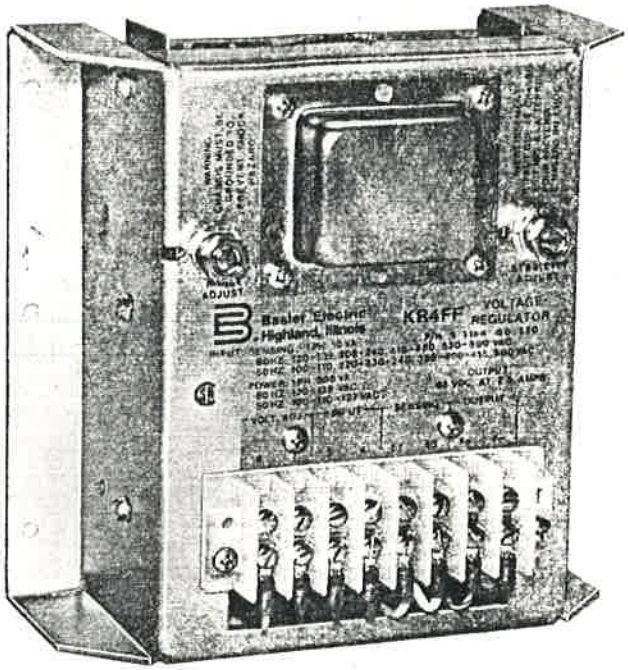
INSTRUCTION MANUAL
FOR
VOLTAGE REGULATOR
Models: KR2F/FM, KR2FF/FFM
KR4F/FM, KR4FF/FFM
KR7F/FM, KR7FF/FFM
Part Numbers: 9 1160 00 XXX through 9 1165 00 XXX



Basler Electric
Highland, Illinois

Publication Number: 9 1160 00 99X
Date: December, 1976
Revision A: October, 1985

WARNING

To prevent personal injury or equipment damage, only qualified technicians/operators should install, operate or service this device.

CAUTION

Meggers and high potential test equipment must not be used. Incorrect use of such equipment could damage components contained in the device.

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SECTION 1.0

GENERAL INFORMATION

1.1 GENERAL

The KR series of Basler voltage regulators control generator output voltage by regulating the amount of current to the exciter field. They include Electromagnetic Interference (EMI) filtering. Underfrequency roll-off characteristic is a built-in feature of the KR-FF series. The operation and specifications of the KR-FM are identical to the KR-F. The same applies for the KR-FFM and the KR-FF.

1.2 SPECIFICATIONS

The following specifications are applicable to both the KR-F and KR-FF series voltage regulators except as noted.

Input Power	See Table 1-1
Output Power	See Table 1-1
Input Sensing Voltage	120-139/208-240/416-480/520-600 Vac +10%(60 Hz); 100-110/220-230-240/380-400-415/500 Vac ±10%(50 Hz)
Phase	Single
Burden (maximum)	10 Va
Field Resistance	See Table 1-1
Regulation Accuracy	±1% maximum over full range of alternator/generator loading and 5% frequency variation.
Regulator Response	Less than 17 milliseconds (20 milliseconds on 50 Hz)
Regulator Drift	Less than 1% for a 72°F (40°C) ambient temperature change.
Voltage Adjust Range	Minimum ±10% of nominal voltage
Regulator Sensing	Single Phase
Operating Temperature Range	-40°F (-40°C) to +140°F (+60°C)
Storage Temperature Range	-85°F (-65°C) to +185°F (+85°C)
Power Dissipation	Less than 20 watts at maximum continuous rating.

Underfrequency Operational Threshold (KRFF series only):	54 Hz nominal in 60 Hz systems. See Figure 1-2 44 Hz nominal in 50 Hz systems. See Figure 1-3
Mounting:	The unit is designed to operate when mounted directly on diesel or turbine driven generator systems. It can also be mounted in switchgear or control panels.
Shock:	Withstands up to 20 G's in each of three mutually perpendicular planes.
Vibration:	Withstands 5 to 26 Hz @ 1.2 G's; 27 to 52 Hz @ .036 double amplitude; 53 to 260 Hz 5.0 G's.
Electromagnetic Interference (EMI) Filtering	See Figure 1-1
Weight	6.0 lbs. net (2.718 kg); 7.0 lbs. shipping (3.171 kg)

