffix
		DM suffix: Voltage meter accuracy is ±(0.2% E _{Omax} + 2 counts); current meter accuracy is ±(3% I _{Omax} + 2 counts).
Mounting (in Std. 19 in. racks)		Mounting ears supplied
Finish: Fed. Std. 595		Dark and light gray, Color 26440
Cooling		Forced air
		Exhaust to rear

TABLE 1-3. ATE DYNAMIC SPECIFICATIONS, RESISTIVE LOAD

OUTPUT VOLTAGE RATING	PROGRAMMING BANDWIDTH (FAST MODE) (KHz)		PROGRAMMING TIME CONSTANT (FAST MODE) (μ sec)	
	Typical	minimum	Typical	maximum
6V	23.0	16.0	7.0	10.0
15V	20.0	10.6	8.0	15.0
25V	11.5	8.0	14.0	20.0
36V	8.0	6.4	20.0	25.0
55V	4.8	4.0	33.0	40.0
75V	4.3	3.5	37.0	45.0
100V	2.7	2.5	60.0	65.0
150V	1.8	1.7	88.0	95.0

NOTES:

1. Voltage Recovery for a Step load Current in Fast Mode: The time required for the stabilized output voltage to recover to within 10mV of the output voltage setting, for a 10 to 100% step in rated load current is typically less than 50 μ Sec., 100 μ Sec. maximum.
2. Current Recovery for Step load Voltage in Slow Mode: The stabilized output current recovers from a step in load (compliance) voltage with an exponential response, the time constant of which is determined by the load resistance and the tabulated output capacitance (See Table 1-1).
3. Programming Speed: The speed with which the power supply output responds to external programming signals is determined by:
 - a) The Programming Time Constant (τ), is given in Slow Mode by either the load resistance (R_L) and the value of the output capacitor (C_O , see Table 1-1): $\tau = R_L C_O$, or by the Feedback Time Constant, given by the product of the feedback capacitor and the feedback resistor: $\tau = R_f C_f$, whichever is greater. In the Fast Mode, the Programming Time Constant and bandwidth (-3dB) for the Voltage Control Channel is shown above.
For the Current Control Channel, the Programming Time Constant in Fast Mode is 25 μ Sec. typical, 50 μ Sec. maximum.
 - b) The MAXIMUM RATE OF CHANGE that the power supply output can respond to is given by the setting of the power supply's CURRENT control setting (I_{LIM}), divided by the ATE output capacitor (C_O see Table 1-1):

$$\text{MAXIMUM RATE OF CHANGE} = I_{LIM}/C_O.$$

TABLE 1-4. ATE STATIC SPECIFICATIONS

INFLUENCE QUANTITY	OUTPUT EFFECTS VOLTAGE MODE		OUTPUT EFFECTS CURRENT MODE		OFFSETS ⁽⁴⁾		
	TYPICAL	MAXIMUM	TYPICAL	MAXIMUM	ΔE_{IO}	ΔI_{IO}	
SOURCE VOLTAGE (min. - max.)	<0.0005% E_O max.	<0.001% E_O max.	<0.002% I_O max.	<0.005% I_O max.	<1 μ V	<1nV	
LOAD (no load - full load):	<0.001% E_O max.	<0.002% E_O max.	<0.5 mA ⁽¹⁾	<1 mA ⁽¹⁾	-	-	
TIME (8 hour drift)	<0.005% E_O max.	<0.01% E_O max.	<0.01% I_O max.	<0.02% I_O max.	<20 μ V	<1nV	
Temperature per °C	<0.005% E_O max.	<0.01% E_O max.	<0.01% I_O max.	<0.02% I_O max.	<20 μ V	<2nV	
Ripple and noise ⁽²⁾⁽⁵⁾ (Slow mode)	rms:	<0.1mV	<0.3mV	<0.01% I_O max.	<0.03% I_O max.	-	-
	p-p: ⁽³⁾	<1mV	<3mV	<0.1% I_O max.	<0.3% I_O max.	-	-
Ripple and noise ⁽²⁾⁽⁵⁾ (Fast mode)	rms:	<1mV	<3mV ⁽⁴⁾	<0.01% I_O max.	<0.03% I_O max.	-	-
	p-p: ⁽³⁾	<10mV	<30mV ⁽⁴⁾	<0.1% I_O max.	<0.3% I_O max.	-	-

- (1) For $I_O > 50A$, load effect = 2mA typ., 5mA max in slow mode. The output capacitor adds 0 - 6 mA to current mode load effect.
 (2) One terminal grounded so that common mode current does not flow through load or current sense resistor.
 (3) Bandwidth: 20Hz - 10 MHz.
 (4) Preamp offsets are given for the calculation of the output effects of preamplifiers (A, B) if either of these amplifiers is used for operational programming. In this case, the value of the external feedback and input resistors, the amplifier offsets and the reference voltage variations are combined in the "Error Equation," which represents the "worst case" output effects for the application at hand:

$$\Delta E_{O(\text{preamp})} = \Delta E_{\text{ref}}(R_f/R_i) + \Delta E_{IO}(1 + R_f/R_i) + \Delta EI_{IO}R_f$$

where: $\Delta E_{O(\text{preamp})}$ = Total Preamp Output Voltage change
 ΔE_{ref} = Change in the Voltage Reference
 ΔE_{IO} = Change in Offset Voltage
 ΔI_{IO} = Change in Offset Current
 R_f = External Feedback Resistor
 R_i = External Input Resistor

NOTE 1: Variations in the value of the feedback and input resistors are considered secondary effects in the error equation.

NOTE 2: In the voltage mode of operation, the calculated preamp output effect $\Delta E_{O(\text{preamp})}$, must be multiplied by the (fixed) gain of the ATE voltage channel to find out the total effect on the output voltage of the ATE power supply. The (fixed) gain of the ATE voltage channel is given by $GAIN = E_{O \text{ max}}/10$, where $E_{O \text{ max}}$ is the maximum rated output voltage of each ATE model. In the current mode of operation, the effect of the preamplifier offsets on the total output current may be expressed as a percentage of $I_{O \text{ max}}$ by the equation:

$$\Delta I_O(\%) = \frac{\Delta E_{O(\text{preamp})}}{1 \text{ Volt}} \times 100\%$$

- (5) For high voltage ATE 325-0.8M the maximum output ripple and noise is 10mV rms and 50 mV p-p.

1.5 FEATURES

1.5.1 VOLTAGE CHANNEL

Output voltage is controlled continuously throughout the range by a panel-mounted, 10-turn potentiometer. External control can be exercised by resistance or by a control voltage. See Section 3.

1.5.2 CURRENT CHANNEL (INTERNAL)

Output current is controlled continuously throughout the range by a panel-mounted, 10-turn potentiometer. External control can be exercised by resistance or by a control voltage (See Section 3). When controlling the external current channel, the power supply's panel-mounted CURRENT control serves as an adjustable maximum current limit.

1.5.3 CURRENT CHANNEL (EXTERNAL)

Output current may be controlled by means of a separate current channel, applying a 0 to 1V d-c control signal at the rear programming connector for control over the rated current range. This same channel, properly programmed, may control the output of the power supply, responding to control and feedback voltages from temperature or pressure sensors, chemical reactions and the like. For these types of applications, the ATE unit serves as the power delivery element of a closed loop (see Section 3).

1.5.3.1 CROWBAR CIRCUIT (OVERVOLTAGE PROTECTOR)

An overvoltage crowbar circuit protects the load from momentary or long term overvoltages. The crowbar conducts across the power supply output and the POWER ON/OFF switch/circuit breaker is tripped if such overvoltage occurs. The setting of the front panel CROWBAR SET LEVEL control determines the threshold between the operating voltage of the power supply and the level at which the crowbar circuit will be activated. The crowbar level is set from the front panel (refer to PAR. 3.5). Remote control of the crowbar level can be exercised by connecting a 0 - 10V control source to the rear programming connector. Automatic tracking of the crowbar level with the output voltage level may be achieved by simultaneous connection of the voltage channel programming source to the tracking input.

1.5.4 MODE FLAG

A pair of LED indicators operate to indicate whether the voltage channel or (by exclusion) the current channel has control of the output. In addition, an isolated flag signal is provided through an opto-isolator at the rear programming connector, with the optocoupler's output transistor OFF for voltage mode and ON (saturated) for current mode.

1.5.5 REMOTE ERROR SENSING:

Separate voltage-sensing terminals permit 4-wire connections to a load. This will compensate for static load effects up to 0.5V per lead (0.25V for 6V models). An additional 1V output voltage (0.5V for 6V models) beyond the nominal voltage rating of each ATE model, is provided for this purpose.

1.5.6 REFERENCE SUPPLIES

Two dual reference sources are available at the rear programming connector: $\pm 6.2V$ d-c @ 1mA and $\pm 15V$ d-c @ 10mA.

1.5.7 CURRENT SENSING AMPLIFIER

The output of the current sensing amplifier is available on the rear programming connector. It provides a voltage analog of the output current. The range of the analog output is 0 to +1V, corresponding to output currents of 0 to 100%.

1.6 EQUIPMENT SUPPLIED

Equipment supplied is listed in Table 1-5

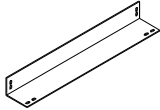
TABLE 1-5. EQUIPMENT SUPPLIED

ITEM	FUNCTION	PART NUMBER
Rear Programming Connector	PC 12 connector installed on rear panel, pre-wired for local (front panel) control of ATE 3/4-rack and full- rack models.	PC 14
Line Cord (Full Rack models)	Power cord (7 ft.) connects ATE full rack models to mains power.: NEMA 5-20P connector, AWG #12 conductors, ring terminals	118-0583
Line Cord (3/4-rack models)	Power cord (7-1/2 ft.) connects ATE 3/4 rack models to mains power.: 5-15P to IEC 320 C-13	1180557

1.7 ACCESSORIES

Accessories for the ATE Power Supply are listed in Table 1-6.



TABLE 1-6. ACCESSORIES

ITEM	FUNCTION	PART NUMBER
Rear Programming Connector	Unwired, Allows access to signals and flags for control and monitoring of ATE power supply.	PC 12
Rear Programming Connector	Prewired to allow front panel control of ATE full rack, 3/4-rack and 1/2 rack power supplies.	PC 14
Side Support "L" Bracket	L bracket mounts to vertical rails to provide additional side support for rack-mounted models. 19.6 in. long x 2.3 in. high x 3.5 in. wide. Two (2) required per unit. 	128-1775
Master/Slave Parallel Cables	Allows Master/Slave Parallel Configuration of identical ATE 3/4-rack or full-rack models.	KIT 219-0609
Rack Adapter ⁽¹⁾ ⁽²⁾	Allows rack mounting of all Kepco 1/4-rack, 1/2-rack and 3/4-rack models, or a mixture of them. Filler panels to cover empty slots, if the adapter is not used to its full capacity, are available.	RA 24
Rack Adapter ⁽¹⁾ ⁽²⁾	Allows rack mounting of (two) Kepco 1/4-rack models or (one) 1/2-rack model. Has additional space for (three) 1/6-rack modular Kepco units. Filler panels to cover empty slots, if the adapter is not used to its full capacity, are available.	RA 32
Rack Adapter ⁽¹⁾	For Kepco ATE models only. Accepts 1/4-rack, 1/2-rack or 3/4-rack ATE models or a mixture of them. The model RA-37 can be used without filler support	RA 37
<p>NOTES:</p> <p>(1) All Kepco Rack Adapters fit standard EIA rack dimensions. They are drilled for standard chassis slides and are provided with slide support brackets.</p> <p>(2) Filler panels to cover empty slots, if the adapter is not used to its full capacity, are available.</p>		

1.8 SAFETY

There are no operator serviceable parts inside the case. Service must be referred to authorized personnel. Using the power supply in a manner not specified by Kepco, Inc. may impair the protection provided by the power supply. Observe all safety precautions noted throughout this manual. Table 1-7 lists symbols used on the power supply or in this manual where applicable.

TABLE 1-7. SAFETY SYMBOLS

SYMBOL	MEANING
	CAUTION: RISK OF ELECTRIC SHOCK.
	CAUTION: REFER TO REFERENCED PROCEDURE.
WARNING	INDICATES THE POSSIBILITY OF BODILY INJURY OR DEATH.
CAUTION	INDICATES THE POSSIBILITY OF EQUIPMENT DAMAGE.



WARNINGS

1. Remove a-c power from the ATE before making any connections.
2. Wires and/or cables, connected from the ATE terminals to external components or programming devices must be properly insulated and securely terminated on both sides to make accidental touch impossible.
3. The ATE chassis and cover must be safety-grounded to a reliable a-c source ground. A safety-ground may be established by using the power cord supplied with a grounded a-c power outlet or, if the latter is not available, by means of a separate wire, from the provided GROUND terminal (at the rear barrier strip) to a reliable a-c source ground point.

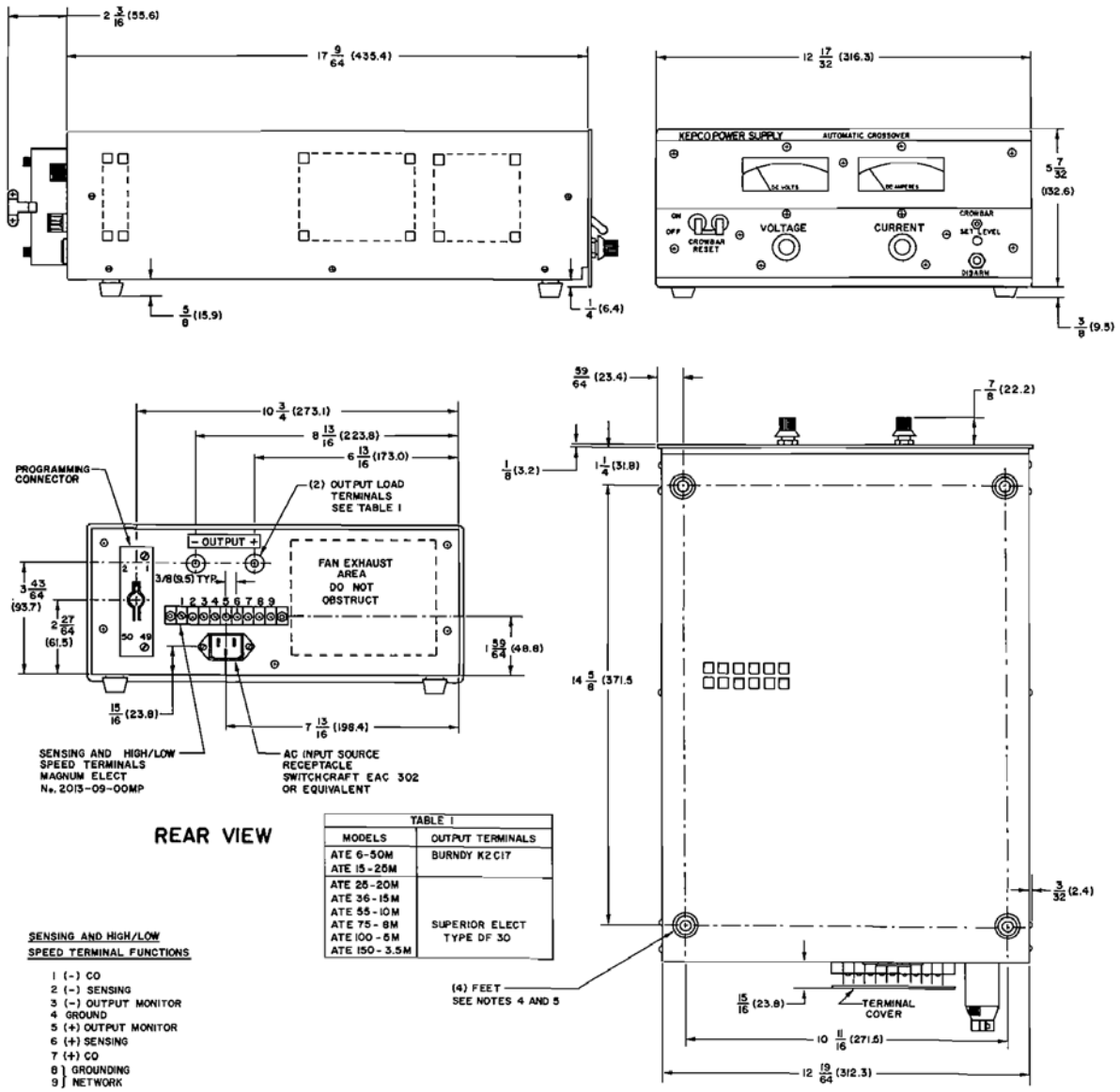
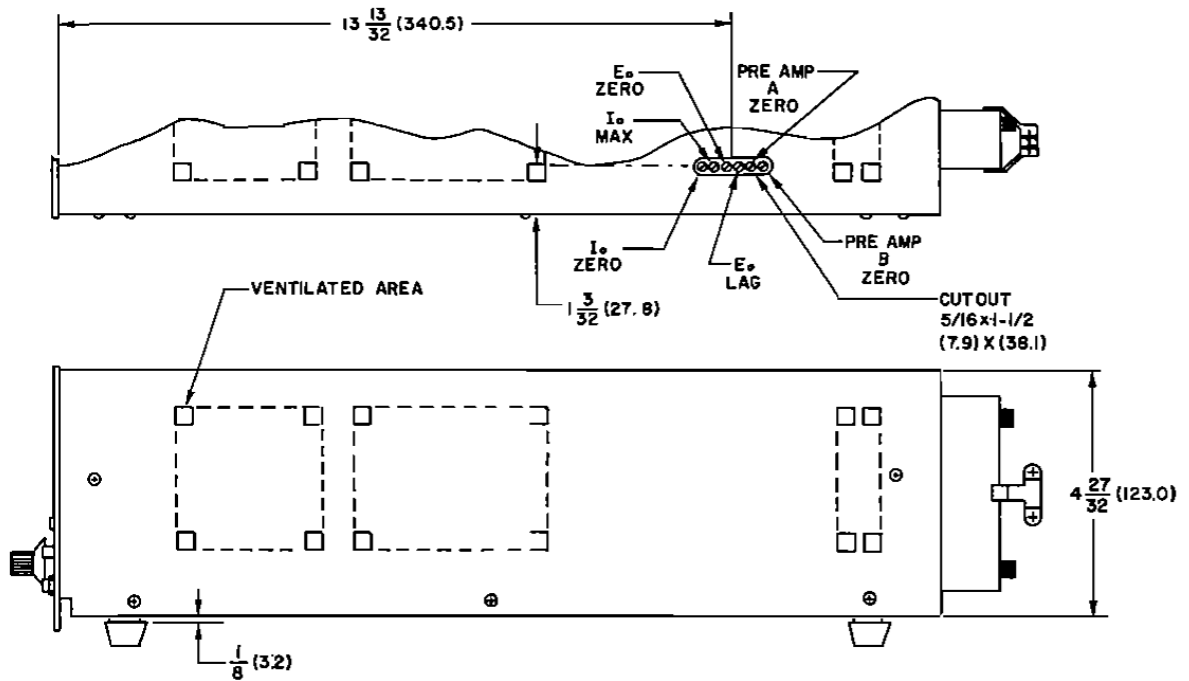


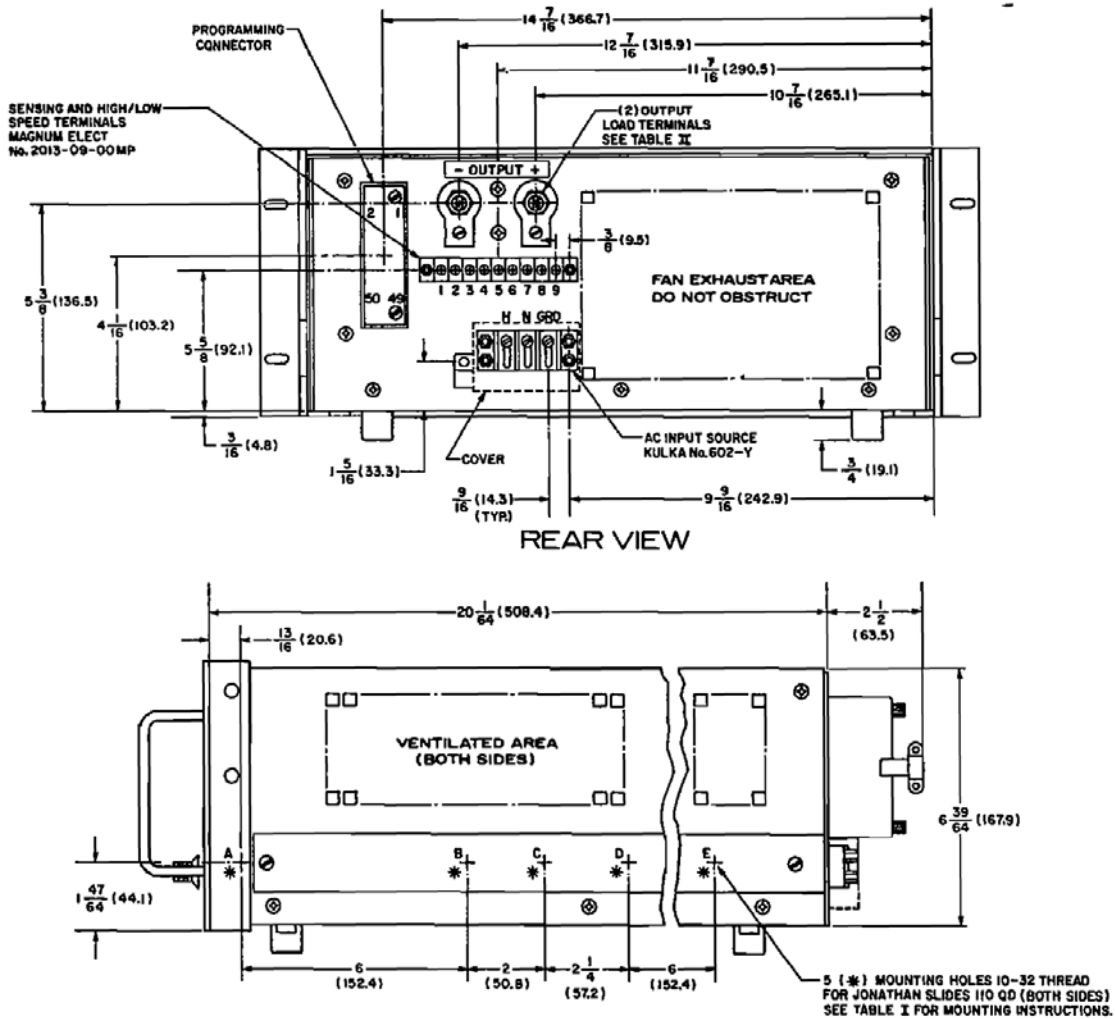
FIGURE 1-2. MECHANICAL OUTLINE DRAWING, 3/4-RACK MODELS (SHEET 1 OF 2)



NOTES:

- 1) THIS DRAWING IS FOR THE FOLLOWING MODELS:
ATE 6-50M, ATE 15-26M, ATE 25-20M, ATE 38-15M
ATE 65-10M, ATE 75-8M, ATE 100-5M, ATE 150-3.6M
- 2) MATERIAL:
A) CHASSIS AND BACK PLATE: NO. 18 GA (.050) C.R.S.
B) FRONT PANEL: 1/8 THICK ALUMINUM.
C) COVER: NO. 18 GA (.047) C.R.S.
- 3) FINISH:
A) CHASSIS AND BACK PLATE: CADMIUM PLATE WITH CHROMATE WASH.
B) FRONT PANEL: LIGHT GRAY PER FEDERAL STD 595, COLOR NO. 26440.
C) COVER: CHARCOAL GRAY VINYL TEXTURE.
- 4) RACK MOUNTING: REMOVE (4) FEET FROM BOTTOM OF CHASSIS.
- 5) (4) PLASTIC MOUNTING INSERT UNDER FEET, FOR 8-18 x 5/8 SELF-THREADING SCREWS (WITH 1/8 THICK MOUNTING PLATE).
- 6) DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.
- 7) TOLERANCES:
A) BETWEEN MOUNTING HOLES $\pm 1/64$ (± 0.4).
B) ALL FRONT PANEL DIMENSIONS TO MIL-STD 189.
C) ALL OTHER DIMENSIONS $\pm 1/32$ (± 0.8), EXCEPT AS NOTED.

FIGURE 1-2. MECHANICAL OUTLINE DRAWING, 3/4-RACK MODELS (SHEET 2 OF 2)



NOTES:

1) THIS DRAWING IS USED FOR THE FOLLOWING MODELS:
 ATE 8-100M, ATE 15-50M, ATE 25-40M, ATE 30-30M,
 ATE 55-20M, ATE 75-15M, ATE 100-10M, ATE 150-7M

2) MATERIAL:

- A) CHASSIS AND BACK PLATE: NO. 14 GA C.R.S.
- B) FRONT PANEL: 1/8 THICK ALUMINUM.
- C) COVER: NO. 18 GA C.R.S.

3) FINISH:

- A) CHASSIS AND BACK PLATE: CADMIUM PLATE WITH CHROMATE WASH.
- B) FRONT PLATE: LIGHT GRAY PER FEDERAL STD 595, COLOR NO. 28440.
- C) COVER: CHARCOAL GRAY VINYL TEXTURE.

4) FIXED ANGLE BRACKETS AND CHASSIS SIDE SUPPORT BARS (BOTH SIDES) USED FOR RACK OR CABINET INSTALLATION CAN BE REMOVED FOR BENCH OPERATION.

5) RACK OR CABINET MOUNTING: REMOVE (4) METAL FEET.

6) (4) PLASTIC INSERTS FOR 1/4-20 THREAD CUTTING SCREWS, 5/8 LONG (WITH 1/8 MOUNTING SURFACE THICKNESS).

7) IF INSTALLATION WITHOUT SLIDES IS DESIRED, THE UNIT MUST BE SUPPORTED BY A RIGID PLATFORM OR BY FIXED BRACKET MOUNTED ON THE RACK.

8) DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.

9) TOLERANCES:

- A) BETWEEN MOUNTING HOLES ± 1/64 (±0.4)
- B) ALL FRONT PANEL DIMENSIONS TO MIL-STD-189.
- C) ALL OTHER DIMENSIONS ± 1/32 (±0.8), EXCEPT AS NOTED.

SLIDE TYPE	USED MOUNTING HOLE				
	A	B	C	D	E
110 QD-20-2	X	X	NOT USED	X	●
110 QD-22-2	X	NOT USED	X	NOT USED	●
110 QD-24-2	X	NOT USED	X	NOT USED	●

● "E" HOLE HAS TO BE ADDED TO SLIDES BOTH SIDES .188 DIA HOLE 16% FROM "A" HOLE.

