CATERPILLAR®

SENR5833-06
March 2003

Specifications
Systems Operation
Testing and Adjusting

Digital Voltage Regulator

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.

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

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique 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 be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

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. Caterpillar dealers have the most current information available.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar 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.

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Specifications Section

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Electrical

SMCS Code: 4467

Table 1

Specifications	
Regulation	0.25% from no load to full load.
Regulator temperature drift	Less than 0.5% for any 40 °C (72 °F) change over the ambient operating temperature range.
Configurable Volts/Hz characteristic	Two slope ranges adjustable from 1 to 10 V/Hz. See the Regulation Characteristic Illustration.
Regulator response time	Maximum of 10 milliseconds.
Regulator sensing	True RMS 3-phase sensing is standard. Single phase sensing is available. Variable sense range: 90 to 600 volts.
Regulator stability	The regulator responds to the fundamental component of the sensed voltage and remains stable for total harmonic distortion of the generator output voltage waveform, up to 20%.
Telephone influence factor (TIF)	Less than 50. Complies with MIL STD 461C Part 9 and VDE 0875 level N.
Fine voltage adjust range	± 10% of regulator sensing voltage.
Regulator voltage gain (Line loss compensation)	Adjustable from 0 to 10%.
Fault detection and identification	Diagnostics identify operation outside of programmed limits. Specific fault information is available even after the unit has been powered down.
Regulator start-up voltage	Meets ISO8325-3 class G2 specifications.
Harmonic tolerance	The digital voltage regulator maintains precise control of the generator output with up to 20% harmonic distortion in the generator output voltage.
Reactive droop adjustment	Adjustable from 0 to 10%.
Overexcitation protection	Shuts off generator output when excitation current exceeds normal operating currents for 15 seconds or instantaneous shutoff if output is shorted.
Ambient operating temperature	−40 °C (−40 °F) to +70 °C (+ 158 °F).
Storage temperature range	−40 °C (−40 °F) to +85 °C (+ 185 °F).
Power dissipation	5 watts at idle, 55 watts at rated output.
Shock	Withstands up to 20 g’s.
Vibration	Withstands 4.5 g’s at frequencies between 18 and 2000 Hz in three mutually perpendicular planes.
Salt spray	Meets MIL-STD-810C, method 509.1.
Sealing	Withstands up to 35 kPa (5.08 psi).
Weight	5 kg (11 lb).
Electromagnetic compatibility	Meets 89/336/EEC Electromagnetic Compatibility Directive.
Power supply	24 ± 6 volt DC power supply required (0.5 amp).

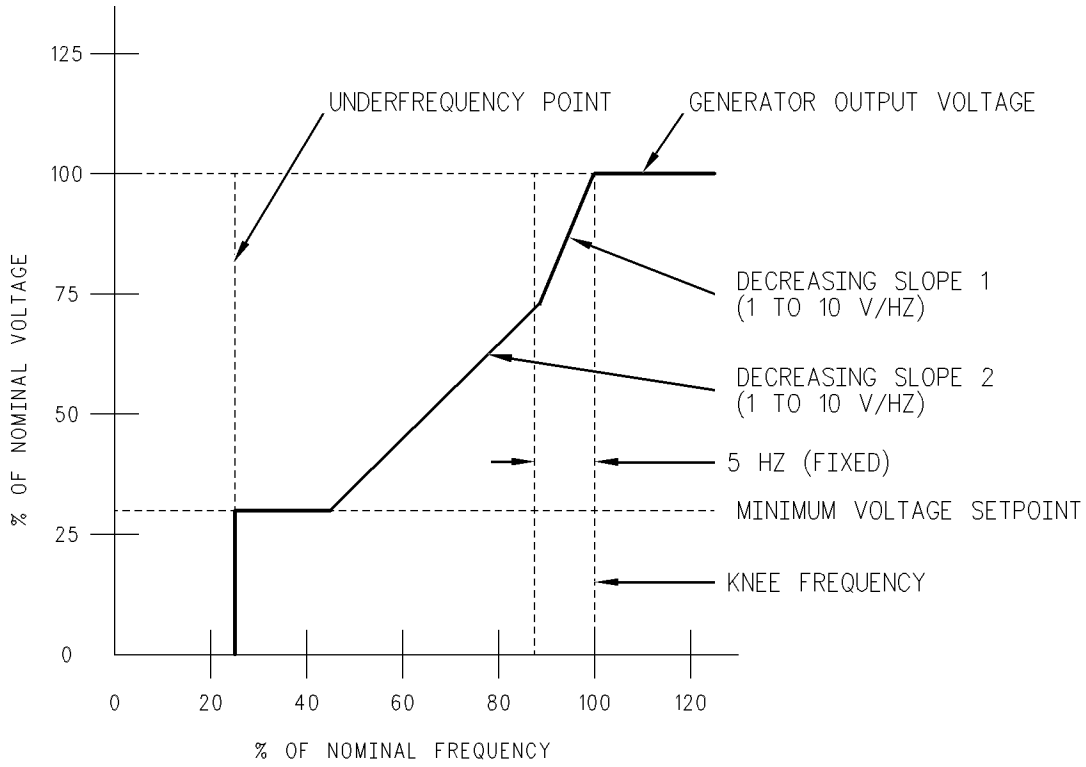

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Illustration 1

Regulation Characteristic Illustration

Table 2

Summary of Operating Parameters														
		Power Input			Output Rating				Sensing		Reactive Droop Input		Exciter Field Resistance	
Voltage Regulator Rating	Generator Type	V	Freq. Hz	VA	Max. Continuous		Min. Forcing		V	Max. VA Burden per Ø	Max. Voltage	Max. VA Burden	Min. Ohms	Max. Ohms
					V	A	V	A						
120 Volt	PM/SE	70-120 3 Ø	50-240	1500	48	12	84	21	79/124	1	5	1	3	10
240 Volt	PM/SE	70-120 3 Ø	50-240	1500	48	12	84	21	125/249	1	5	1	3	10
480 Volt	PM/SE	70-120 3 Ø	50-240	1500	48	12	84	21	250/600	1	5	1	3	10

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Dimensions

SMCS Code: 4467

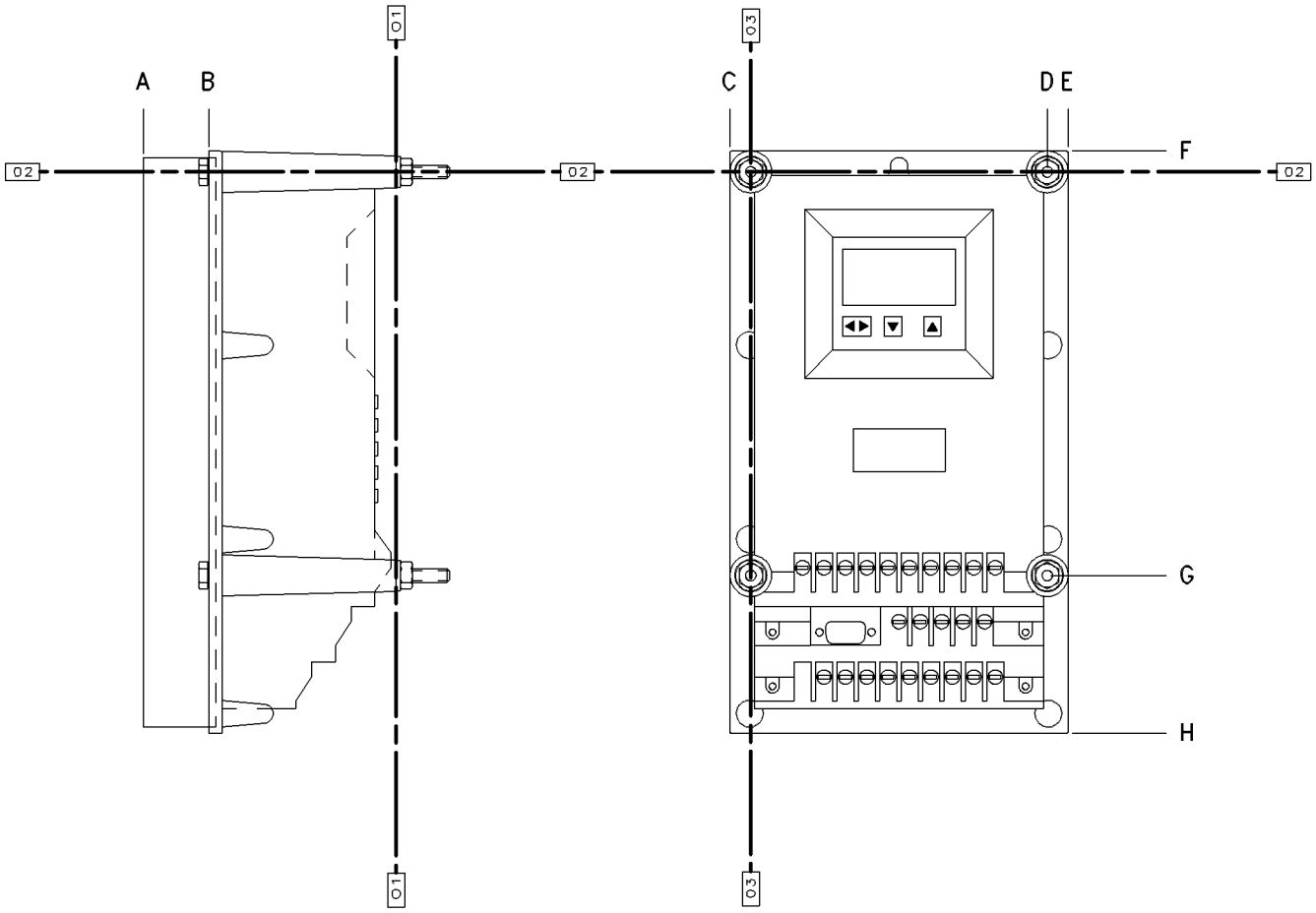

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Illustration 2

Dimensions Of The Digital Voltage Regulator

(The dimensions are referenced to centerlines.)

(A) 119.9 mm (4.72 in)
(B) 88.9 mm (3.50 in)
(C) 9.9 mm (0.39 in)
(D) 140.7 mm (5.54 in)
(E) 150.6 mm (5.93 in)
(F) 9.9 mm (0.39 in)
(G) 191.5 mm (7.54 in)
(H) 266.4 mm (10.49 in)

Systems Operation Section

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General Information

SMCS Code: 4467

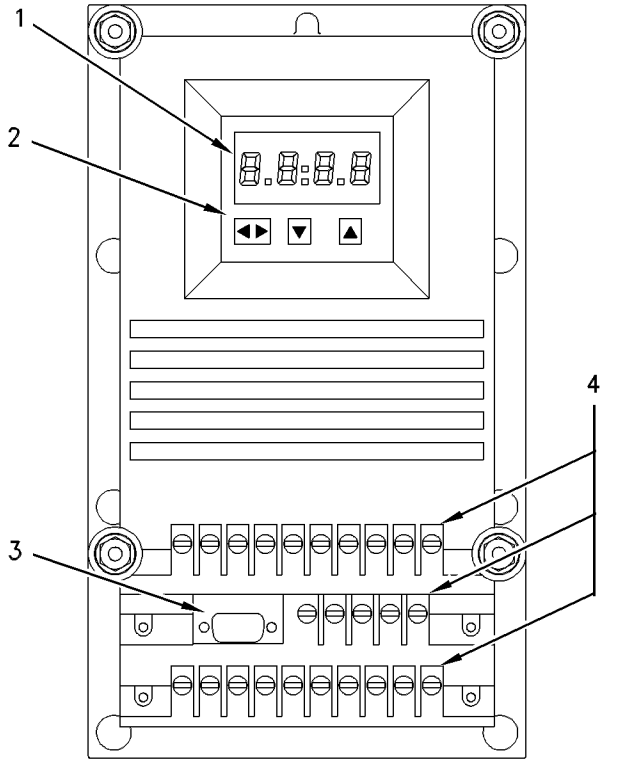

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Illustration 3

Digital Voltage Regulator

(1) Display

(2) Keypad

(3) J1 connector

(4) Screw terminals

Display (1) of the digital voltage regulator, shows numbers that represent different parameters of the digital voltage regulator system. Keypad (2) is used to change the information that is shown on display (1). J1 connector (3) is used to join the digital voltage regulator to a personal computer. Screw terminals (4) are used to join the digital voltage regulator to the generator and various customer options.

The digital voltage regulator is a microprocessor based voltage regulator. The main purpose of the digital voltage regulator is to regulate output voltage of a generator which is used with an engine generator set. Service personnel can modify (configure) certain regulation characteristics. The modifications will allow the engine generator set performance to be optimized. The digital voltage regulator can also integrate into one package many options that were previously panel mounted. The options include KVAR/PF controller, overexcitation protection, fault detection, overvoltage protection, undervoltage protection, diode monitor, reverse power relay and system parameter monitoring.

The configurable parameters of the digital voltage regulator are listed below.

- Voltage versus frequency (V/Hz) characteristic
- Fine voltage level adjustment
- Droop adjustment
- Overvoltage trip point with adjustable trip time
- Undervoltage trip point with adjustable trip time
- Gain
- Single-phase or three-phase true RMS sensing
- Underfrequency trip point
- Knee frequency
- Performance gains
- Generator set parameters
- Minimum voltage
- Diode monitor ripple level
- Reverse VAR trip time
- Reverse power trip point with adjustable trip time
- Optional KVAR level
- Optional power factor level

The protective functions that the digital voltage regulator provides are listed below.

- Overvoltage protection
- Undervoltage protection
- Loss of sensing
- Rotating diode monitor

- Overexcitation protection
- Reverse VAR detection
- Underfrequency protection
- Instantaneous field over current trip
- Optional reverse power relay
- Loss of frequency

The digital voltage regulator can be set up for a specific application by using the configurable parameters. Parameters are preset at the factory. Parameters may need to be adjusted in order to meet the specific requirements of a site. The digital voltage regulator also detects faults and sets the appropriate alarm or caution. Certain system parameters can also be monitored on the display of the digital voltage regulator.

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Display and Keypad

SMCS Code: 4467

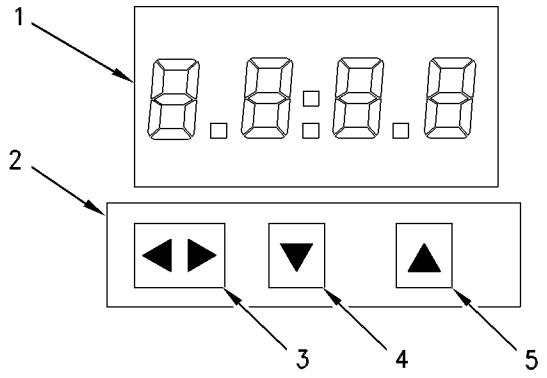

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Illustration 4

Display And Keypad

(1) Display

(2) Keypad

(3) Function key

(4) Scroll down key

(5) Scroll up key

Note: For a list of parameter codes and the corresponding range of values, see System Operation, “Parameters”.

Display (1) and keypad (2) are used to select and manipulate parameter values that control the operation of the digital voltage regulator. Display (1) of the digital voltage regulator has four digits. A colon in the display indicates that the number showing is a parameter code. If a colon is not present, then the number showing is a parameter value. A decimal point in the display is used to indicate the precision of the parameter value.

Keypad (2) has three keys. The keys are listed below.

- Function key (3)
- Scroll down key (4)
- Scroll up key (5)

Display (1) has two modes, parameter code mode and parameter value mode. Function key (3) is used to toggle back and forth between the two modes. Scroll down key (4) and scroll up key (5) are used to decrease and increase the parameter number or value number that is showing on display (1).

Table 3

Parameter Code	Parameter Value
:01	0480
	0481
	0482
	0483
:02	0001
	0002
	0003
	0004
:03	0004
	0003
	0002
:04	0100
	0099
	0100
	0101

The operation of display (1) and keypad (2) can be described as a table. Pressing function key (3) toggles the display back and forth between the two columns of the table (parameter code and parameter value). If a colon is present, the display is in parameter code mode. If a colon is not present, the display is in parameter value mode.

Pressing a scroll up key (5) or scroll down key (4) will increase or decrease the display to the next number within a column. Use of the scroll keys cannot cause the display to change columns of the table.

In order to configure a parameter code (change the value), follow the procedure below.

1. Select the desired parameter code by pressing scroll key (4) or (5).
2. Access the parameter value by pressing function key (3).
3. Select the desired parameter value by pressing scroll key (4) or (5).
4. Enter the chosen value into the memory of the digital voltage regulator by pressing function key (3).

Example

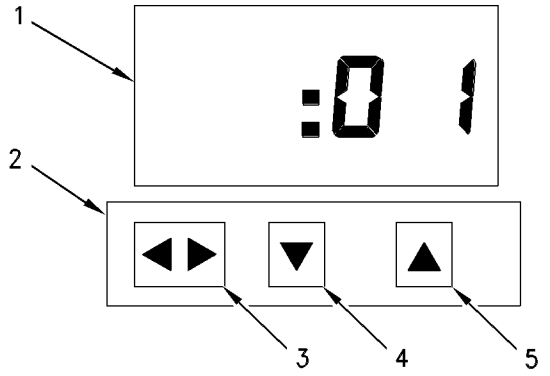

Illustration 5 g00538864

Example Illustration - Display Shows Parameter Code Of :01

(1) Display

(2) Keypad

(3) Function key

(4) Scroll down key

(5) Scroll up key

This example is a demonstration of scrolling and selection of parameter codes. Also the scrolling and configuration of values is demonstrated.

After the digital voltage regulator is powered up (battery voltage applied) parameter code ":01" is shown on the display. The engine does not have to be running for the digital voltage regulator to show parameter codes. The colon indicates that a parameter code is being shown.

The user has the option of pressing function key (3), scroll down key (4), or scroll up key (5).

If scroll up key (5) is pressed, the display moves (scrolls) up to the next parameter code, ":02". Again, the colon is on. This is the entry point for parameter code :02.

Then, if scroll down key (4) is pressed, the display moves (scrolls) down to the preceding parameter code, ":01" again.

If scroll down key (4) is pressed again, the display moves (scrolls) to the highest parameter code, ":96".

Note: When scroll key (4) or (5) is held down for more than five seconds, the display will scroll rapidly. Otherwise, the display changes at the rate of one parameter per second.

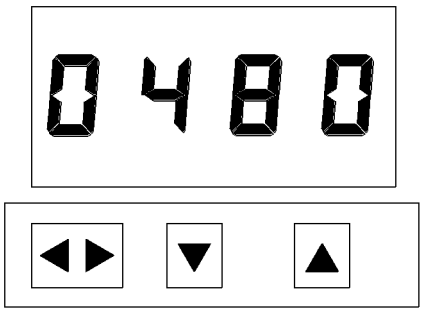

Illustration 6 g00538865

Example Illustration - Display Shows Value Of "0480"

Note: The value of some parameter codes is only for viewing by the user. Such parameters are not configurable. See System Operation, "Parameters". View the value. Then, press function key (3) in order to return the display to showing parameter codes.

If function key (3) is pressed, the display changes to show the value "0480" of parameter code :01. Notice that the colon is off. The value of parameter code :01 can now be changed (configured).

If scroll up key (5) is pressed, the display moves (scrolls) up to the next value, "0481". The colon remains off.

Then if scroll down key (4) is pressed, the display moves (scrolls) down to the preceding value, "0480" again.

To enter (configure) a new value for a parameter code, scroll the display until the desired new value is showing, then press function key (3). Now, the new value is entered into the memory of the digital voltage regulator. The display returns to showing the parameter codes.

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Startup Profile Function

SMCS Code: 4467

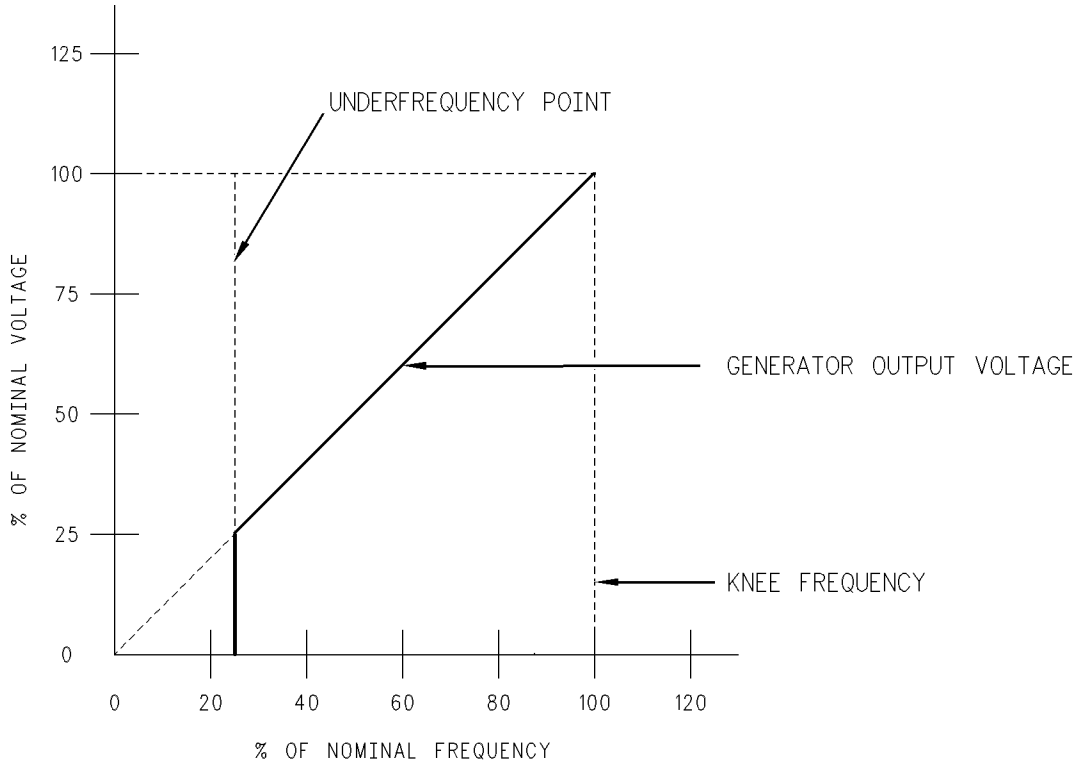

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Illustration 7

Startup Profile Function Illustration

The parameters that are related to the startup profile function are listed below.

01 – Generator Output Voltage

03 – Generator Type

06 – Knee Frequency

10 – Underfrequency Point

The startup profile function sets up the volts per hertz profile (V/Hz) during startup only. The digital voltage regulator will begin to build voltage following a 1:1 volts per hertz profile after the configurable underfrequency point (parameter :10) has been reached. When the speed reaches the knee frequency point (parameter :06), the loading/stopping profile takes effect. The startup profile function will not be initiated again unless the frequency drops below the underfrequency point (parameter :10). The underfrequency point is defaulted to 25 Hz, with a range of 20 to 40 Hz. This is the same underfrequency setpoint used by the loading/stopping setpoint. The startup V/Hz slope is set to 1. The startup V/Hz slope is not adjustable. A V/Hz slope of 1 indicates that a change of 1% voltage will result for every 1% of frequency change. The knee frequency point is the point above which the digital voltage regulator will regulate to the voltage specified by the generator output voltage parameter. The generator type selects whether the frequency being detected is the actual generator output frequency (SE) or one of the permanent magnet (PM) frequencies.

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Loading and Stopping Profile

SMCS Code: 4467

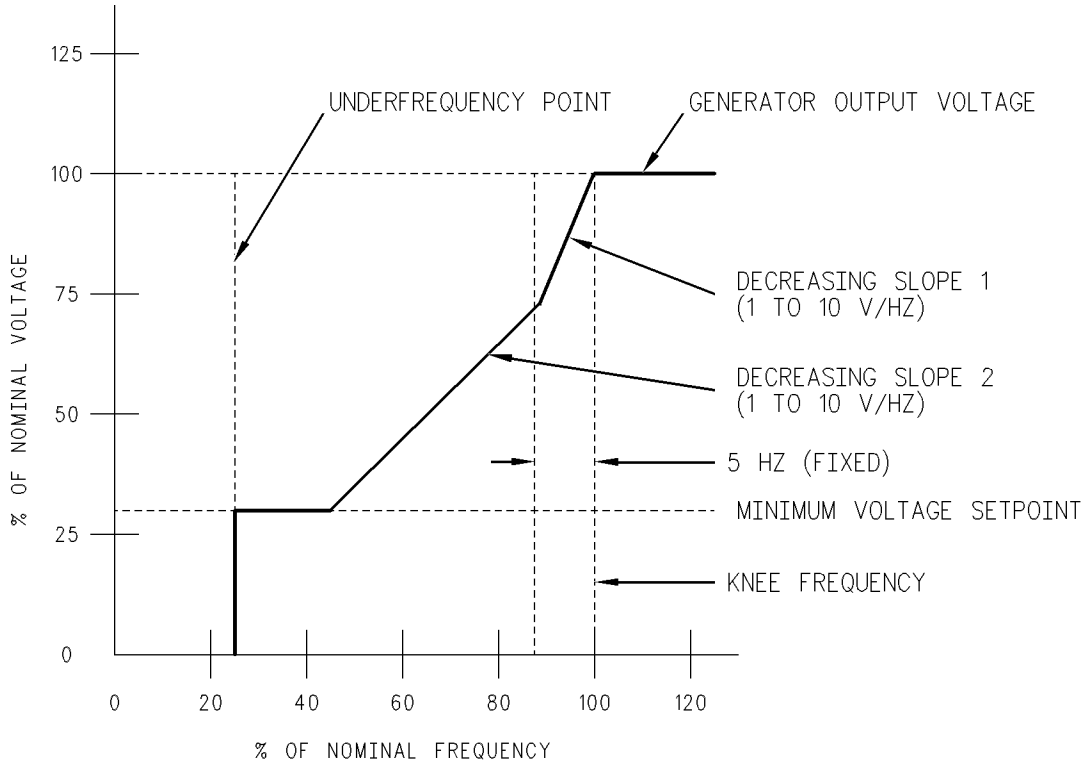

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Illustration 8

Illustration Of The Loading And Stopping Profile

The parameters that are related to the loading and stopping profile are listed below.

