INSTRUCTIONS
FOR
VOLTAGE REGULATOR
KR4FFX/FFMX and KR7FFX/FFMX
9 1610 00 101/9 1606 00 101 and 9 1611 00 101/9 1607 00 101

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INTRODUCTION

The Basler KR Series Voltage Regulators precisely control the output voltage of an ac electric generating system by controlling the amount of current supplied to the exciter (or generator) field. The KR Series Voltage Regulators contain built-in Electromagnetic Interference (EMI) filtering and an underfrequency roll-off characteristic.

ELECTRICAL SPECIFICATIONS

Input Power Requirements

KR4FFX/FFMX: 120 to 139 Vac (nom.), 1ϕ, 60 Hz, 300 VA. 100 to 127 Vac (nom.), 1ϕ, 50 Hz, 300 VA.

KR7FFX/FFMX: 208 to 277 Vac (nom.), 1ϕ, 60 Hz, 840 VA. 220 to 240 Vac (nom.), 1ϕ, 50 Hz, 840 VA.

Input Sensing Requirements

50 Hz, 1ϕ: 100-110/220-230-240/380-400-415/500 Vac, ±10%, 60 Hz, 1ϕ; 120-139/208-240/416-480/520-600 Vac, ±10%.

Input Sensing Burden

10 VA per phase

Power Output

KR4FFX/FFMX: 2.5 A @ 63 Vdc maximum continuous. 3.5 A @ 90 Vdc 1 minute forcing (120 Vac input).

KR7FFX/FFMX: 3.5 A @ 125 Vdc maximum continuous. 5.0 A @ 180 Vdc 1 minute forcing (240 Vac input).

Field Resistance

KR4FFX/FFMX: 25 ohms minimum, 400 ohms maximum.

KR7FFX/FFMX: 36 ohms minimum, 400 ohms maximum.

Regulation Accuracy

±1% from no-load to full-rated load and 5% frequency variation.

Thermal Stability

±1% voltage variation for a 40°C (104°F) change within the operating range.

Power Dissipated

<20 watts at maximum continuous rating.

Underfrequency Operational Threshold

54 Hz nominal in 60 Hz systems (see Figure 1).
44 Hz nominal in 50 Hz systems (see Figure 2).

Regulator Response

<17 milliseconds in 60 Hz systems.
<20 milliseconds in 50 Hz systems.

Frequency Compensation

Variable. Frequency roll-off is preset at the factory for 48.5 Hz (50 Hz systems) and 58.5 Hz (60 Hz systems). Either V/Hz or 2 V/Hz can be selected. Refer to Figures 1 and 2.

Electromagnetic Interference (EMI) Filtering

Refer to Figure 3.

PHYSICAL SPECIFICATIONS

Operating Temperature: -40° C (-40° F) to +60° C (+140°F).

Storage Temperature: -65° C (-85° F) to +85° C (+185° F).

Weight 6.0 lbs. (2.7 kg) net. 7.0 lbs. (3.2 kg) shipping.

Vibration: Withstands the following: 5 to 26 Hz at 1.2 g. 27 to 52 Hz at 0.036 inch double amplitude. 53 to 260 Hz at 5.0 g.

Shock: Withstands 20 g in each of three mutually perpendicular planes.

Mounting The unit is designed to operate when mounted directly on a diesel or turbine driven generator system. The unit can also be mounted in switchgear or control panels.

Accessories

The KR Series Voltage Regulator is designed to be compatible with any of the following listed accessories and equipment.

1. VAR/Power Factor Controller (SCP 250)
2. Series Boost Option
3. Current Transformers (CT2 through CT50)
4. Minimum/Maximum Excitation Limiter (EL 200)
5. Auto-Synchronizer (BE3-25A)
6. Auto-Synchronizer (BE1-25A)
7. Line Drop Compensator (LDC 300)

CONTROLS

External Voltage Adjust

This 175 ohm, 25 watt rheostat is supplied as a loose item for remote panel mounting. It provides an adjustment of ±10% of the nominal voltage of the regulated generator voltage. When connected as shown in Figure 4, adjustment of the rheostat to maximum resistance (CCW) will obtain minimum generator voltage output. Maximum generator voltage output is obtained by turning the rheostat clockwise (CW) to the minimum resistance position.

