Electronic Measurements

E/M

SCR 1Ø

MODEL ____________________

SER. No. ____________________

1 Ø SCR MANUAL

INSTRUCTION MANUAL

SCR SINGLE PHASE POWER SUPPLY

SECTION I

GENERAL INFORMATION

1.1 DESCRIPTION

This manual contains operation and maintenance instructions covering the Electronic Measurements, Inc. series of Single Phase SCR controlled power supplies. These supplies are constant voltage/constant current automatic crossover sources of regulated DC power packaged in 3½, 5½, and 7" high relay rack enclosures.

1.2 SPECIFICATIONS

The following specifications describe the published operational characteristics of this series of power supplies.

Number of package ratings: (4) - 500W, 800W, 1600W and 2400W nominal output.

AC INPUT: 500W, 800W and 1600W models, 117VAC ± 10% 47-63 HZ; 208/220 VAC ± 10% 47-63 HZ optional. 500W and 800W units shipped with line cord and plug. 1600W and 2400W units have barrier strip AC input. 2400W models, 208/220VAC ± 10% 47-63 HZ standard.

REGULATION:

VOLTAGE MODE: For line voltage variations and load current variations within the rating of the supply, the output voltage will not vary more than .1% of the maximum voltage rating.

CURRENT MODE: For line voltage variations and load voltage variations within the rating of the supply, the output current will not vary more than .25% of the maximum current rating.

RIPPLE: Measured with either positive or negative grounded and 100% output voltage and current into a resistive load. (See Rating Chart.)

STABILITY: The output voltage or current will remain within 0.05% for 8 hours after warm-up, with constant external effects.

TRANSIENT RESPONSE: Upon instant application of loads up to 50% or the maximum rating of the supply, the output voltage will recover to within 1.0% of its final value within 50ms. Instantaneous line variations are corrected for within 50ms of their occurance.

TEMPERATURE COEFFICIENT: Output voltage T.C. is 0.02% per degree C of maximum rating. Output current T.C. is 0.03% per degree of maximum rating.

OPERATING TEMPERATURE: 0-50 C with no derating required. Consult factory for output ratings at higher temperatures.

STORAGE TEMPERATURE: -40 to +85 C.

GENERAL:

RESOLUTION: The voltage control is a ten turn potentiometer. The current control is a one turn cermet type potentiometer.

INSTRUMENTATION: Voltmeter, ammeter and mode of operation indicator lights.

CONTROLS: Circuit Breaker on-off control voltage and current controls.

COOLING: All units are fan cooled and thermostatically protected. Air enters at sides of unit and exits at the rear. Consequently, no heat will be applied to other equipment above or below the power unit.

SIZE: 500W and 800W packages are 3½" x 19" x 18", 58 lbs. (89 x 483 x 457 mm, 26.4 Kg); and 2400W is 7" x 19" x 18", 150 lbs. (178 x 483 x 457 mm, 68.2 Kg). Weights are average for given package size.

RATINGS AND ADDITIONAL SPECIFICATIONS

VOLTAGE	CURRENT (AMPS)	CV-rms RIPPLE	CC-rms RIPPLE	% EFF. (NOMINAL)	AC INPUT CUR. @ NOM. AC INPUT
0-7.5	60	80mv	640ma	62	8
	100	75mv	1000ma	63	13
	180	80mv	1920ma	65	26
	250	80mv	2990ma	66	20
0-10	40	80mv	320ma	65	8
	80	75mv	600ma	65	13
	150	80mv	1200ma	68	26
	210	80mv	1680ma	69	19
0-20	25	80mv	100ma	67	8
	40	60mv	120ma	67	13
	80	80mv	320ma	70	25
	120	80mv	480ma	73	18
0-40	13	100mv	33ma	68	8
	20	60mv	30ma	68	13
	40	100mv	100ma	75	24
	60*	100mv	150ma	80	18
0-60	9	120mv	18ma	70	8
	13	70mv	15ma	70	13
	26	90mv	39ma	81	23
	40	90mv	60ma	81	18
0-80	6	150mv	11ma	75	8
	10	80mv	10ma	77	12
	20	120mv	30ma	83	21
	30**	100mv	35ma	82	18

RATINGS AND ADDITIONAL SPECIFICATIONS (CON'T)

VOLTAGE	CURRENT (AMPS)	CV-rms RIPPLE	CC-rms RIPPLE	% EFF. (NOMINAL)	AC INPUT CUR. @ NOM. AC INPUT
0-150	3	300mv	6ma	80	8
	5	150mv	5ma	80	10
	10	200mv	13ma	87	20
	15	200mv	20ma	84	18
0-300	1.5	500mv	3ma	84	8
	3	250mv	3ma	85	10
	5	300mv	5ma	87	20
	8	300mv	8ma	85	17
0-600	.75	1000mv	2ma	87	8
	1.5	700mv	2ma	87	10
	3	700mv	4ma	88	20
	4	750mv	5ma	85	17

* Specify Model No. SCR 40-58

** Specify Model No. SCR 80-28

FINISH: Front panel painted tan; markings are black silk screened.

