CATERPILLAR®

FORM NO. SENR3906-01

FOR USE IN SERVICE MANUAL:
ELECTRIC SET GENERATORS, SENR7958

Service Manual

VR4 Voltage Regulator

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Index

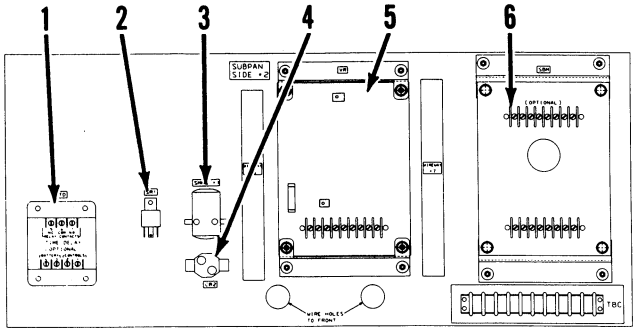
Attachments

Systems Operation

Testing And Adjusting

Systems Operation

Introduction

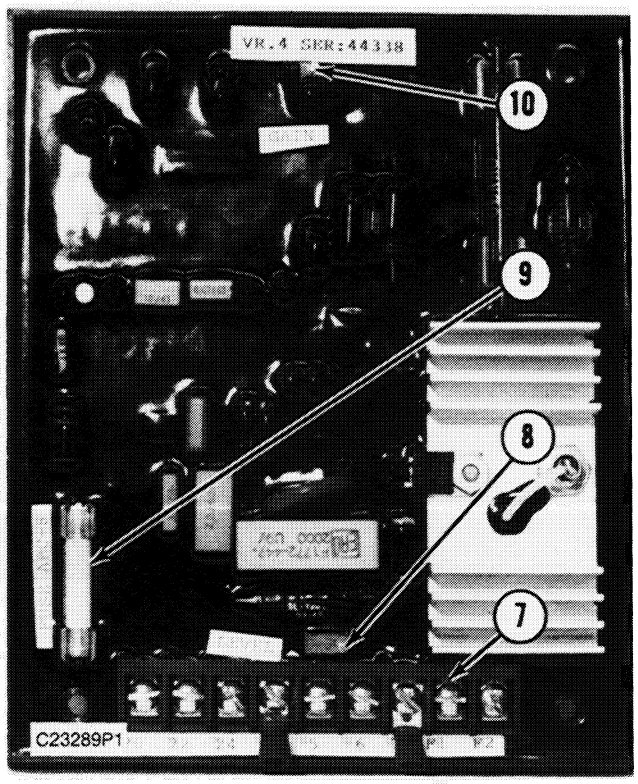


Typical Subpan (Partial View)
(1) Time delay relay. (2) Slave relay. (3) Starting motor magnetic switch. (4) Circuit breaker. (5) VR4 voltage regulator. (6) Series boost (attachment).

The VR4 is one of the voltage regulators available for SR4 generators. The VR4 is only used on standby SR4 generators which are: self-excited, 10/12 lead, and rated up to 400KW. **Follow all safety procedures and warnings in the SR4 generator manuals.**

VR4 regulator (5) is located on side two of the subpan. The subpan is mounted above the generator.

Operation

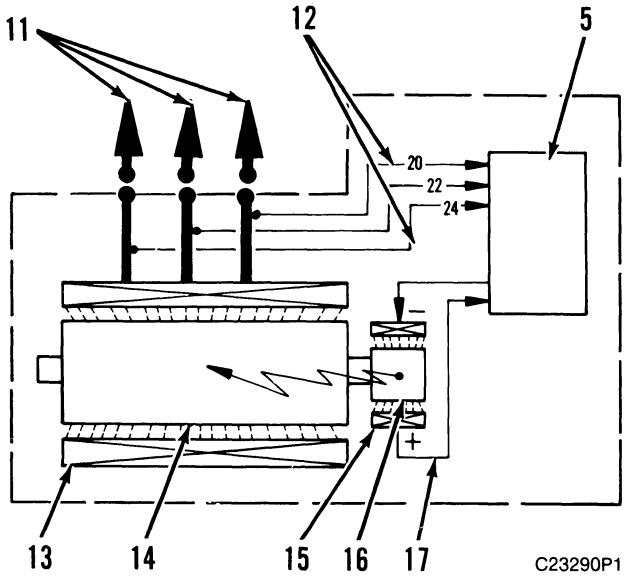


VR4 Regulator
(7) Terminal strip. (8) Rheostat (voltage level). (9) Fuse. (10) Rheostat (voltage gain).

