

**INSTRUCTION MANUAL**  
**FOR**  
**VOLTAGE REGULATOR**  
**SR32A**



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# INTRODUCTION

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This instruction manual provides information about the operation and installation of the SR32 voltage regulator. To accomplish this, the following information is provided:

- General Information and Specifications
- Functional Description
- Installation Information
- Operating Instructions
- Maintenance and Troubleshooting Instructions

## **WARNING!**

To avoid personal injury or equipment damage, only qualified personnel should perform the procedures in this manual.

## **NOTE**

Be sure that the device is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the case ground terminal. When the device is configured in a system with other devices, it is recommended to use a separate lead to the ground bus from each unit.

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It is not the intention of this manual to cover all details and variations in equipment, nor does this manual 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, contact Basler Electric.

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# SECTION 1 • GENERAL INFORMATION

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## INTRODUCTION

The SR32A voltage regulator is designed to regulate the output voltage of a 50/60 hertz generator that has a 32 Vdc field. Regulation is achieved by controlling the level of current supplied by the SR32A to the generator or exciter field. The SR32A can be used on any generating system that has a field excitation requirement within the SR32A's rating.

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## SPECIFICATIONS

SR32A electrical and physical specifications are listed in the following paragraphs.

### Power Input

Nominal Voltage:	60 Vac (If the correct input voltage is not available, a suitable power transformer must be used.)
Nominal Frequency:	50/60 Hz
Power Dissipation:	<170 W at continuous rating
Burden:	1200 VA, when regulator is operated at less than maximum output (Determine the power isolation transformer rating by multiplying the input voltage by the dc output current.)

### Sensing Inputs

Nominal Voltage:	120, 208, 240, 416, 480, or 600 Vac, 1-phase or 3-phase
Burden (Per Phase):	10 VA

### Parallel Compensation Input

Nominal Current:	5 Aac
Burden:	25 VA
Droop Adjustment:	5% maximum

### Field Power Output

Continuous Rating:	32 Vdc, 20 Adc, maximum
1 Minute Forcing Rating:	45 Vdc, 28 Adc, maximum
Minimum Field Resistance:	1.6 $\Omega$

### Regulation

Accuracy:	$\pm 0.5\%$ over full range of alternator loading
Response	
60 Hz:	<17 ms
50 Hz:	<20 ms
Drift:	$\pm 0.5\%$ per 104°F (40°C) ambient temperature change
Voltage Adjustment Range:	$\pm 10\%$ of nominal voltage

### Voltage Buildup

Generator output voltage is possible with a residual voltage of approximately 10% of nominal.

### Overvoltage Limiting

Built-in overvoltage circuit limits the generator output voltage to a maximum voltage, adjustable over the range of 130 to 140% of nominal.

### Type Tests

Vibration:	Withstands up to 5 G at 260 Hz
Shock:	Withstands up to 15 G

## Temperature

Operating: -55 to 70°C (-67 to 158°F) without de-rating  
Storage: -65 to 100°C (-85 to 212°F) without degradation of components

## Dimensions

Height: 13.0 in (330 mm)  
Width: 8.53 in (217 mm)  
Depth: 7.19 in (183 mm)

## Weight

Net: 18 lb (8.16 kg)  
Shipping: 20 lb (9.07 kg)

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## STYLE NUMBER

Voltage regulator features are determined by a model and style number. SR32 regulator style options are illustrated in Figure 1-1.

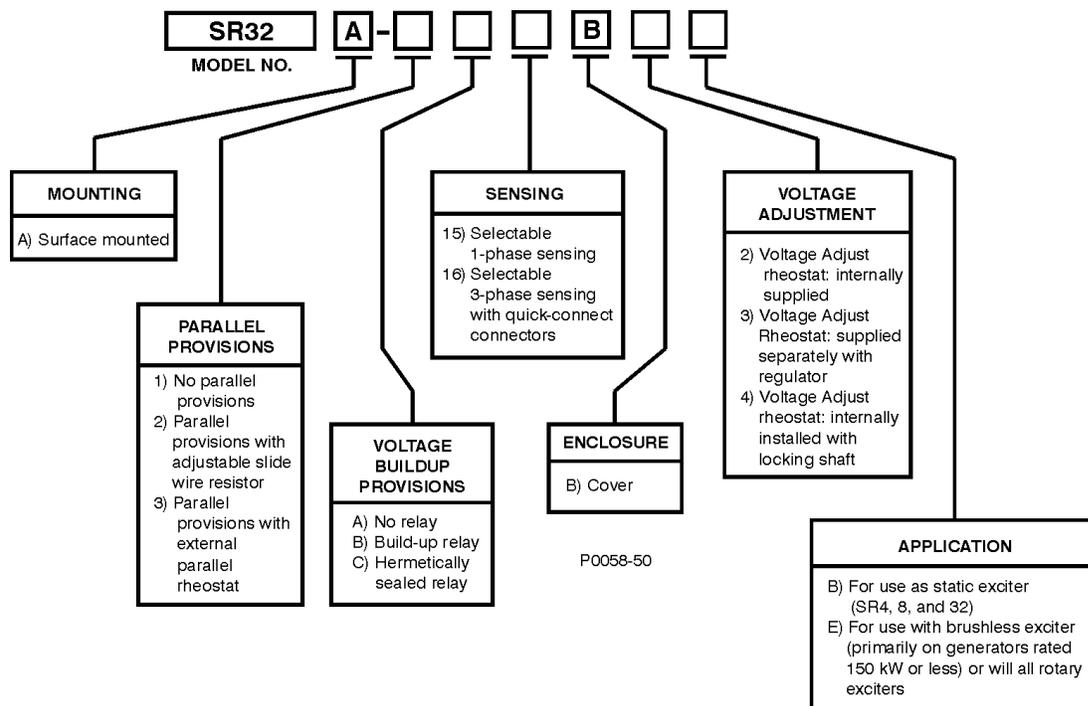


Figure 1-1. SR32 Style Chart

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## ACCESSORIES

Optional accessories are not designated in the SR32 style number and must be selected as separate items. Available accessories include:

- Power transformers
- Paralleling current transformers
- Excitation support systems (series boost options)
- Underfrequency-overvoltage control modules
- Manual voltage control modules
- SR regulators with RFI suppression
- Motor operated potentiometers
- Wide range voltage adjustments
- Volts per hertz modules
- DC generator voltage controls
- Var/power factor controllers

# SECTION 2 • FUNCTIONAL DESCRIPTION

## FUNCTIONAL CIRCUIT

As illustrated in Figure 2-1, the voltage regulator senses the generator voltage, rectifies and compares a sample of that voltage with a reference (zener diode) voltage, and supplies the field current required to maintain a predetermined ratio between the generator voltage and the reference voltage. The SR32 consists of five basic circuits: a sensing circuit, an error detector, an error amplifier, a power controller, and a stabilization network. With the exception of the power controller and part of the sensing circuit, all of these circuits are contained on a printed circuit board.