All other metallic parts are either plated or chemical film treated. Exterior surface is gold irridite color.

NOTES: For operation at 50HZ, ripple and transient response are degraded by a factor of 30% from 60HZ ratings.

On those units in which the percentage of voltage or current ripple exceeds the specified load regulation, the load regulation will appear to be degraded due to the effect of this ripple on the measurement.

1.3 FEATURES

The single phase SCR line contains electrical and mechanical features, many of which will be described in additional detail in other sections. Some of these features are as follows:

- Circuit Breaker input protection.
- Optional adjustable over voltage protection.
- Remote programming of voltage and current by external voltage, current and resistance.
- Remote sensing.
- 10 turn high resolution voltage control.
- 1 turn, cermet (high resolution) current control. 10 turn current control optional.

1.4 COOLING

Each power supply enclosure is cooled by a suitable sized blower fan exhausting warm air to the rear. Fresh air intake is from each side. No surface of the supply radiates heat to adjacent equipment. At least five inches of space should be allowed behind the supply and one inch along each side in the vicinity of the air inlet holes for unimpeded air flow.

1.5 MECHANICAL

The supply is capable of being rack or bench mounted. For rack mounting, additional support other than that provided by the front panel is required, except for short term stationary mounting. Angle iron slide in mounting support or cross beam member support are required for permanent mounting. The sides of each supply are equipped with mounting holes for rack slide mounting.

Model numbers C-300-S-18, non tilt, C-300-B-18, tilting, and C-300-D-18, tilt lock, from chassis Trak Corp. are used for 500W and 800W power supplies. Model CSXX-Xsm/220300 from Emcor is used for 1600W and 2400W power supplies. For bench mounting, four mounting feet are provided which are adhesive mounted to the base surface of the supply.

1.6 INSTALLATION

This supply is intended for rack or bench mount. Horizontal mounting is preferred, however mounting in any position is allowed. DO NOT operate the supply continuously with the covers removed since the air flow pattern within the chassis will be adversely affected.

1.7 POWER REQUIREMENTS

A suitable source of AC power is required for this supply. The unit will operate on 50 or 60HZ line frequence. The line impedance from the power source should be fairly low since high peak currents are drawn. The service rating and connecting wire awg is in the table shown below. Note that this rating is not the actual specified line current, but a slightly higher service rating.

	120V SERVICE RATING	AWG	220V SERVICE RATING	AWG
500W 800W	15A	#14*	7.5A	#16
1600W	25A	#10	15A	#14
2400W			20A	#12

*This unit is supplied with 6' line cord and plug.

Load line power runs should be made with conductor sized to match the current ratings of the supply. The following chart may be helpful in determining the proper sizes.

CURRENT	RECOMMENDED AWG
200A	4/0
150A	2/0
125A	0
100A	1
80A	3
70A	4
50A	6
40A	8
30A	10
20A	12
15A	14
10A	16
8A	18
6A	20
LESS	20

SECTION II

OPERATING INSTRUCTIONS

CONTROLS AND INDICATORS

The front panel surface contains all the controls and indicators necessary to operate the supply in its normal mode. From left to right these include (1) Circuit Breaker - ON/OFF Switch (Illuminated) (2) DC Voltmeter (3) Voltage Adjustment Control and Mode of Operation Indicator Light (4) DC Ammeter (5) Current Adjustment Control and Mode of Operation Indicator Light.

2.2 GENERAL OPERATION

As shipped, the power supply is connected for local sensing, internal programming and nominal AC input as specified. The front panel voltage and current controls will set the boundary limits for the output voltage and current limits respectively. The impedance of the load will determine whether the unit is voltage or current controlled and the illumination of the respective mode indicator light will indicate the state. If either control is set to maximum counter-clockwise rotation, the other control will have little or no effect. Each control must be set to the appropriate position for the proper operation.

2.3 PREPARATION FOR USE

2.3.1 UNPACKING

Carefully unpack unit saving all packaging material and included enclosures. Inspect for possible shipping damage. Check that there are no broken knobs or connectors, that the external surface is not scratched or dented, that meter faces are not damaged, and that all controls move freely. Any external damage may be an indication of internal damage.