The purpose of the VR4 regulator is to keep generator output voltage at a rated value. There are two controls on the VR4 that are standard.

- Voltage level rheostat (8) provides a no load voltage adjustment of approximately + 10 to - 25%.
- Voltage gain rheostat (10) provides an adjustment to compensate for engine RPM droop with load. Rheostat (10) can be adjusted to keep the same voltage at no load and full load, even when there is a small change in frequency (rpm).

The rheostats are multiple (30) turn. The adjusting screw on the rheostat does not have a fixed stop. To ensure the lowest position, turn the rheostat 32 full turns counterclockwise from the current position. To ensure the highest position, turn the rheostat 32 full turns clockwise from the current position.



SR4 Generator Schematic (Self-Excited 10/12 Lead)
(5) VR4 regulator. (11) Lines (3-phase output voltage). (12) Lines (sensing voltage and AC power). (13) Main stator. (14) Main rotor. (15) Exciter stator. (16) Exciter rotor. (17) Lines (VDC excitation voltage).

VR4 regulator (5) senses generator output voltage between two phases. Lines (12) function as sensing lines by tapping into generator output. These lines are connected to terminals 20 and 24 on the VR4. Terminal 22 is also connected but is not used on the VR4. Like other SR4 generator regulators, the VR4 regulates voltage based on volts per hertz.

Leads (12) also function to provide AC power for excitation to the VR4 regulator. The regulator rectifies the AC voltage and controls the excitation current to exciter stator (15).

Fuse (9) limits the field current in the case of an internal short circuit or exciter field fault.

NOTE: VR4 regulators include an overcurrent shutoff to protect generator components. If the unit operates for an extended period of time at low rpm, the overcurrent shutoff may trip. It will reset automatically when the generator is completely shutoff. The approximate recommended minimum operating speed is:

Four pole generator ..... 1200 rpm
Six pole generator ..... 750 rpm

Testing And Adjusting

⚠ WARNING

When servicing or repairing electric power generation equipment, do the following:

a. Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged "DO NOT OPERATE".

b. Make sure the generator engine is stopped.

c. Make sure all batteries are disconnected.

d. Make sure all capacitors are discharged.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present. Make sure the testing equipment is designed for and correctly operated for the high voltage and current tests being made. Improper test equipment may fail and present a high voltage shock hazard to its user.