01 – Generator Output Voltage

03 – Generator Type

06 – Knee Frequency

07 – Decreasing V/Hz Slope 1

08 – Decreasing V/Hz Slope 2

09 – Minimum Voltage

10 – Underfrequency Point

Voltage regulators are generally of the volts per hertz type or the constant voltage type. The digital voltage regulator can perform as a constant voltage regulator or a volts per hertz type regulator depending on user configuration. Volts per hertz type regulators are commonly used with reciprocating internal combustion engine driven generator sets because they provide an automatic means for the engine to recover from a large block load. In the digital voltage regulator, the block load recovery performance is configurable so that it may be field optimized for each specific application.

When the generator is running and if a large load is applied, the frequency and voltage will drop. The loading/stopping function minimizes the amount of time that it takes the engine and generator to recover and increases the ability to pick up large loads. After the knee frequency has been reached on startup, this function will modify the voltage reference based upon the frequency of the generator.

As a large load is applied, the engine speed will begin to drop (frequency decreases). As the frequency decreases below the knee frequency, the voltage reference will decrease on a Volts/Hz slope according to the decreasing slope 1 value (parameter :07). If the frequency decrease continues beyond the knee frequency minus 5 Hz, then the voltage reference will decrease on a Volts/Hz slope according to the decreasing slope 2 value (parameter :08) until the minimum voltage level (parameter :09) is reached. The digital voltage regulator will try to regulate the generator output voltage at the minimum voltage, unless the underfrequency point (parameter :10) is reached where the generator output voltage will decrease to a minimum value.

As the engine recovers from the load increase, the voltage will increase in the reverse order as it decreased, unless the frequency dropped below the underfrequency point. If the frequency dropped below the underfrequency point, the startup profile will be used for the recovery.

In some applications it is desirable to maintain a constant voltage at the possible sacrifice of a larger frequency dip during load transients. The digital voltage regulator can accommodate these applications if the knee frequency (parameter :06) is configured for a lower value than normal. The actual value will depend on the specific application. When used in this application, the load transients must be kept small in order to allow the engine to recover without dropping below the knee frequency.

When a large block load is switched on to the system, the engine speed temporarily decreases as the engine produces the additional power requirement by burning more fuel. If the regulator is set to act as a volts per hertz type, it will reduce the output voltage according to the slope of the V/Hz curve. The reduction in voltage reduces the power requirement of the load, thus allowing the engine to recover faster for a given block load. If the regulator is set to act as a constant voltage type, the regulator will not reduce the output voltage for a change in speed (addition of block load). Therefore, it will take the engine a longer time to regain speed and supply the total power requirement of the load. If the regulator is set to act as a constant voltage type, care must be taken to keep block load applications small enough so that the engine can recover in acceptable time.

i01073831

Voltage Regulation

SMCS Code: 4467

The parameters that are related to voltage regulation are listed below.

:01 – Generator Output Voltage

:02 – Ratio of Output Voltage to Sensing Voltage

:03 – Generator Type

:06 – Knee Frequency

:16 – Integral Gain

:17 – Proportional Gain

Once startup has been achieved and the generator output frequency is above the knee frequency, the regulator will normally act to keep the generator output voltage constant. As changes in generator loading cause the voltage to sag or rise, the regulator will automatically adjust generator excitation to maintain the output voltage as set by parameter :01. If loading causes the generator frequency to drop below the knee frequency, the loading and stopping profile as previously described will be followed. See System Operation, “Loading And Stopping Profile”.

A remote voltage adjust rheostat may be used to fine tune the generator output voltage. When used, the active value of voltage reference may be adjusted ±10% about the value set in parameter :01.

i01073865

Line Loss Compensation

SMCS Code: 4467

In some installations where a single generator is used with long feeder lines to the load, it may be advantageous to provide line loss compensation. Line loss compensation is commonly referred to as IR compensation. In this mode, a CT must be provided in order to measure the generator current.

The parameters that are related to line loss compensation are listed below.

:01 – Generator Output Voltage

:02 – Ratio of Output Voltage to Sensing Voltage

:03 – Generator Type

:04 – Rated Generator Output Current

:05 – CT Voltage at Rated Generator Current

:06 – Knee Frequency

:15 – Voltage Gain (Line Loss Compensation)

:16 – Integral Gain

:17 – Proportional Gain

Current flowing through a long cable conductor causes a voltage drop due to the resistance of the wire. Therefore, the voltage at the load end of the conductor will be lower than at the generator end due to the voltage drop along the conductor. This condition is commonly referred to as line losses. In order to improve the power quality, the digital voltage regulator can compensate for this phenomenon. As generator load increases, the regulator will cause the output voltage to rise slightly at the generator terminals in order to compensate for line losses. Voltage gain (parameter :15) controls the amount of compensation. It should be adjusted to yield a constant voltage at the location of the load.

If line loss compensation is desired, droop percentage (parameter :30) should be set to zero, as the two functions are counteracting. If a CT is provided but line loss compensation is not desired, voltage gain (parameter :15) must be set to zero.

i01074092

Reactive Voltage Droop

SMCS Code: 4467

Parameters that are related to voltage regulation with reactive droop are listed below.

:01 – Generator Output Voltage

:02 – Ratio Of Output Voltage To Sensing Voltage

:03 – Generator Type

:04 – Rated Generator Output Current

:05 – Current Transformer (CT) Voltage At Rated Generator Current

:06 – Knee Frequency

:15 – Voltage Gain

:16 – Integral Gain

:17 – Proportional Gain

:22 – Droop/CCC Select (only on part number 155-xxxx and later)

:30 – Droop Percentage

When generators operate in parallel, two primary objectives are for the generators to share both the real power requirements and the reactive power requirements of the system electrical load. The engine governors will control sharing of the real power requirements (kW) and the voltage regulator will control sharing of the reactive power requirements (KVAR) of the total system load. If the output voltage of one generator is slightly higher than the other generators, it will supply lagging reactive current to the other generators connected in the group. This current will circulate between generators, possibly causing ampere overloading. One method of minimizing this effect is to cause an individual generator's output voltage to sag, or "droop", in proportion to the lagging reactive current flow from it as measured with a current transformer (CT). For proper reactive load sharing, the regulator must know the rated generator output current (parameter :04), the CT voltage at rated generator current (parameter :05) and the desired percentage of output voltage droop (parameter :30) when the generator is at rated reactive output current.

As reactive lagging generator output current increases, the regulator will cause the output voltage to droop (lower the voltage) proportionally. If the measured reactive output current is leading, the output voltage will rise. In either case, this action will tend to reduce the reactive current for better KVAR sharing with other units. The droop percentage (parameter :30) controls how much the generator output voltage will vary for a given amount of reactive current. It is important that the connected CT polarity is correct for the voltage to droop with lagging current flow. The line loss compensation voltage gain (parameter :15) function can adversely affect load sharing. For reactive droop to work properly, parameter :15 should be set to zero.

i01074156

Cross Current Compensation

SMCS Code: 4467

Parameters related to voltage regulation with cross current compensation (CCC) are listed below.

:01 – Generator Output Voltage

:02 – Ratio of Output Voltage to Sensing Voltage

:03 – Generator Type

:04 – Rated Generator Output Current

:05 – CT Voltage At Rated Generator Current

:06 – Knee Frequency

:15 – Voltage Gain

:16 – Integral Gain

:17 – Proportional Gain

:22 – Droop/CCC Select (only on part number 155-xxxx and later)

:30 – Droop Percentage

Cross current compensation is often used to minimize circulating current flow between the generators which are connected in parallel. The advantage of this operating mode is that all generators contribute to establish the same output voltage to the load. A utility voltage connection is not necessary to do so. Operation is similar to the reactive voltage droop mode except that the secondary circuits of the current measuring CT's of all generators are interconnected in a series string. Each generator is initially adjusted in order to provide the same output voltage via parameter :01. When all generators share the same current, in magnitude and phase (according to their CT ratio), there will be no significant voltage output on the secondary of any generator CT. If one of the generators carries more current or the current that the generator carries is lagging or leading relative to the others, a net difference voltage signal will be created on the burden resistor for that CT. If that generator is supplying more reactive (lagging) current than other generators, the phase polarity and the magnitude of the signal returned to the digital voltage regulator will be such to cause a slight decrease in the generated voltage, reducing the amount of reactive current. Less reactive (or more leading) current will cause the generator voltage to rise. The net result is that the generated voltage and the output current of each generator is trimmed toward an operating point where all generators will share the same load current in proportion to their CT ratio, with the little or no circulating current between them. Parameter :30 controls the amount of individual generator voltage droop (or rise) for a given amount of CT signal.

However, because the CT secondary circuits are all interconnected, the CT signal seen by any individual regulator is not representative of the actual current flowing in that particular generator. Any display or calculations that might use that signal as if it were the actual generator current will provide erroneous results. This is the case with the digital voltage regulator on all models with part numbers of 130-xxxx or older (smaller prefix number).

Beginning with regulator part numbers 155-xxxx and newer, another parameter was added to signal the digital voltage regulator when the CT is measuring differential compensation current or normal generator line current. Parameter :22 is used to notify the regulator that CCC is in effect, and to turn off the features that would be erroneous in that configuration. When parameter :22 is set to a "1" (CCC selected), the reverse VAR detection and optional reverse power fault detection are turned OFF, as well as the ability to view all current related parameters, such as parameters :52, :53, :54, :56, :57, and :58. If any current related parameters are selected for display when CCC mode is selected, the value for these parameters will read zero.

i01073672

KVAR Regulation

SMCS Code: 4467

Note: KVAR regulation is an optional feature.

Parameters that are related to KVAR regulation are listed below.

:01 – Generator Output Voltage

:02 – Ratio Of Output Voltage To Sensing Voltage

:03 – Generator Type

:04 – Rated Generator Output Current

:05 – CT Voltage At Rated Generator Current

:31 – PF/KVAR Select

:33 – KVAR Reference

:36 – Paralleling Integral Gain

:37 – Paralleling Proportional Gain

Note: Parameters :36 and :37 are only available on part number 155-xxxx or newer.

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 digital voltage regulator to regulate the reactive power output which is supplied by the generator. There are two methods for regulating the reactive power output.

- KVAR Regulation

- Power Factor (PF) Regulation

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

When the digital voltage regulator is in the KVAR operating mode, it regulates so that the generator produces a constant value of reactive power (KVARs), regardless of the real power output of the generator. In this case, the generator power factor will change when the real power output of the generator changes. A current transformer (CT) is necessary for this mode to work.

The KVAR mode is active when parameter :31 is set to a logic 1, and the external switch on terminal 41 is closed indicating that the generator is connected in parallel with utility lines. In KVAR mode, the generator will supply a constant amount of KVARs to the system as set in parameter :33 (or a remote rheostat), regardless of the real power (kW) output of the generator set. The generator will supply real power (kW) to the system as determined by the engine governor and/or load sharing device. It is common that utility loads are too reactive (low power factor), which can cause ampere overloading of the system due to large reactive current requirements. In the KVAR mode, the generator can supply a fixed amount of KVARs to the system to provide a less reactive load, which will improve the power factor of the load and reduce the ampere demand on the system.

A remote PF/KVAR adjust rheostat may be connected in the KVAR mode. When in the KVAR mode (parameter :31 set to 1), the remote rheostat adjustment will override the setting for parameter :33.

For stable operation of the generator in the KVAR regulating mode, the generator must be connected to a utility or system that is much larger than the generator. When the tie breaker is closed to the utility, use the external control switch contact at regulator terminal 41, via the gen/utility 52/a aux contact, to enable the KVAR mode. When the terminal 41 contact logic is open, the regulator will be in a voltage control operating mode with or without droop or line loss compensation as previously described.

i01073755

Power Factor Regulation

SMCS Code: 4467

Note: The power factor (PF) regulation is an optional feature.

Parameters that are related to PF regulation are listed below.

:01 – Generator Output Voltage

:02 – Ratio Of Output Voltage To Sensing Voltage

:03 – Generator Type

:04 – Rated Generator Output Current

:05 – CT Voltage At Rated Generator Current

:31 – PF/KVAR Select

:32 – PF Reference

:33 – KVAR Reference

:36 – Paralleling Integral Gain

:37 – Paralleling Proportional Gain

:38 – PF Switch Point

Note: Parameters :36, :37 and :38 are only available on part number 155-xxxx or newer.

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 digital voltage regulator to regulate the reactive power output which is supplied by the generator. There are two methods for regulating the reactive power output.

- KVAR Regulation
- Power Factor Regulation

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

When the digital voltage regulator is in the power factor operating mode, it regulates so that 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 current transformer (CT) is necessary for this mode to work.

Operation of the power factor mode has changed a number of times, each time to improve the behavior at low levels of real current. The first change took place when the PROM ID (parameter :91) changed to 1.03. This is also coincident with the new fault parameter methods. The second change took place when the regulator part number changed to 155-xxxx and PROM ID changed to 1.05.

Original Power Factor Operation

When parameter :31 is set to zero, and the external switch on terminal 41 is closed, the regulator will operate in power factor control mode. The regulator assumes the generator is connected to an infinite bus, so that the voltage cannot be changed. In power factor mode the generator will supply a varying amount of reactive power (KVARs) based upon the real power output (KW) of the generator to obtain the desired power factor set in parameter :32 (or a remote rheostat).

PROM ID 1.03 Power Factor Operation

When parameter :31 is set to zero, and the external switch on terminal 41 is closed, the regulator will start up in the KVAR mode supplying 0 KVAR. When the real current measurement is equal to or above 10% of rated generator output current, the regulator will switch to the power factor control mode of operation. The rated generator output current is parameter :04. Thus, the generator set needs to provide a significant amount of real kW power before the digital voltage regulator will regulate in the power factor mode. The start up value of 0 KVAR is a fixed value and cannot be adjusted. While the measured real current is below 10%, the remote rheostat input will be ignored. Once the real generator output current exceeds 10%, the power factor will then be regulated according to parameter :32 (or a remote rheostat). In power factor mode the generator will supply a varying amount of reactive power (KVARs) based upon the real power output (KW) of the generator to obtain the desired power factor set in parameter :32 (or a remote rheostat). When the real current output of the generator decreases to 5% or less of the rated generator output current, the controller will switch back to regulating only KVARs as described above. The switch-back point has hysteresis to avoid ringing.

PROM ID 1.05 Power Factor Operation

When parameter :31 is set to zero, and the external switch on terminal 41 is closed, the regulator will start up in the KVAR mode and will regulate according to the KVAR reference level which is set in parameter :33. When the real current measurement is equal to or above the percentage which is set in parameter :38, the regulator will switch to the power factor control mode of operation. Thus, the generator set needs to provide a significant amount of real kW power before the digital voltage regulator will regulate in the power factor mode. In the power factor mode the generator will supply a varying amount of reactive power (KVARs) based upon the real power output (kW) of the generator to obtain the desired power factor set in parameter :32 (or a remote rheostat). When the real current output of the generator becomes 5% less than the percentage configured in parameter :38, the controller will switch back to regulating only KVARs as described above. The actual switch-back point has hysteresis. For further information see the detailed explanation for parameter :38.

A remote PF/KVAR adjust rheostat may be connected in the power factor operating mode. When in the power factor mode (parameter :31 set to zero), the remote rheostat adjustment will override the PF reference in parameter :32, but at levels of current below the PF/KVAR switch point, the KVAR reference will be as set by parameter :33. For stable operation of the generator in the power factor regulating mode, the generator must be connected to a utility or system that is much larger than the generator. When the tie breaker is closed to the utility, use the external control switch contact at regulator terminal 41, via the gen/utility 52/a aux contact, to enable the power factor mode. When the terminal 41 contact logic is open, the regulator will be in a voltage control operating mode with or without droop or line loss compensation as previously described.

i01041643

Parameters

SMCS Code: 4467

Parameter Table

Table 4

PARAMETERS					
Parameter	**Title**	**Type**	**Units**	**Range Of Value**	**Default Value**
01	Generator Output Voltage	Program	Volts	0080 - 9999	0480(1)
02(2)	Ratio Of Output Voltage To Sensing Voltage	Program	-	001.0 - 100.0	001.0
03	Generator Type	Program	-	0000 - 0004	0004
04	Rated Generator Output Current	Program	Amps	0000 - 9999	0600
05(2)	CT Voltage At Rated Generator Current	Program	Volts	01.00 - 05.00	05.00
06	Knee Frequency	Program	Hz	045.0 - 065.0	050.0
07	Decreasing Volts/Hz Slope 1	Program	Volts/Hz	001.0 - 010.0	002.0
08	Decreasing Volts/Hz Slope 2	Program	Volts/Hz	001.0 - 010.0	002.0
09	Minimum Voltage	Program	%	050.0 - 100.0	050.0
10	Underfrequency Point	Program	Hz	020.0 - 040.0	025.0
11	Overvoltage Trip Point	Program	%	0105 - 0140	0140
12	Overvoltage Trip Time	Program	Seconds	0002 - 0030	0002
13	Undervoltage Trip Point	Program	%	0060 - 0095	0060
14	Undervoltage Trip Time	Program	Seconds	0030 - 0120	0030
15	Voltage Gain (IR Compensation)	Program	%	000.0 - 010.0	0000
16(3)	Integral Gain	Program	-	001.0 - 020.0	006.0
17(4)	Proportional Gain	Program	-	001.0 - 020.0	005.0
18	Single Phase Sensing Select (0 = three phase, 1 = single phase)	Program	-	0000, 0001	0000
19	Diode Monitor Trip Point	Program	Amps	001.0 - 010.0	002.0
20	Reverse VAR Trip Time	Program	Seconds	000.1 - 009.9	000.5
21	Reverse VAR Fault Selection	Program	-	0000 - 0002	0002
22	Droop/CCC Select (0 = Droop, 1 = CCC)	Program	-	0000, 0001	0000
30	Droop Percentage	Program	%	000.0 - 010.0	0000
31(5)	PF/KVAR Select (0 = PF, 1 = KVAR)	Program	-	0000, 00001	0000
32(5)	PF Reference	Program	-	00.60 - 01.10	01.00
33(5)	KVAR Reference	Program	Per Unit	00.00 - 01.00	0000
34	Reverse Power Trip Point	Program	%	000.0 - 020.0	010.0
35	Reverse Power Trip Time	Program	Seconds	000.0 - 020.0	010.0
36(5)	Paralleling Integral Gain	Program	-	000.1 - 030.0	003.3
37(5)	Paralleling Proportional Gain	Program	-	000.1 - 009.9	001.3
38(5)	PF Switch Point	Program	%	0010 - 0025	0015

(continued)

(Table 4, contd)

PARAMETERS					
Parameter	**Title**	**Type**	**Units**	**Range Of Value**	**Default Value**
50	Generator Output Frequency	View	Hz	-	-
51	Generator Output Voltage	View	Volts	-	-
52	Generator Output Current	View	Amps	-	-
53	Generator Reactive Output Current	View	Amps	-	-
54	Generator Real Current	View	Amps	-	-
55	Exciter Field Current	View	Amps	-	-
56(5)	Three Phase Kilowatts (“KE” and later)	View	kW	-	-
57(5)	Power Factor (PF)	View	-	-	-
58(5),(6)	Three Phase KVAR (“KE” and later)	View	-	-	-
60	Hours	View	Hours	-	-
70(5),(7)	Voltage Adjust	View	-	0000 - 0200	0100
71(5),(7)	PF/KVAR Adjust	View	-	0000 - 0200	0100
90	Password	Program	-	0000 - 9999	0200
91	Software ID	View	-	-	-
92	Latest Fault	View	-	-	0000
93	Previous Fault	View	-	-	0000
94	Fault Clear	Switch	-	-	-
95(8)	Alarm Fault	View	-	-	-
96	Shutdown Fault Reset	Switch	-	-	-

(1) Default value for the output voltage is different depending on the regulator sensing voltage. If the regulator is designed for 120 volts sensing, then the default output voltage is 4160 volts. All other sensing types have the default output voltage set to 480 volts.
(2) Digital voltage regulators with earlier software (“KD” and earlier) have one less digit to the right of the decimal point.
(3) Earlier versions had a range of 0001-099.9 and default value of 002.0.
(4) Earlier versions had a range of 0001-099.9 and default value of 003.0.
(5) This is an optional feature.
(6) New parameter on serial number prefix “KE” and later digital voltage regulators.
(7) Parameter only available for adjustment through the serial link. See System Operation, “Parameters”, topic Parameter Descriptions for more details.
(8) Parameter is only available on earlier software versions (“KD” and earlier).

General Information

Parameters are pieces of information which are used within the memory of the digital voltage regulator. Each parameter has a specific range of values. Parameters tell the digital voltage regulator how to operate. Service personnel can configure certain parameters to the requirements of a specific site. Configuration changes the value of a particular parameter. There is an upper and lower limit for the value of each parameter. The limits can not be exceeded.

Not all parameters are configurable. Some parameters are only used as meters meant for viewing or monitoring purposes. Some parameters act like a switch that activates a digital voltage regulator function. Parameters :01 through :49 are configurable parameters and can be changed. Parameters :50 through :79 are monitor or view parameters and can only be viewed. Parameters :90 through :99 are system parameters which are primarily alarm/fault parameters for the entire system.

Each parameter is assigned a specific two digit code. These parameters can be shown on the display of the digital voltage regulator. Parameters are preceded by a colon. The value of each parameter can also be shown on the display of the digital voltage regulator. The parameter value is a four digit number and is not preceded by a colon.

Proper activation of the keypad is necessary to view or configure the values of the parameters. See System Operation, “Display And Keypad”. Also, see Testing And Adjusting, “Parameter Viewing And Configuring Procedure”.

Parameter Descriptions

Parameter :01 – Generator Output Voltage. This is the voltage expected (desired) at the generator output terminals. Modify this parameter in order to adjust the normal generator output voltage. A remote voltage adjust rheostat will provide a ±10% voltage adjustment range from the value entered for generator output voltage.

Parameter :02 – Ratio Of Output Voltage To Sensing Voltage. This is the ratio of the generator output voltage to the regulator sensing voltage. The generator output voltage appears at the terminals of the generator. The regulator sensing voltage appears at terminals 20, 22, and 24 of the digital voltage regulator. In order to determine the ratio of output voltage to sensing voltage if the generator output is less than 700 VAC, divide the generator output voltage by the voltage range on the digital voltage regulator ID nameplate. The number actually used for the voltage range listed on the digital voltage regulator ID nameplate varies with the frequency (Hz) of the generator. The numbers used for the different digital voltage regulator voltage ranges are listed below.

- If the range is 79-124 use 100 volts for 50 Hz or 120 volts for 60 Hz.
- If the range is 125-249 use 200 volts for 50 Hz or 240 volts for 60 Hz.
- If the range is 250-600 use 400 volts for 50 Hz or 480 volts for 60 Hz.

For example, if the generator output voltage is 480 volts and the digital voltage regulator voltage range is 125-249 and the frequency of the generator is 60 HZ, then the ratio is 480 divided by 240 which equals 2. The below method may also work for generators below 700 VAC depending on the connection diagram employed.

If the generator output voltage is more than 700 VAC, then use the transformer ratio of the sensing transformers. For example, if the generator output voltage is 4160 VAC and the sensing transformers are 4200:120, the voltage ratio is 35 (4200 divided by 120).

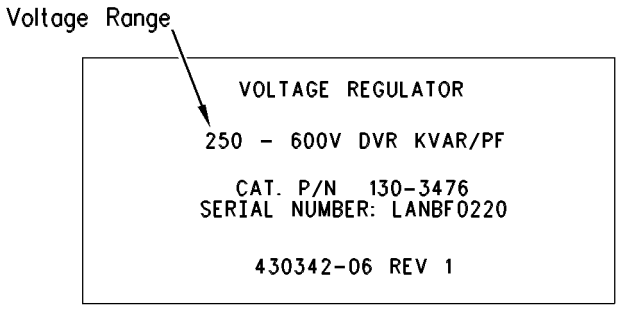

Illustration 9 g00551383

Typical Nameplate On Digital Voltage Regulator

Another method to find the ratio is by performing the following measurement.

1. Remove wires 26 and 30 from regulator terminals 26 and 30 in order to eliminate the possibility for overvoltage. Remove the wire from B- in order to avoid fault code 803.
2. Start the engine and run at rated speed (high idle).
3. Measure residual generator output voltage.
4. Measure voltage across terminals 20 and 22 of the digital voltage regulator.
5. Shut down the engine.
6. Voltage ratio is equal to measured generator output voltage divided by measured voltage across terminals 20 and 22.

