



# Specifications Systems Operation Troubleshooting Testing and Adjusting

## **VR6 Voltage Regulator**

JCA1-Up (Generator Set)
LEA1-Up (Package Generator Set)

R7A1-Up (Generator Set)

ZBA1-Up (Generator Set)

CCB1-Up (Generator Set)

TGC1-Up (Generator Set)

R7E1-Up (Generator Set)

CAH1-Up (Generator Set)

TAM1-Up (Generator Set)

DJN1-Up (Generator Set)

EDNA Up (Concretor Cot

FDN1-Up (Generator Set)

9EP1-Up (Generator Set)

KAP1-Up (Generator Set)

KAR1-Up (Generator Set) PBR1-Up (Generator Set)

X3R1-Up (Generator Set)

X4R1-Up (Generator Set)

8NS1-Up (Generator Set)

9ES1-Up (Generator Set)

GZS1-Up (Generator Set)

TFT1-Up (Generator Set)

**BCW1-Up (Generator Set)** 

LRW1-Up (Generator Set)

CBX1-Up (Generator Set)

LRX1-Up (Generator Set)

LRY1-Up (Generator Set)

RTY1-Up (Generator Set)

4BZ1-Up (Generator Set)

8AZ1-Up (Generator Set)

CSZ1-Up (Generator Set)

## **Important Safety Information**

Most accidents that involve 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 to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is 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 explains the hazard and can be either written or pictorially presented.

A non-exhaustive list of 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. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Cat dealers have the most current information available.

#### **WARNING**

When replacement parts are required for this product Caterpillar recommends using Cat replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

RENR2480-05

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## **Specifications Section**

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## **Electrical**

SMCS Code: 4467

		Charifications
		Specifications
Regulator Characteristics	Regulation	Less than ±1% of voltage setpoint from no load to full load
	Response time	Maximum of 4 milliseconds
	Voltage drift	Less than ±1% steady state
	Temperature drift	Less than ±1% for any 40 °C (104.0 °F) change over the operating temperature range
	Sensing voltage	True RMS three-phase sensing is standard. Single phase sensing is available. The variable sensing range is 180 to 280 VAC for 50 or 60 Hz.
	Stability	The regulator responds to the main component of the sensed voltage and remains stable for total harmonic distortion of the generator output voltage waveform, up to 20%.
Regulation	Volts/Hz characteristic	The characteristic is linearly proportional to frequency. 1 V/Hz characteristic can be selected by placing the jumper between terminals 6A and 8. 2 V/Hz characteristic can be selected by removing the jumper between terminals 6A and 8. These characteristics provide matched engine/generator performance for improved block load performance.
	Knee frequency	The knee frequency is adjustable from 45 Hz to 65 Hz. Refer to the Testing and Adjusting, "Knee Frequency - Adjust" for more information.
Adjustment Characteristics	Voltage adjust range	+10% to -25% of regulator sensing voltage
	Reactive droop adjustment	Adjustable from 0 to 10% at rated input current and 0.8 power factor. Either a 1 Ampere current transformer (CT) or a 5 Amperes CT can be used with a VA<1.0.
	External Voltage Adjust Potentiometer	10 K Ohm, 2 Watts
Protection	For Overexcitation	The protection shuts off the generator output when excitation current exceeds normal operating currents for 30 seconds at 90 VDC ± 5%.
Power	Power dissipation	Maximum 50 watts at rated output
Characteristics	Input	180 to 280 VAC, single-phase or three-phase on 50 Hz or 60 Hz applications 90 to 120 VAC, three-phase, on 100 Hz to 240 Hz permanent magnet (PMG) applications. Maximum of 3125 VA. 240 VAC, single-phase, on 100 Hz to 240 Hz permanent magnet (PMG) applications. Maximum of 3125 VA.
	Output (with a 240 VAC Input)	12 Amperes DC at 65 VDC maximum continuous 25 Amperes DC at 125 VDC forcing for 10 seconds
	Turn On Voltage	Approximately 6 VDC
Temperature	Ambient operating	−40 °C (−40 °F) to +70 °C (+ 158 °F).
Range	Storage	−40 °C (−40 °F) to +70 °C (+ 158 °F).
Physical	Weight	1.1 kg (2.4 lb).
Specifications	Shock	Withstands up to 20 g's.
	Vibration	Withstands 0.5 g's at frequencies between 18 and 2000 Hz in three mutually perpendicular planes.

RENR2480-05 Specifications Section

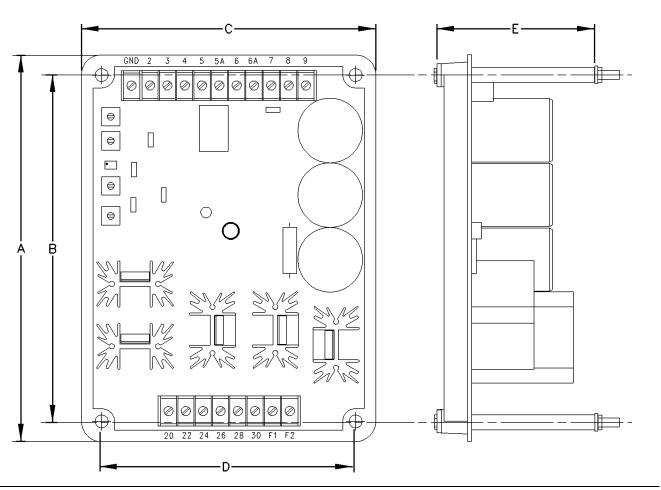
(Table 1, contd)

Specifications				
Conformity	Electromagnetic compatibility	Meets 89/336/EEC Electromagnetic Compatibility Directive. Contains internal EMI suppression filter.		
	UL	UL 508 Listed		
	CSA	Certified per Standard CAN/CSA-C22.2 No. 14-95, CSA File No. LR 23131		
	CE	Conforms to the following standards: Radiated Emissions EN50081-2 Radiated Immunity (electric field) EN61000-4-3 (10 V/m) Radiated Immunity (conducted) EN61000-4-6 (10 VRMS) Conducted Emissions EN50081-2 (EN55011, Class A) ESD Immunity EN50082-2 (4 KV contact, 8 KV air) EFT Immunity EN50082-2 (2 KV coupling clamp) Magnetic Immunity EN50082-2 (30ARMS, 50 Hz) Safety EN61010-1		

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### **Dimensions**

SMCS Code: 4467



g00779068 Illustration 1

Dimensions of the VR6 Voltage Regulator

(A) 212.75 mm (8.376 inch) (B) 190.50 mm (7.500 inch)

(C) 161.95 mm (6.376 inch) (D) 139.70 mm (5.500 inch) (E) 87.4 mm (3.441 inch)

## **Description of Terminals**

**Note:** When the voltage regulator is used with a permanent magnet generator, ensure that the jumpers are removed between the following terminals: 20 - 28, 22 - 30, and 24 - 26. For regulators that were manufactured before June 2003, ensure that a jumper is installed between terminals 28 and "GND".

Table 2

Name 2	December 11	
Number of the Terminal	Description	
GND	Ground	
2	Auxiliary input from VAR/PF Controller	
3	Auxiliary input from VAR/PF Controller	
4	This terminal is used in conjunction with terminal 7 for selecting internal voltage adjustment. Place the jumper between terminals 4 and 7 for using internal voltage adjustment. Remote voltage adjustment requires a remote voltage adjust potentiometer between terminals 6A and 7.	
5	1 Ampere Current Transformer (CT)	
5A	5 Ampere Current Transformer (CT)	
6	Common for the Current Transformer	
6A	Common connection for selectable features	
7	This terminal is used in conjunction with terminal 4 for selecting external voltage adjustment. Place the jumper between terminals 4 and 7 for using internal voltage adjustment. Remote voltage adjustment requires a remote voltage adjust potentiometer between terminals 6A and 7.	
8	Connect terminal 8 to terminal 6A in order to select a 1 V/Hz underfrequency slope.	
9	Connect terminal 9 to terminal 6A in order to select three-phase sensing.	
20	Sensing input on phase C	
22	Sensing input on phase A	
24	Sensing input on phase B	
26	Three-phase power input	
28	Single-phase power input or three-phase power input	
30	Single-phase power input or three-phase power input	
F1	Positive field lead	
F2	Negative field lead	

#### **NOTICE**

Terminals 26, 28, and 30 are designed to be connected directly to a power source that is **NOT** switched. Either a permanent magnet or the generator's output is preferred so the voltage will gradually build. Connecting the terminals directly to a switched power source may cause damage to the regulator unless an inrush current reduction device is utilized.

## **Internal Adjustments**

Table 3

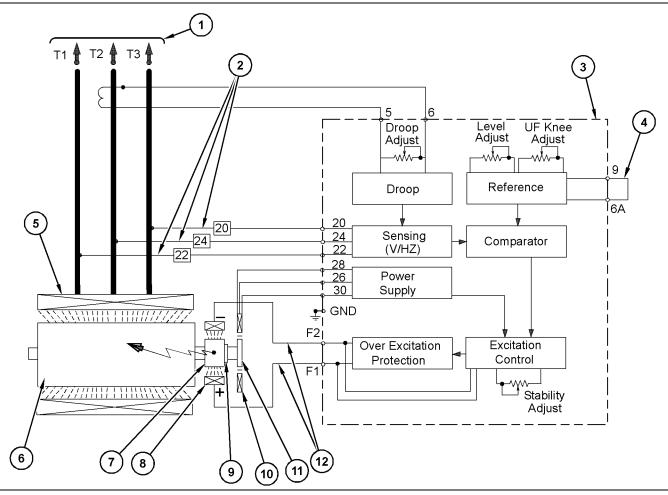
Adjustment	Description
"DRP"	Adjustment of the Voltage Droop
"FAC CAL"	This is the factory calibration of the voltage adjustment range. Adjustment by the customer is not required.
"VLT ADJ"	Voltage Adjustment
"UF"	Underfrequency Knee Adjustment
"STB"	Stability Adjustment

## **Systems Operation Section**

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#### **General Information**

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g02198577 Illustration 2

Typical Block Diagram of SR4B Permanent Magnet Permanently Excited (PMPE) Generator with VR6 Voltage Regulator

- (1) Generator lines (output voltage)
- (2) Generator lines (sensing voltage and AC power)
- (3) VR6 voltage regulator
- (4) Jumper

- (5) Main stator
- (6) Main rotor
- (7) Exciter rotor (8) Exciter stator
- (9) Three-phase rectifiers

- (10) Permanent magnet stator
- (11) Permanent magnet
- (12) Generator lines (DC excitation voltage)

This manual covers the VR6 voltage regulator which is used on 4/6 and 10/12 lead self-excited generators and permanent magnet generators. The VR6 regulator is typically located in the generator terminal box. The regulator may also be located in the marshaling box. In some applications, the regulator may be remotely mounted.

The VR6 voltage regulator (3) keeps the generator output voltage constant with changing loads. The voltage regulator controls the DC voltage and current that is supplied to the exciter stator (8).

The regulator senses the generator voltage through the generator sensing leads (2). The sensing leads are connected to the following terminals: 20, 22, and 24. The sensed voltage is then compared to a reference voltage. The reference voltage value is set by the voltage adjust potentiometer on the regulator. The reference voltage value may also be set by an external voltage adjust potentiometer.

Systems Operation Section

When the regulator senses a decrease in output voltage due to an increase in load, the regulator will increase the DC voltage on wires F1 and F2 (12). This increases the magnetic field in the exciter stator (8). The increased magnetic field in the exciter stator increases the AC voltage and current, which is induced in the exciter rotor (7). This increased three-phase AC voltage from the exciter rotor causes more AC current to flow. The three-phase AC voltage is then rectified to DC voltage by the three-phase full wave bridge rectifier (9). The increased DC output from the bridge rectifier is carried to the main rotor (6) by conductors, which are routed through a passage in the rotor shaft. Increased current through the main rotor increases the magnetic field of the generator. The increased magnetic field induces a larger AC voltage into the main stator (5). Therefore, the three-phase AC voltage (1) increases until the voltage regulator no longer senses a decreased output voltage.

When the voltage regulator senses an increase in output voltage due to a decrease in load, the regulator will decrease the DC voltage to the stator. A decrease in generator voltage will occur due to similar responses, as described above.

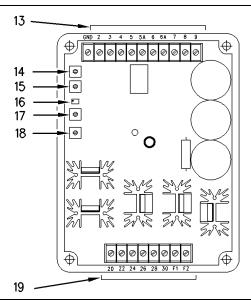


Illustration 3

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The VR6 Voltage Regulator

- (13) Terminal strip for attachments
- (14) Droop adjustment
- (15) Factory calibration of the voltage adjustment range
- (16) Voltage adjustment
- (17) Knee frequency adjustment
- (18) Stability adjustment
- (19) Terminal strip for sensing and power

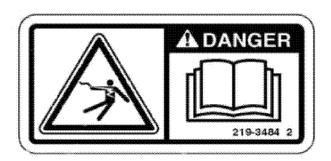


Illustration 4

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#### **DANGER**

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious iniury or death.