2.3.2 ELECTRICAL CHECK

Check that the barrier strip jumper straps are as shown in the figure depicting "normal local sense and programming configuration". It is recommended that the following brief electrical check be made shortly after unpacking the supply.

Set all controls to full counter-clockwise, turn the circuit breaker on/off switch to "off" and connect a short circuit to the power output studs on the rear panel. WARNING: Never attempt to remove the power from the supply be means of the barrier strip (terminals 1 & 8) since the wiring is not sized to handle the current capacity of the supply. Connect the supply to a suitable source of AC voltage. For this test only 50% of rated AC current is required. Turn the circuit breaker on/off switch to "on". The illuminated switch should light and the fan should start. There should be no output voltage or current. Advance the coltage control one turn clockwise and slowly advance the current control. The DC ammeter should deflect smoothly from zero to the rated current of the supply as this control is advanced to full clockwise. Return all controls fully counter-clockwise and turn supply off. Disconnect output stud short circuit. Turn supply "on" advance current control ¼ turn and slowly advance voltage control.

The DC voltmeter should deflect from zero to maximum rating of the supply. If any of these events does not occur, the supply is defective and should not be operated. Depending on circumstances, either warranty service or trouble shooting as described elsewhere in this manual is required.

2.4 MODES OF OPERATION

The following five paragraphs discuss the various standard and optional modes of operation built into the design of the power supply.

2.4.1 NORMAL MODE

When shipped from the factory, the supply is configured for local sensing and internal adjustment control. Local sensing is accomplished by having barrier jumpers in place between TB-1-1 and 2 and TB1-7 and 8. This connects the point of voltage sensing of the internal control circuitry to power output terminals. Therefore, regulation within the full capability of the supply is provided at the power output terminals. Internal or local voltage and current control is present when barrier jumpers are present between the following groups of terminals on TB-1: Connection of terminals 3, 4 and 5 connect the voltage programming current to the voltage sensing amplifier input and to the internal programming resistance (adjustment control). Connection of 6 and 7 connect the low side of the programming resistance to the negative remote point. Connections of 9, 10 and 11 interconnect the current programming current, the current sensing amplifier and the current programming resistance (current adjust control). Normal mode operation is usually used in most applications. All performance specifications unless otherwise stated are defined in this configuration. Ripple, programming speed, transient response and stability are optimized with the supply so configured.

2.4.2 REMOTE SENSING

In applications where the effect of the voltage drop (IXR) of the DC load wires would adversely affect the performance of the load, it is possible to sense the voltage at the load instead of the supply terminals. Remote sensing will therefore remove the effect of changes in load current through the power distribution system.

To operate in this mode, disconnect the jumpers between TB-1-1 and 2 and TB-1-7 and 8. Connect one end of a twisted pair of #20 AWG wires (shielded if strong AC or RF fields exist) to terminals 2 and 7 of TB-1 and the other end of the pair to the point of the load. The wire connected to terminal 2 must be terminated at the positive point of load and the wire to terminal 7 to the negative point of load. It is sometimes necessary, to assure stability to connect a capacitor within the range of .5 to 50ufD at the point of load or near the point of load at the point the twisted pair of sense leads join if the sense points are separated by some distance. If the capacitor used is electrolytic, be sure to observe polarity and voltage rating.

2.4.3 REMOTE PROGRAMMING

The supply may be operated in a remotely programmed mode (externally controlled) by the use of external resistance voltage or current control.

WARNING

If the control function is external programming fails so that the supply is programmed to voltage levels greater than 15% above ratings, damage to the electrolytic filter capacitors will occur. To protect against this, it is suggested that the over voltage protection module option be used which will limit the maximum voltage excursion and safely shut the supply down.

2.4.3.1 REMOTE PROGRAMMING, EXTERNAL RESISTANCE

Voltage Channel: Remove barrier jumper between TB-1-4 and 5. Connect the external programming resistance between terminal 4 and 6. The programming resistance is 5000 ohms for full rated voltage output. For any voltage output within the range of the supply:

$$R_{prog}\ (OHMS) = \frac{\text{DESIRED VOLTAGE}}{\text{FULL RATED OUTPUT}} \times 5000$$

Current Channel: Remove the barrier jumper between 10 and 11. Connect programming resistance between terminal 10 and 12. The programming resistance for full rated output is 100 ohms. For any current output within the range of the supply:

$$R_{prog}\ (OHMS) = \frac{\text{DESIRED CURRENT}}{\text{FULL RATED OUTPUT}} \times 100$$

2.4.3.2 REMOTE PROGRAMMING, EXTERNAL VOLTAGE

Voltage Channel: Remove barrier jumpers between 3, 4 and 5. Connect the source of voltage programming between terminal 4 (positive) and terminal 6 (negative). This source must float with respect to the output of the supply unless local sensing is used. A programming source of 0 to 5 volts drives the supply from zero to full rated output voltage.

