INSTRUCTION MANUAL
FOR
VOLTAGE REGULATOR
Models: SR4F & SR8F
Part Numbers: 9 0597 00 108
through
9 0597 00 111

Basler Electric
Highland, Illinois

Publication Number: 9 0597 00 99X
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Revision B: December, 1987

WARNING

To prevent personal injury or equipment damage, only qualified technicians/operators should install, operate, or service this device.

CAUTION

Meggers and high potential test equipment should be used with extreme care. Incorrect use of such equipment could damage components contained in the device.

It is not the intention of this manual to cover all details and variations in equipment, nor does it provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Should further information be required, call Basler Electric Company, Highland, Illinois.

REV	ECA
A	8298
B	9694

TABLE OF CONTENTS

SECTION 1.0

GENERAL INFORMATION

1.1 DESCRIPTION

This manual contains a description, principles of operation, installation and operation instructions, maintenance and troubleshooting information, outline, schematic and interconnection drawings pertaining to the following voltage regulators manufactured by Basler Electric Company.

Model Number	Part Number
SR4F1 (Single Phase Sensing)	90 59700 110
SR4F3 (Three Phase Sensing)	90 59700 109
SR8F1 (Single Phase Sensing)	90 59700 108
SR8F3 (Three Phase Sensing)	90 59700 111

1.2 PURPOSE

These regulators are used to precisely control the output voltage of an ac power generating system. They regulate the generator voltage by controlling the amount of current supplied to the exciter or generator field.

1.3 APPLICATION

These regulators can be used with any generating system that has exciter or generator field power requirements within their ratings (See Table 1-1). This includes brush type rotary exciters, brushless rotary exciters, or direct excitation into the generator field. Table 1-1 lists the regulator sensing voltages below 600 Vac. These regulators can also be used on high voltage (above 600 Vac) generating systems when appropriate step-down potential transformers are used.

Table 1-1. Specifications

Sensing (Terminals E1, E2 and E3)		
Voltage	120/208/240/416/480/600 Vac	
VA (Maximum Continuous)	Less than 10 VA per line.	
Input Power (Terminals 3 and 4)	SR4F	SR8F
Voltage	108-132 Vac	180-264 Vac
Burden	840	1680

	SR4F	SR8F
Output Field Power (Terminals F+ and F-)		
Maximum Continuous	63 Vdc at 7A	125 Vdc at 7A
Maximum Forcing	90 Vdc at 10A	180 Vdc at 10A
DC Field Resistance (Min.)	9 Ohms	18 Ohms
Frequency	50/60 Hz	
Voltage Regulation	Less than ±1/4%	
Response Time	Less than 1 cycle	
EMI (Electromagnetic Interference)	MIL-STD-461B, Part 9, UM04	
(See figures 3-2 and 3-3 for interconnection requirements).	Conducted, Radiated, or Susceptibility	
Voltage Adjust Range	±10% of Nominal Voltage	
Overvoltage Limiting:		
Factory set -	162 Vac, 324 Vac	
Adjustment Range	156-168 Vac, 312-336 Vac	
Ambient Operating Temperature	-55°C +70°C (-67°F to +158°F)	
Storage Temperature	-65°C to +100°C (-85°F to +212°F)	
Temperature Coefficient	Less than ±1/2% for 50°C (122°F) temperature change (after 20 minutes warm-up)	
Power Dissipation	Less than 60 watts	

Vibration - Tested to withstand 1.3G from 5 to 26 Hz, 0.036" displacement from 26 to 52 Hz and 5 G's from 52 to 260 Hz.

Mounting - Designed to be mounted directly on gasoline, diesel or turbine-driven generator systems.

Parallel Compensation (Terminals 1 and 2)	Accepts 5 Amperes (5 VA) from external current transformer Droop Adjustable to approximately 5% of nominal voltage
Overall Dimensions	
Height	17.750 inches
Width	13.5 inches
Depth	8.0 inches
Weight	Approximately 50 pounds

Finish - Dark green, lusterless, textured, baked enamel.

1.4 GENERAL

The SR4F and SR8F voltage regulators are solid state, contain no electrolytic capacitors and have a solid state build up circuit. They are relatively unaffected by temperature, humidity, vibration or shock and conductive dust. (See Table 1-1.) All components are mounted in a formed sheet-metal enclosure.

1.5 STANDARD FEATURES

1.5.1 EMI Suppression

These regulators contain an internal electromagnetic interference filter (EMI). This filter reduces the EMI level to within the specifications of MIL-STD-461B, Part 9, UM04, conducted, radiated, and susceptibility, and C.I.S.P.R. Publication 11A and VDE 0878/6.77 Dated June, 1977 ("G" and "N" limits for conducted and "G", "N", and "K" limits for radiated). To meet this specification, the regulator chassis must be mounted within its enclosure, the F+ and F- leads must be a twisted shielded pair grounded only at the regulator chassis, and the 6 and 7 leads to a remotely mounted voltage adjust rheostat (if used) must be a twisted pair grounded at both ends.

1.5.2 Parallel Compensation

These regulators contain the necessary provisions for parallel generator operation. The only external component required is a current transformer to sense generator line current. The regulator can be operated parallel droop compensation (reative droop compensation) or parallel cross-current compensation (reactive differential compensation). The current transformer should have a standard 5 ampere secondary rating. The CT burden of the parallel compensation circuit is 5 VA.

1.5.3 Overvoltage and Underfrequency Limiting

These regulators contain internal circuitry that limits overvoltage conditions to approximately 162 Vac for the SR4F and 324 Vac for the SR8F. This limit is adjustable (±5%) by R52 located on the PC board. The regulator is designed to withstand the stress of continuous underfrequency operation as low as 30 Hz. However, the regulator will attempt to maintain rated voltage independent of frequency. Therefore, the exciter field winding or other magnetic equipment could be damaged by continuous underfrequency operation.

1.5.4 Voltage Stability Provisions

Each regulator contains the internal circuit components necessary for voltage stability on brush type exciter applications, brushless exciter applications and when the regulator is operated as a static exciter directly into the generator field.

1.6 ACCESSORIES

a. The following accessories are available for use with the SR4F and SR8F voltage regulators.

(1) Power Transformers
(2) Paralleling Current Transformers
(3) Excitation Support Systems (Series Boost Options)
(4) Underspeed-Overvoltage Control Modules (UFOV)
(5) Manual Voltage Control Modules (MVC)
(6) Volts-Per-Hertz Sensing Modules

b. Information covering these accessories may be obtained by consulting the applicable instruction manual or product bulletin or by contacting your nearest Basler Electric Sales Representative or Basler Electric Company, Highland, Illinois.

SECTION 2.0

PRINCIPLES OF OPERATION

2.1 FUNCTIONAL CIRCUITS (Refer to Figure 2-1)

2.1.1 General

The voltage regulator senses the generator output voltage, and compares a sample of that voltage with a reference voltage and supplies the field power necessary to maintain the predetermined ratio between the generator voltage and the reference. The unit consists of four basic sections: Voltage sensing, printed circuit board, power controller and parallel compensation.