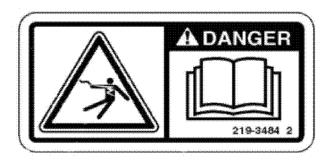
Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

There are five adjustments on the VR6 voltage regulator:

- Droop adjustment (14)
- Factory calibration of the voltage adjustment range (15)
- Voltage adjustment (16)
- Knee frequency adjustment (17)
- Stability adjustment (18)

The factory calibration of the voltage adjustment range (15) should not be adjusted by the user. For the other adjustments, refer to the Testing and Adjusting Section within this manual.



g01021519 Illustration 5

#### **DANGER**

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

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The excitation circuit can be disabled by removing the power from the VR6.

The VR6 voltage regulator can operate in one of the following modes:

- · three-phase sensing
- · single-phase sensing

For three-phase sensing, place the jumper between terminals 6A and 9. Sensing leads (2) should be connected to terminals 20, 22 and 24 for three-phase sensing.

For single-phase sensing, the jumper should be removed. Sensing leads (2) should be connected to terminals 20 and 22 for single-phase sensing.

**Note:** The VR6 voltage regulators are sensitive to A-B-C phase rotation. Connections should be "T1" to 22, "T2" to 24 and "T3" to 20. Incorrect connections can result in high circulating currents during parallel operation.

**Note:** Rated sensing voltage for the VR6 is 240 VAC for 60 Hz systems and 200 VAC for 50 Hz systems. The sensing voltage can be adjusted from 180 to 280 V. When the generator has a different operating voltage, the following methods can be used in order to step down the output voltage to the regulator voltage: generator taps, connection of the sensing lead to midpoint generator connections, and power transformers (PT).

On "Permanent Magnet Permanently Excited" (PMPE) generators, leads from permanent magnet (11) are connected to terminals 26, 28 and 30. These leads provide power to the regulator. Terminals 26, 28, and 30 are part of the terminal strip for sensing and power (19).

On self-excited generators, terminal 20 is jump wired to terminal 28. Terminal 22 is jump wired to terminal 30. Terminal 24 is jump wired to terminal 26. The sensing leads provide the power to the regulator. Terminals 20, 22, 28, and 30 are part of the terminal strip for sensing and power (19).

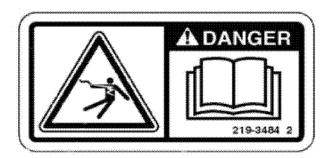


Illustration 6 g01021519

#### **DANGER**

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

The terminal strip for attachments (13) accommodates the following optional connections:

- KVAR/PF controller
- External voltage adjust potentiometer
- Droop current transformer (CT)
- Selection of the under frequency slope
- Selection of the sensing phase

The KVAR/PF controller is connected at terminals 2 and 3. Terminals 2 and 3 should be jump wired if the KVAR/PF controller is not used.

If an external voltage adjust potentiometer is used, there should be no jumper between terminals 4 and 7. An external voltage adjust potentiometer is rated at 10 K Ohm and 2 W. An external voltage adjust potentiometer is connected between terminals 6A and 7. If the internal voltage adjust potentiometer is used, place the jumper between terminals 4 and 7.

If a 1 A droop current transformer (CT) is used, the CT secondary should be connected between terminals 5 and 6. If a 5 A droop current transformer (CT) is used, the CT secondary should be connected between terminals 5A and 6.

In order to create a 1 V/Hz under frequency slope, place the jumper between terminals 6A and 8. Leave these terminals unconnected for a 2 V/Hz under frequency slope.

Connect terminal 6A to terminal 9 for three-phase sensing. Do not connect these terminals for single-phase sensing.

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#### **Features**

SMCS Code: 4467

#### Sensing Voltage

The sensing voltage is the three-phase AC voltage at terminals 20, 22 and 24. The ratio of the sensing voltage to the generator voltage depends on the following conditions:

- The connection point of the sensing leads to the generator leads
- The use of power transformers (PT)

#### Reference Voltage

The reference voltage is set by the voltage adjust potentiometer or by an external voltage adjust potentiometer. The reference voltage is the desired voltage on the output of the generator at rated frequency.

## **Knee Frequency**

The knee frequency is adjusted by turning the knee frequency adjustment. Without setting the knee frequency, generator voltage would follow generator frequency proportionally. If the generator frequency is above the adjusted knee frequency, the regulator maintains the generator voltage at the reference voltage.

#### V/Hz Slope

If the generator frequency drops below rated frequency, the regulator will regulate the voltage to a lower reference voltage. This helps the engine to recover quickly during block loading. The reference voltage is proportional to the generator frequency. There are two slopes that can be selected: 1 V/Hz and 2 V/Hz. The jumper between terminals 6A and 8 creates a 1 V/Hz slope. In this case, a 1 percent change in frequency below the knee frequency adjustment will produce a 1 percent lower reference voltage. In order to select a 2 V/Hz slope, remove the jumper between terminals 6A and 8. In this case, a 1 percent change in frequency below the knee frequency adjustment will produce a 2 percent lower reference voltage.

#### Droop

When a generator set operates in parallel with another generator set, it is necessary for the output voltages to match in order to prevent circulating currents. Depending on the power factor, the droop raises the reference voltage or the droop lowers the reference voltage. This slight raising of the output voltage or lowering of the output voltage results in the reactive load sharing between gensets that are operating in parallel.

#### **Stability**

Because of a time delay from the moment when the regulator senses a change in voltage to the moment when the generator voltage is increased or decreased, the generator voltage can become unstable (or hunt). The time delay varies. This delay depends on time constants for the exciter and the generator. The stability circuit slows the response of the regulator in order to stabilize the voltage. The stability adjustment is used in order to ensure that the regulator responds as quickly as possible, while still keeping the voltage stable.

#### **Over Excitation Protection**

The over excitation protection will shut the regulator off at 90 VDC ± 5%. The over excitation protection takes the output to zero in greater than 30 seconds. The output can be 125 VDC for greater than 10 seconds.

The generator set must be shut down or the input voltage to the regulator must be held below 6 VAC for a minimum of 2 seconds in order to reset the regulator.

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## **Remote Voltage Control**

SMCS Code: 4467

The generator output voltage level can be controlled from a remote location. The generator output voltage can be controlled with the use of a remotely mounted voltage adjust potentiometer. In order to control the voltage from a remote location, perform the following steps:

**1.** Remove the jumper between terminals 4 and 7.

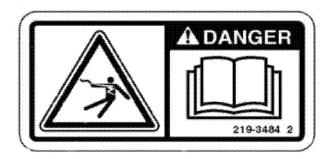


Illustration 7 g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

**2.** Connect a 10 K Ohm, 2 Watt potentiometer between terminals 6A and 7 on the voltage regulator.

For an acceptable voltage control, the remote mounted potentiometer must be 10 K Ohm +5% with three turns or more and a dielectric strength of 1000 VAC minimum. The terminals of the remote mounted potentiometer are fragile.

The wiring that is connected to a remote mounted potentiometer, should not have a diameter larger than 18 gauge. A wire with a larger diameter is not recommended. The wire should be 600 Volt class with 90 °C (194.0 °F) insulation.

When the remote potentiometer is mounted a long distance (up to 15.24 m (50 ft)) from the generator set, a shielded cable may be necessary in order to isolate the signal from noise.

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## **Manual Voltage Control**

SMCS Code: 4467

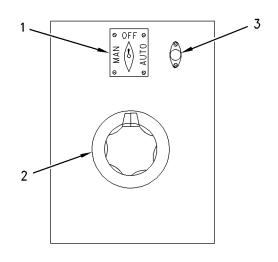


Illustration 8 g00779092

Manual Voltage Control Panel (Option)

- (1) Switch (OFF, AUTO, and MAN positions)
- (2) Voltage control potentiometer
- (3) Fuse

The manual voltage control is an option. The manual voltage control can be used to control the generator voltage when there is a failure in the generator regulator assembly. The manual voltage control will manually control the current flow to the exciter stator. The manual voltage control panel has a switch (1) and a voltage control potentiometer (2) for the manual operating mode. The switch (1) is used to make the selection between the following positions: AUTO, MAN, and OFF.

In the AUTO position, the VR6 voltage regulator controls the generator voltage.

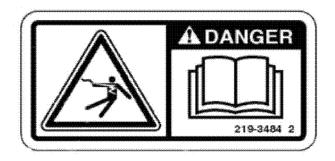


Illustration 9 g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

In the OFF position, the generator output voltage will go to near zero.

In the MAN position, the generator output voltage is controlled by the voltage control potentiometer (2).

Note: The manual voltage control panel must not be installed in a location that is subject to engine vibrations or to outside weather.

**Note:** When the manual voltage control is operating in the manual mode, power **MUST** be removed from the VR6. Refer to the Testing and Adjusting, "Wiring Diagrams" for proper connections.

Note: Do not rapidly switch the "Manual Voltage Control" (MVC) from "Manual" to "Auto" or from "Auto" to "Manual". The switch must stop or pause at the "OFF" position momentarily. If the position of the switch is changed too rapidly, then the VR6 will shut down due to the "Over Excitation" protection function. i02652066

## **Voltage Droop Control**

SMCS Code: 4467

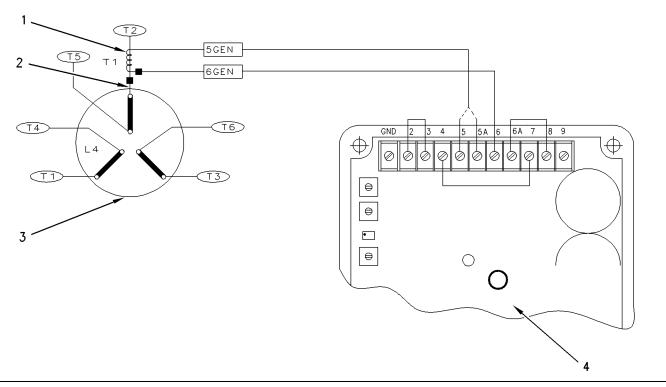


Illustration 10 g00779093

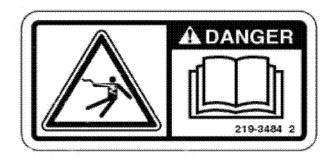
Voltage Droop Control (Typical Example)

- (1) Voltage droop transformer T1
- (2) Lead

- (3) Main stator
- (4) VR6 voltage regulator

There are two primary requirements for parallel operation:

- Genset engines should share the real power requirements (kW) of the electrical load.
- Generators should share the reactive power requirements (kVAR) of the electrical load.



#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

The engine governors will control sharing of the real power requirements (kW). The voltage regulator will control sharing of the reactive power requirements (KVAR) of the total system load. Occasionally, one generator output voltage may be slightly higher than the output voltage other generators. This will supply lagging reactive current flow to the other generators that are connected in the group. The lagging reactive current flow will circulate between generators. This could possibly cause current overloading.

Illustration 11 g01021519

In order to share reactive loads, an individual generator output voltage droops in proportion to the lagging reactive current flow. The reactive current flow is measured with a current transformer (CT). As reactive generator output current increases, the regulator will cause the output voltage to lower proportionally. If the measured reactive current is leading, the output voltage will rise. In either case, this action will tend to reduce the reactive current for better sharing of kVAR with other units.

The following items are required in order to provide the voltage droop function:

- Droop CT 1 Ampere CT or 5 Ampere CT (1)
- wiring harness

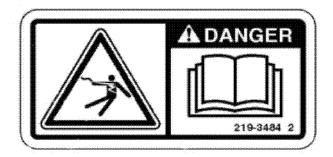


Illustration 12

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#### A DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

The droop CT senses load current in lead "T2" (2) of 4/6 lead generators or in lead "T8" of 10/12 lead generators. The droop adjustment adjusts the droop voltage. The droop CT may be standard on some generators or an attachment on other generators. The wiring harness may be standard on some generators or an attachment on other generators.

Note: At full rated current (1 Ampere or 5 Ampere), the droop adjustment is up to 10%. As the CT current decreases, the amount of droop adjustment decreases proportionally. It is important to size the CT correctly for the load which will be carried by the generator.