TABLE II	
MODELS	OUTPUT TERMINALS
ATE 8-100M	BURNDY K2C23B1
ATE 15-50M	BURNDY K2C17
ATE 25-40M	
ATE 30-30M	
ATE 55-20M	SUPERIOR ELECT TYPE DF 30
ATE 75-15M	
ATE 100-10M	
ATE 150-7M	

FIGURE 1-3. MECHANICAL OUTLINE DRAWING, FULL-RACK MODELS (SHEET 1 OF 2)

**SENSING AND HIGH/LOW
SPEED TERMINAL FUNCTIONS**

1. (-) CO
2. (-) SENSING
3. (-) OUTPUT MONITOR
4. GROUND
5. (+) OUTPUT MONITOR
6. (+) SENSING
7. (+) CO
8. GROUNDING
9. NETWORK

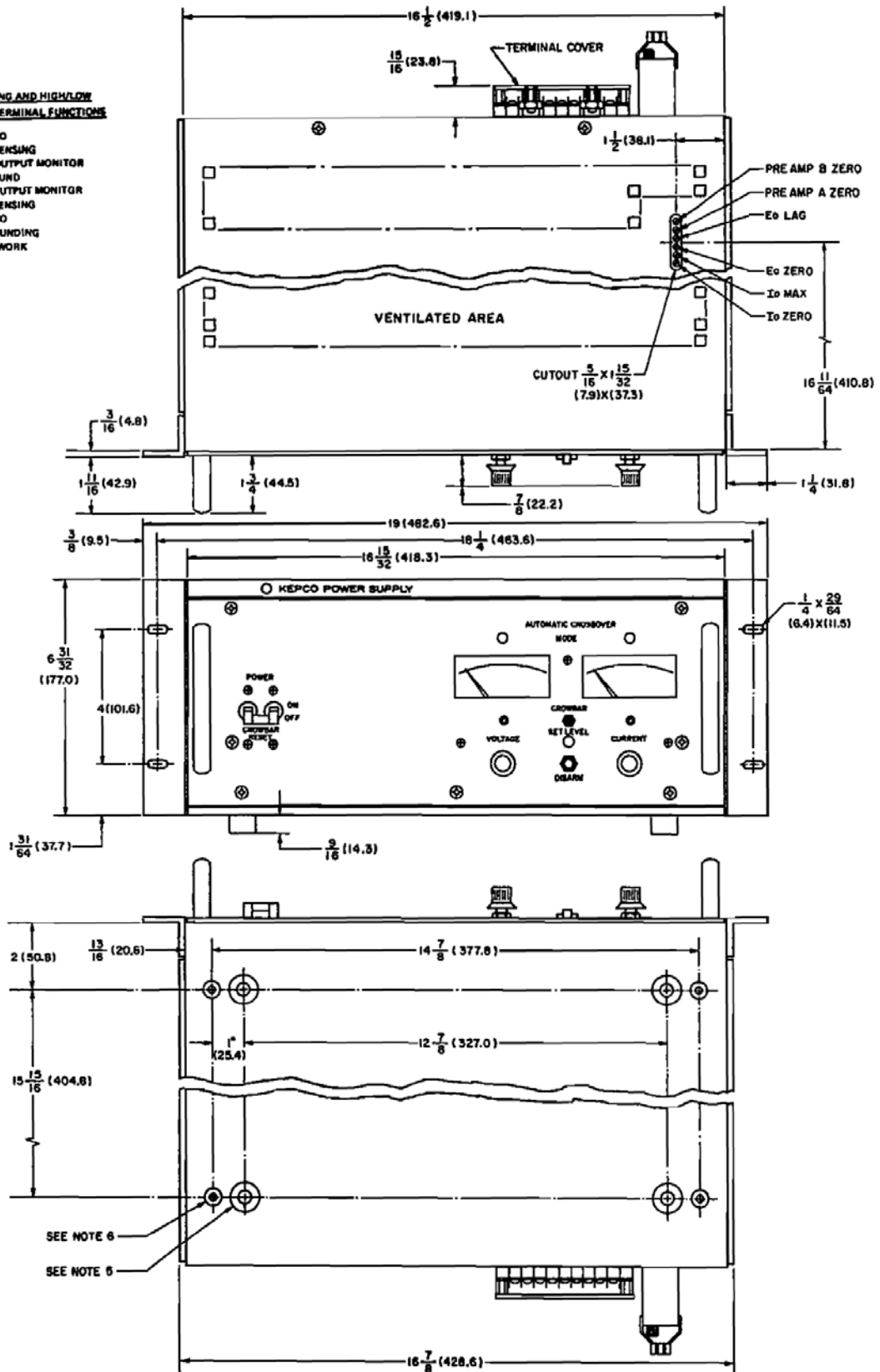


FIGURE 1-3. MECHANICAL OUTLINE DRAWING, FULL-RACK MODELS (SHEET 2 OF 2)

SECTION 2 - INSTALLATION

2.1 UNPACKING AND INSPECTION

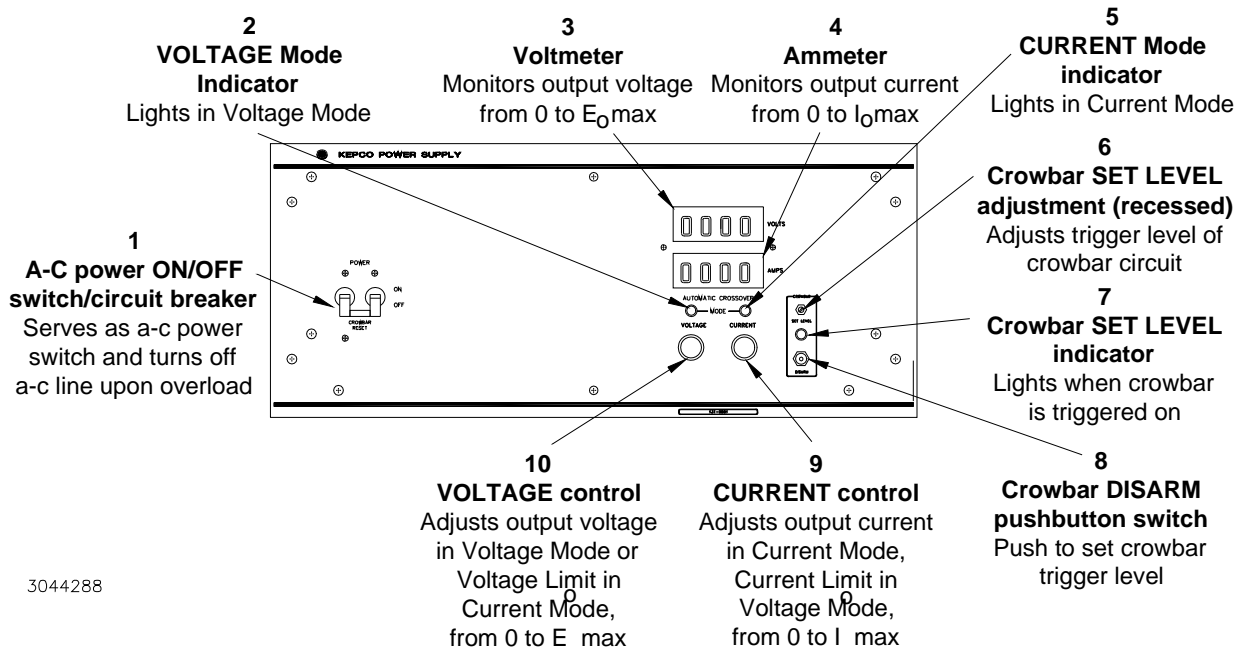
This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After carefully unpacking, inspect for shipping damage before attempting to operate. Perform the preliminary operational check as outlined in PAR. 2.5 below. If any indication of damage is found, file an immediate claim with the responsible transport service.

2.2 TERMINATIONS AND CONTROLS

- a) Front Panel: Refer to Table 2-1 and Figure 2-1.
- b) Rear panel: Refer to Table 2-2 and Figure 2-2.
- c) Internal Controls: See Table 2-3 and Figure 2-4.

TABLE 2-1. FRONT PANEL CONTROLS, INDICATORS AND TERMINATIONS

FIGURE 2-1 INDEX NO.	CONTROL OR TERMINATION	FUNCTION
1	A-C Power ON/OFF switch/circuit breaker	Serves as a-c power switch and turns a-c power off upon heatsink overtemperature, output overvoltage detection or (if enabled) power loss.
2	VOLTAGE Mode indicator	Energizes in Voltage Mode.
3	Voltmeter	Monitors output voltage from 0 to E_{Omax}
4	Ammeter	Monitors output current from 0 to I_{Omax}
5	CURRENT Mode Indicator	Energizes in Current Mode.
6	Crowbar SET LEVEL control	Adjusts trigger level of crowbar circuit.
7	Crowbar SET LEVEL indicator	Lights when crowbar is triggered "ON."
7	CROWBAR indicator	Lights when crowbar is triggered "ON."
8	Crowbar DISARM pushbutton switch	Push to set crowbar trigger level
9	CURRENT control	Adjusts output current in Current Mode or Current Limit in Voltage Mode, from 0 to I_{Omax}
10	VOLTAGE control	Adjusts output voltage in Voltage Mode or Voltage Limit in Current Mode, from 0 to E_{Omax}



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FIGURE 2-1. ATE FULL-RACK, 3/4-RACK SERIES FRONT PANEL

TABLE 2-2. REAR PANEL TERMINATIONS

FIGURE 2-2 INDEX NO.	TERMINATION	FUNCTION
1	Rear Programming Connector	Used to gain access to internal circuitry for fast mode conversion, remote programming, flags, crowbar signals, troubleshooting and parallel/serial connections. See Figure 2-3 for details.
2	Rear Panel Barrier Strip	Nine terminals provided: 1, 7: C _O (-) and C _O (+) used to used access ATE output capacitor. 2, 6: S (-) and S (+) used to access output error sensing terminals for a Kelvin type load connection with remote error sensing. 3, 5: M (-) and (+) used to access local power output voltage monitoring. 4: GRD (Ground) connected to chassis and to input a-c source ground via the a-c input cable. 8, 9: Used to connect or disconnect internal grounding network (see PAR. 2.6.1.2)
3	Output terminals	Used to connect load
4	Source power terminal block	Used to connect source power; accepts 3-wire a-c input cord (supplied).

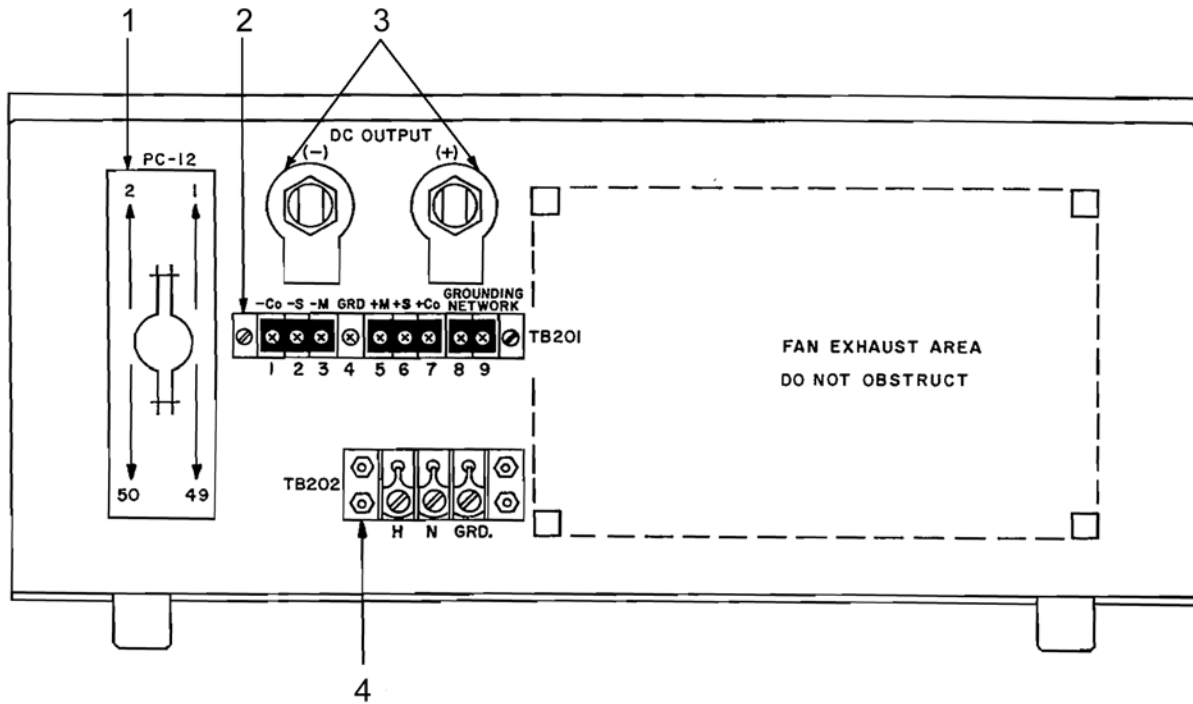
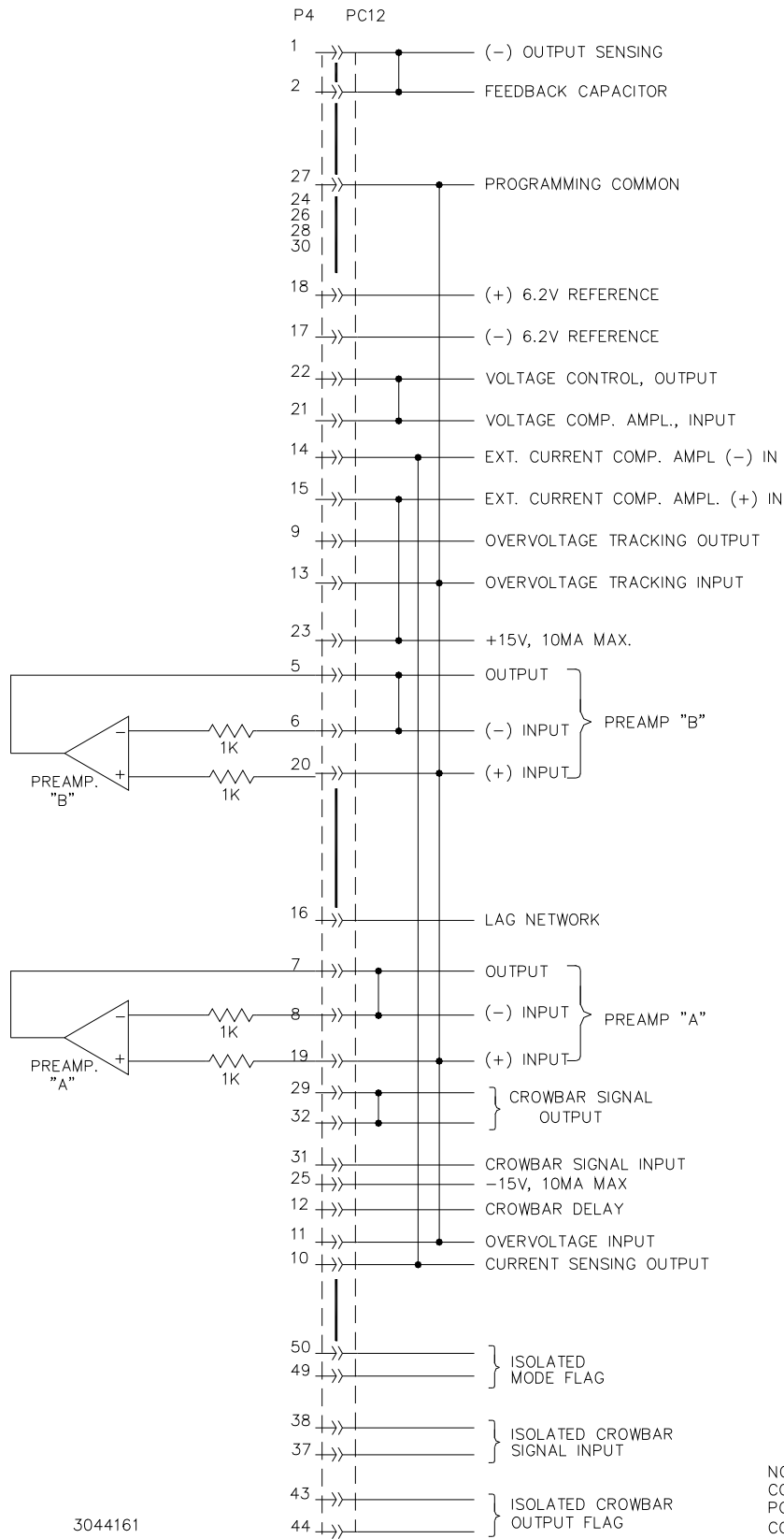


FIGURE 2-2. ATE FULL RACK, 3/4 RACK SERIES REAR PANEL



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NOTE:
CONNECTIONS SHOWN ARE FOR
PC 12 PRE-WIRED FOR LOCAL
CONTROL (PC 14).

TABLE 2-3. INTERNAL CONTROLS AND THEIR FUNCTIONS

REFERENCE DESIGNATION	CONTROL	PURPOSE
R18	I_o MAX	Maximum Output Current
R27	E_o LAG	Voltage Channel Stability Control
R30	E_o ZERO	Voltage Channel Zero Control
R35	I_o ZERO	Current Channel Zero Control
R67	PREAMP "A" ZERO	Offset Zero Control for PREAMP "A"
R68	PREAMP "B" ZERO	Offset Zero Control for PREAMP "B"

FIGURE 2-3. REAR PROGRAMMING CONNECTOR PIN FUNCTIONS SHOWING PC 12 PRE-WIRED FOR LOCAL CONTROL CONNECTIONS (PC 14)

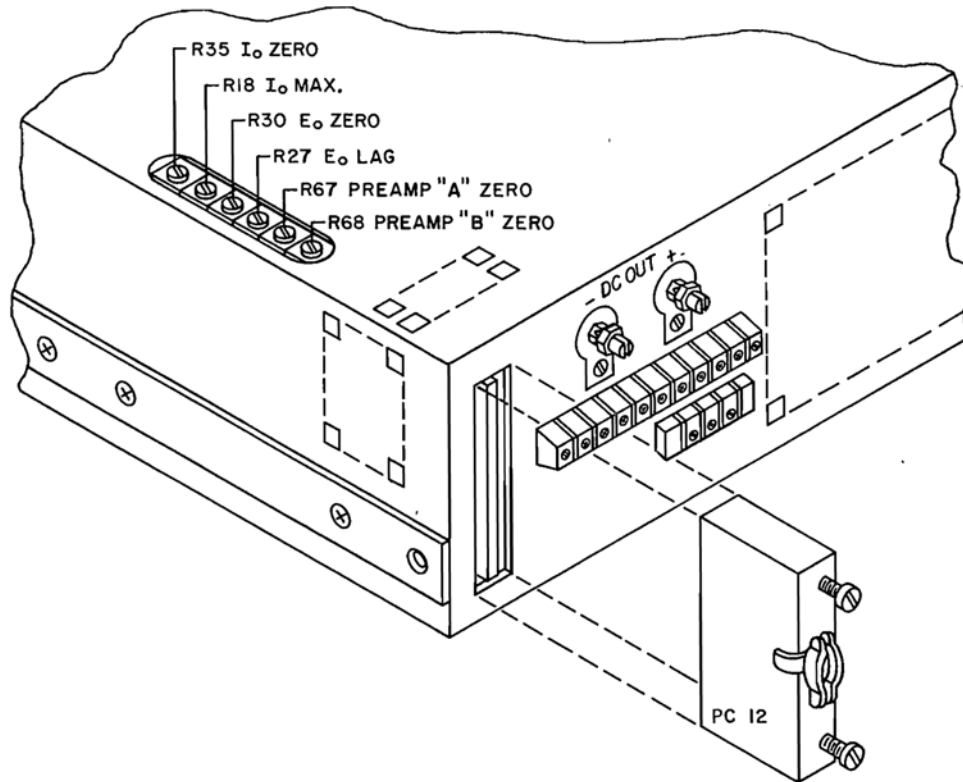


FIGURE 2-4. LOCATION OF INTERNAL CONTROLS

2.3 SOURCE POWER REQUIREMENTS

This power supply is normally configured for operation on a single phase, nominal 115V a-c line. For conversion to other a-c source voltages, refer to Figure 2-5. Select your nominal source voltage and change the links on the barrier strip of T201 according to the tables provided in Figure 2-5. The circuit breaker (CB101) remains equally effective at all input voltages.

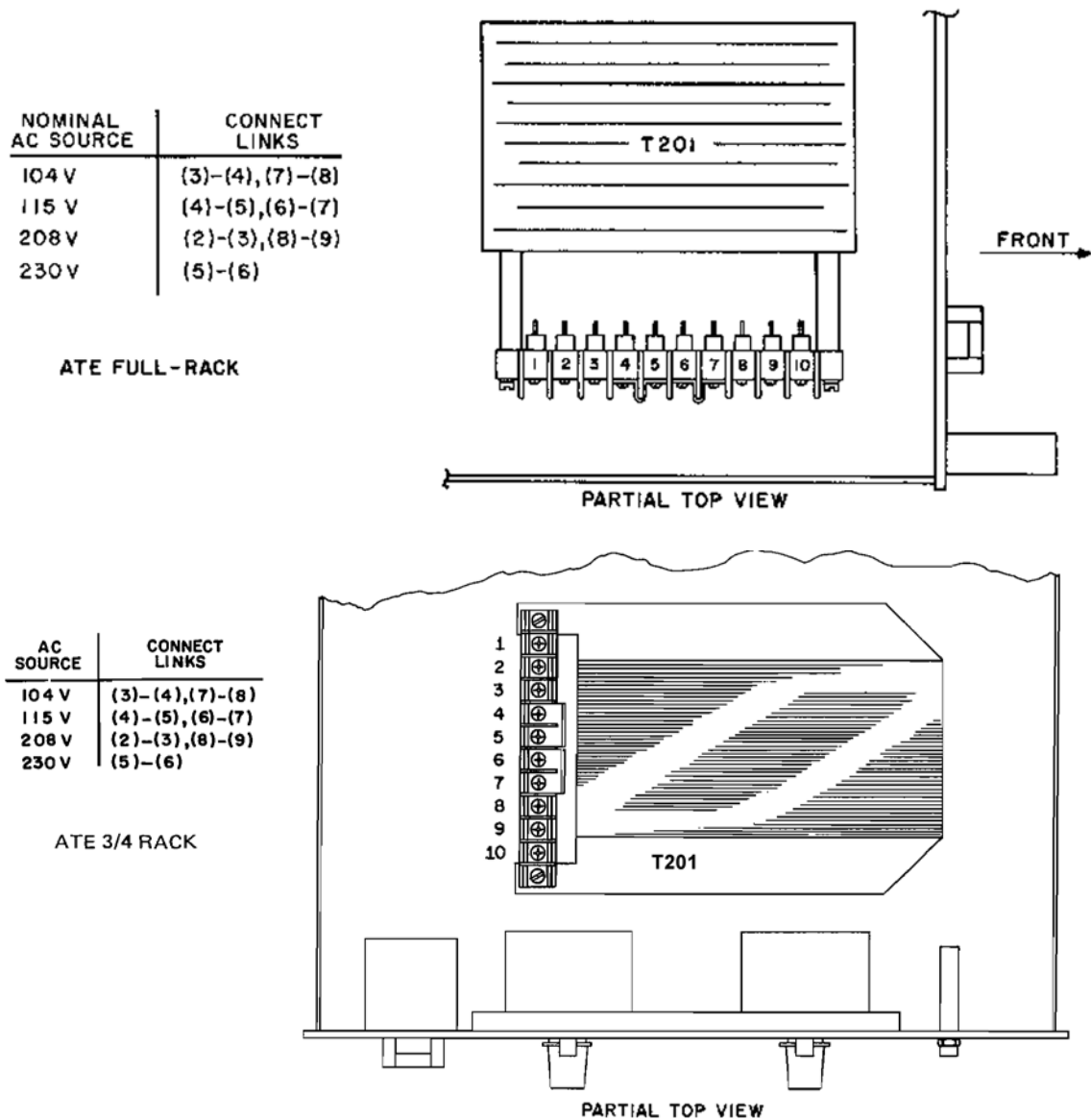


FIGURE 2-5. A-C INPUT SOURCE VOLTAGE SELECTION

2.4 COOLING

The power transistors and rectifiers in the ATE power supplies are maintained within their operating temperature range by means of special heat sink assemblies, cooled by internal fans. SIDE AND REAR PANEL OPENINGS AND THE TOP OF THE CASE MUST BE KEPT CLEAR FROM OBSTRUCTIONS TO INSURE PROPER AIR CIRCULATION. Periodic cleaning of the interior of the power supply is recommended. If the power supply is rack mounted, or installed into confined spaces, care must be taken that the ambient temperature (the temperature immediately surrounding the power supply) does not rise above the limit specified (refer to Table 1-2).

2.5 PRELIMINARY OPERATIONAL CHECK

A simple operational check after unpacking and before equipment installation is advisable to ascertain whether the power supply has suffered damage resulting from shipping.

Refer to Figures 2-1 and 2-2 for location of operating controls and terminations. Tables 2-1 and 2-2 explain the functions of operating controls/indicators and terminations respectively.

1. With A-C POWER switch/circuit breaker set to OFF position, connect the power supply to source power.
2. Turn CURRENT control fully clockwise. Turn VOLTAGE control fully counterclockwise.
3. Set A-C POWER switch/circuit breaker to ON. The VOLTAGE MODE indicator should be lit. Slowly turn VOLTAGE control clockwise and observe the gradual increase of the output voltage. When fully clockwise the VOLTS meter should read full scale plus 1V, or (0.5V for 6V models) (see Table 1-1).
4. Check the overvoltage crowbar circuit as follows:
 - a) Turn the VOLTAGE control to about one-half of its range.
 - b) Depress the DISARM pushbutton and turn the (recessed) Crowbar LEVEL SET control slowly counterclockwise until the CROWBAR indicator lights.
 - c) Turn VOLTAGE control slightly counterclockwise and release DISARM pushbutton.
 - d) To reset the adjusted crowbar point, press DISARM pushbutton again and advance VOLTAGE control clockwise. Note voltage at which CROWBAR indicator goes on. Readjust LEVEL control, if necessary, by repeating step (b) and check again by repeating steps (c) and (d).
 - e) Set A-C POWER switch/circuit breaker to OFF.
5. Place a short circuit across ATE output terminals. Turn CURRENT control counterclockwise. Set A-C POWER switch/circuit breaker to ON. The CURRENT MODE indicator should now be on. Slowly turn CURRENT control clockwise and observe gradual increase in output current. When fully clockwise the AMPS meter should read full scale output current (see Table 1-1).

2.6 INSTALLATION (Refer to Figure 1-3 or 1-2)

The Power Supply may be rack-mounted or operated as a bench-type instrument. If the ATE is intended to be rack-mounted; the (4) bottom feet must be removed.

For all installations into confined spaces, care must be taken that the temperature immediately surrounding the unit does not exceed the maximum specified ambient temperature (see Table 1-2).

2.6.1 GROUNDING

2.6.1.1 A-C (SAFETY) GROUND

The power supply is equipped with a 3-wire safety line cord and polarized plug. The third (green) wire in the line cord is connected to the chassis and the case of the unit. If a 2-terminal receptacle in combination with an adapter is used, it is imperative that the chassis of the power supply be returned to a-c ground with a separate lead. A grounding terminal is provided (at the rear barrier strip) for this purpose.