Note: On occasion, it may be necessary to flash the field in order to get enough residual voltage for this test.

Parameter :03 – Generator Type. This relates to the type of generator which the digital voltage regulator is controlling. This is required for the digital voltage regulator to properly measure the output frequency of the generator. The digital voltage regulator measures frequency using two of the PM power inputs (26 and 30). The generator frame size is indicated on the nameplate which is located on the outside of the generator terminal box.

NOTICE

Additional components (potential transformers) are required when the digital voltage regulator is set for SE operation. If the SE generator and the digital voltage regulator are not connected properly, the digital voltage regulator can be permanently damaged.

In a self-excited application (SE), the PM power inputs to the digital voltage regulator must be connected to power transformers. Two power transformers are required to be connected in an ungrounded open delta configuration. Each transformer must be capable of supplying 1200 VA. The PM inputs must not exceed 120 VAC line to line. For example, if the generator has a 480 VAC output, use 4:1 transformers. The transformers must be fused on the primary side.

Table 5

Parameter Code :03 - Generator Type				
Parameter Value	**Exciter Type**	**Frame Size**	**Gen Poles**	**Engine Speed**
0	SE	All	All	All
1	PM	440	6	1000/1200
2	PM	440	4	1500/1800
3	PM	580-820	6	1000/1200
4	PM	580-820	4	1500/1800

Parameter :04 – Rated Generator Output Current. This parameter is set to the nameplate rated output current of the generator at 0.8 power factor. This is the 100% maximum rating, including the real and reactive currents. The digital voltage regulator does not use this parameter to limit current. However, the parameter must be set properly for the paralleling and line loss compensation functions in order to operate correctly. The rated generator output current is indicated on the nameplate. The nameplate is located on the outside of the generator terminal box.

Parameter :05 – CT Voltage At Rated Generator Current. The voltage that the digital voltage regulator will have at the droop current transformer (CT) input at rated generator current. This entry is used for droop, line loss compensation, KVAR/PF control, and calculation of the monitoring parameters :52, :53, :54, :56, :57, and :58. The parameter must be set properly for the monitoring, paralleling, and line loss compensation functions in order to operate correctly. The value can be calculated by using the following formula.

$V_{ct}=(I \times W \times R \times N) / (T \times O \times C)$

V_{ct} – CT Voltage At Rated Generator Current

I – rated generator output current per phase (value entered for parameter :04)

W – the number of times each generator wire goes through the droop CT window

R – ohms of CT burden resistor

N – number of wires going through the droop CT

T – CT turns ratio or (I_{CT} primary) / (I_{CT} secondary)

O – total number of generator output wires per phase, of which some or all may go through the droop CT.

C – generator output voltage connection: 1 for high, 2 for low. Four or six lead generators can only be 1 (high). Ten or twelve lead generators connected in series are also 1 (high). Ten or twelve lead generators connected in parallel are considered 2 (low voltage). Twelve lead generator connected in delta are considered 2 (low voltage). Six lead generators connected in delta are still considered 1 (high).

Another method to determine the value for parameter :05 is listed below.

1. Start and run the generator set at full load (available loading).
2. Select and monitor parameter :52 (generator output current).
3. If the value monitored on parameter :52 is not approximately equal (± 5%) to the actual current on phase “B”, then adjust parameter :05 up or down until the current monitored is equal to the actual current.

Note: Increasing parameter :05 will lower the value of parameter :52. Decreasing parameter :05 will increase the value of parameter :52.

Parameter :06 – Knee Frequency. For a visual description see System Operation, “Startup Profile Function”. Also, see System Operation, “Loading And Stopping Profile”. This parameter is set in hertz (Hz). For better stability, it is recommended that this setting be 0.2 to 1.0 Hz below the operating frequency. For voltage sensitive applications, it may be desirable to set the value lower still.

Parameter :07 – Decreasing V/Hz Slope 1. For a visual description see System Operation, “Loading And Stopping Profile”. This parameter is set in % voltage change per % frequency change.

Parameter :08 – Decreasing V/Hz Slope 2. For a visual description see System Operation, “Loading And Stopping Profile”. This parameter is set in % voltage change per % frequency change.

Parameter :09 – Minimum Voltage. For a visual description see System Operation, “Loading And Stopping Profile”. This parameter is set in volts as a percentage of rated voltage (% of parameter :01).

Note: The undervoltage trip point and undervoltage trip time prevent the engine/generator from operating in an undervoltage condition for an extended time. The minimum voltage (parameter :09) is the lowest operating voltage where it is expected that the engine/generator will recover from a large load application. Setting the minimum voltage above the undervoltage trip point (parameter :13) eliminates most of the undervoltage protection.

Parameter :10 – Underfrequency Point. For a visual description see System Operation, “Startup Profile Function”. See also System Operation, “Loading And Stopping Profile”. This parameter is set in hertz (Hz).

Parameter :11 – Overvoltage Trip Point. If the voltage is more than this value for a period of time greater than the overvoltage trip time, then an overvoltage shutdown fault will occur. This point is set in % of generator output voltage (parameter :01). See also parameter :12. This feature is intended to operate like an ANSI 59 protective relay.

Parameter :12 – Overvoltage Trip Time. The time, in seconds, required that the output voltage must be greater than the overvoltage trip point before tripping an overvoltage shutdown fault. See also parameter :11.

Parameter :13 – Undervoltage Trip Point. If the voltage is less than this value for a period of time greater than the undervoltage trip time, then an undervoltage shutdown fault will occur. This point is set in % of generator output voltage (parameter :01). See also parameter :14. This protection is not enabled when the optional excitation disable switch is closed or when the running/operating profile is not in effect. This feature is intended to operate like an ANSI 27 protective relay.

Parameter :14 – Undervoltage Trip Time. The time, in seconds, required that the output voltage must be lower than the undervoltage trip point before tripping an undervoltage shutdown fault. See also parameter :13.

Note: The undervoltage trip point and undervoltage trip time prevent the engine/generator from operating in an undervoltage condition for an extended time. The minimum voltage (parameter :09) is the lowest operating voltage where it is expected that the engine/generator will recover from a large load application. Setting the minimum voltage above the undervoltage trip point (parameter :13) eliminates most of the undervoltage protection.

Parameter :15 – Voltage Gain (Line Loss Compensation). This parameter increases the voltage reference to compensate for voltage drops in the wires (resistance) from the generator to the load. This drop is dependent on the amount of current flowing through the wires. The value is entered in percentage of generator output voltage (parameter :01). Reactive droop (parameter :30) may have an effect on the voltage reference in the opposite direction. Either voltage gain or voltage droop may be used. However, both of the parameters should not be used simultaneously. One or both of these parameters should always be zero. See System Operation, “Voltage Regulation”. See also System Operation, “Line Loss Compensation”. This feature requires the presence of a droop current transformer.

Parameter :16 – Integral Gain. This parameter changes the transient performance of the digital voltage regulator when in voltage control mode. This is preset at the factory for the generator and should not be adjusted unless the resulting effect is fully understood. An incorrect adjustment may make the output voltage overshoot or oscillate. Increasing this value may improve regulation accuracy but can cause it to be more unstable. The shorter the generator time constant the higher this parameter should be set. Hunting may be experienced if the gain is too low. This parameter should generally be set within the range of 1.0 to 9.0.

Parameter :17 – Proportional Gain. This parameter changes the transient performance of the digital voltage regulator when in voltage control mode. This parameter is preset at the factory for the generator and should not be adjusted unless the resulting effect is fully understood. Increasing this value will improve the response of the regulator to load changes but may cause voltage overshoot or become unstable. This parameter should generally be set within the range of 1.0 to 9.0. This parameter should be close to the value for parameter :16.

Parameter :18 – Single Phase Sensing Select. If single phase sensing is required, set this value to 1. The default setting is 0 for three phase sensing. This is required to regulate the proper voltage. When single phase sensing is selected, all KVAR/PF features are disabled, including viewing of monitor functions :56, :57, and :58. On 155-xxxx part number regulators, when single phase sensing is selected, all KVAR/PF, reverse VAR, and reverse power features are disabled, including viewing of monitor functions :56, :57, and :58.

Parameter :19 – Diode Monitor Trip Point. This parameter sets the allowable amount of field current variation (ripple) before the digital voltage regulator detects a possible bad rotating diode. If the value is exceeded for a period of five seconds, a rotating diode shutdown fault will occur. Initially, this value should be set to the no-load field current monitored on parameter :55. Lower the value (increase sensitivity) in order to lower the allowable current difference. Raise the value (decrease sensitivity) in order to raise the allowable current difference.

Parameter :20 – Reverse VAR Trip Time. This parameter represents the time, in seconds, required to trip the reverse VAR faults (fault codes 604 and 704). This protective fault is defined as 0.4 Per Unit or greater leading KVARs. Entering a longer time will allow for compensation of added loads. The system settle time for added loads depends on the size of the added load. See also parameter :21. This parameter was added on regulator part numbers 155-xxxx and newer. This feature is intended to operate like an ANSI 40 protective relay.

Parameter :21 – Reverse VAR Fault Selection. This parameter configures the digital voltage regulator's action when subjected to a reverse VAR condition. This fault may be configured to be a shutdown fault, an alarm fault, or to be disabled (no fault). When parameter :21 is set to 0, detection of the reverse VAR fault is disabled. This disables fault code 604 and fault code 704. When parameter :21 is set to 1, the fault is treated as an alarm fault. This enables the fault code 604, while disabling the fault code 704. When parameter :21 is set to 2, the fault is treated as a shutdown fault. This enables the fault code 704, while disabling the fault code 604. See also fault code 604 and fault code 704. This parameter was added on part numbers 155-xxxx and newer.

Parameter :22 – Droop/CCC Select. This parameter is used to select between voltage regulation/droop and cross current compensation (CCC) modes when operating in voltage control mode. When CCC mode is selected, parameters :52, :53, :54, :56, :57, and :58 are disabled as well as the reverse power fault code 705 and reverse VAR fault codes 604 and 704. This parameter has no effect on the KVAR or PF modes of operation and is ignored when terminal 41 is closed to terminal 50, thus enabling the optional KVAR or PF regulation mode. This parameter was added on regulator part numbers 155-xxxx and newer.

Parameter :30 – Droop Percentage. See System Operation, "Reactive Voltage Droop Function". See also System Operation, "Cross Current Compensation". This parameter defines generator output voltage droop, in percent, at rated generator reactive current. The parameter is effective only when in voltage droop mode (see parameter :22). Generator rated current is defined by parameter :04 and parameter :05. Either voltage gain or voltage droop may be used but both should not be used simultaneously. One or both of these parameters should always be zero. This parameter has no effect on the KVAR or PF modes of operation and is ignored when terminal 41 is closed to terminal 50, which enables the optional KVAR or PF regulation mode. This feature requires the presence of a droop current transformer. Note that with leading reactive current, the voltage will rise rather than droop.

Parameters :31 through :38 apply only to the digital voltage regulators with the optional KVAR/PF and reverse power functions. All the features require the presence of a droop current transformer. Several notes for this option are listed below.

- The KVAR/PF option is not operable if the 52/a contacts are not closed (shorting terminal 41 to 50). Parameters :4 and :5 must be configured correctly for proper operation in KVAR/PF mode.
- The reverse power function is not active unless the KVAR/PF mode is enabled or unless the droop mode is selected in parameter :22.
- If the droop current transformer (CT) is connected in a cross current compensation (zero droop) configuration and 52/a contacts are closed (thus enabling the PF/KVAR controller), the regulator will not operate properly and will trip out with various faults (usually, the reverse VAR fault). Properly located contactors may be used to allow the setup of both configurations so that either one can be used at any given time.

- If the KVAR/PF mode is enabled when the generator is connected to an isolated load (not connected to a utility), then an unstable operating condition exists because it is not possible to regulate voltage and power factor (or KVAR) simultaneously.

- If single phase sensing is selected (parameter :18), all PF/KVAR optional features will be disabled as well as monitoring functions :56, :57, and :58.

Parameter :31 – PF/KVAR Select (optional feature). This parameter selects whether power factor (PF) or KVARs will be regulated when the PF/KVAR mode is activated by applying 24 volts DC to the VAR/PF enable input at regulator terminal 41 (Always use terminal 50 for the 24 volts DC source). Set parameter :31 to 0 for PF control. Set parameter :31 to 1 for KVAR control. The default for parameter :31 is 0.

Parameter :32 – PF Reference (optional feature). When power factor (PF) control is active, the value entered for this parameter is used as the reference for regulation. Power factor is the ratio of real power (KW) divided by apparent power (KVA) of the generator. The value range of this parameter is adjustable from 0.6 (lagging) to 1.1, where 1.1 represents a leading power factor of 0.9. When the remote adjustment rheostat is used for manually adjusting the power factor, the setting of parameter :32 will not be modified, but will be ignored and not used. See System Operation, “Customer Options”. The PF/KVAR switch at terminal 41 must be enabled, and the real generator output must be above the level defined by parameter :38 for this feature to operate. See System Operation, “Power Factor Regulation” for more details and for the history of changes to this feature.

Parameter :33 – KVAR Reference (optional feature). When KVAR control is active, the value entered for this parameter is used as the reference for KVAR regulation. This value is entered as per unit KVARs, with an adjustment range of 0.0 to 1.0. The PF/KVAR mode switch at regulator terminal 41 must be enabled for this feature to operate.

The digital voltage regulator defines 1 Per Unit KVARs as 100% of rated KVARs, where rated KVARs is equal to 0.6 of rated generator KVA. This fixed definition is based on the fact that most generators are rated for their KW capacity at 0.8 power factor, which defines the ratio to overall KVA capacity. Parameters :01 and :04 define rated generator KVA. By definition, $KVA^2 = KW^2 + KVAR^2$. Therefore, at full rated conditions and with a power factor of 0.8, where KW/KVA = 0.8, the KVARs will be 0.6 times rated KVA.

When a remote adjustment rheostat is connected at regulator terminals 44 and 45, and parameter :31 is set to 1 (selecting KVAR regulation), the rheostat will have a full range of adjustment of the KVAR reference. The range of adjustment will be 0.0 to 1.0 Per Unit. The KVAR reference (parameter :33) value will not be modified, but will be ignored and not used.

On regulators with part number 155-xxxx and newer this value is used in power factor mode as well. When in PF control mode (parameter :31 is set to zero), the value entered in parameter :33 will be used as the KVAR reference when the generator real current level is below that defined by the PF switch point (parameter :38). See System Operation, “KVAR Regulation” for more detail. See also System Operation, “Power Factor Regulation”.

Parameter :34 – Reverse Power Trip Point. If the generator is subjected to a reverse power level greater than this value for a period of time greater than the reverse power trip time, a reverse power shutdown fault will occur. This value is set in percent of rated real power (KW). See also parameter :35. This feature requires the PF/KVAR mode switch at regulator terminal 41 to be enabled or the droop / CCC mode (parameter :22) to be set as droop (0) on units with that parameter available. This feature is intended to operate like an ANSI 32 protective relay.

Parameter :35 – Reverse Power Trip Time. The time, in seconds, required that the generator be subjected to a reverse power level greater than the reverse power trip point before tripping a reverse power fault (fault code 705). See also parameter :34.

Parameter :36 – Paralleling Integral Gain (optional feature). This parameter changes the transient performance of the digital voltage regulator only when in KVAR or power factor mode. This is preset at the factory for the generator and should not be adjusted unless the resulting effect is fully understood. Increasing this parameter will improve the regulation accuracy but possibly more unstable. It should be set similarly to parameter :37. This parameter was added on regulator part numbers 155-xxxx and newer.

Parameter :37 – Paralleling Proportional Gain (optional feature). This parameter changes the transient performance of the digital voltage regulator only when in KVAR or power factor mode. This is preset at the factory for the generator and should not be adjusted unless the resulting effect is fully understood. Increasing this parameter will make the generator more responsive to reactive load changes but possibly more unstable. This parameter should be set similarly to parameter :36. This parameter was added on regulator part numbers 155-xxxx and newer.

Parameter :38 – PF Switch Point (optional feature). Power factor cannot be calculated or regulated at low power levels, so the regulator must have a default control until an appropriate level is reached. This parameter is the amount of real current, as a percent of rated generator current, that is needed before power factor (PF) mode becomes active when PF mode is selected. Until the real current reaches this point, the unit will run in KVAR mode using parameter :33 for a reference. After the generator has switched to power factor control, if the real current falls 5% below the value set for this parameter, the digital voltage regulator will switch from the power factor control back into KVAR control. This 5% hysteresis is built in to prevent ringing, or unstable operation. Parameter :33 must be set to an appropriate level to ensure a smooth transition to PF mode. The rated generator current is as defined in parameters :04 and :05. This parameter was added on regulator part numbers 155-xxxx and newer.

Parameter :50 – Generator Output Frequency (view only). This parameter is the output frequency of the generator as calculated by the digital voltage regulator. It is based on the measured frequency of AC power input to the digital voltage regulator (PMG terminals 26 and 30), and the generator type (parameter :03), SE or PM.

Parameter :51 – Generator Output Voltage (view only). This parameter is the true RMS output voltage as measured by the voltage input of the digital voltage regulator (after the sensing voltage transformers if present). The value is the average of all three sensing voltage inputs unless single phase sensing is selected. The value is based on parameters :01 and :02.

Parameter :52 – Generator Output Current (view only - total current). This parameter is the measured generator output current in amps of the “B” phase. The accuracy depends upon proper adjustments to parameter :04 and parameter :05. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode (parameter :22 is set to 1). For older models, this monitor will not be correct if the digital voltage regulator is connected in cross current compensation mode. This feature requires the presence of a droop current transformer. See parameters :04, :05, and :22.

Parameter :53 – Generator Reactive Output Current (view only). This parameter is the digital voltage regulator calculated reactive portion of the generator “B” phase output current. It is the reactive portion of the current represented in parameter :52. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode. For older models, this monitor will not be correct if the digital voltage regulator is connected in cross current compensation mode. This feature requires the presence of a droop current transformer. See parameters :04, :05, and :22.

Parameter :54 – Generator Real Output Current (view only). This parameter is the calculated real portion of the generator output current. It is the real portion of the current represented in parameter :52. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode. For older models, this monitor will not be correct if the digital voltage regulator is connected in cross current compensation mode. This feature requires the presence of a droop current transformer. See parameters :04, :05, and :22.

Parameter :55 – Exciter Field Current (view only). This parameter is the measured exciter field current (in amps) at the output of the digital voltage regulator.

Parameter :56 – Kilowatts (view only). This parameter is the digital voltage regulator calculated measurement of the generator output in kilowatts. This function is only available on the PF/KVAR optional version and when 3 phase sensing is selected. The accuracy depends upon proper adjustments to parameter :04 and parameter :05. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode. For older models, this monitor will only operate when the KVAR/PF control mode is enabled. This feature requires the presence of a droop current transformer. Monitoring parameter :56 was previously providing only single phase (phase “B”) information for KW. Effective with serial number prefix “KE” and later, digital voltage regulator parameters :56 and :58 now provide three phase information on KW and KVAR. However, there is only one current transformer (CT) and the three phase information is based on a balanced three phase load. If the load is unbalanced, the error will be proportional to the unbalance. See also parameters :04, :05, and :22.

Parameter :57 – Power Factor (view only). The value of this parameter is the digital voltage regulator calculated ratio of real power (KW) divided by apparent power (KVA), or the cosine of the angle between those two. This function is only available on the KVAR/PF optional version and when 3 phase sensing is selected. The accuracy depends upon phase load balance and proper adjustments to parameter :04 and parameter :05. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode. For older models, this monitor will only operate when the KVAR/PF control mode is enabled. This feature requires the presence of a droop current transformer. See also parameters :04, :05, and :22.

Parameter :58 – KiloVARs (view only). This function is only available on the PF/KVAR optional version when 3 phase sensing is selected. This parameter is the digital voltage regulator calculated measurement of the generator output in KVARs. There is only one current transformer (CT) and three phase information is based on a balanced three phase load. If the load is unbalanced, the error will be proportional to the unbalance. This parameter has been added effective with serial number prefix “KE” and later units. The accuracy depends upon phase load balance and proper adjustments to parameter :04 and parameter :05. For units with parameter :22, this monitor will read zero if the digital voltage regulator is operated in cross current compensation mode. For older models, this monitor will only operate when the KVAR/PF control mode is enabled. This feature requires the presence of a droop current transformer. See also parameters :04, :05, and :22.

Parameter :60 – Hours (view only). This parameter is the number of hours that a measurable frequency has been applied to the AC power input of the digital voltage regulator. This will typically occur when the generator is operated above 15% normal rpm. Time is accumulated in 0.25 hours and shown in full hours only.

Parameter :70 – Voltage Adjust (optional feature). This parameter is available only through the serial communications port. It is designed to allow a remote control device (PLC) to modify the regulated voltage level reference by up to ±10% from the value set in parameter :01. The minimum value, 0 (zero), will decrease the regulated voltage level by 10%. The maximum value of 200 will increase the voltage level by 10%. A value of 100 will leave the voltage level reference unchanged. The value of parameter :01 does not change. The internal voltage reference value changes. The value of parameter :70 is stored in computer memory but not in non-volatile memory. This feature allows the remote control device to repeatedly send a new reference voltage value to parameter :70 without risk of wearing out the non-volatile memory storage device. The value of parameter :70 will default to 100 (zero offset) on each re-application of +24 VDC power to “B+” and “B-”. It will also reset to 100 (no offset) upon generator shutdown (defined as zero frequency). When the generator is restarted, it will remain at 100 (no offset) until modified from the serial communications link. See System Operation, “Remote Communications”. This parameter was added on regulator part numbers 155-xxxx and newer.

If a remote voltage adjust rheostat is present, it will work in conjunction with the value of parameter :70. The position of the remote voltage adjust rheostat is internally converted to a percentage offset similar to that described above. The percentage offset from the rheostat is added to the percentage offset from parameter :70 to create a combined offset. The net result will be limited to a maximum total deviation of ±10% from the setting of parameter :01.

Parameter :71 – PF/KVAR Adjust (optional feature). This parameter is available only through the serial communications port. It is designed to allow a remote control device (PLC) to provide the regulation reference for control of power factor (PF) or KVARs when that operating mode is active. The reference value (PF or KVAR) to be modified is determined by parameter :31. The actual reference to be modified can be from either parameter :32 (PF) or :33 (KVARs), or from the remote PF/KVAR adjust rheostat, if provided. Note, however, when parameter :31 is configured for PF operation and the PF switch point (parameter :38) has not been reached, no remote adjustment of the KVAR level is possible. Remote adjustment is only possible when the PF switch point (parameter :38) has been reached. See the description of KVAR/PF operation for further clarification. This parameter was added on regulator part numbers 155-xxxx and newer.

The numeric value range of parameter :71 is 0 - 200. It will act as a ± offset to the value of the selected reference as calculated in the following manner.

- In the KVAR mode (parameter :31 set to 1), the offset is calculated as:

KVAR Offset = (Parameter :71)/100 - 1.

This offset is combined with the existing KVAR reference using signed addition, then limited so that the resulting effective reference will be between 0 (zero) and 1.0 (maximum rated KVARs). Refer to the explanation of parameter :33. A numeric value of parameter :71 larger than 100 will therefore cause an increase in lagging KVARs. A value less than 100 will reduce lagging KVARs. A value of 100 will cause no offset change. The range of parameter :71 is such that the serial communications control device can adjust the KVARs over the entire operating range, regardless of the setting of parameter :33 or the remote PF/KVAR adjust rheostat (if one is present).

- In the PF mode (Parameter :31 set to zero), the offset is calculated as:

PF Offset = 0.4 x (1 - (Parameter :71)/100)

This offset is combined with the existing PF reference using signed addition, then limited so that the resulting effective reference will be between 0.6 (minimum lagging PF) and 1.1 (maximum PF, 0.9 leading). Refer to the explanation of parameter :32. A numeric value of parameter :71 less than 100 will therefore increase the PF, making it less lagging (more leading). A value greater than 100 will reduce it (more lagging). A value of 100 will cause no offset change. The range of parameter :71 is such that the serial communications control device can adjust the PF over the entire operating range only if parameter :32 or the remote PF/KVAR adjust rheostat (if one is present) is set for a PF of or between 0.7 and 1.0. Adjustment of PF is still possible when parameter :32 is set outside 0.7 to 1.0 but the full range is not available.

The value of parameter :71 is stored in computer memory but not in non-volatile memory. This allows the remote control device to repeatedly send a new reference PF/KVAR value to parameter :71 without risk of wearing out the non-volatile memory storage device. Parameter :71 will default to 100 (zero offset) on each re-application of +24 VDC power to “B+” and “B-”. It will also reset to 100 (no offset) upon generator shutdown (defined as zero frequency). When the generator is restarted, it will remain at 100 (no offset) until modified from the serial communications link.