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## **Cross Current Compensation**

SMCS Code: 4467

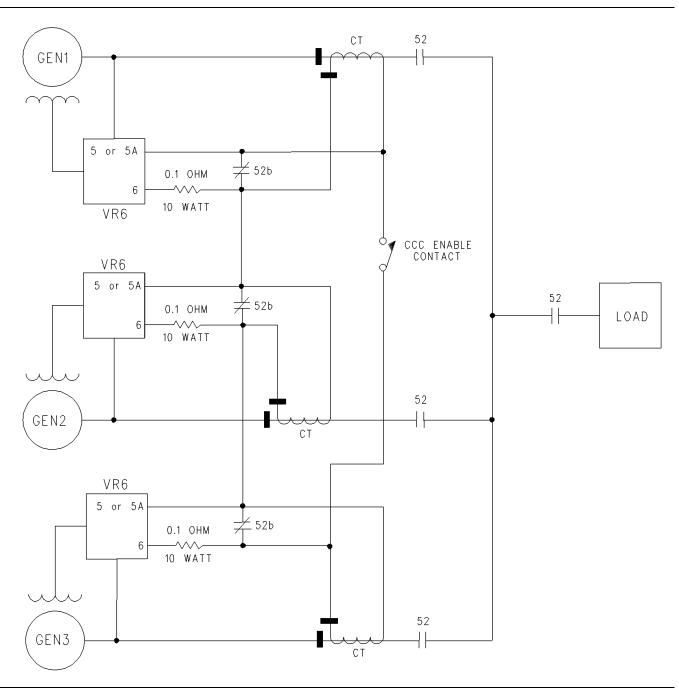


Illustration 13 g00885654

Cross current compensation (CCC) is often used to minimize circulating current flow between the generators which are connected in parallel. All generators contribute toward establishing the same output voltage to the load.

The operation is similar to the reactive voltage droop mode, except that the secondary circuits of the current transformers of all generators are interconnected in series. Each generator is initially adjusted in order to provide the same output voltage.

When all generators share the same current according to the current transformer (CT) ratio, there will be no significant voltage output on the secondary winding of any current transformer (CT) for the generators. A net difference voltage signal will be created on the burden resistor for that current transformer (CT) if one of the generators carries more current.

If the current that is being carried by the generator is lagging relative to the other generators or leading relative to the other generators, a net difference voltage signal will be created on the burden resistor for that current transformer (CT).

If that generator is supplying more reactive current than other generators, the polarity and the magnitude of the signal that is returned to the voltage regulator will cause a slight decrease in the voltage that is generated. This will reduce the amount of reactive current. Less reactive current will cause the generator voltage to rise.

The output voltage and current of each generator is trimmed toward an operating point. All generators will share the same load current at that operating point. This current will be in proportion to the CT ratio. There will be little or no circulating current between generators.

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#### **Series Boost**

SMCS Code: 4467

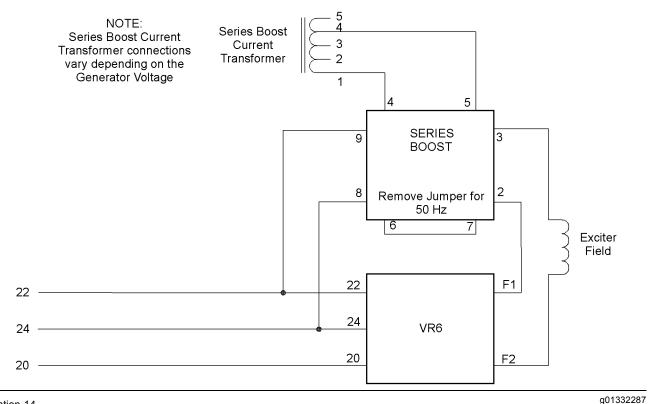


Illustration 14

Typical Example of a Series Boost Module

A series boost module is an option. Series boost allows the self-excited generators to stay on the line (approximately 10 seconds) when there is a short in the generating circuits or in the load circuits.

Therefore, circuit breakers in the load distribution system have the opportunity to trip in sequence. When circuit breakers trip in sequence, there is less chance for a total loss of power of the entire electrical system.

Series boost consists of the series boost module and current transformers (CT).

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

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

If there is a short circuit in the system 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 the current transformer will be rectified. This current will be applied directly to the exciter stator. 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 the current transformer. Current flow to the exciter stator will be zero, until the short circuit is corrected.

**Note:** A PM generator will provide a similar short circuit current characteristic.

Systems Operation Section

i02652184

## **Power Factor Regulation and KVAR** Regulation

SMCS Code: 4467

When the generator is connected in parallel with an infinite bus (utility), the voltage of the generator is controlled by the infinite bus. The voltage of the generator will change as the infinite bus voltage changes.

It is not possible to control the system voltage when the generator is connected to an infinite bus. In this instance, it is necessary for the voltage regulator to regulate the reactive power output that is supplied by the generator. There are two methods for regulating the reactive power output.

- Power Factor Regulation
- KVAR Regulation

Power factor (PF) determines the relationship between true power and apparent power. The true power is also known as the active power. The apparent power is also called kVA. The true power (kW) is the work that is done on the load by the engine.

The true power determines the amount of power that is available for the load to do work. The apparent power (kVA) is the total power that is produced by the generator. Power factor can be calculated by using the following formula.

PF = KW / KVA,

**KW** - kilowatts

**KVA** - Kilo-Volt-Ampere

KVAR stands for Kilo-Volt-Ampere-Reactive, which is the unit of measurement for reactive power.

**Note:** The generator does NOT control power factor. Power factor is determined by the load.

The voltage regulator can be used with an external device (KVAR/PF controller) in order to control one of the output parameters of the generator such as KVAR or PF.

When the voltage regulator is in the power factor mode, the generator produces a constant power factor regardless of the real power output of the generator.

In this case, the reactive current will change when the real power output of the generator changes. A 5 Amperes current transformer is necessary for any mode of operation to work.

When the voltage regulator is in the KVAR operating mode, the generator produces a constant value of reactive power (KVAR) regardless of the real power output of the generator. In this case, the power factor of the generator will change when the real power output of the generator changes.

A 5 Amperes current transformer is necessary for any mode of operation to work.

## **Troubleshooting Section**

#### Introduction

i02652217

#### **General Information**

SMCS Code: 4467

#### **WARNING**

Personal injury or death can result from high voltage.

When power generation equipment must be in operation to make tests and/or adjustments, high voltage and current are present.

Improper test equipment can fail and present a high voltage shock hazard to its user.

Make sure the testing equipment is designed for and correctly operated for high voltage and current tests being made.

When servicing or repairing electric power generation equipment:

- Make sure the unit is off-line (disconnected from any utility and/or other generators that can provide power service), and either lock out or tag as "DO NOT OPERATE".
- · Remove all fuses.
- Make sure the generator engine is stopped.
- Make sure all batteries are disconnected.
- Make sure all capacitors are discharged.

Failure to do so could result in personal injury or death. Make sure residual voltage in the rotor, stator and the generator is discharged.

#### **WARNING**

When the engine-generator, or any source to which the engine-generator is synchronized to, is operating, voltages up to 600V are present in the control panel.

Do not short these terminal with line voltage to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

#### **WARNING**

Do not connect 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 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.

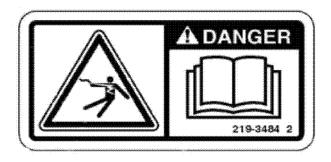


Illustration 15

g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

i02655752

## **Service Tools**

**SMCS Code:** 0785

Table 4

Tools Needed			
Part Number	Description	Amount	
237-5130	Digital Multimeter	1	
9U-7330	Multimeter (Option) for frequency and duty cycle measurements	1	
146-4080	Digital Multimeter (RS-232)	1	
225-8266	AC/DC Clamp-On Ammeter	1	

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Troubleshooting Section

## **Symptom Procedures**

i04837331

## Low Voltage

SMCS Code: 4467-035

## Test Step 1. PERFORM THE INITIAL CHECK

**A.** Shut down the generator set. Remove all power to the generator set.

**Note:** If the low voltage condition has been caused by the regulator over-excitation shutdown protection feature, removing regulator power will reset the over excitation protection feature.

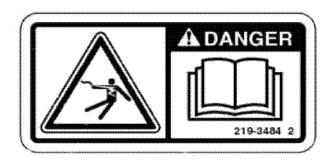


Illustration 16

g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

- B. Check for loose terminals.
- C. Check for corroded terminals.
- **D.** Check for proper connections between the voltage regulator and the generator.

#### **Expected Result:**

All initial checks show no problems.

#### Results:

- YES There are no loose terminals or corroded terminals. The connections are correct. Proceed to test step 2.
- NO One or more of initial checks shows a problem.

**Repair:** Tighten loose terminals. Replace corroded terminals. If the connections are incorrect, connect the wiring properly according to the wiring diagram.

STOP.

## Test Step 2. CHECK CONNECTIONS FOR THE VAR/PF CONTROLLER

- **A.** If the VAR/PF controller is used, verify whether there is no jumper between terminals 2 and 3.
- **B.** If the VAR/PF controller is not used, place the jumper between terminals 2 and 3.

#### **Expected Result:**

The jumper has been placed accordingly.

#### Results:

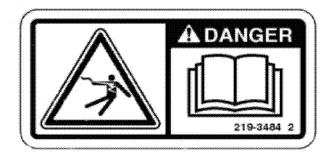
- YES The jumper is installed when the VAR/PF controller is not used. There is no jumper between terminals 2 and 3 when the VAR/PF controller is used. Proceed to test step 3.
- NO The connections are not correct.

**Repair:** Place the jumper according to the wiring schematic.

STOP.

#### **Test Step 3. CHECK METERS**

- **A.** If attached, disconnect any PF/VAR controller from the VR6 voltage regulator. Place a jumper across terminals 2 and 3 of the VR6 voltage regulator.
- **B.** Start the genset.
- C. Run the genset at no load.







The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

**D.** Ensure the accuracy of the voltmeter. If you are reading the voltage from the control panel, check that voltage with a multimeter.

**Note:** Take the voltage readings on terminals 20 and 22 at the regulator. Also take voltage readings on terminal 24 if 3 phase sensing is used.

#### **Expected Result:**

Meters are accurate.

#### Results:

- YES Meter readings are accurate. Proceed to test step 4.
- NO The meter readings do not match.

**Repair:** Troubleshoot the metering circuit. Verify the schematic for the metering circuit. Verify whether the meters are connected correctly.

STOP.

# Test Step 4. CHECK CONNECTIONS OF THE VOLTAGE ADJUST POTENTIOMETER

A. Turn off the genset.

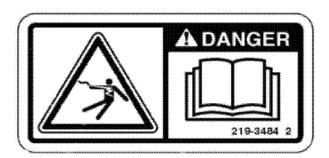


Illustration 18 g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

B. Check if there is the jumper between terminals 4 and 7.

#### **Expected Result:**

There is a jumper that is placed between terminals 4 and 7.

#### Results:

- YES If a remote voltage adjust potentiometer is NOT used, the jumper is properly installed. Proceed to test step 6.
- YES If a remote voltage adjust potentiometer is used, the jumper should be removed from terminals 4 and 7. In this case, the remote voltage adjust potentiometer should be connected to terminals 6A and 7. Proceed to test step 5.
- NO There is no jumper between terminals 4 and 7. The regulator may go into the overexcitation shutoff.

**Repair:** Verify the wiring schematics. Install the jumper in accordance with the wiring schematic.

STOP.

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Troubleshooting Section

# Test Step 5. CHECK THE RESISTANCE OF THE REMOTE VOLTAGE ADJUST POTENTIOMETER

- A. Disconnect, float, and isolate the connecting wires from the VR6 voltage regulator terminals 6A and 7.
- B. Measure the resistance of the remote voltage adjust circuit. Measure the resistance at the wire ends.

#### **Expected Result:**

The resistance should be between 0 K Ohm and 10  $\pm$  0.5 K Ohm.

#### Results:

- YES The resistance increases smoothly within the specified range. Proceed to test step 6.
- NO The resistance is not within the specified value of above zero ohms to 10K ohms. The resistance jumps to a high value when the potentiometer is adjusted or reads zero or infinity ohms.

Repair: If the value is erratic, replace the remote voltage adjust potentiometer. Inspect all of the wiring and wiring terminations, including the solder joints that are at the remote voltage adjust potentiometer terminals. Look for wires that may have become pinched or that have damaged wire insulation. Pinched or damaged wire insulation may create an open or short circuit. Replace the wiring and reheat any solder joints as necessary. Use care to avoid excessive heat exposure to the potentiometer terminals when soldering the connecting wires to the potentiometer.

STOP.

## Test Step 6. CHECK THE SENSING CONNECTIONS

A. Check if there is a jumper between terminals 6A and 9.

**Note:** If you are using three-phase sensing, terminals 6A and 9 should be jumpered. If you are using single-phase sensing, this jumper should be removed.

#### **Expected Result:**

The jumper may be installed or the jumper may not be installed, based on the phase sensing selection.

#### Results:

- YES The jumper is installed between terminals 6A and 9 for three-phase sensing. For single-phase sensing, the jumper is not installed between terminals 6A and 9. Proceed to test step 7.
- NO The jumper is not installed between terminals 6A and 9 for three-phase sensing. The jumper is installed between terminals 6A and 9 for single-phase sensing.