2.6.1.2 ISOLATION FROM GROUND.

The d-c output is isolated from the a-c source and from any direct connection to chassis or ground. The maximum output voltage that can be supported between either output terminals and chassis ground is 500V d-c or plus the maximum output voltage of the power supply, Either side of the output may be grounded.

A resistor/capacitor network is connected from the negative monitor terminal to the metal chassis of the power supply. If this internal network is *not* desired, the connection to the chassis can be opened by removing the link (8)-(9) on TB201 (see Figure 2-2).

2.7 FAST MODE CONVERSION OF THE ATE POWER SUPPLY

Power supplies designed to operate in voltage, as well as in a current stabilizing modes, often represent a compromise between the conflicting requirements of a good voltage and a good current source. A good voltage source must have low output impedance, good output voltage stability and good dynamic stability in the presence of loads with capacitive and/or inductive content. It achieves these goals by relying to a great extent upon an output capacitor that has a very low series resistance, a very high parallel resistance and a large energy storing ability.

Unfortunately, the requirements for a good current source are quite opposite to that of the voltage source described above. A current source should have *high* output impedance and its terminal voltage must be able to assume rapidly any value as may be needed to keep the output current at the predetermined level, while the load is changing.

To satisfy these conflicting requirements, the ATE power supply was designed for quick manual change-over from the Slow Mode to the Fast Mode of operation. In the Slow Mode, the ATE power supply approaches an ideal voltage source. Heavy output and feedback capacitors provide for low output noise, excellent voltage stability and good transient response. In the Fast Mode, the output and main feedback capacitors are completely removed, thereby providing the characteristics of a wide-band amplifier, ideal for applications requiring a current stabilizer or for high speed voltage or current programming.

2.7.1 PRECAUTIONS.

The output capacitor, and to a lesser extent, the feedback capacitor of a power supply, control the programming speed and the current mode recovery time. The removal of these capacitors in the Fast Mode results in greatly improved power supply performance in these areas. The power supply's dynamic stability, however, is reduced, making the output sensitive to the load phase angle. For this reason, the load presented to the power supply in the Fast Mode must not con-

tain excessive capacitance (limit: 1,000pF). Also, with the output and main feedback capacitors removed, there will be an increase in output noise, mainly high frequency noise and pickup, so that external shielding of programming leads and good grounding practices assume added importance in the Fast Mode of operation.

2.7.2 LAG NETWORK ADJUSTMENT

The ATE power supply operating in the Fast Mode, is dynamically stabilized by means of an internal lag network (E_O LAG, R27, see Figure 2-4 for location). This control should be adjusted, for each application, by monitoring the load with an oscilloscope and turning the LAG control for best output response and maximum dynamic stability under all operating conditions.

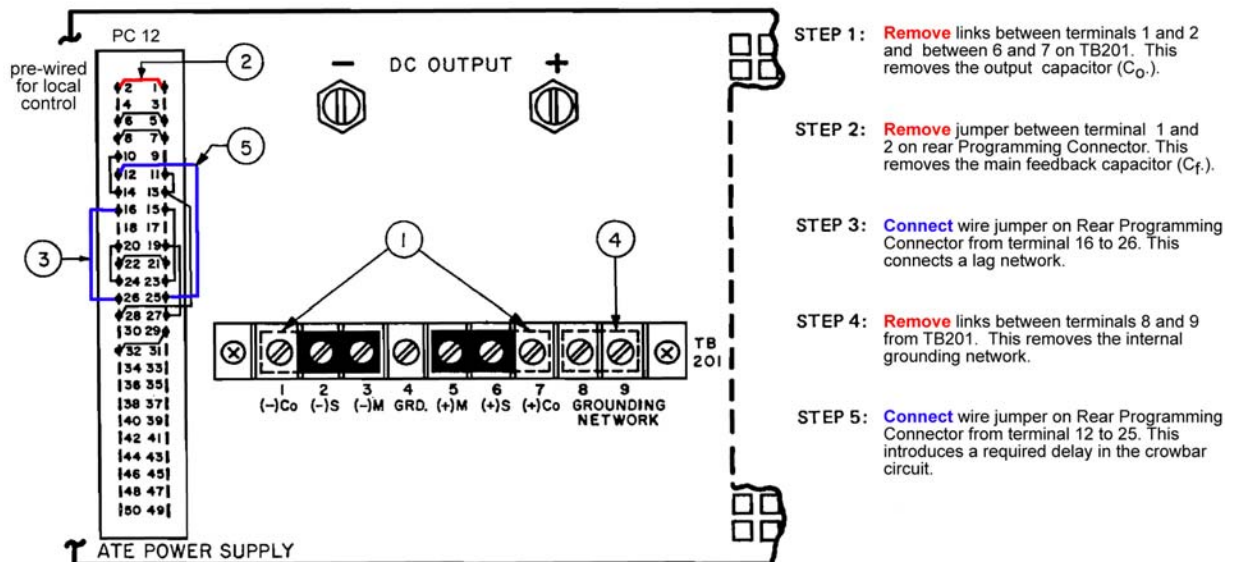
2.7.3 CROWBAR OPERATION, FAST MODE

The crowbar circuit in the ATE power supply is not completely removed in Fast Mode, but continues to offer protection against d-c voltage surges which may harm the load.

NOTE: For Fast Mode operation into a load interrupted by contactors or relays (Arcing Load), a small, high-frequency-type capacitor may be required across the contacts of the interrupting device, or the power supply output terminals, or directly across the load terminals. A ceramic disc capacitor (0.01 μ F) has been found to be adequate to prevent spurious triggering of the overvoltage circuit.

2.7.4 MANUAL CHANGE-OVER, SLOW/FAST MODE

The ATE power supply is normally delivered for operation in Slow Mode. By changing jumper connections at the rear of the power supply, the user can convert from the Slow Mode to the Fast Mode or vice versa as shown in Figure 2-6.



NOTE: NUMBERS IN CIRCLES REFER TO STEPS OF PAR. 2.7.4.

FIGURE 2-6. REQUIRED STEPS FOR ATE FAST MODE CONVERSION

SECTION 3 - OPERATION

3.1 GENERAL

Interconnections between an a-c power source and a stabilized power supply, and between the power supply and its load are as critical as the interface between other types of electronic equipment. If optimum performance is expected, certain rules for the interconnection of source, power supply and load must be observed by the user. These rules are described in detail in the following paragraphs.

3.1.1 SAFETY GROUNDING

National and international safety rules dictate the grounding of the metal cover and case of any instrument connected to the a-c power source.



WARNING

KEEP INSTRUMENT GROUNDED WHILE IT IS CONNECTED TO THE A-C POWER SOURCE.

Kepeco power supplies with a flexible a-c power cord are equipped with a 3-prong safety plug, which must be connected to a *grounded* a-c power outlet.

3.1.2 D-C (OUTPUT) GROUNDING

Connections between the power supply and the load (load and sensing connections), as well as connections to the power supply amplifiers (programming connections) may, despite all precautions such as shielding, twisting of wire-pairs, etc., pick up radiated noise of a wide frequency spectrum. To minimize these undesired effects, one side of the power supply output/load circuit should be grounded.

Successful d-c grounding depends on careful analysis of the individual situation and only general guide lines can be provided here. One of the major points, however, is to avoid GROUND LOOPS. Ground loops are created when two (or more) points are grounded along the output circuit. Due to the wire impedance between the separated grounded points, a noise voltage is developed which subsequently is superimposed on the load. The only way to avoid ground loops is to investigate the output circuit (including the connected load) carefully by means of an ohmmeter for any resistance to ground. A single d-c ground point can be selected only if the output circuit is completely isolated. A single point is selected along the power supply output/load circuit and this point is returned to ground with a single wire. The exact location of this "best" d-c ground-point is entirely dependent on the application at hand. For single, isolated loads, the d-c ground-point may be located directly at one of the output terminals of the power supply which may be connected to ground. If error sensing is employed, d-c ground can be established at the remote load. In case of an internally grounded load, the d-c ground is automatically established directly at the load.

ATE Power Supplies have **one** side of the output returned to the case over a resistor/capacitor combination (refer to Section 2, PAR. 2.6.1). In those cases, therefore, where the **load** is internally grounded, or where the signal ground must be established elsewhere, the resistor/capacitor combination must be removed from the power supply case in order to avoid ground loop problems. If there is a choice in selecting either the positive or the negative output of the power supply for the d-c ground point, both sides should be tried, and preference given to the ground point producing the least noise. Output ripple specifications (as measured at the output) are,

however, equally valid for either output side grounded. Care should be taken in measuring the ripple and noise at the power supply output or at the load, Measuring devices which are a-c line operated often introduce ripple and noise into the circuit.

In the case where the load must be kept completely off ground (d-c isolated) or it must be operated above ground potential, grounding can be accomplished by means of a suitable capacitor connected from either side of the power supply output to the signal ground. The size of the capacitor should be carefully selected. A value between 0.1 and 1 microfarad has been found to be successful in many cases.

Even simple remote control tasks, such as error sensing or resistance programming, require careful shielding with 2-wire shielding cable, with the shield (single-ended) returned to the single d-c ground point. In cases where external programming sources are used, additional precautions are required. If all other grounding problems have been solved and a single ground point has been assigned to the system, the programming source must be evaluated for system compatibility. Some of the older signal generators, for example, cannot be successfully used for programming, since their cases are connected permanently to one of the output leads. Aside from these initial problems, the power supply/load system must have the correct polarity for voltage programming; e.g., the programming source common must be connected to the previously grounded output side. If this is not possible because of polarity considerations, three choices are open: either the programming source must be floated; i.e., it must operate above ground by an amount given by the output voltage of the power supply, or the selected d-c ground point must be changed to the polarity coinciding with that of the programming source, or the polarity of the programming source must be reversed by using the uncommitted preamplifiers of the ATE, as described in this section.

3.1.3 POWER SUPPLY/LOAD INTERFACE

The general function of a voltage or current stabilized power supply is to deliver the rated output quantities to the connected load. The load may have any conceivable characteristic: It may be fixed or variable; it may have predominantly resistive, capacitive, or inductive parameters; it may be located very close to the power supply or it may be a considerable distance away. The power supply designer cannot anticipate every conceivable application, location or nature of the load. The product must be designed for the widest possible application range and performance specifications at the output terminals of the power supply. The aim of the following paragraphs is to aid the user in the final use of the product: The interface of the power supply and the load.

The perfect interface between a power source and its load would mean that the specified performance at the output terminals would be transferred without impairment to any load, regardless of its characteristics, distance from the power supply or environment. To approach this ideal, the power supply must satisfy certain requirements, interconnecting rules must be closely followed and Ohm's Law, as well as basic a-c theory must be considered in selecting the interface wiring.

3.1.3.1 LOAD WIRE SELECTION

For power load connections, use wires (twisted pair or tied together) rated for at least the unit's nominal output current and having their jacket/sleeving rated for at least 500 Vd-c (or peak) plus the unit's nominal output voltage.

The stabilized d-c power supply is definitely not an ideal voltage or current source with zero output impedance (Voltage Mode) or infinite output impedance (Current Mode) at all frequencies: All *voltage* sources have some amount of impedance which *increases* with frequency and all *current* sources have an output impedance which *decreases* with frequency (refer to Figure 3-1).

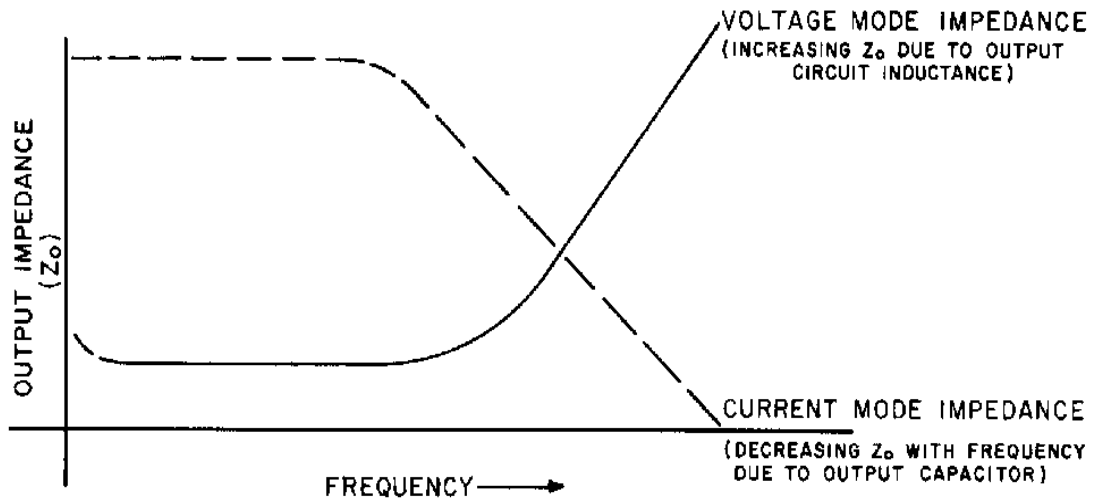


FIGURE 3-1. TYPICAL OUTPUT IMPEDANCE VS. FREQUENCY PLOT FOR STABILIZED D-C SOURCES

NOTE: Load connections for applications requiring solely stabilized **output current** are not as critical as those requiring stabilized **output voltage**:

- a. D-C wire drops do not influence the current stabilizing action, but must be subtracted from the available compliance voltage.
- b. Wire inductance is “swamped-out” by the action of the output capacity. Emphasis in the following paragraphs is therefore placed on the power supply as a *voltage source*, rather than a current source.

A more realistic model for a voltage stabilized power supply must, for example, include a series resistance, representing the small d-c and low frequency source impedance, in series with an inductance, representing the source impedance at higher frequencies. Load wire selection should therefore proceed with those facts in mind. The load wire size should not only be selected for minimum voltage drop (Error Sensing, as discussed below, will take care of that), but also the series inductance of the load wire must be kept as small as possible compared to the source inductance of the power supply (Error Sensing *cannot* compensate for this). These dynamic considerations are especially important if:

1. The load is constantly changing in value.
2. The load is switched on and off.
3. The output of the power supply is step programmed.
4. The load has a primarily reactive characteristic.
5. All other cases where the dynamic output response of the power supply is considered important.

3.1.3.2 REMOTE SENSING WIRE SELECTION

For stable operation when using remote sensing, the ATE output capacitor is tied to the load through the sensing wires. Therefore the sensing wires should be able to carry the output capac-

itor's charging/discharging current. Since the charging/discharging current can reach the unit's nominal output current, use the same type of wires for remote sensing load connections as for the power load wires . When remote error sensing load connection is employed, use separate wires (twisted pair or tied together) for the sensing connections and for the output power connections.

3.2 LOAD CONNECTION

3.2.1 GENERAL

Kepeco has provided a group of terminals on the rear programming connector and on the barrier strip (TB201) at the rear of the power supply, which permit maximum flexibility in power supply/load interface techniques. Although all applications tend to exhibit their own problems, the basic interconnections described may be used as a general guide in the interconnection between power supply and load.

The Kepeco power supply is shipped from the factory with several jumper links (see Figure 3-2, connected to the barrier strip (TB201). These links may be removed and replaced at will, depending on the operating mode and application of the power supply. Positioned as shown in Figure 3-2, the links are connected for front panel (local) control of the output voltage, output current and OVP crowbar level with the power supply operating in Slow Mode. **Links on the barrier strip must be tightened.** LOOSE LINKS AT THE BARRIER STRIP WILL CAUSE MALFUNCTION OF THE POWER SUPPLY.

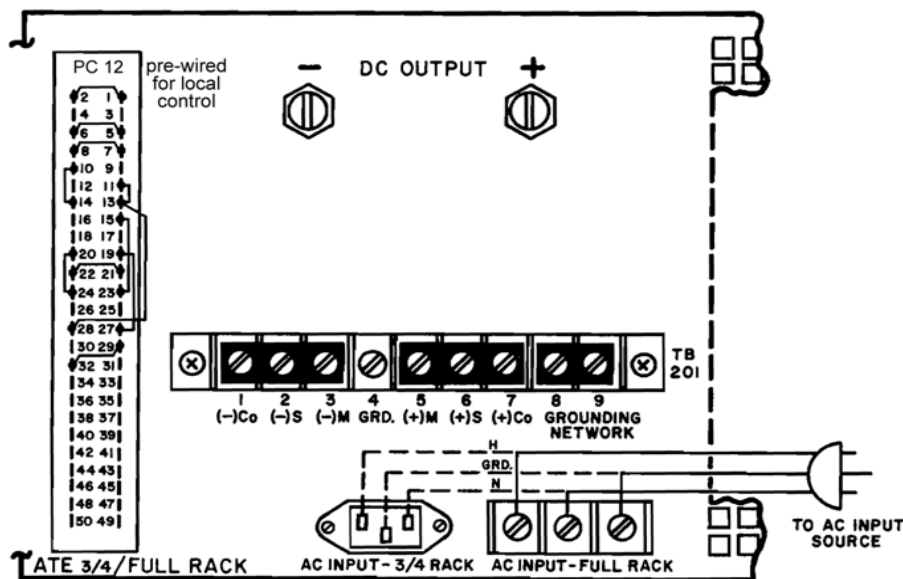


FIGURE 3-2. STANDARD JUMPER LINK CONNECTIONS FOR LOCAL (FRONT PANEL) CONTROL OF OUTPUT VOLTAGE, OUTPUT CURRENT AND VP CROWBAR LEVEL (SLOW MODE)

Note: Connection diagrams in Section 3 are applicable to full-rack and 3/4 rack ATE power supplies. These diagrams represent partial views of the ATE rear panel. Source power connections are deleted on all further diagrams to simplify the presentation. The PC 12 Rear Programming Connector (unwired) is shown prewired for local control (PC 14); see Figure 2-3 for details.

3.2.2 LOAD CONNECTION, METHOD I (LOCAL ERROR SENSING) (SEE FIGURE 3-3.)

The most basic power supply interconnection, to primarily resistive, relatively constant loads, located close to the power supply, or for loads requiring stabilized current exclusively, consists of a 2-wire connection from the rear output terminals. Load wire is selected as described previously (refer to PAR. 3.1.3.1). The load leads should be tightly twisted or tied together to reduce pick-up from stray magnetic fields. After the grounding rules have been applied (refer to PAR's. 3.1.1 and 3.1.2), the power supply can be connected to the a-c source and operation may commence.

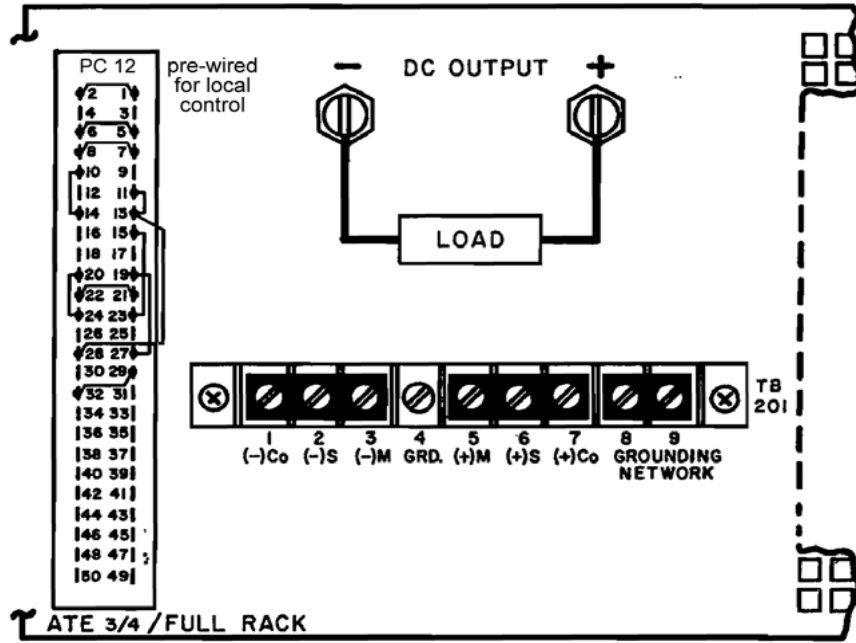


FIGURE 3-3. LOAD CONNECTION METHOD I, LOCAL ERROR SENSING

3.2.3 LOAD CONNECTION, METHOD II (REMOTE ERROR SENSING)

To avoid excessive output effects at remote loads, error sensing must be used. A twisted pair of wires from the sensing terminals directly to the load will compensate for load wire voltage drops up to 0.5 volt per wire, 0.25 volt per wire for 6V models (refer to Figure 3-4). Observe polarities: **The negative sensing wire must go to the negative load wire, and the positive sensing wire goes to the positive load wire.**

ATTENTION

When using remote error sensing with large capacitive loads and long lead and sensing wires, low frequency oscillations may be observed at the load. To eliminate the problem the FEEDBACK CAPACITOR should be disconnected from the (-) OUTPUT SENSING terminal and reconnected to the (-) OUTPUT MONITOR terminal. Remove jumper between terminals (1) and (2) on the Rear Programming Connector (PC 12). Connect a short wire from PC 12 terminal (2) to the REAR BARRIER-STRIP, TB201 -M (-3).

This method of load interconnection is suitable for loads which do not require rapid changes in voltage or current, or for programming with gradually changing waveforms (sine wave, triangular wave shapes, etc.). See PAR. 3.2.4 for load connections suitable for rapid (step) changes in the load or in programming.

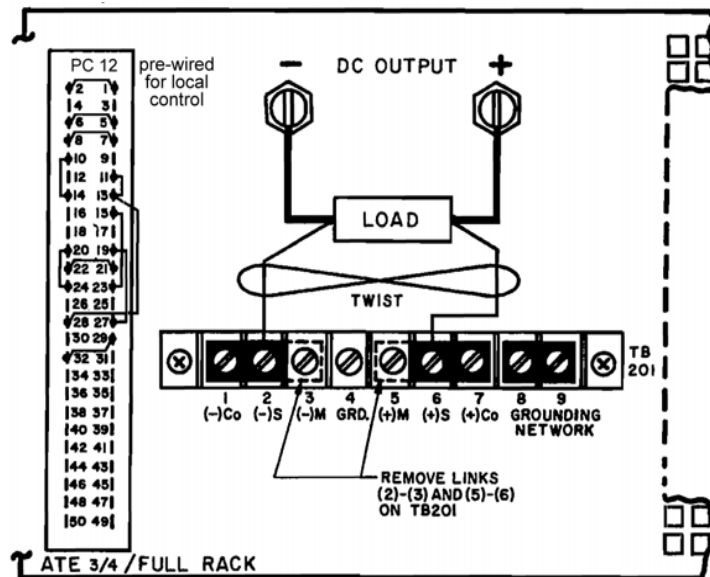
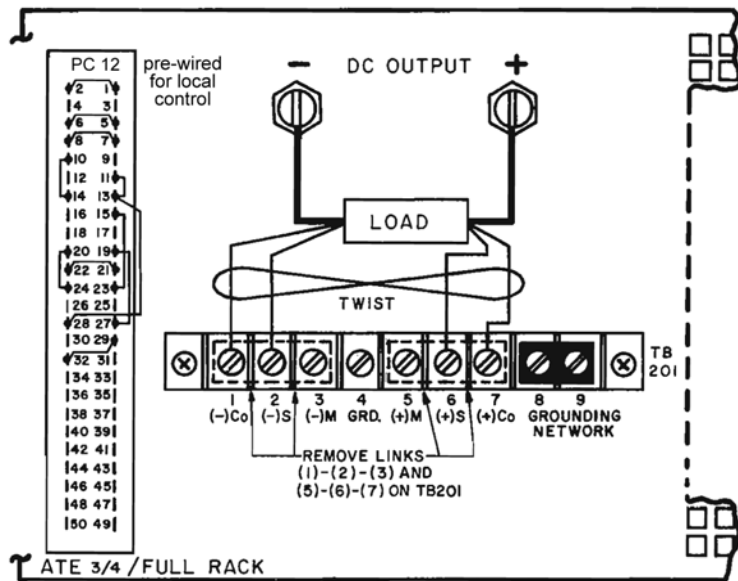


FIGURE 3-4. LOAD CONNECTION, METHOD II USING REMOTE ERROR SENSING.

3.2.4 LOAD CONNECTION, METHOD III

This method is suitable if step changes in the load are expected, for example if the load is rapidly changing in value, or if the power supply is programmed with step functions (square wave, pulse, etc.) and maximum dynamic performance is expected directly at the load terminals. In these cases, the output capacitor is disconnected at the power supply and brought with a pair of heavy wires (twisted pair, or tied together) directly to the remote load. When remote error sensing is employed, use separate wires (twisted pair or tied together) for the sensing connections and for the output capacitor connections (refer to Figure 3-5).



NOTE:
 Remote sensing shown.
 For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-5. LOAD CONNECTION, METHOD III

Since the output capacitor (C_O) is now removed from the output terminals of the power supply and directly connected to the load, it may be possible in some cases that it can no longer perform its bypass function as far as the *power supply* is concerned. If oscillations are observed at the output or at the load, C_O should be left connected in the power supply (by connecting terminals - C_O (1) and -M (3) and terminal +M (5) and - C_O (7) on TB201). The load should be decoupled with another high quality capacitor of a value equal to or greater than C_O . Alternatively, good results can sometimes be achieved by disconnecting the internal C_O and operating with an external bypass capacitor across the load exclusively. For pulsed loads which drop to zero current during the off period, any external output capacitor should be paralleled with a bleeder resistor. The value of this resistor is determined by the value of the external capacitor, the desired response and the amount of output current which can be sacrificed. As a minimum, the RC time constant of the external output capacitor (C_O ext.) and the bleeder resistor (R_O ext.) should be comparable with the internal output capacitor (C_O) and the bleeder resistor (R_O), so that:

$$R_O \text{ ext. } C_O \text{ ext.} \leq C_O R_O$$

For values of the internal output capacitor C_O (C208) refer to the applicable model listed in Table 1-1 (SHUNT C, SLOW). Bleeder resistor R_O (A1R11) values are listed in Table 3-1, or refer to the Parts List found in the applicable Service Manual.

NOTE: There is, unfortunately, no "best" method for interconnecting the load and the power supply. Individual applications, location and nature of the load require careful analysis in each case. Grounding a single point in the output circuit is of great importance. It is hoped that the preceding paragraphs will be of some assistance in most cases. For help in special applications or difficult problems, consult directly with Kepco's Application Engineering Department.