If the generator installation is intended to be monitored and controlled by a programmable logic controller (PLC) using serial communications to parameter :71, it is recommended that parameter :32 (PF) or :33 (KVAR) (whichever is intended to be remotely controlled) be consistently set to 1.0 PF or 0.0 KVARs, and that a manual PF/KVAR remote adjust rheostat not be connected. If a manual remote adjustment rheostat is required, it should be disconnected with a control relay when the PLC serial communications control is active so that the known numeric value stored in parameter :32 or :33 is used for the offset calculation. The remote PLC will then have a consistent numeric means to control the PF or KVARs regardless of the position of the rheostat. The exact expressions that the PLC would need to calculate are listed below.

- Parameter :71 $_{KVAR}$ = 100 x (1 + Desired_PU_KVARs - Parameter :33)

- Parameter :71 $_{PF}$ = 100 x (1- (Desired_PF - Parameter :32) / 0.4)

If the above recommendations are followed (Parameter :33 = 0.0, Parameter :32 = 1.0, no remote rheostat), values between 100 to 200 will set KVARs from 0 to 1.0 per unit and values between 200 to 75 will set the effective PF reference from 0.6 to 1.1.

Parameter :90 – Password. The Password function operates as a lockout to help prevent accidental modification of other parameter settings. When parameter :90 is set to “0009”, no other parameters can be modified from the keypad or serial communication link (including parameters :70 and :71). When parameter :90 is set to any other value, all configurable parameters may be modified from either the keypad or serial communications link.

Parameter :91 – Software ID (PROM ID) (view only). Software ID (PROM ID) (view only). This parameter is the number or version of the software within the digital voltage regulator, used for a factory guided reference.

Parameter :92 – Latest Fault. This parameter contains the fault code of the most recently declared, or current, fault that has occurred after the last fault was reset. It may contain either alarm or shutdown faults. If a shutdown fault is active (has not been reset) and an additional fault occurs, the additional fault will be ignored. However, if an alarm is active (has not been reset) and an additional shutdown fault occurs, the alarm code will be moved into the Previous Fault location (parameter :93) and the new shutdown fault will be stored in the Latest Fault location (parameter :92). When no active fault is present (any previous fault has been reset) and parameter :94 is activated, the value of parameter :92 is moved to :93 while leaving zero in :92. The fault code is retained during power-down and power-up of the digital voltage regulator. For earlier digital voltage regulators, see System Operation, “Parameters”, the topic Parameter Exceptions.

Parameter :93 – Previous Fault. This parameter contains the fault code for the previous fault (both alarm and shutdown faults) that was stored in parameter :92. There is an exception. This parameter may contain an active alarm if an active alarm was present in parameter :92 and a shutdown fault occurred. When the parameter :92 is cleared using the fault clear function (parameter :94), or a new fault is declared, the fault code stored in parameter :92 is moved to this location (parameter :93), and any previous fault code stored in this location will be lost. The fault code is retained during power-down and power-up of the digital voltage regulator. For earlier digital voltage regulators, see System Operation, “Parameters”, the topic Parameter Exceptions.

Parameter :94 – Fault Clear. This parameter acts like a switch to clear fault codes from the latest fault (parameter :92) and the previous fault (parameter :93) locations. In order to activate this function, select parameter :94 on the display and press the function key. Each time the fault clear function is used, the display will flash three times, the fault code stored in parameter :92 is moved to parameter :93, and the display returns to parameter :01. If there is a fault code in the previous fault location (parameter :93), it will be lost since the value from the latest shutdown fault will now occupy that location. The fault codes stored in parameters :92 and :93 cannot be cleared until the active fault has been reset. For earlier digital voltage regulators, see System Operation, “Parameters”, the topic Parameter Exceptions.

Parameter :95 – Alarm Fault. Parameter :95 is not used. For earlier digital voltage regulators, see System Operation, “Parameters”, the topic Parameter Exceptions.

Parameter :96 – Shutdown Fault Reset. This parameter acts like a switch to reset an active fault. Resetting an active fault will allow the digital voltage regulator to begin regulation again and stop the display from flashing the fault code. In order to activate this function, select parameter :96 on the display and press the function key. The display will flash three more times and then return parameter :01. Note, that if there is no active fault, the display will flash three times and remain at parameter :96. This parameter applies to all alarm and resettable shutdown faults, fault codes 6xx and 7xx. In order to reset non-resettable shutdown faults (800 level), power-down the digital voltage regulator (remove 24 VDC from “B+/B-” inputs). Resetting an active fault does not affect the contents of parameters :92 and :93. Active resettable shutdown faults may also be reset using the Fault Reset input terminal, see System Operation, “Customer Options”. For earlier digital voltage regulators, see System Operation, “Parameters”, the topic Parameter Exceptions.

NOTICE

When a shutdown fault code is reset, the digital voltage regulator will begin operation again. If the generator is being driven, it will begin to regulate according to engine /generator speed and the regulation mode selected.

Parameter Exceptions For Earlier Digital Voltage Regulators

The chart lists the serial number break between the earlier and the current fault parameters. All digital voltage regulator part numbers starting with 116 (116-xxxx) and some of the regulator part numbers starting with 130 (130-xxxx) use the earlier fault parameters. The current fault parameters will be implemented on all versions of the digital voltage regulator built after March 1996. Another method to determine if a digital voltage regulator uses the current fault parameters is to check the PROM ID (parameter :91). A value of 1.03 or greater indicates use of the current alarm/fault parameters.

Note: Alarm and fault troubleshooting is discussed in Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulators”.

Table 6

Earlier Fault Parameter Serial Number Break	
Digital Voltage Regulator Part Number	**Earlier Fault Parameter Serial Number**
130-3471	LBNBA1-0123
130-3472	LBNBB1-0301
130-3473	LBNBC1-0176
130-3474	LBNBD1-0190
130-3475	LBNBE1-0392
130-3476	LBNBF1-0238

Parameter :92 – Latest Fault. This parameter contains the fault code of the shutdown fault that first occurred since this parameter was reset. If any additional shutdown faults occur, they are not recorded until the existing fault is reset. The fault code is retained during power-down and power-up of the digital voltage regulator. When a shutdown fault occurs, the corresponding fault code is automatically flashed on the display. Any information shown on the display flashes until the shutdown fault reset parameter :96 is activated. When no fault is present and parameter :92 is cleared, the value of parameter :92 is zero.

Parameter :93 – Previous Fault. This parameter contains the fault code for the last shutdown fault that was reset and cleared. When an active shutdown fault (parameter :92) is reset and cleared, the fault code is moved to this location (parameter :93). The fault code is retained during power-down and power-up of the digital voltage regulator. An active shutdown fault is reset using the fault reset switch or the parameter :96. It is cleared and moved into parameter :93 using the fault clear parameter :94.

Parameter :94 – Fault Clear. This parameter acts like a switch to clear fault codes from the latest fault parameter :92 and the alarm fault parameter :95. Each time the fault clear function is used, the alarm fault parameter :95 is cleared to zero and the value in the latest fault parameter :92 is moved to the previous fault parameter :93. If there is a fault code in the previous fault parameter :93, it will be lost since the value from the latest fault will now occupy that location. Clearing a fault code also stops the display from flashing. Clearing DOES NOT RESET shutdown faults. Before clearing an alarm/fault, check parameters :92 and :95 to see if an active fault is present, as this may aid in troubleshooting. To clear a fault code, select parameter :94 on the display and press the function key.

Parameter :95 – Alarm Fault. This parameter contains the fault code of the first alarm fault that occurred since this parameter was cleared. If any additional alarm faults occur, they are not recorded until the existing alarm fault is cleared. The code is retained during power-down and power-up of the digital voltage regulator. When an alarm fault occurs, the corresponding fault code is automatically flashed on the display. The alarm code information shown on the display flashes until the fault clear parameter :94 is activated. When no alarm fault is present, parameter :95 is zero. The regulator will continue to operate when an active alarm fault exists.

Parameter :96 – Shutdown Fault Reset. This parameter acts like a switch to reset a shutdown fault so that the digital voltage regulator can begin operation again. This parameter only applies to resettable shutdown faults. In order to reset non-resettable shutdown faults, power-down the digital voltage regulator by removing 24 VDC from “B+/B-” inputs. When a shutdown fault code is reset, the digital voltage regulator is able to begin operation again. Resetting a fault code also stops the display from flashing. Resetting does nothing to the latest fault parameter :92) or the alarm fault parameter :95). In order to reset a resettable shutdown fault code, select parameter :96 on the display and press the function key. Parameter :96 performs the same function as the external fault reset switch. See the Customer Options diagram in Testing And Adjusting, “Wiring Diagrams”.

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Fault Classifications

SMCS Code: 4467

There is a degree of severity that is attached to every fault. There are four classes of faults which the digital voltage regulator will annunciate.

- Alarm Fault
- Resettable Shutdown Fault
- Non-Resettable Shutdown Fault
- Severe Fault

Alarm Fault

Alarm faults indicate a condition that will not inhibit the function of the digital voltage regulator and the generator set. Alarm faults have fault codes in the 600's range. A condition such as a partial internal memory failure is an alarm fault. The generator set continues to operate at a normal level. When an alarm fault occurs, the fault code will flash on the display of the digital voltage regulator. Pressing the function key toggles the display to show the parameter for the latest fault. The user can then investigate the various parameters of the digital voltage regulator through the keypad and display. All information that is shown on the display will be flashing. Alarm faults must be reset before another alarm fault can be declared. However, a successive shutdown fault will override an alarm fault, and move the alarm fault code to the previous fault location. In order to clear an alarm fault, see System Operation, "Parameters".

Resettable Shutdown Fault

Resettable shutdown faults indicate a condition where the digital voltage regulator or the generator set exhibit a degradation of power generation performance. Resettable shutdown faults have fault codes in the 700's range. Conditions such as undervoltage and overvoltage are resettable shutdown faults. The generator set continues to operate, but at a reduced level too low to sustain load (excitation voltage of 3.0 VDC or less at F1 and F2). When a resettable shutdown fault occurs, the fault code will flash on the display of the digital voltage regulator. Pressing the function key toggles the display to show ":92", the parameter for the latest faults. The user can then investigate the various parameters of the digital voltage regulator through the keypad and display. All information that is shown on the display will be flashing. In order to reset a resettable shutdown fault, activate parameter :96 or the fault reset switch. See System Operation, "Customer Options". After the fault is reset, the display will stop flashing and return to parameter :01, but parameter :92 will still contain the fault code. The digital voltage regulator will immediately begin to regulate voltage again. In order to clear the fault code, use parameter :94.

Non-Resettable Shutdown Fault

Non-Resettable shutdown faults indicate a condition where the digital voltage regulator cannot be safely run. Non-resettable shutdown faults have fault codes in the 800's range. Conditions such as sensing loss and frequency loss are non-resettable shutdown faults. The generator set continues to operate, but at a reduced level too low to sustain load (excitation voltage of 3.0 VDC or less at F1 and F2). When a non-resettable shutdown fault occurs, the fault code will flash on the display of the digital voltage regulator. Pressing the function key toggles the display to show ":92", the parameter for the latest faults. The user can then investigate the various parameters of the digital voltage regulator through the keypad and display. All information that is shown on the display will be flashing. In order to reset a non-resettable shutdown fault, remove power from the digital voltage regulator (remove 24 VDC from "B+"/"B-" inputs).

Severe Fault

Severe faults indicate the existence of a condition which would be dangerous if not harmful to run the digital voltage regulator. Severe faults have fault codes in the 900's range. An example of a severe fault is fault code 901 which indicates that the internal memory of the digital voltage regulator is not functioning properly. The memory contains parameter data that is read each time the digital voltage regulator is powered-up (24 VDC applied to "B+"/"B-" inputs). The parameters configure the digital voltage regulator to the specific generator set. When a severe fault occurs, the fault code will flash on the display of the digital voltage regulator. Also, the keypad will be disabled (the keys will have no effect on the digital voltage regulator and the external shutdown fault reset will have no effect on the digital voltage regulator). A severe fault cannot be reset. These faults occur at power-up or when writing a new value to EEPROM memory. Severe faults cause the digital voltage regulator to prohibit power generation. The digital voltage regulator must be replaced.

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Fault Codes

SMCS Code: 4467

Table 7

Active Shutdown Faults (Parameter :92)		
Fault Code	**Description**	**Classification**(1)
0000	No Fault Present	-
701	Undervoltage	Resettable Shutdown Fault
702	Overvoltage	Resettable Shutdown Fault
703	Overexcitation	Resettable Shutdown Fault
704	Reverse VAR(2)	Resettable Shutdown Fault
705	Reverse Power	Resettable Shutdown Fault
801	Instantaneous Trip	Non-Resettable Shutdown Fault
802	Loss Of Sensing	Non-Resettable Shutdown Fault
803	Loss Of Frequency	Non-Resettable Shutdown Fault

(1) Resettable shutdown faults are reset by selecting parameter :96 (shutdown fault reset) on the display and pressing the function key or with the fault reset switch (external attachment) or through J1 connector. Non-resettable shutdown faults are reset by powering down the digital voltage regulator (removing 24 VDC).

(2) The digital voltage regulator looks for 0.4 and greater leading power factor for shutdown.

Table 8

Alarm Faults (Parameter :95)		
Fault Code	**Description**	**Classification**(1)
0000	No Fault Present	-
601	Internal Memory Failure	Alarm Fault
602	Internal Watchdog Failure	Alarm Fault
603	Rotating Diode Fault	Alarm Fault
604	Reverse VAR(2)(3)	Alarm Fault

(1) Alarm faults are cleared by selecting parameter :94 (fault clear) on the display and pressing the function key.

(2) The digital voltage regulator looks for 0.4 and greater leading power factor for shutdown.

(3) Available only on part numbers 155-xxxx and newer.

Each fault is assigned a unique three digit code that is called the fault code. Fault codes are the values of parameter :92. Parameter :92 shows the latest fault.

Note: An additional fault (fault code 901) exists. Fault code 901 indicates a significant failure of the internal memory that stores current parameter data. This fault can only occur at power-up and when making changes to configurable parameter values. This is a shutdown fault, and the digital voltage regulator will prohibit power generation. Fault code 901 is classified as a severe fault. This fault code can not be reset. Therefore, the digital voltage regulator must be replaced.

Note: Parameter :95 only appears on the earlier digital voltage regulator. Parameter :95 shows an alarm fault. See System Operation, “Parameters” in order to determine the serial number break.

A fault is a condition that does not conform (an abnormal condition) to the rules (program) by which the digital voltage regulator operates. Some examples of a fault are listed below.

Undervoltage – Generator voltage is less than specified for too long a time.

Overexcitation – The measured field current is too high for too long a time.

When a fault occurs, the digital voltage regulator automatically flashes the corresponding fault code on the display and takes the necessary preventive action. For shutdown faults, the digital voltage regulator disables the output to the exciter. While a fault is present, the fault code information shown on the display will be flashing. If a shutdown fault occurs, the shutdown fault MUST BE RESET in order for the digital voltage regulator to begin operation again. The method to reset a shutdown fault depends upon the classification of the fault. When a fault code is reset, the display will stop flashing. The digital voltage regulator will begin generator output regulation again, according to generator/engine speed and the mode selected. For more information, see System Operation, “Fault Classifications”.

Fault code 601 – Internal Memory Failure. This fault is an alarm fault. The EEPROM failed during a read action.

Note: Reset the fault. Clear the fault. If the alarm reoccurs, check all parameter values between 1 and 38 by using the function keys on the face of the digital voltage regulator or remote communications. This refreshes the programmed values and should eliminate the alarm condition. If the alarm persists, verify that proper grounding, shielding, and electromagnetic noise reduction practices have been followed in the installation before replacing the digital voltage regulator.

Fault code 602 – Internal Watchdog Failure. This fault is an alarm fault. A microprocessor watchdog is intended to detect when the microprocessor gets "lost" and to restart the microprocessor again. The watchdog alarm indicates that the digital voltage regulator just came out of a watchdog-induced microprocessor restart.

Note: A possible cause is electro magnetic interference (EMI). It may be necessary to provide shielded cable, grounded on one end, for all potentiometers. Another possible cause is the battery voltage being too low (less than 18 VDC). See watchdog alarm, fault code 602. Refer to Testing And Adjusting, “Watchdog Alarm - Troubleshoot”.

Fault code 603 – Rotating Diode. Check the diodes as per the generator service manual. This fault is a resettable shutdown fault. The digital voltage regulator detects that the variation (ripple) of exciter field current exceeds the diode monitor trip point (parameter :19) for a period of five seconds. A large variation in the exciter field current will occur if a rotating diode fails, shorted or open. This may also occur with good diodes under varying loads if the diode monitor trip point is set too low (too sensitive).

Note: For troubleshooting purposes it is useful to know that this alarm fault is often followed by an overexcitation shutdown fault. If an overexcitation shutdown fault (fault code 703) is found in parameter :92, check parameter :93 (or the alarm parameter :95 if it exists) for the presence of the rotating diode monitor alarm code.

Fault code 604 – Reverse VAR (only available on 155-xxxx and later regulators). This fault is an alarm fault. The fault code 604 will occur when the digital voltage regulator detects 0.4 Per Unit or greater leading reactive power for a time greater than the value entered in reverse VAR trip time (parameter :20). This fault is only active if parameter :21 is set to 1, which means that reverse VAR fault selection is set to an alarm. The fault code 604 will not be active if parameter :22 is set to 1, which means that droop/CCC select is set to CCC.

Note: A current measuring CT must be present for this feature to operate. Possible causes for erroneous 604 codes are incorrect CT/PT polarity or large circulating currents due to incorrect voltage droop adjustment. See Testing And Adjusting, “Reverse VAR Shutdowns - Troubleshoot”.

Fault code 701 – Undervoltage. This fault is a resettable shutdown fault. The digital voltage regulator detected that the generator voltage has been less than the undervoltage trip point (parameter :13) for the amount of time specified by the undervoltage trip time (parameter :14). This fault is disabled when the excitation disable switch at terminal 42 has been enabled and when the digital voltage regulator is in the startup profile. Refer to System Operation, “Customer Options”. See also System Operation, “Startup Profile Function”.

Note: This fault may be caused by a decline in utility voltage or incorrect parameter settings. Check parameters :01, :02, :06, :13, and :30. This fault also may be caused by the remote voltage adjust potentiometer setting being too low.

Fault code 702 – Overvoltage. This fault is a resettable shutdown fault. The digital voltage regulator detected that the generator voltage has been greater than the overvoltage trip point (parameter :11) for the amount of time specified by the overvoltage trip time (parameter :12).

Note: This fault may be caused by an increasing utility voltage or incorrect parameter settings. Check parameters :01, :02, :09, :11, and :15. This fault may also be caused by the remote voltage adjust potentiometer setting being too high.

Fault code 703 – Overexcitation. This fault is a resettable shutdown fault. The digital voltage regulator has measured that the exciter field current has been at a high current level for too long a time. If field current is not removed, high current may cause permanent overheating damage to the regulator, generator, or wiring. When exciter field current is greater than 12 amps, the digital voltage regulator will shut off the exciter field current and declare a fault after a timeout determined by the excitation current level.

This shutdown will occur between 14 and 120 seconds after the detection of a sustained overcurrent in the field circuit, depending on the level of overexcitation.

Note: Possible causes are the loss of all three phases of sensing, failed diodes, short in exciter stator or rotor, short in the main rotor, or a downstream line/load fault.

Fault code 704 – Reverse VAR. This fault is a resettable shutdown fault. A Reverse VAR fault code will occur when the digital voltage regulator detects 0.4 Per Unit or greater leading reactive power for greater than 0.5 seconds. For regulator part numbers of 155-xxxx and newer, 0.4 Per Unit or greater leading reactive power must be detected for a time longer that the reverse VAR trip time (parameter :20) to activate this fault. This fault will shutdown the digital voltage regulator and remove excitation to the field. The fault output driver can be used to activate the shunt trip of the generator circuit breaker to remove the generator set from the system to provide protection against a sustained reverse VAR condition. For regulators with part number 155-xxxx and newer, this fault is only active if parameter :21 is set to 2 (reverse VAR fault selection is set to shutdown) and will not be active if parameter :22 is set to 1 (droop/CCC select is set to CCC).

Note: A current measuring CT must be present for this feature to operate. Possible causes for erroneous 704 codes are incorrect CT/PT polarity or large circulating currents due to incorrect voltage droop adjustment. See Testing And Adjusting, “Reverse VAR Shutdowns - Troubleshoot”.

Fault code 705 – Reverse Power. This fault is a resettable shutdown fault. The digital voltage regulator detected that the generator real power output has been greater than the reverse power trip point (parameter :34) for the amount of time specified by the reverse power trip time (parameter :35). This fault only considers the real portion of the generator output. This shutdown fault is active only when the auxiliary contact (terminal 41) is closed in order to enable the PF/KVAR operating mode. There is an exception. On regulators with part number 155-xxxx and newer it is active in voltage regulation/droop and PF/KVAR operating modes but not active in cross current compensation mode (parameter :22 set to 1).

Note: Possible causes for erroneous 705 codes are incorrect CT/PT polarity, the engine/generator set shed (removed) load but the breaker did not shunt trip, or parameter :35 (reverse power trip time) was set too low for the loading scheme.

Fault code 801 – Instantaneous Trip. This fault is a non-resettable shutdown fault. The digital voltage regulator detects that the exciter field current is greater than approximately 28 amps. If this occurs, the digital voltage regulator instantaneously shuts off the exciter field current.

Note: Possible cause is a short in the exciter stator. This fault code can also be generated due to high levels of electromagnetic noise. The noise can be present on the wires or in the cabinet were the regulator is mounted. See Testing And Adjusting, “Instantaneous Trip Shutdown - Troubleshoot”.

Fault code 802 – Loss Of Sensing. This fault is a non-resettable shutdown fault. The digital voltage regulator detects that one of the sense inputs (terminals 20, 22, 24) has been open (disconnected) or shorted to another input.

Note: Possible causes are blown customer fuse or faulty wiring. A severe load imbalance may also cause this fault to occur. If the digital voltage regulator sees a 20% voltage unbalance between phases for 750 ms or longer, it will generate the loss of sensing shutdown fault.

Fault code 803 – Loss Of Frequency. This fault is a non-resettable shutdown fault. The digital voltage regulator detects that there is no AC frequency present for 200 msec while the measured voltage is greater than 50% of nominal. The frequency is measured from the PM inputs, NOT from the sensing inputs.

Note: Another possible cause is electro magnetic interference (EMI). It is necessary to provide shielded cable, grounded on one end, for all customer optional wiring. This fault may also be caused by a microprocessor restart after the digital voltage regulator has obtained rated voltage. See Testing And Adjusting, “Loss of Frequency Shutdown - Troubleshoot”.

Fault code 901 – Digital Voltage Regulator Memory Failure. This fault is a severe fault. The EEPROM device, within the digital voltage regulator, failed the power-up test and the digital voltage regulator will no longer function properly. The EEPROM stores the parameter values of all the program parameters. This fault can also occur after writing (storing) a new parameter value if the EEPROM device has just failed.

Note: The EEPROM will no longer accept new values. This means that the EEPROM is inoperable and the digital voltage regulator must be replaced.

i01041650

Remote Communication

SMCS Code: 4467

The digital voltage regulator has the capability to communicate with a remote personal computer or programmable logic controller. The J1 connector of the digital voltage regulator provides a RS422 port necessary for communication. The RS422 port is a 5-wire communication media including a wire pair for Receive, a wire pair for Transmit, and a common Signal Ground. For noise immunity, it is required that the wire pairs be twisted and shielded. The shield(s) should be grounded at the remote end of the cable only. The common signal ground is NOT a bonding ground and should not be grounded to the case or frame. It is to be connected to the RS422 device Signal Ground connection point. Cable length should be limited to 1000 meters maximum for the RS422 signal wiring.

An isolated, regulated power supply is also required for the remote communication port to operate. The digital voltage regulator is optically isolated from the communications port to ensure complete isolation of voltage levels. In order to maintain this isolation, power for the communications circuitry must be provided from outside the regulator. The supply may be from 8.55 VDC to 10.35 VDC where 9 VDC is considered nominal and should be able to source 100 mA of current. This voltage is measured at the voltage regulator. If the supply is provided in a remote location, ensure that the voltage present at the regulator is still above 8.55 VDC (preferably at 9 VDC or slightly above).

A windows program is available to communicate with the digital voltage regulator. The program is called DVRVIEW. For proper connection of the digital voltage regulator to the personal computer, see Testing And Adjusting, “Wiring Diagrams”, the illustration Remote Communications.

DVRVIEW allows the user to perform the following operations.

- Viewing and modifying the parameters in a windowed PC environment
- Sending a “recipe” of parameters to the digital voltage regulator
- Saving the existing digital voltage regulator settings to a recipe file

For the DVRVIEW supporting software and documentation, see Digital Voltage Regulator Software - 3.5" Disks, LERX5100. This reference includes a manual and a software. In order to obtain a copy of the manual only, order Digital Voltage Regulator Software - User Manual Only, LERX5662. The manual also contains the software protocol used to communicate with the digital voltage regulator. The protocol is very simple and can be implemented in switchgear or office equipment to provide customized communication with the digital voltage regulator.