**Repair:** Connect the jumper in accordance with the phase sensing selection.

STOP.

# Test Step 7. CHECK CONNECTIONS FOR THE DROOP CURRENT TRANSFORMER (CT)

- A. The genset remains off.
- **B.** For a 1 A CT, verify that the connections are to terminals 5 and 6.
- **C.** For a 5 A CT, verify that the connections are to terminals 5A and 6.

**Note:** For troubleshooting purposes, the voltage regulator can be operated when the droop CT is disconnected. However, the droop CT secondary wires must be connected together.

**D.** Verify that the polarity connection of the droop CT is connected to terminal 6.

#### **Expected Result:**

The connections are correct.

#### Results:

- YES The connections are correct. If a permanent magnet generator is used, proceed to test step 8.
   If a self-excited generator is used, proceed to test step 9.
- NO The connections are not correct or the connections are impossible to verify.

**Repair:** Run an individual genset with a reactive load. If the voltage increases as the reactive load increases, the CT secondary is not connected properly. Stop the genset and reverse the CT lead connections.

STOP.

# Test Step 8. CHECK THE VOLTAGE INPUTS ON A PERMANENT MAGNET GENERATOR

- **A.** Check the voltages between the following terminals:
  - 26 and 28
  - 26 and 30
  - 28 and 30

#### **Expected Result:**

The voltages are between 90 VAC and 120 VAC.

#### Results:

- YES The voltage is between 90 VAC and 120 VAC. Proceed to test step 10.
- NO The voltage is below 90 VAC.

**Repair:** There is no power from the permanent magnet generator to the voltage regulator. Correct the wiring according to schematics. Refer to the Testing and Adjusting, "Wiring Diagrams". If the measured voltages are balanced, but the voltages are between 20 VAC and 89 VAC, replace the PM exciter rotor.

STOP.

# Test Step 9. CHECK THE VOLTAGE INPUTS ON A SELF-EXCITED GENERATOR

- A. Check the voltages between the following terminals.
  - a. For input power that is single phase, check between terminals:
    - 28 and 30
  - **b.** Check between the following terminals for three phase input power applications.
    - 26 and 28
    - 26 and 30
    - 28 and 30
- **B.** Measure the sensing voltages between the following terminals.
  - 20 and 22
  - 20 and 24 (if three phase sensing is used)
  - 22 and 24 (if three phase sensing is used)

#### **Expected Result:**

The voltages match accordingly. The voltages are between 230 VAC and 250 VAC.

#### Results:

- YES For single phase power input, the voltage between terminals 28 and 30 matches the voltage between terminals 20 and 22. Proceed to test step 10
- YES For input power that is three phase applications, all of the following are correct: The voltage between terminals 26 and 28 matches the voltage between terminals 20 and 24. The voltage between terminals 26 and 30 matches the voltage between terminals 22 and 24. The voltage between terminals 28 and 30 matches the voltage between terminals 20 and 22. Proceed to test step 10.
- NO The voltages do not match.

**Repair:** Check the jumpers between terminals 20 and 28. Check the jumpers between terminals 22 and 30. Also check the jumpers between terminals 24 and 26 if 3 phase sensing is used. Place the appropriate jumpers according to the wiring diagram. Refer to the Testing and Adjusting, "Wiring Diagrams".

STOP.

## Test Step 10. VERIFY THE SENSING VOLTAGE

- A. Make sure that the generator set is off.
- **B.** If the generator uses power transformers (PT) to step down the generator output voltage to the sensing voltage, check the sensing voltage range. The sensing voltage range should lie between the following limits:
  - 180 VAC to 280 VAC on 50/60 Hz gensets
- C. Verify that sensing wires 20 and 22 are connected correctly. If three phase sensing is used, verify that sensing wire 24 is connected correctly. Wire 20 should be connected to T3 phase. Wire 22 should be connected to T1 phase. Wire 24 should be connected to T2 phase.

#### **Expected Result:**

The sensing voltage is correct. The sensing wires are connected properly.

#### Results:

 YES – The sensing voltage is correct. The connections are correct. Proceed to test step 11.

Troubleshooting Section

 NO – The sensing voltage is NOT correct and/or the sensing wires are NOT connected properly.

**Repair:** Install a PT with correct ratios. Connect the sensing wires to correct terminals.

STOP.

## Test Step 11. CHECK THE OUTPUT VOLTAGE

- A. Start the genset.
- B. Run the genset at no load.
- **C.** Read the output voltage from the control panel.

#### **Expected Result:**

The generator voltage is lower than the nominal voltage. The generator voltage is steady.

#### Results:

- YES The generator voltage is still low but steady.
   Proceed to test step 12.
- NO The generator voltage oscillates. The voltage goes high. Then, the voltage goes low.

**Repair:** Add load to the genset. If the voltage still oscillates, turn off the genset in order to reset the voltage regulator. Start the genset again and run at no load. Add load to the generator. If the voltage oscillates again, go to the Troubleshooting, "Unstable Voltage". If the voltage is no longer low, the problem has been fixed.

STOP.

## Test Step 12. CHECK THE OPERATING FREQUENCY OF THE GENSET

**A.** Measure the generator frequency. Use the frequency meter on the control panel. You may use a multimeter with the frequency measuring function.

#### **Expected Result:**

The generator frequency is below 5% of the rated frequency.

#### Results:

YES – The frequency is below the rated frequency.
 In this case, the voltage will be lower than the rated voltage.

**Repair:** Adjust the generator frequency. Reset the knee frequency. Refer to the Testing and Adjusting, "Knee Frequency - Adjust".

STOP.

 NO – The generator frequency is same as the rated frequency. The low voltage problem still exists. Proceed to test step 13.

#### Test Step 13. CHECK THE REGULATOR

A. Adjust the operating voltage range by using the voltage adjustment. Refer to the Testing and Adjusting, "Voltage - Adjust".

#### **Expected Result:**

The voltage should be adjustable between 180 VAC and 280 VAC for 50 to 60 Hz operation.

#### Results:

- YES If the voltage regulator performs the adjustment to operating voltage range and the low voltage problem has not been eliminated, troubleshoot the attachments. Refer to the appropriate section within the troubleshooting section. STOP.
- NO The regulator does not perform the adjustment to operating voltage, as described above.

**Repair:** Check the generator diodes. Refer to the appropriate Operations and Maintenance Manual for the particular generator. If the problem has not been eliminated, test the voltage regulator. Refer to the Testing and Adjusting, "Voltage Regulator - Test". If necessary, replace the voltage regulator.

STOP.

i04838289

## **High Voltage**

**SMCS Code:** 4467-035

## Test Step 1. PERFORM THE INITIAL CHECK

- A. Turn off the genset.
- **B.** Check for loose terminals.
- **C.** Check for corroded terminals.
- **D.** Check for proper connections between the voltage regulator and the generator.

#### **Expected Result:**

All initial checks show no problems.

#### Results:

- YES There are no loose terminals or corroded terminals. The connections are correct. Proceed to test step 2.
- NO One or more of initial checks shows a problem.

**Repair:** Tighten loose terminals. Replace corroded terminals. If the connections are incorrect, connect the wiring properly according to the wiring diagram.

STOP.

#### Test Step 2. CHECK METERS

- A. If attached, disconnect any PF/VAR controller from the VR6 voltage regulator. Place a jumper across terminals 2 and 3 of the VR6 voltage regulator.
- B. Start the genset.
- C. Run the genset at no load.
- **D.** Ensure the accuracy of the voltmeter. If you are reading the voltage from the control panel, check that voltage with a multimeter.

**Note:** Take the voltage readings on terminals 20 and 22 at the regulator. Also take voltage readings on terminal 24 if 3 phase sensing is used.

#### **Expected Result:**

Meters are accurate.

#### Results:

- YES Meter readings are accurate. Proceed to test step 3.
- NO The meter readings do not match.

**Repair:** Troubleshoot the metering circuit. Verify the schematic for the metering circuit. Verify whether the meters are connected correctly.

STOP.

# Test Step 3. CHECK CONNECTIONS OF THE VOLTAGE ADJUST POTENTIOMETER

A. Turn off the genset.

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

**B.** Check if there is the jumper between terminals 4 and 7.

#### **Expected Result:**

There is a jumper that is placed between terminals 4 and 7.

#### Results:

- YES If a remote voltage adjust potentiometer is NOT used, the jumper is properly installed. Proceed to test step 5.
- YES If a remote voltage adjust potentiometer is used, the jumper should be removed from terminals 4 and 7. In this case, the remote voltage adjust potentiometer should be connected to terminals 6A and 7. Proceed to test step 4.
- NO There is no jumper between terminals 4 and 7. The regulator may go into the overexcitation shutoff.

**Repair:** Verify the wiring schematics. Install the jumper in accordance with the wiring schematic.

STOP.

# Test Step 4. CHECK THE RESISTANCE OF THE REMOTE VOLTAGE ADJUST POTENTIOMETER

- A. Disconnect the wires from terminals 6A and 7.
- **B.** Measure the resistance of the remote voltage adjust potentiometer while the potentiometer is being adjusted over the operating range.

#### **Expected Result:**

The resistance should be between 0 K Ohm and 10 ± 0.5 K Ohm.

#### Results:

• YES – The resistance increases smoothly within the specified range. Proceed to test step 5.

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Troubleshooting Section

 NO – The resistance is not within the specified value. The resistance jumps to a high value when the potentiometer is adjusted.

**Repair:** Replace the remote voltage adjust potentiometer.

STOP.

## Test Step 5. CHECK THE SENSING CONNECTIONS

A. Check if there is a jumper between terminals 6A and 9.

**Note:** If you are using three-phase sensing, terminals 6A and 9 should be jumpered. If you are using single-phase sensing, this jumper should be removed.

#### **Expected Result:**

The jumper is installed or the jumper is not installed, based on the phase sensing selection.

#### Results:

- YES The jumper is installed between terminals 6A and 9 for three-phase sensing. The jumper is not installed between terminals 6A and 9 for single-phase sensing. Proceed to test step 6.
- NO The jumper is not installed between terminals 6A and 9 for three-phase sensing. The jumper is installed between terminals 6A and 9 for single-phase sensing.

**Repair:** Connect the jumper in accordance with the phase sensing selection.

STOP.

# Test Step 6. CHECK CONNECTIONS FOR THE DROOP CURRENT TRANSFORMER (CT)

- **A.** Stop the genset.
- **B.** For a 1 A CT, verify that the connections are to terminals 5 and 6.
- C. For a 5 A CT, verify that the connections are to terminals 5A and 6.

**Note:** For troubleshooting purposes, the voltage regulator can be operated when the droop CT is disconnected. However, the droop CT secondary wires must be connected together.

D. Verify that the polarity connection of the droop CT is connected to terminal 6.

#### **Expected Result:**

The connections are correct.

#### Results:

- YES The connections are correct. Proceed to test step 7.
- NO The connections are not correct or the connections are impossible to verify.

**Repair:** Run an individual genset with a reactive load. If the voltage increases as the reactive load increases, the CT secondary is not connected properly. Stop the genset and reverse the lead connections.

STOP.

## Test Step 7. VERIFY THE SENSING VOLTAGE

- **A.** Make sure that the generator set is off.
- **B.** If the generator uses Power Transformers (PT) to step down the generator output voltage to the sensing voltage, check the sensing voltage range. The sensing voltage range should lie between the following limits:
  - 180 VAC to 280 VAC on 50/60 Hz gensets
- C. Verify that sensing wires 20 and 22 are connected correctly. If three phase sensing is used, verify that sensing wire 24 is connected correctly. Wire 20 should be connected to T3 phase. Wire 22 should be connected to T1 phase. Wire 24 should be connected to T2 phase.

#### **Expected Result:**

The sensing voltage is correct. The sensing wires are connected properly.

#### Results:

- YES The sensing voltage is correct. The connections are correct. Proceed to test step 8.
- NO The sensing voltage is NOT correct and/or the sensing wires are NOT connected properly.

**Repair:** Install a PT with correct ratios. Connect the sensing wires to correct terminals.

STOP.

## Test Step 8. CHECK THE OUTPUT VOLTAGE

A. Start the genset.

- **B.** Run the genset at no load.
- **C.** Read the output voltage from the control panel.

#### **Expected Result:**

The generator voltage is higher than the nominal voltage. The generator voltage is steady.

#### Results:

- YES The generator voltage is still high but steady. Proceed to test step 9.
- NO The generator voltage oscillates. The voltage goes high. Then, the voltage goes low.

Repair: Add load to the genset. If the voltage still oscillates, turn off the genset in order to reset the voltage regulator. Start the genset again and run at no load. Add load to the generator. If the voltage oscillates again, go to the Troubleshooting, "Voltage Regulator". If the voltage is no longer high, the problem has been fixed.