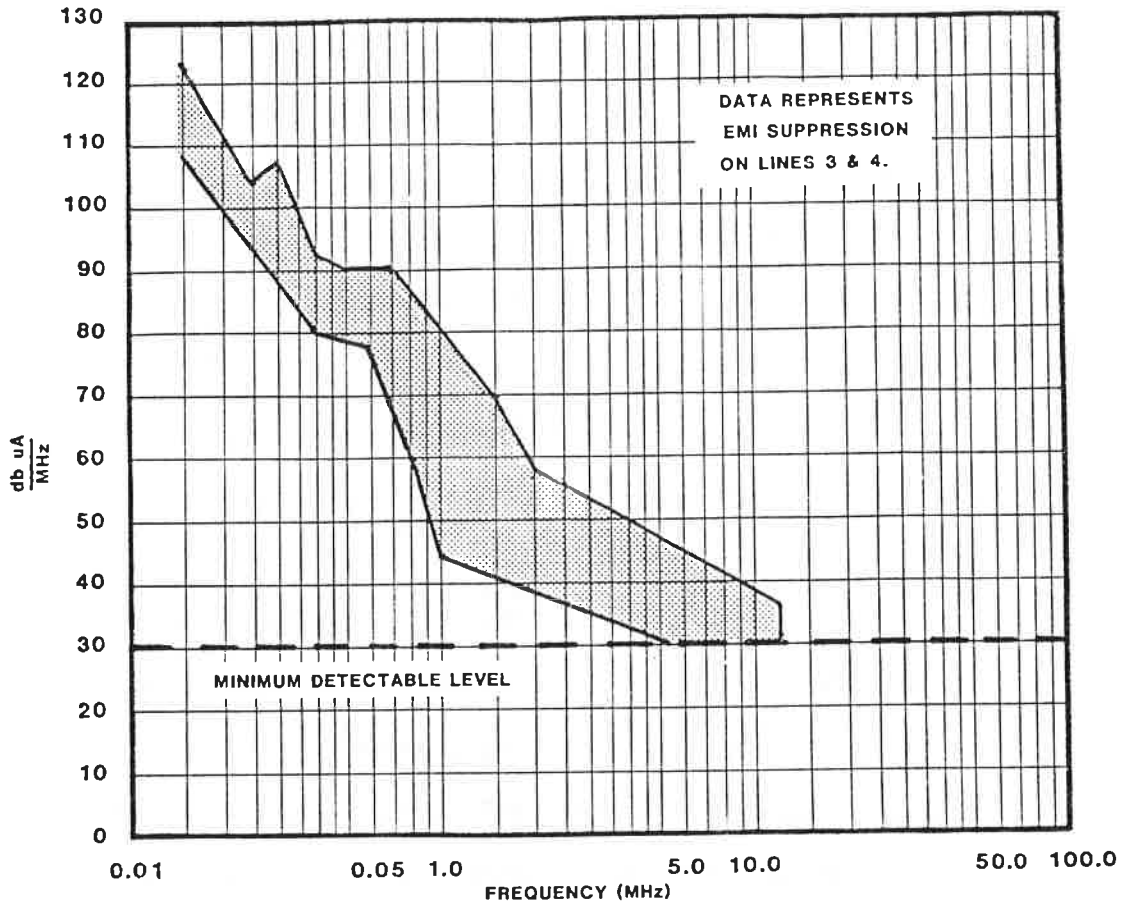


Figure 1-1 Typical Suppression of Conducted EMI

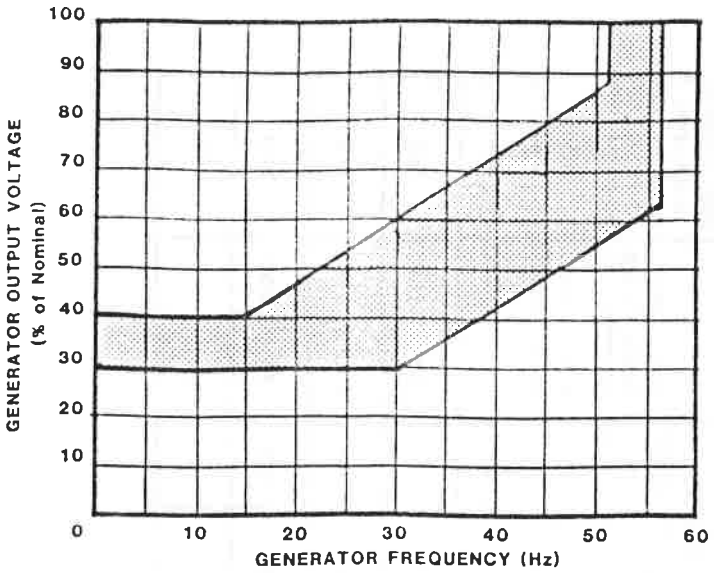


Figure 1-2 Voltage-Frequency Roll-Off Curve.
(60 Hertz System KR-FF Series Only)

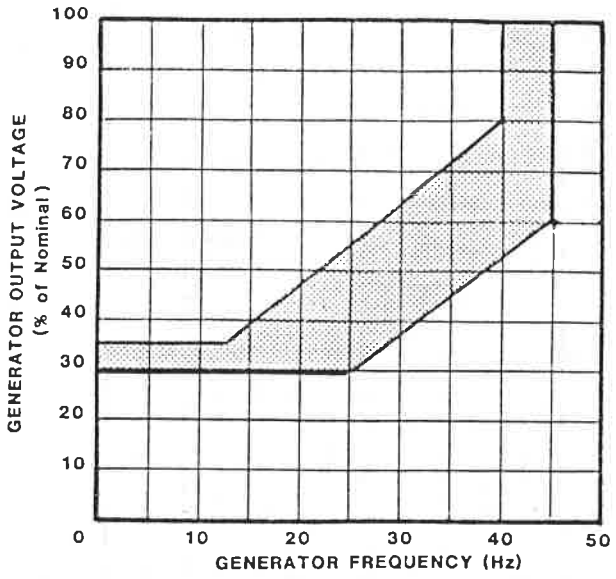


Figure 1-3 Voltage-Frequency Roll-Off Curve.
(50 Hertz System KR-FF Series Only)

Table 1-1. Power Requirements

MODEL	PART NUMBER	POWER INPUT (1)			POWER OUTPUT				FIELD RESISTANCE		UNDER-FREQUENCY ROLL-OFF
					MAXIMUM CONTINUOUS		1 MINUTE FORCING				
		AC VOLTS (3)	FREQ. (Hz)	BURDEN (VA)	VOLTS DC	AMPS DC	(4) VOLTS DC	AMPS DC	MIN. OHMS	MAX. OHMS	
KR2F/FM (2)	9 1160 00 XXX	120-139 100-127	60 50	640 640	32	8	45	12	4.25	400	NO
KR4F/FM	9 1161 00 XXX	120-139 100-127	60 50	300 300	63	2.5	90	3.5	25	400	NO
KR7F/FM	9 1162 00 XXX	208-277 220-240	60 50	840 840	125	3.5	180	5	36	400	NO
KR2FF/FFM (2)	9 1163 00 XXX	120-139 100-127	60 50	640 640	32	8	45	12	4.25	400	YES
KR4FF/FFM	9 1164 00 XXX	120-139 100-127	60 50	300 300	63	2.5	90	3.5	25	400	YES
KR7FF/FFM	9 1165 00 XXX	208-277 220-240	60 50	840 840	125	3.5	180	5	36	400	YES

NOTES:

(1) If correct voltage is not available, a suitable power transformer must be used.

(2) When using a transformer with this regulator, use an airgap isolation transformer.

(3) All voltage ranges in Vac, Plus or Minus 5%.

(4) Voltage forcing ratings based on the following inputs: KR2F, KR2FF, KR4F, KR4FF - 120 Vac
KR7F, KR7FF - 240 Vac

SECTION 2.0

PRINCIPLES OF OPERATION

(Refer to Figure 2-1)

2.1 EMI FILTERING

Power for the regulator is applied to terminals 3 and 4 and then to an electromagnetic interference (EMI) filter which reduces the interference generated by the regulator. The output of the filter is applied to the Thyristor Power Stage.