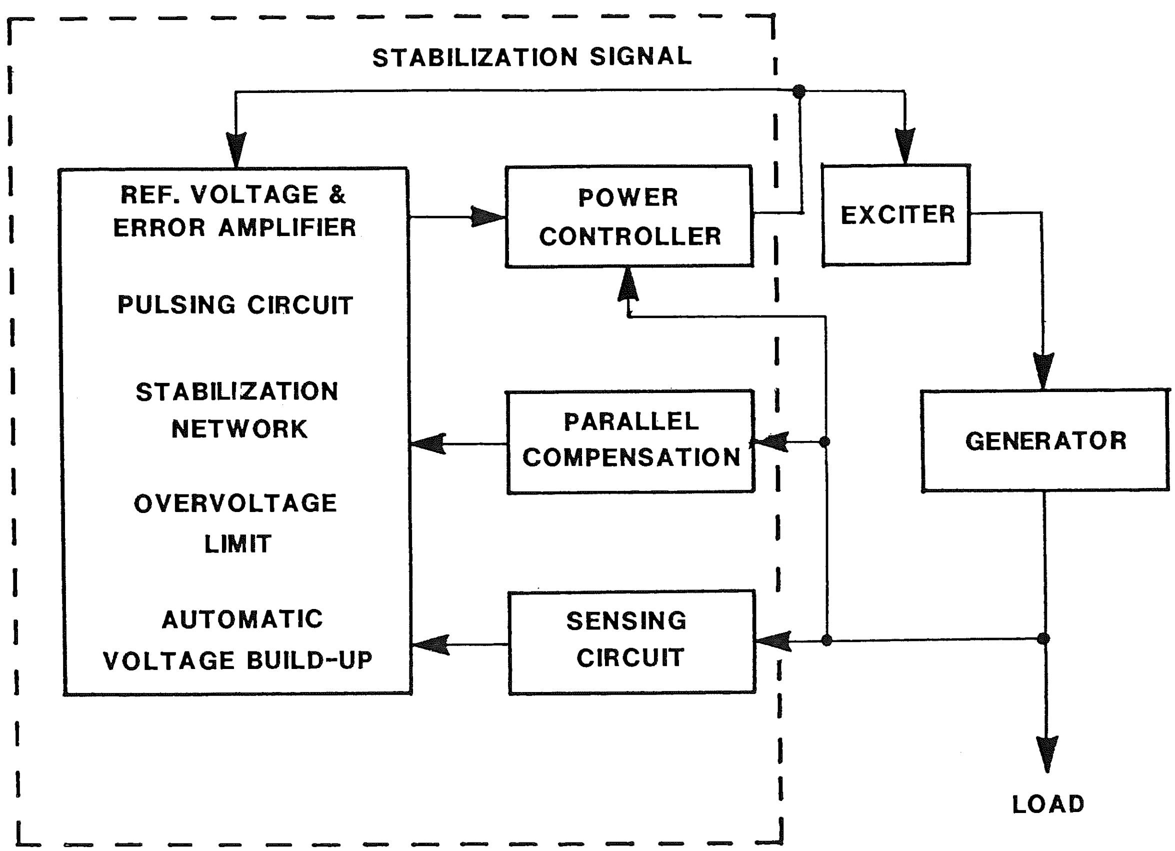


Figure 2-1. Voltage Regulator Block Diagram

2.1.2 Voltage Sensing

The voltage regulator senses the generator ac voltage on terminals E1 and E3 on single phase sensing models and on terminals E1, E2 and E3 on three phase sensing models. Sensing transformer(s) step down the voltage which is converted to dc by diodes on the printed circuit board and filtered by a choke. This filtered dc signal is applied to the integrated circuit on the printed circuit board.

2.1.3 Printed Circuit Board

The printed circuit board contains the following:

a. Integrated Circuit (I.C.) - The I.C. contains the reference voltage and error amplification circuitry.

b. Pulsing Circuit - The pulsing circuit contains a unijunction transistor. Its output pulses fire (turn on) the SCR's (thyristors) in the power controller circuit. The conduction time (when SCR's are fired) is determined by the I.C.

c. Stabilization Networks - The unit contains the various stability circuits for brush type exciters, brushless exciters and static exciter applications. The circuit required can be selected by the stability selection links on terminal strip TS2. Also provided is a stability adjustment potentiometer R11.

d. Voltage Range Adjustment - Potentiometer R14 varies the range of the external voltage adjust rheostat.

e. Overvoltage Limit - This overvoltage circuit limits the voltage applied to the regulator power input (terminals 3 and 4) to approximately 162 Vac for the SR4F and 324 Vac for the SR8F.

f. Automatic Voltage Build-Up Circuit - Voltage build-up is accomplished without a relay or other moving parts.

2.1.4 Power Controller

The power controller circuit consists of SCR's (thyristors) and diodes. The conduction time of the SCR's and the resistance of the field winding determine the amount of current supplied to the exciter field.

2.1.5 Parallel Compensation

This circuit allows paralleled generators to share reactive loads and reduce circulating currents between them.

SECTION 3.0

INSTALLATION

3.1 MOUNTING

This unit is convection cooled and should not be mounted near heat generating equipment or inside totally enclosed switchgear where the temperature rise could exceed its operating limit. Vertical mounting is recommended to obtain optimum convection cooling. Refer to Figure 3-1 for dimensions and mounting holes.

3.2 ELECTROMAGNETIC INTERFERENCE FILTER

WARNING

To prevent an electrical shock hazard, the regulator chassis must be connected to the power system ground because filter capacitors are connected between the ac line and the regulator chassis.

a. The grounding stud for the EMI filter is located at the bottom of the regulator cabinet. Normally, a good metal-to-metal (unpainted surface) electrical connection from this stud to the system power ground will reduce EMI to an acceptable level. The power system ground is that point to which all exposed metal parts such as generators, switchgear, metal walkways, steelwork of buildings, etc., are bonded together and grounded so that dangerous potentials cannot exist between them.

b. It should be noted that a good electrical ground is not necessarily a good EMI ground; therefore, on applications with stringent EMI suppression requirements, the ground lead to the regulator should be kept as short as possible. A copper strap with a width 1/5 of its length is recommended. On applications involving radio reception, EMI suppression can be further improved by connected the system ground to earth ground.