STOP.

#### Test Step 9. CHECK THE OPERATING FREQUENCY OF THE GENSET

**A.** Measure the generator frequency. Use the frequency meter on the control panel or a multimeter with frequency measuring function.

#### **Expected Result:**

The generator frequency is above 5% of the rated frequency.

#### Results:

 YES – The frequency is above the rated frequency. In this case, the voltage will be higher than the rated voltage.

Repair: Adjust the generator frequency. Reset the knee frequency. Refer to the Testing and Adjusting, "Knee Frequency - Adjust".

STOP.

• NO – The generator frequency is same as the rated frequency. The high voltage problem still exists. Proceed to test step 10.

#### Test Step 10. CHECK THE REGULATOR

**A.** Adjust the operating voltage range by using the voltage adjustment. Refer to the Testing and Adjusting, "Voltage - Adjust".

#### **Expected Result:**

The voltage should be adjustable between 180 VAC and 280 VAC for 50 to 60 Hz operation.

#### Results:

- YES If the voltage regulator performs the adjustment to operating voltage range and the high voltage problem has not been eliminated, troubleshoot the attachments. Refer to the appropriate section within the "Troubleshooting" section, STOP.
- NO The regulator does not perform the adjustment to operating voltage, as described above.

Repair: Check the generator diodes. Refer to the appropriate Operations and Maintenance Manual for the particular generator. If the problem has not been eliminated, test the voltage regulator. Refer to the Testing and Adjusting, "Voltage Regulator -Test". If necessary, replace the voltage regulator.

STOP.

i04841669

## **Unstable Voltage**

SMCS Code: 4467-035

#### Test Step 1. PERFORM THE INITIAL CHECK

- A. Turn off the genset.
- B. Check for loose terminals.
- C. Check for corroded terminals.
- **D.** Check for proper connections between the voltage regulator and the generator.

#### **Expected Result:**

All initial checks show no problems.

#### Results:

- YES There are no loose terminals or corroded terminals. The connections are correct. Proceed to test step 2.
- NO One or more of initial checks shows a problem.

Repair: Tighten loose terminals. Replace corroded terminals. If the connections are incorrect, connect the wiring properly according to the wiring diagram.

STOP.

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#### **Test Step 2. CHECK METERS**

- **A.** If attached, disconnect any PF/VAR controller from the VR6 voltage regulator. Place a jumper across terminals 2 and 3 of the VR6 voltage regulator.
- **B.** Start the genset.
- C. Run the genset at no load.
- **D.** Ensure the accuracy of the voltmeter. If you are reading the voltage from the control panel, check that voltage with a multimeter.

**Note:** Take the voltage readings on terminals 20 and 22 at the regulator. Also take voltage readings on terminal 24 if 3 phase sensing is used.

#### **Expected Result:**

Meters are accurate.

#### Results:

- YES Meter readings are accurate. Proceed to test step 2.
- NO The meter readings do not match.

**Repair:** Troubleshoot the metering circuit. Verify the schematic for the metering circuit. Verify whether the meters are connected correctly.

STOP.

# Test Step 3. CHECK CONNECTIONS OF THE VOLTAGE ADJUST POTENTIOMETER

A. Turn off the genset.

#### A DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

B. Check if there is the jumper between terminals 4 and 7.

#### **Expected Result:**

There is a jumper that is placed between terminals 4 and 7.

#### Results:

- YES If a remote voltage adjust potentiometer is NOT used, the jumper is properly installed. Proceed to test step 4.
- YES If a remote voltage adjust potentiometer is used, the jumper should be removed from terminals 4 and 7. In this case, the remote voltage adjust potentiometer should be connected to terminals 6A and 7. Proceed to test step.
- NO There is no jumper between terminals 4 and 7. The regulator may go into the overexcitation shutoff.

**Repair:** Verify the wiring schematics. Install the jumper in accordance with the wiring schematic.

STOP.

# Test Step 4. CHECK THE RESISTANCE OF THE REMOTE VOLTAGE ADJUST RHEOSTAT

- **A.** Ensure that the generator set is stopped.
- **B.** Disconnect the wires from terminals 6A and 7.
- **C.** Measure the resistance of the remote voltage adjust potentiometer while the potentiometer is being adjusted over the operating range.

#### **Expected Result:**

The resistance should be between zero (0) Ohms and 10 K Ohms ± 0.5 K Ohm.

#### Results:

- Yes The resistance increases smoothly within the specified range. Proceed to test step 5.
- No The resistance is not within the specified value. The resistance jumps to a high value when the potentiometer is adjusted.

**Repair:** Replace the remote voltage adjust potentiometer.

STOP.

# Test Step 5. CHECK CONNECTIONS FOR THE DROOP CURRENT TRANSFORMER (CT)

- A. Stop the genset.
- **B.** For a 1 A CT, verify that the connections are to terminals 5 and 6.
- **C.** For a 5 A CT, verify that the connections are to terminals 5A and 6.

**Note:** For troubleshooting purposes, the voltage regulator can be operated when the droop CT is disconnected. However, the droop CT secondary wires must be connected together.

D. Verify that the polarity connection of the droop CT is connected to terminal 6.

#### **Expected Result:**

The connections are correct.

#### Results:

- YES The connections are correct. Proceed to test step 6.
- NO The connections are not correct or the connections are impossible to verify.

**Repair:** Run an individual genset with a reactive load. If the voltage increases as the reactive load increases, the CT secondary is not connected properly. Stop the genset and reverse the lead connections.

STOP.

#### **Test Step 6. CHECK ENGINE RPM**

- A. Start the genset.
- **B.** Run the genset at no load.
- C. Monitor the engine speed.

#### **Expected Result:**

Engine speed is stable.

#### Results:

- YES Engine speed is stable. Proceed to test step 7.
- NO When the engine speed is unstable, the frequency will be also unstable. The unstable frequency causes the voltage to become unstable as well.

**Repair:** Troubleshoot the engine RPM. Refer to the appropriate engine service manual.

STOP.

## Test Step 7. VERIFY THE STABILITY ADJUSTMENT SETTING

**A.** Readjust the stability adjustment. Refer to the Testing and Adjusting, "Stability - Adjust".

#### **Expected Result:**

Voltage has stabilized.

#### Results:

- YES The voltage is stable. Add the load to the generator. If the voltage remains stable, the problem has been resolved. Otherwise, proceed to test step 8.
- NO Voltage is still unstable.

**Repair:** Check the voltage regulator.

Proceed to test step 9.

#### Test Step 8. CHECK HARMONICS

**A.** Check distortion of the harmonics. Use either an oscilloscope or a harmonic analyzer.

#### **Expected Result:**

The distortion in load is above 20% or severe notching is present.

#### Results:

- YES There is a harmonic distortion in load.
   Consult a Caterpillar dealer in order to obtain information to reduce harmonics distortion. STOP.
- NO There is no harmonic distortion in the load.

**Repair:** Check if there is a harmonic noise in the circuit from the attachments, which can cause voltage to become unstable. Disconnect the attachments one at a time in order to isolate the problem.

If the problem has not been resolved, proceed to test step 9.

#### Test Step 9. CHECK THE REGULATOR

A. Adjust the operating voltage range by using the voltage adjustment. Refer to the Testing and Adjusting, "Voltage - Adjust".

#### **Expected Result:**

The voltage should be adjustable between 180 VAC and 280 VAC for 50 to 60 Hz operation.

#### Results:

 YES – If the voltage regulator performs the adjustment to operating voltage and the problem has not been eliminated, troubleshoot the attachments. Refer to the appropriate section within the Troubleshooting Section. STOP.  NO – The regulator does not perform the adjustment to operating voltage, as described above.

**Repair:** Check the generator diodes. Refer to the appropriate Operations and Maintenance Manual for the particular generator. If the problem has not been eliminated, test the voltage regulator. Refer to the Testing and Adjusting, "Voltage Regulator - Test". Replace the voltage regulator if the regulator is determined to be the problem.

STOP.

#### Troubleshooting Section

# Diagnostic Functional Tests

i02655746

## **Remote Voltage Control**

SMCS Code: 4467-038

#### Test Step 1. CHECK THE WIRING

- A. Turn off the genset.
- **B.** Turn the remote voltage adjust potentiometer in a fully counterclockwise direction.
- C. Disconnect the wires from terminals 6A and 7.
- **D.** Measure the resistance of the remote voltage adjust potentiometer between wires 6A and 7.
- E. Turn the remote voltage adjust potentiometer in a fully clockwise direction.
- **F.** Measure the resistance between wires 6A and 7.

#### **Expected Result:**

Resistance between wires 6A and 7 should be less than 5 Ohm when the remote voltage adjust potentiometer is turned in a fully counterclockwise direction. Resistance should be between 9.5 K Ohm and 10.5 K Ohm when the remote voltage adjust potentiometer is turned in a fully clockwise direction.

#### Results:

- YES Resistance lies within specified range.
   Proceed to test step 2.
- NO Resistance is outside specified range.

**Repair:** Check if the wires are broken. Check for the wires that are shorted to ground. Check for bad solder joints. Check for adequate wire size to the remote voltage adjust potentiometer.

STOP.

## Test Step 2. CHECK THE REMOTE VOLTAGE ADJUST POTENTIOMETER

- A. Reconnect the remote voltage adjust potentiometer to the voltage regulator.
- **B.** Start the genset.
- C. Run the genset at no load.

#### **Expected Result:**

The generator voltage lies within specified range.

#### Results:

- YES The problem has been eliminated. STOP.
- NO The problem still exists.

**Repair:** Replace the remote voltage adjust potentiometer. Refer to the Testing and Adjusting, "Wiring Diagrams".

STOP.

i04838679

## **Voltage Droop Control**

**SMCS Code:** 4467-038

#### Test Step 1. CHECK THE DROOP CIRCUIT

- A. Turn off the genset.
- **B.** Connect the droop circuit to the voltage regulator. Verify that connections are correct. Refer to the Testing and Adjusting, "Wiring Diagrams".
- C. Start the genset.
- **D.** Add a reactive load to the genset.

#### **Expected Result:**

The voltage is within the specified or excepted range.

#### Results:

 NO – The voltage is outside of the specified or excepted range. That is, the voltage increases rapidly to a high value then goes to a low value. The rapid change also happens in the case of an over excitation shutdown.

**Repair:** Stop the genset. Switch wires to terminals 5 and 6 for a one A current transformer (CT). Switch wires to terminals 5A and 6 for a five A CT. Start the genset and run the genset at no load.

STOP.

YES – The voltage is within specified range.
 Proceed to test step 2.

## Test Step 2. CHECK THE CURRENT TRANSFORMER (CT)

A. Check the voltage between terminals 5 and 6 for a 1 A CT. Check the voltage between terminals 5A and 6 for a 5 A CT.

#### **Expected Result:**

There is no voltage between specified terminals.

#### Results:

 YES – The voltage between terminals 5 and 6 is less than 100 V for a 1 A CT. The voltage between terminals 5A and 6 is less than 100 V for a 5 A CT.

**Repair:** Replace the CT. Refer to the Testing and Adjusting, "Wiring Diagrams".

STOP.

 NO – The voltage is present. The problem has been eliminated. STOP.

i02655747

## Radio Frequency Interference Filter

SMCS Code: 4467-038

#### CHECK THE RFI FILTER

- A. Stop the genset.
- **B.** Disconnect the RFI filter from the voltage regulator.
- **C.** Start the genset and run the genset at no load.

#### **Expected Result:**

The problem has been eliminated.

#### Results:

- YES The problem has been eliminated. STOP.
- NO The RFI filter is faulty.

Repair: Turn off the genset. Replace the RFI filter.

STOP.

i02655750

# Power Factor Regulation and KVAR Regulation

**SMCS Code:** 4467-038

#### CHECK THE KVAR/PF CONTROLLER

- A. Stop the genset.
- **B.** Disconnect the KVAR/PF controller from the voltage regulator.

- C. Connect a jumper to terminals 2 and 3.
- **D.** Start the genset and run the genset at no load.

#### **Expected Result:**

The problem has been eliminated.

#### Results:

- YES The problem has been eliminated. STOP.
- NO The KVAR/PF controller is faulty.

**Repair:** Turn off the genset. Replace the KVAR/PF controller. Refer to the Testing and Adjusting, "Wiring Diagrams".

STOP.