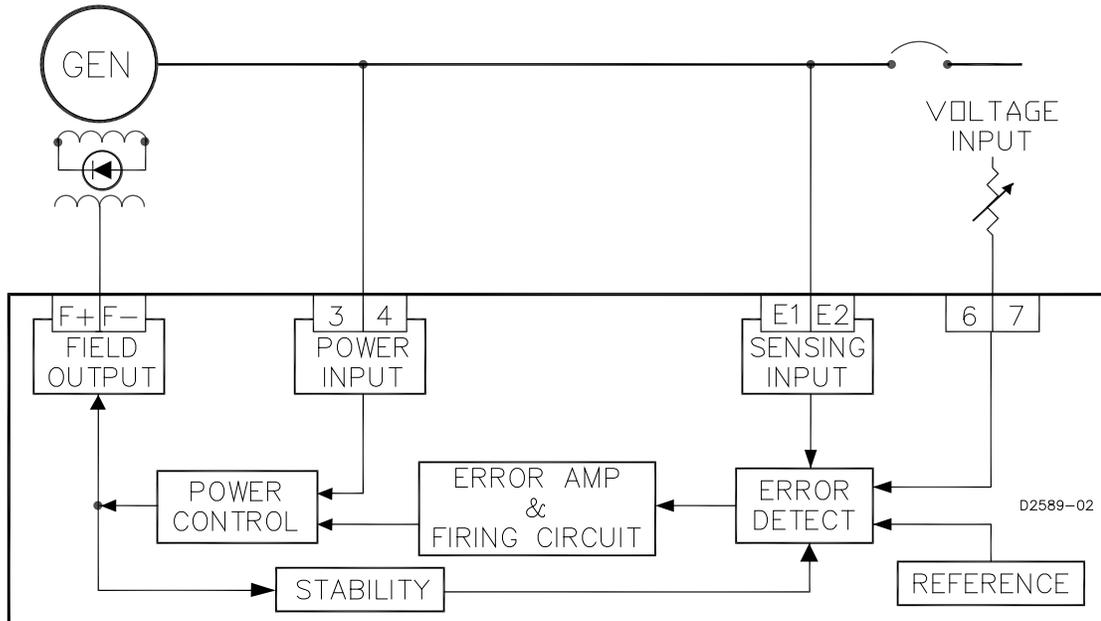


Figure 2-1. Input Phase Relationship

## AUTOMATIC VOLTAGE BUILDUP

Relay K1 provides automatic voltage buildup from generator residual voltage. A normally-closed contact (relay de-energized) provides a current path to fire the control rectifiers to allow the generator residual voltage to be converted to dc by diodes CR13 and CR14 and rectifiers CR11 and CR12. This dc voltage is then applied to the exciter field. When the generator voltage reaches approximately 75% of rated, the relay pulls in, removing the buildup circuit and allowing the control rectifiers to regulate the generator output voltage. A minimum, residual generator voltage of 3 Vac is required for automatic voltage buildup. If the residual voltage is less than 3 Vac, external field flashing may be required.

## MOTOR STARTING OR SHORT-CIRCUIT OPERATION

In brushless (or static) exciter applications, the exciter output is not available for self-excitation during heavy loading. The addition of a Series Boost option (SBO) prevents collapse of excitation by providing constant voltage to the regulator for all operating conditions.

## PARALLEL OPERATION

When parallel operation is required, additional components are required in the regulating system: resistor R25, voltage transformer T3, and current transformer CT1. R25 and T3 are included in a parallel-equipped voltage regulator. CT1 is a separate item and must be interconnected as shown in Figure 3-2.

The current transformer (CT1) is installed in line 2 of each generator and develops a signal that is proportional in amplitude and phase to the line current. This current signal develops a voltage across resistor R25. A slider on R25 supplies a part of this voltage to the primary winding of transformer T3. The secondary windings of T3 are connected in series with the leads from the secondary winding of sensing transformer T1 and the sensing rectifiers located on 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 supplied through T3 (terminals 1 and 2). The voltage supplied to the sensing rectifiers by the parallel CT is very 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.

When a resistive (unity power factor) load is connected to the generator, the voltage that appears across R25 (and the 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 the generator output voltage.

When a lagging power factor (inductive) load is connected to the generator, the voltage across R25 becomes more in phase with the sensing voltage. 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.

When a leading power factor (capacitive) load is applied to the generator, the voltage across R25 becomes out-of-phase with the sensing voltage. The combined vectors of the voltage result in a smaller voltage being applied to the sensing rectifiers. The regulator reacts by increasing the generator voltage.

If two generators are operating in parallel and the field excitation on one generator becomes excessive, a circulating current can flow between generators. To the generator with excessive field current, this current will appear as a lagging power factor (inductive) load. To the other generator, the circulating current will appear as a leading power factor (capacitive) load. On the generator with the lagging power factor load, the parallel compensation circuit will cause the voltage regulator to decrease the field excitation. On the generator with the leading power factor load, the parallel compensation circuit will cause the voltage regulator to increase the field excitation. This will minimize the circulating current between the generators. This action and circuitry is called parallel droop compensation. It allows two or more paralleled generators to proportionally share inductive loads by causing a decrease of droop in the generator system voltage.

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 output voltage. This is accomplished by the circuitry described above for parallel droop compensation with the addition of cross-connecting leads between the parallel CT secondary windings as shown in Figure 3-3. By connecting the finish of one parallel CT to the start of another, a closed series loop is formed that interconnects the CTs of all generators to be paralleled. The signals from the interconnected CTs cancel each other when the line currents are proportional, in phase, and with no decrease in system voltage these regulators provide the circuit isolation necessary for parallel cross-current compensation.

# SECTION 3 • INSTALLATION

## MOUNTING

The SR32 can be mounted in any position without affecting its operating characteristics. However, the regulator should be mounted vertically to obtain optimum cooling. Mounting is possible in any location where the ambient temperature remains within  $-55$  to  $70^{\circ}\text{C}$  ( $-67$  to  $158^{\circ}\text{F}$ ). The regulator's rugged construction enables it to be mounted directly on the generator. Overall SR32 mounting dimensions are illustrated in Figure 3-1.

NOTE: All dimensions in inches (millimeters).