Voltage Range Adjustment

This screwdriver adjustment is factory set to establish the nominal ranges of sensing voltages associated with 60 Hz operation. If 60 Hz sensing is used, this control will not normally need adjustment.

When nominal 50 Hz sensing voltages are required, this control is used to establish the desired nominal sensing voltage. This is done in the following manner.

(1) Set the External Voltage Adjust Rheostat to the middle of its adjustment range.

(2) Ensure that the appropriate sensing voltage connection is made (refer to Figure 4) and that the 50 Hz connection is made.

(3) With the regulator properly connected into the system (Figure 4), bring the generator up to rated frequency (50 Hz).

(4) While watching the generator voltmeter, adjust the Internal Voltage Range Adjustment until the nominal generator voltage is obtained. (Voltage increases with CW rotation.)

After the internal Voltage Range Adjustment has been properly set, the External Voltage Adjust Rheostat will provide a voltage adjustment of ±10% of nominal (both 50 and 60 Hz systems).

Stability Adjustment

This screwdriver adjustment adjusts the system stability by controlling the amount of feedback that is applied to the Sensing and Gating Circuitry. Normally, it is factory preset near the extreme clockwise (CW) position. This setting normally assures good stability, but tends to slow the response time of the generator. If rotated counterclockwise (CCW), the system response time becomes faster. However, if rotated too far CCW, the generator voltage may oscillate (hunt). It should then be rotated CW well above the point where oscillating occurred. The system voltage stability is most critical at no-load. If a setting is desired that provides the fastest possible voltage response with good generator stability, an oscilloscope or some load transient voltage recording device should be used.

Sensing Transformer Reconnection

An internal sensing transformer has provisions for the following voltages:

60 Hz: 120-139/208-240/416-480 and 520-600; ±10%
50 Hz: 100-110/220-230-240/380-400-415 and 500; ±10%

The transformer is normally factory connected to the 120 Vac tap and must be reconnected to another tap before operation if a voltage other than the 120 Vac sensing is used. Reconnection is facilitated through the use of solderless connectors. Figure 4 shows the sensing transformer location and the voltage tap identification.

INSTALLATION

General

The Regulator must be connected to the generator system as instructed in this section and as shown in the basic interconnection diagram (Figure 5).

Input Power (Terminals 3 and 4)

The voltage regulator operates on a power input voltage applied to terminals 3 and 4. If the correct voltage is not available at the generator, or if the field flashing circuit is grounded, a power isolation transformer must be used. The transformer is not furnished with

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the regulator but can be ordered separately from the Basler Electric Company.

The KR Voltage Regulators contain filter capacitors that are internally connected between terminal 3 and the chassis and between terminal 4 and the chassis. Each capacitor is rated at 370 Vac. When using these regulators with generators whose output is above 370 Vac, ensure that the voltage between terminal 3 and ground and terminal 4 and ground does not exceed 370 Vac. The voltage across the regulator's filter capacitors can exceed 370 Vac on an ungrounded generating system when the line-to-line voltage exceeds 370 Vac.

Example (Figure 6): On a 480 Vac generating system with an ungrounded neutral lead and regulator chassis, if the KR7FFX regulator input power (terminals 3 and 4) is obtained line-to-neutral (277 Vac), and then a ground occurs on one of the other two generator lines, 480 Vac will be applied across one of the voltage regulator filter capacitors.

On this same system with the same conditions, but with the regulator connected phase-to-phase (T7 and T9) at the generator's Wye connection tie point (240 Vac) the voltage across the regulator's filter capacitors would have been reduced to 366 Vac.

If the line-to-line voltage of the generating system is reduced to 416 Vac, the voltage across the regulator's filter capacitors is reduced to 318 Vac.

The power input leads are EMI filtered. In most applications, securing the regulator with a good metal-to-metal bond ensures a reduction in interference to acceptable limits. As in all interference reduction situations, it is necessary to maintain a good electrical connection between the filter ground and the system ground. A good electrical power ground is **not** necessarily a good interference ground. Ground leads should be as short as possible, preferably of a copper braid whose width is 1/5 of the length. For applications involving radio reception, additional improvement can be noticed by connecting the system to earth ground. This is because radio reception takes place between an antenna and earth ground. Grounding the system to earth ground simply makes all grounds common.