2.2 THYRISTER POWER STAGE

It is the conduction time of the Thyristor Power Stage that determines the amount of output current to the generator exciter field. Conduction time, in turn, is controlled by the timing of gating pulses from the Sensing and Gating Circuitry. The greater the time of conduction of the thyristor(s), the greater the output voltage.

2.3 GENERATOR SENSING

The generator sensing voltage is connected at E1 and E3. The tap selection on the primary winding of the transformer is as shown in paragraph 3.4. The output voltage from one of the sensing transformer secondary windings is rectified and a representative sample, taken from a voltage divider network is applied to the Sensing and Gating Circuitry.

2.4 SENSING AND GATING CIRCUITRY

The Sensing and Gating Circuitry is comprised of electronic components which sense any change in generator output voltage and translate such changes into gating pulses. The gating pulse is sent to the Thyristor Power Stage to permit it to conduct and provide the correct exciter field current to maintain a constant generator voltage. When the Sensing and Gating Circuitry determines that generator output is low, the gating pulse is applied to the thyristor(s) earlier in the cycles causing a greater output current to flow. When the generator output voltage is high, the gating pulse is applied later in the cycle causing less current to flow to the exciter field.

2.5 VOLTAGE BUILD-UP

When the generator is first placed into operation, the Thyristor Power Stage is bypassed through the closed contacts of K1. During this time, residual generator voltage is rectified and applied directly to the generator exciter field. When the generator voltage builds up to a sufficient value, K1 energizes and gating pulses are applied to the Thyristor Power Stage, as required, from the Sensing and Gating Circuitry.

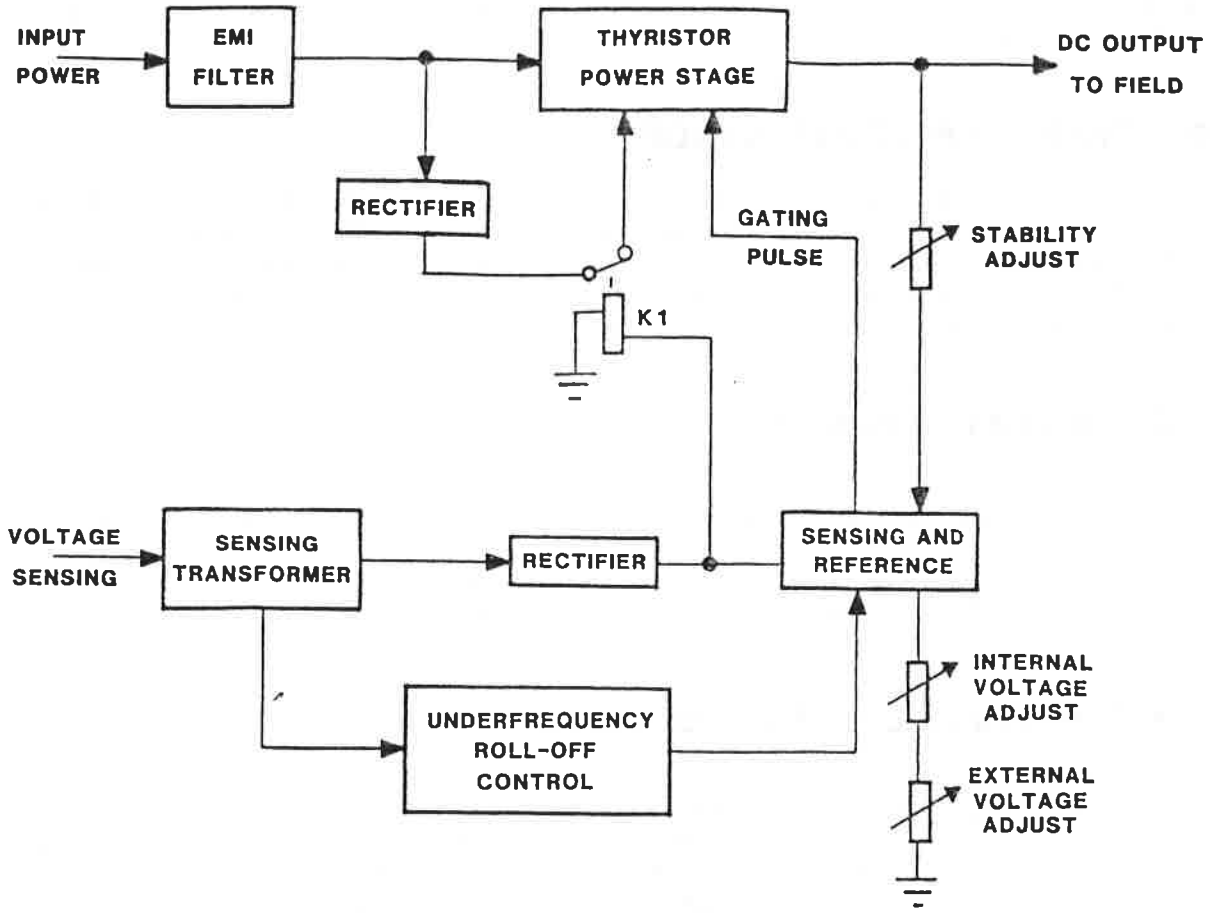


Figure 2-1. Block Diagram.

2.6 STABILITY ADJUSTMENT

A feedback signal taken from the F1 terminal is applied to the Sensing and Gating Circuitry. This signal, controlled by the stability adjustment prevents voltage from hunting or oscillating. (Refer to paragraph 3.3)

2.7 INTERNAL VOLTAGE RANGE ADJUSTMENT

This control permits adjustment of the External Voltage Adjust Rheostat range (refer to paragraph 3.2).

2.8 EXTERNAL VOLTAGE ADJUST RHEOSTAT

The external voltage adjust rheostat connected across terminals 6 and 7 allows adjustment of generator voltage ±10% of nominal. (Refer to paragraph 3.1).