Current Channel: Remove barrier jumpers between 9, 10 and 11. Connect the programming source between terminal 10 (positive) and terminal 12 (negative). The programming signal for zero to full output current is 0 to 100MV. A signal from a higher potential source may be attentuated to this 100MV level by a resistor divider. For best performance, the source impedance of this divider should not exceed 1000 ohms.

2.4.3.3 REMOTE PROGRAMMING, EXTERNAL CURRENT

Voltage Channel: Remove the barrier jumper between 3 and 4. Connect the positive terminal of the current source to terminal 4 and the negative terminal to terminal 6. A current of 0 to 1MA programs the supply from zero to full voltage output. The voltage adjust pot must be fully clockwise.

Current Channel: Remove the barrier jumper between 9 and 10. Connect the positive terminal of the current source to terminal 10 and the negative terminal to terminal 12. A current of 0 to 1MA programs the supply from zero to full current output. The current adjust pot must be fully clockwise.

2.4.2 PARALLEL OPERATION

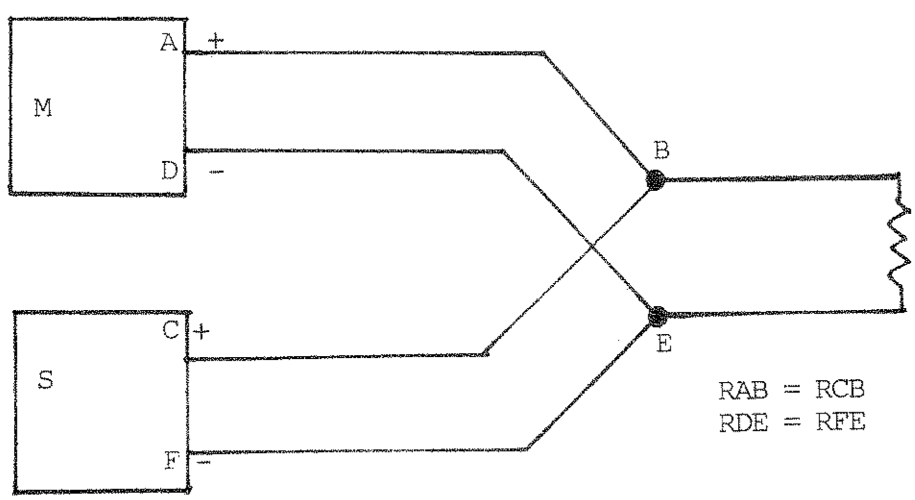
The SCR series power supplies are equipped with provisions for parallel operation.

2.4.4.1 PARALLEL OPERATION - DIRECT CONNECTION

The simplest parallel connection involves attaching the positive terminals of all supplies to be paralleled to the positive point of load and the negative terminals to the negative point of load. Equal wire lengths (impedances) should be used. Set all supplies to the approximate output voltage (open circuit). Turn off supplies and connect load. Set current limit to maximum. Turn on supplies one at a time until the sum of the supply current capability exceeds the load current drawn. Balance each supply voltage for equal current. Set current limiting just above the running current so that if a unit drifts up in voltage, it will become current limited rather than carry an excessive share of load current.

2.4.4.2 PARALLEL OPERATION - MASTER/SLAVE

In this configuration, one supply is designed "Master" and drives itself and other supplies connected to it to equal output current, without the benefit of the voltage or current circuits operative in the slaves. To use in this mode, disconnect the jumper between TB-1-13 and 14 on all slave supplies, (maximum 3) and connect a wire between the master supply TB-1-12 and TB-1-13 of each slave. Then, on each slave, disconnect the jumper between TB1 terminal 9, 10 and 11 and connect a jumper wire between TB-10 and 12. Turn each slave on and then the master. Adjust the master for required output voltage or current. The output leads from each power supply must be of equal resistance to a point of load near the supply to assure equal sharing. (See Fig.)



2.4.5 SERIES OPERATION

Two or more supplies may be operated in series simply by connecting the negative of one supply to the positive of another. Each units adjustment functions independently and the output is the sum of each unit output. No plus or minus voltage should exceed 600 volts with respect to chassis ground.

SECTION III

PRINCIPLES OF OPERATION

3.1 GENERAL

This power supply series converts alternating current within the rating of the particuliar unit into a regulated, adjustable direct current. The means of regulation and adjustment is by SCR phase control of the primary input alternating current. The DC output is obtained by rectification and L/C filtering. The block diagram below shows the major functional areas of the supply.