WARNING!
To eliminate any electrical shock hazard, it is imperative that the regulator chassis (filter ground) be connected to the system power ground. This is because the filter capacitors are connected between the line and the regulator case.

Output Power (Terminals F+ and F-)

The dc resistance of the exciter field winding must be at least the minimum value specified in the *Electrical Specifications*. If the field resistance is less than this value, a series resistor is required to increase the field resistance. This additional resistance is required to limit the regulator field current forcing because excessive current may damage the regulator semiconductors. This resistance must not be of such a value as to restrict the excitation at full load.

Because the regulator output leads are not connected to any part of the system except the generator field, they are not filtered. Since EMI is present on these leads, it may be necessary to observe precautions with regard to the lead installation. Optimum results will be obtained when the field leads are kept as short as possible and shielded. Effective shielding can be achieved by routing both leads through a standard 0.5 inch diameter conduit. Not more than one or two feet of the field leads should be unshielded. If the regulator is installed on the generator frame, it is possible to achieve satisfactory results with short, unshielded leads.

External Voltage Adjust Rheostat

The voltage adjust rheostat (Terminals 6 and 7) is furnished with the voltage regulator for remote mounting and wiring. It should be 175 ohms and 2 watts minimum.

MOUNTING

The Voltage Regulator may be mounted in any position. However, it should be vertically mounted to obtain optimum cooling. The Regulator can be mounted in any location where the ambient temperature does not exceed the operational limits. Due to its rugged construction, the Regulator can be mounted directly on the generator. Mounting hardware should be selected based upon the vibration and shock expected to be encountered during shipping/transport and normal operation. Refer to Figure 7 for the outline drawing of the unit which provides overall and mounting dimensions.

ACCESSORY ITEMS

Voltage Shutdown Switch

The system can be equipped with a switch to allow the removal of the excitation in case of an emergency or when the generator prime mover must be operated at reduced speed. This switch **must always** be placed in the input power line that is connected to the regulator at terminals 3 and 4.

CAUTION!
The voltage regulator dc output (terminals F+ and F-) must never be opened during operation. To do so will produce inductive arcing that can possibly destroy the exciter and/or the voltage regulator. Therefore, **never** place the voltage shutdown switch in the exciter field circuit.

Parallel Operation

An APM 300 Paralleling Module is available for use with the voltage regulator and will provide for the parallel operation of two or more generators.

Manual Voltage Control

A Manual Voltage Control is available for use with the voltage regulator to provide a manual backup that is independent of the voltage regulator.

Excitation Support System

In brushless exciter applications, no source of power is available for field forcing during short circuit and large motor starting conditions. The addition of an Excitation Support System will prevent the collapse of excitation by providing constant voltage to the regulator for all load conditions and short circuits.

OPERATION

This section contains operation procedures. Before operating, ensure that the regulator is connected into the system as shown on the interconnection diagram (Figure 5). Even momentary operation with an incorrect connection can damage the regulator or other control equipment.

Field Flashing

CAUTION!
Do not attempt to flash the machine when it is rotating.

When the Voltage Regulator is operated with the generator for the first time, the polarity of residual magnetism may not be correct or of sufficient magnitude. If the generator does not build up after start-up, check for 6 volts or more residual at the regulator terminals TB1-3 and TB1-4. If the voltage is below 6 volts, shut down the prime mover and proceed as follows:

1. With the prime mover at rest, connect a limiting resistor of 25 to 30 ohms in series with the field (terminals F+ and F-).
2. Observe polarity and apply a dc source (non-grounded) of not more than 12 Vdc, to the series circuit of the field and resistor.
3. Allow approximately 3 seconds before removing the dc source.
4. With the voltage regulator power input disconnected (terminals 3 and 4), start the prime mover and measure the voltage at the generator terminals. If the generator output is less than 6 volts, repeat steps 1 through 3. If the voltage is greater than 6 volts, voltage build-up should occur. Stop the prime mover and reconnect the regulator input power.

Preliminary Operation

Verify that all wiring is properly and securely connected (Refer to Figure 5).