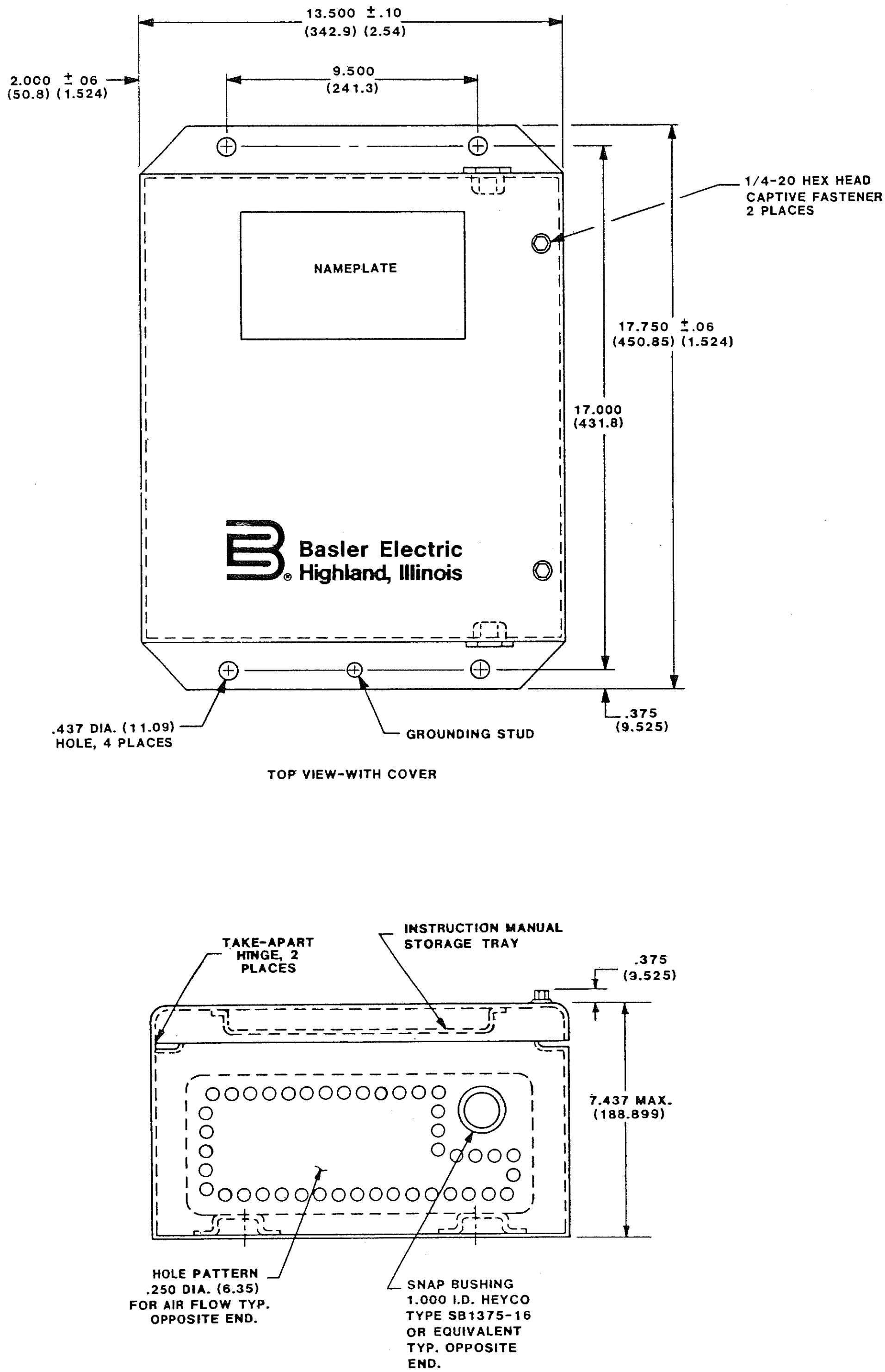


Figure 3-1. Outline Drawing

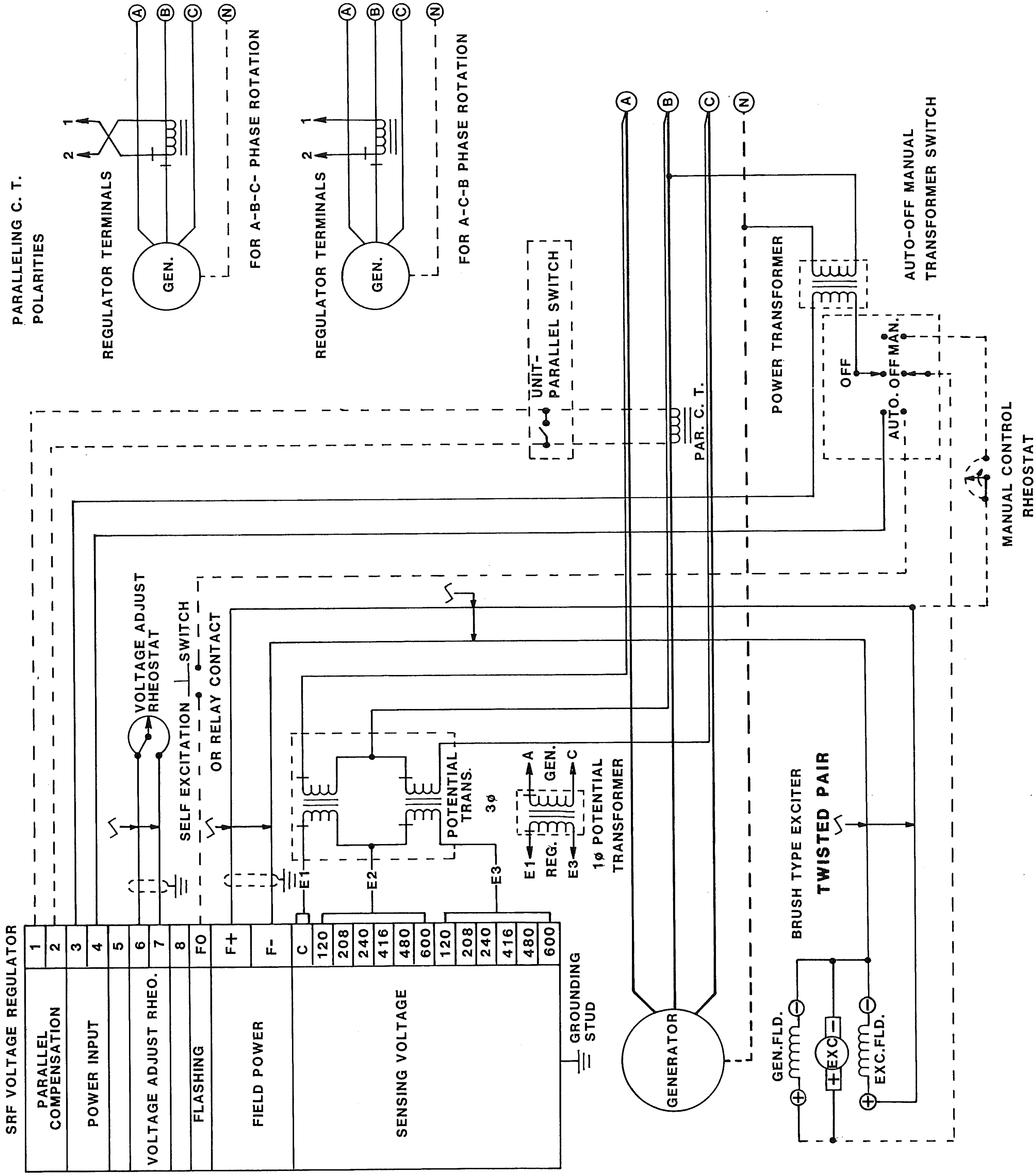


Figure 3-2. Brush Type Rotary Exciter Interconnection Diagram

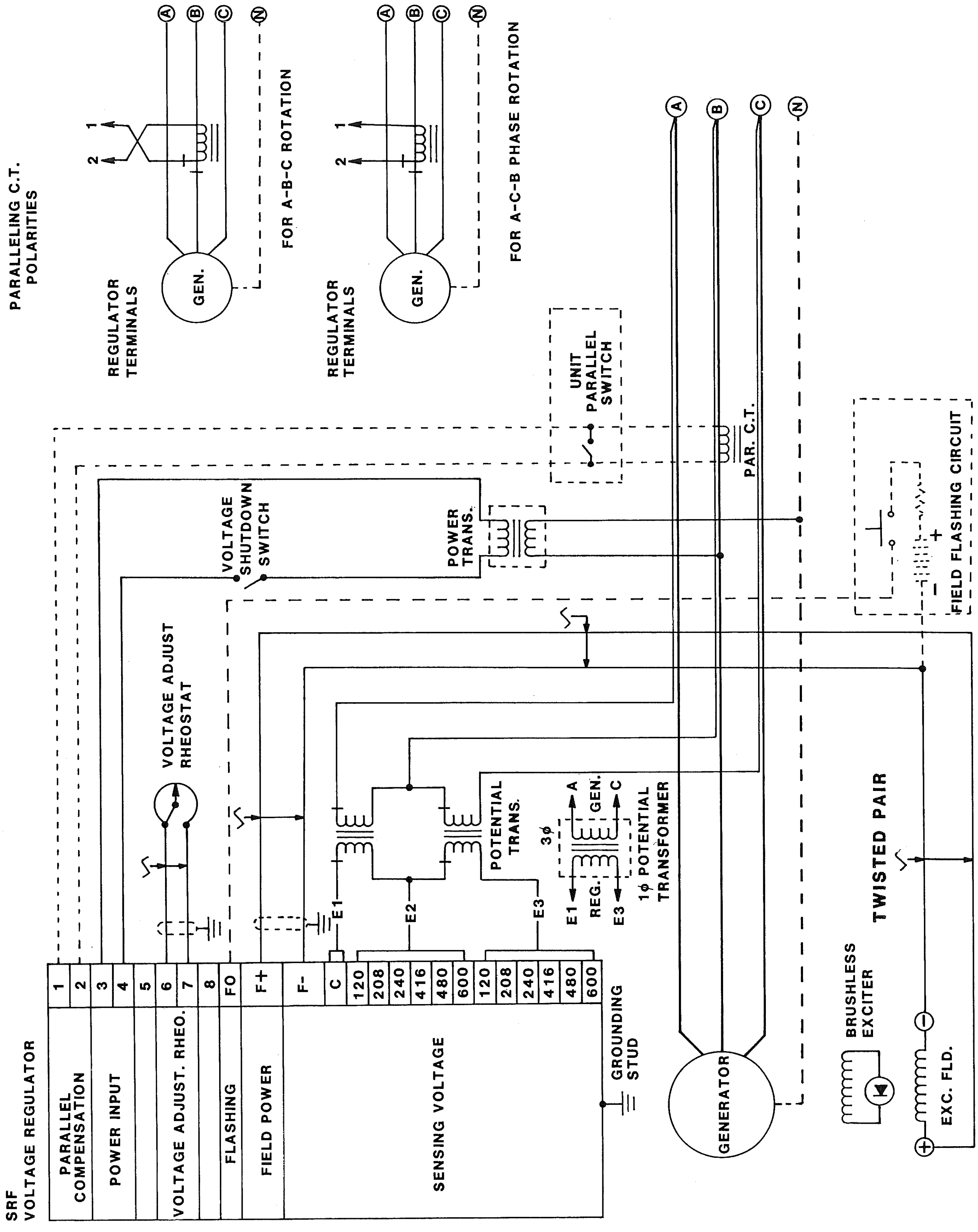


Figure 3-3. Brushless Exciter and Static Exciter Interconnection Diagram

3.3 INTERCONNECTION

CAUTION

Meggers and high potential test equipment must not be used. Incorrect use may destroy the regulator.

3.3.1 General

The regulator must be connected to the generator system as instructed in this section and as shown in the basic interconnection diagrams (Figures 3-2 and 3-3). Number 14 gauge wire (or larger) should be used for all connections to the regulator.

3.3.2 Voltage Regulator Sensing (Terminals E1, E2, and E3)

a. The regulator has an internal sensing transformer(s) T1 (T2) with taps for sensing voltage of 120, 208, 240, 416, 480 and 600 Vac. Single phase sensing models have transformer T1. Three phase sensing models have two transformers, T1 and T2. All the taps for the various sensing voltages are brought out to the regulator terminal strip. The sensing connection is made to the terminal with the voltage that matches the generator voltage to be sensed. On single phase sensing models, the sensing leads are connected to terminal E1, and to the corresponding voltage terminal under E3. On three phase sensing models, the sensing leads are connected to terminal E1 and the corresponding voltage terminal under E2 and E3.

b. On generating system with voltages above 600 Vac, instrument type potential transformers must be used to step down the voltage to match one of the regulator sensing voltages. The regulator sensing circuit load is less than 10 VA per phase.

c. For precise regulation, the sensing leads should be connected as closely as possible to the point where regulation is desired. The regulator regulates the voltage applied to its sensing terminals and cannot correct for cable or bus voltage drop that may occurs at points other than where the sensing leads are connected. The sensing leads should not be used to supply the regulator power stage (terminals 3 and 4) or any other equipment. The regulators sense average values of generator voltage (not RMS).

3.3.3 Field Power (Terminals F+ and F-)

The maximum continuous output current of these regulators is 7 Adc (see Table 1-1). The dc resistance of the field into which the SR4F operates must be 9 ohms or more. The dc resistance into which the SR8F operates must be 18 ohms or more. If the resistance is less, additional resistance must be added in series with the field. This resistor plus the field resistance must exceed the preceding minimum values. Consideration must also be given to the resistor wattage rating. (Refer to the example in paragraph 3.3.3.1). When adding resistance in series with the field it must not limit field forcing during load application.