TABLE 3-1. BLEEDER RESISTOR VALUES

ATE 3/4 Rack Model	A1R11 (R _O int) Typical Values	ATE Full Rack Model	A1R11 (R _O int) Typical Values
ATE 6-50DM	510Ω	ATE 6-100DM	25Ω
ATE 15-25DM	1kΩ	ATE 15-50DM	200Ω
ATE 25-20DM	2.7kΩ	ATE 25-40DM	500Ω
ATE 36-15DM	1kΩ	ATE 36-30DM	600Ω
ATE 55-10DM	12kΩ	ATE 55-20DM	2kΩ
ATE 75-8DM	22kΩ	ATE 75-15DM	5kΩ
ATE 100-5DM	7.5kΩ	ATE 100-10DM	7.5kΩ
ATE 150-3.5DM	12kΩ	ATE 150-7DM	12kΩ

3.3 VOLTAGE MODE OPERATION (FRONT PANEL CONTROL)

Once the load is connected to the output terminals of the ATE Power Supply and safety, as well as grounding rules have been applied as previously described (see PAR's. 3.1 through 3.2.4), power supply operation can proceed:

1. Turn VOLTAGE control completely counterclockwise. Set A-C POWER switch/circuit breaker to ON. (The VOLTAGE MODE indicator should be lit). Observe front panel VOLTS meter and adjust VOLTAGE control to the desired output voltage level. Set A-C POWER switch/circuit breaker to OFF.
2. Turn the CURRENT control completely counterclockwise.
3. Apply a short circuit across the output terminals of the ATE Power Supply. Set A-C POWER switch/circuit breaker to ON (the CURRENT MODE indicator should be lit).
4. Observe front panel AMPS meter and adjust CURRENT control to the required load current value, plus 2%. In voltage mode operation, this setting will determine the voltage/current crossover point. Set A-C POWER switch/circuit breaker to OFF.
5. Remove the short circuit from the output terminals. The power supply is now ready for operation.

3.4 CURRENT MODE OPERATION (FRONT PANEL CONTROL)

NOTE: Refer to PAR. 2.7 for fast mode conversion of the ATE.

Apply all safety and output grounding rules as described in PAR. 3.1 and 3.2, then proceed as follows:

1. **BEFORE connecting the load to the power supply output terminals:** Set A-C POWER switch/circuit breaker to ON (the VOLTAGE MODE indicator should be lit). Observe the front panel VOLTS meter and adjust the VOLTAGE control to the required compliance (output voltage) level. Set A-C POWER switch/circuit breaker to OFF and connect a short circuit to the output terminals of the ATE.

2. Set A-C POWER switch/circuit breaker to ON. Observe the front panel AMPS meter and adjust CURRENT control to the desired value. The CURRENT MODE indicator should go on to indicate that the power supply is truly in the current mode of operation. Set A-C POWER switch/circuit breaker to OFF
3. Remove the short circuit, connect the load and set A-C POWER switch/circuit breaker to ON. If the ATE does not enter current mode (front panel CURRENT MODE indicator lit), the load resistance (R_L) is too high. Either R_L must be **decreased**, or the VOLTAGE control setting must be **increased**, or the CURRENT control setting must be **decreased**. The ATE is now ready for operation.

3.5 OVERVOLTAGE CROWBAR SETUP AND CHECK

The overvoltage crowbar circuit protects the load from momentary or long-term overvoltages. The crowbar SCR conducts across the power supply output, and the A-C POWER switch/circuit breaker is tripped if an overvoltage occurs. The front panel Crowbar SET LEVEL control determines the threshold between the actual operating voltage of the power supply and the level at which the crowbar circuit will be activated. The SET LEVEL control can be set from the greater of 3 Volts or 1.6% E_{Omax} to 110% of the rated output voltage. The SET LEVEL control may be adjusted very close to the operating voltage (minimum threshold = 2% of rated output voltage or 0.5 Volt, whichever is greater). Operation of the crowbar circuit can be checked *without* actually triggering the crowbar. All operating controls are accessible at the front panel (refer to Figure 2-1).

1. Without connecting the load to the power supply turn recessed Crowbar SET LEVEL control **fully clockwise**.
2. Set A-C POWER switch/circuit breaker to ON. Observe the front panel VOLTS meter and use VOLTAGE control to set the desired value **at which the crowbar must trigger** (NOT to the actual operating voltage).
3. Depress the DISARM button (and keep it depressed) while turning the SET LEVEL control **counterclockwise**, until the crowbar SET LEVEL indicator energizes (simulated crowbar action).
4. With the DISARM button still depressed, turn VOLTAGE control slightly counterclockwise to the **actual operating voltage**. Release the DISARM button.

NOTE: This last adjustment established the threshold, i.e., the difference voltage between the output voltage and the voltage at which the power supply will crowbar. For minimum false triggering use the largest threshold your load can tolerate.

5. To check the adjusted crowbar trigger level, depress DISARM pushbutton and turn VOLTAGE control **clockwise** while observing front panel VOLTS meter and note the voltage at which the crowbar SET LEVEL indicator energizes. Correct SET LEVEL adjustment as described above if necessary. Use VOLTAGE control to reduce power supply output voltage to its operating value.

NOTE:1 Readjustment of the SET LEVEL control may be required after load and power supply have reached thermal equilibrium.

NOTE:2)If an *exact* crowbar point at a **remote load** must be established, **remote error sensing**, as described in PAR. 3.2.3 must be used.

3.6 INTRODUCTION TO REMOTE CONTROL OF ATE OUTPUT

For local (front panel) control the VOLTAGE control channel, the CURRENT control channel and the Overvoltage Protector of the ATE are locally adjusted by means of their respective front panel controls, with the jumper connections on the rear programming connector as shown on Figure 3-32. The internal control voltages for the VOLTAGE and CURRENT Control channels are created by their individual control amplifiers, while the Overvoltage Protector crowbar level is adjusted by a potentiometer, connected across the +15 volt supply (see Figure 3-33).

By disconnecting the internal control sources at the rear programming connector and substituting remote control circuitry, the ATE VOLTAGE and CURRENT control channels, as well as the Overvoltage Protector crowbar level, can be programmed externally. Control can be exercised individually or simultaneously on all three programming channels, although individual programming will be illustrated and discussed in the following paragraphs.

3.6.1 REAR PROGRAMMING CONNECTOR

The Model PC 12 Rear Programming Connector is an unwired 50-pin connector with terminals that allow external access to internal control signals and flags. The Model PC 14 Rear Programming Connector is a PC 12 that has been prewired to allow local control of the ATE full rack output. Unless otherwise noted, references to PC 12 refer to a rear programming connector that has been prewired for local control of the output. See Figure 2-3 for a schematic showing PC 12 pin connections and functions; Figure 3-32 shows the PC 12 connections to the ATE internal structure/circuitry.

3.7 VOLTAGE CONTROL CHANNEL PROGRAMMING

NOTE: To reduce the rise time delay when using external programming in either Slow Mode or Fast Mode, make sure that for the "low" level of the programming signal the output voltage has a small value, at least 0.1% of nominal (with the correct polarity).

The ATE output voltage which is controlled by the front panel VOLTAGE control in the local control mode, can be remotely controlled by disconnecting the internal VOLTAGE CONTROL amplifier (see Figure 3-32) at the rear programming connector and substituting an external control signal at the input of the VOLTAGE COMPARISON amplifier with reference to the Programming Common. For this direct drive method of voltage control, the control signal must be a positive-going 0 to 10 Volt d-c voltage source, able to supply at least 1 mA of control current. An application, demonstrating this control method is described in PAR. 3.7.1; connections are shown in Figure 3-6.

Since all terminals of two independent preamplifiers (PREAMP "A" and PREAMP "B") are available at the rear programming connector, output voltage control can be exercised in many other ways. Each preamplifier can be used as an uncommitted operational amplifier using the applicable transfer functions. The static offsets of each preamplifier can be zeroed with the built-in ZERO controls. The offset variations for each preamplifier, versus the various influence quantities, are specified in Table 1-4).

Making use of the ATE preamplifiers allows the user to accommodate a variety of programming sources. The basic principle to keep in mind is that a 0 to 10 Volts, 1 mA signal, presented at the VOLTAGE COMPARISON amplifier input, will program the ATE output over its rated output voltage range. If the available programming input source does not have the required amplitude, or if the required control current cannot be supplied, the ATE preamplifiers can be used to adapt most input sources and provide the required parameters. The examples presented in the follow-

ing paragraphs should suffice to outline the wide variety of programming circuits which are possible with the ATE power supply.

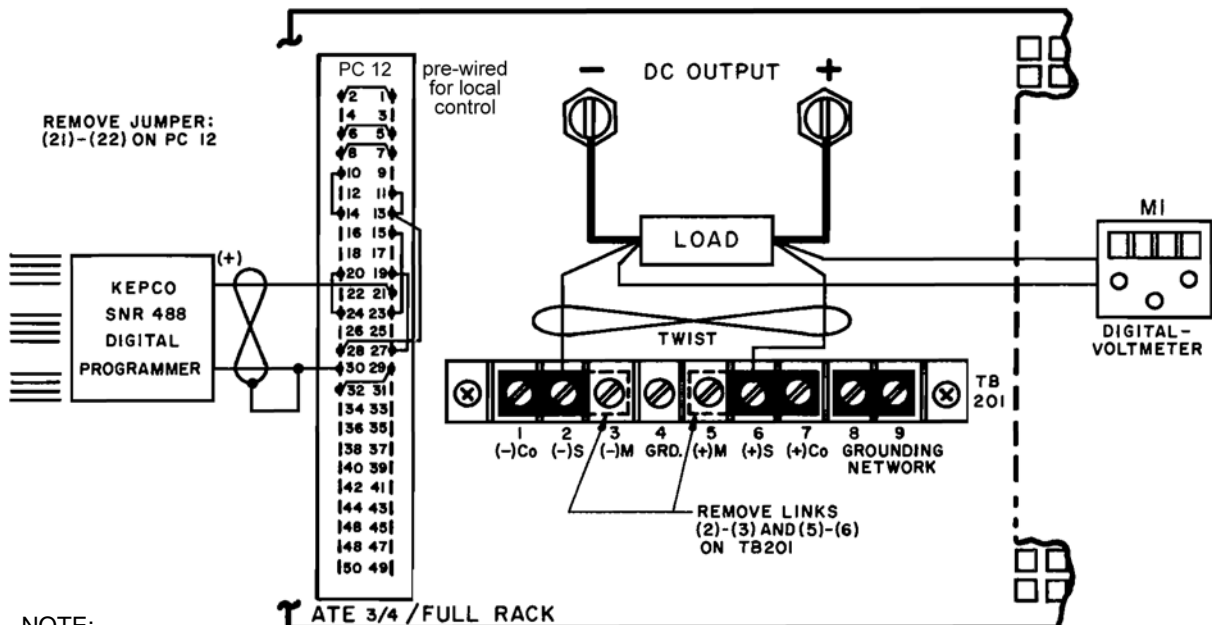
3.7.1 OUTPUT VOLTAGE CONTROL WITH AN EXTERNAL 0-10 VOLT D-C CONTROL SIGNAL

NOTE: When using external programming, either fast or slow mode, the rise time delay can be reduced by making sure that for the "low" level of the programming signal the output voltage has a small value, at least 0.1% of nominal (with the correct polarity).

An interesting example of the direct drive method of voltage programming is the control of the ATE output voltage by means of a Kepco Digital Programmer. The IEEE 488 bus compatible Kepco SN 488 system, for example, responds to digital input data and can be addressed either by a computer, or manually. The output signal of the SN 488 is a voltage from either zero to 10 Volts or zero to 1 Volt and constitutes the input program for the ATE. Since the SN 488 has two independent outputs (A and B), only one output is needed for voltage control, while the other may be used to control the ATE output current (See par. 3.8.1).

PROCEDURE

1. Connect the External Control Voltage (SN 488 Digital Programmer), the Load and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-6,
2. With the SN 488 at zero, set A-C POWER switch/circuit breaker to ON.
3. Vary the input voltage to the ATE from the SN 488 from zero to 10 Volts. The ATE output voltage, as read on M1, should vary from approximately zero volts to its maximum rated output voltage. Return the SN 488 output to zero volts.



NOTE: Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-6. OUTPUT VOLTAGE CONTROL WITH AN EXTERNAL (0 - 10V, 1 mA D-C CONTROL SIGNAL

CALIBRATION

NOTE: Refer to Figure 2-4 for location of all internal controls.

4. Check the Precision Voltmeter (M1) for zero reading and correct, if necessary. with the ATE E_O ZERO control.
5. Set the SN 488 input for the ATE to 10 Volts. Observe M1 and calibrate the ATE output voltage to the exact maximum rated output voltage by means of the SN 488 calibration control.
6. Set the SN 488 output to zero again and check the previously calibrated zero point on M1. Correct with the ATE E_O ZERO control if required.
7. Set the ATE front panel CURRENT control according to your load requirements, following the procedure given in PAR. 3.3, steps 2 through 5, or use one of the output current programming circuits for remote control of the output current as described in PAR. 3.8.1 or 3.8.2.

3.7.2 VOLTAGE CONTROL WITH A TWO-TERMINAL RESISTANCE

As mentioned previously (see PAR. 3.7), a wide variety of external programming sources can be used to control the ATE voltage channel. By means of one, or both, of the ATE's uncommitted preamplifiers, the external control potential can be amplified, inverted and/or summed with an internal d-c signal. Alternatively, the preamplifier can be used to perform remote, two-terminal resistance programming of the ATE voltage channel. As seen in Figure 3-7, the INT. REFERENCE SOURCE (6.2V @ 1 mA) is connected to PREAMP "A" and the external input/feedback components are calculated to produce the required 0 to 10 Volts control signal from the preamplifier output.

The preamplifier (Figure 3-7) functions in the inverting configuration, producing its output voltage (E_P), which is made equal to the required control voltage (E_i) according to the equation

$$E_P = \frac{E_{ref}}{R_r} \times R_f \quad (\text{Eq. 1})$$

where:

R_r = Ext. Reference resistor

E_P = Preamplifier output voltage equal to the required control voltage (E_i)

E_{ref} = Internal Reference Voltage 6.2V

R_f = Ext. Feedback Resistor (Voltage Control)

Since the ratio E_{ref}/R_r may be expressed as a control current ($E_{ref}/R_r = I_b$), Eq. 1 can be simplified to read:

$$E_P = E_O (\text{Preamplifier}) = I_b R_f \quad (\text{Eq.2})$$

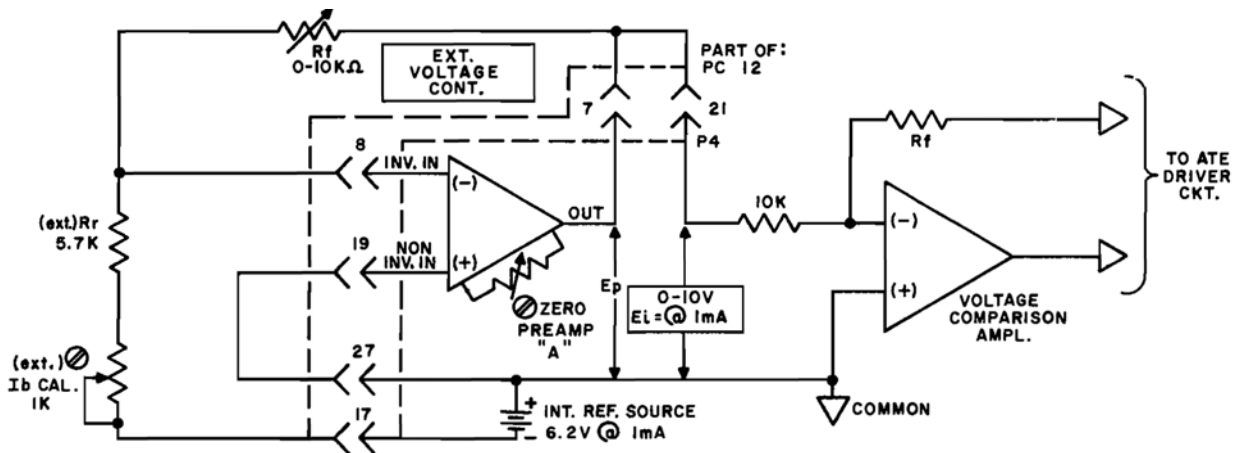


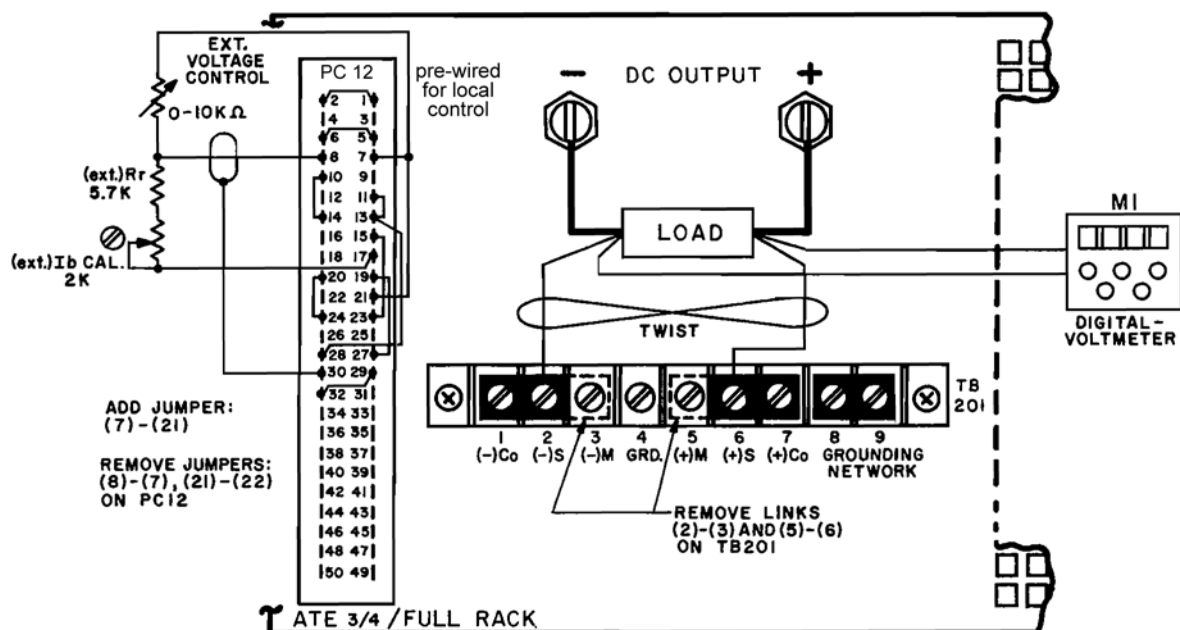
FIGURE 3-7. TWO-TERMINAL RESISTANCE PROGRAMMING (VOLTAGE CHANNEL),

3.7.2.1 USING PREAMP "A" AND INTERNAL REFERENCE SOURCE

If, for example, I_b is selected to be 1 mA (with 0.1 to 1 mA the recommended range), a 0 to 10k Ohm rheostat, decade or other variable resistance will produce the required 0-10 Volt control potential and thereby control the ATE output voltage from zero to its maximum rated value. If a 0-10K ohm voltage control resistance is not available, the control current (I_b) can be changed to accommodate the available resistance value, making use of the preamplifier output equation (Eq. 2). If, for example, a 15k Ω precision potentiometer is available, the control current (I_b) must be: $10V/15k\Omega = 0.67$ mA. Since the built-in INT. REF. SOURCE is (nominal) 6.2V, the external R_f must be: $6.2V/0.67mA \approx 9.3K\Omega$, which can be made up from a 8k Ω fixed, and a 2k Ω trim resistor (I_b CAL.).

PROCEDURE

1. Connect the external components, the LOAD and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-8.
2. With EXT. VOLTAGE CONTROL at zero Ohms, set ATE A-C POWER switch/circuit breaker to ON.
3. Vary the EXT. VOLTAGE CONTROL from zero Ohms to its maximum resistance. The ATE output voltage, as read on M1, should vary from approximately zero Volts to its rated maximum value. Return the EXT. VOLTAGE CONTROL to its zero Ohm position



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-8. CONNECTIONS FOR VOLTAGE CONTROL WITH A TWO-TERMINAL RESISTANCE

CALIBRATION

NOTE: Refer to Figure 2-4 for location of all internal controls.

4. Check the Precision Voltmeter (M1) for “zero” reading and correct, if necessary, with the ATE E_O ZERO control.
5. Set EXT. VOLTAGE CONTROL to its maximum resistance. Observe M1 and calibrate the ATE output voltage to the exact maximum rated value by adjusting the EXT. I_b CAL. control.
6. Set EXT. VOLTAGE CONTROL to zero ohms again, re-check the previously calibrated zero point on M1 and correct with the PREAMP “A” ZERO control if required.
7. Set the ATE front panel CURRENT control according to the LOAD requirements, following the procedure given in PAR. 3.3, steps 2 through 5, or use one of the output current programming circuits for remote control of the output current as described in PAR. 3.8.1 or 3.8.2. Set the overvoltage protector as described in PAR. 3.5.
8. Operation can now proceed. Check the ATE power supply output, by means of an oscilloscope, for dynamic stability and output ripple amplitude. Refer to PAR. 3.1.2 if high ripple is present. If the power supply output is dynamically unstable (oscillations), review the paragraphs on power supply/load interface and grounding (PAR.’s. 3.1.2 through 3.2.4). Adjust the E_O LAG control if the ATE is configured for fast mode operation (see PAR. 2.7.2).

3.7.3 VOLTAGE CONTROL WITH A HIGH IMPEDANCE CONTROL SOURCE

External control sources which cannot supply at least 100µA of control current can be best accommodated by using one of the preamplifiers in the non-inverting configuration. The control source is connected to the ATE as shown in Figure 3-9.

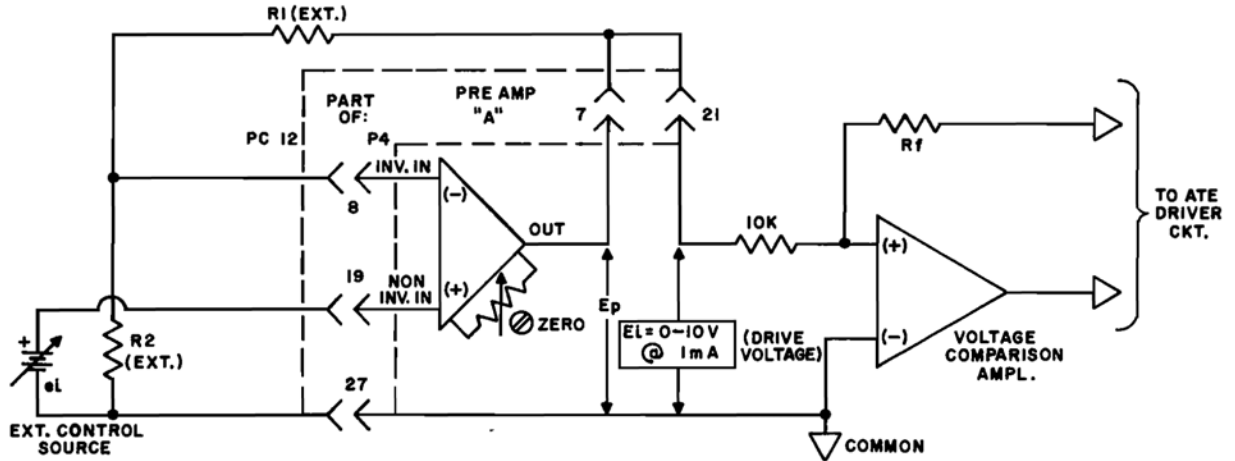


FIGURE 3-9. USING PREAMP "A" TO GENERATE THE 0-10V @ 1 mA CONTROL

The preamplifier Figure 3-9) output voltage (E_p) is made equal to the required drive voltage (E_i) by calculating the external resistors (R_1 , R_2) for the required gain, using the equation:

$$E_i = E_p = e_i \times \frac{R_1 + R_2}{R_2} \quad (\text{Eq. 3})$$

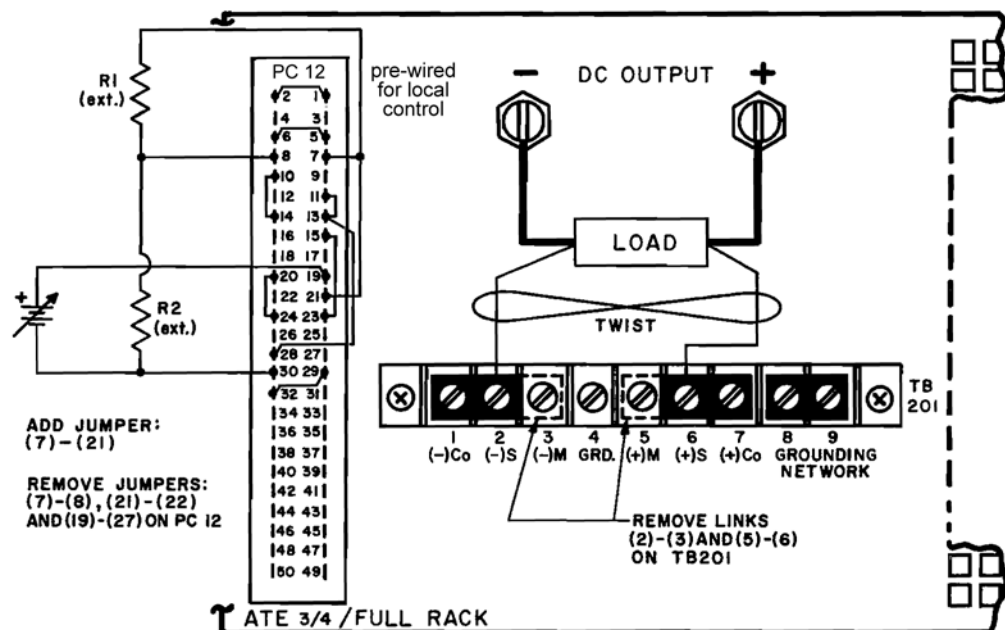
where:

- E_p = Preamplifier Output Voltage, equal to the required drive voltage (E_i)
- e_i = Available programming source
- R_1 , R_2 External feedback resistors

If, for example, a 0 to 0.5 Volts control source is available, the preamplifier gain, and therefore the ratio $(R_1 + R_2)$ over R_2 must equal $10/0.5 = 20$, so that R_1 , R_2 can be $38k\Omega$ and $2k\Omega$ respectively. If a 0 - 10 Volts source is available, but cannot deliver 1 mA of control current, R_1 can be replaced by a short circuit and the preamplifier then operates as a voltage-follower.

PROCEDURE

1. Connect the external components, the LOAD and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-10.
2.) With the EXT. CONTROL SOURCE at zero, set A-C POWER switch/circuit breaker to ON.
3. Vary the EXT. CONTROL SOURCE from zero to its maximum output level. The ATE output voltage, as read out on M1 , should vary from approximately zero volts to its rated maximum value. Return the EXT. CONTROL SOURCE to its zero position.



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-10. CONNECTIONS FOR VOLTAGE CONTROL WITH A HIGH IMPEDANCE INPUT SOURCE.

CALIBRATION

NOTE: Refer to Figure 2-4 for location of all internal controls.

4. Check the Precision Voltmeter (M1) for "zero" reading and correct, if necessary, with the ATE E_O ZERO control.
5. Set EXT. CONTROL SOURCE to maximum output. Observe M1 and calibrate the ATE output voltage to the exact maximum rated value by adjusting the Calibrating Control in the EXT. CONTROL SOURCE.
6. Set EXT. CONTROL SOURCE to zero again, re-check the previously calibrated zero point on M1 and correct with the PREAMP "A" ZERO control if required.
7. Set the ATE front panel CURRENT control according to the LOAD requirements, following the procedure given in PAR. 3.3, steps 2 thru 5) or use one of the output current programming circuits for remote control of the output current as described in PAR. 3.8.1 or 3.8.2. Set the overvoltage protector as described in PAR. 3.5.
8. Operation can now proceed. Check the ATE power supply output, by means of an oscilloscope, for dynamic stability and output ripple amplitude. Refer to PAR. 3.1.2 if high ripple is present. If the power supply output is dynamically unstable (oscillations) review the paragraphs on power supply/load interface and grounding (PAR.'s 3.1.2 and 3.1.3). Adjust the E_O LAG control (see PAR. 2.7.2), if the ATE is configured for fast mode.