2.9 UNDERFREQUENCY CONTROL (KR-FF ONLY)

The output from a secondary winding of the generator sensing transformer is applied to the Underfrequency Control Circuit. This circuit reduces the regulator output current to the exciter field when the generator is operated at less than rated speed. The percentage of generator output voltage that will be obtained for a specific reduction in frequency is illustrated in Figures 1-2 and 1-3. The horizontal axis of each graph represents generator frequency and the vertical axis represents percent of nominal generator output voltage. The operational envelope (shaded area) indicates the limits within which generator output voltage will be reduced. The shaded area is primarily a function of operational temperature and normal tolerances in components. Typical curves will track between the two extremes, usually closer to the upper limit than the lower. The operation threshold is factory set at 54 Hz for 60 Hz generators and 44 Hz for 50 Hz generators.

SECTION 3.0
CONTROLS AND INDICATORS

3.1 EXTERNAL VOLTAGE ADJUST

This 500 ohm, 25 watt rheostat is supplied as a separate item for panel mounting. It provides adjustment of the regulated generator voltage ±10% of nominal. When connected as shown in Figure 4-1 adjusting it to its maximum resistance position (CCW), minimum generator voltage is obtained. Maximum generator voltage is obtained with minimum resistance (CW).

3.2 VOLTAGE RANGE ADJUSTMENT

This screwdriver adjustment is factory set to establish the nominal ranges of sensing voltage associated with 60 Hz operation. If 60 Hz sensing is employed, this control need not normally be adjusted.

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 (paragraph 3.1) to the middle of its adjustment range, (2) insure that the appropriate sensing voltage connection is made (paragraph 3.4) and that the 50 Hz connection is made (paragraph 3.5), (3) with the regulator properly connected into the system (Figure 4-1) 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 voltage adjustment ±10% of nominal. NOTE: This voltage range adjustment capability exists with 60 Hz operation as well.

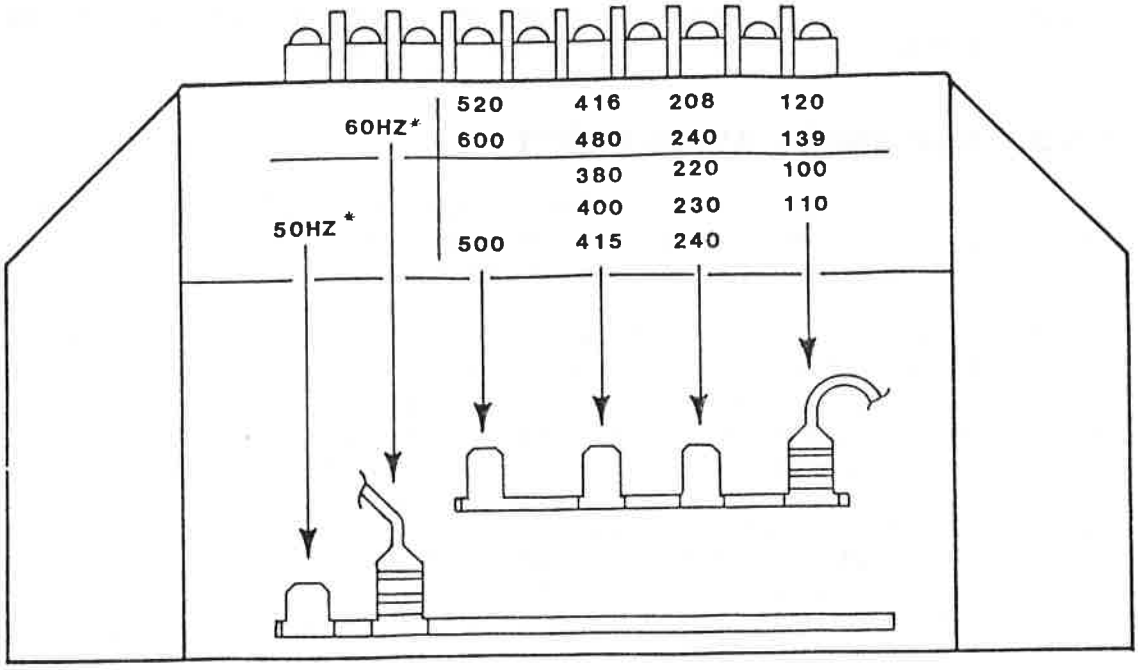
3.3 STABILITY ADJUSTMENT

This screwdriver adjustment adjusts stability by controlling the amount of feedback that is applied to the Sensing and Gating Circuitry. Normally it is factory set 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.

3.4 SENSING TRANSFORMER RECONNECTION

An internal sensing transformer has provisions for sensing 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%



* These terminals apply only to the KR-FF series.

Figure 3-1 Sensing Transformer Connections

The transformer is normally factory connected to the 120 volt tap, and must be reconnected to another tap before operation if other than 120 volt sensing is employed. Reconnection is facilitated through the use of solderless connectors. Figure 3-1 shows the sensing transformer location and the voltage tap identification.

3.5 50/60 HZ CONNECTION (KR-FF ONLY)

The regulator is supplied connected for 60 Hz underfrequency roll-off. If operation is at 50 Hz, move the quick disconnect lead from the 60 Hz position to the 50 Hz position (See Figure 3-1).

SECTION 4.0

INSTALLATION

4.1 INTERCONNECTION (See Figure 4-1)

CAUTION

Meggers and high potential test equipment must not be used. Incorrect use of such equipment will destroy the semiconductors in the regulator.

4.1.1 General

The regulator connects with the generator system as shown in the overall interconnection diagram, Figure 4-1. Number 14 gauge wire or larger should be used for connections to the voltage regulator.

4.1.2 Input Power (Terminals 3 and 4)

The voltage regulator operates on a power input voltage applied to terminals 3 and 4 (see Table 1-1 for input voltages). 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.