⚠ WARNING

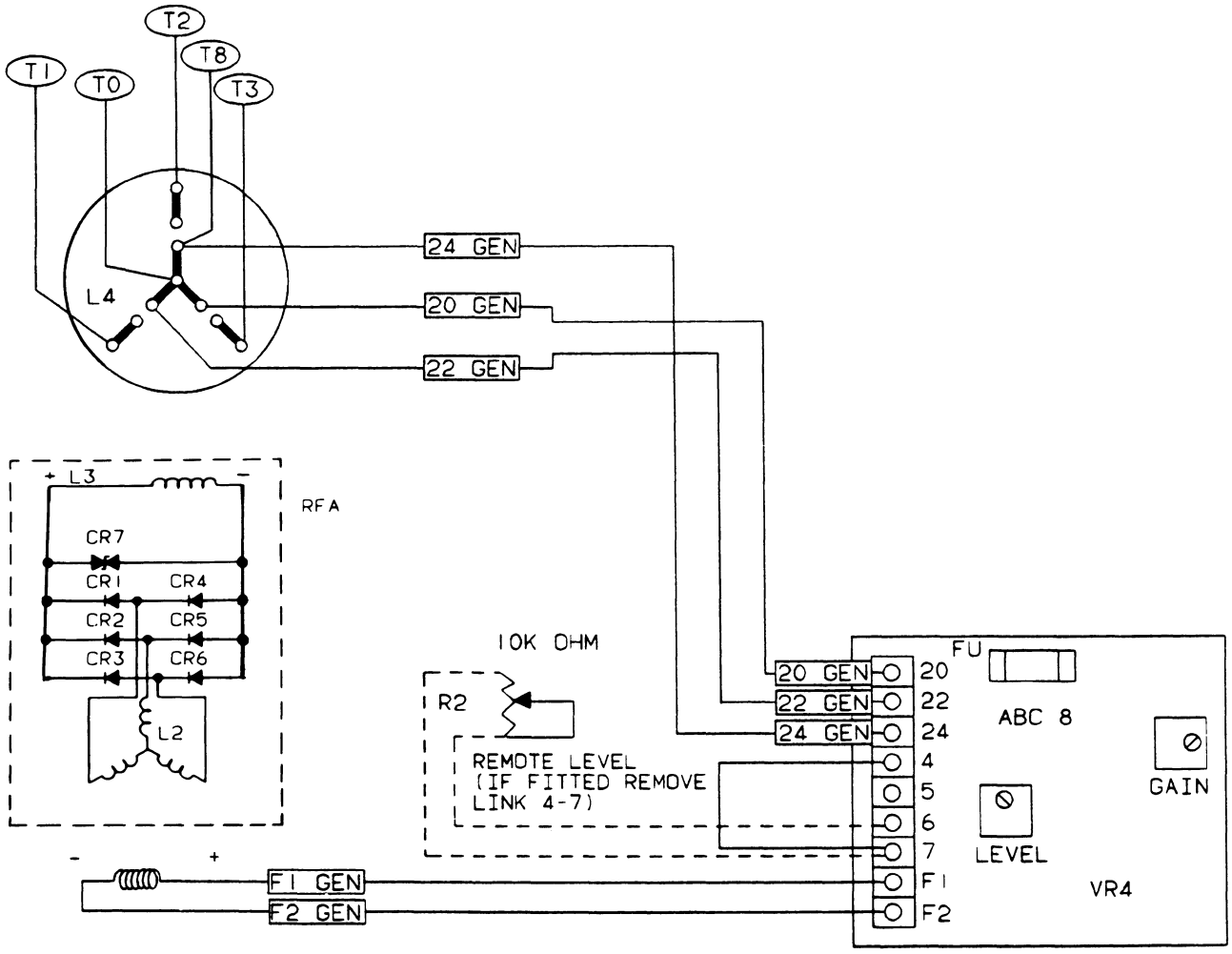
Do not connect the generator to a utility electrical distribution system, unless it is isolated from the system. Electrical feedback into the distribution system can occur and could cause personal injury or death.

Open and secure the main distribution system switch or, if the connection is permanent, install a double throw transfer switch to prevent electrical feedback. Some generators are specifically approved by a utility to run in parallel with the distribution system and isolation may not be required. Always check with your utility as to the applicable circumstances.

Test Equipment

6V7070 Heavy Duty Digital Multimeter

Caterpillar Digital Multimeters measure voltage, resistance, or current up to 10 amps. The diode function checks rectifiers. See Special Instruction SEHS7734 for the operation of 6V7070.



SR4 Generator Schematic (10/12 Lead, Self-Excited)

Introduction

Check for loose or corroded terminals. Make sure wire connections are correct. Check the accuracy of the voltmeter and frequency meter/tachometer.

To reduce troubleshooting time, simplify the system or circuit by eliminating non-essential components. If, at this point, it is determined that the basic system is functioning, the circuits or components can be added back in, one at a time until the problem is located.

If elimination of non-essential components does not correct the problem, the troubleshooting procedure will check components in the basic system. If all other basic components (i.e. rotating field assembly, exciter stator etc.) are operating correctly, then replace the VR4 regulator. As a last step after confirming correct operation under no load conditions, operate the generator under a load.