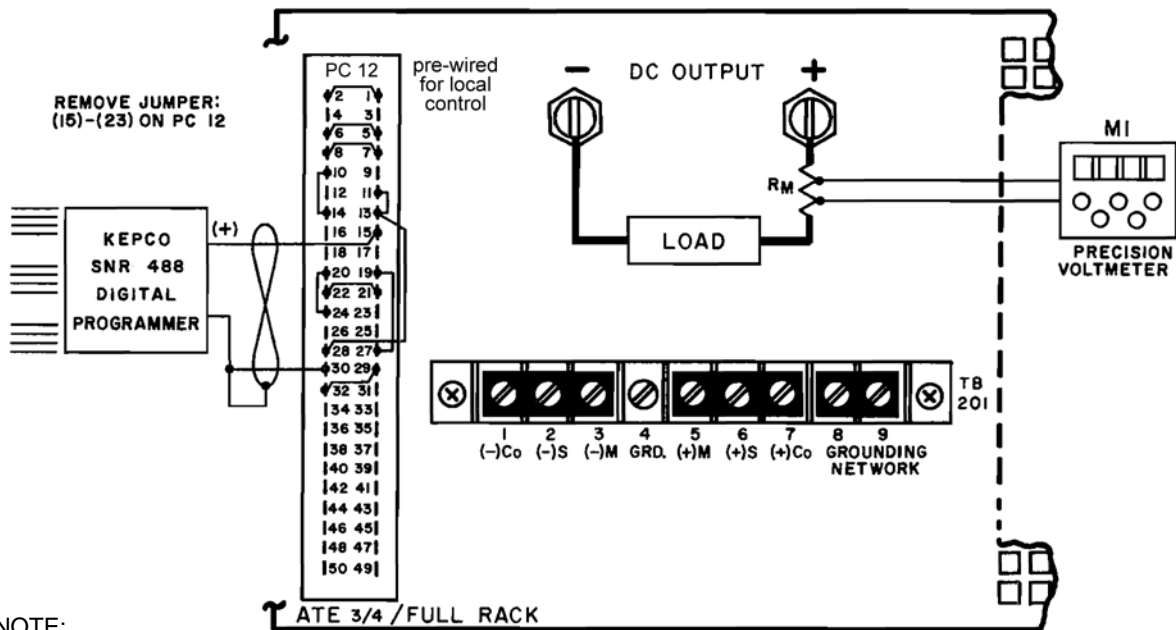
3.8 CURRENT CONTROL CHANNEL PROGRAMMING

The ATE output current, controlled by a front panel CURRENT control rheostat in the local control mode, can be remotely controlled by disconnecting the 15V bias from the non-inverting input of the EXT. CURRENT COMPARISON amplifier at the rear programming connector, and applying a 0 to 1 Volt external control signal with reference to the ATE COMMON terminal. Since the non-inverting input of the EXT. CURRENT COMPARISON amplifier is used, only the small amplifier bias current must be supplied by the external control source.

CAUTION: In all current programming applications, the front panel CURRENT control setting of the ATE acts as a back-up current limit and must be set slightly higher than the required maximum output current.

An application, demonstrating this control method is described in PAR.3.8.1 and illustrated in Figure 3-11.

If the available programming source does not have the required amplitude or polarity, one of the ATE's uncommitted preamplifiers may be used to scale the programming source to the required control potential (0 to 1 Volt), or provide the correct polarity. Typical examples of some possible applications are provided in the following paragraphs.



NOTE:
Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-11. OUTPUT CURRENT CONTROL WITH AN EXTERNAL 0 - 1V, 1 μ A D-C CONTROL SIGNAL

3.8.1 OUTPUT CURRENT CONTROL WITH AN EXTERNAL 0 - 1 VOLT D-C CONTROL SIGNAL

An interesting example of the direct drive method is the control of the ATE output current by means of a Kepco SN 488 Digital Programmer. The SN 488 responds to digital input signals, is IEEE 488 bus compatible and can be addressed either by a computer or manually by means of

a keyboard. The attenuated output signal of the SN 488 is a voltage from zero to 1 Volt and constitutes the input program for the ATE current channel. Since the SN 488 has two independent outputs (A and B) and only one is needed for current control, the other output may be used to control the ATE output voltage (See par. 3.7).

PROCEDURE

1. Connect the EXT. CONTROL VOLTAGE, (Model SN 488 Digital Programmer), the LOAD and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-11.

NOTE: The output current value can be measured directly by means of a suitable ammeter in series with the load or, as indicated in Figure 3-11, indirectly by means of the precision voltmeter (M1) across a precision current measuring resistor (R_M). R_M should be selected such that a convenient range on the precision voltmeter can be used, e.g., for a 10 Ampere output current, use a 0.1 Ohm, resistor to produce a one Volt full scale reading. If an electronic voltmeter is used, it should be battery-operated to avoid ground loops.

2. With the SN 488 output at zero, set A-C POWER switch/circuit breaker to ON.
3. Vary the input voltage to the ATE from the SN 488 from zero to 1 Volt. The ATE output current, as read-out on M1, should vary from approximately zero volts to its maximum rated value. Return the SN 488 output to zero volts.

CALIBRATION

NOTE: Refer to Figure 2-4 for location of all internal controls.

4. Check the Precision Voltmeter (M1) for zero reading and correct, if necessary, with the ATE I_O ZERO control.
5. Set the SN 488 input for the ATE to 1 Volt. Observe M1 and calibrate the ATE output voltage to the exact maximum rated output current by means of the SN 488 calibration control.
6. Set the SN 488 output to zero again and check the previously calibrated zero point on M1. Correct with the ATE I_O ZERO control if required.
7. Set the ATE front panel VOLTAGE control according to your load requirements, or use one of the output voltage programming circuits for remote control of the output voltage as described in PAR's. 3.7.1.through 3.7.3.

3.8.2 CURRENT CONTROL WITH A TWO-TERMINAL RESISTANCE

In this control mode one of the ATE's preamplifiers is used in conjunction with one of the ATE's reference sources to produce the 0 to 1 Volt control signal. The external feedback resistor (R_{CC}) serves as the two-terminal external current control.

The preamplifier (Figure 3-12) functions in the inverting configuration, producing its output voltage (E_P), which is made equal to the required control voltage (E_i) according to the equation

$$E_i = E_P = \frac{E_{ref}}{R_r} \times R_f \quad (\text{Eq. 1})$$

where:

R_r = Ext. Reference resistor

E_P = Preamplifier output voltage equal to the required control voltage (E_i)

E_{ref} = Internal Reference Voltage 6.2V
 R_{CC} = Ext. Feedback Resistor (Current Control)

Since the ratio E_{ref}/R_f may be expressed as a control current ($E_{ref}/R_f = I_b$), Eq. 1 can be simplified to read:

$$E_i = E_p \text{ (Preamplifier)} = I_b R_f \quad (\text{Eq.2})$$

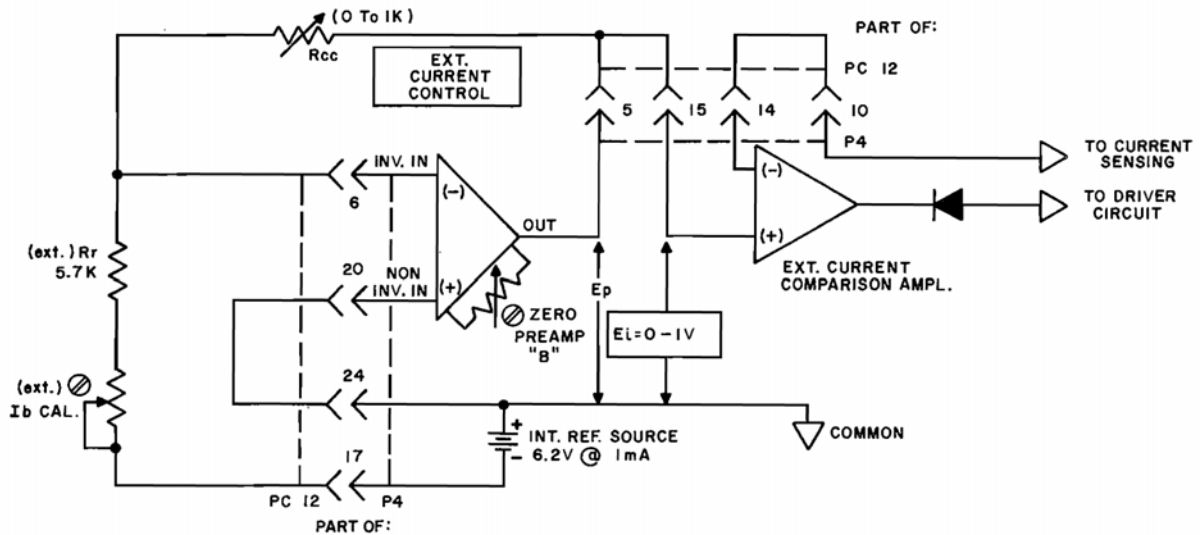


FIGURE 3-12. TWO-TERMINAL RESISTANCE PROGRAMMING (CURRENT CHANNEL), USING PREAMP "A" AND INTERNAL REFERENCE SOURCE

If, for example, I_b is selected to be 1 mA (with 0.1 to 1 mA the recommended range), a 0 to 10k Ohm rheostat, decade or other variable resistance will produce the required 0-10 Volt control potential and thereby control the ATE output voltage from zero to its maximum rated value. If a 0-10K ohm voltage control resistance is not available, the control current (I_b) can be changed to accommodate the available resistance value, making use of the preamplifier output equation (Eq. 2). If, for example, a 15k Ω precision potentiometer is available, the control current (I_b) must be: $10V/15k\Omega$ 0.67 mA. Since the built-in INT. REF. SOURCE is (nominal) 6.2V, the external R_f must be: $6.2V/0.67mA \approx 9.3K\Omega$, which can be made up from a 8k Ω fixed, and a 2k Ω trim resistor (I_b CAL.).

PROCEDURE

1. Connect the external components, the LOAD and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-8.

NOTE: The output current value can be measured directly by means of a suitable ammeter in series with the load or, as indicated in Figure 3-13, indirectly by means of the precision voltmeter (M1) across a current measuring resistor (R_M). R_M should be selected such that a convenient range on the precision voltmeter can be used, e.g., for a 10 Ampere output current, use a 0.1 Ohm resistor to produce a one Volt full scale reading. If an electronic voltmeter is used, it should be battery-operated to avoid ground loops.

2. With EXT. CURRENT CONTROL at zero Ohms, set ATE A-C POWER switch/circuit breaker to ON.

- Vary the EXT. CURRENT CONTROL from zero Ohms to its maximum resistance. The ATE output current, as read on M1, should vary from approximately zero Volts to its rated maximum value. Return the EXT. CURRENT CONTROL to its zero Ohm position

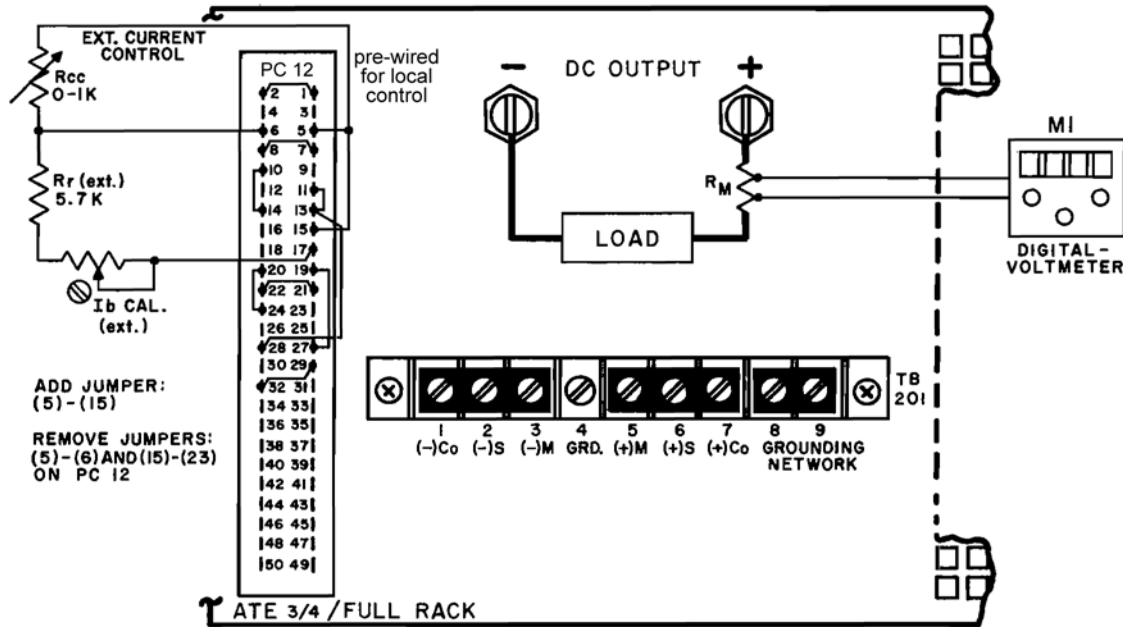


FIGURE 3-13. CONNECTIONS FOR CURRENT CONTROL WITH A TWO-TERMINAL RESISTANCE

CALIBRATION

NOTE: Refer to Figure 2-4 for location of all internal controls.

- Check the Precision Voltmeter (M1) for "zero" reading and correct, if necessary, with the power supply E_0 ZERO control.
- Set EXT. CURRENT CONTROL to its maximum resistance. Observe M1 and calibrate the ATE output voltage to the exact maximum rated value by adjusting the EXT. I_b CAL. control.
- Set EXT. CURRENT CONTROL to zero ohms again, re-check the previously calibrated zero point on M1 and correct with the PREAMP "B" ZERO control if required.
- Set the ATE front panel VOLTAGE control according to the LOAD requirements, following the procedure given in PAR. 3.3, steps 2 through 5, or use one of the output voltage programming circuits for remote control as described in PAR.'s 3.3 thru 3.8.2.

8. Operation can now proceed. Check the ATE power supply output, by means of an oscilloscope across R_M , for dynamic stability and output ripple amplitude. Refer to PAR. 3.1.2 if high ripple is present. If the power supply output is dynamically unstable (oscillations), review the paragraphs on power supply/load interface and grounding (PAR.'s. 3.1.2 through 3.2.4).

3.9 OVERVOLTAGE PROTECTOR PROGRAMMING

The ATE overvoltage protector crowbar level is normally set by the front panel (screwdriver adjusted) SET LEVEL control. This local operating mode has been previously described in PAR. 3.5. The crowbar level can be independently remotely controlled by setting the internal crowbar level to zero, turning the front panel SET LEVEL control completely counterclockwise and applying an external control signal (0 to 10V d-c) at the OVERVOLTAGE INPUT (PC 12 pin 11 referenced to PROGRAMMING COMMON). In another programming mode, the crowbar level can be controlled in a Tracking Mode where the 0 to 10 Volt output voltage programming signal can simultaneously be applied to the overvoltage protector, so that the crowbar level automatically tracks the ATE output voltage level. Typical examples of these programming applications are presented in the following paragraphs.

3.9.1 REMOTE CROWBAR LEVEL CONTROL WITH AN EXTERNAL 0 - 10 VOLT D-C CONTROL SIGNAL

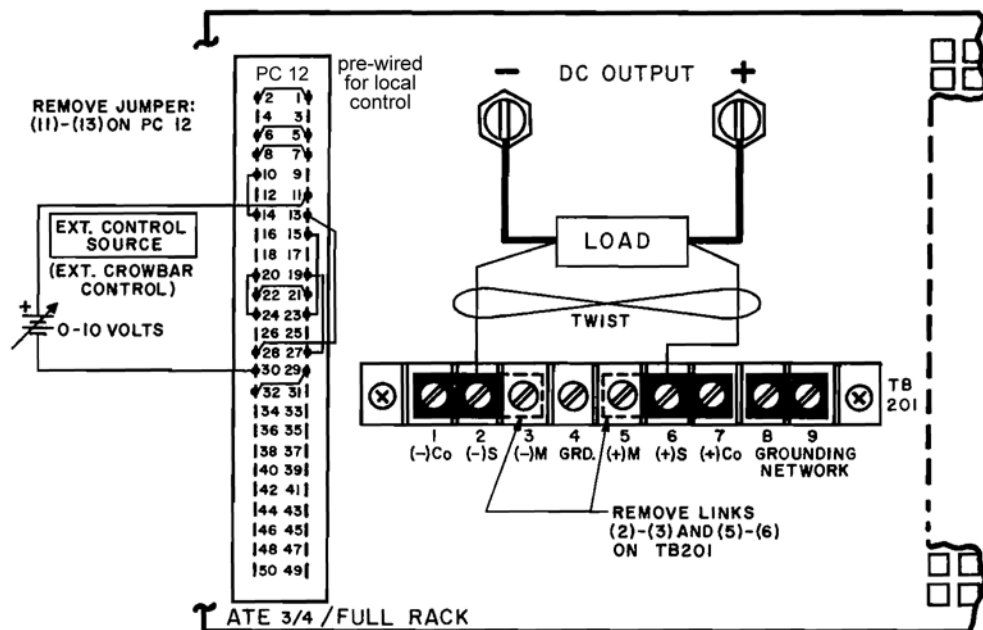
The ATE crowbar level can be remotely controlled by an external 0 to 10 volt, 1 mA d-c control source. One example of such a control source is the Kepco SN 488 Digital Programmer, which responds to digital input signals and can be controlled by computer or manually. The output of the SN 488 is from zero to 10 Volts or 0 to 1 Volt per channel and serves as the input to the ATE overvoltage protector.

PROCEDURE

1. Turn front CROWBAR SET LEVEL completely counterclockwise.
2. Connect a substitute LOAD and the EXT. CONTROL SOURCE to the ATE as shown in Figure 3-14. Set the EXT. CONTROL SOURCE to its maximum value.
3. Set A-C POWER switch/circuit breaker to ON and adjust the front panel VOLTAGE control to the desired crowbar level, i.e., the level at which the ATE is to shut down, not to your load voltage level.

NOTE: Monitor the power supply voltage either by means of the front panel meter, or if required, connect a precision voltmeter across the load.

4. Slowly reduce the level of the EXT. CONTROL SOURCE and note if the ATE shuts down at the correct crowbar level.
5. Turn the ATE front panel VOLTAGE control one turn counterclockwise and re-activate the ATE circuit breaker.
6. Test the previously set crowbar level again by turning the front panel VOLTAGE control slowly clockwise and observing the voltmeter. If the ATE does not shut down at the intended crowbar level. correct the setting of the EXT. CONTROL SOURCE, turn front panel VOLTAGE control one turn counterclockwise, re-activate the ATE circuit breaker and test again.
7. Turn the ATE front panel VOLTAGE control to the exact operating voltage which the LOAD requires.



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-14. REMOTE CROWBAR LEVEL CONTROL WITH AN EXTERNAL (0 - 10V, 1 mA D-C SOURCE

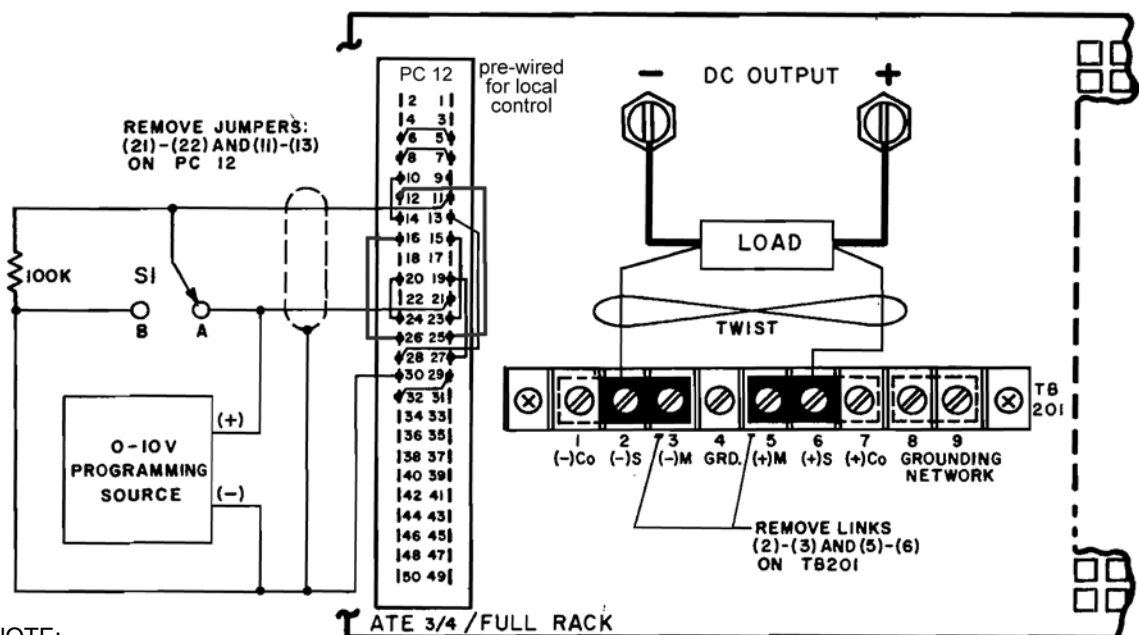
3.9.2 AUTOMATIC (TRACKING) CONTROL OF CROWBAR LEVEL

In this application, an ATE's voltage output is remotely controlled by a 0 - 10 Volt external programming signal which is simultaneously applied as a control signal to the overvoltage protector. As the ATE output voltage is now programmed by the external programming source throughout the specified range of the ATE, the crowbar level tracks the output voltage. i.e., it always remains higher than the instantaneous ATE output voltage, thus providing automatic overvoltage protection throughout the range.

3.9.2.1 PROCEDURE (ATE SET TO SLOW MODE)

1. Connect jumpers on the rear programming connector as indicated in Figure 3-15 and connect switch (S1) as shown. Turn front panel CROWBAR LEVEL SET control fully counter-clockwise.
2. Connect a substitute LOAD and the EXT. PROGRAMMING SOURCE as shown in Figure 3-15.
3. To test the overvoltage protector action, set A-C POWER switch/circuit breaker to ON and set output voltage by means of the EXT. PROGRAMMING SOURCE to a nominal value. Set switch S1 from position A to B. The overvoltage protector will crowbar the ATE output. The CROWBAR indicator will light momentarily and the ATE AC POWER switch/circuit breaker will trip.
4. Remove S1 from the circuit shown in Figure 3-15, and connect a jumper between terminals (13) and (21) of rear programming connector. Disconnect the substitute load and connect the actual LOAD. Then reactivate the ATE circuit breaker and commence operation. Should

erratic triggering occur in actual operation, set front panel CROWBAR LEVEL SET control slightly clockwise. This increases the threshold voltage; i.e., the difference voltage between the crowbar level and the operating voltage.



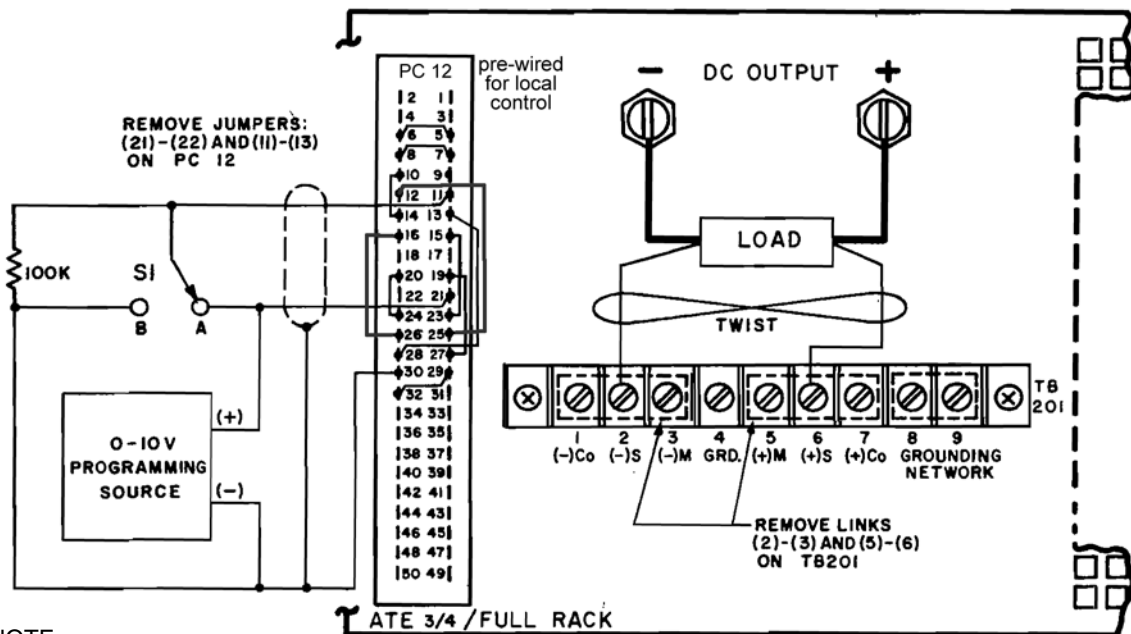
NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-15. CONNECTIONS FOR SIMULTANEOUSLY PROGRAMMING ATE (SLOW MODE) OUTPUT VOLTAGE AND CROWBAR LEVEL (AUTOMATIC TRACKING)

3.9.2.2 PROCEDURE (ATE SET TO FAST MODE)

1. Connect jumpers on the rear programming connector as indicated in Figure 3-15A and connect switch (S1) as shown. Turn front panel CROWBAR LEVEL SET control fully counter-clockwise.
2. Connect a substitute LOAD and the EXT. PROGRAMMING SOURCE as shown in Figure 3-15A.
3. To test the overvoltage protector action, set A-C POWER switch/circuit breaker to ON and set output voltage by means of the EXT. PROGRAMMING SOURCE to a nominal value. Set switch S1 from position A to B. The overvoltage protector will crowbar the ATE output. The CROWBAR indicator will light momentarily and the ATE AC POWER switch/circuit breaker will trip.
4. Remove S1 from the circuit shown in Figure 3-15A, and connect a jumper between terminals (13) and (21) of rear programming connector. Disconnect the substitute load and connect the actual LOAD. Then reactivate the ATE circuit breaker and commence operation. Should erratic triggering occur in actual operation, set front panel CROWBAR LEVEL SET control slightly clockwise. This increases the threshold voltage; i.e., the difference voltage between the crowbar level and the operating voltage.