System Checkout

Perform the following steps to ensure the proper operation of the regulator initial operation.

Step 1. Start the prime mover and bring up to rated speed. If a voltage shutdown switch is used, close the switch to apply excitation. When this switch is not used, generator voltage will build-up automatically.

Step 2. Verify the generator output voltage. Note that any of the following conditions may occur:

(a) *Overvoltage*. If this condition occurs, open the shutdown switch and stop the prime mover. determine the cause of the overvoltage. If necessary refer to the troubleshooting chart.

(b) *No Voltage Build-up*. If this condition occurs, field flashing may be required.

(c) *Undervoltage*. If this condition occurs, adjust the External Voltage Adjust Rheostat. If not corrected, refer to the troubleshooting chart.

(d) *Voltage Builds Up and Then Collapses*. If this condition occurs, stop the prime mover and determine the cause by referring to the troubleshooting chart.

(e) *Oscillating Voltage*. If this condition occurs, rotate the Stability Adjustment Potentiometer (R15) to correct. If the voltage continues to oscillate and the Stability Adjustment (R15) has no effect, refer to the troubleshooting chart.

Step 3. Adjust the External Voltage Adjust Rheostat for nominal generator output voltage.

Step 4. Apply a load to the generator.

Step 5. Verify that voltage regulation is within ±1%. If it is not, refer to the troubleshooting chart.

Step 6. Alternately remove and apply the load several times to determine if the generator voltage is stable.

MAINTENANCE AND TROUBLESHOOTING

Preventive Maintenance

The only preventive maintenance required on the KR Series Voltage Regulators is to periodically check that the connections between the Regulator and system are clean and tight and that the air flow is not obstructed by accumulations of dirt and dust.

Corrective Maintenance

The KR Series Voltage Regulators are designed for ease of repair by the replacement of major parts, such as the transformers, heatsinks, or the printed circuit board.

Warranty and Repair Service

The Basler KR Series Voltage Regulators are warranted against defective material and workmanship for 18 months from the date of shipment from our factory. Units submitted for warranty repair should be returned to the factory in Highland, Illinois, freight prepaid, with a complete description of the installation and the reported problem. Pre-arrangement with either the nearest Basler Sales Office or with the factory will assure the fastest possible turn around time.

Functional Testing

To functional test the KR Voltage Regulator, refer to Figure 8 and proceed as follows:

Step 1. Move the wire on the regulator sensing transformer to the 120 V tap.

Step 2. Connect regulator as shown in Figure 8. The light bulb should be 120 Vac with a wattage reading below 200 W.

Step 3. Adjust the External Voltage Adjust Rheostat for maximum resistance (fully counter-clockwise).

Step 4. Connect the regulator to a 120 Vac, 60 Hz. source. Note that the light bulb will flash momentarily when the voltage is applied.

Step 5. Slowly adjust the External Voltage Adjust Rheostat toward minimum resistance (CW). Before reaching full CW rotation, the light bulb should come on to near full brilliance. If the light bulb(s) do not illuminate, the regulator is defective.

Step 6. At the regulating point, a small change in the External Voltage Adjust Rheostat should turn the light bulb on or off.

Step 7. This test may not reveal a stability problem.

Step 8. Before installing the regulator back into the system, connect the regulator sensing transformer back to the original tap selected.

Troubleshooting Chart

Common generator system malfunctions and the appropriate repair procedures are listed in the following paragraphs.

<u>*Voltage Does Not Build up to Rated Value*</u>

Step 1. Check for low residual voltage (less than 6 volts). If low residual voltage exists, flash the field in accordance with *Field Flashing*. If residual voltage is normal, proceed to Step 2.

Step 2. Check that Shutdown Switch is closed and that fuses are intact. If Shutdown Switch is closed and fuses are intact, proceed to Step 3.

Step 3. Check that prime mover is up to speed. If prime mover is operating at rated speed, proceed to Step 4.

Step 4. Verify that generator output is not shorted or heavily loaded. If output is not shorted, proceed to Step 5.

Step 5. Verify that wiring and external Voltage Adjust Rheostat is not defective. If wiring is defective, repair or replace wiring. If rheostat is defective, replace rheostat. If wiring and rheostat are not defective, proceed to Step 6.