The VR4 regulator will be serviced as a complete unit. Its fuse is the only replaceable part. **VR4 regulators must be checked through the bench test before making a claim on warranty (see Bench Test).**

Problem List

Problem 1 - No AC Voltage.

Problem 2 - Low AC Voltage.

Problem 3 - High AC Voltage.

Problem 4 - Unstable AC Voltage.

Problem 1 - No AC Voltage

Procedure A - Check AC voltage at regulator between terminals 20 and 22.

- If above 200 volts:
  Check meters.

- If 0 volts:
  Flash the field. See SR4 Generator Service Manual, SENR3985.

- If 0 to 15 volts:
  Go to Procedure B.

Procedure B - Isolate Regulator

Disconnect leads from regulator terminals F1 and F2. Connect a 12 volt automotive type battery across exciter leads F1 (+) and F2 (-). Operate generator at half of the rated speed. Then slowly increase rpm.

- If voltage at regulator terminals 20 and 22 is 0 to 15 volts (AC):
  a. Check exciter stator (L1) continuity.
  b. Check rotating rectifier block.
  c. Check main rotor (L3) continuity.
  d. Check exciter rotor (L2) continuity.

  NOTE: For more information, see SR4 Generator Service Manual, SENR3985.

- If balanced AC voltage between regulator terminals 20-22-24 increases with rpm:
  Go to Procedure C.

Procedure C - Isolate Attachments

Reconnect leads to regulator terminals F1 and F2. Disconnect all attachments such as series boost and remote voltage control.

NOTE: If remote mounted voltage adjustment is disconnected, connect jumper across terminals 4 and 7.

Check all connections to regulator and the regulator fuse.

- If generator output voltage is normal:
  Check attachments.

- If voltage at regulator terminals 20 and 22 is 0 to 15 volts:
  a. Replace regulator.
  b. Bench test the regulator (see Bench Test).

Problem 2 - Low AC Voltage

Procedure A - Check Engine RPM (Frequency)

Gen. Poles	Frequency	RPM
6	50 Hz.	1000
6	60 Hz.	1200
4	60 Hz.	1800
4	50 Hz.	1500

Procedure B - Adjust Voltage Level With Gain Adjustment Full Counterclockwise

- Voltage level adjustment range should be within +10 to -25% of rated voltage.
  a. Check meters.
  b. Go to Procedure C.

Procedure C - Check AC Voltage Between Regulator Terminals 20 And 22

- If greater than 200 volts:
  Check meters.

- If lower than 200 volts:
  Go to Procedure D.

Procedure D - Isolate Regulator

Disconnect leads from regulator terminals F1 And F2. Connect a 12 volt automotive type battery across exciter leads F1 (+) and F2 (-). Operate generator at half of the rated speed. Then slowly increase RPM.

- If voltage at regulator terminals 20 and 22 is less than 100 volts:
  a. Check rotating rectifier block. See SR4 Generator Service Manual, SENR3985.
  b. Check exciter stator (L1) resistance between F1 and F2 leads. Exciter stator resistance should be approximately 2 to 6 ohms. See SR4 Generator Service Manual, SENR3985.

- If balanced AC voltage between regulator terminals 20-22-24 increases with RPM:
  Go to step E.

Procedure E - Isolate Attachments

Connect exciter stator (L1) leads to regulator terminals F1 and F2. Disconnect all attachments such as series boost and remote voltage control.

NOTE: If remote mounted voltage adjustment is disconnected, connect jumper across terminals 4 and 7. Check all connections to the regulator and regulator fuse.

- If generator output voltage is normal:
  Check attachments.

- If voltage at regulator terminals 20 and 22 cannot be adjusted to rated voltage and rated frequency at no load:
  a. Replace regulator.
  b. Bench test the regulator (see Bench Test).

Problem 3 - High AC Voltage

Procedure A - Check Engine RPM (Frequency)

Gen. Poles	Frequency	RPM
6	50 Hz.	1000
6	60 Hz.	1200
4	60 Hz.	1800
4	50 Hz.	1500

Procedure B - Adjust Voltage Level With Gain Adjustment Full Counterclockwise.