NOTE:

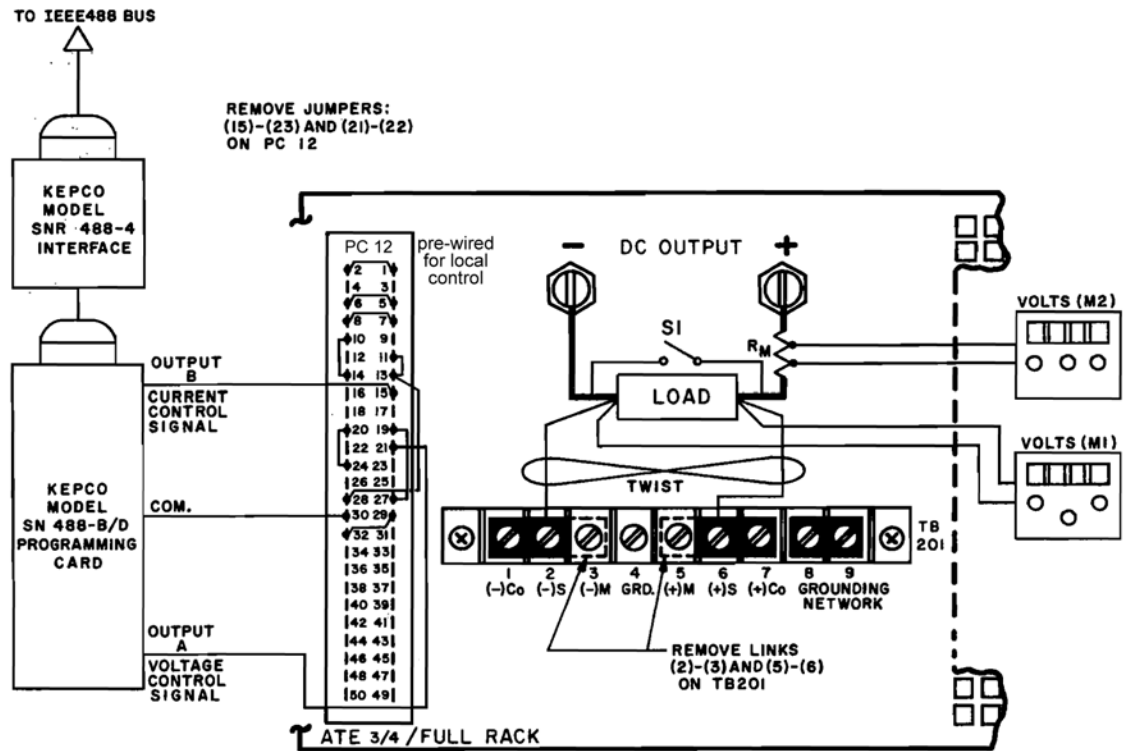
Remote sensing and Fast Mode shown (see Figure 2-6 for Fast Mode changes to PC 12 jumpers and links). For local sensing disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load and install links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S.

FIGURE 3-15A. CONNECTIONS FOR SIMULTANEOUSLY PROGRAMMING ATE (FAST MODE) OUTPUT VOLTAGE AND CROWBAR LEVEL (AUTOMATIC TRACKING)

3.10 PROGRAMMING OUTPUT VOLTAGE AND CURRENT SIMULTANEOUSLY USING EXTERNAL REMOTE CONTROL VOLTAGES

The output voltage, and the output current of the ATE power supply can be controlled simultaneously by means of remotely located variable voltage sources. The control voltages required to drive the voltage and current channels over the rated output range are 0 to 10 Volts at 1 mA for the Voltage Channel and 0 to 1 Volt for the Current Channel. An ideal programming source is the Kepco SN 488 Digital Programming System, which provides two independent control voltages of the correct magnitude per programming card.

- NOTES: 1. For control sources not within the given specifications, the two preamplifiers may be used, as described in PAR.'s 3.7.2 and 3.8.2, to scale the available control voltage up or down as required.
2. To reduce the rise time delay when using external programming in either Slow Mode or Fast Mode, make sure that for the "low" level of the programming signal the output voltage has a small value, at least 0.1% of nominal (with the correct polarity).



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-16. CONNECTIONS FOR SIMULTANEOUS CONTROL OF OUTPUT VOLTAGE AND CURRENT BY MEANS OF EXTERNAL, VARIABLE CONTROL VOLTAGES

3.10.1 PROCEDURE, PROGRAMMING OUTPUT VOLTAGE AND CURRENT SIMULTANEOUSLY

1. Connect external components, the LOAD, the precision voltmeters and the voltage measuring resistor (R_M) as shown in Figure 3-16.
2. With the Voltage Control Signal (Channel A) at some non-zero value and the Current Control Signal (Channel B) at zero, set A-C POWER switch/circuit breaker to ON.
3. Close S1. Vary the Current Control Signal from zero to its maximum value. The power supply output current, as read-out on M2, should vary from approximately zero to the rated maximum output current. Leave Current Control Signal at its maximum setting.
4. Open S1. Vary the Voltage Control Signal from its initial setting to its maximum value. The output voltage, as read on M1, should vary from approximately zero to the rated maximum output voltage.

3.10.2 CALIBRATION, VOLTAGE CONTROL CHANNEL

NOTE: Refer to Figure 2-4 for location of all internal controls.

1. Open S1. Set VOLTAGE CONTROL SIGNAL to zero. Check the Precision Voltmeter (M1) for zero reading and correct, if necessary, with the power supply E_O ZERO control.
2. Set Voltage Control Signal to its maximum value. Observe M1 and calibrate the power supply output voltage to the exact maximum rated value by adjusting the external control voltage (Channel A, full-scale cal. control).
3. Set Voltage Control Signal to zero again, re-check the previously calibrated zero point on M1 and correct with the power supply E_O ZERO control if required.
4. This concludes the calibration of the voltage channel. Leave the Voltage Control Signal at approximately 1/3 its maximum setting.

3.10.3 CALIBRATION, CURRENT CONTROL CHANNEL

The output current value can be measured directly by means of a suitable ammeter in series with the load or, as indicated in Figure 3-16, indirectly by means of the precision voltmeter (M1) across a current measuring resistor (R_M). R_M should be selected such that a convenient range on the precision voltmeter can be used, e.g., for one Ampere output current, use a 0.1 Ohm resistor to produce 100mV full scale. If an electronic voltmeter is used, it should be battery-operated to avoid ground loops.

1. Close S1. Set Current Control Signal to zero. Check the Precision Voltmeter (M2) for zero reading and correct, if necessary, with the power supply I_O ZERO control.
2. Set Current Control Signal to its maximum value. Observe M2 and calibrate the power supply output current to the exact maximum rated value by adjusting the external control voltage (Channel B, full-scale cal. control).
3. Set Current Control Signal to zero again, re-check the previously calibrated zero point on M2 and correct with the power supply I_O ZERO control if required. Open S1.

Operation can now proceed. Using an oscilloscope, check the output for dynamic stability and output ripple amplitude. Refer to PAR. 3.1.2 if high ripple is present. If the power supply output is dynamically unstable (oscillations) review the paragraphs on power supply/load interface and grounding (PAR.'s 3.1.2 and 3.1.3).

3.11 USING THE EXT. CURRENT COMPARISON AMPLIFIER FOR GENERAL FEEDBACK CONTROL

The output of the ATE power supply is normally controlled either by the VOLTAGE COMPARISON, or by the INT. CURRENT COMPARISON amplifier, depending on the prevailing operating mode. A glance at the simplified schematic diagram (See Figure 3-32 at end of Section 3), however, shows that a third control channel is available, via the EXT. CURRENT COMPARISON amplifier, which is normally biased off. The use of this amplifier has previously been shown in an application for external current control (See PAR.'s 3.8 and 3.8.1). Since both inputs of the EXT. CURRENT COMPARISON amplifier are available at the rear programming connector (PC 12), it can be used advantageously to control the power supply output in response to feedback from such diverse physical phenomena as light, temperature, pressure, chemical reactions and the

like, Since the (open loop) gain of this third control channel is very high, only minute feedback signals in combination with an appropriate external control are required.

The design of the required external circuitry is shown by the following example: A target object requires constant illumination, supplied by a lamp, which is connected at the power supply output. The feedback is supplied by a photo cell, the output of which is 0-100mV, depending on the light input. A Brightness Control is required to adjust various illumination levels,

Note: Depending upon the characteristics of both lamp and photo-cell, fast mode operation of the ATE might be advisable.

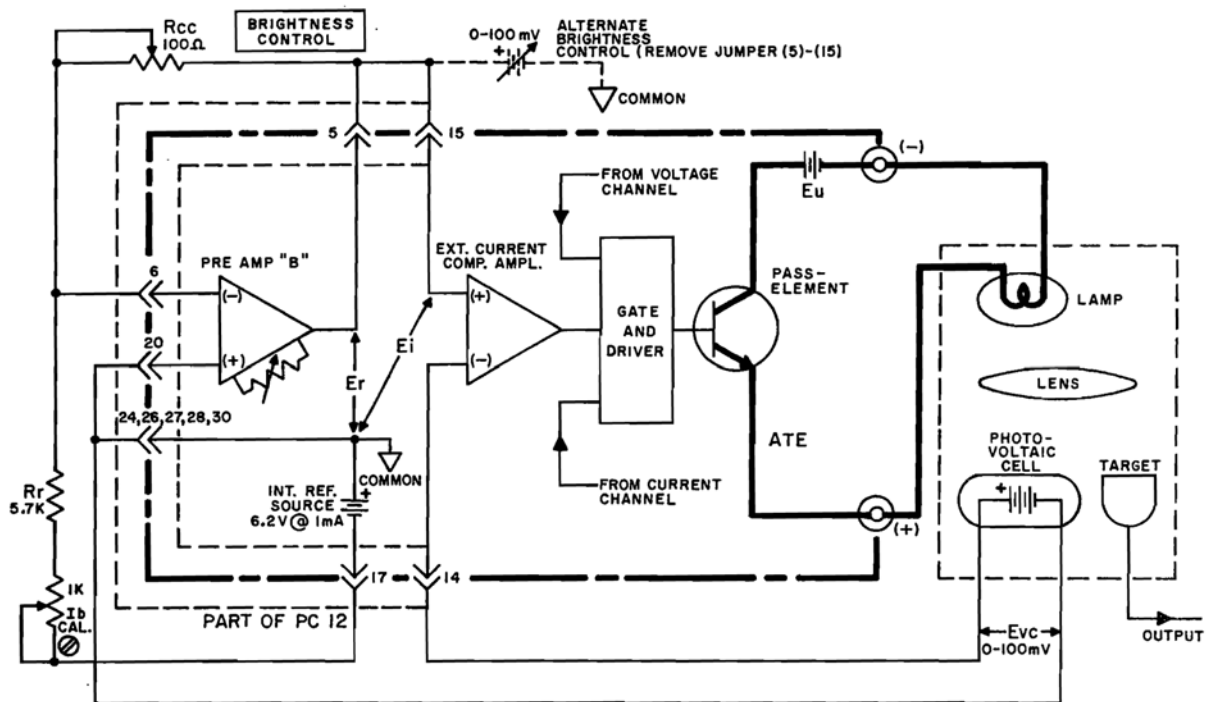


FIGURE 3-17. ILLUMINATION CONTROL CIRCUIT WITH THE ATE POWER SUPPLY

Assuming the ATE power supply is compatible with the requirements of the lamp load, the control circuit may be designed using either one of the ATE preamplifiers, or using an alternate external control voltage source (indicated by the dashed lines) as shown in Figure 3-17. The external source should be adjustable in the range from 0 to 100mV if illumination control is desired, or it should have a means of calibration if a fixed external source is used for a constant illumination level.

In the example, an ATE internal preamplifier (PRE AMP B) is used to develop the control signal ($E_i = 0-100mV$), which is compared with the photo-cell output at the input to the EXT. CURRENT COMPARISON amplifier. The external reference resistor (R_r) and the control rheostat (R_{CC}) are

selected to produce the control signal, similar to the example described in a previous application (See PAR. 3.8.2).

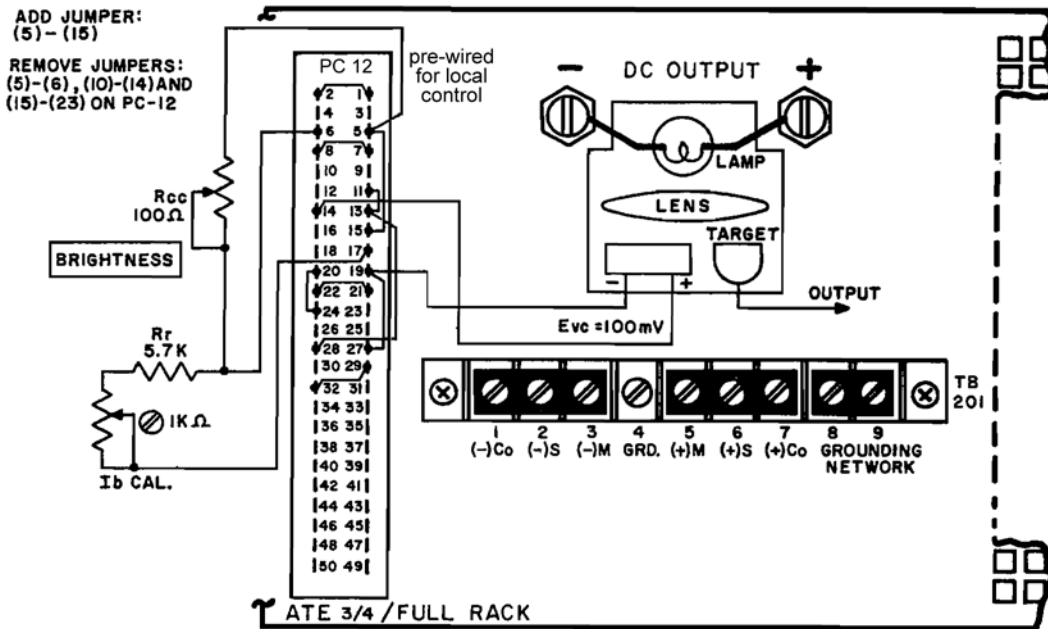


FIGURE 3-18. CONNECTIONS FOR ILLUMINATION CONTROL, USING EXTERNAL CURRENT COMPARISON AMPLIFIER

PROCEDURE

1. Connect the external components to the ATE power supply as shown in Figure 3-18.
2. At ATE front panel, adjust both VOLTAGE and CURRENT controls to approximately 10% beyond the values required by the LAMP which represents the power supply load. Although the neither the voltage nor current channel are in control in this application, setting the front panel output controls close to the lamp requirements serve as a back-up voltage and current limit should feedback control from the photo-cell be lost.
3. Turn the external BRIGHTNESS control to its mid-range and set ATE A-C POWER switch/circuit breaker to ON. Vary the BRIGHTNESS control through its range and observe its effect on the LAMP. The lamp brightness should vary from zero (dark) to the approximate maximum brightness.

CALIBRATION

Turn the BRIGHTNESS CONTROL (R_{CC}) to its maximum clockwise position and adjust the external I_b CAL. control until the maximum desired brightness is measured.

3.12 MULTIPLE POWER SUPPLY AND SYSTEMS OPERATION

In applications where several power supplies are used it is often necessary to shut down all power supplies if a malfunction on a single supply forces its shut-down. Sometimes, a "panic button" arrangement is desired, where all system power supplies can be shut down with a single manual switch or a common signal from a controller. ATE power supplies are ideally suited for multi-unit operation since all necessary crowbar control circuit connections are terminated at the rear programming connector (PC 12). The crowbar control connections in a multi-unit applica-

tion can be externally wired to form a closed loop fault-detection circuit as shown in Figure 3-19. Although only three ATE power supplies are shown, the control loop may be extended to include as many ATE power supplies as are required.

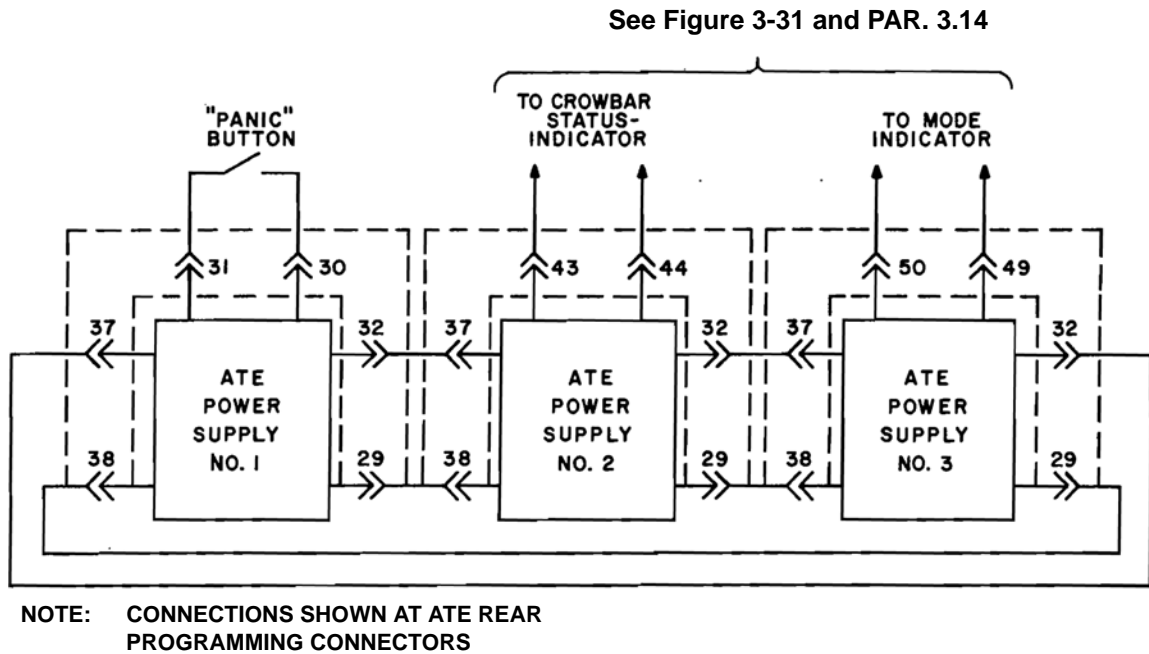


FIGURE 3-19. MULTIPLE POWER SUPPLY FAULT DETECTION LOOP.

In addition to the crowbar input/output terminals, optically isolated flag signals are available at the rear programming connector (PC 12) of each ATE power supply. These signals may be used to indicate the crowbar status and the operating mode of each ATE power supply (See Figures 3-19 and 3-32 and PAR. 3.14).

3.12.1 SERIES CONNECTION OF ATE POWER SUPPLIES

Kepeco ATE power supplies may be connected in series for increased voltage output. Series connection of two ATE units is described here, but several units, up to an output voltage total of 500 volts may be interconnected. Two basic methods of series connection are commonly used: Automatic and Master/Slave configurations. The choice between these two methods will depend on the application at hand. If individual power supply control is desired, the Automatic series connection should be used. If the output of the interconnected power supplies is to be controlled simultaneously, the Master/Slave method is recommended. For either method, some general rules should be remembered.

1. Series connect supplies only up to a total of 500 volts output voltage, this is the isolation voltage limit for the ATE power supply.

NOTE: Each of the ATE output terminals can sustain, and is tested for, 500V d-c (or peak) plus the unit's nominal output voltage with respect to the unit's chassis, referenced to earth-ground.

2. Series-connected supplies should have the same current rating. Otherwise, reduce the current limits to a value equal to the lowest output current rated power supply.

3. Use error sensing, as shown in Figure 3-20). to compensate for load wire drops.

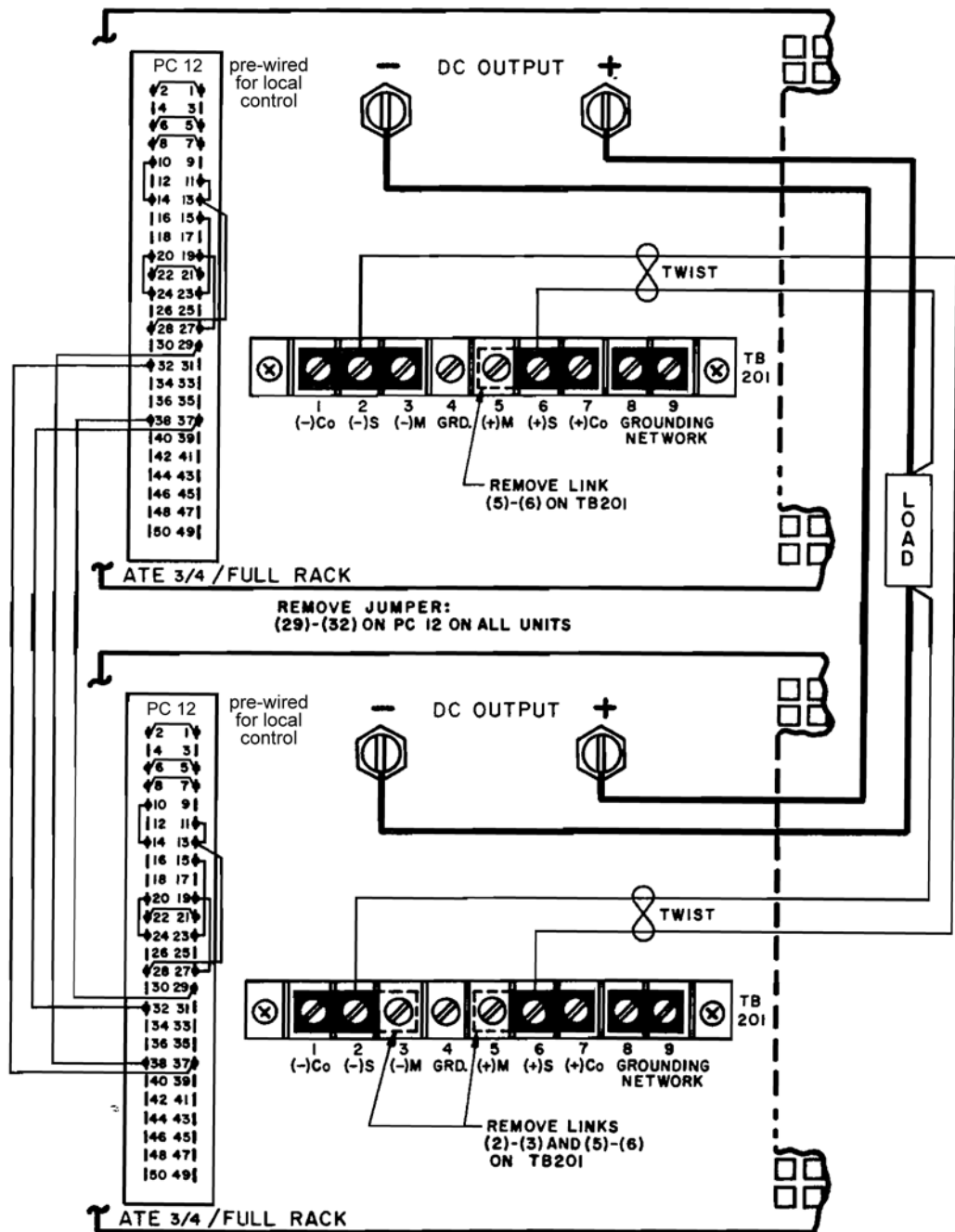
NOTE: Sensing leads are not required if the application calls for current mode operation exclusively,

4. The load wires should be as short as practicable. Select the load wires as heavy as possible and twist the load wire pair tightly, Approximately equal lengths of load wire between each pair of supplies is recommended.
5. Use the Fault Detection Loop, as described in par.3.12.
6. All previously described programming circuits may be used on the MASTER power supply, to program the series connected system.

3.12.1.1 AUTOMATIC SERIES CONNECTION

Recommended when individual power supply control is desired. Refer to Figure 3-20.

1. Without connecting the power supplies to the load, set A-C POWER switch/circuit breaker of all ATE power supplies to ON, and adjust the output voltage on each supply to the required level (the sum of the output voltages will be applied to the load).
2. Adjust CURRENT control on each power supply to its extreme counterclockwise position. Set A-C POWER switch/circuit breaker of all ATE power supplies to OFF. Connect a short circuit. consisting of a short. heavy wire, across the output terminals of each power supply. Set A-C POWER switch/circuit breaker of all ATE power supplies to ON and adjust each ATE CURRENT control to the required load current. Set A-C POWER switch/circuit breaker of all ATE power supplies to OFF. Remove shorting wires from output terminals.
3. Make all load connections as shown in Figure 3-20).
4. Set A-C POWER switch/circuit breaker of all ATE power supplies to ON. Observe output metering and front panel MODE indicators on all series connected ATE power supplies. The output current should be identical on all series connected supplies and all supplies should operate in voltage mode (VOLTAGE MODE indicators lit).
5. On those supplies not operating in the voltage mode. turn CURRENT control slightly clockwise until the VOLTAGE MODE indicator energizes.
6. If current mode operation is desired, turn the front panel CURRENT control on one of the series connected ATE power supplies slightly counterclockwise. such that the CURRENT MODE INDICATOR is just energizing. The remaining supply (supplies) should remain in the voltage mode of operation. Operation can now proceed.



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-20. AUTOMATIC SERIES CONNECTION

3.12.1.2 MASTER/SLAVE SERIES OPERATION.

In this mode of operation the total output voltage of all supplies in the series connection is controlled from a common Master supply, while the voltage output of the Slave supplies follow the output voltage of the Master.

As seen in Figure 3-21) in each Slave supply, the input to the VOLTAGE COMPARISON amplifier is disconnected from the output of the VOLTAGE CONTROL amplifier and an external drive signal is derived from the output voltage of the Master supply (E_{OM}) and applied via a coupling resistor (R_t) to the Slave supply.