3.3.3.1 The following example shows how to select a series field resistor.

EXAMPLE

An SR4F voltage regulator is required to operate into an exciter field with a dc resistance of 6 ohms. The exciter field current requirement is 2 Adc at no load and 4.5A at full load 0.8 pf. Since the SR4F requires a minimum field resistance of 9 ohms, at least 3 ohms additional resistance are required. We select a 5 ohm resistor and connect it in series with the field. This results in a total impedance of 11 ohms. With this additional resistance added, the no load regulator output voltage is 22 Vdc. The full load regulator output voltage is 50 Vdc. The regulator is now operating into an impedance above its minimum rating protecting it against overcurrent damage. Its output during full load is less than 63 Vdc insuring good field forcing capability. We complete our calculations by determining that the maximum exciter field current during forcing will be approximately 8 amps (90 Vdc/11 ohms = 8 amps). Therefore, the minimum resistor rating should be 320 watts. (8A times 8A = 64 times 5 ohms = 320 watts (I^2R = W).

3.3.3.2 When making connections to the rotary exciter, polarities should be observed. The regulator F+ terminal connects to the exciter field positive terminal and the F- terminal to the negative terminal. With brush type rotary exciter applications, it is important to observe polarities between generator field, exciter output and exciter field. They should be as shown in the interconnection diagram, Figure 3-2. If the polarities are not known and the system has manual voltage control, polarities can be determined by operating the system on manual voltage control before connecting the regulator.

3.3.4 Field Flashing Input (Terminals FO and F-)

a. The regulator contains an internal automatic voltage build-up circuit; therefore, external flashing should not be required. However, if the generator residual voltage is less than 10% of rated voltage, flashing may be necessary. The dc flashing source connects to F- and FO. An internal blocking diode prevents the regulator output current from flowing into the flashing source.

b. The dc flashing current should not exceed 1/2 of the no load exciter field current. If necessary, connect a current limiting resistor in series with the FO terminal.

c. The field flashing source must be removed after nominal generator voltage is obtained. This can be accomplished with a pushbutton or switch on manual field flash applications, and with a relay an automatic field flash applications. If a relay is used, it should sense the generator voltage and open the flashing circuit at approximately 70% of rated voltage. On automatic field flashing applications, provisions (such as speed switch) must be made to open the field flashing circuit when the generator is secured (not rotating). For proper connection instructions, refer to interconnection diagram, Figure 3-3. Also review paragraph 3.3.7 if the flashing source is grounded.

3.3.5 <u>Modified Voltage Regulator Input (Terminals 5 and 8)</u>

These terminals are used only on special modified versions, for which special wiring instructions will be provided to explain their use. Connections must not be made to terminals 5 and 8 when used in normal ac generating systems.

3.3.6 <u>Voltage Adjust Rheostat (Terminals 6 and 7)</u>

The external rheostat is rated 500 ohms, 25 watts. It connects across terminals 6 and 7. Figure 3-4 shows outline and mounting dimensions and the jumper connections.

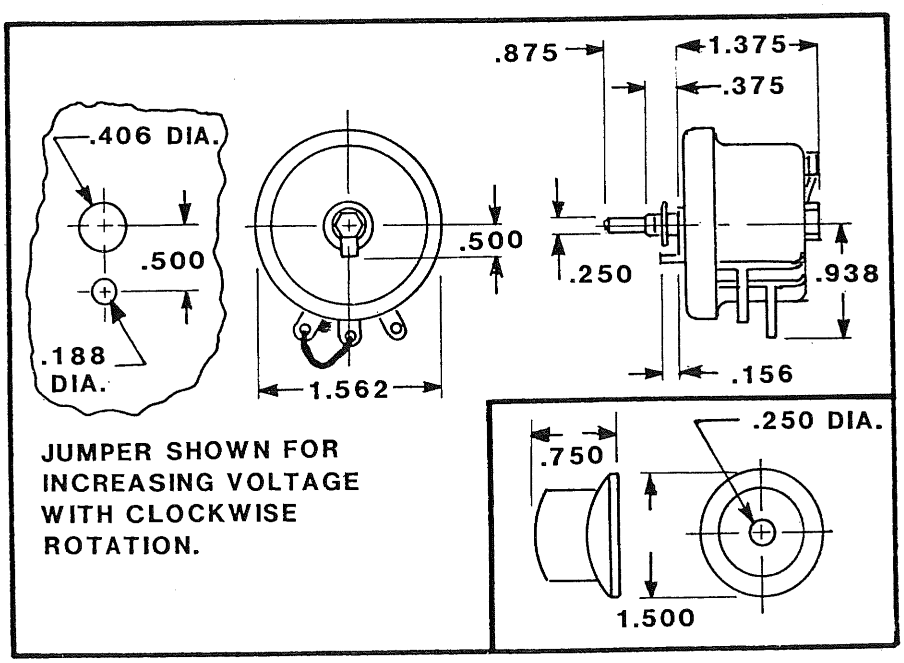


Figure 3-4. Outline Drawing, Voltage Adjust Rheostat P/N 06874

3.3.7 Power Input (Terminals 3 and 4)

a. The maximum continuous input rating is 840 VA for the SR4F, and 1680 VA for the SR8F. (See table 1-1). The current requirements of the field into which the regulator operates determines the actual input VA for a particular application. The nominal voltage applied to the regulator power input stage (terminals 3 and 4) must be 120 Vac for the SR4F and either 208 or 240 Vac for the SR8F. The input power may be taken from any generator lines that provide this voltage (line to line or line to neutral). On single phase sensing model regulators, it is recommended that the input power be taken from a phase other than the one used for regulator sensing.

b. If the generator voltage available is different than these values, a power transformer must be used to match the generator voltage to the regulator power input. If the field or field flashing circuit is grounded, a power isolation transformer must be used to isolate the regulator input from ground. Failure to use an isolation transformer may result in open fuses and regulator damage.

3.3.8 Parallel Compensation (Terminals 1 and 2)

Complete parallel installation instructions are included in Section 5.0.

SECTION 4.0

OPERATION

4.1 GENERAL

Before initial operation, review this section and section 3.0 to be certain that the installation and operation instructions are understood and followed. Also review the application interconnection drawings, Figure 3-2 or 3-3.

4.2 VOLTAGE SHUTDOWN

a. A switch may be installed in series with the voltage regulator's power input stage terminal 3 or 4. This allows voltage shutdown in an emergency or when the generator prime mover is operated at reduced speed. If such a switch is not furnished, it is recommended that one be temporarily installed during initial operation. When used, this switch must always be in series with one of the regulator's power input lines, terminal 3 or 4.

CAUTION

The field circuit (terminals F+ and F-) must never be opened during operation. If opened, a dangerously high flyback voltage will develop.

b. A voltage shutdown circuit using field discharge resistors must not be used; it can cause damage to the regulator. Such a shutdown method is not required. Safe voltage shutdown can be accomplished as described in the above paragraphs.

4.3 VOLTAGE REGULATOR ADJUSTMENT

a. All necessary regulator adjustments are described in the following paragraphs. These adjustments are made before and during initial operation; additional adjustments are not usually required during the life of the regulator.

b. The voltage adjust rheostat is mounted external to the voltage regulator. It is normally set so that a mid-range adjustment results in nominal generator voltage. When adjusted to its maximum resistance position (CCW), minimum generator voltage is obtained. Maximum generator voltage is obtained with minimum resistance (CW).

4.3.1 Voltage Range Set Adjust (R14)

Potentiometer R14 is located on the etched circuit board. It provides a means of varying the limits of the external voltage adjust rheostat. Normally, the external voltage adjust rheostat is set to mid-range and R14 adjusted for rated generator voltage. This allows an external voltage adjust range of ±10%.

4.3.2 Stability Adjustment (R11)

Potentiometer R11 is located on the printed circuit board. It provides a means of adjustment for stable voltage operation by controlling the amount of feedback signal. Normally it is factory set near the extreme clockwise (CW) position. This setting usually assures good stability, but tends to slow the transient response. If the potentiometer (R11) is rotated CCW, response time becomes faster. If rotated too far CCW, the voltage may oscillate (hunt). It should be rotated CW well beyond the point where instability occurs. Voltage stability is usually most critical at no load. If a setting is desired that provides the fastest possible voltage response with good generator stability, an oscilloscope or other voltage recording instrument should be used. The stability potentiometer R11 operates in conjunction with the stability selection links described in the next paragraph.

4.3.3 Stability Selection Links (TS2) (Refer to Figure 4-1)

The stability selection links are part of terminal strip TS2 located on the printed circuit board. With these links the regulator's two basic stability time constants can be changed. These are "exciter" time constant and "generator" time constant. The "exciter" time constant can be changed to "fast" or to "slow". The "generator" time constant can be changed to "fast", "medium", or "slow". These two links provide six different time constant selections. Each time constant operates in conjunction with the stability adjust potentiometer R11 to provide a wide range of stability adjustment. The stability time constant provided allows operation on applications consisting of brush type rotary exciters, brushless rotary exciters and a static exciter operating directly into a generator field.