An RS422 to RS232 (computer serial port) converter is available from the Caterpillar Parts Department. Use part number 131 - 7416 Converter Control. The converter comes with a regulated power supply and a wiring harness to connect the converter to the digital voltage regulator. A standard serial cable must be provided to connect the converter to a PC. If connecting to a modem, it may be necessary to use a null modem cable or adapter on the RS232 side of the converter. RS232 wiring should be limited to 15 m (50 ft).

i01041600

Customer Options

SMCS Code: 4467

Fault Shutdown Output Driver

The fault shutdown driver is intended to provide an external signal to operate a circuit breaker shunt trip and other alarm lights and/or horns in the event of a shutdown fault. The fault shutdown driver is normally pulled low (sinking up to 100 mA). When a fault occurs the output driver will open, allowing the output to go high, to +24 VDC.

Note: The output driver is “pull down” only. It will not source current when a fault occurs. Use input terminal 50 for a current source. Refer to the Customer Options illustration in Testing And Adjusting, “Wiring Diagrams”.

This method was chosen as a safety feature to protect against loss of battery voltage which will also cause the regulator to cease operation and, therefore, the generator voltage to collapse.

Alarm Output Driver

The alarm driver is intended to provide an external signal to operate alarm lights and/or horns in the event of an alarm fault condition. The alarm driver is normally pulled low (sinking up to 100 mA). When an alarm occurs, the output driver will open, allowing the output to go high, to +24 VDC.

Note: The output driver is “pull down” only. It will not source current when a fault occurs. Use input terminal 50 for a current source. Refer to the Customer Options illustration in Testing And Adjusting, “Wiring Diagrams”.

Note: The alarm output and fault shutdown output drivers may change state during engine cranking, indicating a false alarm or shutdown fault condition. If the “B+”/“B-” inputs to the digital voltage regulator are supplied from the engine cranking batteries, it is likely that insufficient voltage will be present during cranking. Therefore, during cranking the state of the fault shutdown output driver may change. The fault shutdown output driver should be ignored until the crank terminate speed has been reached.

Excitation Disable

The excitation disable switch is intended to provide a method of disabling the regulator field output (F1 and F2) in a manner which is safe for the regulator internal components. This feature is activated by shorting terminal 42 to terminal 50. Refer to the Customer Options illustration in Testing And Adjusting, “Wiring Diagrams”. Activation of the excitation disable switch will also disable the undervoltage shutdown fault.

NOTICE
The generator will always have residual voltage still remaining; therefore, it is important to stop the generator set if downstream maintenance is to be performed.

Fault Reset

The fault reset contact is provided as a method to reset a resettable shutdown fault through the use of an external switch. This operation is equivalent to using parameter :96 in the user interface. Operating the fault reset contact (momentarily shorting terminal 43 to terminal 50) will reset a resettable fault and allow the voltage to build again. However, on the "original" fault handling versions, the display will still show the flashing fault and the fault will remain in the active position in memory. On the "new" fault handling versions, the display will stop flashing, return to showing “:01”, and the fault will remain in the active fault parameter :92. The fault reset contacts should never be continuously shorted together. A momentary contact is all that is necessary to reset the fault.

Utility 52/a Contacts

The generator 52/a auxiliary contact is closed only when the generator breaker is closed. The utility 52/a auxiliary contact is closed only when the breaker which ties the generator to the utility is closed. When BOTH of these breakers are closed the generator is assumed to be operating in parallel to the utility grid. This will activate (enable) the PF/KVAR mode when connected as shown in the wiring diagrams for this manual. It will also enable the reverse power fault if it is not already enabled. See description of parameter :34 in Systems Operation, “Parameters”. See also descriptions of fault codes 604, 704, and 705 in Systems Operation, “Fault Codes”.

Remote Voltage Adjust Rheostat

The remote voltage adjust rheostat inputs are provided to allow the use of a 10 kOhm rheostat to remotely adjust the regulated voltage level. Increasing the resistance at the input causes the voltage to increase from the level configured in parameter :01. Turning the remote voltage adjust rheostat will not change the value displayed in parameter :01. However, it will modify an internal reference which will cause the generator output voltage to change in proportion to the rheostat movement. The range of the remote voltage rheostat adjustment is limited to a ±10% change in output voltage from the value set in parameter :01. When installing the remote voltage adjust rheostat, always use shielded cable. See parameter :70 for an explanation of using the voltage adjust rheostat in conjunction with the serial communications control.

Remote PF/KVAR Adjust Rheostat

The remote PF/KVAR adjust rheostat inputs are provided to allow the use of a 10 kOhm rheostat to remotely adjust the regulated PF or KVAR level. Connecting a rheostat to this input causes the local values which are programmed in parameters :32 and :33 to become inactive. See description for parameters :32 and :33 for detailed explanation. Varying the remote PF/KVAR rheostat will not change the values displayed in parameters :32 and :33. However, it replaces the internal reference which controls PF or KVAR regulation depending on which mode is selected in parameter :31. Increasing the resistance when in power factor mode causes the power factor to become more lagging, with a range of 0.9 power factor leading to 0.6 power factor lagging. Increasing the resistance when in KVAR mode causes the lagging KVAR reference to increase, with a range of 0.0 to 1.0 Per Unit. When installing the remote PF/KVAR adjust rheostat, always use shielded cable. See parameter :71 for an explanation of using the PF/KVAR adjust rheostat in conjunction with serial communications control.

Application Note

Remote voltage adjust and PF/KVAR adjust rheostats should be installed with shielded cable. The shield drain wire should be connected to terminal 45 of the digital voltage regulator and be insulated from all other circuits, including Earth ground.

Communication Port Voltage Adjust

Beginning with part number 155-xxxx regulators, a convenient voltage adjust method is available via the communications port. The voltage adjust parameter is available as parameter :70 but cannot be seen from the display on the digital voltage regulator. This parameter allows ±10% voltage adjustment around the nominal value of voltage entered in parameter :01. Further details on the operation of this parameter are discussed in the System Operation, “Parameters”. Refer to parameter :70, voltage adjust. Writing a value to this parameter location will NOT cause a write to the EEPROM and will not be saved during a loss of power. This parameter was added to aid in wire reduction so that automatic voltage adjustments can be made by customer supplied equipment for voltage matching during synchronizing by utilizing a communications interface already present.

Communication Port PF/KVAR Adjust

Beginning with part number 155-xxxx regulators, a convenient PF and KVAR adjust method is available via the communications port on the optional PF/KVAR models only. The adjustment parameter is available as parameter :71. The adjustment parameter cannot be seen from the display on the digital voltage regulator. This parameter allows full range of PF or KVAR adjustment depending on which mode is active (via parameter :31 selection). Further details on the operation of this parameter are discussed in System Operation, “Parameters”. Refer to parameter :71, PF/KVAR adjust. Writing a value to this parameter location will NOT cause a write to the EEPROM and will not be saved during a loss of power. This parameter was added to aid in wire reduction so that automatic adjustments can be made by customer supplied equipment for PF or KVAR correction by utilizing a communications interface already present. Adjustments made to this parameter will not be effective unless the regulator is operating in the PF/KVAR control mode with terminal 41 closed.

Remote Installation Notes

When the digital voltage regulator is remotely installed from the generator, special care should be given in the installation process to ensure proper engineering procedures are followed to prevent electromagnetic noise from reducing the performance of the regulator. While the digital voltage regulator has been designed to meet the 89/336/EEC Electromagnetic Compatibility Directive, poor wiring practices can generate electromagnetic noise levels much greater than the levels the regulator was designed to accomodate. When remote mounting the regulator, the sensing wires, PMG wires, and F1 and F2 exciter field wires should each be routed in their own separate tray or conduit. The optional customer wiring should be separated from all other signals in a control wiring conduit only. The voltage sensing wires attached to terminals 20, 22, and 24 should be twisted together. The F1 and F2 exciter field wires should also be twisted together. The droop current transformer burden resistor, R1, should be mounted within 3 m (10 ft) of the regulator. If this is not possible, use two burden resistors, each with twice the nominal resistance of R1, and locate one at the regulator and one at the droop current transformer.

Manual Voltage Control

An optional manual voltage control may be used to provide a backup method for controlling the generator output voltage in case of failure of the digital voltage regulator. This device will manually adjust the output voltage by controlling the current flow to the exciter stator (L1). The manual voltage control has a mode selector switch and a voltage adjust dial. The selector switch can be set to MAN, OFF, or AUTO. When the switch is in the MAN position, the generator output voltage is controlled by the manual control by varying the amount of current to the exciter stator via the voltage adjust dial. When the switch is in the OFF position, no current will flow to the exciter stator and the generator output voltage will be zero. In the AUTO position, the manual voltage control will be bypassed, and the generator output voltage will be controlled by the digital voltage regulator.

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

Note: When the manual voltage control is operating in the “MAN” mode, it is not necessary for the digital voltage regulator to be connected to the generator. If the digital voltage regulator remains installed and powered on during manual control, it will annunciate the loss of frequency fault (fault code 803) since the PM input is disconnected and the regulator will no longer be able to sense the frequency.

Testing and Adjusting Section

Testing and Adjusting

i01041639

General Information

SMCS Code: 4467

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.

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

When servicing or repairing electric power generation equipment:

- **Make sure the unit is either locked out or tagged 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.**
- **Make sure residual voltage in the rotor, stator and the generator is discharged.**

Failure to do so could result in personal injury or death.

i01041654

Service Tools

SMCS Code: 0785

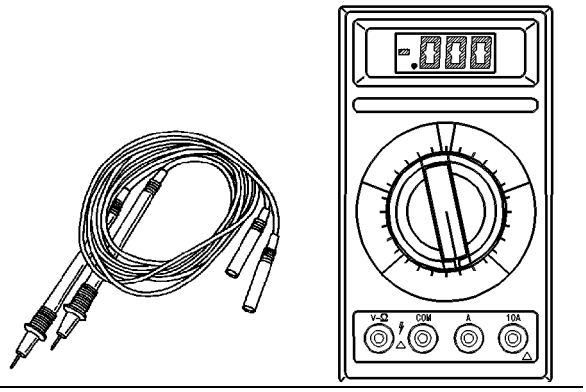


Illustration 10 g00241203

6V-7070 Caterpillar Digital Multimeter

Caterpillar Digital Multimeters can be used to measure voltage, resistance or current up to 10 amperes. Rectifiers can also be checked by using the diode function. See Special Instruction, SEHS7734, “Use Of The 6V-7070 And 6V-7800 Multimeter” for the correct operation of the 6V-7070 Digital Multimeter.

g00538441

Illustration 11

8T-0900 AC/DC Clamp-On Ammeter

The 8T-0900 Ammeter may be used to measure current up to 1200 amperes. When you are measuring line current on multiple lead units, measure the current in each conductor per phase and add the currents together. See Special Instruction, SEHS8420, “Using the 8T900 AC/DC Clamp-On Ammeter 0651” for the correct operation of the 8T-0900 Ammeter.

i01041658

Startup Procedure

SMCS Code: 4467

1. Connect the digital voltage regulator. Refer to Testing And Adjusting, “Wiring Diagrams” for a proper illustration. Take care to follow notes and observe polarities.

2. Apply battery power only to the digital voltage regulator. Verify that all of the parameters are properly adjusted for the application.

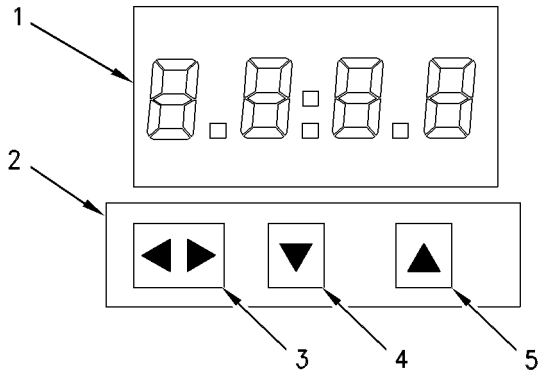
3. Start the engine. Make the final adjustments, as required.

4. Record all settings.

i01041642

Parameter Viewing and Configuring Procedure

SMCS Code: 4467-NQ



g00538863

Illustration 12

Display And Keypad

(1) Display

(2) Keypad

(3) Function key

(4) Scroll down key

(5) Scroll up key

Note: Before performing this procedure, study the list of parameters in order to determine the desired parameter code and the corresponding range of values. Refer to System Operation, “Parameters”. The value of some parameter codes is only for viewing by the user and may not be configurable.

Note: While performing this procedure, it will be convenient to have the entire list of parameters available. See System Operation, “Parameters”.

1. **Select the parameter code.**

   Press scroll up key (5) and scroll down key (4) until the desired parameter code is showing on display (1). Remember that parameter codes are always preceded by a colon.

2. **View the value of the parameter.**

   Press function key (3) to view the value of the chosen parameter code of Step 1. Remember that values are not preceded by a colon.

Note: The following Steps do not apply to parameter codes that are not configurable. Press function key (3) and the display will return to showing parameter codes as in Step 1.

3. **Select a new value.**

   Press scroll up key (5) or scroll down key (4) until the desired new value is showing on display (1).

4. **Configure a new value.**

   With the desired new value showing, press the function key (3). The new value is now entered into the memory of the digital voltage regulator. The display returns to showing parameter codes as in Step 1.

i01041634

Fault Handling

SMCS Code: 4467

Note: For earlier digital voltage regulators go to Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulators”.

Fault Identification

1. **Check the excitation.**

   a. Use a multimeter across the exciter field outputs F1 and F2. A multimeter should be set for VDC. Another way to verify that the regulator is providing excitation is by looking at parameter :55. Parameter :55 describes excitation current.

   Expected Result: The regulator is providing excitation to the generator.

   Results:

   - OK: Go to Step 2.
   - NOT OK: Go to Step 4.

2. **Check the status of the alarm.**

   a. Check the display on the digital voltage regulator.

   b. Check the status of the alarm output.

   Expected Result: The display on the digital voltage regulator is flashing or the alarm output is off. When alarm output is off, an alarm is active.

   Results:

   - OK: An alarm has occurred. The alarm is active. No new alarms will be detected until the fault has been reset. However, fault detection is still enabled. Go to Step 5.
   - NOT OK: Go to Step 3.

3. **Check the status of the latest fault.**

   a. Check if a new alarm has been logged in parameter :92. Parameter :92 describes the latest fault.

   Expected Result: A new alarm has been logged in parameter :92.

   Results:

   - OK: A fault or alarm has occurred and has been reset. Troubleshoot the problem using the code in parameter :92 and the service manual (or clear the alarm). Go to Testing And Adjusting, “Fault Handling”, section Fault Clearing.
   - NOT OK: No new alarm has occurred. STOP.

4. **Check the status of the fault.**

   a. Check the display on the digital voltage regulator.

   b. Check the status of the fault output.

   Expected Result: The display on the regulator is flashing or the fault output is off. When fault output is off, a fault is active.

   Results:

   - OK: A shutdown fault has occurred and is active. No new alarms/faults will be detected until this fault is reset. Go to Step 5.
   - NOT OK: Refer to Testing And Adjusting, “Troubleshooting”. STOP.

5. **Check the shutdown fault log.**

   a. Check the number logged in the shutdown fault log. The shutdown fault log is described by parameter :92. Check the flashing number on the display.

   Expected Result: The number starts with a 6 (6xx).

   Results:

   - OK: The number starts with a 6 (6xx). An alarm has occurred. This will not shut down the digital voltage regulator. The alarm is resettable without removing power by activating either parameter :96, the external fault reset switch contact, or by cycling the 24 VDC. Follow the troubleshooting procedures in the service manual for the alarm code shown in parameter :92. Continue the procedures until the alarm has been reset.

- NOT OK: The number does not start with a 6 (6xx). Go to Step 6.

6. Check the shutdown fault log (continued).

a. Check the number logged in the shutdown fault log. The shutdown fault log is described by parameter :92. Check the flashing number on the display.

Expected Result: The number starts with a 7 (7xx).

Results:

- OK: The number starts with a 7 (7xx). A resettable fault has occurred. This fault is resettable without removing power by activating either the shutdown fault reset parameter :96, the external fault reset switch, or by cycling the 24 VDC. Follow the troubleshooting procedures in the service manual for the fault code shown in parameter :92 and any possible active alarm shown in parameter :93. Note, that if the engine is running when the fault is reset, the digital voltage regulator will provide excitation to the generator. Continue the procedures until the fault has been reset.

- NOT OK: The number does not start with a 7 (7xx). Go to Step 7.

7. Check the shutdown fault log (continued).

a. Check the number logged in the shutdown fault log. The shutdown fault log is described by parameter :92. Check the flashing number on the display.

Expected Result: The number starts with an 8 (8xx).

Results:

- OK: The number starts with a 8 (8xx). A non-resettable fault has occurred which is resettable only after removing all power to the digital voltage regulator, troubleshooting and correcting the problem, and reapplying the power. Follow troubleshooting procedures in the service manual for the fault code shown in parameter :92 and any active alarm code in parameter :93. Hardware output driver(s) is/are reset, unit is operational, display returns to :01, and the fault is still logged in the latest fault log, parameter :92. If an active alarm was present when the fault was received, then it will be found in the previous fault log, parameter :93. The display stops flashing to indicate all alarms and faults are reset. New alarms/faults may be detected again. Go to Testing And Adjusting, “Fault Handling”, section Fault Clearing.

- NOT OK: A number is logged in shutdown fault log, parameter code :92 or is flashing in the display starting with a 9 (9xx). This indicates a severe fault has occurred and the unit must be replaced. STOP.

Fault Clearing

An alarm/fault has occurred and has been reset. The digital voltage regulator is fully operational, the alarm/fault is reset but not cleared. A 6xx, 7xx, or 8xx is logged in the fault log, parameter :92. If another alarm/fault is received, it will be logged in parameter :92 and the original contents of parameter :92 will be shifted to parameter :93.

In order to clear the alarm/faults, select parameter :94 on the display and press the function key. The regulator screen blanks briefly and returns to “:01”. Fault value in parameter :92 is moved to parameter :93 and parameter :92 is cleared to “0000”.

Note: If another alarm/fault has occurred, the new number will be logged in parameter :92. No change will occur to parameter :93. Return to Testing And Adjusting, “Fault Handling”, section Fault Identification, Step 1.

Note: In order to clear the previous fault (parameter :93), select parameter :94 on the display and pressing the function key. Parameter :93 is cleared to “0000”. Parameter :92 remains at 0000 and the display returns to “:01”. STOP.

i01041633

Fault Handling for Earlier Digital Voltage Regulators

SMCS Code: 4467

The chart lists the serial number break between the earlier fault parameters and current fault parameters. All digital voltage regulator part numbers starting with 116 (116-XXXX) and some of the regulator part numbers starting with 130 (130-XXXX) use the earlier alarm/fault handling procedures. The current fault parameters/procedure is implemented on all versions of the digital voltage regulator built after March 1996. Another method to determine if a digital voltage regulator uses the current alarm/fault handling procedures is to check the PROM ID (parameter :91). A value of 1.03 or greater indicates use of the current alarm/fault parameters/procedures.

Table 9

Earlier Fault Parameter Serial Number Break	
Regulator Part Number	**Earlier Fault Parameter Serial Number**
130-3471	LBNBA0001-0123
130-3472	LBNBB0001-0301
130-3473	LBNBC0001-0176
130-3474	LBNBD0001-0190
130-3475	LBNBE0001-0392
130-3476	LBNBF0001-0238
116-XXXX	All

Fault Identification (For Earlier Digital Voltage Regulator)

1. Check the excitation.

a. Use a multimeter across the exciter field outputs F1 and F2. A multimeter should be set for VDC. Another way to verify that the regulator is providing excitation to the generator is by looking at parameter :55. Parameter :55 describes excitation current.

Expected Result: The digital voltage regulator is providing the excitation to the generator.

Results:

- OK: Go to Step 2.
- NOT OK: Go to Step 4.

2. Check the status of the alarm.

a. Check the display on the digital voltage regulator.

b. Check the status of the alarm output.

Expected Result: The display on the regulator is flashing or the alarm output is off (open circuit). When alarm output is off, an alarm is active.

Results:

- OK: Go to Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulator”, section Alarm Clearing (For Earlier Digital Voltage Regulator).
- NOT OK: Go to Step 3.

3. Check the alarm fault log.

a. Check the status of the alarm fault log. The alarm fault log is described by parameter :95.

Expected Result: The alarm fault log shows “0000”.

Results:

- OK: The alarm fault log shows “0000”. No new alarm has occurred. STOP.
- NOT OK: Go to Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulator”, section Alarm Clearing (For Earlier Digital Voltage Regulator).

4. Check the status of the fault.

a. Check the display on the digital voltage regulator.

b. Check the status of the fault output.

Expected Result: The display on the regulator is flashing or the fault output is off (open circuit). When fault output is off, a fault is active.

Results:

- OK: A shutdown fault has occurred and is active. No new faults will be detected until active shutdown fault is reset. Go to Step 5.
- NOT OK: Go to Testing And Adjusting, “Troubleshooting”.

5. Check the shutdown fault log.

a. Check the number logged in the shutdown fault log. The shutdown fault log is described by parameter :92. Check the flashing number on the display.

Expected Result: The number starts with a 7 (7xx).

Results:

- OK: The number starts with a 7 (7xx). A resettable fault has occurred. It can be reset without removing power by activating either shutdown fault reset, parameter :96 or the external fault reset switch. The fault can also be reset by cycling the power to 24 VDC power inputs (“B+”/“B-”). Note, that if the engine is running when the fault is reset the digital voltage regulator will provide excitation to the generator when the fault is reset. Go to Step 6.

- NOT OK: Go to Step 7.

6. Check the status of the shutdown fault reset.

a. Select parameter :96 which describes shutdown fault reset. Depress the function key in order to reset the fault.

Expected Result: Shutdown fault reset has been activated.

Results:

- OK: Shutdown fault reset has been activated. The fault output driver is reset and the unit is operational. The display continues to flash and the fault is still logged in the shutdown fault log, parameter :92. A flashing display indicates a fault in the shutdown fault log, parameter :92. New faults may be detected again. Go to Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulator”, section Fault Clearing (For Earlier Digital Voltage Regulator).

- NOT OK: Shutdown fault reset has not been activated. Go to Step 5.

7. Check the shutdown fault log.

a. Check the number logged in the shutdown fault log. The shutdown fault log is described by parameter :92. Check the flashing number on the display.

Expected Result: The number starts with an 8 (8xx).

Results:

- OK: The number starts with an 8 (8xx). A non-resettable fault has occurred. This fault is resettable only after removing all power to the digital voltage regulator, troubleshooting and correcting the problem, and reapplying the power. Go to Testing And Adjusting, “Fault Handling For Earlier Digital Voltage Regulator”, section Fault Clearing (For Earlier Digital Voltage Regulator).

- NOT OK: The number logged in the shutdown fault log, parameter :92 or flashing on the display starts with a 9 (9xx). A severe fault has occurred. The unit must be replaced. STOP.

Alarm Clearing (For Earlier Digital Voltage Regulator)

An alarm has occurred but the digital voltage regulator is still operational. No new alarms will be recorded until the present alarm is cleared. A 6xx number is flashing on the display and logged in the alarm fault log, parameter :95. Troubleshoot per the specific alarm description in service manual.

Note: If power is removed with an active fault, upon power-up the display will stop flashing. However, the fault will remain in the alarm fault log, parameter :95.

If you want to reset and clear the alarm, clear the alarm/fault by selecting parameter :94 on the display and pressing the function key. The digital voltage regulator screen should blank briefly, stop flashing and return to parameter :94. The Alarm Fault Log in parameter :95 should be cleared to “0000” and the alarm driver output should be reset. This also affects the values in parameters :92 and :93.

Fault Clearing (For Earlier Digital Voltage Regulator)

A shutdown fault has occurred. A 7xx or 8xx number is flashing on the display. A 7xx or 8xx number is logged in the shutdown fault log, parameter :92. Troubleshoot per the specific fault description.

Note: If power is removed with an active fault, upon power-up the display will stop flashing. However, the fault will remain in the shutdown fault log, parameter :92.

Reset a 7xx fault by selecting parameter :96 and depress the function key to reset the fault. Reset an 8xx fault by removing all power to the digital voltage regulator, troubleshooting and correcting the problem, and reapplying the power.

After the fault has been reset, clear the alarm/fault by selecting parameter code :94 on the display and pressing the function key. The digital voltage regulator screen should blank briefly, stop flashing and return to parameter :94.

The alarm/fault log in parameter :95 should be cleared to “0000”. The fault value in parameter :92 is moved to parameter :93 and parameter :92 is cleared to “0000”.

Note: In order to clear previous fault (parameter :93), select parameter :94 on the display and press the function key. Parameter :93 is cleared to “0000”. Alarm log parameter :95 is also cleared to “0000” again.

i01041696

Troubleshooting

SMCS Code: 4467

Table 10

Common Troubleshooting Procedures[1][2]	
Problem	**Troubleshooting Procedure**
Reverse Power Shutdown	Check CT polarity. Check connections to the digital voltage regulator terminals 5 and 6.
No Voltage (50 ACV or Less)	Check for the fault codes. Correct the fault codes. Determine if DC voltage is properly connected (“B+”/“B-”). Check for loose sensing or PM wires. Check for blown PM fuses. Determine if underfrequency setpoint (parameter :10) is too high. Temporarily disconnect battery from the digital voltage regulator. Then, connect battery to the regulator. Restart the regulator. Check terminal 42. Battery voltage (24 VDC) should not be present. (Excitation disable circuit) Check rotating diodes on the generator.
Low Voltage (Residual to Less Than Rated Output Voltage)	Check for the fault codes. Correct the fault codes. Determine if generator output voltage setpoint (parameter :01) is set too low. Determine if droop setpoint (parameter :30) is set to zero. Droop setpoint should be 0. Check parameter :03 for correct generator type. Determine if parameter :06 is less than the expected generator operating frequency. Check parameter :02 for the correct PT ratio. Check that parameter :02 is not doubled. Check that one PM fuse is not blown. Check rotating diodes on the generator.
High Voltage (Voltage Higher Than Range Allows)	Check for the fault codes. Correct the fault codes. Check parameter :02 for the correct PT ratio. Check that parameter :02 is not too low. Check that parameter :15 (IR Compensation) is set to zero. Determine if the generator output voltage setpoint (parameter :01) is set too high. Determine if the minimum voltage setpoint (parameter :09) is set too high.
Unstable Voltage (Voltage Fluctuation Greater Than 0.25%)	Check for the fault codes. Correct the fault codes. Remove the remote voltage adjust rheostat. Disconnect droop current transformer. Check for loose wiring. Check rotating diodes on the generator.
Initial Voltage Overshoot	Check parameter :03 for correct generator type.