Step 6. Verify that all wiring is correctly connected at power input terminals 3 and 4 and that input power is of correct value. If power input is low or not present, repair wiring. If power input is present, proceed to Step 7.

Step 7. Verify that connections at terminals F+ and F- are correct. If connections are incorrect, repair wiring. If connections are correct, proceed to Step 8.

Step 8. Verify that correct sensing tap has been selected. If wrong sensing tap has been selected, reconnect to proper tap. If correct tap has been selected, proceed to Step 9.

Step 9. Verify generator/exciter operation. If generator/exciter operation is improper, contact generator/exciter manufacturer. If generator/exciter operation is proper, proceed to Step 10.

Step 10. If the above steps fail to correct the malfunction, replace the voltage regulator.

<u>*Voltage Builds up and Then Decays*</u>

Step 1. Check for open circuit from external Voltage Adjust Rheostat. If wiring is defective, repair wiring. If rheostat is defective, replace rheostat. If connections are proper and not defective and rheostat is not defective, proceed to Step 2.

Step 2. Replace the voltage regulator.

<u>*Voltage High and Uncontrollable with Voltage Adjust Rheostat*</u>

Step 1. Verify that sensing voltage is available at terminals E1 and E3 and that the proper taps are used. If sensing voltage is not available, correct wiring. If sensing voltage is proper, proceed to step 2.

Step 2. Replace the voltage regulator.

<u>*Voltage High and Controllable with Voltage Adjust Rheostat*</u>

Step 1. Verify that the sensing voltage is available at terminals E1 and E3 and that the proper taps are used. If the sensing voltage is not available, repair wiring. If the sensing voltage is proper, proceed to Step 2.

Step 2. Check for defective voltmeter. If voltmeter is defective, replace voltmeter. If voltmeter is not defective, proceed to Step 3.

Step 3. If the above steps fail to correct the malfunction, replace the regulator.

<u>*Poor Stability (Hunting).*</u>

Step 1. Verify that the frequency is stable. If the frequency is unstable, consult with the governor manufacturer. If the frequency is stable, proceed to Step 2.

Step 2. Check the adjustment of the Stability Adjustment (R15). If adjusting the Stability Adjustment does not correct the malfunction, proceed to Step 3.

Step 3. Verify that the no-load field voltage is not below rated. If the no-load field voltage is below rated, refer to *Installation, Output Power (Terminals F+ and F-)*, and change the field series resistance. If the no-load field voltage is at rated, proceed to Step 4.

Step 4. Verify generator/exciter operation. If generator/exciter operation is improper, contact generator/exciter manufacturer. If generator/exciter operation is proper, proceed to Step 5.

Step 5. If the above steps fail to correct the malfunction, replace the voltage regulator.

<u>*Poor Regulation.*</u>

Step 1. Verify that the field voltage/current requirements at full load are not in excess of the maximum regulator output capability. If regulator limits are being exceeded (per *Specifications)*, consult with the factory for a suitable model. If regulator limits are not exceeded, proceed to Step 2.

Step 2. Verify that the input power to terminals 3 and 4 is correct (see *Specifications*). If input power is incorrect, connect proper power input. If input power is correct, proceed to Step 3.

Step 3. Verify that the generator output voltmeter is connected at the same location as sensing inputs. If voltmeter location is different, reconnect. If voltmeter location is the same, proceed to Step 4.

Step 4. Check for waveform distortion due to harmonic content in generator output voltage. (Regulator senses average voltage, meter may be indicating RMS value.) If waveform distortion is present, use an average sensing (rectifier type) voltmeter to verify regulation accuracy. If waveform distortion is not present, proceed to Step 5.

Step 5. Verify that the Unit/Parallel switch is in Unit position except during parallel operation. If Unit/Parallel is in an incorrect position, place switch into proper position. If Unit/Parallel switch is in proper position, proceed to Step 6.

Step 6. Verify generator/exciter operation. If generator/exciter operation is improper, contact generator/exciter manufacturer. If generator/exciter operation is proper, proceed to step 7.

Step 7. If the above steps fail to correct the malfunction, replace the voltage regulator.