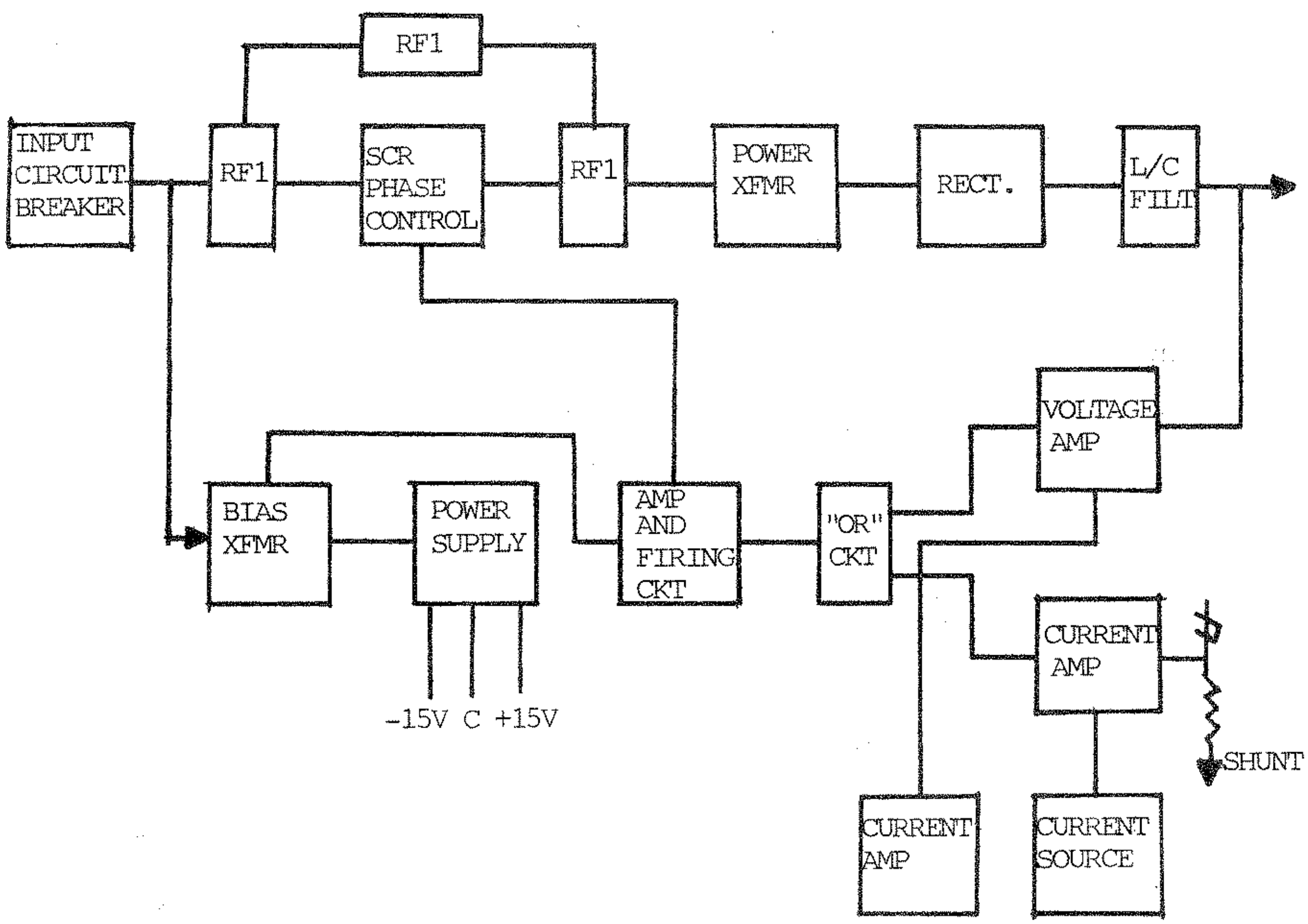


FIGURE BLOCK DIAGRAM

Power is applied to the bias transformer through the closure of the circuit breaker. The bias transformer energizes the ±15V bias supply which operates all control circuitry. It also provides a phase related signal for line frequency referencing the firing circuit. The firing circuit combines this AC signal with a DC level from an "or" circuit, the combination of which drives the phase control SCR's. The "or" circuit is driven from the over-riding signal from either the voltage comparator/amplifier or the current comparator/amplifier, whichever predominates, depending on control adjustment or load impedance.
The comparator/amplifiers are referenced by two stable current sources which develop a comparison voltage when driven through the voltage and current adjustment controls. These resultant voltages are compared to a portion of the actual output voltage and current in the comparator/amplifier. The DC output of the "or" circuit, which is proportional to the setting of the adjustment, controls the phase angle of the primary SCR's and therefore the DC output of the supply. The phase controlled AC signal is transformer coupled to a rectifier bridge and the resulting variable energy pulsating DC voltage is filtered (averaged and smoothed) in a L/C filter. Additional circuitry such as fans, mode indicators, metering. RFI suppression and frequency compensation which are also present will be discussed in detail later.