CAUTION

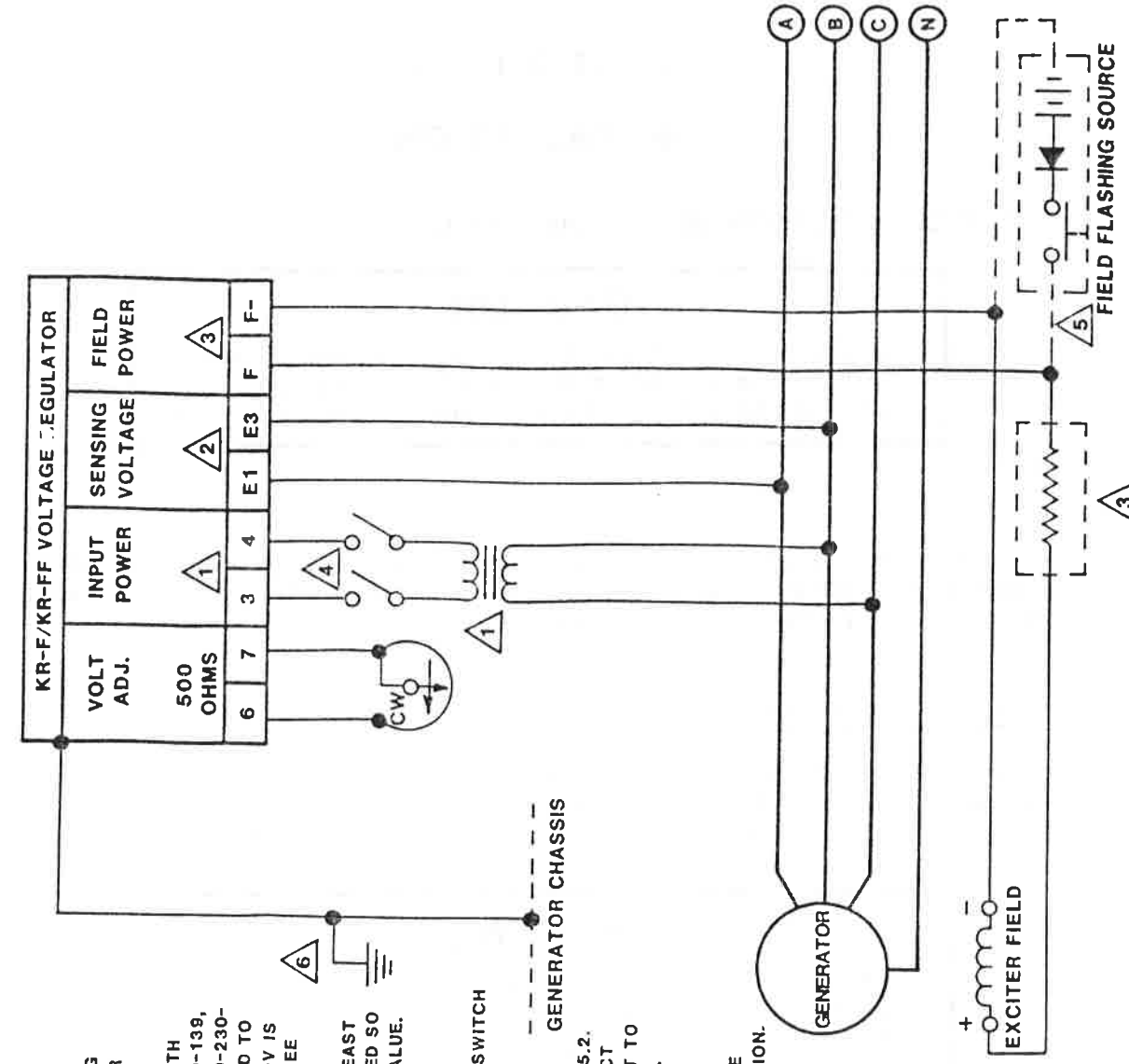
Without the use of this transformer, a ground in the field circuit and a grounded generator output will destroy the thyristor power stage.

The transformer is not furnished with the regulator but can be ordered separately from Basler Electric Company.

CAUTION

Pertains only to ungrounded generator system. (Refer to Figure 4-2.)

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 be careful that the voltage between terminal 3 and ground and the voltage between 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.



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. (SEE SECTION 4.0)
2. INTERNAL SENSING TRANSFORMER IS PROVIDED WITH TAPS FOR THE FOLLOWING VOLTAGES: 60 HZ; 120-139, 208-240, 416-480, 520-600: 50 HZ; 100-110, 220-230-240, 380-400-414, 500. IT IS SHIPPED CONNECTED TO THE 120 VOLT TAP. IF VOLTAGE OTHER THAN 120V IS REQUIRED CONNECT WIRE TO APPLICABLE TAP. (SEE PARAGRAPH 3.4)
3. THE EXCITER FIELD DC RESISTANCE MUST BE AT LEAST *OHMS. IF NOT, A SERIES RESISTOR MUST BE ADDED SO THAT THE TOTAL RESISTANCE IS AT LEAST THIS VALUE. (SEE PARAGRAPH 4.1.3).
4. SHUTDOWN SWITCH ALLOWS REMOVAL OF FIELD EXCITATION. IF SWITCH IS NOT USED, TEMPORARY SWITCH SHOULD BE INSTALLED DURING INITIAL OPERATION.
5. THE REGULATOR CONTAINS AN INTERNAL RELAY FOR VOLTAGE BUILD-UP. ALTHOUGH FLASHING IS SELDOM REQUIRED IF IT IS REFER TO PARAGRAPH 5.2. IF PERMANENT FIELD FLASHING IS DESIRED CONNECT AS SHOWN (ALWAYS LIMIT THE FLASHING CURRENT TO LESS THAN 50% OF THE NO LOAD FIELD CURRENT). DIODE MUST HAVE MINIMUM RATING OF 15A 800 VOLT PIV.
6. THE REGULATOR AND GENERATOR CHASSIS MUST BE GROUNDED. THIS IS PERTINENT FOR EMI SUPPRESSION. IF UNGROUNDED, THE KRFF REGULATOR WILL BE ELECTRICALLY HOT. (SEE PARAGRAPH 4.1.2).

* KR2F & KR2FF - 4.25 OHMS
KR4F & KR4FF - 25 OHMS
KR7F & KR7FF - 36 OHMS

Figure 4-1. Interconnection Diagram (Typical).