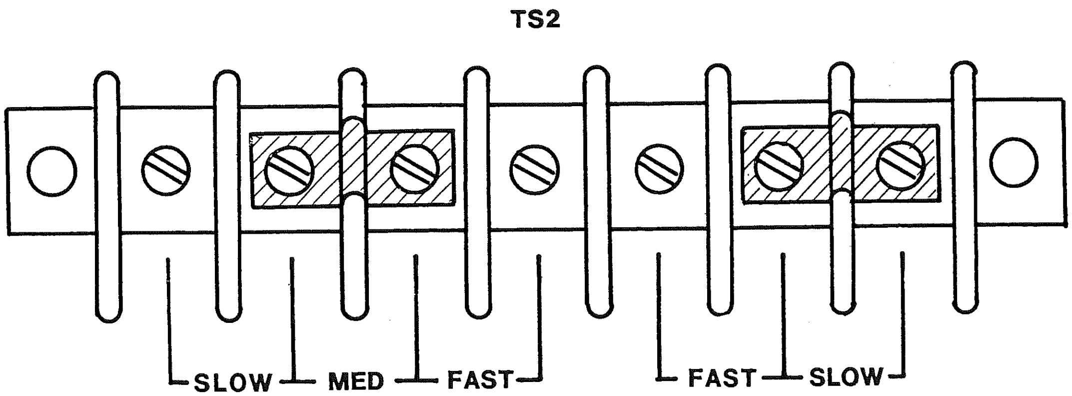


Figure 4-1 - Typical Stability Link Connection

(Normally, regulators are shipped with the above stability link connection).

STABILITY LINK SELECTION GUIDE

Type of Application	Exciter Link	Generator Link
Brush type rotary exciter	Slow	Med or Slow
Brushless rotary exciter or generators rated above 150 kW	Slow	Med or Slow
Brushless rotary exciter or generators rated below 150 kW	Slow	Fast or Med
Static exciter applications operating directly into generator field	Fast	Fast or Med

4.3.4 Parallel Compensation Adjust (R40)

The parallel compensation adjust rheostat (R40) is located near the top of the regulator on the fuse mounting bracket. It provides a method of adjusting the amount of reactive droop compensation. It is factory set the near the full CW position. This setting provides maximum (approximately 5%) voltage droop. The rheostat is provided with a locking nut so that it can be permanently set when the amount of droop desired is determined.

4.4 INITIAL OPERATION

The initial operating instructions are contained in the following paragraphs. These procedures should be reviewed before operating the system.

4.4.1 Operation (No-Load)

a. Set the external voltage rheostat to approximately mid-range.

b. Start the prime mover and bring it up to rated speed. If a voltage shutdown switch is used (see paragraph 4.2), close switch. When this switch is not used, generator voltage should build up automatically. (If field flashing is necessary, see paragraph 4.5).

c. Adjust Voltage Range Adjust (R14) until that generator voltage is within ±10% of rated. Slight voltage corrections can be made with the voltage adjust rheostat.

If an overvoltage, undervoltage or unstable voltage condition results, review the following paragraphs:

a. Overvoltage Condition (+15% or more above rated). If an overvoltage condition occurs, open the shutdown switch immediately and/or stop the prime mover. The regulator's internal overvoltage limit circuitry should prevent an overvoltage condition from exceeding the levels indicated in table 1-1. An overvoltage condition may result because the regulator sensing leads are not connected. If the cause of the overvoltage cannot be determined, refer to the troubleshooting section of this manual.

b. Undervoltage Condition (-15% or less of rated). If an undervoltage condition exists, stop the prime mover and determine the cause. If necessary, refer to the troubleshooting section of this manual.

c. Unstable Generator Voltage If the system voltage oscillates or hunts, adjust the voltage stability potentiometer R11 located on the printed circuit board. If the voltage cannot be stabilized with R11, refer to paragraph 4.3.2 for instructions on stability link adjustment and/or to paragraph 4.3 If the system cannot be stabilized by any of the above methods, refer to the troubleshooting section.

4.4.2 Operation (With Load)

a. Apply rated load to the generator.

b. Verify that no load to full load regulation is less than ±1/4%. If generating system has a paralleling CT, make certain that CT secondary is shorted before starting the test. If acceptable regulation is not obtained, refer to paragraph 3.2.2 and/or the troubleshooting section.

c. Alternately remove and apply load to determine that the generator voltage remains stable. If the generator voltage becomes unstable, readjust R11.

4.5 FIELD FLASHING

a. The voltage regulator contains internal circuitry to allow automatic voltage build-up. There is usually sufficient generator residual voltage to allow generator voltage build-up without flashing.

b. A voltage build-up problem may occur if the residual voltage applied to regulator power input terminals 3 and 4 is less than 6 Vac for an SR4F and 12 Vac for an SR8F.

c. On systems where generator voltage does not build up and no field flashing provisions are provided, proceed as follows to restore the residual voltage.

> With the prime mover at rest (not rotating), apply a dc flashing source across terminals F0 and F- on the voltage regulator for approximately three seconds. The positive of the flashing source must be connected to F0 and the negative to F-. Voltage source must not exceed 125 Vdc. Flashing current should be limited to 1 ampere or less.

d. For information on systems requiring or incorporating automatic or manual field flashing provisions, refer to paragraph 3.3.4.

4.6 PARALLEL OPERATION

For complete information concerning parallel operation, refer to Section 5.0.

SECTION 5.0

PARALLELING

5.1 GENERAL

a. This section contains information pertaining to operation of generator sets in parallel.

b. These regulators have all necessary paralleling components contained internally except for an external current transformer (and a Unit-Parallel switch, if used). This circuitry allows parallel generators to share reactive load and reduce circulating currents between them.

5.2 PRINCIPLES OF OPERATION

a. The paralleling circuit operates in the following manner. A current transformer with 3 to 5 amperes secondary current at rated load must be installed in Phase B of the generator. It provides a signal that is proportional in amplitude and phase to the line current. This current signal develops a voltage across resistor R40. The tap on R40 supplies a part of this voltage to the primary of transformer T3. The secondaries of T3 are connected in series with the leads from the secondary of the sensing transformer T1 and the printed circuit board. The ac voltage applied to the sensing rectifier bridge is the vector sum of the stepped down sensing voltage (terminals E1 and E3 and the parallel CT signal through T3 (terminals 1 and 2). The voltage supplied to the sensing rectifier by the paralleling CT is small in relation to the signal supplied by the sensing voltage. The regulator input sensing voltage (terminals E1 and E3) and the parallel compensation signal (terminals 1 and 2) must be connected to the generator system so as to provide the correct phase and polarity relationship.

b. When a resistive load (unity P.F.) is applied to the generator, the voltage that appears across R40 (and T3 windings) leads the sensing voltage by 90 degrees. The vector sum of the two voltages is nearly the same as the original sensing voltage; consequently, almost no change occurs in generator output voltage and/or the generator field excitation.

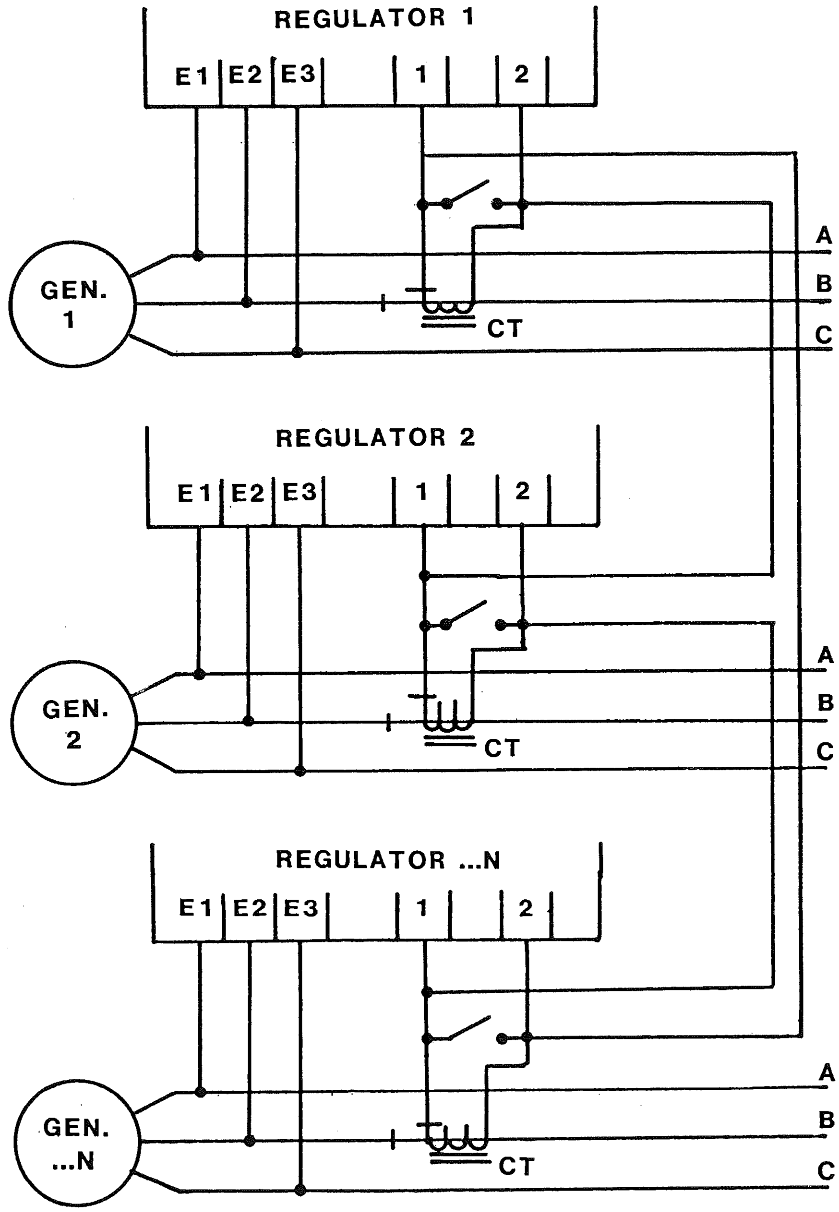
c. When a lagging power factor (inductive) load is applied to the generator, the voltage across R40 becomes more in phase with the sensing voltage and the combined vectors of the two voltages result in a large voltage being applied to the sensing rectifiers. Since the action of the regulator is to maintain a constant voltage at the sensing rectifiers, the regulator reacts by decreasing the generator output voltage and/or the generator field excitation.