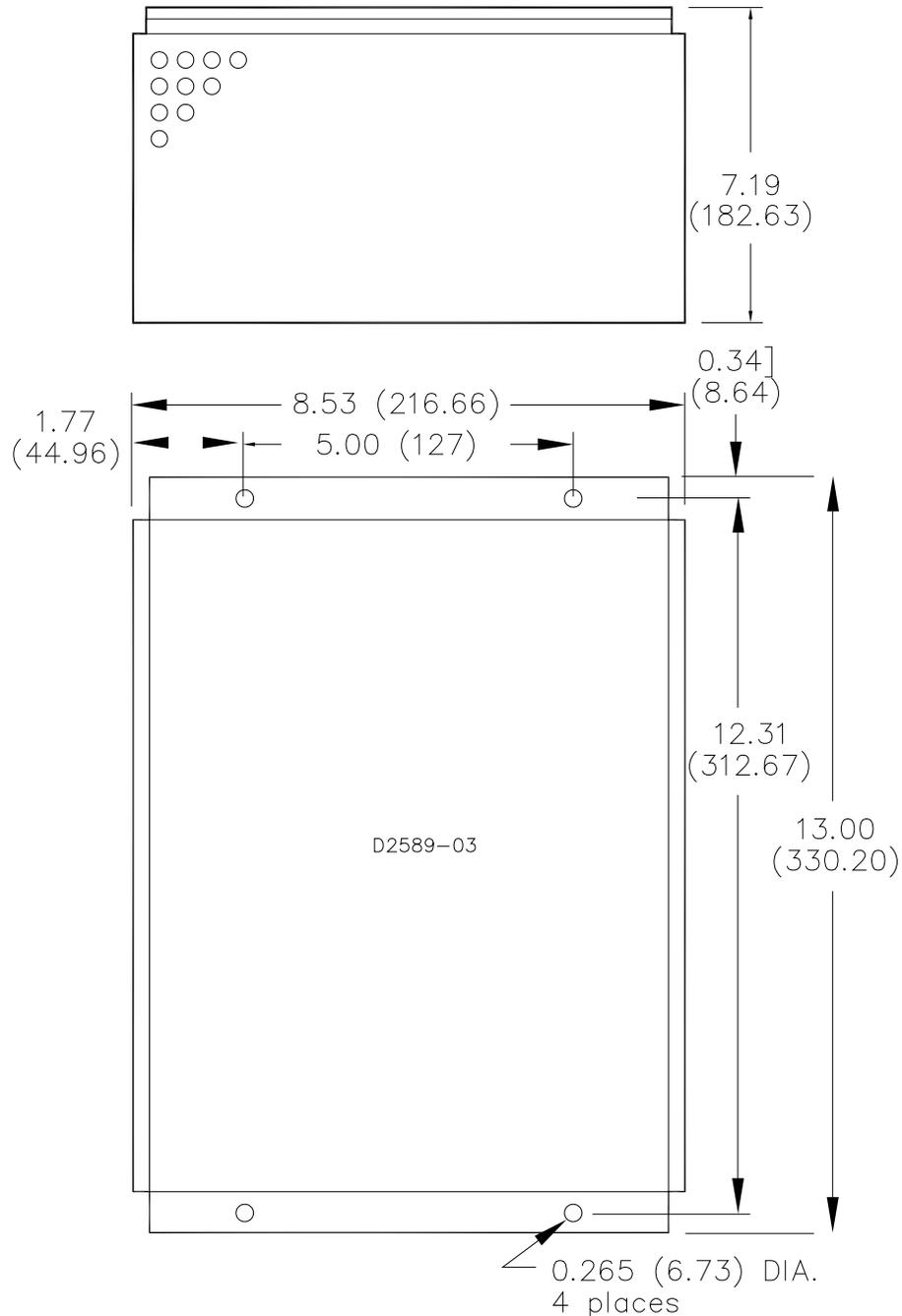


Figure 3-1. Outline Drawing

## CONNECTIONS

SR32 voltage regulator connections are illustrated in Figure 3-2. All regulator connections should be made with 16 AWG (or larger) wires.

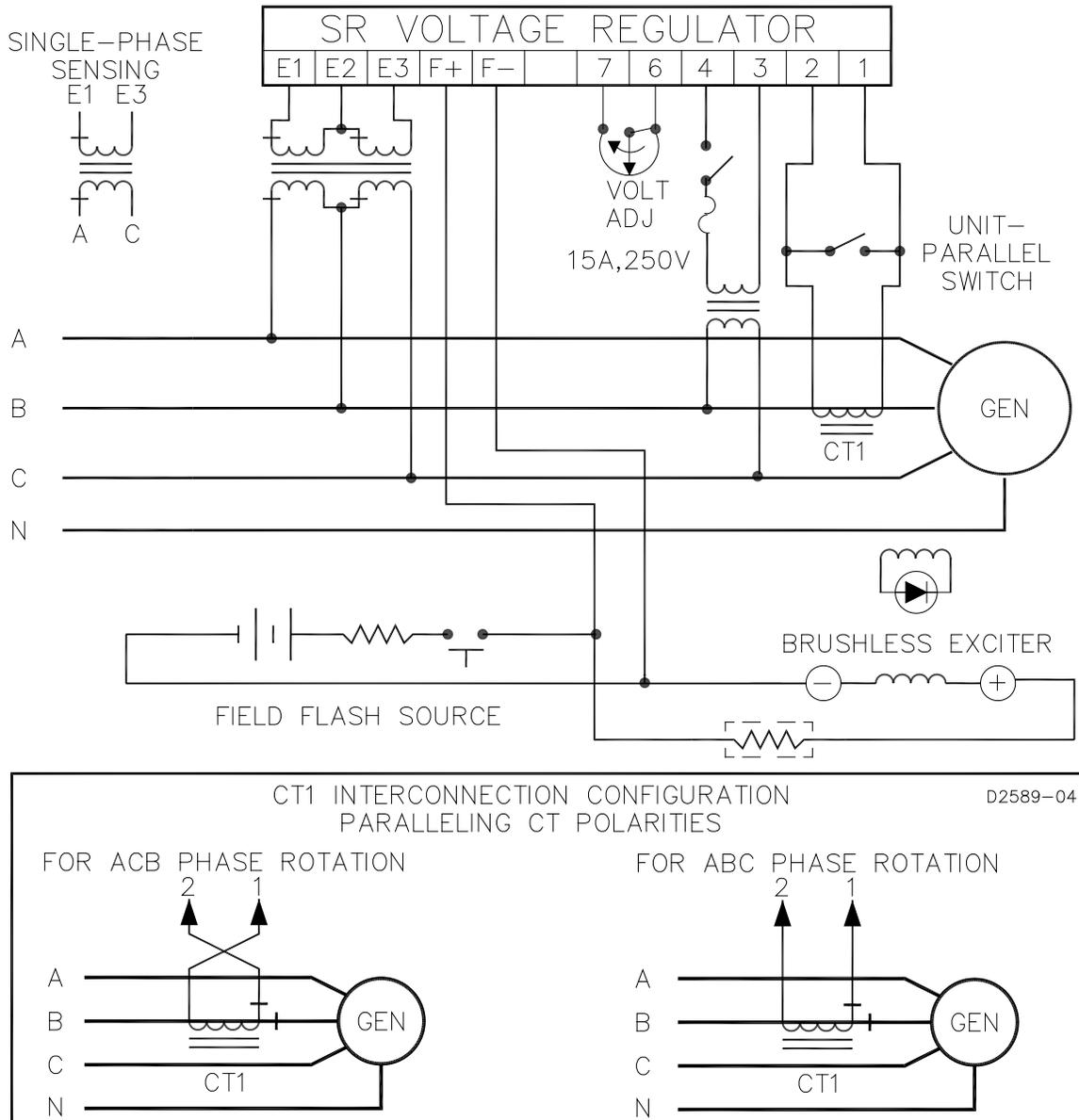


Figure 3-2. SR32 Connections

### Regulator Sensing (Terminals E1, E2, and E3)

#### NOTE

All SR32 voltage regulators are factory-preset for 120 Vac sensing.

The SR32 regulates the voltage that is applied to its sensing terminals. Therefore, it cannot correct for voltage drops in leads that may occur at points other than where the regulator sensing leads are connected. The leads that supply regulator sensing should not be used to supply power to any other equipment or to the regulator power stage (terminals 3 and 4).

If the generator will be operated in parallel with other generators, the phase relationship of the sensing voltage and the parallel current transformer is very important. See *Parallel Compensation* for further details.

The regulator is equipped with one or two internal sensing transformers: T1 or T1 and T2. These transformers have taps for input sensing voltages of 120, 208, 240, 416, 480, and 600 Vac (see Figure 3-3). The style number determines whether the regulator is equipped for single-phase sensing (T1) or three-phase (T1 and T2) sensing. See Figure 1-1 for style number interpretation. For operation with generator voltages above 600 Vac, a potential transformer (or transformers) must be used to supply the regulator sensing voltage. This transformer should be of metering quality. The regulator sensing circuit load is less than 10 VA. Correct polarity must be observed when connecting the sensing input.

Single-phase voltage sensing connections are made at terminals E1 and E3. Three-phase voltage sensing connections are made at terminals E1, E2, and E3. For precise voltage regulation, the sensing leads should be kept as short as possible.