- Voltage level adjustment range should be within +10% to -25% of rated voltage.
  a. Check meter.
  b. Go to Procedure C.

- Check accuracy of generator set voltmeter.

Procedure C - Check Connections To Regulator.

- If connections are correct:
  Go to Procedure D.

Procedure D - Isolate Attachments

Disconnect all attachments such as series boost and remote voltage control. Operate at rated rpm.

NOTE: If remote mounted voltage adjustment is disconnected, connect jumper across terminals 4 and 7.

- If generator output voltage is normal:
  Check attachments.

- If voltage cannot be adjusted to rated voltage at rated frequency:
  a. Replace regulator.
  b. Bench test the regulator (see Bench Test).

Problem 4 - Unstable AC Voltage

Procedure A - Check Engine RPM

- Governor operation is unstable.
  a. Correct engine problem. Reference engine service manual.
  b. Go to Procedure B.

Procedure B - Check for loose connections.

- If connections are okay:
  Go to Procedure C.

Procedure C - Isolate Regulator.

Disconnect leads F1 and F2 from their respective terminals on the regulator. Connect a 12 volt automotive type battery across exciter leads F1 and F2. Operate at half of rated speed and then slowly increase rpm.

- Voltage at regulator terminals 20-22 is unstable.
  a. Check connections to rotating rectifier block, main field poles and other connections on the rotating (revolving) field.
  b. Check connections to excitor stator.

- If stable balanced AC voltage between regulator terminals 20-22-24 increases with rpm:
  Go to Procedure D.

Procedure D - Isolate Attachments

Reconnect leads to regulator terminals F1 and F2. Disconnect attachments such as series boost and remote voltage control. Operate at rated rpm.

NOTE: If remote mounted voltage adjustment is disconnected, connect jumper across terminals 4 and 7.

Check all connections to the regulator and its fuse.

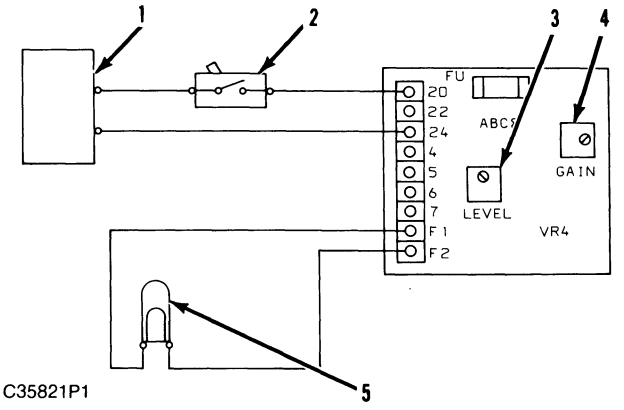
- If generator output voltage is normal:
  Check attachments.

- If voltage at regulator terminals 20-22 is unstable at rated frequency with no load:
  a. Replace regulator.
  b. Bench test the regulator (see Bench Test).

Bench Test

NOTE: An alternative to the following test procedure is available. The 4C4693 Regulator Tester with NEHS0535 Operating Manual can be used to bench test the regulator.

Tools Needed		
4C4029	Trimmer Adjust Tool	1
	Bench Test Circuit	1



Bench Test Circuit
(1) AC power source. (2) On/Off switch. (3) Voltage level rheostat. (4) Voltage gain rheostat. (5) 100W Light bulb.

1. Construct and connect the bench test circuit. AC power source (1) must be:
   60 Hz units ..... 220 to 240 VAC
   50 Hz units ..... 180 to 200 VAC

2. Turn voltage level rheostat (3) and voltage gain rheostat (4) counterclockwise 32 full turns.

NOTE: Voltage level rheostat (3) and voltage gain rheostat (4) are multiple (thirty) turn rheostats. The adjusting screw on the rheostat does not have a fixed stop. To ensure the lowest position, turn the rheostat 32 full turns counterclockwise from the current position. To ensure the highest position, turn the rheostat 32 full turns clockwise from the current position. The adjusting screw can be turned past the rheostat stop (ratchet action) without further changing the rheostats setting.