(1) A regulator may fail to perform correctly if it is not properly connected. A regulator may also fail if there is a failure of downstream equipment, such as diodes.

(2) It is possible to get an unexplained reverse VAR fault if the CT is connected backward. Check the CT connection if this fault occurs.

This section provides troubleshooting procedures for generator voltage problems that are related to the digital voltage regulator.

Note: Before starting to troubleshoot, check the part number to determine if the digital voltage regulator being used is proper for the application. The part number label on the digital voltage regulator indicates the sensing voltage range and whether or not the regulator is the optional KVAR/PF model. Refer to the following chart.

Table 11

Digital Voltage Regulator Application Chart				
Regulator Version	**Voltage Range**	**Early Part Number**	**Former Part Number**	**Current Part Number**
Basic	79 to 124 Volt 3 phase sensing	116-7480	130-3471	155-3831
Basic	125 to 249 Volt 3 phase sensing	116-7481	130-3472	155-3832
Basic	250 to 600 Volt 3 phase sensing	116-7482	130-3473	155-3833
KVAR/PF Optional Version	79 to 124 Volt 3 phase sensing	116-7483	130-3474	155-3834
KVAR/PF Optional Version	125 to 249 Volt 3 phase sensing	116-7484	130-3475	155-3835
KVAR/PF Optional Version	250 to 600 Volt 3 phase sensing	116-7485	130-3476	155-3836

i01041690

No Voltage - Troubleshoot

SMCS Code: 4467-035

1. **Check for the proper version of the regulator.**

   a. Check the part number of the digital voltage regulator. Refer to the chart in Testing And Adjusting, “Troubleshooting”. Check whether the digital voltage regulator is proper for the application.

   Expected Result: The digital voltage regulator is proper for the application.

   Results:

   - OK: Go to Step 2.
   - NOT OK: Install the proper digital voltage regulator. STOP.

2. **Check the status of the display.**

   a. Stop the generator set.

   b. Observe the display on the digital voltage regulator.

   Expected Result: The display should contain a number.

   Results:

   - OK: Proceed to Step 4.
   - NOT OK: No number is present on the display. Proceed to Step 3.

3. **Check the DC voltage.**

   a. Check for proper DC voltage from terminal “B+” to “B-”. The acceptable voltage range is 18 VDC to 32 VDC.

   Expected Result: The sufficient DC voltage is present.

   Results:

   - OK: The sufficient DC voltage is present. Remove the DC power wires from terminals “B+” and “B-” for 30 seconds. Reconnect the DC power wires to the “B+” and “B-” terminals. If the display of the regulator is still blank, the regulator is faulty. Then, the regulator needs to be replaced. If this condition has occured, verify that the correct burden resistor or the rheostat is connected between the droop current transformer and the regulator. If no resistor is present, the regulator was destroyed because of high current on the CT input. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.
   - NOT OK: The sufficient DC voltage is not present. Repair the supply voltage wiring, fuses and circuit breakers, if necessary. STOP.

4. **Verify the proper configuration of the parameters.**

   Parameters :10 or :13 must not be set too high.

   a. If the underfrequency point (parameter :10) is set too close to the nominal operating frequency, then the voltage may not build. Look for an undervoltage fault code. If the code is found, try the default value.

b. If the undervoltage trip point (parameter :13) is set too close to the nominal operating voltage, the voltage regulator may shutdown and report an undervoltage fault code. Try the default value.

c. Display the number in parameters :92, :93, and :95 (if present). A display of “0000” indicates no faults. If a fault code is present, see System Operation, “Parameters”.

Expected Result: The problem has been resolved.

Results:

- OK: The problem has been resolved. STOP.
- NOT OK: The problem has not been resolved. Proceed to Step 5.

5. Check the PM inputs.

a. Turn the engine off.

b. Check that all of the digital voltage regulator connections are tight and properly made per the appropriate wiring diagram.

c. Check PM fuses (connecting to terminals 26 and 30 of the digital voltage regulator).

d. Restart the engine.

e. Check the PM inputs (26, 28, and 30) of the digital voltage regulator. Measure the AC voltage between terminals 26 to 28, 28 to 30, and 26 to 30.

f. If the digital voltage regulator is connected as a self-excited regulator, check if the power transformers are properly wired as an open delta configuration for the according wiring diagrams. Check if the power transformers are properly sized in order to provide a minimum of 1200 VA each.

Expected Result: The proper voltage is approximately 95 VAC for 60 Hertz generator sets and 79 VAC for 50 Hertz generator sets. The voltage must be stable. Voltages up to 120 VAC, 60 HZ are acceptable.

Results:

- OK: The voltage is correct. Go to Step 6.
- NOT OK: The voltage is incorrect or unstable. PM stator or PM rotor is damaged. Troubleshoot the PM unit. Replace the faulty component. STOP.

6. Check the sensing inputs.

a. Check the sensing inputs between the digital voltage regulator terminals 20 to 22, 22 to 24, and 20 to 24.

Expected Result: All 3 readings should be balanced and with proper PT ratio to the output voltage.

Result:

- OK: All three readings are balanced. Go to Step 7.
- NOT OK: The readings are unbalanced. Check all connections to the regulator. Check all connections to the output terminals. Make sure that proper potential transformers are installed, if applicable. Check the neutral connection. Check for the correct phase rotation. STOP.

7. Check the generator set.

a. Turn the engine off.

b. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

c. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Proceed to Step 8.
- NOT OK: The generator set does not operate properly. Proceed to Step 9.

8. Check the accessory.

a. Reconnect one accessory. Operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found.

Expected Result: The problem has been resolved.

Results:

- OK: The problem has been resolved. STOP.
- NOT OK: The problem has not been resolved. Proceed to Step 9.

9. Check the exciter output voltage.

a. Start the generator set.

b. Measure the voltage from F1 to F2.

Expected Result: The proper voltage is from 6 to 14 VDC at no load.

Results:

The 3 possible results are listed below.

- The voltage is present for a short time, but trails off to or near zero. Shut the generator down. Megger the exciter stator and rotor. Check the rotating diodes.
- The voltage between F1 and F2 is near zero immediately after the generator set starts. Stop the generator set. Remove the wires F1 and F2 from the digital voltage regulator. Restart the generator set. Measure the voltage from F1 to F2 on the digital voltage regulator.
- The voltage between F1 and F2 is near zero immediately after the generator set starts and after Step 5 has been thoroughly completed. The digital voltage regulator is faulty. The digital voltage regulator needs to be replaced.

i01041688

Low Voltage - Troubleshoot

SMCS Code: 4467-035

1. Check for the proper version of the regulator.

a. Check the part number of the digital voltage regulator. Refer to the chart in Testing And Adjusting, “Troubleshooting”. Check whether the digital voltage regulator is proper for the application.

Expected Result: The digital voltage regulator is proper for the application.

Results:

- OK: Go to Step 2.
- NOT OK: Install the proper digital voltage regulator. STOP.

2. Check the status of the display.

a. Stop the generator set.

b. Observe the display on the digital voltage regulator.

Expected Result: The display should contain a number.

Results:

- OK: Proceed to Step 4.
- NOT OK: No number is present on the display. Proceed to Step 3.

3. Check the DC voltage.

a. Check for proper DC voltage from terminal “B+” to “B-”. The acceptable voltage range is 18 VDC to 32 VDC.

Expected Result: The sufficient DC voltage is present.

Results:

- OK: The sufficient DC voltage is present. Remove the DC power wires from terminals “B+” and “B-” for 30 seconds. Reconnect the DC power wires to the “B+” and “B-” terminals. If the regulator display is still blank, the regulator is faulty. Then, the regulator needs to be replaced. If this condition has occured, verify that the correct burden resistor or rheostat is connected between the droop current transformer and the regulator. If no resistor is present, the regulator was destroyed because of high current on the CT input. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.
- NOT OK: The sufficient DC voltage is not present. Repair the supply voltage wiring, fuses and circuit breakers as necessary. STOP.

4. Verify the proper configuration of the parameters.

Pay particular attention to parameters :01, :02, and :30.

a. If the rated voltage, parameter :01 is increased, the output voltage will increase.

b. If the sensing transformer ratio, parameter :02 is decreased, the output voltage will increase.

c. If the voltage droop, parameter :30 is increased, the output voltage will decrease as the generator output current increases. Try the default value.

d. If generator type is set incorrectly, the regulator may operate constantly in the under frequency curve. Check parameter :50 and compare actual frequency to verify.

e. If the current transformer is installed or wired incorrectly (reverse polarity) and voltage gain (parameter :15) is greater than zero, the output voltage will decrease as the generator output current increases. Reverse the wires on terminal 5 and terminal 6.

f. Display the number in parameters :92, :93, and :95 (if present). A display of “0000” indicates no faults. If a fault code is present, see System Operation, “Parameters”.

Expected Result: The problem has been resolved.

Results:

- OK: The problem has been resolved. STOP.
- NOT OK: The problem has not been resolved. Proceed to Step 5.

5. Check the PM inputs.

a. Turn the engine off.

b. Check that all of the digital voltage regulator connections are tight and properly made per the appropriate wiring diagram.

c. Check PM fuses (connecting to terminals 26 and 30 of the digital voltage regulator).

d. Restart the engine.

e. Check the PM inputs (26, 28, and 30) of the digital voltage regulator. Measure the AC voltage between terminals 26 to 28, 28 to 30, and 26 to 30.

f. If the digital voltage regulator is connected as a self-excited regulator, check if the power transformers are properly wired as an open delta configuration for the according wiring diagrams. Check if the power transformers are properly sized in order to provide a minimum of 1200 VA each.

Expected Result: The proper voltage is approximately 95 VAC for 60 Hertz generator sets and 79 VAC for 50 Hertz generator sets. The voltage must be stable. Voltages up to 120 VAC, 60 HZ are acceptable.

Results:

- OK: The voltage is correct. Go to Step 6.
- NOT OK: The voltage is incorrect or unstable. PM stator or PM rotor is damaged. Troubleshoot the PM unit. Replace the faulty component. STOP.

6. Check the sensing inputs.

a. Check the sensing inputs between the digital voltage regulator terminals 20 to 22, 22 to 24, and 20 to 24.

Expected Result: All 3 readings should be balanced and with proper PT ratio to the output voltage. The PT ratio should match parameter :02 in most cases.

Result:

- OK: All three readings are balanced. Go to Step 7.
- NOT OK: The readings are unbalanced. Check all connections to the regulator. Check all connections to the output terminals. Make sure that proper potential transformers are installed, if applicable. Check the neutral connection. Check for the correct phase rotation. STOP.

7. Check the generator set.

a. Turn the engine off.

b. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

c. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory. Operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.
- NOT OK: The generator set does not operate properly. The digital voltage regulator is faulty. The digital voltage regulator needs to be replaced.

i01041681

High Voltage - Troubleshoot

SMCS Code: 4467-035

1. **Check for the proper version of the regulator.**

   a. Check the part number of the digital voltage regulator. Refer to the chart in Testing And Adjusting, “Troubleshooting”. Check whether the digital voltage regulator is proper for the application.

   Expected Result: The digital voltage regulator is proper for the application.

   Results:

   - OK: Go to Step 2.
   - NOT OK: Install the proper digital voltage regulator. STOP.

2. **Check the status of the display.**

   a. Stop the generator set.

   b. Observe the display on the digital voltage regulator.

   Expected Result: The display should contain a number.

   Results:

   - OK: Proceed to Step 4.
   - NOT OK: No number is present on the display. Proceed to Step 3.

3. **Check the DC voltage.**

   a. Check for proper DC voltage from terminal “B+” to “B-”. The acceptable voltage range is 18 VDC to 32 VDC.

   Expected Result: The sufficient DC voltage is present.

   Results:

   - OK: The sufficient DC voltage is present. Remove the DC power wires from terminals “B+” and “B-” for 30 seconds. Reconnect the DC power wires to the “B+” and “B-” terminals. If the regulator display is still blank, the regulator is faulty. Then, the regulator needs to be replaced. If this condition has occured, verify that the correct burden resistor or rheostat is connected between the droop current transformer and the regulator. If no resistor is present, the regulator was destroyed because of high current on the CT input. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.
   - NOT OK: The sufficient DC voltage is not present. Repair the supply voltage wiring, fuses and circuit breakers as necessary. STOP.

4. **Verify the proper configuration of the parameters.**

   Pay particular attention to parameters :01, :02, and :15.

   a. If the rated voltage, parameter :01 is increased, the output voltage will increase.

   b. If the sensing transformer ratio, parameter :02 is increased, the output voltage will decrease.

   c. If the voltage gain (line loss compensation), parameter :15 is increased, the output voltage will increase when the generator output current increases. Try the default value.

   d. If generator type is set incorrectly, the regulator may operate constantly in the under frequency curve. Check parameter :50 and compare actual frequency to verify.

   e. Display the number in parameters :92, :93, and :95 (if present). A display of “0000” indicates no faults. If a fault code is present, see System Operation, “Parameters”.

   Expected Result: The problem has been resolved.

   Results:

   - OK: The problem has been resolved. STOP.
   - NOT OK: The problem has not been resolved. Proceed to Step 5.

5. **Check the PM inputs.**

   a. Turn the engine off.

b. Check that all of the digital voltage regulator connections are tight and properly made per the appropriate wiring diagram.

c. Check PM fuses (connecting to terminals 26 and 30 of the digital voltage regulator).

d. Restart the engine.

e. Check the PM inputs (26, 28, and 30) of the digital voltage regulator. Measure the AC voltage between terminals 26 to 28, 28 to 30, and 26 to 30.

f. If the digital voltage regulator is connected as a self-excited regulator, check if the power transformers are properly wired as an open delta configuration for the according wiring diagrams. Check if the power transformers are properly sized in order to provide a minimum of 1200 VA each.

Expected Result: The proper voltage is approximately 95 VAC for 60 Hertz generator sets and 79 VAC for 50 Hertz generator sets. The voltage must be stable. The voltage must be stable. Voltages up to 120 VAC, 60 HZ are acceptable.

Results:

- OK: The voltage is correct. Go to Step 6.
- NOT OK: The voltage is incorrect or unstable. PM stator or PM rotor is damaged. Troubleshoot the PM unit. Replace the faulty component. STOP.

6. Check the sensing inputs.

a. Check the sensing inputs between the digital voltage regulator terminals 20 to 22, 22 to 24, and 20 to 24.

Expected Result: All 3 readings should be balanced and with proper PT ratio to the output voltage.

Result:

- OK: All three readings are balanced. Go to Step 7.
- NOT OK: The readings are unbalanced. Check all connections to the regulator. Check all connections to the output terminals. Make sure that proper potential transformers are installed, if applicable. Check the neutral connection. Check for the correct phase rotation. STOP.

7. Check the generator set.

a. Turn the engine off.

b. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

c. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory. Operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.
- NOT OK: The generator set does not operate properly. The digital voltage regulator is faulty. The digital voltage regulator needs to be replaced.

i01041694

Unstable Voltage - Troubleshoot

SMCS Code: 4467-035

1. Check for the proper version of the regulator.

a. Check the part number of the digital voltage regulator. Refer to the chart in Testing And Adjusting, “Troubleshooting”. Check whether the digital voltage regulator is proper for the application.

Expected Result: The digital voltage regulator is proper for the application.

Results:

- OK: Go to Step 2.
- NOT OK: Install the proper digital voltage regulator. STOP.

2. Check the status of the display.

a. Stop the generator set.

b. Observe the display on the digital voltage regulator.

Expected Result: The display should contain a number.

Results:

- OK: Proceed to Step 4.
- NOT OK: No number is present on the display. Proceed to Step 3.

3. Check the DC voltage.

a. Check for proper DC voltage from terminal “B+” to “B-”. The acceptable voltage range is 18 VDC to 32 VDC.

Expected Result: The sufficient DC voltage is present.

Results:

- OK: The sufficient DC voltage is present. Remove the DC power wires from terminals “B+” and “B-” for 30 seconds. Reconnect the DC power wires to the “B+” and “B-” terminals. If the regulator display is still blank, the regulator is faulty. Then, the regulator needs to be replaced. If this condition has occured, verify that the correct burden resistor or rheostat is connected between the droop current transformer and the regulator. If no resistor is present, the regulator was destroyed because of high current on the CT input. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.
- NOT OK: The sufficient DC voltage is not present. Repair the supply voltage wiring, fuses and circuit breakers as necessary. STOP.

4. Verify the proper configuration of the parameters.

Pay particular attention to parameters :06, :10, :16, and :17.

a. If parameter :06 is set too close to the nominal operating frequency, then the voltage could become unstable. Try the default setting.

b. If parameter :10 is set too close to the nominal operating frequency, then the voltage could become unstable. Try the default setting.

c. Some combinations of the gain parameters :16 and :17 may cause unstable operation. Try the default settings.

d. Display the number in parameters :92, :93, and :95 (if present). A display of “0000” indicates no faults. If a fault code is present, see System Operation, “Parameters”.

Expected Result: The problem has been resolved.

Results:

- OK: The problem has been resolved. STOP.
- NOT OK: The problem has not been resolved. Proceed to Step 5.

5. Check the PM inputs.

a. Turn the engine off.

b. Check that all of the digital voltage regulator connections are tight and properly made per the appropriate wiring diagram.

c. Check PM fuses (connecting to terminals 26 and 30 of the digital voltage regulator).

d. Restart the engine.

e. Check the PM inputs (26, 28, and 30) of the digital voltage regulator. Measure the AC voltage between terminals 26 to 28, 28 to 30, and 26 to 30.

f. If the digital voltage regulator is connected as a self-excited regulator, check if the power transformers are properly wired as an open delta configuration for the according wiring diagrams. Check if the power transformers are properly sized in order to provide a minimum of 1200 VA each.

Expected Result: The proper voltage is approximately 95 VAC for 60 Hertz generator sets and 79 VAC for 50 Hertz generator sets. The voltage must be stable. Voltages up to 120 VAC, 60 HZ are acceptable.

Results:

- OK: The voltage is correct. Go to Step 6.
- NOT OK: The voltage is incorrect or unstable. PM stator or PM rotor is damaged. Troubleshoot the PM unit. Replace the faulty component. STOP.

6. Check the sensing inputs.

a. Check the sensing inputs between the digital voltage regulator terminals 20 to 22, 22 to 24, and 20 to 24.

b. If the digital voltage regulator has been located in a switchgear cabinet, ensure that no wiring is located in the same cable tray with the generator output wires or any other high voltage or high current wiring. The digital voltage regulator should be separated from the circuit breaker by a metal, grounded plate or by large physical distance. The digital voltage regulator should never be located in the same cabinet as a medium voltage circuit breaker.

Expected Result: All 3 readings should be balanced and with proper PT ratio to the output voltage. The PT ratio should match parameter :02 in most cases.

Result:

- OK: All three readings are balanced. Go to Step 7.
- NOT OK: The readings are unbalanced. Check all connections to the regulator. Check all connections to the output terminals. Make sure that proper potential transformers are installed, if applicable. Check the neutral connection. Check for the correct phase rotation. STOP.

7. Check the generator set.

a. Turn the engine off.

b. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

c. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory. Operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.
- NOT OK: The generator set does not operate properly. The digital voltage regulator is faulty. The digital voltage regulator needs to be replaced.

i01041685

Inaccurate Display - Troubleshoot

SMCS Code: 4467-035

Note: This section refers to parameters :50 through :58.

Note: If you change a parameter, you must exit the parameter before the change of the parameter will take effect.

1. Check the wiring.

a. Stop the generator set.

b. Check the wiring.

Expected Result: The wiring is correct.

Results:

- OK: Go to Step 2.
- NOT OK: The CT polarity or PT polarity is incorrect. Reverse the polarity. See the proper wiring diagram for details. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.

2. Check the parameter values.

a. Start the generator set and load with 25% to 50% of rated load. Use 0.8 power factor inductive load, if at all possible.

b. Check the values in parameters :04 and :05.

Note: Parameter :52 (current) provides the measured value of the current in the B phase only.

c. Measure the ampere load on the B phase.

d. Measure the signal voltage level at regulator terminals 5 and 6.

e. Verify that it is in correct proportion to load amperes and agrees with the settings of parameters :04 and :05.

Expected Result: Any parameters show negative numbers.

Results:

- OK: If any parameters show negative numbers, a CT or PT polarity is incorrect or the phase rotation is wrong. Verify the polarity and the rotation. STOP.
- NOT OK: Go to Step 3.

3. **Check the value of the generator output current.**

   a. Compare the value of parameter :52 to the actual generator current.

   Expected Result: Parameter :52 reads less than the actual generator current, which was measured by another meter.

   Results:

   - OK: Parameter :52 reads less than the actual generator current, which was measured by another meter. Slowly decrease parameter :05 until the currents match.
   - NOT OK: Parameter :52 reads more than the actual generator current which is measured by another meter. Slowly increase parameter :05 until the currents match.

Note: If the generator set neutral is connected to ground or a neutral bus, then measure the neutral current. If a significant amount of circulating current is present, it may cause incorrect readings. A harmonic analysis is recommended in order to help determine the nature of the problem.

Note: It is normal for the accuracy to be reduced at levels below 15% of rated load. The digital voltage regulator is sensitive to the size of CT. The droop current transformer should be sized in order to provide no more than 5 VAC (RMS) at full rated load but not less than 3.5 VAC either. Proper sizing will significantly aid the accuracy at lower power levels.

i01041691

Reverse Power Shutdown or Reverse VAR Condition - Troubleshoot

SMCS Code: 4467-035

1. **Check the wiring.**

   a. Stop the generator set.

   b. Check the wiring.

   Expected Result: The wiring is correct.

   Results:

   - OK: Go to Step 2.
   - NOT OK: CT polarity or PT polarity is incorrect. The incorrect polarity may generate erroneous faults. Reverse the polarity. See the proper wiring diagram for details. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.

2. **Check the parameter values.**

   a. Start the generator set and load with 25% to 50% of rated load. Use 0.8 power factor inductive load, if at all possible.

   b. Check value in parameters :04 and :05.

Note: Parameter :52 (current) provides the measured value of the current in the B phase only.

   c. Measure the ampere load on the B phase.

   d. Measure the signal voltage level at regulator terminals 5 and 6.

   e. Verify that it is in correct proportion to load amperes and agrees with the settings of parameters :04 and :05.

   Expected Result: Any parameters show negative numbers.

   Results:

   - OK: If any parameters show negative numbers, a CT or PT polarity is incorrect or the phase rotation is wrong. Verify the polarity and the rotation. STOP.
   - NOT OK: Go to Step 3.

3. **Check the value of the generator output current.**

   a. Compare the value of parameter :52 to the actual generator current.

   Expected Result: Parameter :52 reads less than the actual generator current, which was measured by another meter.

   Results:

   - OK: Parameter :52 reads less than the actual generator current, which was measured by another meter. Slowly decrease parameter :05 until the currents match.
   - NOT OK: Parameter :52 reads more than the actual generator current which is measured by another meter. Slowly increase parameter :05 until the currents match.

Note: It is normal for the accuracy to be reduced at levels below 15% of rated load. In these cases, the digital voltage regulator may observe a 0.4 Per Unit leading KVAR due to unbalanced cross current compensation networks. The digital voltage regulator is sensitive to CT sizing. The droop current transformer should be sized to provide no more than 5 VAC (RMS) at full rated load but not less than 3.5 VAC either. Proper sizing will significantly aid the accuracy at lower power levels.

Note: If the digital voltage regulator is part number 155-xxxx or newer, check the value in parameter :20. If the value is very small, try increasing it until the problem is eliminated.

i01041684

Improper PF Regulation or KVAR Regulation - Troubleshoot

SMCS Code: 4467-035

1. **Check the wiring.**

   a. Stop the generator set.

   b. Check the wiring.

   Expected Result: The wiring is correct.

   Results:

   - OK: Go to Step 2.
   - NOT OK: The erroneous regulation may be observed if the CT polarity or PT polarity is incorrect. Reverse the polarity. See the proper wiring diagram for details. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.

2. **Check the parameter values.**

   a. Start the generator set and load with 25% to 50% of rated load. Use 0.8 power factor inductive load, if at all possible.

   b. Check the values in parameters :04 and :05.