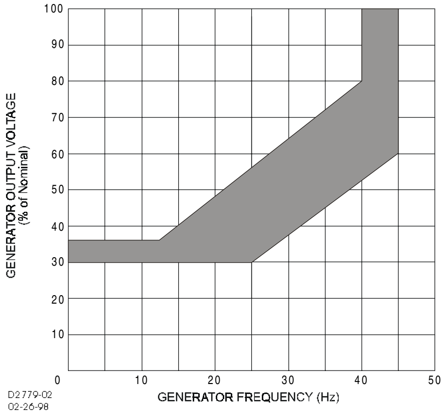

Figure 1. 50 Hz Frequency Compensation

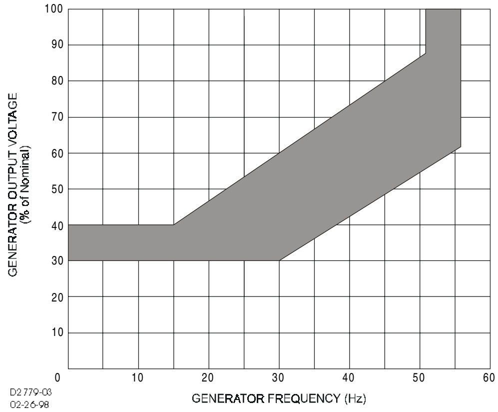

Figure 2. 60 Hz Frequency Compensation

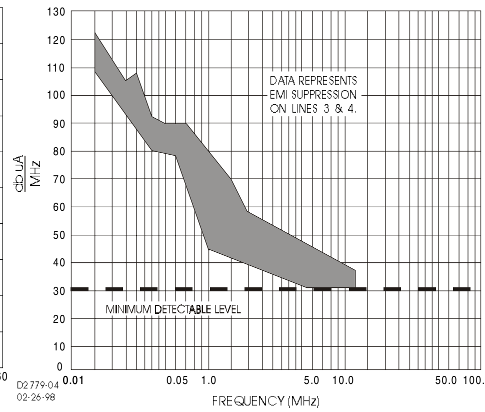

Figure 3. Typical Suppression of Conducted EMI

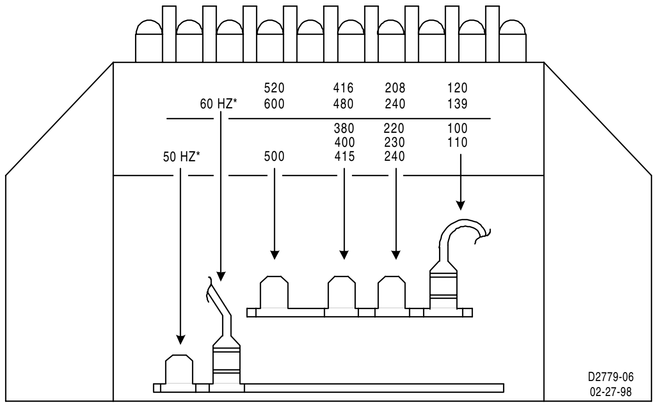

Figure 4. Sensing Transformer Connections

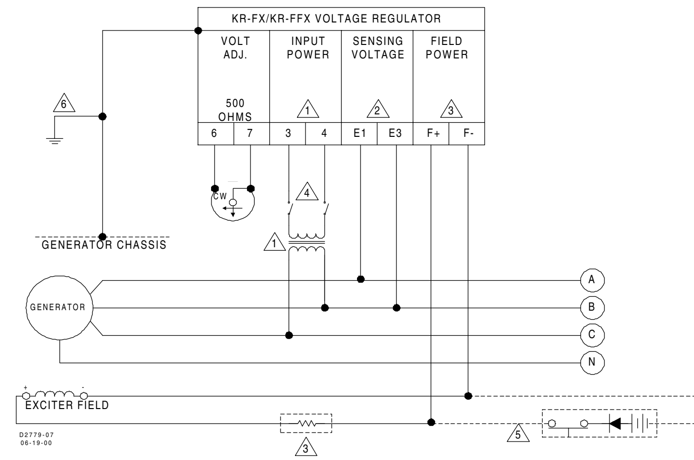

Figure 5. Interconnection Diagram (Typical)