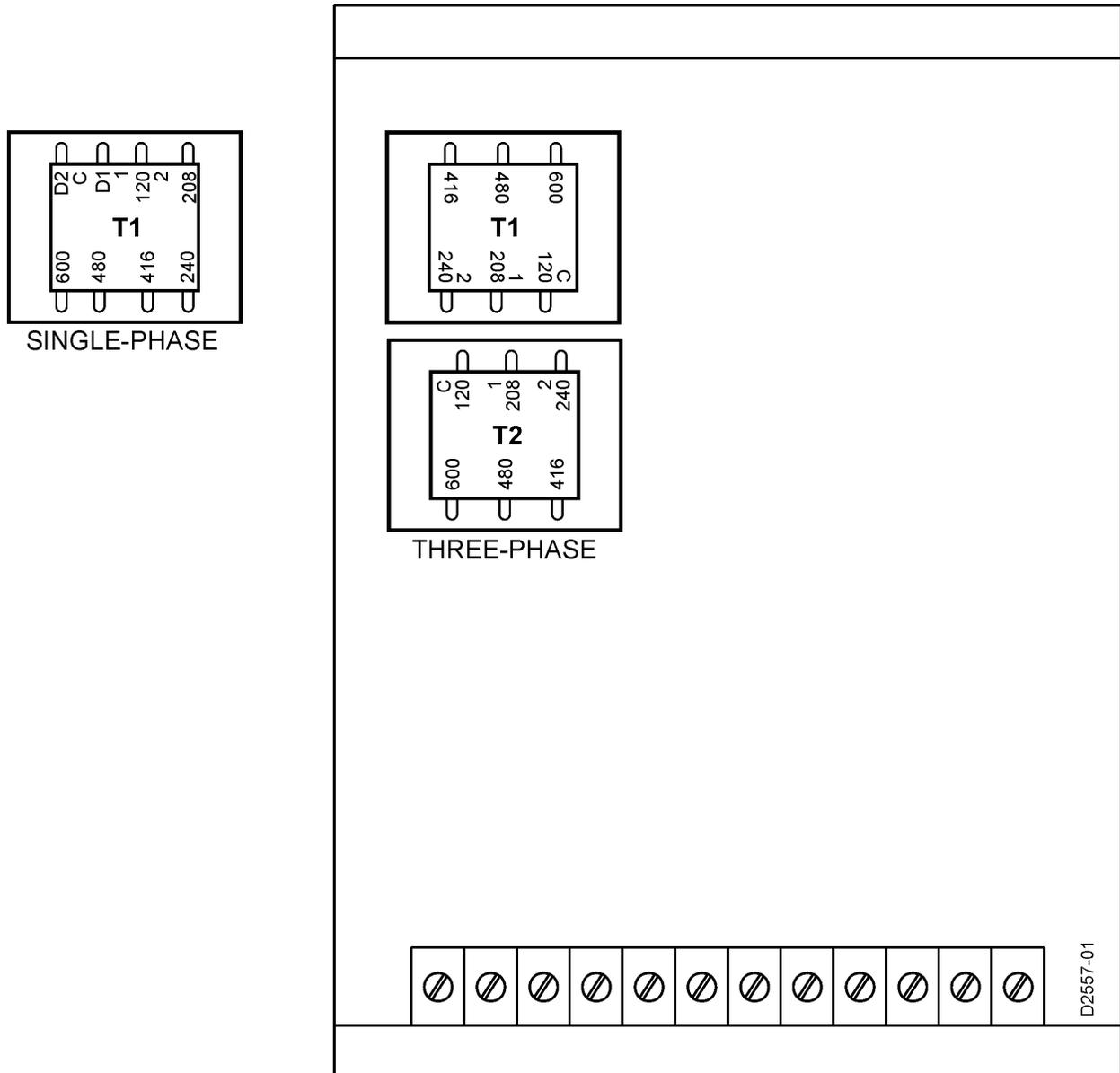


Figure 3-3. Sensing Transformer Connections

SR32 regulators are factory-preset for 120 Vac sensing voltage. To change the regulator sensing voltage to a value other than 120 Vac, perform the following steps.

1. Remove the cover (if applicable).
2. Remove the nine hex screws.

3. Remove the printed circuit board without disconnecting the wires.
4. Locate transformer T1 (for single-phase sensing units) or T1 and T2 (for three-phase sensing units). These transformers use quick-connect connectors for changing the sensing taps.
  - a. For a regulator with single-phase sensing, move the wire that is connected to the T1-120 to the T1 terminal labeled with the desired sensing voltage.
  - b. For a regulator with three-phase sensing, move the wires connected to the T1-120 and T2-120 terminals to the T1 and T2 terminals labeled with the desired sensing voltage.

### Field Power (Terminals F+ and F-)

The numerical digits of the model number SR32 indicate the level of field power that the regulator is designed to deliver. The “3” indicates the voltage level (32 Vdc) and the “2” indicates the current level (20 Adc).

The dc resistance of the field receiving power from the SR32 must be no less than 1.57 ohms. If the field resistance is less than 1.57 ohms, a resistor must be added in series with the field. The sum of the field resistance and the series resistor must exceed 1.57 ohms.

Good generator stability usually results when the regulator output is above 10 Vdc at no load. If the voltage is less than 10 Vdc and there is voltage instability, it may be necessary to add resistance in series with the field. The additional resistance raises the regulator output voltage which increases the stability signal.

When adding resistance in series with the field, the resistor value must not restrict field forcing during full-load conditions. The following example explains how the proper resistance is calculated.

#### Field Resistance Calculation Example

An SR32 regulator is required to operate with an exciter field that has a dc resistance of 1 ohm and current requirements of 7.0 Adc at no load and 15 Adc at full load. Since the SR32 has a minimum field resistance requirement of 1.57 ohms, a resistor of at least 1.57 ohms must be connected in series with the field. The no-load regulator output will be the product of 1.57 ohms and 7.0 Adc or 11.0 Adc ( $1.57 \times 7.0 = 11.0$ ). The full-load regulator output will be the product of 1.57 ohms and 15.0 Adc or 23.5 Adc ( $1.57 \times 15 = 23.5$ ). This conforms to the 10 Vdc minimum at no load and provides a sufficient amount of forcing at full load (up to 45 Vdc).

### Input Power (Terminals 3 and 4)

The current requirement of the field connected to the regulator will determine the actual input current. The nominal voltage applied to the regulator input power stage (terminals 3 and 4) must be 60 Vac. This input power may be taken from any generator line that provides the correct voltage (line-to-line or line-to-neutral). The phase relationship of this input to the other circuits is not important.

#### **CAUTION**

Excessive input voltage can destroy the diodes and SCRs in the power controller circuit.

Failure to isolate the regulator input from ground can result in destruction of the SCR bridge.

When the generator output voltage is other than 60 Vac, a power transformer must be used to match the generator voltage to the regulator input.

If the field or field flashing circuit is grounded, a power transformer must be used to isolate the regulator input from ground.

On a SR32 regulator with single-phase sensing, the input power should be taken from a phase other than the one used for input sensing.