3.2 DETAIL THEORY OF OPERATION

The detailed theory of operation will be discussed my major functional areas and by the physical segregation of circuit functions in the unit. Major areas will include the power flow circuitry, circuit functions on the printed circuit board, metering and auxiliary functions. References to schematic symbol numbers are made to ease understanding and it is best to refer to the enclosed schematic while reading this section.

3.2.1 POWER FLOW CIRCUITRY

AC power is transformed from the line cord or input barrier strip (depending on model) through an RFI filter to an intermediate internal strip, through circuit breaker CB-1 to the SCR network and primary of the power transformer.
The SCR's are connected in reverse so that the AC waveform is positive Q_2 will conduct and when negative Q_1 will conduct. The alternate half cycle conduction of each SCR when delayed an equal period of time from zero axis crossings provides a partial sinusoid to the primary of transformer T-1. As the sine wave is delayed, the energy available in the resultant wave form is reduced and when it is advanced (toward a full sine wave) maximum energy is available.
Transformer T-1 converts the line voltage to the appropriate AC component of the load voltage and current. The secondary configuration is either full wave or full wave center tapped, depending on model. Diodes CR-1 through CR-4 or CR-8 (depending on model) rectify the phase controlled AC voltage from T-1. The pulsating DC is filtered by L-1 and C-1 and C-2. At load currents that allow L-1 to remain "critical" (continuous current flow) the filter averages the voltage waveform at the input of the filter. At very low load currents, the inductance is somewhat ineffective and the capacitor peak charges to provide filtering. The phase delay of the input waveform must be greater then 90 and capable of approaching 180 at low output voltage and current.

R-4 and C-4 form a snubber network across the SCRs to prevent false triggering due to dv/dt effects. L-2, L-3 and C-3 form an RFI suppression network which reduces the amplitude of the spike appearing in the DC output voltage each time an SCR conducts. R-10 and C-7 minimize the effects of diode commutation by absorbing high frequency energy. Resistors R-5-A through N act as a preload to assure stability of the loop and to improve the transient response when a load is suddenly disconnected from the supply.

3.2.2 CIRCUIT FUNCTIONS ON THE PRINTED CIRCUIT BOARD

The PC board contains a bias transformer and power supply, current and voltage channel current sources, the fixed portion of the programming resistors, voltage and current channel comparator/amplifiers, an "or" circuit, mode of indicator drivers, a DC amplifier with soft start circuitry, the SCR phase control and pulse generation circuitry, the necessary loop frequency compensation networks and the barrier terminal strip necessary for alternate operating configuration of the supply.

The bias transformer has two center tapped secondaries. Terminals 5 and 7 produce 50 volts RMS with respect to the center tap terminal and provide oppositely poled polarities for line frequency referencing the SCR firing circuit. Terminals 8 and 10 produce 20 volts RMS with respect to terminal 9. This voltage when full wave produces plus and minus voltages on capacitors C-106 and C-107.

The control circuitry of the supply uses a ±15VDC bias level. Plus 15V drain is about 150Ma and minus 15V drain is 30Ma. These voltages are regulated in the bias power supply. Q-103 is used as an emitter follower driven from the voltage level on Zener Diode CR-108, to produce the positive 15 volts. Resistor R-111 and Zener Diode CR-109 regulate the negative supply.

The signal necessary to provide control over the SCR firing circuitry is derived from amplified samples of a portion of the output voltage and current compared to the set point levels of the adjustment controls. The voltage signals produced at the adjustment controls are proportional to a constant reference current multiplied by the value of the resistance of the adjustment control in the circuit at any time.

A separate constant current reference is provided for the voltage and current channel. The collector current of Q-108 drives the voltage channel and Q-109 the current channel. These current sources are referenced by the voltage across CR-121, a 1N823A temperature compensated Zener Diode. Since the voltage difference across the summing junction of IC-101 (terminals 8 & 9) is essentially zero, the voltage across the series combination of R-143 and R-144 (also R-145 and R-146 since the Vbe of Q-108 and Q-109 is essentially equal). A constant voltage across a fixed resistance produces a constant current. The current level from each of these sources is adjustable to 1Ma by R-143 and R-145.