3. Turn switch (2) to the ON position.

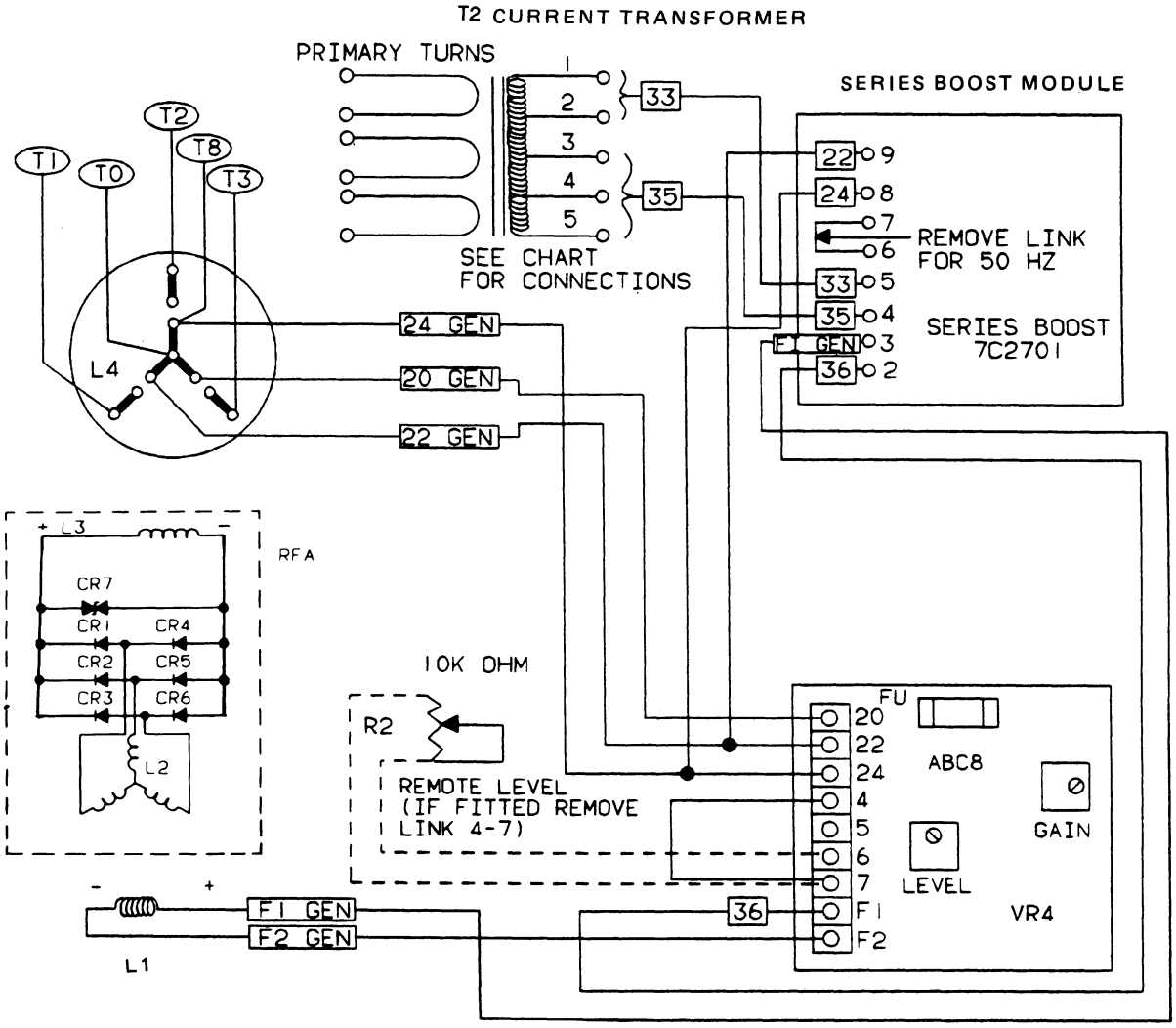
4. Turn voltage level rheostat (3) clockwise until light (5) first turns ON (approximately ten turns). The light should increase and decrease in intensity as rheostat (3) is turned clockwise and counterclockwise respectively. After 10 to 15 seconds at maximum intensity, light (5) should go OFF.