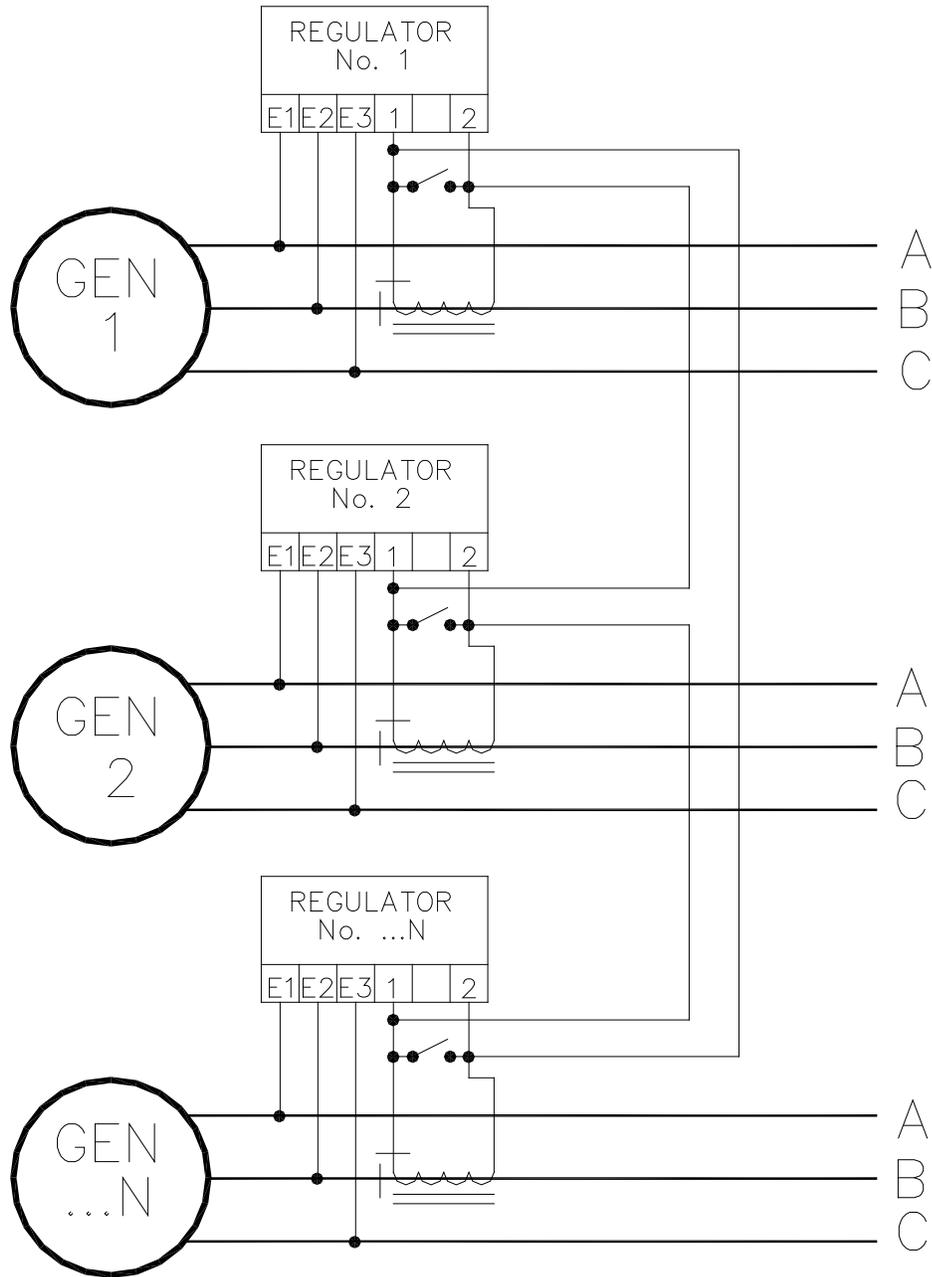
### Parallel Compensation (Terminals 1 and 2)

For parallel compensation, a 25 VA current transformer (CT) is required. The CT is connected in a generator line and should deliver from 3 to 5 Aac of current to regulator terminals 1 and 2.

The CT signal/regulator sensing voltage phase relationship must be correct or the systems will not parallel properly. On three-phase sensing models, the CT must be installed in the line supplying sensing voltage to regulator terminal E2. On single-phase models, the CT must be installed in the line that does not supply sensing to the regulator.

Figure 3-4 illustrates the correct CT polarity for L1-L2-L3 phase rotation. If the phase sequence is L1-L3-L2, the CT secondary leads must be interchanged. The correct CT secondary polarity can be determined by performing the procedure under *Parallel Operation* in Section 4, *Operating Instructions*.

For droop compensation, connect the CT to its respective regulator as shown in Figure 3-4.



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Figure 3-4. Reactive Differential Compensation (Cross-Current Compensation) CT Connections

For cross-current compensation, connect each CT to its respective regulator and connect the CTs in series. Connect the finish of the first CT to the start of the second CT, the finish of the second CT to the start of the third CT, and so forth, until all CTs are connected. The final step will be to connect the finish of the last CT to the start of the first CT.

A unit/parallel switch shorts the parallel CT secondary to prevent any droop signal from being applied to the regulating system during single-unit operation. The switch may not be required on parallel droop compensation applications in which a voltage drop is not objectionable.

In parallel cross-current compensation applications consisting of more than two generators, a unit/parallel switch should be used if all of the generators are not always on the load bus. If the switch is not used, a voltage droop will be introduced into the system. This is because the unloaded generator voltage CT does not supply a compensating signal, but instead allows a voltage drop across the CT. This drop also causes the voltage of the incoming generator to fluctuate prior to paralleling. Ideally, this switch is an auxiliary contact on the circuit breaker that opens when the circuit breaker is closed.

# SECTION 4 • OPERATING INSTRUCTIONS

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## INTRODUCTION

The following procedures should be reviewed before initial operation is attempted. Startup procedures are detailed under *Initial Operation* and *Field Flashing*.

### NOTE

All SR32 voltage regulators are factory-preset for 120 Vac sensing.

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## OPERATION AT REDUCED SPEEDS

### CAUTION

Without adequate protection, prolonged operation at speeds lower than normal can cause extensive damage to the voltage regulator and exciter field.

Do not operate the generating system at reduced speeds with the voltage regulator in operation unless adequate precautions are taken to protect the regulator. If operation at reduced speed is essential, either remove regulator input power or add an Underfrequency/Overvoltage module to the system.

## VOLTAGE SHUTDOWN

### CAUTION

Do not install a switch in the field circuit (terminals F+ or F-). If a switch is installed in the field circuit, a high flyback voltage will develop. To prevent high voltage arcing, the field circuit must never be opened during operation.

A shutdown circuit using field discharge resistors is not required and should not be used.

Your regulator may be equipped with an input power switch to allow the removal of excitation from the field in an emergency or when the generator prime mover must be operated at reduced speed. This switch is shown in Figure 3-2. If not permanently installed, it should be temporarily installed for initial operation. The input power switch must always be installed in the input power line to the regulator (terminals 3 or 4).

## ADJUSTMENTS

Adjustments pertaining to regulator and system operation are described in the following paragraphs. These adjustments are made during initial operation and normally do not have to be repeated during the life of the regulator.

### Stability Adjustment (R4)

The stability adjustment provides stable regulator operation by controlling the amount of feedback that is applied to the regulator's error amplifier stage. Normally, the stability adjustment is factory set in the extreme clockwise position. This setting normally assures good stability but tends to slow the generator response time. If rotated counterclockwise, system response time quickens. However, if rotated too far counterclockwise, the generator voltage may oscillate (hunt). If the generator voltage oscillates, the adjustment should be rotated clockwise well ahead of the point where oscillation occurs. The system voltage stability is critical at no load conditions. If a setting is desired that provides the fastest possible voltage response with good generator stability, an oscilloscope or some voltage recording device should be used.

### Generator Voltage Adjustment (R1)

This adjustment controls the generator voltage. When adjusted to its maximum resistance position (counterclockwise), minimum generator voltage is obtained. Maximum generator voltage is obtained with minimum resistance (counterclockwise rotation).