# Testing and Adjusting Section

## **Testing and Adjusting**

i02655758

## Stability - Adjust

**SMCS Code:** 4467-025

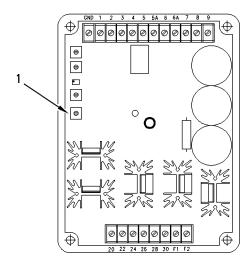


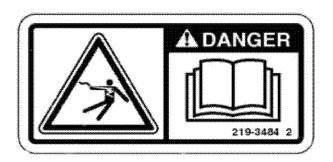
Illustration 19

Illustration 20

g00779264

VR6 Voltage Regulator

(1) Stability adjustment



g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

An oscilloscope or other voltage recording device should be used if an optimal stability setting is desired. Rotate stability adjustment (1) in the clockwise (CW) direction if you need to slow the response time. Rotate stability adjustment in the counterclockwise (CCW) direction if you need to speed the response time. If the adjustment is rotated too far in a CCW direction, the generator voltage may oscillate or the voltage may hunt.

Good response can be obtained with the following procedure:

- 1. Start the generator.
- 2. Run the generator at no load.
- Rotate stability adjustment (1) CW until the voltage becomes stable.
- **4.** Rotate stability adjustment (1) CCW until the system just begins to oscillate.
- **5.** Rotate stability adjustment (1) CW just past the point at which oscillation occurred.

**Note:** If the voltage remains stable when the adjustment is fully CCW, leave the adjustment fully CCW. This gives the fastest response to load changes.

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g00779323

## Voltage - Adjust

**SMCS Code:** 4467-025

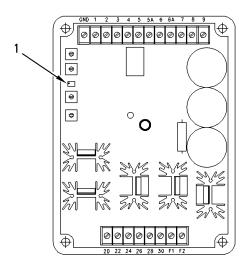


Illustration 21 VR6 Voltage Regulator

(1) Voltage adjustment

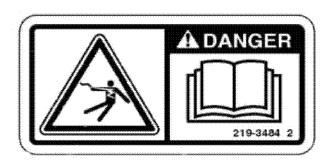


Illustration 22 g01021519

#### A DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

Rotate the voltage adjustment (1) in the clockwise direction in order to increase the voltage. Rotate the voltage adjustment (1) in the counterclockwise direction in order to decrease the voltage.

When the jumper is installed between terminals 4 and 7, the nominal voltage of the generator can be varied over the operating range by using the voltage adjustment (1).

In order to use an external voltage adjust potentiometer, perform the following procedure:

- **1.** Stop the genset.
- 2. Remove the jumper between terminals 4 and 7.
- Connect an external voltage adjust potentiometer across terminals 6A and 7. The potentiometer should be rated at 10 K Ohm.

**Note:** On some gensets, the voltage adjust potentiometer is located on the control panel.

**4.** Turn the voltage adjustment (1) on the regulator in a fully clockwise direction in order for the external adjustment to operate properly.

i02655761

## **Knee Frequency - Adjust**

**SMCS Code:** 4467-025

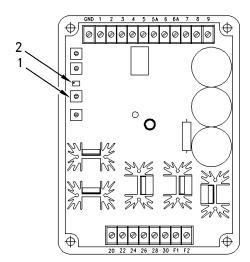


Illustration 23

VR6 Voltage Regulator

- (1) Knee frequency adjustment
- (2) Voltage adjustment

g00779342

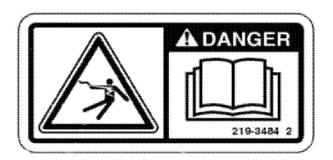


Illustration 24

#### **A** DANGER

g01021519

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

#### **Operation at 60 Hz**

- **1.** Adjust the generator frequency for 60 Hz.
- 2. Turn the knee frequency adjustment (1) fully counterclockwise (CCW) or until voltage does not increase with further turning.
- **3.** Turn the voltage adjustment (2) until the voltage is at 240 VAC on terminals 20, 22, and 24.
- Slowly turn the knee frequency adjustment (1) clockwise (CW) until the voltage begins to decrease.
- **5.** Turn the knee frequency adjustment (1) CCW until the voltage just returns to 240 VAC. The knee frequency is now set just below the nominal operating frequency.

**Note:** Further rotation in the CCW direction will lower the frequency at which underfrequency compensation begins.

- **6.** Connect a jumper from terminal 8 to terminal 6A in order to provide an underfrequency slope of 1 V/Hz. No connection to terminal 8 will result in an underfrequency slope of 2 V/Hz.
- **7.** Start the generator.
- **8.** Run the generator at no load.

**9.** Decrease the engine RPM and observe the frequency at which the voltage starts to decrease. If the knee frequency is lower than 5 Hz below the rated frequency, readjust the knee frequency.

#### Operation at 50 Hz

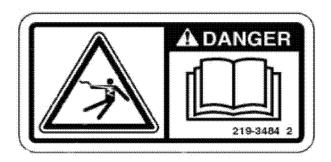


Illustration 25 g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

- **1.** Adjust the generator frequency for 50 Hz.
- 2. Turn the knee frequency adjustment (1) fully counterclockwise (CCW) or until voltage does not increase with further turning.
- **3.** Turn the voltage adjustment (2) until the voltage is at 200 VAC on terminals 20, 22, and 24.
- Slowly turn the knee frequency adjustment (1) clockwise (CW) until the voltage begins to decrease.
- **5.** Turn the knee frequency adjustment (1) CCW until the voltage just returns to 200 VAC. The knee frequency is now set just below the nominal operating frequency.

**Note:** Further rotation in the CCW direction will lower the frequency at which underfrequency compensation begins.

6. Connect a jumper from terminal 8 to terminal 6A in order to provide an underfrequency slope of 1 V/Hz. No connection to terminal 8 will result in an underfrequency slope of 2 V/Hz.

- 7. Start the generator.
- 8. Run the generator at no load.
- **9.** Decrease the engine RPM and observe the frequency at which the voltage starts to decrease. If the knee frequency is lower than 5 Hz below the rated frequency, readjust the knee frequency.

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g00779370

# **Droop - Adjust**

SMCS Code: 4467-025

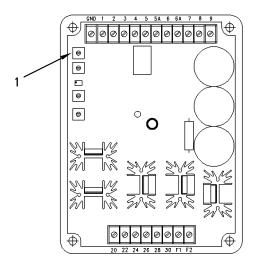
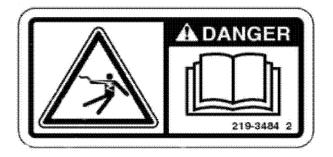


Illustration 26

VR6 Voltage Regulator

(1) Droop adjustment



**DANGER** 

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

Variable levels of parallel droop compensation can be obtained by adjusting the droop potentiometer (1). Clockwise rotation increases the amount of droop for a given condition.

i02655660

# Voltage Adjustment Range - Calibrate

**SMCS Code:** 4467-524

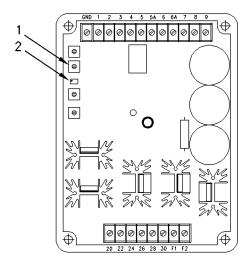


Illustration 28

VR6 Voltage Regulator

- (1) Factory calibration adjustment
- (2) Voltage adjustment

g00825354

Illustration 27 g01021519

i02655756

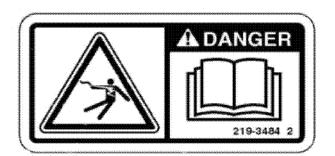


Illustration 29

g01021519

#### **A** DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

#### NOTICE

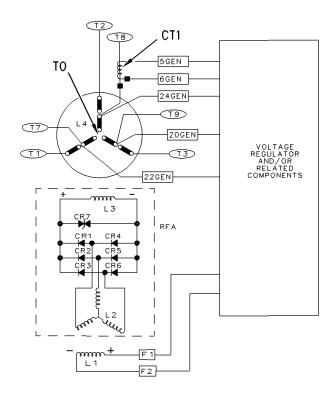
Do not operate generator at a voltage greater than 5% above the name plate rating.

The factory calibration adjustment (1) should be used by the factory technicians only. The following procedure can be used if the factory calibration has been disturbed:

- **1.** Remove the seal from the factory calibration adjustment (1).
- 2. Start the genset.
- 3. Run the genset at no load.
- **4.** Turn the factory calibration adjustment (1) in a fully counterclockwise direction.
- Turn the voltage adjust potentiometer (2) in a fully clockwise direction.
- Slowly turn the factory calibration adjustment (1) CW until the voltage on 20-22-24 is 252 ± 1 VAC for 60 Hz (226 ± 1 VAC for 50 Hz).
- 7. Turn the voltage adjust potentiometer (2) CCW.
- **8.** Verify that the voltage on 20-22-24 is between 156 VAC and 180 VAC. The unit is calibrated.
- **9.** Seal the factory calibration adjustment (1).

#### **Exciter Field - Flash**

SMCS Code: 4470-025



g00874825

Illustration 30

Wiring Diagram of the Self-Excited Generator

(CR1-C6) Diodes

(CR7) Varistor

- (L1) Exciter field (stator)
- (L2) Exciter armature (rotor)
- (L3) Main field (rotor)
- (L4) Main armature (stator)
- (RFA) Rotating field assembly
- (CT1) Optional Voltage Droop Transformer
- (T0, T1, T2, T3, T7, T8, T9) Generator terminals

Self-excited generators may lose the residual magnetism that normally exists in the exciter field (L1) and the main field (L3). Residual magnetism is necessary to start the generation process. The magnetism can be restored by flashing exciter field (L1) with direct current. A 6 VDC battery can be used to supply the direct current.

#### **NOTICE**

Do not flash permanent magnet excited (PME) generators. Damage to the generator set can occur.

There are two methods of flashing the field:

- Static Flashing (stopped engine)
- Dynamic Flashing (running engine)

#### Static Flashing (Stopped Engine)

Table 5

TOOLS NEEDED		
Tool	Quantity	
6 VDC Battery	1	

- 1. Stop the engine.
- At the voltage regulator, disconnect wire F1 GEN from terminal F1 and disconnect wire F2 GEN from terminal F2.
- Connect the positive cable of the 6 volt source to wire F1 GEN.
- **4.** Momentarily put the negative cable of the 6 volt source on wire F2 GEN (two or three times).

**Note:** Do not hold the negative cable to wire F2 GEN for more than one or two seconds.

Connect all wires that were previously disconnected.

# Dynamic Flashing (Running Engine)

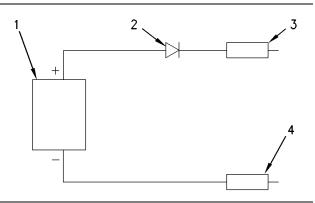


Illustration 31

g00614470

Dynamic Flashing Circuit

- (1) Battery (≤ 6 VDC)
- (2) Diode
- (3) Red test lead "+"
- (4) Black test lead "-"

Table 6

TOOLS NEEDED				
Part Number	Tool	Quantity		
237-5130	Digital Multimeter	1		
9P-5153	Diode (MR-504)	1		
	Dynamic Flashing Circuit	1		

- Construct the dynamic flashing circuit that is shown in Illustration 31.
- 2. Stop the engine.
- **3.** Connect a multimeter (set on ACV) to terminals 20 and 22 at the voltage regulator.
- **4.** Start the engine and run the engine at low idle.

#### **NOTICE**

Do not hold the flashing circuit's test leads on the terminals longer than necessary. This can cause the voltage to become too high. Excessive voltage can cause damage to the generator and can cause damage to the flashing circuit.

- **5.** Hold the red lead of the dynamic flashing circuit to terminal F1.
- **6.** Monitor the voltmeter. Touch the black lead to terminal F2 of the dynamic flashing circuit.
- 7. When the voltmeter shows an increase in voltage, remove the test leads from terminal F1 and terminal F2. If the generator voltage does not increase within 5 to 10 seconds, remove the test leads from terminals F1 and F2.

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# **Voltage Regulator - Test**

SMCS Code: 4467-081-TB

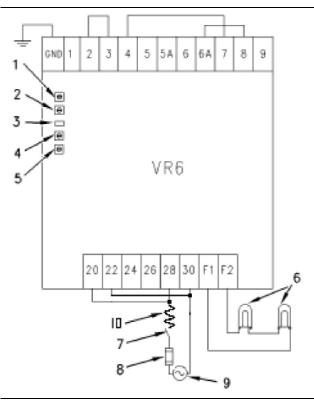
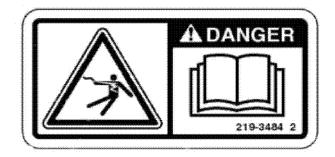


Illustration 32

g01332879

#### **Test Circuit**

- (1) Droop adjustment
- (2) Factory voltage adjustment (3) Voltage adjustment
- (4) Knee frequency adjustment
- (5) Stability adjustment
- (6) 100 Watt light bulbs
- (7) Switch (300 VAC and 15 Amperes)
- (8) AGC10 fuse
- (9) The AC power source (240 V ± 5%)
- (10) 20 Ohm Resistor, 15 Watt Minimum 7D-5829 Resistor



q01021519 Illustration 33

#### DANGER

The Cat VR6 presents an electrical shock/electrocution hazard. This hazard will cause serious injury or death.