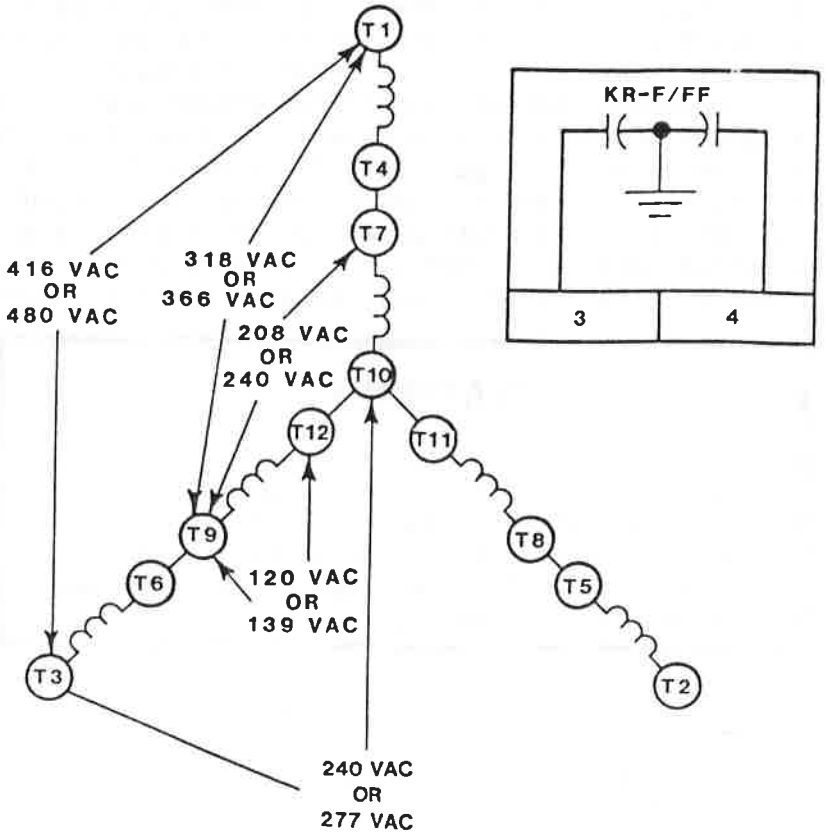


Figure 4-2. Ungrounded Neutral Generator System (Typical).

For example; on a 480 Vac generating system with an ungrounded neutral lead and regulator chassis, if the KR7F/FF 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 generating system with the same conditions just described, but with the KR7F/FF voltage regulator connected from phase to phase (T7 and T9) at the generator's Wye connection tie point (240 Vac - KR7F/FF only) the voltage across the regulator's filter capacitors would have been reduced to 366 Vac.

NOTE: On this same generating system using a KR2F/FF or KR4F/FF voltage regulator connected T9 to T12 (120-139) Vac, one filter capacitor would also be subjected 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 insures reducing interference to acceptable limits. As in all interference reduction situations, it is necessary to maintain a good 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 copper strap whose width is 1/5 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 electrical shock hazard, it is necessary that the regulator chassis (filter ground) be connected to the system power ground because of filter capacitors connected between the line and regulator case.

4.1.3 Output Power (Terminals F+ and F-)

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

*KR2F and KR2FF 4.25 Ohms Min.
KR4F and KR4FF 25.00 Ohms Min.
KR7F and KR7FF 36.00 Ohms Min.

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 in the field leads are kept as short as possible and shielded. Effective shielding can be achieved by routing both leads through standard 1/2 inch conduit. Not more than one or two feet of 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.

4.1.4 External Voltage Adjust Rheostat (Terminals 6 and 7)

The voltage adjust rheostat is furnished with the unit for remote mounting and wiring.

4.2 MOUNTING

This unit is convection cooled and should not be mounted near heat generating equipment or inside totally enclosed switchgear where the temperature rise could exceed its operating limit. Vertical mounting is recommended to obtain optimum convection cooling. (See Figure 4-3.)