### Nominal Voltage Range Set Adjustment (R3)

This adjustment varies the limits of generator voltage adjustment R1. Normally, R3 is set to provide R1 with an adjustment range of  $\pm 10\%$  of the rated voltage.

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## WIRING VERIFICATION

Before initial operation is attempted, verify that the regulator is connected correctly as shown in Figure 3-2.

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## INITIAL OPERATION

The initial operating instructions should be thoroughly reviewed and understood before system operation is attempted. Controls and adjustments pertinent to system operation also should be reviewed.

### Single Unit Operation (No Load)

1. Start the prime mover and bring it up to rated speed. If a voltage shutdown switch is used, close the switch to apply excitation. If this switch is not used, generator voltage will build up automatically. If field flashing is necessary, see the paragraphs under *Field Flashing*.
2. Observe the generator voltage; check for the following conditions:
  - a. If overvoltage (+15% or more) exists, open the shutdown switch immediately or stop the prime mover. Determine the cause of the overvoltage. If necessary, consult the procedures of Section 5.
  - b. If the voltage fails to build, field flashing may be required. See the paragraphs under *Field Flashing*.
  - c. If undervoltage (-15% or more) exists, stop the prime mover and determine the cause of the undervoltage. If necessary, consult the procedures of Section 5.
  - d. If the voltage builds and then collapses, stop the prime mover and determine the cause of the collapse. If necessary, consult the procedures of Section 5.
  - e. If the voltage oscillates (hunts), refer to the procedures of Section 5. Voltage oscillation can be caused by an unstable prime mover.
3. If the voltage is unstable, perform the following steps:
  - a. Loosen the locking nut on the stability adjustment (R4).
  - b. Rotate R4 clockwise approximately 30 degrees beyond the point where stable operation is obtained. If this step does not stabilize the voltage, refer to the *Field Power* paragraphs in Section 3.
  - c. When satisfied with the voltage stability, tighten the R4 locking nut.
4. To adjust the voltage range  $\pm 10\%$ , perform the following steps:
  - a. Verify that the generator voltage adjustment (R1) is adjusted to the center of its rotation.
  - b. Loosen the locking nut on the nominal voltage range set adjustment (R3) and adjust it to obtain the rated generator voltage
  - c. Tighten the R3 locking nut.
5. Perform a load test on the voltage regulator as follows:
  - a. Apply load to the generator
  - b. Verify that the voltage regulation is within  $\pm 0.5\%$ . If regulation is not within this range, refer to the procedures of Section 5.
  - c. Alternately remove and apply the load to determine if the generator voltage is stable.
  - d. If the generator voltage becomes unstable, adjust R4 for stable operation. If adjusting R4 does not stabilize the voltage, see *Increasing Stability*.

## Increasing Stability

Instability may occur when the no-load field requirements of the exciter or generator are near the minimum working voltage of the regulator. Increased stability may be obtained by adding a resistor in series with the field.

An unstable governor is frequently the cause of generator voltage instability. If a stability problem persists, thoroughly check the governor.

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## FIELD FLASHING

The following procedure is for use in applications where the generator voltage does not build and there are no provisions for field flashing. Usually, there is sufficient residual magnetism to allow generator voltage buildup without additional flashing circuitry.

1. With the prime mover at rest (not rotating), apply a dc flashing source across regulator terminals F+ and F-. The positive side of the flashing source must be connected to F+ and the negative side must be connected to F-.
2. If automatic field flashing is required, a dc source not in excess of 125 Vdc should be used. The circuit must be connected as shown in Figure 3-2. The flashing source must not provide more than 50% of the current required for no-load conditions. A blocking diode in series with the regulator F- terminal prevents the regulator output from flowing into the flashing source.

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## PARALLEL OPERATION

The following paragraphs describe the procedure for operating two or more generator sets in parallel.

### Prerequisites

To ensure proper parallel operation, the following requirements must be met:

- The voltage regulating systems must cause the generators to share the total kvar load.
- The speed governing system must cause the generators to share the total kW load.

### Preliminary Instructions

A review of the operation of components that facilitate operation is recommended. This includes components external to the regulator as well as internal regulator components.

It is essential that the paralleling signal at regulator terminals 1 and 2 have the proper phase relationship with the sensing voltages at terminals E1, E2 (if used), and E3. Verify that the connections to these terminals are exactly as shown in Figure 3-2.

If cross-current compensation is desired, the paralleling CTs must be connected as described in the *Parallel Compensation* paragraphs of Section 3. A CT must be selected that will furnish 3 to 5 Aac at the rated generator load current.

Prior to operation, the slide adjustment of resistor R25 on each regulator should be set to the same position: near the end of R25 (farthest from the terminal strip). This setting provides maximum droop signal.

### Preliminary Operation

Before attempting to parallel two or more generator sets, it is recommended that the individual sets be tested as follows to verify that the paralleling features function properly.

1. Place each set in operation in accordance with the procedures listed in *Initial Operation, Single Unit Operation (No Load)*.
2. Verify that the paralleling CT secondary winding is not shorted and that the unit/parallel switch is in the Parallel position.
3. Apply a 25 to 100%, unity power factor load to the set under test. The generator voltage should change less than 1%. If the governor is set for droop operation, the frequency should decrease.
4. Apply a 25 to 100%, 0.8 power factor (inductive) load. The voltage should droop from 4 to 6% with rated load. If the voltage rises instead of drooping, reverse the CT sensing leads.

During the tests, verify that the voltage and speed do not drift or jump erratically. Generator voltage sequence can also be verified during the tests.

## Conditions Necessary for Paralleling

To prevent damage to the generator or prime mover or both, paralleling should be attempted only when the speeds (frequencies) are equal, at the instant when the generator voltages are also equal. That is, the generators have the same phase sequence of voltage and the voltages are in phase.

## Metering

To initiate paralleling and to check for proper parallel operation, all generators should be equipped with the following monitoring equipment:

- ac voltmeter (one or two)
- frequency meter (one or two)
- synchroscope or set of lights to indicate in-phase condition
- ac ammeter (one per generator set)
- kW meter (one per generator set)
- kvar or power factor meter (one per generator set)
- field ammeter

## Sequence of Operation (Parallel)

The proper procedure for paralleling generators is composed of the following steps. This procedure should be reviewed completely, understood, and walked through before paralleling is attempted.

1. Start generator set No. 1.
2. Close the circuit breaker connecting set No. 1 to the bus.
3. Adjust the generator voltage and frequency to the nominal values.
4. Apply load. If possible, the load should be 10% or more of the unit's kW rating.
5. Start generator set No. 2.
6. Adjust the No. 2 set's voltage to nominal.
7. Adjust the No. 2 set's speed to slightly higher than the speed of set No. 1.
8. Observe the synchroscope or synchronizing lights. When set No. 2 is in phase with set No. 1, close the circuit breaker connecting set No. 2 to the bus.
9. Immediately after closing the breaker, note the reading of the ammeter for set No. 2. The ammeter should read well within the rating of the generator. If the reading is beyond the generator's rating, stop the system and refer to Section 5. If operation is unstable, refer to the paragraphs under *Parallel Operation, Sequence of Operation (Parallel)*. If operation is stable, proceed to step 10.
10. Adjust the speed of set No. 2 to the point where each set is carrying the desired share of kW load.
11. Adjust the voltage of set No. 2 until the ammeter readings of both sets are near minimum.
12. If kvar or power factor meters are available, adjust the voltage adjust rheostat for equal or proportional kvar or power factor readings.
13. If the sets are equipped with power factor meters instead of kW meters, alternately adjust the speed and voltage on set No. 2 until the ammeter readings are proportional and the power factor readings are equal.