Service by trained personnel only.

The terminals and heat sinks are live at hazardous voltages when power is applied and for up to 8 minutes after power is removed.

Perform the following procedure in order to determine whether the voltage regulator is providing proper excitation.

- 1. Connect the voltage regulator according to Illustration 33.
- 2. Adjust stability (5) by turning adjustment in a fully clockwise direction.
- 3. Turn voltage adjustment (3) for five turns in a counterclockwise direction.
- **4.** Close switch (7) in order to apply AC power. The AC power source is 240 V ± 5% for 60 Hz applications. The AC power source is 200 V ± 5% for 50 Hz applications.
- **5.** If the lights (6) turned on, turn the voltage adjustment (3) in a counterclockwise direction. The lights should decrease in intensity. The lights should finally go out. Go to step 7.

If the lights (6) did not come on, go to step 6.

- 6. Turn the voltage adjustment in a clockwise direction. The lights should increase in intensity as the voltage adjustment is turned CW. The regulator will shut off and the lights (6) will turn off if one of the following conditions occurs:
  - The voltage that is being applied to the lights (6) is above 90 V for 30 seconds.
  - The voltage that is being applied to the lights (6) is above 125 V for 10 seconds.
- 7. Open switch (7) for at least 15 seconds. The lights (6) will flash momentarily.
- **8.** Close switch (7).
- **9.** Slowly turn the voltage adjustment (3) CCW until the lights (6) come ON. Try to maintain a low light intensity to medium light intensity by adjusting the voltage adjustment (3).

**Expected Result**: The light bulbs (6) operate, as described above.

#### Results:

- "YES": The voltage regulator functions properly.
- "NO": The light bulbs (6) react differently. Replace the voltage regulator.

**Note:** Droop (1) should be adjusted during generator's operation.

**Note:** Knee frequency (4) should be adjusted during generator's operation.

**Note:** Stability (5) should be adjusted during generator's operation.

i02655646

# Voltage Regulator - Replace

SMCS Code: 4467-510

- Install the voltage regulator. Refer to the installation instructions. See the Testing and Adjusting, "Wiring Diagrams".
- 2. Start the engine.
- Run the engine at rated engine RPM and at no load.
- **4.** Turn the knee frequency adjustment counterclockwise (CCW).
- **5.** Adjust the voltage level. Refer to the Testing and Adjusting, "Voltage Adjust".
- **6.** Adjust the knee frequency. Refer to the Testing and Adjusting, "Knee Frequency Adjust".
- Adjust stability. Refer to the Testing and Adjusting, "Stability - Adjust".
- **8.** Return the genset to normal operation.
- **9.** Add load to the genset.
- **10.** Slightly reduce the frequency of the genset. Generator voltage should decrease proportionally with the frequency. Otherwise, readjust the knee frequency again.
- 11. Increase the frequency to the rated frequency.

i02654568

# **Wiring Diagrams**

SMCS Code: 4467; 7566

The following wiring diagrams are shown below:

Table 7

No. of Generator Leads	Excitation	Voltage Sensing	No. of Illustration
10/12	Permanent Magnet (PM)	three-phase	34
	Self-Excited (SE)	single-phase	35
		three-phase	36
4/6	PM	three-phase	37
	SE	single-phase	38
		three-phase	39
Medium Voltage	PM	three-phase	40
	SE	single-phase	41
		three-phase	42
	Attachme	nts	
Series Boost Module			43
Cross Current Compensation		44	
Manual Voltage Control for SE Generators			45
Manual Voltage Control for PM Generators			46
VAR/PF Controller			47

The following notes are referred to throughout each illustration:

Table 8

Note	Comment
Note 1	Connect the wire to terminal 5 for a 1 Ampere CT. Connect the wire to terminal 5A for a 5 Ampere CT. Do not use 1 ampere CT with a VAR/PF Controller.
Note 2	Connect the remote voltage adjust potentiometer between terminals 6A and 7. Remove the jumper between terminals 4 and 7. The remote voltage adjust potentiometer should be rated at 10 K Ohm and 2 Watt. Place the jumper between terminals 6A and 8 for 1 V/Hz underfrequency slope. Remove the jumper between terminals 6A and 8 for 2 V/Hz underfrequency slope. Place the jumper between terminals 6A and 9 for three-phase sensing. Remove the jumper between terminals 6A and 9 for single-phase sensing.
Note 3	Connect terminals 2 and 3 to the VAR/PF controller. Short terminals 2 and 3 when the VAR/PF controller is not used.
Note 4	For three-phase voltage sensing, connect the wiring to the secondary winding. Phase rotation with transformer T1 is important.  Connect terminal 22 to the PT on T1. Connect terminal 24 to the PT on T2. Connect terminal 20 to the PT on T3.
Note 5	Use twisted, shielded cables.
Note 6	Single-phase, 220 VAC to 240 VAC secondary transformer winding, 50 / 60 Hz, 3125 VA
Note 7	Three-phase, 63 VAC to 105 VAC, 50 / 60 Hz, 3125 VA
Note 8	Connect jumper from terminal 28 to ground terminal on "Permanent Magnet" generators as per the following qualifications.  1) LS65-12 Revisions A through E 2) VR6 Revisions A through B 3) VR6 Revisions C and later have an internal jumper and do not require and external jumper.

# 10/12 Lead Permanent Magnet (PM) Excited Generators with Three-Phase Sensing

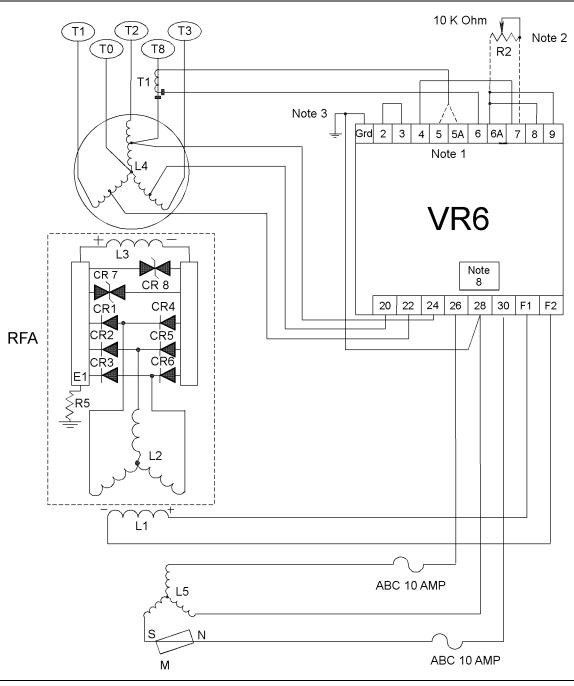


Illustration 34

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes

(E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(L5) PM exciter stator

(M) Rotating permanent magnet

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

Note: Refer to Table 8 for notes.

# 10/12 Lead Self-Excited (SE) Generators with Single-Phase Sensing

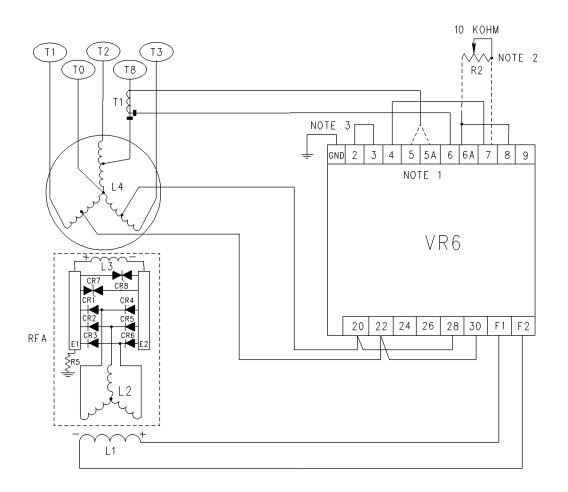


Illustration 35

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

Note: Refer to Table 8 for notes.

### 10/12 Lead Self-Excited (SE) **Generators with Three-Phase** Sensing

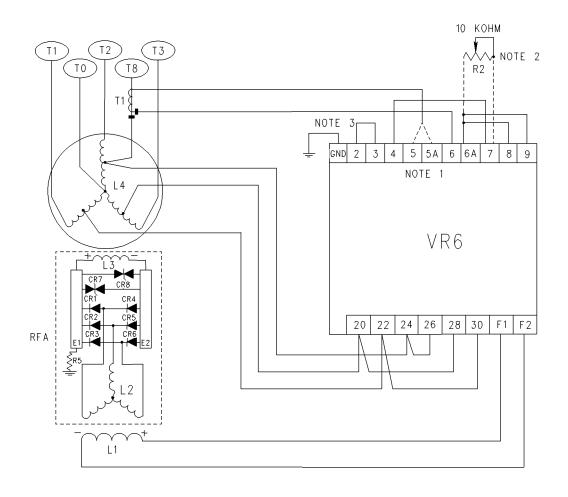


Illustration 36

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

Note: Refer to Table 8 for notes.

# 4/6 Lead Permanent Magnet (PM) Excited Generators with Three-Phase Sensing

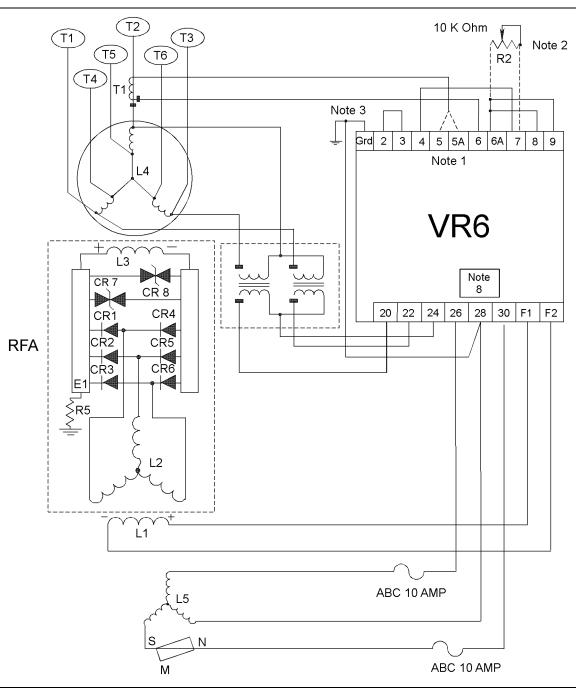


Illustration 37

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes

(E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(L5) PM exciter stator

(M) Rotating permanent magnet

g01333154

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

# 4/6 Lead Self-Excited (SE) **Generators with Single-Phase** Sensing

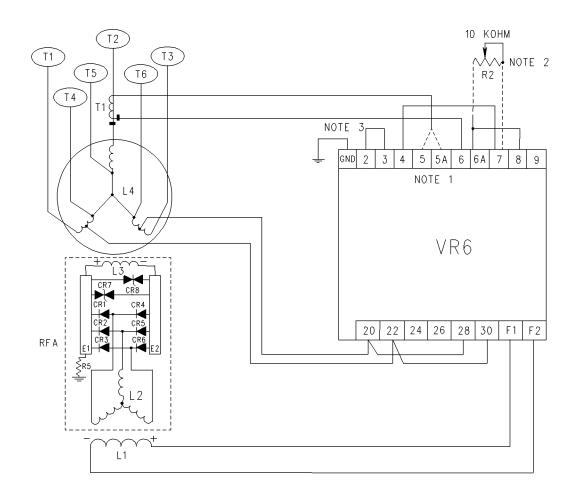


Illustration 38

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

Note: Refer to Table 8 for notes.

# 4/6 Lead Self-Excited (SE) **Generators with Three-Phase** Sensing

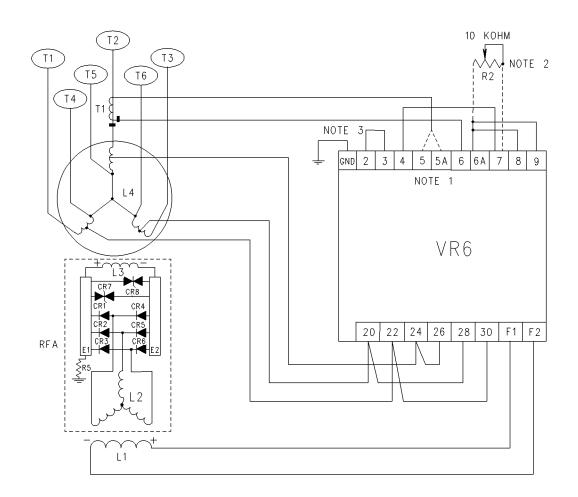


Illustration 39

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

Note: Refer to Table 8 for notes.