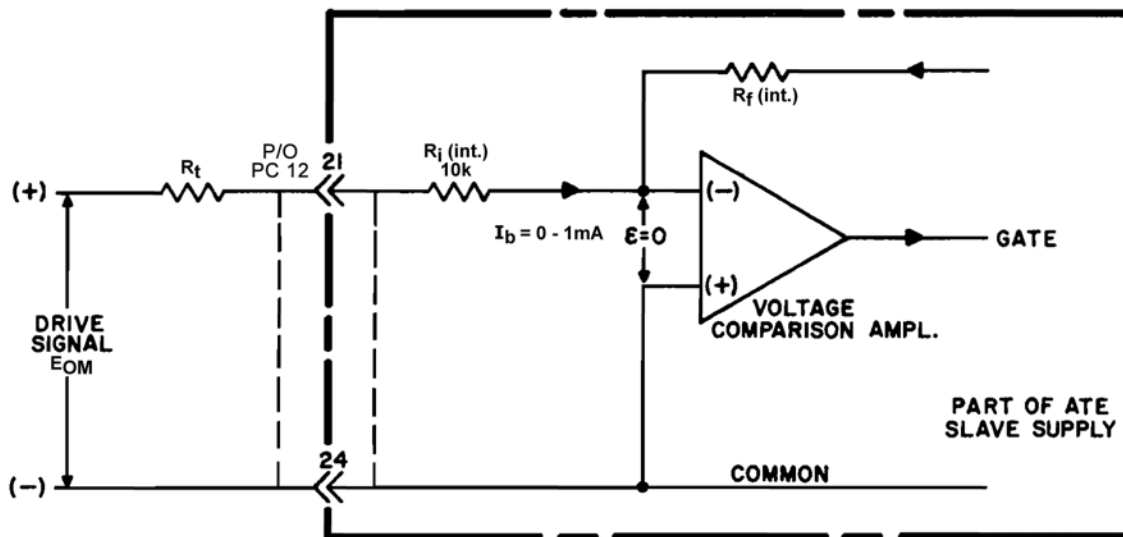


FIGURE 3-21. DRIVING MASTER/SLAVE SERIES-CONNECTED ATE POWER SUPPLIES WITH RATED OUTPUT VOLTAGE > 6V

The output voltage of each Slave supply (E_{OS}) will be from 0 to its maximum rated output voltage if the input signal to its VOLTAGE COMPARISON amplifier (E_i) is proportioned to produce a control current (I_b) in the 0 to 1 mA range. Since the null junction voltage (E) equals zero at balance,

$$I_b = \frac{E_{om}}{R_t + R_{i(int)}} \text{ or } R_t = \frac{E_{om} - I_b R_i}{I_b} = \frac{E_{om}}{I_b} - R_i$$

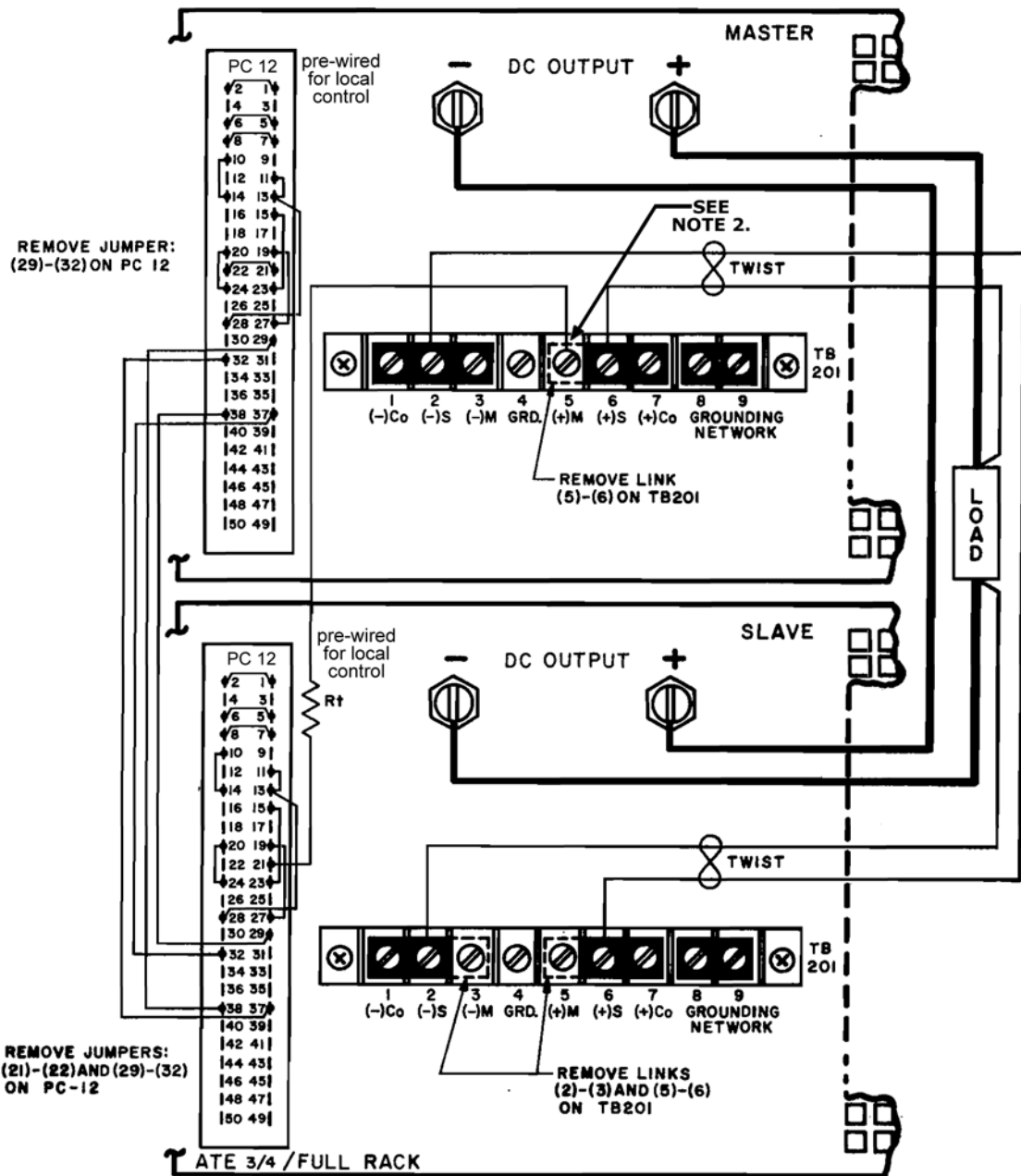
Since $I_b = 1\text{mA}$, $R_i = 10\text{kOhms}$ in all ATE power supplies, $R_t \text{ (kOhms)} = \frac{E_{om}}{1\text{mA}} - 10\text{k}$

For example, if a series connection of two ATE supplies with maximum output voltage of 36 and 55 Volts is planned for an application requiring a voltage supply from 0 to 91 volts into a common load, the coupling resistor is selected as follows:

Let $E_{om} = 0 - 55\text{V}$ (Master Supply). then the Slave Supply (E_{OS}) must vary from zero to 36 volts as the Master Supply is varied over its output voltage range. Calculating the coupling resistor,

$$R_t = \frac{55\text{V}}{1\text{mA}} - 10\text{k} = 45\text{k Ohms}$$

Connecting the system as shown in Figure 3-22 will produce the desired result.



NOTES:

1. Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.
2. For precise load voltage control (especially for remote sensing), connect R_f to master (+) S terminal instead of (+) M.

**FIGURE 3-22. MASTER/SLAVE SERIES CONNECTIONS FOR
ATE POWER SUPPLIES >6V OUTPUT VOLTAGE ONLY**

PROCEDURE

1. Set A-C POWER switch/circuit breaker to OFF at each individual ATE power supply to be connected in series, then connect each ATE to the a-c power line. Adjust the front panel CURRENT control on each ATE completely counterclockwise. Connect a short-circuit consisting of a short wire length across the output terminals of each ATE supply.
2. At each ATE, set A-C POWER switch/circuit breaker to ON, Adjust Master Supply CURRENT control to the required load current plus approximately 3%. Adjust Slave Supply CURRENT control to approximately 5% above the load current. At each ATE, set A-C POWER switch/circuit breaker to OFF and remove short circuits from each ATE..
3. Connect ATE power supplies as shown in Figure 3-22. (NOTE: Only one Slave Supply is shown, but more can be added.) Turn Master Supply VOLTAGE control to its maximum counterclockwise position.
4. At each ATE, set A-C POWER switch/circuit breaker to ON. Observe front panel MODE indicators and verify that all VOLTAGE MODE indicators are on and all front panel meters read approximately zero.
5. Slowly, turn Master VOLTAGE control clockwise until the desired output voltage level is reached. The load voltage is the sum of the Master and all Slave output voltage as displayed on each front panel output VOLTAGE meter. All output CURRENT meters should read the identical load current.
6. Set the output current limit point by turning the CURRENT control on all series-connected supplies counterclockwise until each supply just transfers into the current mode (CURRENT MODE indicator on), then turn each slightly clockwise again, until each VOLTAGE MODE indicator energizes again.
7. If current mode operation is desired, leave the setting of the Master CURRENT control such that the CURRENT MODE indicator is energized. While the output current can now be controlled by the Master supply, the Slave supply will still operate in voltage mode (VOLTAGE MODE indicator on) and deliver additional compliance voltage to the load.

3.12.1.2.1 MASTER/SLAVE SERIES OPERATION WITH ATE 6V POWER SUPPLIES

ATE power supplies with 6 Volts maximum output voltage cannot be master/slave connected as described in PAR..3.12.1.2 and Figure 3-22. Instead, the Master output voltage (6V) must first be amplified to 10 Volts if the Slave supply is to be driven through its full output voltage range. As shown in Figure 3-23,.one of the preamplifiers of the Slave unit may be used to proportion the drive signal to the required level. For a 0 - 1 mA control current (I_b) the input voltage (E_i) to the VOLTAGE COMPARISON amplifier must be 0 - 10 Volts. Therefore, the Master output voltage (E_{om}) is amplified, using PREAMP "A," by selecting the value for the external resistors (R_f and R_i) accordingly.

The values for these resistors are calculated on the basis of the equation

$$E_{out} \text{ (preamp)} = E_i = E_{om} \times (R_f + R_i)/R_i.$$

For the example of two 6 Volt ATE supplies connected in series: $E_{om} = 6V$, therefore $(R_f + R_i)/R_i$ (the closed loop gain of PREAMP "A") must be $6 \times (R_f + R_i)/R_i = 10$ or $(R_f + R_i)/R_i \approx 1.7$.. Letting $R_f = 3k\Omega$, R_i must be approximately $5k\Omega$. R_f may be selected to be a rheostat, so that a convenient gain control is available for calibration.

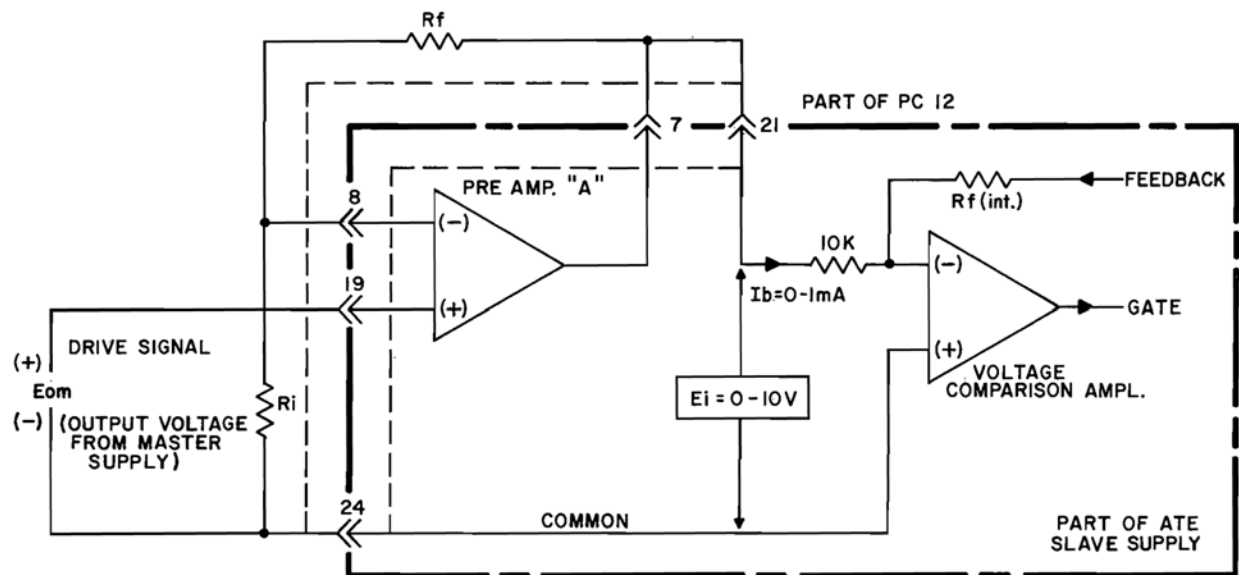


FIGURE 3-23. DEVELOPING THE DRIVE FOR MASTER/SLAVE SERIES-CONNECTED 6V ATE SUPPLIES.

3.12.2 PARALLEL CONNECTION OF ATE POWER SUPPLIES

Normally, crowbar equipped power supplies can not be connected in parallel, since a triggered crowbar in one supply working in a parallel configuration, would present a short circuit to all other supplies and would have to absorb the total output current. In the ATE power supply, crowbar control circuitry is provided, allowing the setup of a fault-detection loop, which shuts off all power supplies in a parallel configuration if one power supply crowbars for any reason.

As for series connections (PAR. 3.12.1), Automatic or Master/Slave connection methods can be chosen for paralleling ATE power supplies. The choice between the two methods will depend on the application at hand. For constant loads or small load variations (load changes smaller than the maximum output range of a single power supply), Automatic parallel connection can be used. For load changes exceeding the maximum rating of a single power supply, Master/Slave method is suitable. Both methods allow operation in the voltage or current mode. For either method, some general rules should be observed:

1. Only parallel supplies which can be adjusted to the same compliance (output) voltage,
2. Error sensing, as shown in the following diagrams, can be used to compensate for load wire voltage drops.
3. Load wires should be as short as practicable. Select wire gauge as heavy as possible and twist wires tightly. Approximately equal lengths of wire should be used.
4. Use the fault detection loop circuit, as described in par. 3.12.

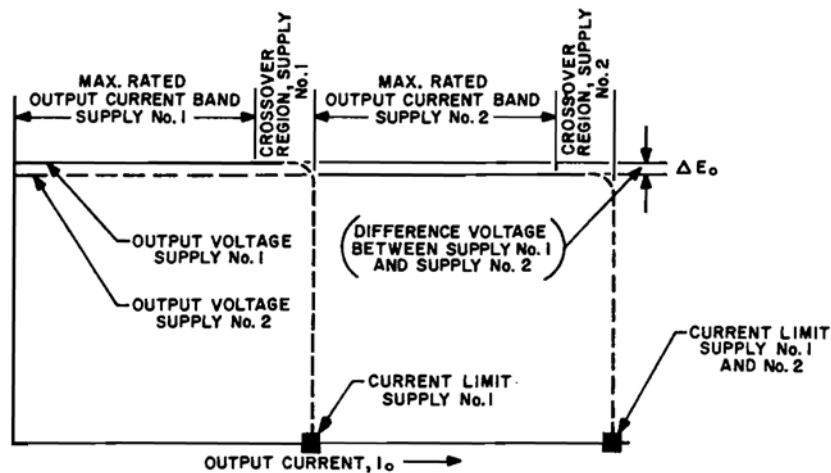


FIGURE 3-24. AUTOMATIC PARALLEL OPERATION (TWO SUPPLIES)

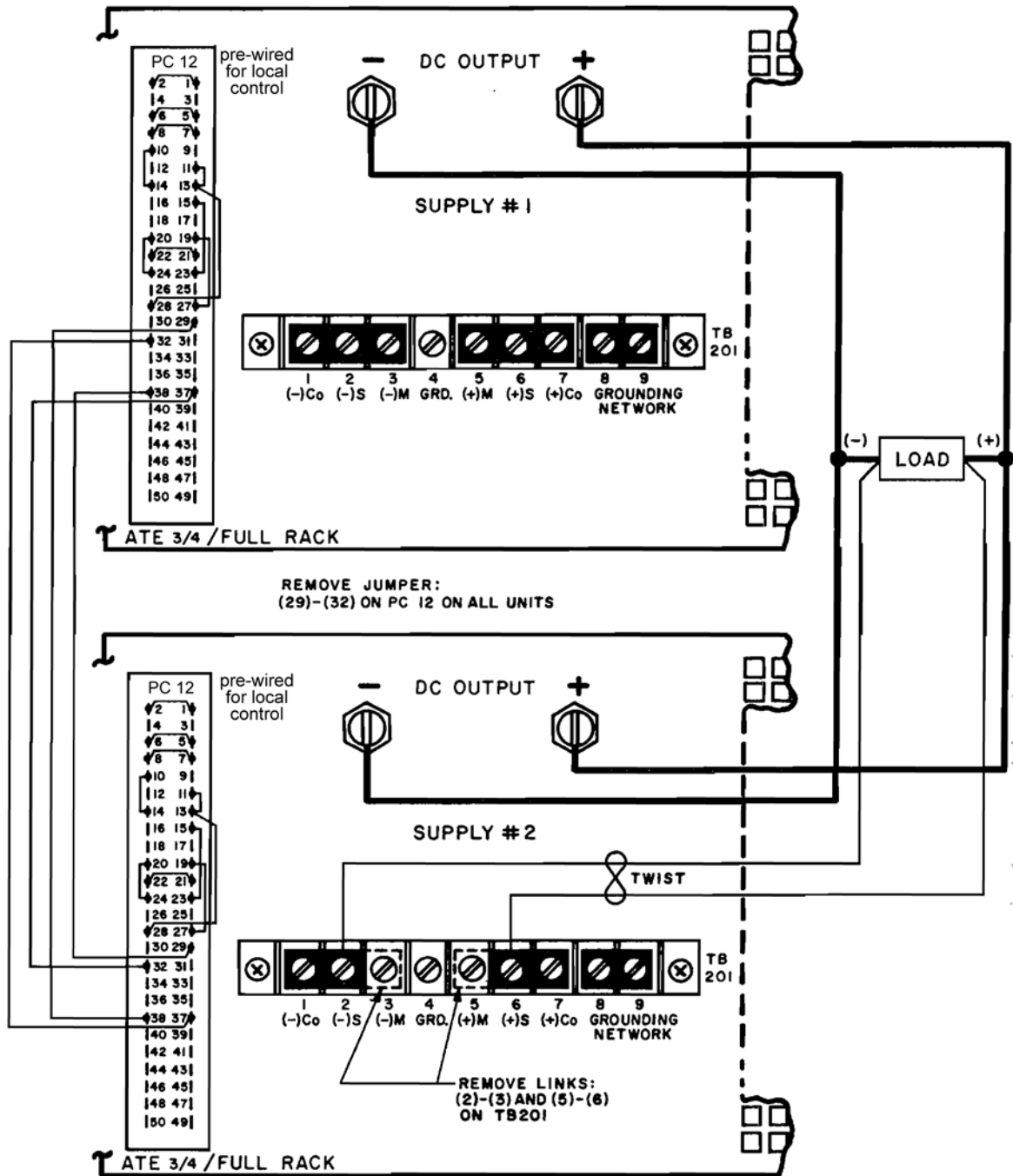
3.12.2.1 AUTOMATIC PARALLEL CONNECTION

Figure 3-24 shows how the two power supplies operate in the automatic parallel mode (connections shown in Figure 3-25). Load variations should be confined to the stabilization region of Supply #2 since there is an initial adjustment error (ΔE_o) between the two supplies.

If stabilized output current (rather than stabilized output voltage) is desired, all previous comments are valid, except that error sensing is not needed. For stabilized output current, the CURRENT control of the supply operating initially in the voltage mode (Supply #2) is readjusted (counterclockwise) to such a value that Supply #2 just switches to the current mode (observe front panel MODE indicators).

NOTE: Although parallel connection of two ATE power supplies is described, more can be connected.

1. Without connecting the power supplies to the load or to each other, set A-C POWER switch/circuit breaker of each ATE to ON, and adjust the VOLTAGE control on each supply to the desired value.
2. Adjust all ATE CURRENT controls to their maximum (extreme clockwise) position. Set A-C POWER switch/circuit breaker on each ATE power supply to OFF.
3. Make all load interconnections as shown in Figure 3-25.
4. Set A-C POWER switch/circuit breaker of each ATE to ON. Observe output CURRENT meters and MODE lights on both units. Since the initial output voltage adjustments were not identical, one of the power supplies (designated Supply #1), will be at a slightly higher output voltage than the other (designated Supply #2), Consequently, Supply #1 will deliver its maximum load current and will operate in current mode (CURRENT MODE indicator on). The rest of the load current is delivered by Supply #2 which is operating in voltage mode (VOLTAGE MODE indicator on).
5. The CURRENT control of Supply #1 can now be adjusted to equalize the total load current between Supply #1 and Supply #2 and operation can proceed.



NOTE:
 Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

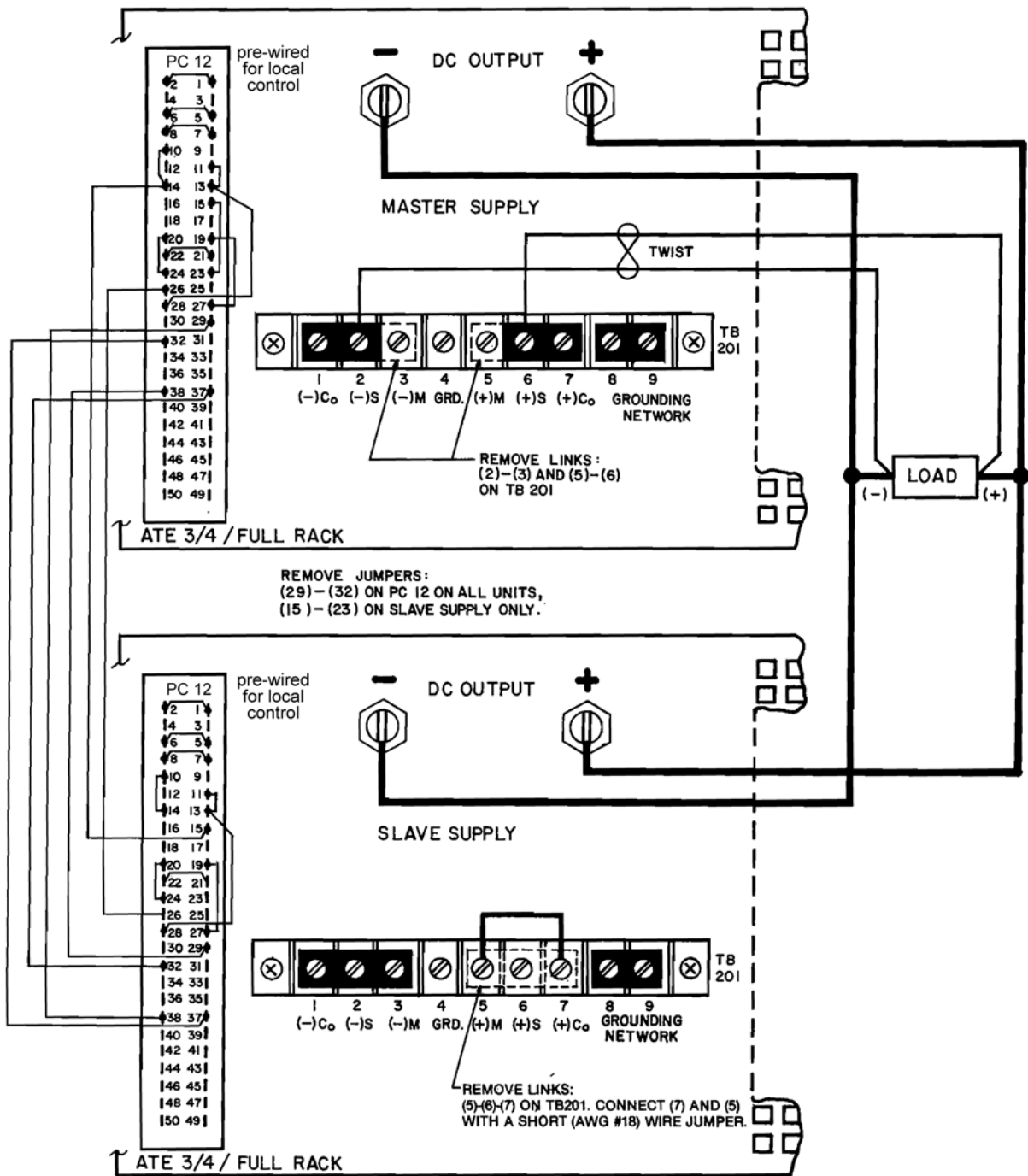
FIGURE 3-25. CONNECTIONS FOR AUTOMATIC PARALLEL OPERATION

3.12.2.2 MASTER/SLAVE PARALLEL CONNECTION

This method is especially convenient with ATE power supplies, since no external current sensing resistors are required and all control connections can be made via the ATE rear programming connectors. In Master/Slave parallel mode, the EXT. CURRENT COMPARISON amplifier on each Slave unit is disconnected from its 15V bias and is driven instead from the common Master CURRENT SENSING amplifier. As the Master supply delivers load current from zero to its rated maximum value, the signal from its CURRENT SENSING amplifier changes from zero to 1 Volt. This signal is applied to each Slave unit to program the output current of the Slave units from zero to maximum value. While all Slave units will operate in current mode, the Master unit can be operated in either voltage or current mode.

PROCEDURE

1. All power supplies to be paralleled must be able to deliver the required compliance (load) voltage. Before paralleling, set each power supply voltage control to this voltage.
2. Set A-C POWER switch/circuit breaker of each ATE to OFF. Make all load and sensing connections as shown in FIG, 3-26.
3. Set A-C POWER switch/circuit breaker of each ATE to ON. Observe front panel meters and MODE indicator(s). Adjust the Master supply output controls for either voltage or current mode operation. CURRENT MODE indicator(s) on all SLAVE supplies should be on.



NOTE:
 Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-26. CONNECTIONS FOR MASTER/SLAVE PARALLEL OPERATION

3.12.2.3 REDUNDANT PARALLEL OPERATION

Two ATE Power Supplies can be connected in parallel to a load in such a way that if one of the power supplies fails or is interrupted in any other manner, the other will continue to supply uninterrupted load current. The two power supplies must be isolated from each other by means of external diodes (D1, D2, see Figure 3-28) which must be rated for the maximum load voltage and current of the ATE units used.

The problem encountered in operating power supplies with overvoltage detection circuits in a redundant parallel configuration is that the overvoltage sensing leads are usually permanently wired to the error sensing leads. If an overvoltage occurs on either power supply, both supplies will shut down, defeating the purpose of the redundant circuit. In the ATE power supplies, provisions are made on the control circuit P.C. card (A1), to disconnect the overvoltage sensing from the error sensing terminal, and reconnect it to the output terminal thus successfully solving the problem described. (See Figure 3-27).

1. Disconnect both ATE units from source power. Remove covers from both ATE power supplies and refer to Figure 3-27 to locate A1 P.C. card. First disconnect C26 then move R48 as shown on Figure 3-27. This disconnects overvoltage sensing from the error sensing terminal.