Note: Parameter :52 (current) provides the measured value of the current in the “B” phase only.

   c. Measure the ampere load on the “B” phase.

   d. Measure the signal voltage level at regulator terminals 5 and 6.

   e. Verify that it is in correct proportion to load amperes and agrees with the settings of parameters :04 and :05.

   Expected Result: Any parameters show negative numbers.

   Results:

   - OK: If any parameters show negative numbers, a CT or PT polarity is incorrect or the phase rotation is wrong. Verify the polarity and the rotation. STOP.
   - NOT OK: Go to Step 3.

3. **Check the parameter values (continued).**

   a. Check the value in parameter :52.

   Expected Result: Parameter :52 reads less than the actual generator current, which was measured by another meter.

   Results:

   - OK: Parameter :52 reads less than the actual generator current, which was measured by another meter. Slowly decrease parameter :05 until the currents match.
   - NOT OK: Parameter :52 reads more than the actual generator current which is measured by another meter. Slowly increase parameter :05 until the currents match.

4. **Check the parameter values (continued).**

   a. On units with part numbers of 130-xxxx and older, check the value in parameter :16 and :17. Some combinations of gain parameters :16 and :17 may cause unstable operation. Try the default settings.

   b. On units with part numbers of 155-xxxx and newer, check the value in parameters :36 and :37. Some combinations of Gain parameters :36 and :37 may cause unstable operation. Try the default settings.

   c. If the problem only exists at low power levels, check the value in parameter :38. Try raising the value. This is not valid for the earlier digital voltage regulator, which does not have parameter :38.

   Expected Result: The problem has been resolved.

   Results:

   - OK: The problem has been resolved. STOP.

- NOT OK: The problem has not been resolved. Go to Step 5.

5. Verify the CT sizing.

a. Remove the remote PF/KVAR adjust rheostat.

b. Retry the operation of the generator set.

Expected Result: The problem has been resolved.

Results:

- OK: The problem has been resolved. STOP.
- NOT OK: The problem has not been resolved. Verify the CT sizing. The digital voltage regulator is sensitive to the CT sizing. The droop current transformer should be sized to provide no more than 5 VAC (RMS) at full rated load but not less than 3.5 VAC either. Proper sizing will significantly aid the accuracy at lower power levels. Go to Step 6.

6. Check the generator set.

a. Turn the engine off.

b. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

c. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory. Operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.
- NOT OK: If the generator set neutral is connected to ground or a neutral bus, then measure the neutral current. If a significant amount of circulating current is present, it may cause improper operation. A harmonic analysis is recommended in order to help determine the nature of the problem.

i01041695

Watchdog Alarm - Troubleshoot

SMCS Code: 4467-035

A 602 alarm is a watchdog alarm. A watchdog alarm can be generated during engine cranking. In order to prevent this alarm, a separate constant 24 VDC supply to the regulator should be provided. If a constant 24 VDC supply is not available, then remove all battery power to the regulator during engine cranking in order to prevent the 602 alarm.

i01041687

Loss of Frequency Shutdown - Troubleshoot

SMCS Code: 4467-035

1. Check the wiring.

a. Turn the engine off.

b. Check the PM wiring.

Expected Result: The wiring is correct.

Results:

- OK: Go to Step 2.
- NOT OK: The CT polarity or PT polarity is incorrect. Reverse the polarity. See the proper wiring diagram for details. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.

2. Check the accessory.

a. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

b. Start the generator set and operate at “No Load”.

Expected Result: The generator set operates properly.

Results:

- OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory and operate the generator set again at “No Load”. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.

- NOT OK: The generator set does not operate properly. Temporarily disconnect and then reconnect the battery voltage to the regulator. If proper AC voltage is present at terminals 26 and 30, and the fault is still present, the regulator is faulty. Replace the regulator.

Note: Shielded cable should be provided for all remote adjustment potentiometers. Connect the shield drain wire to regulator terminal 45. Insulate the wiring shield from touching all other objects, including Earth ground. This will eliminate the possibility of induced voltages (EMI spikes) causing an intermittent shutdown.

Note: It is also possible to get the loss of frequency shutdown fault (fault code 803), if a fault is reset on a self excited generator connection with the generator still spinning. Always stop the generator before resetting faults when using a self excited connection.

i01077455

Instantaneous Trip Shutdown - Troubleshoot

SMCS Code: 4467-035

Instantaneous trip shutdown is fault 801.

Note: Electromagnetic noise spikes can create an erroneous instantaneous trip. Such spikes are often the result of breaker closure. If the digital voltage regulator or any wiring to the digital voltage regulator is in close proximity to a circuit breaker (particularly a medium voltage breaker), this condition may occur. Uninterrupted power systems (UPS), motor drives, and other equipment that generates electromagnetic interference (EMI) spikes or switches large currents must also be avoided. Install the digital voltage regulator in the generator terminal box or in another location away from the offending equipment.

1. **Check the wiring.**

   a. Stop the generator set.

   b. Check the wiring.

   Expected Result: The wiring is correct.

   Results:

   - OK: Go to Step 2.

   - NOT OK: Shorted F1 and F2 wires will cause the instantaneous trip shutdown fault. Megger the exciter stator. See the proper wiring diagram for details. Refer to Testing And Adjusting, “Wiring Diagrams”. STOP.

2. **Check the accessory.**

   a. Disconnect all accessory wiring from terminals 3, 5, 6, 7, 40, 41, 42, 43, 44, 45, and 50. Remove the serial data link, if installed.

   b. Start the generator set. Operate the generator set with the same conditions that caused the problem previously.

   Expected Result: The generator set operates properly.

   Results:

   - OK: The generator set operates properly. There is a problem with an accessory which has been disconnected. Reconnect one accessory. Operate the generator set again. Continue this process of reconnecting one accessory at a time until the faulty accessory is found. STOP.

   - NOT OK: The generator set does not operate properly. Go to Step 3.

3. **Check the nearby equipment.**

   a. Identify nearby equipment that could generate EMI spikes.

   b. Move the digital voltage regulator and the wiring to a temporary location away from the offending equipment and operate the generator again.

   Expected Result: The problem has been resolved.

   Results:

   - OK: The problem has been resolved. Find a new permanent home for the digital voltage regulator away from the offending equipment. Shielded wiring should always be used for rheostat inputs when the regulator and/or rheostat are located off the generator. Connect the shield drain wire to regulator terminal 45. Insulate the wiring shield from touching all other objects, including Earth ground.

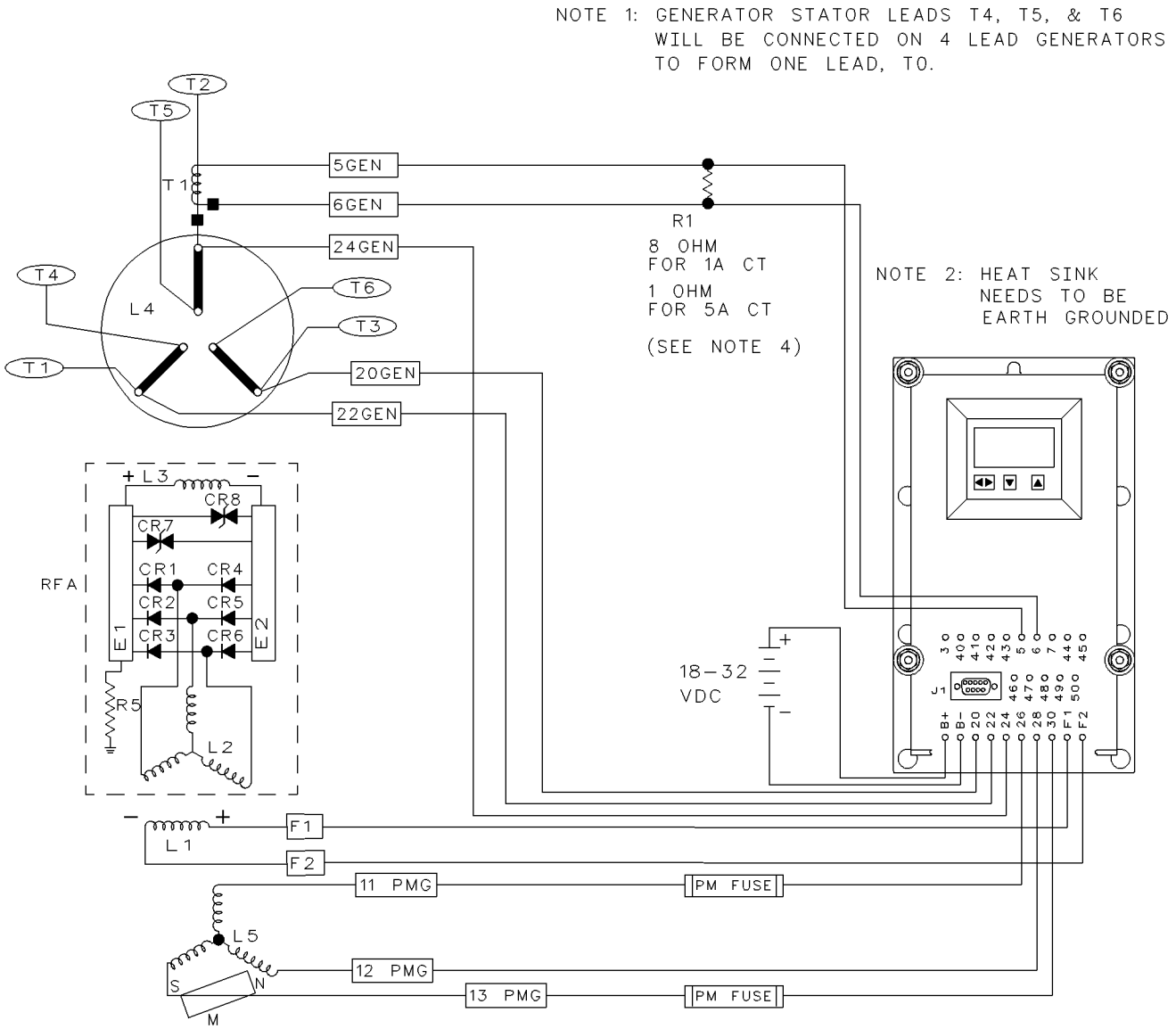
   - NOT OK: The digital voltage regulator is being subjected to other sources of EMI. On methods to reduce EMI, refer to Systems Operation, “Customer Options”, section Remote Installation Notes.

i01041698

Wiring Diagrams

SMCS Code: 4467; 7566

4/6 Lead



CR1−6 ROTATING RECTIFIERS
CR7,8 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

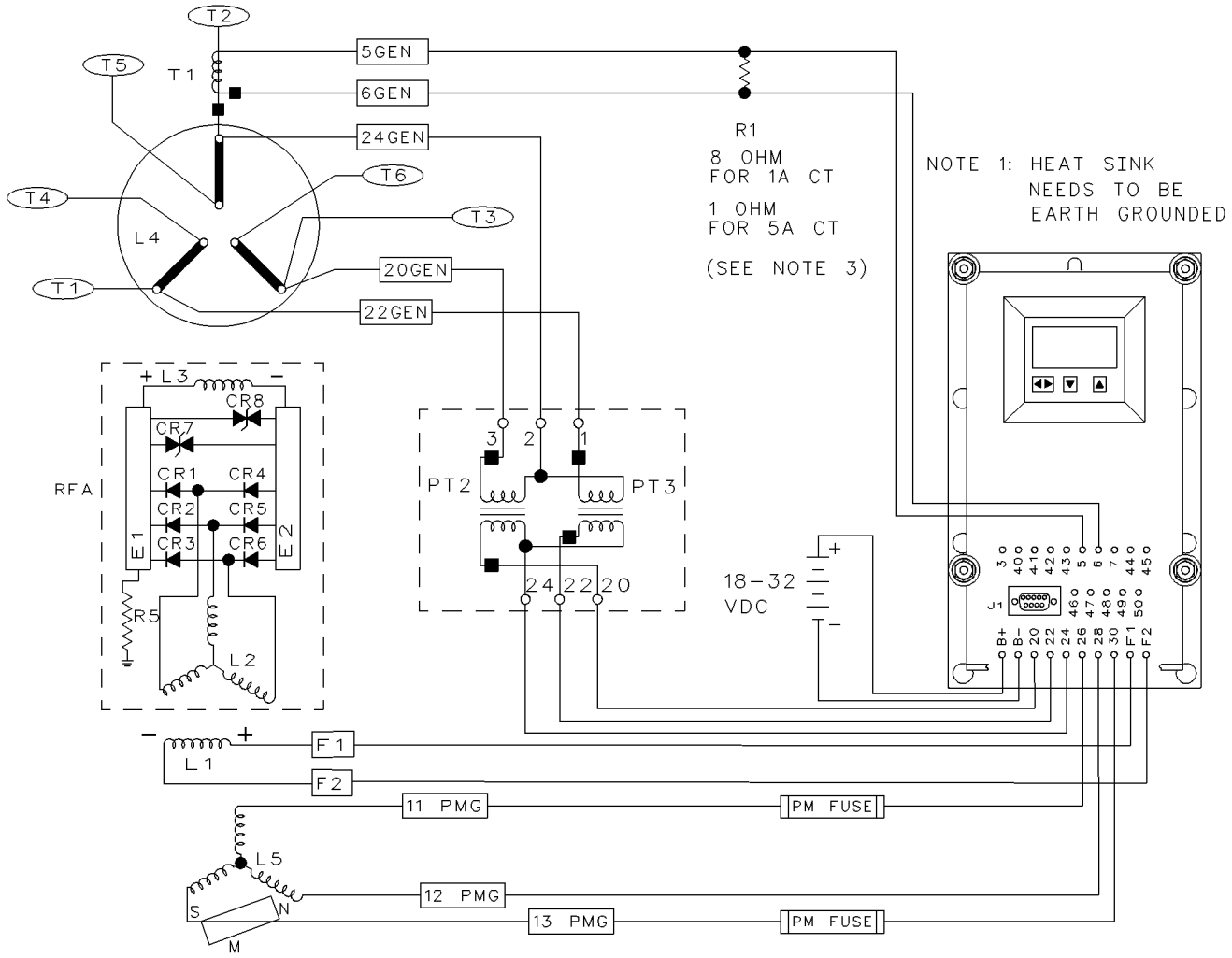
NOTE 3: DROOP TRANSFORMER AND DROOP BURDEN RESISTOR MAY OR MAY NOT BE SUPPLIED

M ROTATING PERMANENT MAGNET
R1 VOLTAGE DROOP BURDERN RESISTOR (SEE NOTE 3)
R5 SUPRESSION RESISTOR
RFA REVOLVING FIELD ASS'Y
T1 VOLTAGE DROOP TRANSFORMER (SEE NOTE 3)
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
■ POLARITY MARKING

NOTE 4: R1 TO BE MOUNTED WITHIN 3 METERS (10 FEET) OF THE REGULATOR

Illustration 13 g00539494

4/6 Lead With Sensing Isolation Transformer



CR1−6 ROTATING RECTIFIERS
CR7,8 SURGE SUPPRESSION DIODES
E1 POSITIVE HEAT SINK
E2 NEGATIVE HEAT SINK

L2 EXCITER ARMATURE(ROTOR)
L3 REVOLVING FIELD(MAIN ROTOR)
L4 MAIN STATOR

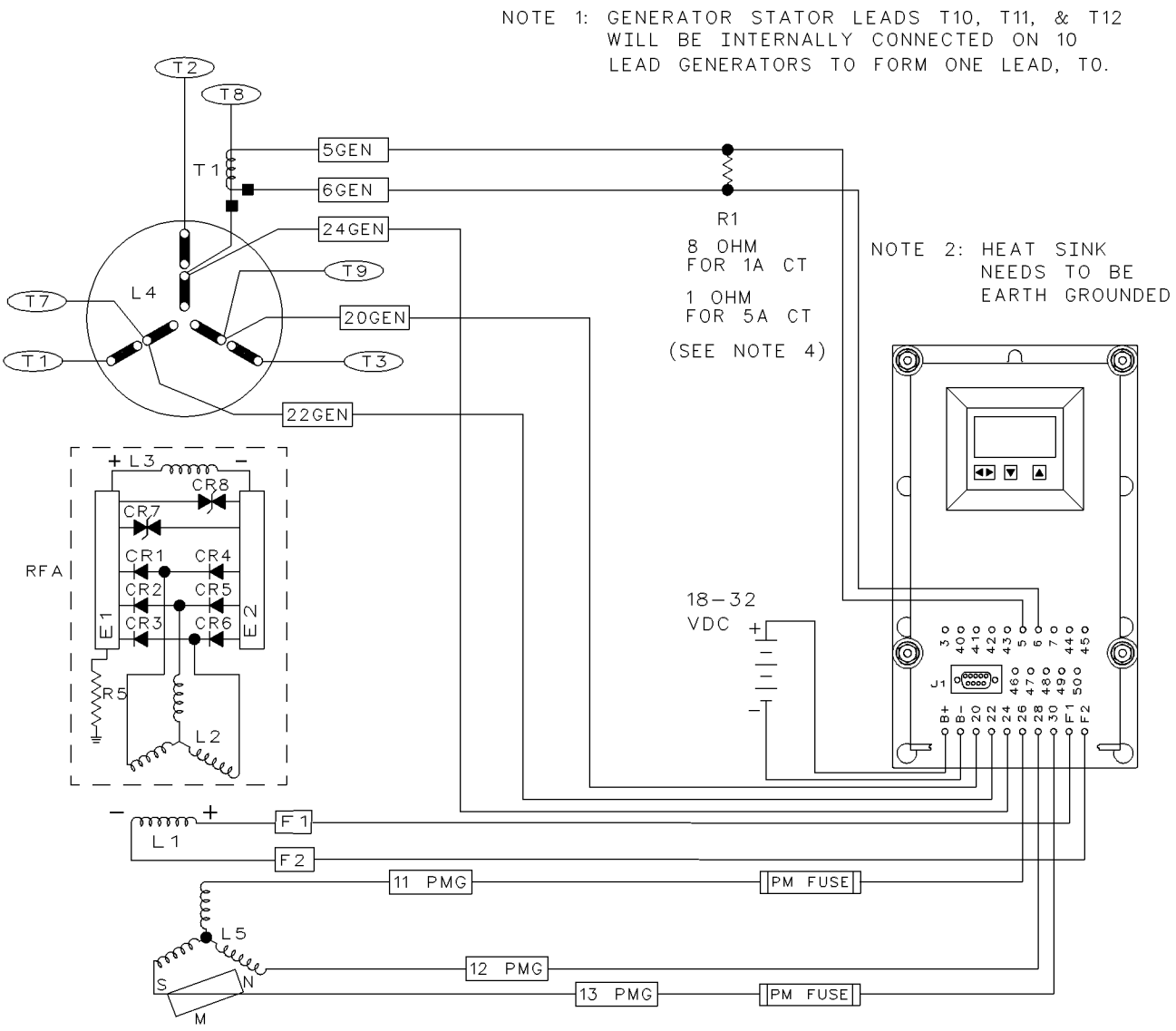
NOTE 2: DROOP TRANSFORMER AND DROOP BURDEN RESISTOR MAY OR MAY NOT BE SUPPLIED

PT2, PT3 SENSING/ISOLATION TRANSFORMERS
M ROTATING PERMANENT MAGNET
R1 VOLTAGE DROOP BURDEN RESISTOR (SEE NOTE 2)
R5 SUPRESSION RESISTOR
RFA REVOLVING FIELD ASS´Y
T1 VOLTAGE DROOP TRANSFORMER (SEE NOTE 2)
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
■ POLARITY MARKING

NOTE 3: R1 TO BE MOUNTED WITHIN 3 METERS (10 FEET) OF THE REGULATOR

Illustration 14 g00539496

10/12 Lead



CR1-6 ROTATING RECTIFIERS
CR7,8 SURGE SUPPRESSION DIODES
E1 POSITIVE HEAT SINK
E2 NEGATIVE HEAT SINK
L1 EXCITOR FIELD (STATOR)
L2 EXCITER ARMATURE(ROTOR)
L3 REVOLVING FIELD(MAIN ROTOR)
L4 MAIN STATOR
L5 PM EXCITOR STATOR

M ROTATING PERMANENT MAGNET
R1 VOLTAGE DROOP BURDEN RESISTOR (SEE NOTE 3)
R5 SUPRESSION RESISTOR
RFA REVOLVING FIELD ASS'Y
T1 VOLTAGE DROOP TRANSFORMER (SEE NOTE 3)
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
■ POLARITY MARKING

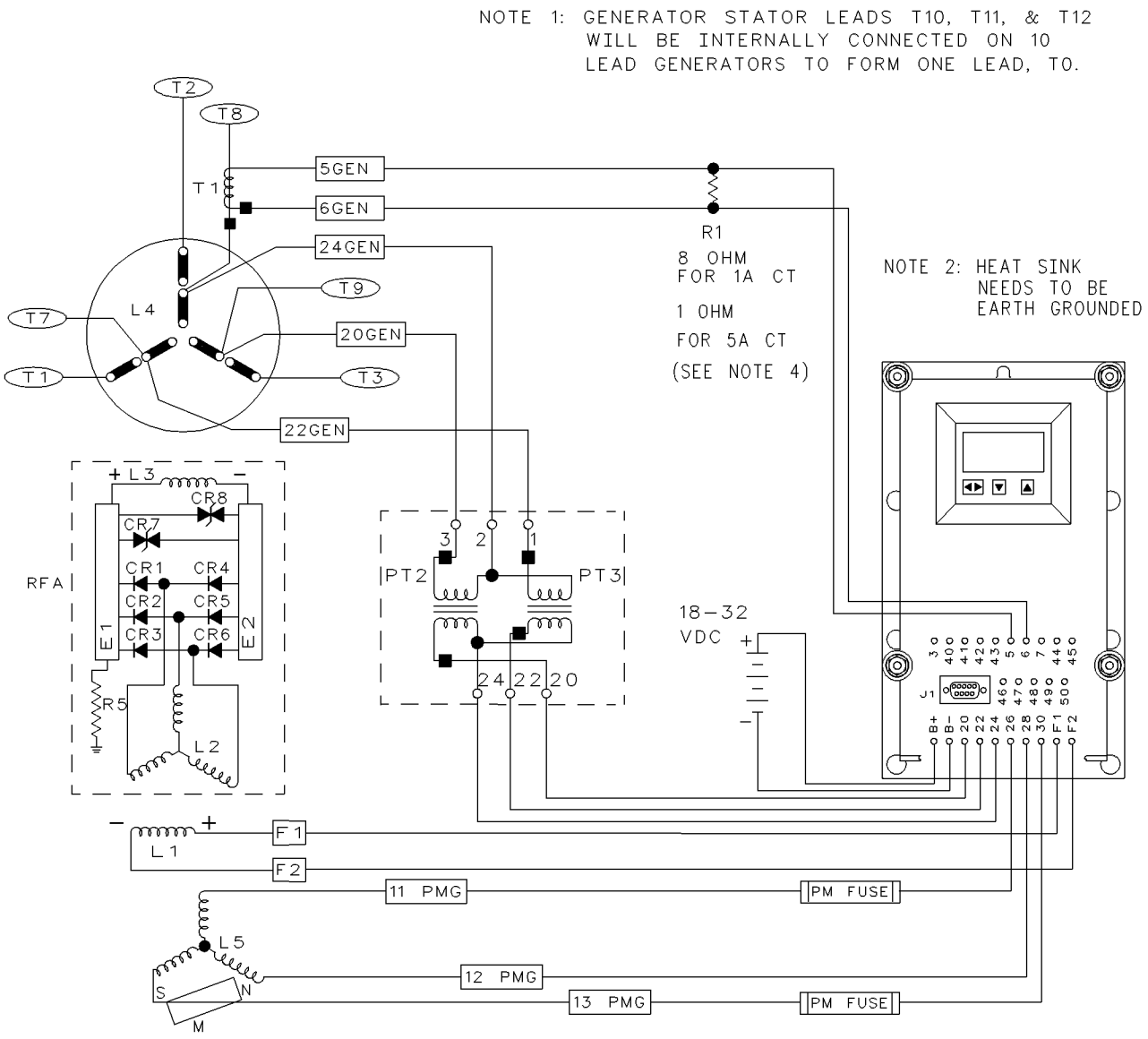
NOTE 3: DROOP TRANSFORMER AND DROOP BURDEN RESISTOR MAY OR MAY NOT BE SUPPLIED

NOTE 4: R1 TO BE MOUNTED WITHIN 3 METERS (10 FEET) OF THE REGULATOR

Illustration 15

g00539518

10/12 Lead With Sensing Isolation Transformer



CR1−6 ROTATING RECTIFIERS
CR7,8 SURGE SUPPRESSION DIODES
E1 POSITIVE HEAT SINK
E2 NEGATIVE HEAT SINK
L1 EXCITOR FIELD (STATOR)
L2 EXCITER ARMATURE(ROTOR)
L3 REVOLVING FIELD(MAIN ROTOR)
L4 MAIN STATOR
L5 PM EXCITOR STATOR