d. When a leading power factor (capacitive) load is applied to the generator, the voltage across R40 becomes out of phase with the sensing voltage and the combined vectors of the two voltages result in a small voltage being applied to the sensing rectifiers. Then the regulator reacts by increasing the generator voltage and/or the generator field excitation.

e. When two generators are operating in parallel, if the field excitation on one generator should become excessive and cause a circulating current to flow between generators, this current will appear as a lagging power factor (inductive) load to the generator with excessive field current and a leading power factor (capacitive) load to the other. The parallel compensation circuit will cause the voltage regulator to decrease the field excitation on the generator with the lagging power factor load and increase the field excitation on the generator with the leading power factor, so as to minimize the circulating current between the generators. When circulating current flow between generators is minimzed in this manner, they will each supply a proportional amount of inductive load current.

f. The action and circuitry just described in called parallel droop compensation (reactive droop compensation). Although it reduces circulating current flow, it allows the system voltage to droop with increasing inductive reactive load.

g. Parallel cross-current compensation (reactive differential compensation) allows two or more paralleled generators to share inductive reactive loads with no decrease or droop in the generator system voltage. These regulators provide the necessary circuit isolation so that parallel cross-current compensation can be used. This is accomplished by the action and the circuitry described previously for paralleled droop compensation, and the addition of cross-current connecting leads between the parallel CT secondaries as shown in Figure 5-1. By connecting the finish of one parallel CT to the start of another, a closed series loop is formed which interconnects the CT's of all generators to be paralleled. The signals from the interconnected CT's cancel each other when the line currents are proportional and in phase.



NOTES:

1) WHEN MORE THAN 3 GENERATORS ARE TO BE PARALLED, CONTINUE CONNECTIONS AS SHOWN

2) PARALLELING CT POLARITIES ARE SHOWN A-B-C PHASE ROTATION

Figure 5-1. Cross Current Compensation CT's Interconnection

5.3 INSTALLATION INSTRUCTIONS

5.3.1 The regulator parallel compensation input consists of terminals 1 and 2. A current transformer with a 5A secondary rating is installed in generator Phase B. This current at rated generator load. The burden of the regulator parallel compensation circuit is 5 VA.

5.3.2 A Unit-Parallel switch can be used to short the paralleling current transformer secondary when the system is operated as single unit (no in parallel). Shorting the CT secondary prevents a droop signal from being injected into the voltage regulator. The system may be operated without a Unit-Parallel switch if the droop that occurs during single unit loading is not objectionable.

5.3.3 The phase relationship between the paralleling current transformer signal applied to the votlage regulator terminals 1 and 2 and the voltage sensing signal applied to regulator terminals E1, E2 and E3 are very important. It is equally important that the paralleling current transformer secondary polarity be correct for the existing generator phase sequence (A-B-C or A-C-B). These connections must be made as described in the interconnection diagrams, Figures 3-2 and 3-3. (Regulator terminal E2 is not used on a single phase sensing regulator.)

5.3.4 Connect voltage regulator terminal E1 to generator Phase A. Connect the appropriate voltage tap under regulator terminal E3 to generator Phase C. On three phase sensing models only, connect the appropriate voltage tap under regulator terminal E2 to generator Phase B.

NOTE

On high voltage generating systems (above 600V) where instrument potential transformers are used to supply regulator sensing voltage, the primary to secondary polarities must be maintained.

5.3.5 The correct polarity for the paralleling current transformer signal supplied to regulator terminals 1 and 2 is determined by the generator phase sequence. The interconnection drawings show the proper polarity connections for both A-B-C and A-C-B phase rotation.

5.3.6 If it cannot be determined which generator lines are Phase A, B and C, follow this procedure.

a. With a three phase sensing voltage regulator, always place the paralleling current transformer in the generator phase that is used to supply sensing voltage to regulator terminal E2. When a single phase sensing regulator is used, place the current transformer in the generator phase that does not supply sensing voltage to the regulator.

b. When step a) is observed, the only unknown remaining is the correct polarity of the paralleling current transformer secondary signal. If an inductive reactive load is available, this can be determined by the test as outlined in paragraph 5.4.4.

c. If the generator load outlined in step b) is not available and it becomes necessary to parallel the generator without knowing the correct paralleling current transformer ssecondary polarity, extreme caution must be observed or equipment damage may result. If abnormally high generator current results after closing the breaker, immediately reopen the breaker, shut down the generating system and reverse the secondary connections of the paralleling current transformer (the leads to regulator terminals 1 and 2. Review paragraph 5.4 before paralleling.

5.3.7 If parallel cross-current compensation (reactive) differential compensation) is desired, make the same installation connections as described in paragraph 5.3.5 and 5.3.6; then interconnect with the cross-current loop as shown in Figure 5-1 and as described in paragraph 5.2.

a. It is recommended that the cross-current connecting loop be left open at one point until proper parallel operation is achieved with the parallel droop compensation circuit only.

b. On applications utilizing cross-current compensation, a unit-parallel switch should be used to short out the current transformer secondary if that generator is not on the load bus. If such a switch is not used, a voltage droop will be introduced into the system because the unloaded generator parallel CT is not supplying the compensating signal and allowing a voltage drop to occur across it. This drop will also cause the voltage of the incoming generator to fluctuate prior to paralleling. If this fluctuation is objectionable, an ideal solution is to connect an auxiliary contact on the main generator circuit breaker across the paralleling current transformer secondary. This auxiliary contact must be closed when the main breaker is open, and open when the main generator breaker closes.

5.4 OPERATION INSTRUCTIONS

a. The following paragraphs describe the procedure for operating generator sets in parallel.

To insure parallel operation, these requirements must be met:

(1) The voltage regulator control system must cause the generators to share the KVAR load.

(2) The speed governing control system must cause the generators to share the kW load.

b. Prior to operation, adjust parallel compensation rheostat R40 to its near full clockwise rotation position. This adjustment provides maximum droop signal and should be nearly identical on all regulators to be paralleled.

5.4.1 Preliminary Test

If a suitable load is available, it is recommended that individual generator sets be tested to verify that the paralleling ciruit functions properly. The following describes such a test:

a. Make certain that the paralleling CT secondary is not shorted (Unit-Parallel switch is in the Parallel position).

b. With generating set operating at rated voltage and frequency, apply from 25 to 100% unity power factor load. Gneerator voltage should not change more than 1%. (The frequency should decrease if the governor is set for droop operation).

c. Apply a 25 to 100% 0.8 power factor load to the generator. The voltage should droop from 4 to 6% (with full load and with parallel compensation rheostat R40 set nearly full clockwise). If the voltage rises instead of drooping, reverse the parallel current transformer secondary leads.

d. Repeat this test on all generators to be operated in parallel. After satisfactory completion of these tests, the generators should parallel properly.

5.4.2 Monitoring Instrumentation

To parallel generators and to check for proper parallel operation, generators should be equipped with the following instrumentation:

AC Voltmeter - to monitor bus voltage and incoming generator voltage.

Frequency Meter
Synchroscope or a set of lights etc. - to indicate an in-phase condition.

AC Ammeter - to monitor incoming generator power.

It is also desirable to have KVAR or Power Factor Meter and Generator or Exciter Field Ammeter.

5.4.3 Conditions Necessary for Paralleling

CAUTION

The incoming generator voltage phase sequence (phase rotation) must be the same as that of the bus to which it is to be paralleled.

To avoid equipment damage, generators should be paralleled only at the instant when the frequency and voltages are nearly equal.

5.4.4 Parallel Operation Sequence

The following procedures are typical of these followed when paralleling generators. These procedures should be reviewed before attempting to parallel.

a. Adjust the voltage of the incoming generator (the generator to be pralleled with the bus) to match the bus voltage.

NOTE

If a unit-parallel switch is used, make certain it is in the parallel position.

b. Adjust the incoming prime mover speed so that its frequency is slightly faster than the load bus.

c. Observing the synchroscope (or synchronizing lights), close the incoming generator circuit breaker when in phase with the bus.

d. Immediately after closing the breaker, observe the generator line ammeter. It should read well within the rating of the generator. If not, immediately reopen the circuit breaker and completely review paragraph 5.3.

e. If operation after paralleling is normal, adjust the prime mover speed control so that the generator takes on load and thereby avoids the possibility of the reverse power relay tripping the generator off line.

f. Adjust voltage and speed so that the generator just placed on the load bus assumes its share of kW and KVAR load.

g. If two or more generators using the same type voltage regulators are on a common bus, vary the bus load and make voltage, speed and parallel compensation (R40) adjustments as necessary to obtain the optimum load sharing.