### NOTE

To obtain the best results, final adjustments should be made with full load on the bus.

14. With full load applied, readjust the speed and voltage on set No. 2 until the desired load division is obtained.

The best adjustment is obtained when both sets are supplying the same percentage of rated current, the kW or power factor meter readings are equal, or the sum of the ammeter currents (of the sets) is minimum.

Closing the circuit breaker for set No. 2 (step 8, above), may result in improper operation. The ammeter reading may be very high and the circuit breaker may open due to current overload or reverse power. Isolate this problem to a faulty speed or voltage regulating system by performing the following steps.

1. Parallel the generators as instructed in steps 1 through 8, above.
2. Immediately after closing the circuit breaker, observe the kW or power factor meter readings. If a high ammeter reading is accompanied by a large kW imbalance, a faulty speed regulating system is indicated. If a high ammeter reading is accompanied by a kvar imbalance, a faulty voltage regulating system is indicated.

An alternate method of isolating the cause for the preceding problem is to parallel the generators using manual voltage control (if available). If proper operation is obtained, a faulty voltage regulating system is indicated. If not, a faulty speed regulating system is indicated.

If a faulty voltage regulating system is indicated, verify the wiring and review the *Parallel Compensation* paragraphs of Section 3 before removing the regulator. It has been found that most problems encountered with the voltage regulator in attempting to parallel generators are due to improper wiring.

To parallel additional generator sets, repeat steps 1 through 14, above, for paralleling set No. 2.

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# SECTION 5 • MAINTENANCE AND TROUBLESHOOTING

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## MAINTENANCE

The voltage regulator should be inspected periodically to ensure that it is free from moisture and accumulations of dust. When inspecting the unit, check that all parts are securely mounted and that all electrical connections are clean and secure. Any accumulation of dust should be removed with a soft brush or with moisture-free compressed air.

### Repairs

Regulator repairs can be made by following the procedures under *Troubleshooting*. Due to a protective, transparent, conformal coating, circuit board repairs are difficult and should not be attempted.

### Replacement Parts

Table 5-1 lists parts and assemblies that have maintenance significance. When ordering parts from Basler Electric, always specify the regulator style number, serial number, item part number, item description, and the quantity required.

Table 5-1. Replacement Parts

Reference	Description	Basler P/N
CB	Circuit board assembly	Specify model and style number
CR11, CR12	SCR	07754
CR8, CR13, CR14, CR15, CR16	Diode	07267
T3	Transformer	BE09024002
—	Sensing transformer(s)	Specify model and style number
L1	Filter inductor	BE08794003
K1	Relay	02686
R25	Paralleling rheostat	02662
R1	Voltage adjust rheostat	03456

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## TROUBLESHOOTING

Troubleshooting procedures for the more common generator system malfunctions are provided in the following paragraphs.

### Voltage does not build up to rated value

1. Check for low residual voltage and/or incorrect polarity relationship between the exciter output and generator field.
  - a. If either condition exists, flash the generator field.
  - b. If neither condition exists, proceed to step 2.
2. Verify that the Voltage Shutdown switch is closed.
  - a. If the voltage shutdown switch is open, close the switch.
  - b. If the voltage shutdown switch is closed, proceed to step 3.
3. Verify that the prime mover is operating at rated speed.
  - a. If the prime mover is not operating at rated speed, adjust the speed.
  - b. If the prime mover is operating at rated speed, proceed to step 4.

4. Check for incorrect or missing voltage at regulator power input terminals 3 and 4.
  - a. If this condition exists, correct the wiring.
  - b. If this condition does not exist, proceed to step 5.
5. Check the regulator output voltage at terminals F+, F–, and A–.
  - a. If the voltage is incorrect, correct the wiring and/or adjust/repair the regulator.
  - b. If the voltage is correct, proceed to step 6.
6. Verify that the generator output is neither shorted nor overloaded.
  - a. If the generator output is shorted, remove the short-circuit and repair the wiring.
  - b. If the generator is overloaded, shed excess load.
  - c. If the generator output is not overloaded or shorted, proceed to step 7.
7. Verify that the external voltage adjust potentiometer (R1) is wired properly.
  - a. If R1 is wired incorrectly, correct the wiring.
  - b. If R1 is wired correctly, proceed to step 8.
8. Verify that the exciter wiring is correct.
  - a. If the exciter wiring is incorrect, reconnect the exciter.
  - b. If the exciter wiring is correct, proceed to step 9.
9. Check for a defective exciter.
  - a. If the exciter is defective, repair or replace the exciter.
  - b. If the exciter is not defective, proceed to step 10.
10. Confirm that the regulator's sensing transformers are on the correct taps.
  - a. If incorrect, change the taps for the correct nominal voltage.
11. If the above steps fail to correct the malfunction, replace or repair the voltage regulator.

#### **Voltage builds up until relay actuates, then decays**

1. Check for a defective voltage adjust rheostat (R1) and/or defective associated circuitry.
  - a. If the circuitry is defective, repair the circuit/wiring.
  - b. If the rheostat is defective, replace the rheostat.
  - c. If neither the rheostat or the circuit is defective, proceed to step 2.
2. Brush-type rotary exciters only—all others proceed to step 3. Check for proper input power at regulator terminals 3 and 4
  - a. If power is not present, check and repair the wiring as necessary.
  - b. If power is present, proceed to step 3.
3. If the above steps do not correct the malfunction, replace or repair the voltage regulator as necessary.

#### **Voltage is high and uncontrollable with voltage adjust rheostat**

1. Check for sensing voltage at terminals E1, E2, and E3.
  - a. If the sensing voltage is not present, repair the wiring.
  - b. If the sensing voltage is present, proceed to step 2.
2. Confirm that the transfer switch (if used) is in the Auto position. If a transfer switch is not used, proceed to step 3.
  - a. If the transfer switch is not in the Auto position, place it in the Auto position
  - b. If the transfer switch is in the Auto position, proceed to step 3.
3. Check for a shorted external voltage adjust potentiometer (R1).
  - a. If R1 is shorted, replace the potentiometer.
  - b. If R1 is not shorted, proceed to step 4.

4. Verify that the sensing transformer is set to the proper tap.
  - a. If the transformer tap is improperly selected, reconnect it at the proper tap.
  - b. If the transformer tap is correct, proceed to step 5.
5. Check for a faulty relay (K1).
  - a. If K1 is defective, replace the relay.
  - b. If K1 is not defective, proceed to step 6.
6. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

**Voltage is high but controllable with voltage adjust rheostat**

1. Check that the sensing transformer is set to the proper tap.
  - a. If the transformer tap is improperly selected, reconnect the transformer at the proper tap.
  - b. If the transformer tap is correct, proceed to step 2.
2. Confirm that the voltage range adjust potentiometer (R3) is not set too high.
  - a. If R3 is set too high, adjust the potentiometer.
  - b. If R3 is within its limits, proceed to step 3.
3. Check that the voltage adjust potentiometer (R1) resistance is not too low.
  - a. If the voltage adjust potentiometer resistance is too low, replace R1 with one of the proper value.
  - b. If the R1 resistance is proper, proceed to step 4.
4. Verify that the sensing leads are properly connected to the generator and regulator.
  - a. If the sensing leads are improperly connected, reconnect them.
  - b. If the sensing lead connections are correct, proceed to step 5.
5. Three-phase sensing models only—for single-phase sensing models, proceed to step 6. Confirm that three-phase sensing is applied to the regulator.
  - a. If single-phase sensing is applied, reconnect the regulator for three-phase sensing.
  - b. If three-phase sensing is applied, proceed to step 6.
6. Verify the accuracy and connection of the voltmeter.
  - a. If the voltmeter is connected improperly, reconnect it.
  - b. If the voltmeter is defective, replace it.
  - c. If the voltmeter is connected properly and functioning properly, proceed to step 7.
7. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