- If light (5) reacts as described:
  Regulator is okay.

- If light (5) reacts different than described:
  Replace VR4 regulator.

Attachments

Series Boost (Attachment)



CR 1-6 ROTATING RECTIFIERS
CR 7 SURGE SUPPRESSION DIODE

FU FUSE

L1 EXCITER STATOR
L2 EXCITER ROTOR
L3 MAIN ROTOR
L4 MAIN STATOR
R2 REMOTE LEVEL RHEOSTAT

RFA REVOLVING FIELD ASS'Y
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
T2 CURRENT TRANSFORMER

C35822P1

Series Boost Module (Attachment)
(1) Series boost module. (2) Current transformer T2

Series boost keeps self-excited SR4 generators on the line, for approximately 10 seconds, when there is a short in the generating or load circuits. This gives circuit breakers a chance to trip in sequence. When circuit breakers trip in sequence, there is less chance for a loss of power to all of the electrical system.

The series boost module and current transformer (T2) make up the series boost.

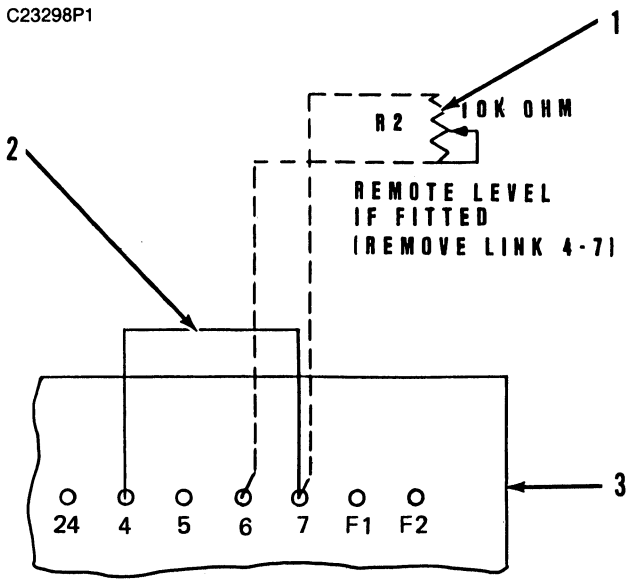
REFERENCE: For the most current information on connecting to the primary side of the transformer, see Special Instructions, SELS0071-01.

Voltage sensing and power are applied to the series boost module from the voltage sensing terminals 22 and 24 of the regulator.

When the sensed voltage is within normal limits, an electrical signal is sent to the gate of a triac located in the series boost module. This triac short circuits current transformer (T2). This prevents any series boost during normal operation.

If there is a short circuit that causes the voltage at the regulator sensing terminals to drop to a low value, the control signal to the gate of the triac will be turned off. Current from current transformer (T2) will be rectified and applied directly to exciter stator (L1). This field current will be enough to give at least three times full load current into a short circuit. After approximately ten seconds a timer within the series boost module will again cause a control signal to be applied to the gate of the triac. The triac will short circuit transformer (T2). Current flow to exciter stator (L1) will be zero until the short circuit is corrected.

Remote Voltage Control (Attachment)



Partial View Of Regulator
(1) Potentiometer. (2) Jumper. (3) Regulator.

Generator output voltage level can be controlled from a remote location. This is done by connecting potentiometer (1) between terminals (6 and 7) on voltage regulator (3).

Remove jumper link (2) between terminals (4 and 7) for remote voltage level control.

For acceptable voltage control, the remote mounted potentiometer must be a three turn, 10K ohm ± 5%, with a dielectric strength of 1000 VAC minimum (reference 7C4471).

Wiring to the remote mounted potentiometer (connecting to) must be 18 gauge or smaller. The wire should be 600 volt class with a 90°C insulation.

NOTE: Either the jumper between terminals (4 and 7) or the remote potentiometer between terminals (6 and 7) is required for operation.

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