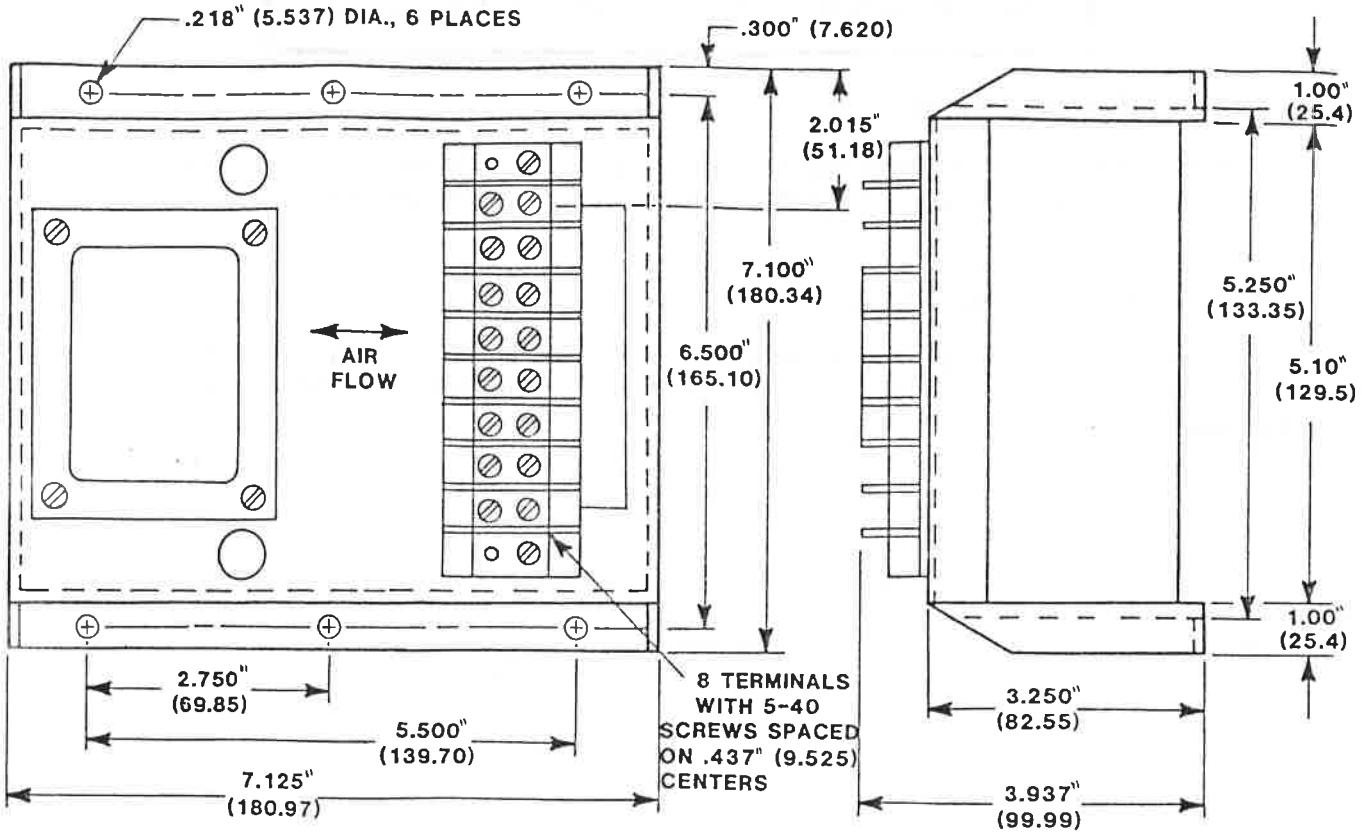


Figure 4-3. Outline Drawing.

4.3 ACCESSORY ITEMS

4.3.1 Voltage Shutdown

The system can be equipped with a switch to allow removal of excitation in 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 to the regulator (terminals 3 or 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.

4.3.2 Parallel Operation

An APM 300 paralleling module is available for use with the voltage regulator to provide parallel operation of two or more generators.

4.3.3 Manual Voltage Control

A manual voltage control module is available for use with the voltage regulator to provide manual voltage control, independent of the voltage regulator.

4.3.4 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 (prevents collapse of excitation by providing constant voltage to the regulator for all load conditions and short circuit.

SECTION 5.0

OPERATION

5.1 GENERAL

This section contains operation and adjustment procedures. Before operating, make certain that the regulator is connected into the system as shown on the Interconnection Diagram (Figure 4-1). Even momentary operation with an incorrect connection can damage this control equipment.

5.2 FIELD FLASHING

CAUTION

Do not attempt to flash the machine while it is rotating

The regulator contains an internal relay for automatic voltage buildup. Usually there is sufficient residual voltage to allow the generator voltage to buildup without flashing. However, if field flashing is required, apply a 12 or 24 Vdc flashing source, (with the prime mover at rest) across terminals F+ and F- on the regulator. The positive of the flashing source must be connected to F+ and the negative to F-. This action remagnetizes the field poles and allows buildup when the system is restarted. Be careful to observe polarities. If these leads are reversed, the flashing secure will be short circuited, resulting in potentially dangerous arcing or heating.

5.2 OPERATION AT REDUCED SPEEDS (KR-F ONLY)

CAUTION

When using the KR-F regulator, do not operate the generating system at reduced speed for an extended period of time. Prolonged operation at speeds lower than normal can seriously damage the voltage regulator and/or exciter field. If prime mover operation at reduced speed is essential, input power should be removed (terminals 3 and 4) from the exciter.

SECTION 6.0

MAINTENANCE AND TROUBLESHOOTING

6.1 PREVENTIVE MAINTENANCE

This unit should be inspected periodically to insure that the air flow is not restricted.

6.2 TROUBLESHOOTING

To avoid trouble during initial operation, the importance of eliminating wiring errors cannot be over-emphasized. The voltage regulator cannot operate properly unless connected correctly, and may fail if operated while incorrectly connected. An effective test, used to determine if the regulator is basically operational, is described in Figure 6-1.

Some of the possible malfunctions that could occur during operation of the voltage regulator and the corrective action are listed in Table 6-1.

It is recommended that the regulator be returned to Basler Electric Company for repair if the problem cannot be resolved using Table 6-1.

NOTES: (1) If, when troubleshooting a generating system, a defective voltage regulator is found, do not install a replacement regulator without first measuring the dc resistance of the exciter field winding to insure that the resistance is above the minimum specified in Table 1-1 for that regulator model.

(2) On generating systems not using a power isolation transformer, or using a power isolation transformer with a grounded secondary, insure that the exciter field winding or circuitry is not grounded before installing a new voltage regulator.

PROCEDURE:

1. MOVE WIRE ON REGULAR SENSING TRANSFORMER TO 120 VOLT TAP.
2. CONNECT AS SHOWN. LIGHT BULB SHOULD BE 120 VOLT (ANY WATTAGE BELOW 200 WATT IS SATISFACTORY).
3. ADJUST EXTERNAL VOLTAGE ADJUST RHEOSTAT FOR MAXIMUM RESISTANCE.
4. PLUG IN REGULATOR TO 120 VOLT 60 CYCLE SOURCE. (LIGHT WILL FLASH ON MOMENTARILY WHEN PLUGGED IN).
5. SLOWLY ADJUST EXTERNAL VOLTAGE ADJUST RHEOSTAT TOWARD MINIMUM RESISTANCE. BEFORE REACHING MINIMUM RESISTANCE LIGHT BULB SHOULD COME ON TO NEAR FULL BRILLANCE. (BRILLANCE WILL BE LESS WHEN TESTING KR2F AND KR2FF.)
6. AT THE REGULATING POINT, A SMALL CHANGE IN THE EXTERNAL VOLTAGE ADJUST RHEOSTAT SHOULD TURN THE LIGHT BULB ON OR OFF.
7. THIS TEST MAY NOT REVEAL A VOLTAGE STABILITY PROBLEM.
8. BEFORE INSTALLING BACK IN SYSTEM, CONNECT REGULATOR SENSING TRANSFORMER TO ORIGINAL TAP.