### Medium Voltage Permanent Magnet Generators with Three-Phase Sensing

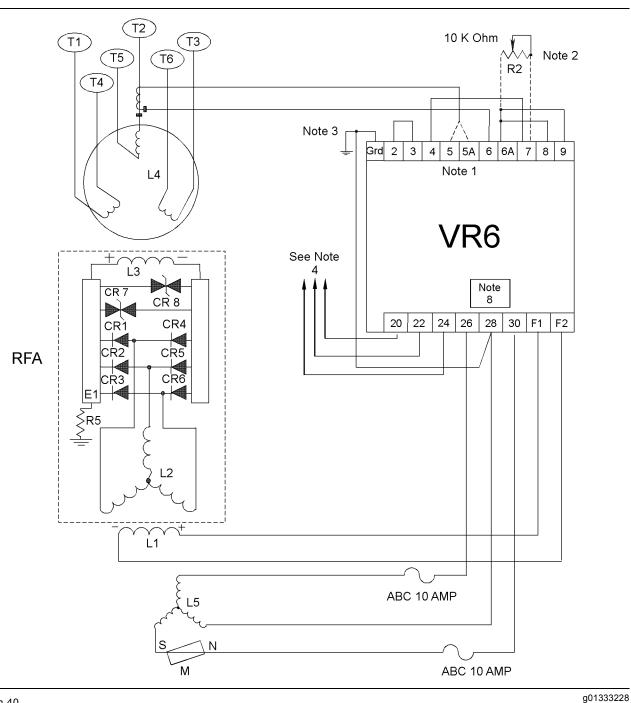


Illustration 40

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes

(E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(L5) PM exciter stator

(M) Rotating permanent magnet

•

(R2) Remote level potentiometer (R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

# **Medium Voltage Self-Excited Generators with Single-Phase** Sensing

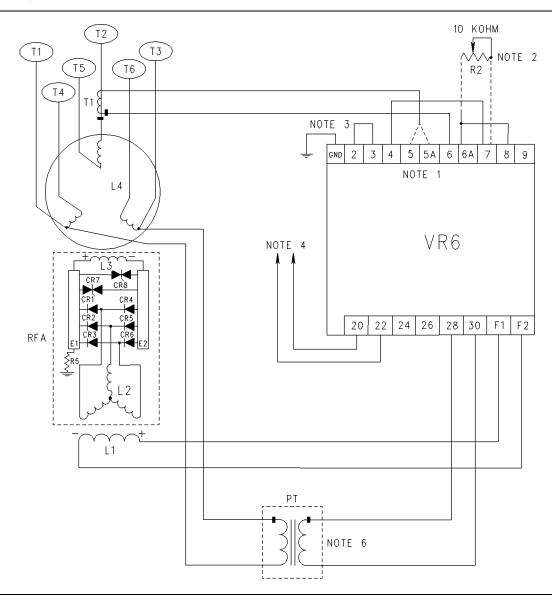


Illustration 41

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

- (E2) Negative heat sink

- (L1) Exciter field (stator)
- (L2) Exciter armature (rotor)
- (L3) Revolving field (main rotor)
- (L4) Main stator

g00779543

- (R2) Remote level potentiometer
- (R5) Suppression resistor
- (RFA) Revolving field assembly
- (T1) Voltage droop transformer (option)

### **Medium Voltage Self-Excited Generators with Three-Phase** Sensing

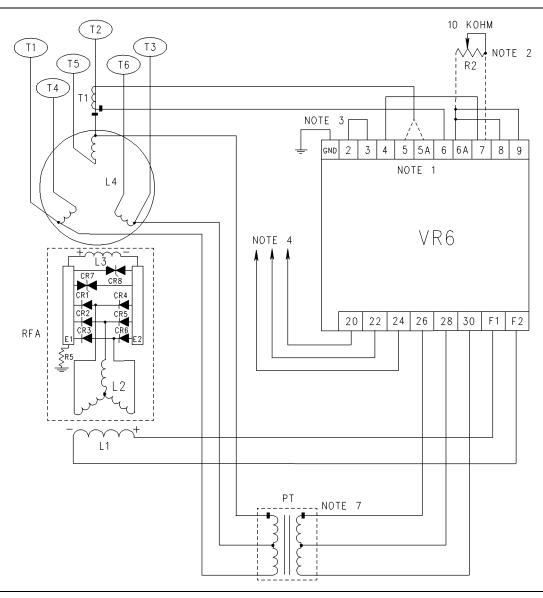


Illustration 42

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes (E1) Positive heat sink

- (E2) Negative heat sink

(L1) Exciter field (stator)

- (L2) Exciter armature (rotor)
- (L3) Revolving field (main rotor)
- (L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

g00847804

#### **Series Boost Module**

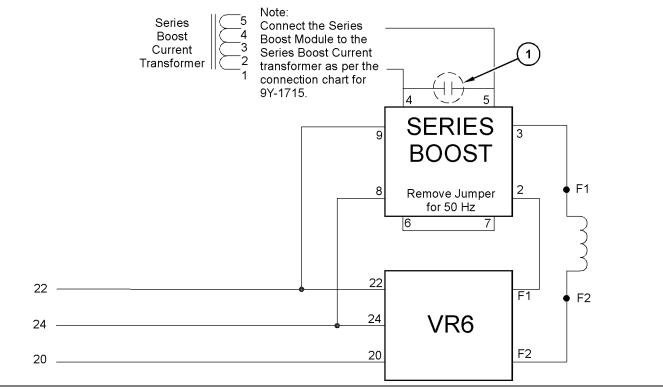


Illustration 43 g01441828

(1) Refer to Illustration 45.

# **Cross Current Compensation**

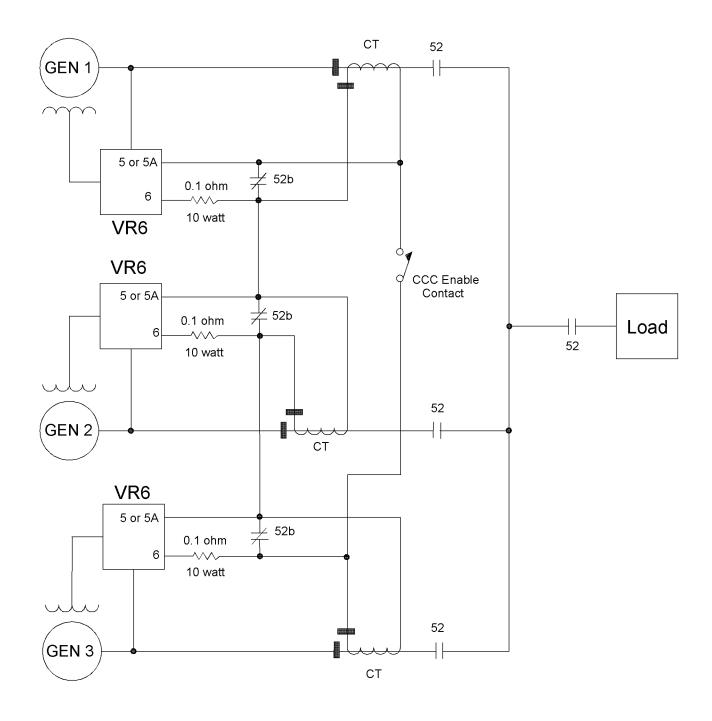


Illustration 44 g01441832

Note: Refer to Table 8 for notes.

Note: Transformer T1 must be a 5 Ampere CT.

#### Manual Voltage Control for SE **Generators**

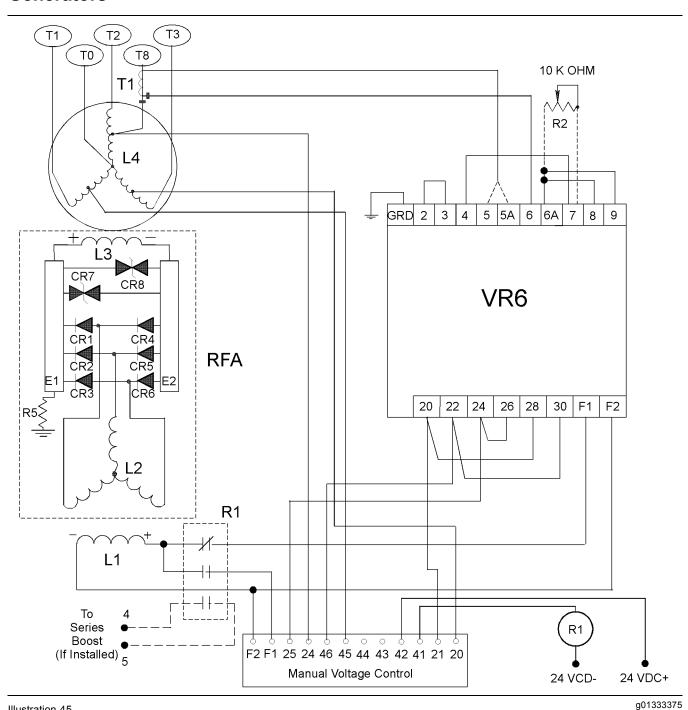


Illustration 45

(CR1-CR6) Rotating rectifiers (CR7, CR8) Surge suppression diodes (E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

#### **Manual Voltage Control for PM Generators**

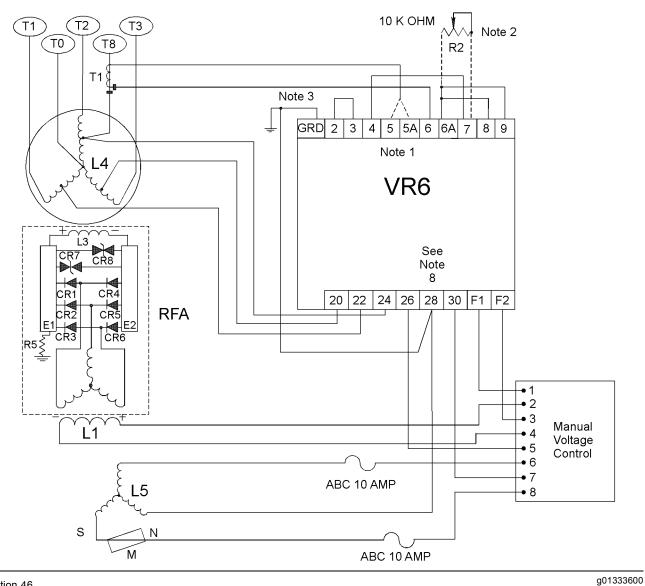


Illustration 46

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes (E1) Positive heat sink

- (E2) Negative heat sink
- (L1) Exciter field (stator)

(L2) Exciter armature (rotor)

- (L3) Revolving field (main rotor)
- (L4) Main stator
- (L5) PM exciter stator
- (M) Rotating permanent magnet

(R2) Remote level potentiometer

- (R5) Suppression resistor
- (RFA) Revolving field assembly
- (T1) Voltage droop transformer (option)

#### **VAR/PF** Controller

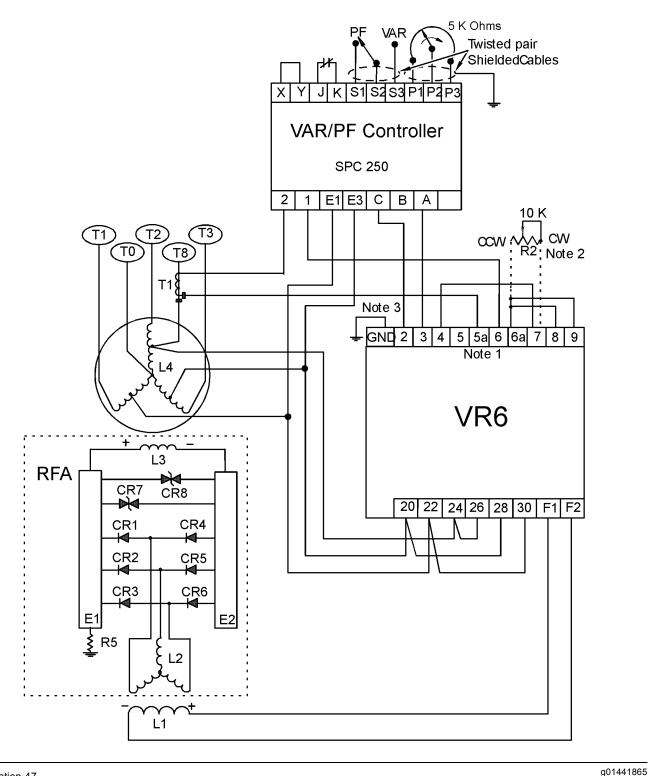


Illustration 47

(CR1-CR6) Rotating rectifiers

(CR7, CR8) Surge suppression diodes

(E1) Positive heat sink

(E2) Negative heat sink

(L1) Exciter field (stator)

(L2) Exciter armature (rotor)

(L3) Revolving field (main rotor)

(L4) Main stator

(R2) Remote level potentiometer

(R5) Suppression resistor

(RFA) Revolving field assembly

(T1) Voltage droop transformer (option)

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