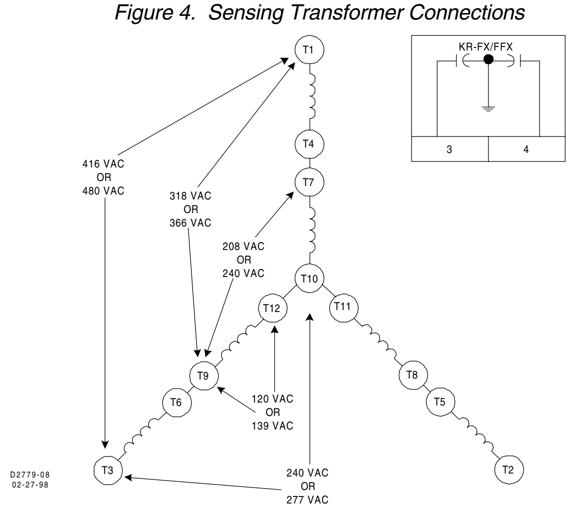

Figure 6. Ungrounded Neutral Generator System (Typical)

NOTES:

1. Power matching transformer is required if appropriate input voltage is not available at generator terminals. If field or flashing circuit is grounded, an isolation transformer is also required.
2. Internal sensing transformer is provided with taps. It is shipped connected to the 120 Volt tap. If voltage other than 120 V is required, connect wire to applicable tap.
3. The exciter field dc resistance must be at least that listed in the *Specifications*. If not, a series resistor must be added so that the total resistance is at least this value.
4. Shutdown switch allows removal of field excitation. If switch is not used, a temporary switch should be installed during initial operation.
5. The regulator contains an internal relay for voltage buildup. If flashing is required, refer to *Field Flashing*. If permanent field flashing is desired, connect as shown and limit flashing current to <50% of no-load field current. Diode rating: 15 A, 600 PIV.
6. Regulator and generator must be grounded. This is pertinent for EMI suppression. If ungrounded, the KR regulator will be electrically hot.

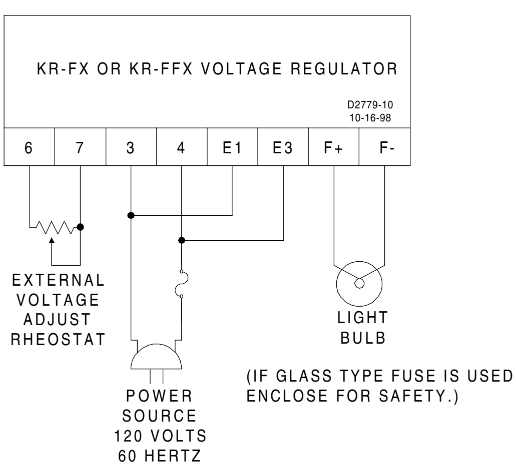

Figure 8. Functional Test Setup

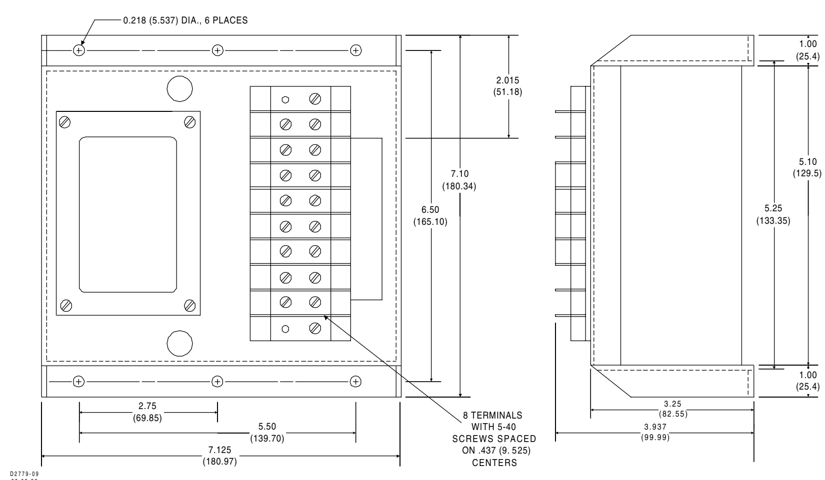

Figure 7. KR Regulator, Outline Drawing