5.4.5 Paralleling Problems

a. If, upon paralleling with the bus, improper operation results, try to determine which control system is at fault, the voltage control or the speed control. A high ammeter reading or circuit breaker opening may occur in either case. Immediately after closing the incoming generator circuit breaker, observe the KVAR and kW meters.

(1) A large KVAR reading (incoming or outgoing) indicates a faulty voltage regulating system.

(2) A large kW loading would indicate a faulty speed regulating system.

b. Another method of determining which control system is at fault is to operate the system on manual voltage control (on systems having manual control). If proper parallel operation is obtained on manual voltage control, the voltage regulating system is probably at fault. If proper operation is not obtained, the speed regulating system is probably at fault.

c. If the trouble is isolated to the voltage regulating system, re-check the interconnection diagrams, Figures 3-2 and 3-3. Almost all paralleling problems encountered with these voltage regulators are caused by incorrect system interconnections.

SECTION 6.0

MAINTENANCE, REPLACEMENT PARTS, AND TROUBLESHOOTING

6.1 PREVENTIVE MAINTENANCE

A periodic inspection should be made to insure that the unit is kept clean and free from excessive dirt and moisture. Also, check connections between the regulator and the system.

6.2 CORRECTIVE MAINTENANCE

a. Repairs can be made on the regulator by following the schematic diagram (Figure 7-1) and troubleshooting guide (Table 6-1). Repairs to the printed circuit board should not be attempted. Basler Electric Company maintains a stock of replacement parts and replacement voltage regulators.

NOTE

(1) If, when troubleshooting a generating system, a defective voltage regulator is found, do not install a replacement regulator without first measuring the dc resistance of the exciter field winding to insure that the resistance is above the minimum specified in Table 1-1 for that regulator model.

(2) On generating systems not using a power isolation transformer, or using a power isolation transformer with a grounded secondary, insure that the exciter field winding or circuitry is not grounded before installing a new voltage regulator.

6.3 WARRANTY AND REPAIR SERVICE

These Basler Electric voltage regulators are warranted against defective material and workmanship. A complete service center is maintained at Basler Electric Company, Highland, Illinois. Prompt turnaround on warranty and non-warranty repairs is provided.

6.4 REPLACEMENT PARTS

Table 6-2 contains parts and assemblies which are maintenance significant. When ordering replacement parts, always specify the complete model number and serial number of the voltage regulator.

TABLE 6-1 - Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE	SOLUTION
Voltage does not build up to rated value.	Low residual or incorrect polarity relationship between exciter output and generator field.	Field flashing is required.
	Voltage shutdown switch open, or Manual-Off-Auto switch is OFF position.	Close switch.
	Prime mover not up to rated speed.	Adjust speed to rated.
	No voltage or improper voltage to input terminals 3 and 4.	Verify wiring.
	No connections to F+ and F-.	Verify wiring.
	Generator output shorted or heavily loaded.	Remove load or short.
	Open fuse.	Replace.
	Defective or improperly wired exciter.	Verify exciter operation or connections.
Voltage high, uncontrollable with voltage adjust rheostat.	No sensing voltage, terminals E1, E2, and E3.	Verify wiring.
	Transfer switch is Manual position (when used).	Place in Auto.
	Sensing connections set to wrong voltage tap.	Connect to correct tap.

TABLE 6-1 - Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE	SOLUTION
Voltage high, uncontrollable with voltage adjust rheostat. (Continued)	Faulty PC board.	Replace.
	SCR's faulty.	Replace SCR's or regulator.
Voltage high, controllable with voltage adjust rheostat.	Sensing connections set to wrong voltage tap.	Connect to correct tap.
	Voltage range adjust (R14) set too high.	Adjust.
	Voltage adjust rheostat resistance too low.	Increase resistance.
	Improper connection of sensing leads to generator.	Verify wiring.
	Voltmeter inaccurate.	Verify operation or replace.
	Defective PC board.	Replace.
	Defective voltage regulator.	Replace.
Voltage low, controllable with voltage adjust rheostat.	R14 set too low.	Adjust.
	Improper connections of sensing leads to generator.	Verify wiring.

TABLE 6-1 - Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE	SOLUTION
Voltage low, controllable with voltage adjust rheostat. (Continued)	Voltmeter inaccurate.	Verify operation or replace.
Poor regulation.	Voltage at terminals 3 and 4 or regulators too low at nominal generator voltage.	Input voltage to the power stage should be 120V for the SR4F, 208 or 240V for the SR8F.
	Output voltage at different location than regulator sensing (voltage drop in leads or wrong phase).	Connect voltmeter at same point as regulator sensing.
	Waveform distortion due to harmonic content in generator voltage; meter may be indicating RMS values).	Consult generator manufacturer.
	Unit-Parallel switch in Parallel position.	Place switch in Unit position, except during parallel operation. (Terminals 1 and 2 shorted).
	Unit-Parallel switch faulty.	Replace.
	Unbalanced load with three phase sensing.	Unit averages all three phase voltages.
	Prime mover not up to rated speed.	Bring up to rated.
	Fault in exciter or generator.	Verify operation.

TABLE 6-1 - Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE	SOLUTION
Poor regulation. (Continued)	Defective PC board.	Replace.
	Defective SCR's or diodes.	Replace.
Poor voltage stability.	Stability adjust R11 misadjusted.	Adjust to proper setting.
	Stability link selection (TS2) incorrect.	Make proper selection. (Refer to paragraph 4.3.3).
	No load field voltage below recommended value.	Refer to Section 5.0.
	Defective printed circuit board.	Replace.
	Fault in exciter or generator.	Verify exciter and generator operation.
Voltage recovery slow with load change.	R11 misadjusted.	Adjust to faster setting.
	Stability link selection too slow.	Reset as instructed in paragraph 4.3.3.
	Insufficient regulator forcing capability.	Improper application of regulator.
Parallel generators do not divide real (kW) load equally.	Improper setting of power sensing governor.	Consult governor manual.

TABLE 6-1 - Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE	SOLUTION
No droop compensation can be obtained for parallel generators.	R40 set to minimum droop position.	Adjust R40 to obtain required droop.
	Parallel CT does not supply the required 3 to 5 amps secondary current.	See section 5.0.
Parallel generators do not divide reactive KVAR load equally. (Circulating reactive currents between generators).	Terminals 1 and 2 of regulator shorted by Unit-Parallel switch.	Place switch in Parallel position.
	Voltage adjust rheostat not set correctly.	Readjust.
	R40 set low droop position.	Adjust for increase droop.
	Parallel CT does not supply the required 3 to 5 amperes secondary current.	Place with proper CT (See section 5.0).
	Paralleling CT's polarity reversed.	Interchange CT secondary leads.
	Paralleling CT not in correct generator line.	Verify wiring. (See Figures 7-5 or 7-6).

TABLE 6-2 - Replacement Parts List

ITEM NO.	DESCRIPTION	BASLER PART NUMBER	
		SR4F	SR8F
1	Etched Circuit Board	90 59701 100	90 59701 100
2	EMI Filter Assembly (FL1)	90 59708 101	90 59708 101
3	Sensing Transformer Single Phase (T1)	BE 00309 005	BE 00309 005
4	Sensing Transformer Three Phase (T1 and T2)	BE 00310 006	BE 00310 006
5	Paralleling Transformer (T3)	BE 10351 003	BE 10351 003
6	Transformer (T5)	BE 10365 002	BE 10365 002
7	Filter Choke (L1)	BE 08794 012	BE 08794 012
8	Diode (CR34, CR35, CR36, CR37, CR38)	06721	07305
9	Silicon Controlled Rectifier (CR32 and CR33)	07017	07295
10	Fuse (F11, F12 and F13)	07115	07115
11	Thermal Switch (S3)	07293	07293
12	Paralleling Rheostat (R40)	07156	07156
13	External Voltage Adjust Rheostat	06874	06874
14	Resistor (R42)	03603	03603
15	Resistor (R43)	07291	07291
16	Resistor (R46)	06648	03993
17	Capacitor (C30 and C31)	04881	04881

SECTION 7.0

DRAWINGS

7.1 GENERAL

The following drawings are provided as aid to maintenance.