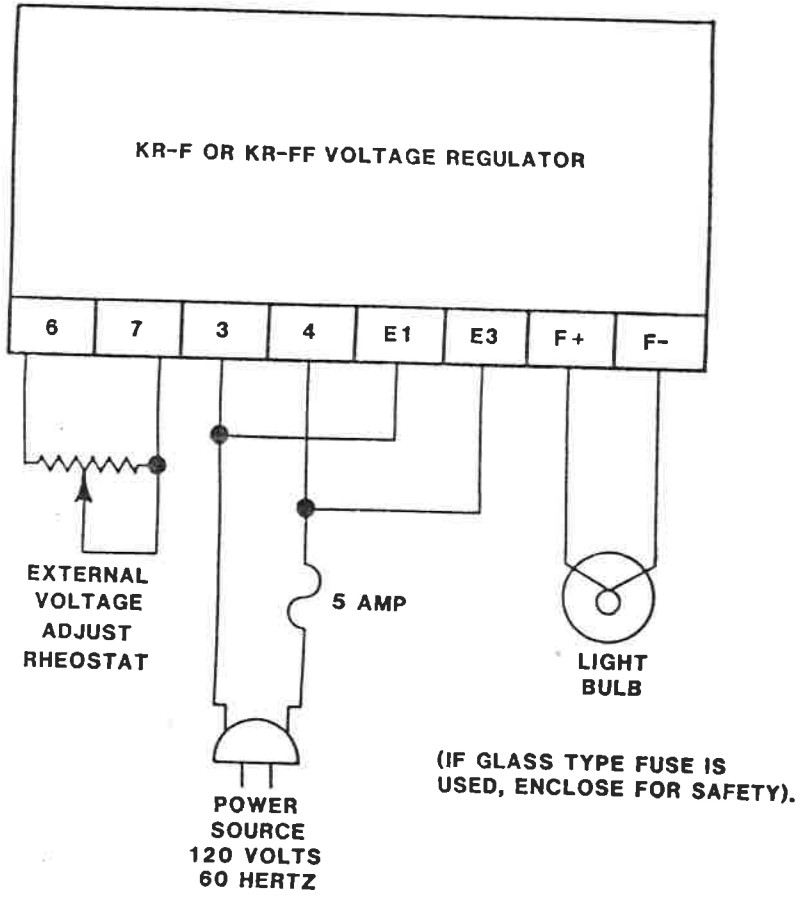


Figure 6-1. Operational Test.

SECTION 7.0
SPARE PARTS

7.1 GENERAL

The spare parts list, Table 7-1, identifies basic parts and assemblies of the voltage regulator with maintenance significance. When ordering parts, specify the complete part number of the voltage regulator, a description of the component part and its part number.

Table 7-1. Spare Parts List

DESCRIPTION	REFERENCE DESIGNATION	BASLER PART NUMBER
EMI Filter	FL1	BE 10281 005
Sensing Transformer	T1	BE 15724 001 (KR-F) BE 15724 002 (KR-FM) BE 15723 001 (KR-FF) BE 15723 002 (KR-FFM)
Resistor, Variable WW, 500 ohm, 25W	External Voltage Adjust Rheostat	06874
Circuit Board Assembly	----------	9 1160 01 120 (KR2F) 9 1160 01 114 (KR2FM) 9 1160 01 117 (KR2FF) 9 1160 01 111 (KR2FFM)
Diode (1N3671AR)	CR14	02677
SCR (16RC40A)	CR17	07476
Circuit Board Assembly	----------	9 1160 01 122 (KR7F) 9 1160 01 116 (KR7FM) 9 1160 01 119 (KR7FF) 9 1160 01 113 (KR7FFM)
SCR (2N4101)	CR15, CR16	09390
Diode (1N3671AR)	CR10, CR11, CR14, CR18, CR19	02677
Circuit Board Assembly	----------	9 1160 01 121 (KR4F) 9 1160 01 115 (KR4FM) 9 1160 01 118 (KR4FF) 9 1160 01 112 (KR4FFM)
SCR (2N4101)	CR15, CR16	09390
Diode (1N3671AR)	CR14, CR18, CR19	02677

Table 6-1 Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE	SOLUTION
Voltage does not buildup to rated value.	Shutdown switch open.	Close switch.
	No input power to terminals 3 and 4.	Verify wiring.
	No connections to F+ and F-.	Verify wiring.
	Low residual voltage (or reverse residual).	Flash Field (see paragraph 5.2).
	Sensing terminals not connected to correct tap.	Verify correct tap (see par. 3.4)
	Prime mover not up to speed.	Bring up to speed.
	Generator output shorted or heavily loaded.	Remove short or load.
	Open in External Voltage Adjust Rheostat or associated circuitry.	Repair open connections or replace rheostat.
	External Voltage Adjust maladjusted. --	Adjust to rated value.
	Faulty voltage regulator.	Replace regulator.
	Defective generator or exciter.	Verify operation of exciter and/or generator.
Voltage high, uncontrollable with the voltage adjust rheostat.	No sensing voltage (terminals E1 and E3).	Verify connections.
	Sensing transformer set to wrong tap.	Verify sensing tap (see paragraph 3.4).
Voltage builds up until relay actuates then decays.	Open in External Voltage Adjust Rheostat or associated circuitry.	Repair open connections or replace rheostat.
	Defective voltage regulator.	Replace regulator.
Poor voltage stability (hunting)	Frequency unstable.	Consult governor manual.
	Stability adjust (R15) out of adjustment.	Adjust CW for increased stability.
	No load field voltage below rated.	See paragraph 4.1.3
	Faulty voltage regulator.	Replace regulator.
	Faulty exciter or generator.	Verify exciter and/or generator operation.
Poor regulation	Unit-Parallel switch in Parallel position. (When Parallel Assembly is used).	Place in Unit position (short parallel CT secondary).
	Regulator sensing and voltage metering not at same location.	Place voltmeter at same point as regulator sensing.
	Waveform distortion in generator voltage. (Regulator senses average voltage; meter; may be indicating RMS value).	Consult generator manufacturer.
	Field requirements exceeds capability of reg.	Verify field requirements.
	Prime mover is not up to rated speed.	Increase speed to rated.
	Input to terminals 3 and 4 low.	Voltage must be that indicated in Table 1-1.
	Faulty voltage regulator.	Replace regulator.
	Faulty exciter or generator.	Verify exciter and/or generator operation.