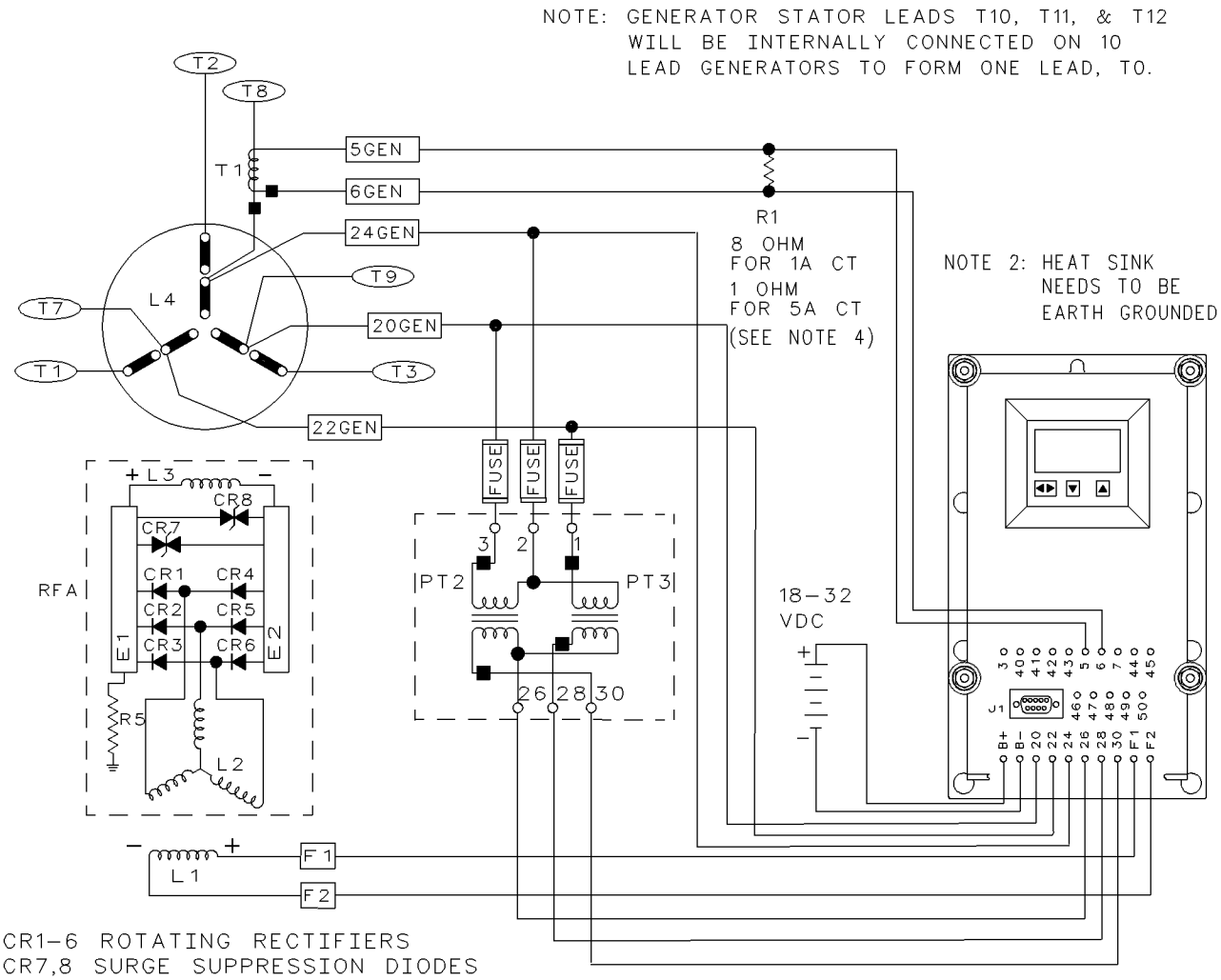
M ROTATING PERMANENT MAGNET
R1 VOLTAGE DROOP BURDEN RESISTOR (SEE NOTE 3)
R5 SUPRESSION RESISTOR
RFA REVOLVING FIELD ASS'Y
T1 VOLTAGE DROOP TRANSFORMER (SEE NOTE 3)
PT2, PT3 SENSING ISOLATION TRANSFORMERS
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
■ POLARITY MARKING

NOTE 3: DROOP TRANSFORMER AND DROOP BURDEN RESISTOR MAY OR MAY NOT BE SUPPLIED

NOTE 4: R1 TO BE MOUNTED WITHIN 3 METERS (10 FEET) OF THE REGULATOR

Illustration 16 g00539520

10/12 Lead With Self-Excitation



CR1–6 ROTATING RECTIFIERS
CR7,8 SURGE SUPPRESSION DIODES
E1 POSITIVE HEAT SINK
E2 NEGATIVE HEAT SINK
L1 EXCITOR FIELD (STATOR)
L2 EXCITER ARMATURE(ROTOR)
L3 REVOLVING FIELD(MAIN ROTOR)
L4 MAIN STATOR

R1 VOLTAGE DROOP BURDEN RESISTOR (SEE NOTE 3)
R5 SUPRESSION RESISTOR
RFA REVOLVING FIELD ASS´Y
T1 VOLTAGE DROOP TRANSFORMER (SEE NOTE 3)
PT2, PT3 SENSING ISOLATION TRANSFORMERS
□ WIRE NUMBER
○ TERMINAL BOARD NUMBER
■ POLARITY MARKING

NOTE 3: DROOP TRANSFORMER AND DROOP BURDEN RESISTOR MAY OR MAY NOT BE SUPPLIED

NOTE 4: R1 TO BE MOUNTED WITHIN 3 METERS (10 FEET) OF THE REGULATOR

NOTE 5: PHASE RELATIONSHIP OF 20, 22, & 24 TO T1 (DROOP TRANSFORMER) IS IMPORTANT PT2 & PT3 SHOWN FOR 240 V PRIMARY AND 120 V SECONDARY. (120 V SECONDARY ALWAYS REQUIRED) PHASE ROTATION OF PT2 & PT3 IS NOT IMPORTANT

Manual Control

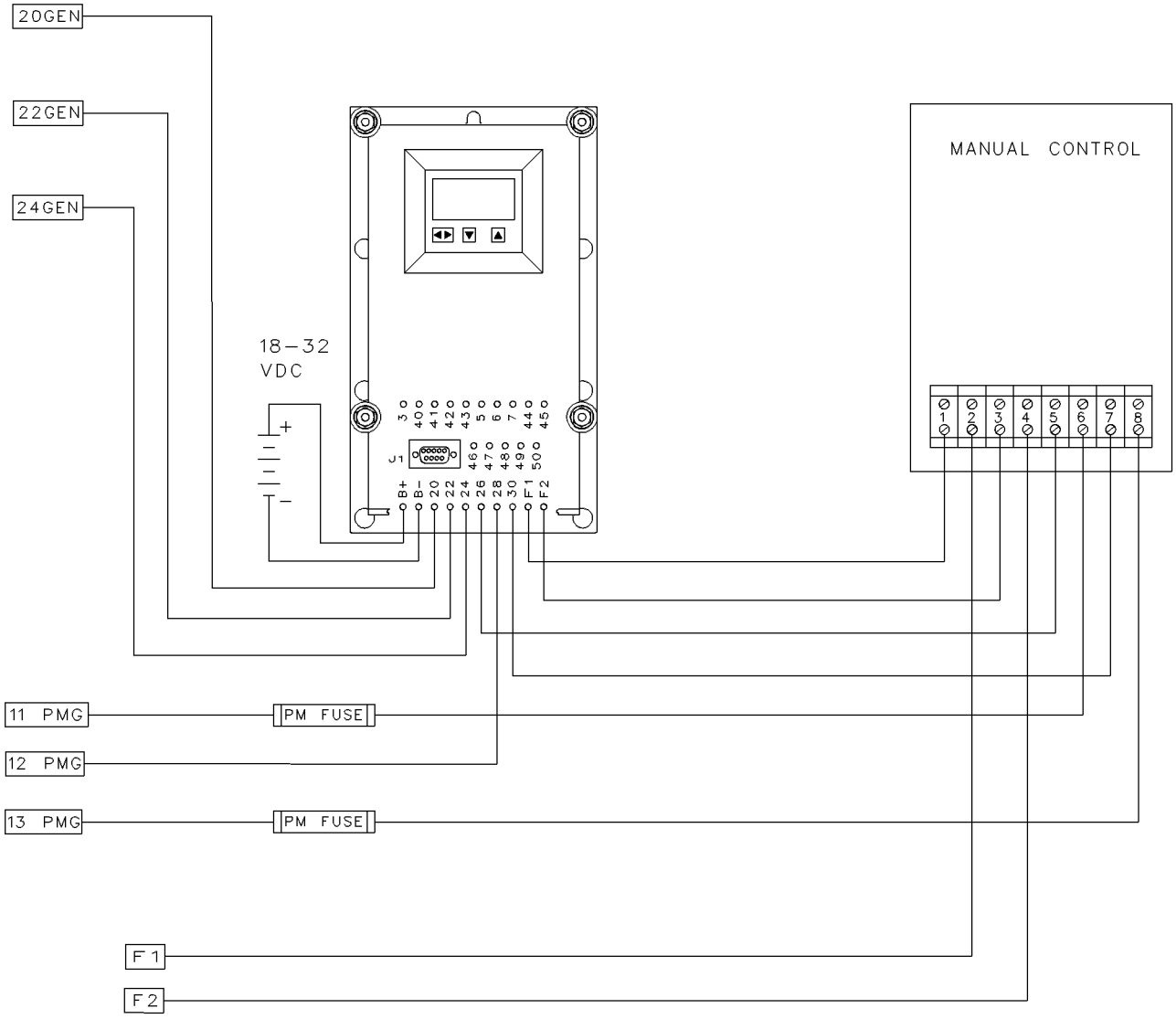
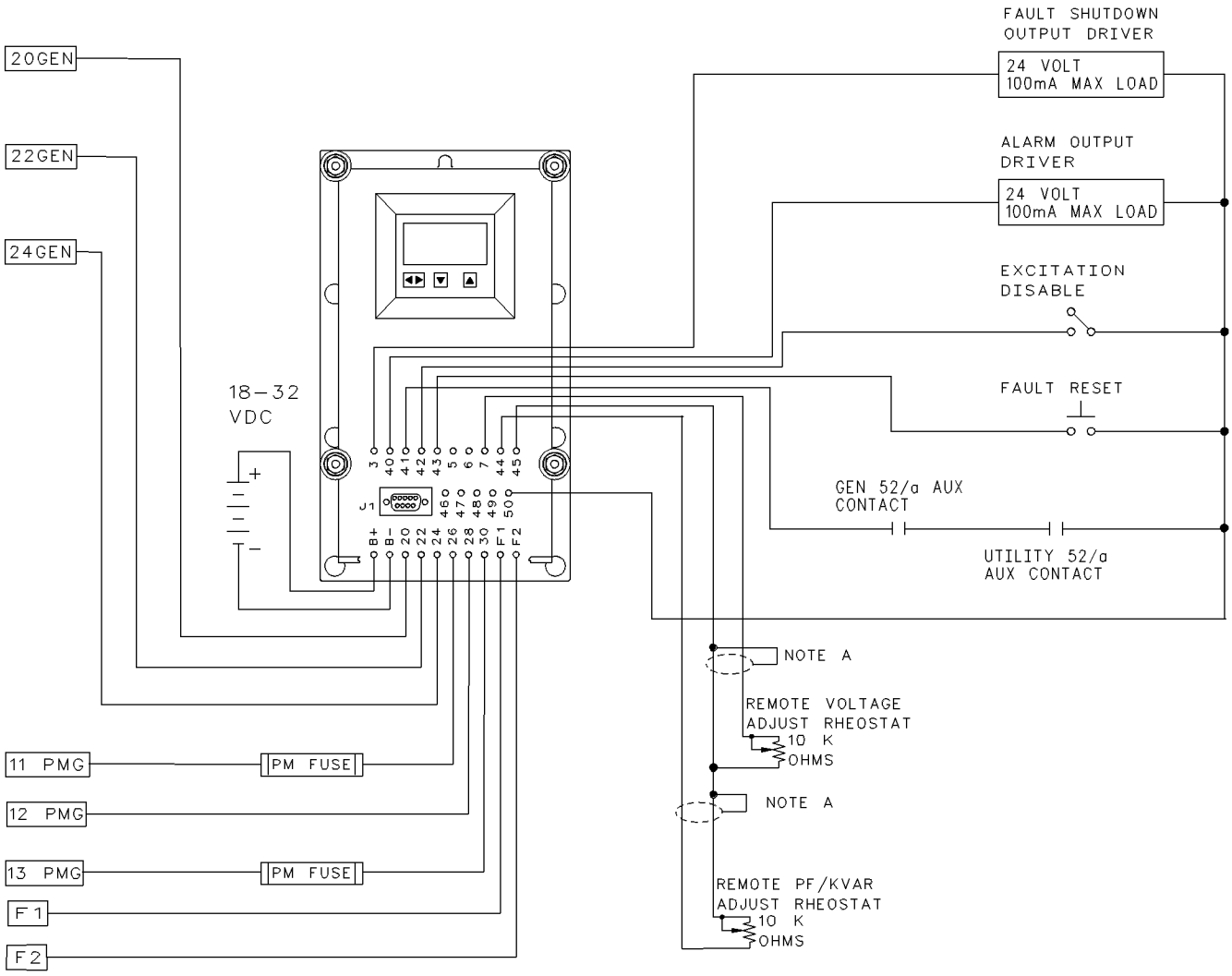


Illustration 18

g00539523

Customer Options



NOTE A: CONNECT SHIELD DRAIN WIRE(S) TO TERMINAL 45. INSULATE SHIELD DRAIN WIRE(S) AT RHEOSTAT END. DO NOT CONNECT SHIELD DRAIN WIRE(S) TO CHASSIS GROUND.

Illustration 19

g00539524

Remote Communications

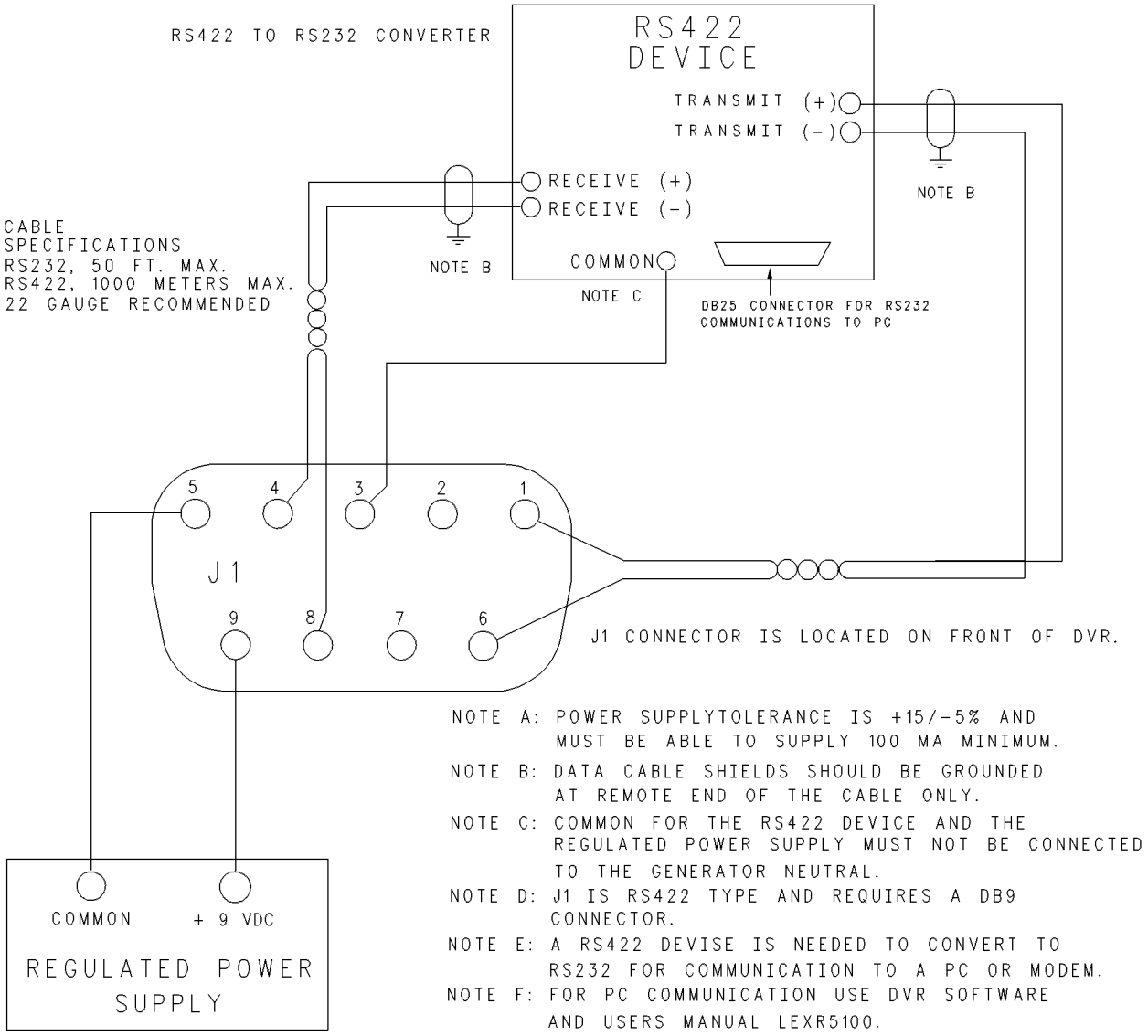
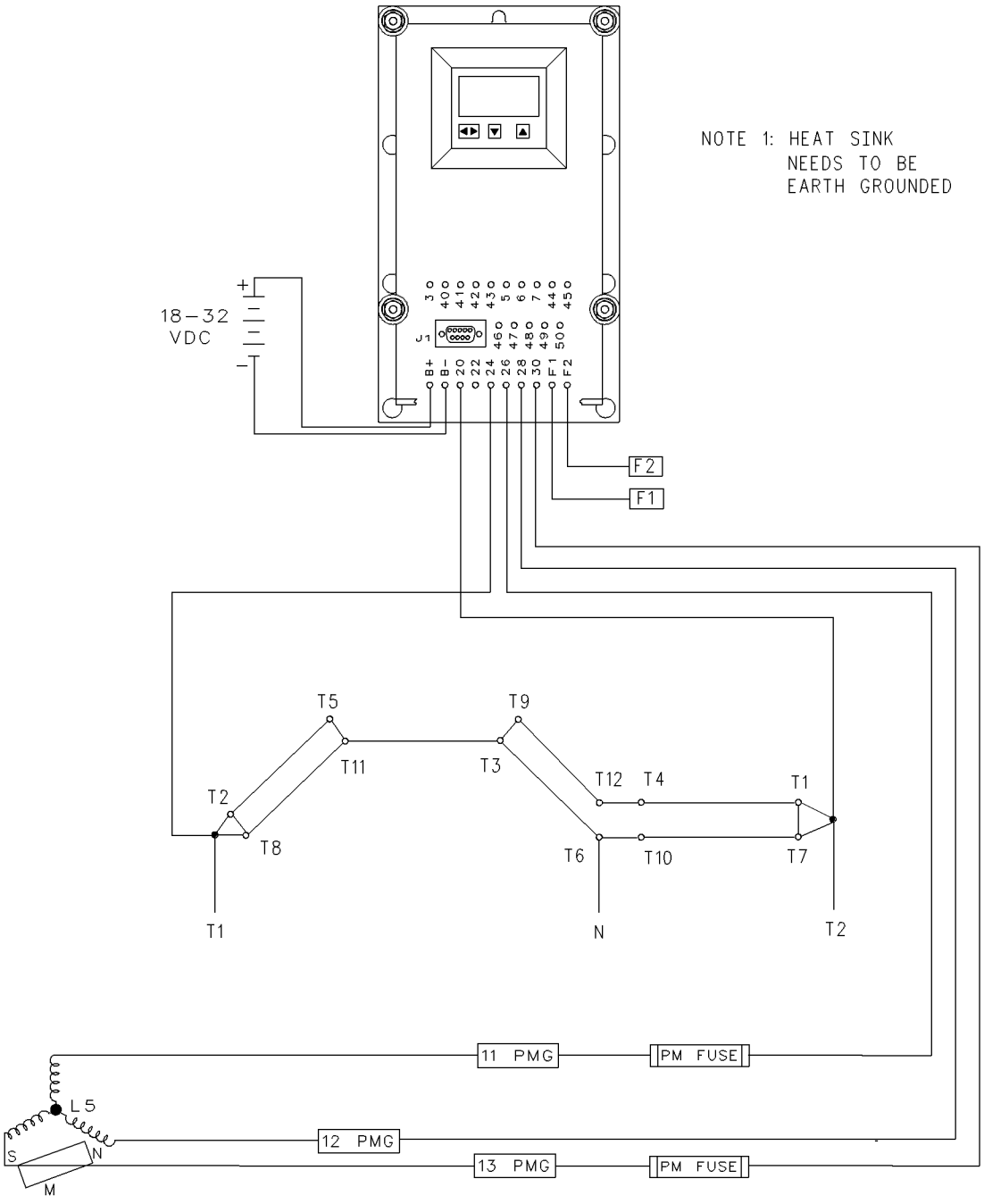


Illustration 20 g00539526

The new 131-7416 Converter Control includes the converter, power supply and the harness. The harness is serviced separately.

Single Phase Sensing - PM



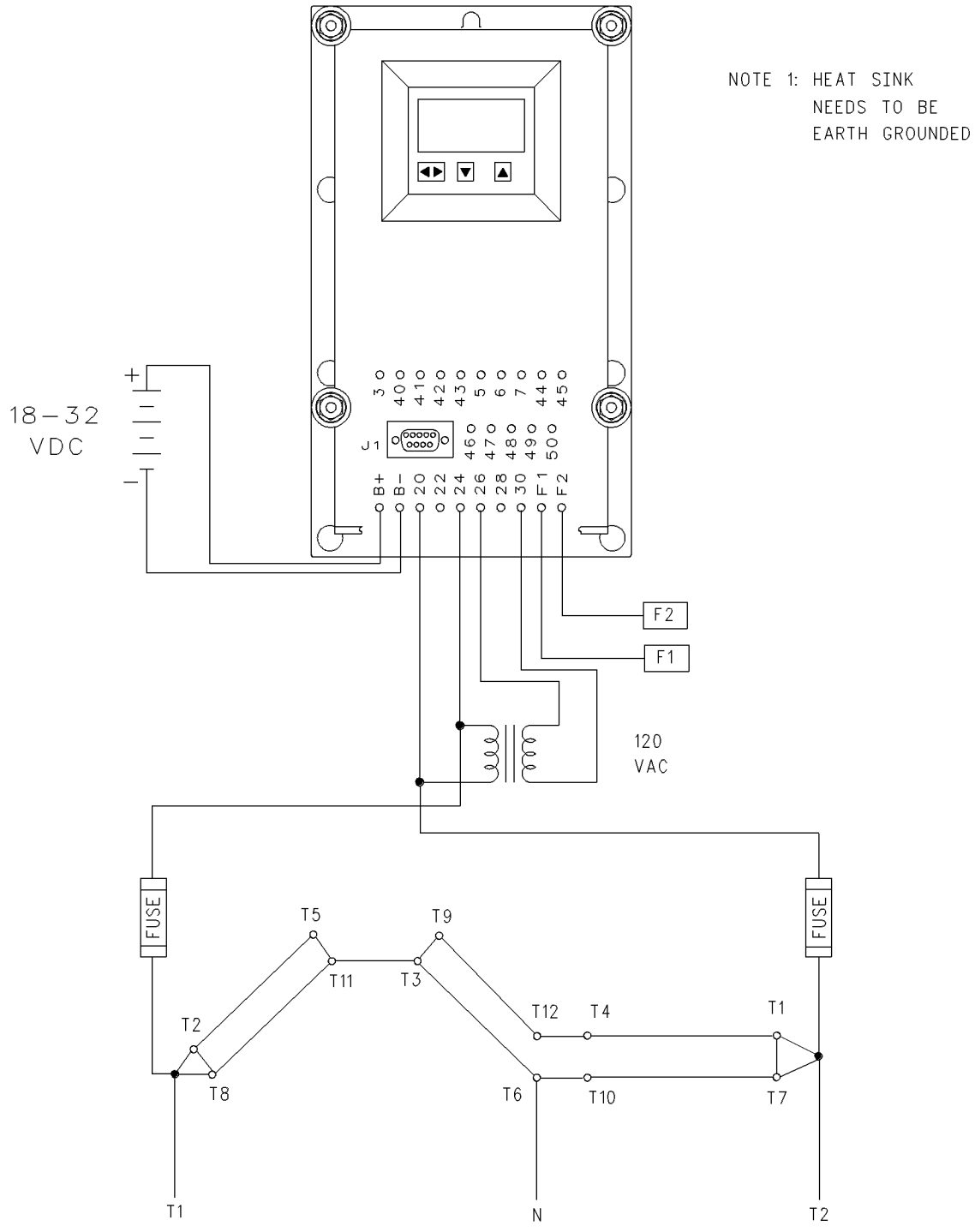
NOTE 2: PARAMETER :18 SHOULD BE SET TO 1.

NOTE 3: PARAMETER :03 SHOULD BE SET TO 0.

Illustration 21

g00586883

Single Phase Sensing - SE



NOTE 1: PARAMETER :03 SHOULD BE SET TO 0.

NOTE 2: PARAMETER :18 SHOULD BE SET TO 1.

Illustration 22

g00586885

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