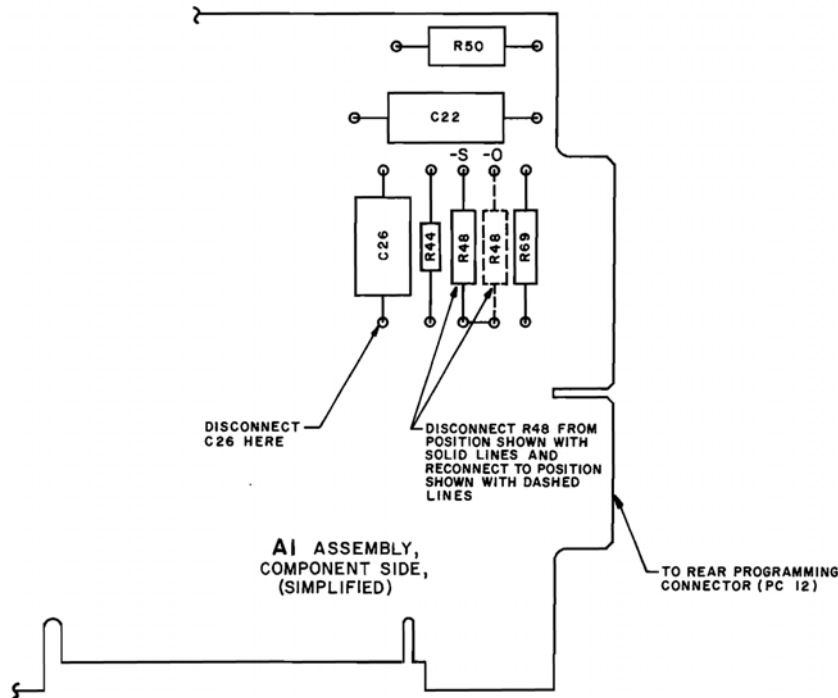
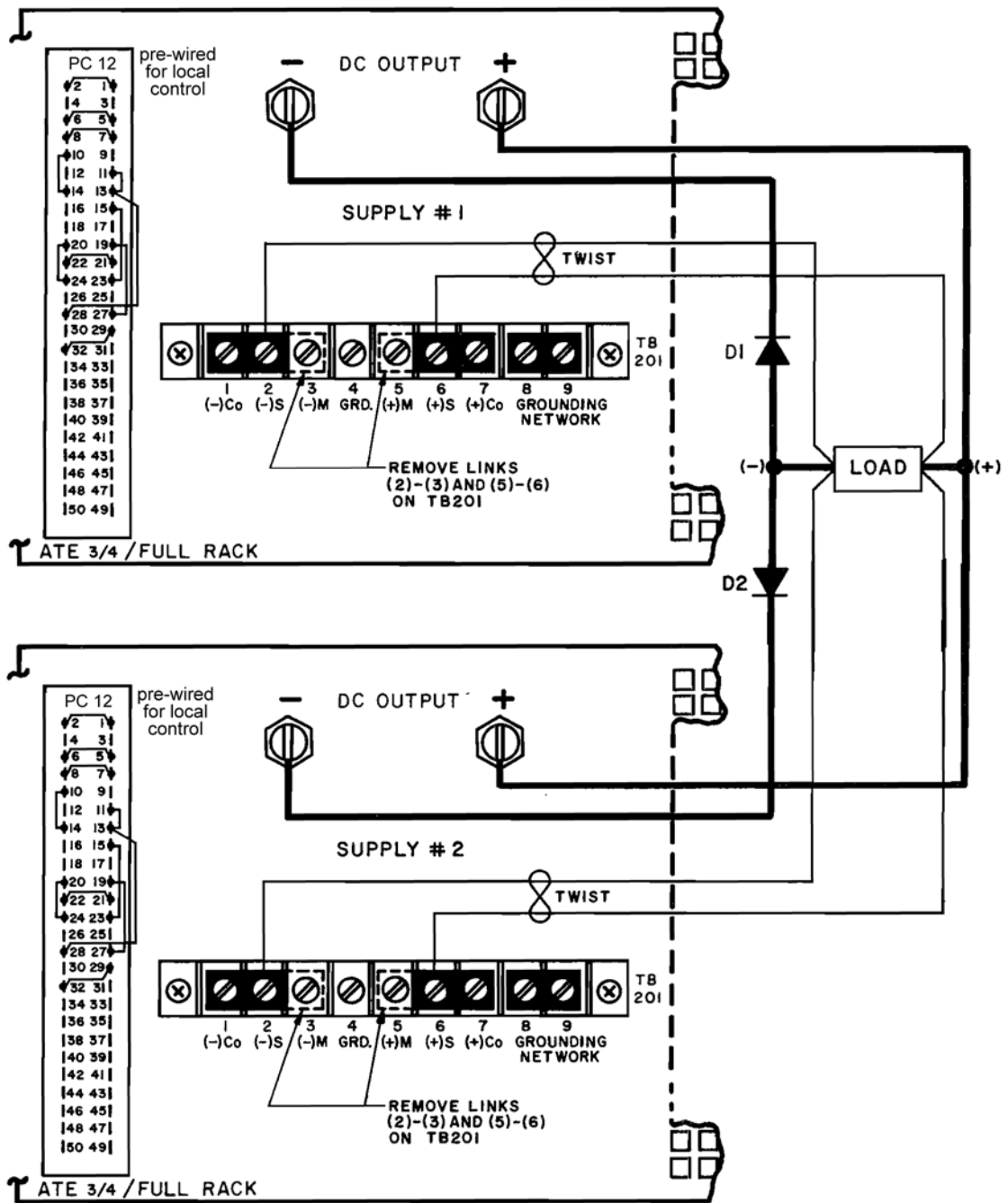


FIGURE 3-27. LOCATION OF OVERVOLTAGE SENSING LEAD DISCONNECT.

2. Replace ATE covers and make all load and sensing connections as shown in Figure 3-28.
3. Reconnect units to source power and set A-C POWER switch/circuit breaker of each ATE to ON. Set both ATE supplies to the desired load voltage. One of the ATE supplies (Supply #1) will invariably be at a slightly higher output voltage than the other (Supply #2). Supply #1 will consequently be in control of the load, while Supply #2 will be cut-off. If Supply #2 is desired as the controller, increase its output voltage slightly, until it takes control of the load as evidenced by the read-out on its front panel meters. It is recommended the loading be at least 10% of the rated maximum ATE output current.
4. Test the redundant parallel system by manually shutting off the a-c power on the controlling power supply. The other supply should now deliver the power to the load.



NOTES:

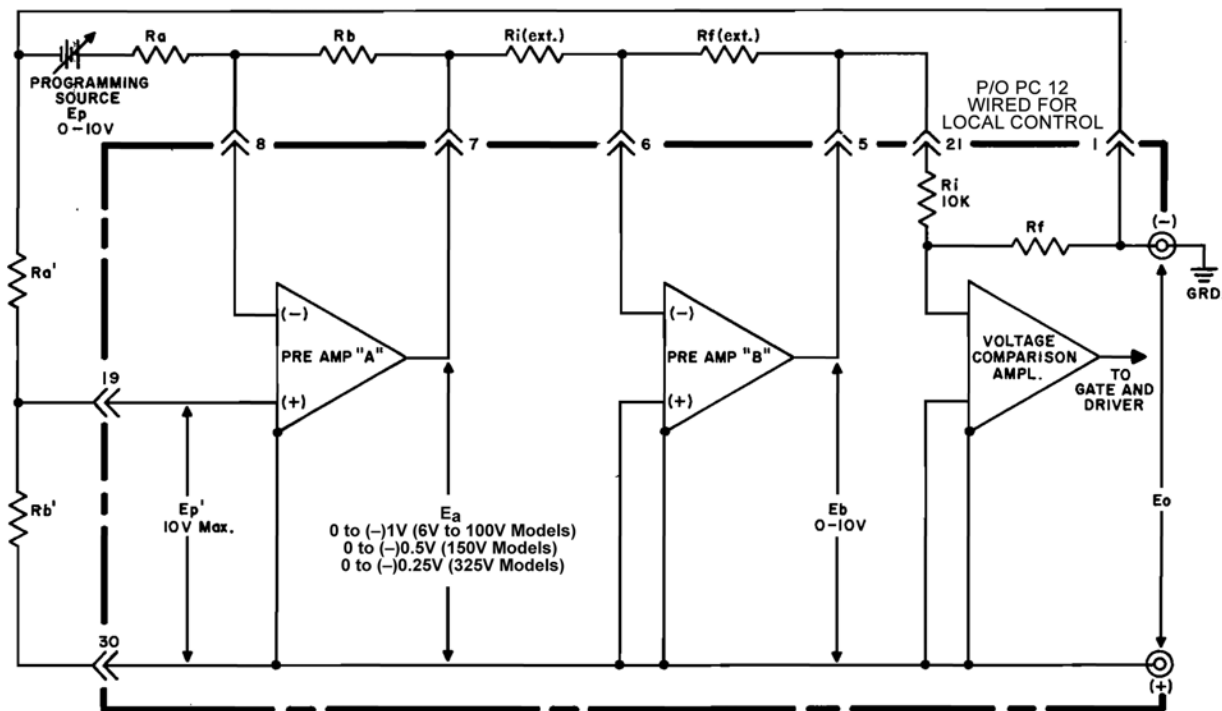
1. Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.
2. External diodes D1 and D2 isolate the two power supplies from each other, and must be rated for the maximum load voltage and current of the ATE units used.

FIGURE 3-28. CONNECTIONS FOR REDUNDANT PARALLEL OPERATION

3.13 PROGRAMMING WITH REFERENCE TO THE NEGATIVE POWER SUPPLY OUTPUT

ATE power supplies may be used in many unique applications. The two uncommitted ATE pre-amplifiers make it possible to solve application problems which would require special circuitry or additional equipment with standard power supplies. One example of such an application problem is the case where the programming common must be the negative output side of the power supply, rather than the positive side. With standard power supplies, either the programming source would have to be completely isolated, or an isolating interface would be required.

This problem is readily solved by using PREAMP "A" as a differential attenuator permitting a level shift of the programming source, while PREAMP "B" brings the programming signal back to the required level (0 - 10V) (see Figure 3-29).



Where:

- E_o = Power Supply Output Voltage
- E_a = PREAMP "A" Output Voltage
- E_b = PREAMP "B" Output Voltage
- $E_{p'}$ = Common Mode Voltage Limit (10 Volts max.)
- E_p = Programming Voltage
- $R_a = R_{a'}$
- $R_b = R_{b'}$ Voltage Divider Network

FIGURE 3-29. PROGRAMMING WITH REFERENCE TO THE NEGATIVE OUTPUT SIDE OF THE ATE

Component selection will depend on the parameters of the programming source and the ATE power output voltage. For example, an ATE model with an output voltage of 0 - 100 Volts is programmed through its full output voltage range by a programming source (E_p) of 0 - 10 Volts which can supply 0.1 mA. The negative output side of the ATE is grounded. Selecting the volt-

age divider (R_a' , R_b'), such that the common mode voltage, $E_p' < 10V$, we let $R_a = R_a' = 1$ megohm, $R_b = R_b' 100kOhms$ (except $R_b = R_b' = 49.9kOhms$ for 150V models and $R_b = R_b' = 24.9kOhms$ for 325V model). In this case the output voltage for PREAMP "A" can be expressed by:

$$(-)E_a = (E_p R_b) / R_a = 0 \text{ to } (-) 1\text{Volt}$$

NOTE: The equation for the standard differential amplifier is derived in Burr-Brown's "Operational Amplifiers."

The next step is to select the input resistor (R_i (ext.)) and the feedback resistor (R_f (ext.)) for PREAMP "B." Since an input voltage (E_b) of 0 to 10 Volts is required to drive the VOLTAGE COMPARISON amplifier (and thereby the power supply output voltage) over its rated range, the previously derived signal from PREAMP "A" must be reversed and amplified with a gain of 10 ((except gain = 20 for 150V models and gain = 40 for 325V models). PREAMP "B" is used in the inverting configuration, for which the output equation is:

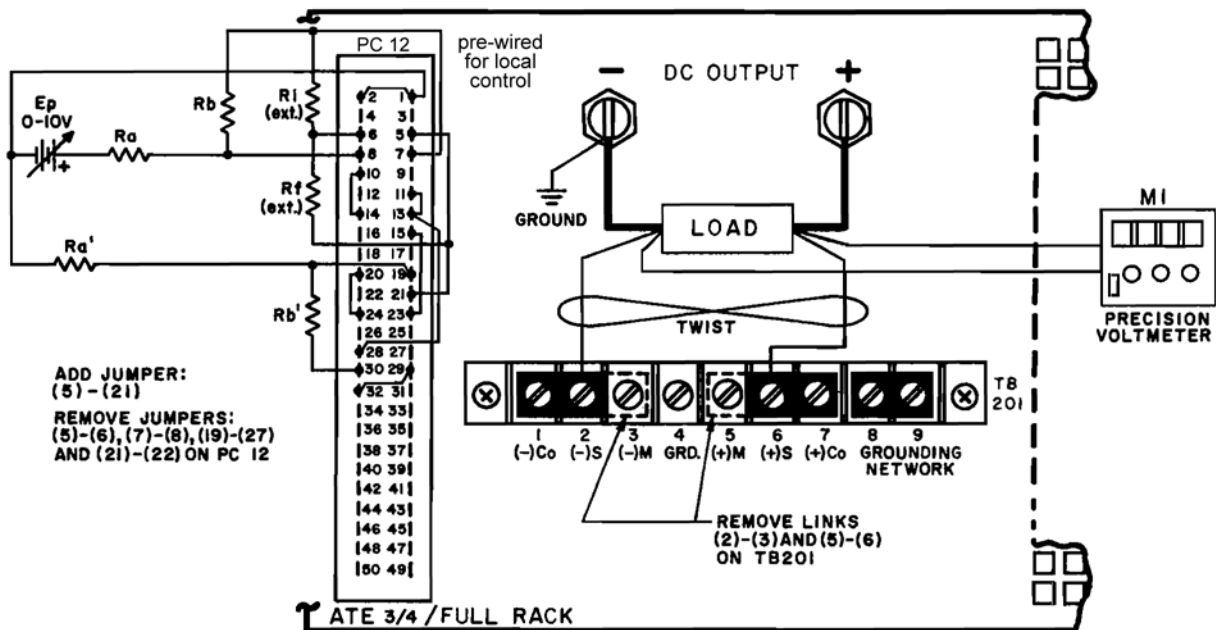
$$E_b = (-)E_a R_f(\text{ext.}) / R_i(\text{ext.})$$

If we select a 1k-Ohm resistor for R_i (ext.), then R_f (ext.) must be 10kOhms (except R_f (ext.) = 20kOhms for 150V models and except R_f (ext.) = 40.2kOhms for 325V models) to achieve the desired result.

Note: The selected resistors should be high quality components with a tolerance of 1%. For 325V models R_a and R_b should be rated 0.5W and 500V minimum. They should be wired as close to the rear programming connector terminals as possible.

PROCEDURE

1. Connect the external components, the LOAD and the Precision Voltmeter (M1) to the ATE as shown in Figure 3-30.
2. With the External Control Source at zero, set A-C POWER switch/circuit breaker to ON.
3. Vary the External Control Source from zero to 10 Volts. The ATE output voltage, as read on M1, should vary approximately from zero voltage to the rated value. Return the External Control Source to zero.



NOTE:

Remote sensing shown. For local sensing leave the links between TB201 terminals 2 (-) S and 3 (-) M and between terminals 5 (+) M and 6 (+) S in place. Disconnect remote sensing wires from TB201 terminals 2 (-) S and 6 (+) S to the load.

FIGURE 3-30. CONNECTIONS FOR PROGRAMMING WITH REFERENCE TO THE NEGATIVE POWER SUPPLY OUTPUT

3.13.1 USING FAST MODE WHEN PROGRAMMING WITH REFERENCE TO NEGATIVE OUTPUT

When the ATE power supply is used in Fast Mode with a programming reference to the negative output of the unit, some oscillation may be present at the output. This can be avoided by installing a ceramic capacitor between pins 1 and 2 of the PC 12 rear programming connector. The capacitor value is model dependent, within the range 1.2nF to 4.7nF, and it must be rated for more than the nominal output voltage of the unit. To optimize the configuration when using Fast Mode observe the following:

1. When the ceramic capacitor is installed at PC 12, pins 1 and 2, the 3-dB frequency bandwidth of the unit in FAST MODE is reduced by a factor of from 1.5 to 2.5. Correspondingly, the response time will be increased by the same factor.
2. To reduce the rise time delay, see NOTE of PAR. 3.7.
3. To reduce the fall time delay, adjust the current limit to a higher value than maximum application current to ensure that for the "high" level of the programming signal the unit is not forced to enter current limit mode.
4. To prevent the unit from going into overvoltage protection and shutting down when the low impedance programming source is disconnected, install a 10kOhm resistor (1%, 0.125W) at the input programming terminals of PC 12.

5. To reduce a-c line-related noise at the output, connect one of the following to the ATE chassis GND terminal:
 - the return of the programming source,
 - the corresponding output terminal of the ATE,
 - the corresponding Load terminal.
6. Make sure that all devices are tied to the same GND connection; it is recommended that all devices in use be powered by the same a-c outlet.

3.14 APPLICATION OF THE ISOLATED FLAG SIGNALS

Two opto-isolated flag signals are provided at the rear programming connector. One signal indicates ATE operating mode (Voltage Mode or Current Mode). The other signal indicates that the ATE crowbar has been tripped. Both flag signals consist of the collector/emitter terminals of a photo-transistor optical isolator and change their impedance from high to low if activated. The ATE flag signals may be converted to TTL logic signals as indicated in Figure 3-31. The photo transistors are capable of sinking at least one (1) standard TTL load (1.6mA). Since the crowbar flag signal is followed by the shut-down of the ATE power supply, the flag signal is forms a pulse, rather than a permanent level shift.

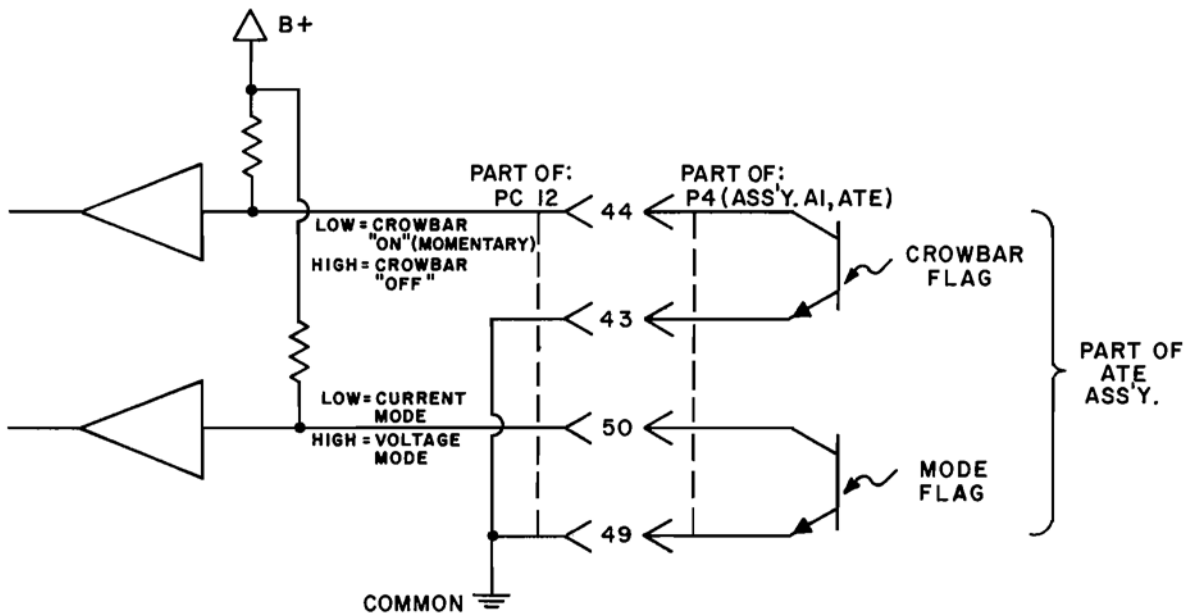


FIGURE 3-31. ISOLATED FLAG SIGNAL OUTPUTS.

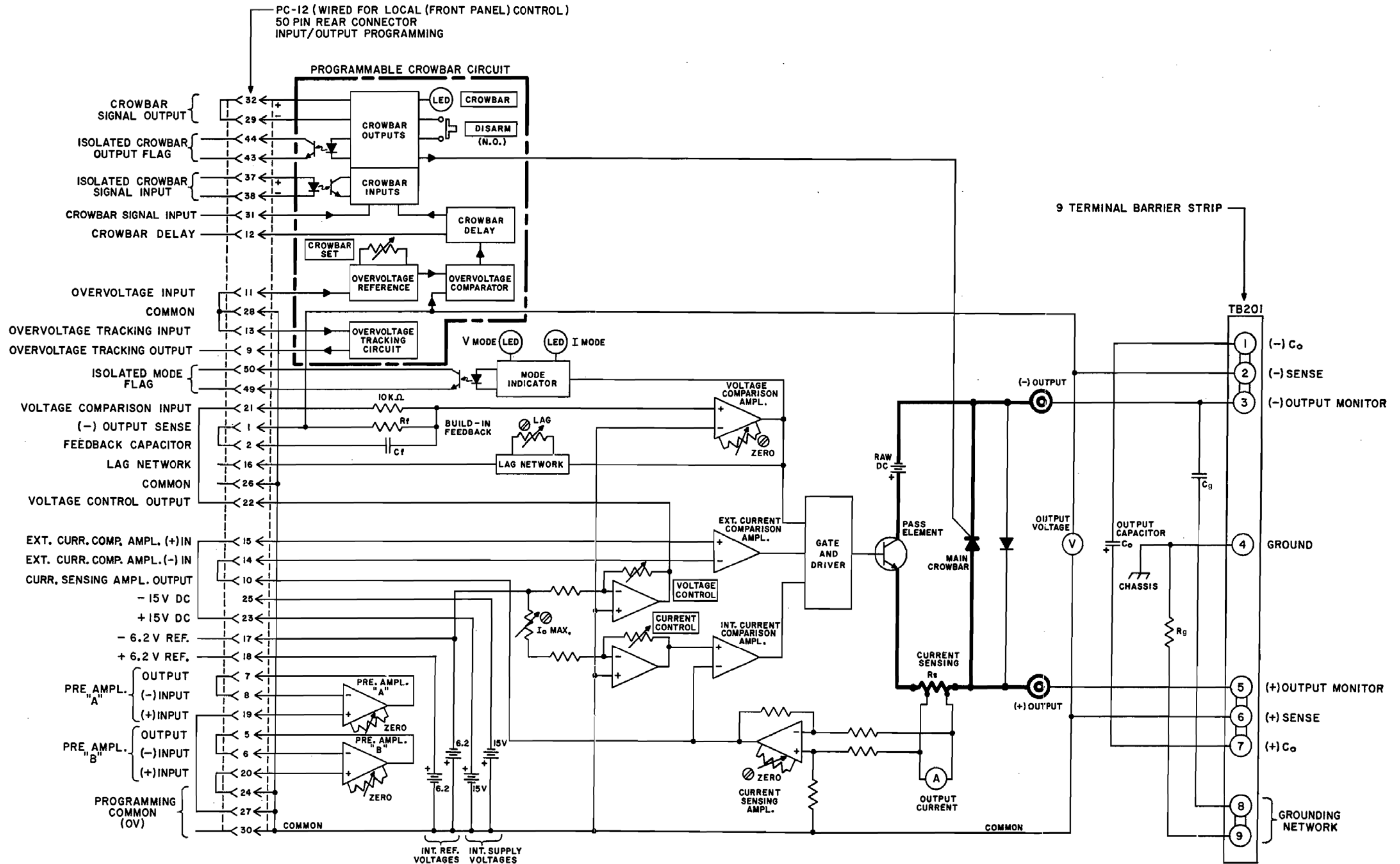
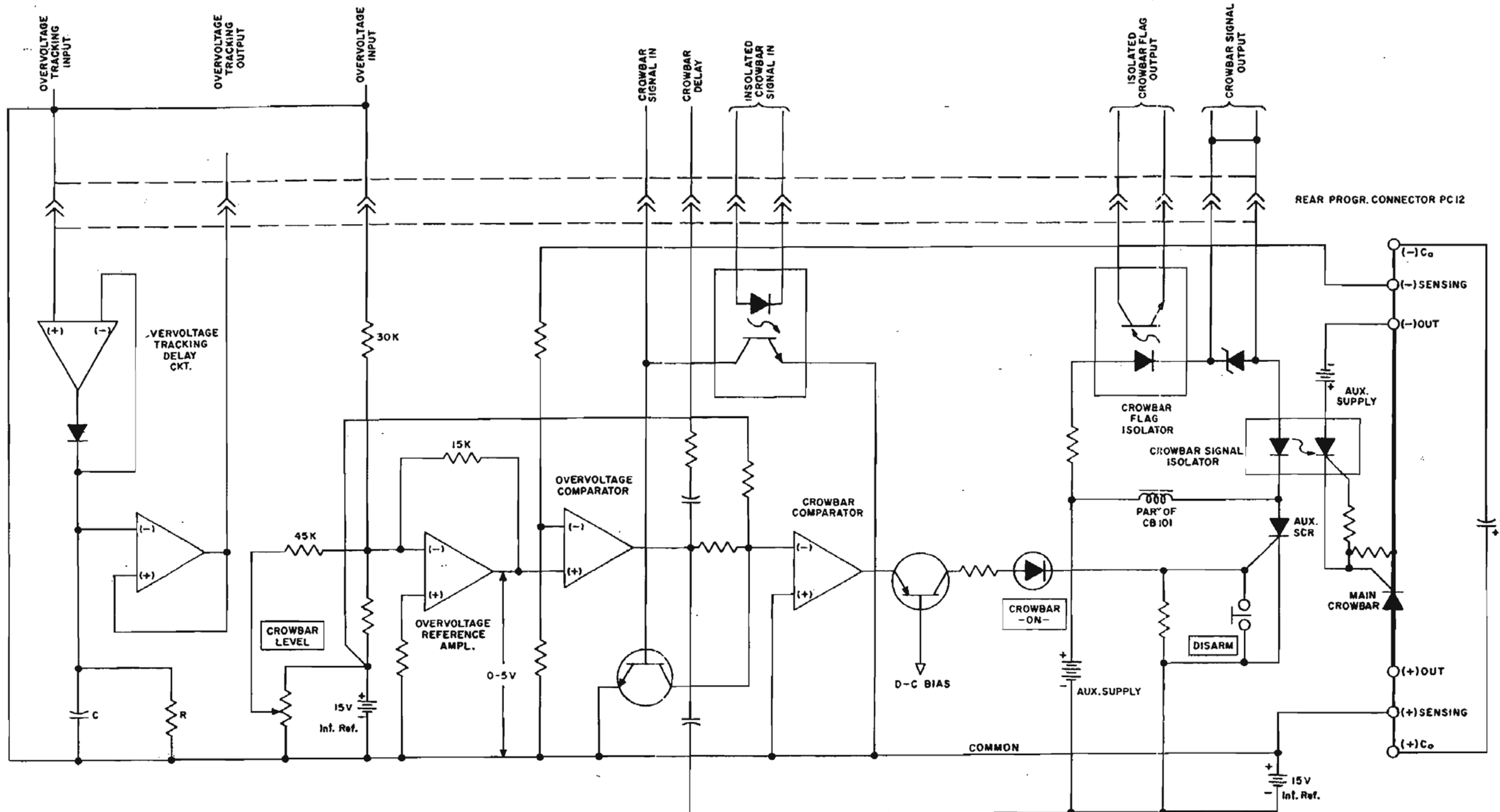


FIGURE 3-32. SIMPLIFIED SCHEMATIC DIAGRAM, ATE 1/2, 3/4 AND FULL RACK



NOTES: 1. NOMENCLATURE SAME AS IN MAIN SCHEMATIC DIAGRAM.
 2. JUMPER CONNECTIONS ON PC 12 ARE FOR FRONT PANEL (LOCAL) OUTPUT CONTROL.

FIGURE 3-33. SIMPLIFIED SCHEMATIC DIAGRAM, PROGRAMMABLE OVERVOLTAGE DETECTOR AND CROWBAR CIRCUIT