**Voltage is low and controllable with the voltage adjust rheostat**

1. Check that the sensing transformer is set to the proper tap.
  - a. If the transformer tap is improperly selected, reconnect it to the proper tap.
  - b. If the transformer tap is correct, proceed to step 2.
2. Check that the voltage range adjust potentiometer (R3) is not set too low.
  - a. If R3 is set too low, adjust the potentiometer.
  - b. If R3 setting is within limits, proceed to step 3.
3. Verify that the prime mover is operating at rated speed.
  - a. If the prime mover is operating below rated speed, adjust it to rated speed.
  - b. If the prime mover is operating at rated speed, proceed to step 4.
4. Confirm that the sensing leads are properly connected at the generator and regulator.
  - a. If the sensing leads are improperly connected, reconnect them.
  - b. If the sensing leads are properly connected, proceed to step 5.
5. Verify the accuracy and connection of the voltmeter.
  - a. If the voltmeter is connected improperly, reconnect it.

- b. If the voltmeter is defective, replace it.
  - c. If the voltmeter is connected properly and functioning properly, proceed to step 6.
6. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

### Poor regulation

1. Verify that the exciter/generator field requirements are not in excess of voltage regulator capability.
  - a. If the regulator application is incorrect for the regulator, contact Basler Electric.
  - b. If the regulator application is within regulator limits, proceed to step 2.
2. Confirm that the input voltage at regulator terminals 3 and 4 is of the correct value.
  - a. If the input voltage is incorrect, correct the voltage applied to terminals 3 and 4.
  - b. If the input voltage is correct, proceed to step 3.
3. Verify that the voltmeter is connected to the same location as the regulator sensing.
  - a. If the voltmeter is not connected to the same location as the regulator sensing, reconnect the voltmeter.
  - b. If the voltmeter is properly connected, proceed to step 4.
4. Check that the generator output waveform is not distorted due to harmonic content. (The regulator senses average voltage—the meter may indicate RMS values.)
  - a. If this condition exists, consult the generator manufacturer.
  - b. If the condition does not exist, proceed to step 5.
5. Confirm that the unit/parallel switch (proceed to step 6 if switch is not used) is in the parallel position when the generator is paralleled and in the unit position when the generator is operating alone. Also check that the switch functions properly.
  - a. If not in the proper position, correct the switch position.
  - b. If the switch is defective, replace it.
  - c. If the switch is operating properly and is placed in the correct position, proceed to step 6.
6. Three-phase sensing models only—proceed to step 7 if single-phase sensing model is being used. Verify that the generator load is balanced as the regulator averages all three phases together.
  - a. If the load is unbalanced, balance the generator load.
  - b. If the generator load is balanced, proceed to step 7.
7. Verify that the prime mover is operating at rated speed.
  - a. If the prime mover is not operating at rated speed, correct the speed.
  - b. If the prime mover speed is correct, proceed to step 8.
8. Check for a fault in either the exciter or generator.
  - a. If a fault exists, correct the condition.
  - b. If no fault exists, proceed to step 9.
9. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

### Poor voltage stability

1. Verify that the generator frequency is stable.
  - a. If the frequency is unstable, consult with the governor manufacturer.
  - b. If the generator frequency is stable, proceed to step 2.
2. Verify that the voltage does not fluctuate to the point that K1 either energizes or de-energizes.
  - a. If this condition occurs, refer to the procedures associated with *Voltage builds up until relay actuates, then decays*.
  - b. *If this condition does not exist, proceed to step 3.*
3. Check that the sensing voltage and input power are not taken from the same power isolation transformer secondary.
  - a. If the above condition exists, reconnect the regulator sensing input to a separate source.

- b. If the above condition does not exist, proceed to step 4.
4. Confirm that R4 is adjusted correctly.
  - a. If R4 is adjusted incorrectly, adjust it to the proper setting.
  - b. If R4 is adjusted correctly, proceed to step 5.
5. Verify that the no-load field voltage is at the rated value.
  - a. If the no-load field voltage is below the rated value, refer to Section 3, *Installation, Connections, Field Power*.
  - b. If the no-load field voltage is at rated value, proceed to step 6.
6. Check for a fault in either the exciter or generator.
  - a. If a fault exists, correct it.
  - b. If no fault exists, proceed to step 7.
7. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

#### **Voltage recovery is slow with a load change**

1. Verify that the correct regulator is being used for the application.
  - a. If the incorrect regulator is being used, contact Basler Electric.
  - b. If the regulator is correct for the application, proceed to step 2.
2. Confirm that R4 is adjusted correctly.
  - a. If R4 is adjusted incorrectly, adjust it to the proper setting.
  - b. If R4 is adjusted correctly, proceed to step 5.
3. Check that the generator frequency is stable.
  - a. If the frequency is unstable, consult with the governor manufacturer.
  - b. If the frequency is stable, proceed to step 4.
4. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

#### **Paralleled generators do not divide the real kW load equally**

Consult with the governor manufacturer for improving the governor power sensing and/or adjustment of the governor droop setting.

#### **No reactive droop compensation can be obtained for parallel generators**

1. Confirm that the tap on R25 is not set to the minimum position.
  - a. If the tap is set to the minimum position, adjust R25 to obtain the required droop.
  - b. If the tap is set properly, proceed to step 2.
2. Verify that the parallel CT provides the required 3 to 5 Aac secondary current.
  - a. If the CT does not provide the required 3 to 5 Aac secondary current, refer to Section 3, *Installation, Connections, Parallel Compensation*.
  - b. If the CT does provide the required current, proceed to step 3.
3. Confirm that regulator terminals 1 and 2 are not shorted by the unit/parallel switch.
  - a. If the switch is set to unit, place the switch in the parallel position.
  - b. If the switch terminals are shorted, replace the switch and/or repair the wiring.
  - c. If the terminals are not shorted, proceed to step 4.
4. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.

#### **Paralleled generators do not divide the reactive kvar load equally (circulating reactive current between the generators)**

1. Confirm that the tap of R25 is not set to the minimum position.
  - a. If the tap is set to the minimum position, adjust R25 to obtain the required droop.
  - b. If the tap is set properly, proceed to step 2.

2. Verify that the parallel CT provides the required 3 to 5 Aac secondary current.
  - a. If the CT does not provide the required current, refer to Section 3, *Installation, Connections, Parallel Compensation*.
  - b. If the CT does provide the required current, proceed to step 3.
3. Check for correct paralleling CT polarity.
  - a. If the CT polarity is incorrect, reverse the CT secondary leads.
  - b. If the CT polarity is correct, proceed to step 4.
4. Verify that the paralleling CT is inserted in the correct generator phase (line).
  - a. If the CT is not inserted in the correct phase, place the CT in the correct line.
  - b. If the CT is located in the correct phase, proceed to step 5.
5. Check that all paralleled generators have the same type of sensing (either single- or three-phase).
  - a. If all paralleled generators do not have the same type of sensing, adjust R25 to compensate.
  - b. If all paralleled generators do have the same type of sensing, proceed to step 6.
6. If the above steps fail to correct the malfunction, replace or repair the voltage regulator as necessary.





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