The reference current level for the voltage channel flows from terminal 3 of TB-1. With jumpers on terminals 3, 4 and 5 the voltage level produced when this current flows through R-6 (the voltage adjustment plot) is applied to pin 13 (a unity gain buffer amplifier) and then to pin 1 of IC-101.

The signal on the other amplifier input of IC-101, pin 2 is derived from the output voltage level by the voltage division of R-137 (& R-138) and R-139. Maximum voltage output of the supply produces 5 volts DC at pin 2 of IC-101. Through the action of the feedback loop, as resistor R-6 (the voltage adjustment pot) is increased in value, the voltage at pin 1 of IC-101 increases. The error signal developed at the output of IC-101, pin 3 causes a proportional change in output voltage which produces a voltage on pin 2 of IC-101 equal to that applied to pin 1.

The action of the current channel is identical to the voltage channel with the exception that the controlled quantity is the current that flows through shunt R-11. The voltage level that this current produces is applied to one input of IC-101, pin 5 while the current adjustment pot R-7 develops the reference potential applied to pin 6 of IC-101. The level of the signal applied to pins 5 and 6 of IC-101 is 0 to 100Mv.

The outputs of the voltage channels comparator/amplifier IC-101 and the current channel comparator/amplifier are "ored" together in diodes CR-113 and CR-114. Whichever IC output is positive over rides the effect of the other, and represents that channel controlling the DC output. A positive going signal at the cathode of diodes CR-113 and CR-114 reduces the output of the supply by retarding or delaying the conduction of the primary SCR's.

The mode indicator lights are also driven from the outputs of IC-101. Whichever output (pin 3 or 4) is negative illuminates the respective light emitting diode indicator.

Transistor Q-104 amplifies and level shifts the control signal from CR-113 and CR-114. The normal operating voltage at the collector of Q-104 is 6.5V and a swing of $\pm$1 volts will range the supply from no output to full output. The lower the collector voltage on Q104 the lower the output of the supply. There are some functions also accomplished in the Q-104 stage. R-117 and C-113 form a "soft start" network which reduces the turn on surge and allows bias levels to build up before output current is permitted. R-150, C-123, Q-105, CR-122 and CR-123 resets the soft start circuitry. Thermostat TS-1 is placed across C-113, and when an over-temperature condition exists, the output voltage is inhibited by closure of the thermostat. The voltage signal developed across R-118 is a source of feedback through C-115 and R-120 and C-114 and R-119 to stabilize the current and voltage channels respectively.

CR-112 functions as a peak conduction angle limiter for the SCR's by limiting the maximum positive voltage on Q-104.

The SCR firing pulses are developed by properly timed conduction of Q-101 and Q-102. This is accomplished by the combination of the phase related AC signals from terminals 5, 6 and 7 and the variable DC level from Q-104.

Examining the firing circuit for one SCR only, R-108 and CR-115 produce a 12V square wave at line frequency with axis crossings at 0 and 180 . R-106 and C-104 integrate the square wave into rising and falling ramp voltages with transition in voltage direction occurring just past 0 and 180 due to phase shifting effect of RC networks.

When a positive DC level from Q-104 is superimposed on the ramp voltage C-104, the base of Q-101 will be driven into conduction sometime during the positive travel of the ramp. This conduction causes a rapid flow of collector current in Q-101 and resulant pulse of gate trigger current in SCR Q-2. Operation of the opposite driving circuit is identical except for 180 pulse displacement which fires Q-1 when its anode is positive. C-101 and C-102 store the SCR gate pulse energy and C-103 serves as an energy reservoir to prevent pulse loading of the +15V supply. Resistor R-147 functions as a balance control to equalize SCR firing angles. Additional loop compensation is provided by R-131 and C-119 voltage channel, CR-108 and R-134 in current channel.

3.3.3 METERING AND AUXILIARY FUNCTIONS

Voltage monitoring is achieved by connection of a self contained DC voltmeter to the sensing terminals of the supply. Output current is measured using a shunt related DC ammeter connected across the shunt R-111. Calibration of this meter is made by adjustment or R-8. The unit is cooled using fan B-1 and is powered upon closure of the circuit breaker. On 3½" units operated on 220V AC, a series resistor is inserted with the fan. The circuit breaker is equipped with an auxiliary trip coil that operates in conjunction with the optional over voltage protection module. It can also remotely shut the supply down whenever 5 amps of DC flows through terminals C-1 and C-2 of the breaker.