Figure 7-1. Component Location
Figure 7-2. Schematic Diagram
Figure 7-3. Wiring Diagram

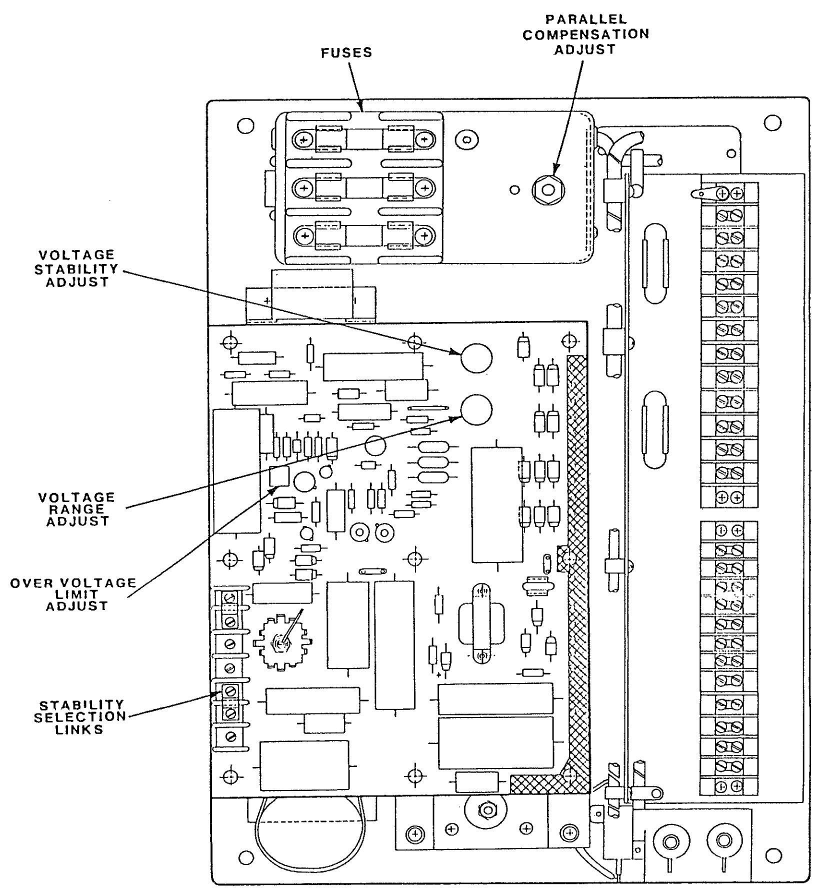


Figure 7-1. Component Location

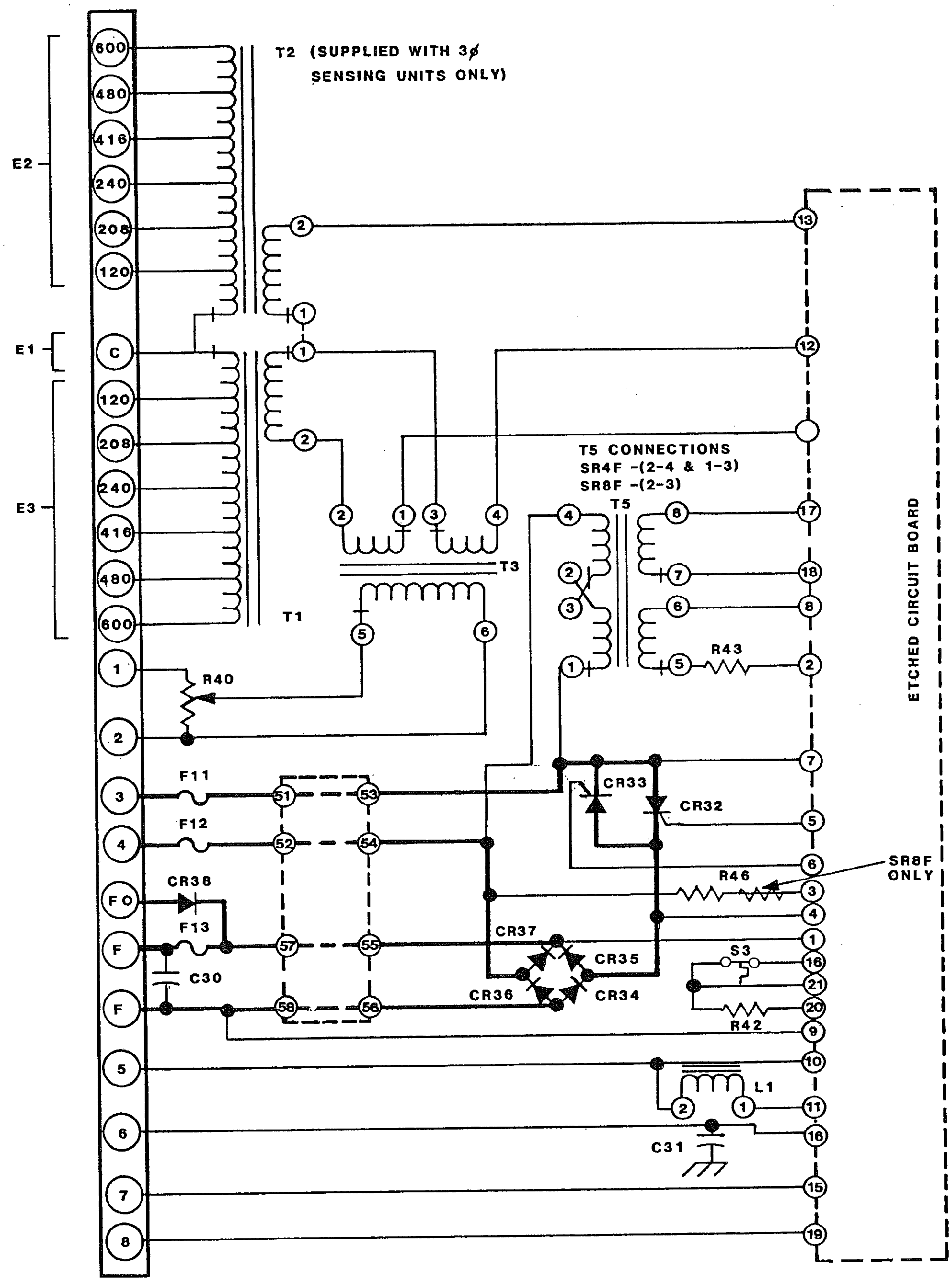


Figure 7-2. Schematic Diagram

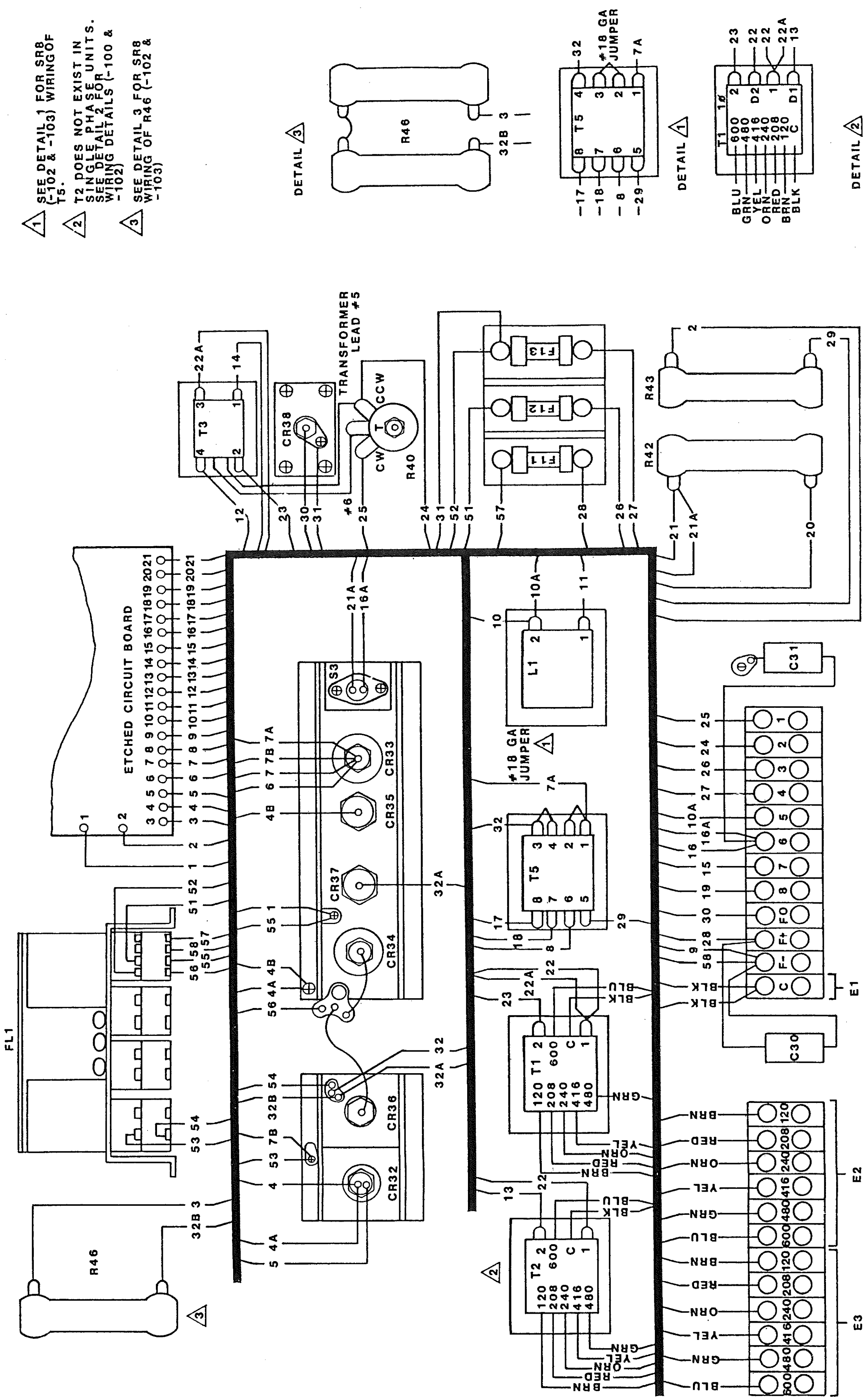


Figure 7-3. Wiring Diagram

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