SECTION IV

MAINTENANCE AND TROUBLE SHOOTING

4.1 GENERAL

The power supply is divided into two basic circuit areas, power flow and signal control. The power flow circuitry consists of circuit breakers, SCR's, power transformer, rectifiers, choke and capacitors as well as the cabling interconnecting them. The signal control circuitry is contained on the removable printed circuit card. Most unit malfunctions will originate on the circuit card.

An understanding of the theory of operation of the supply is useful in trouble shooting the supply. Also necessary is the following basic test equipment: Source of AC power, means of loading supply, a voltmeter with accuracy and resolution better than the unit specifications and an oscilloscope. The chart that follows is a trouble shooting guide that should aid in finding operational problems in the supply.

<u>WARNING</u>: When servicing supply, dangerous voltage levels exist. Be especially careful of person and equipment when measuring primary circuitry since this is at line potential.

4.2 TROUBLE SHOOTING GUIDE

1. Unit blows fuse or opens circuit breaker immediately on turn on.	a. Control circuit defective.	a. Remove J-1 and reapply power. If accepted, problem is in PCB. If not, an SCR is probably shorted.
	b. SCR shorted.	b. Replace.
	c. CR-1 through CR-4 shorted.	c. Replace.
2. Unit goes to high output immediately (may also clear input protection).	a. Control circuit defective.	a. Remove plug which contains pins S, T, U, V, X, W and reapply power. If accepted, problem is in PCB. If not, an SCR is probably shorted.
	b. Both SCR's shorted.	b. Replace.
	c. Programming control open.	c. Check pots and interconnecting wiring.

3. Unit puts out high ripple.	a. C-1 through C-4 defective.	a. Replace.
	b. Unit is oscill-ating.	b. Problem's in control circuitry.
	c. Only one SCR is conducting.	c. Check for sym-metrical wave form across pair of SCR's.

4.3 CONTROL CIRCUIT TROUBLE SHOOTING

Since the entire supply is closed loop circuit, the failure of a single component can have its result presented far from the source. For this reason, trouble shooting any but obvious defects must be done by understanding of the power supply theory and effecting a repair.

1. Does 115VAC reach plug with T and S?
2. Is the voltage on T101-6 and 5, and T101-6 and 7, (on PCB) 50 volts RMS? If not, T-101 may be defective.
3. Is the voltage on T101-9 and 8, and T101-9 and 10, 20 volts RMS? If not, T-101 may be defective.
4. Is the square wave across CR-105 equal in amplitude to CR-106? If not, unequal SCR conduction will occur opening input protection.
5. Are ramps across C-104 and C-105 equal?
6. Does the voltage across C-101 decay rapidly to zero each time Q-101 is forward biased (1.4V since a Darlington Transistor)? Same with C-102?
7. Are there SCR firing pulses at U and V and X and W? Do they arrive at SCR's?
8. Is the DC voltage level at T-1-6 approximately 7 volts?
9. Does IC-101 feel warm to the touch? A failure of this amplifier in output stages causes current to flow through the chip producing heat.
10. Is ±15 volts DC present on B1 and C1 with respect to A1? If not check for problems in the bias supply section.
11. As R6 is rotated from zero to maximum, does the voltage across it cary from zero to 5 volts DC? If not, IC-101 or Q-8 may be defective.
12. As in 11, if R7 is rotated does its voltage vary from zero to 100Mv?
13. On 220V models, is fuse F-1 blown?

4.4 CALIBRATION

There are four calibration controls on the Single Phase unit.

4.4.1 AMMETER CALIBRATION

To calibrate the ammeter, connect a reference DC ammeter equal to the rating of the unit across the output terminals of the supply (do not forget to use a shunt with a shunt rated ammeter). Turn the supply on and adjust the output current for full output current. Adjust R-8 until the unit ammeter equals the reading on the external reference ammeter.

4.4.2 PROGRAMMING CALIBRATION

Resistors R143 and R145 are included to provide approximately 8% variation of the voltage and current channel programming current. Their adjustment depends on the requirements of the user. In the local programming mode they should be adjusted so as to allow full output at or near maximum pot rotation. For external resistance programming, they may be adjusted for an exact programming constant.

4.4.3 ZERO OFFSET

When both voltage and current controls are fully clockwise, the power output is nearly inhibited. At the factory R-154 is selected in test to slightly suppress output current into a short circuit. In the voltage channel into an open circuit a slight voltage may appear at the output. This is caused by current bypassing on Q1 and Q2 through the snubbers C4 and R4 and RFI bypass C3. Additional output preloading will minimize this effect.

4.4.4 FIRING BALANCE

R147 balances the firing angles of Q1 and Q2. At the factory it is adjusted until equal amplitude of AC input current waveforms is achieved. In field use, should adjustment be required, set R147 for even peak voltages from cycle to cycle of the DC output.