Instruction Manual

Installation
Operation
Maintenance

Voltage Regulator
P/N 800-84132-10
P/N 800-84132-13

Publication
351-01006-00A (September 1984)

KATO ENGINEERING™

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SAFETY SUMMARY

Follow the precautions described below when installing, adjusting, testing, operating and repairing this equipment.

WARNING

Lethal voltages, 208 VAC or higher, are present at the voltage regulator when generator set is operating. Stop generator set before making connections, repairs or adjustments to this equipment. Disregarding this precaution can result in serious injury or electrocution.

WARNING

Install this equipment only in accordance with the instructions contained in this manual and wiring diagram provided with generator. Incorrect wiring can cause fire hazard and can destroy this equipment.

CAUTION

The DC output field circuit must not be opened or grounded while the unit is running. To do so will cause inductive arcing that can destroy this equipment.

CAUTION

High potential and megger tests must not be made to the voltage regulator. To do so will destroy this equipment.

CAUTION

Do not attempt to flash the exciter field while the generator set is running and be careful to maintain correct polarity when connecting flashing source. Disregarding this precaution can result in equipment damage.

PUBLICATION NUMBER: 351-01006-00A
PUBLICATION DATE: **SEPTEMBER 1984**
SUPERSEDES PUBLICATION **351-01006-00**

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SECTION 1
THEORY OF OPERATION

REGULATOR CIRCUITS

The voltage regulator consists of magnetic amplifiers and a solid state control that regulates the control current applied to the magnetic amplifiers. Figures 5-1 and 5-2 show parts comprising the voltage regulator assembly. Parts located on the circuit board portion of the regulator are shown on Figures 5-3 and 5-4. The various circuits that make up the voltage regulator are described in the paragraphs that follow.

A. Power Stage

The voltage regulator dc output applied to the generator exciter field is provided by the power stage circuitry. The power stage circuit includes magnetic amplifiers MA-1 and MA-2, and full-wave rectifiers BR1 and BR2 as shown on Figures 5-1 and 5-2. Conducted electromagnetic interference is suppressed through use of an RFI filter. The circuit also includes an inductive load transient voltage suppression network comprised of resistor R32, capacitor C7, and surge suppressor SP1 (shown in Figure 5-3).

The magnetic amplifiers MA-1 and MA-2 consist of gate windings G1 and G2 wound on high permeability ferromagnetic cores. DC control windings C1 and C2 are also wound on the core.

The 120 VAC, 400 hertz regulator input power is applied to a circuit comprised of the gate windings G1 and G2 on the magnetic amplifiers and rectifiers BR1 and BR2.

The magnetic amplifier core is magnetized from low magnetization to saturation by positive pulses across gate windings G1-G2. For the period of time during the duty cycle where magnetization of the core occurs, back emf keeps current flow to the output low. Then when the cores saturate, current flow increases to maximum.

Average dc excitation supplied to the generator exciter field depends on the ratio of each positive half cycle of the input required to saturate the core with respect to the time during the half cycle where the core is saturated. This ratio is controlled through resetting the core by applying direct current to the control winding C1-C2. The further below saturation the cores are driven during each duty cycle, the longer will be the time required to saturate the cores resulting in lower magnetic amplified dc output. Conversely, less control current will result in less reset and increased average dc output.

The control current applied to winding C1-C2 is automatically regulated as described in the paragraphs that follow. The circuitry is shown on Figure 5-3.

B. Sensing Transformer, Sensing Rectifier, and Voltage Divider

Sensing voltage from the generator is applied to the primary winding on sensing transformers T1 and T2 (shown on Figure 5-2). Voltage proportional to the sensing voltage is developed across the sensing transformers secondary winding. This voltage is then fed to a full wave sensing rectifier comprised of diodes D1 through D6 (shown on Figure 5-3). Transformer T2 is omitted for single phase sensing.

The rectifier output is filtered by capacitor C1 and choke L1, then applied across a voltage divider comprised of resistor R2, resistor R4, voltage range adjust potentiometer R3, and the external voltage adjust rheostat. A portion of the voltage across the voltage divider which is proportional to the sensing voltage establishes the base voltage for transistor Q1 in the error detector circuit.

C. Error Detector, Second Stage Differential Amplifier, and Control Signal Amplifier Circuits

The error detector includes an emitter coupled differential signal amplifier comprised of transistors Q1 and Q2 connected as shown on Figure 5-3. A representative portion of the rectified sensing voltage from the voltage divider described in preceding paragraphs provides base voltage to transistor Q1, while a fixed reference voltage established by the Zener voltage across Zener diode Z1 provides base voltage for transistor Q2.

An increase in the representative sample of the sensing voltage applied to Q1 will cause Q1 collector current to be higher than the collector current of Q2. This action will result in an increase in base voltage applied to transistor Q3 in the second stage differential amplifier. This action will cause Q3 to conduct more than Q4, which will increase the base voltage and thereby the output of the control signal amplifier (Q5, Q6). An increase in control signal amplifier output will result in higher control current applied to the magnetic amplifier control winding (C1-C2), reset of the magnetic amplifier further below saturation which will reduce voltage regulator output applied to the generator exciter field, and a proportional decrease in generator output voltage.

A decrease in the representative sample of the sensing voltage applied to Q1 will cause Q1 to conduct less than Q2. This action will result in lower base voltage to Q3 and a decrease in Q3 collector current. Q5 and Q6 will then conduct less, reducing the control current applied to the magnetic amplifier control winding. This action will result in less reset of the magnetic amplifier cores which will allow faster saturation of the cores and increase magnetic amplifier output applied as dc excitation to the generator field winding. The increased excitation will proportionally increase generator output voltage.

The dc power supply for transistor pair Q5, Q6 is obtained from a full wave rectifier comprised of diodes D8 through D11. The rectifier input power is obtained from the secondary winding of a voltage step-down power transformer(T3).

D. Stability Circuit

This circuit prevents oscillation or hunting of the generator output voltage by injecting a stabilizing signal into the error detector circuit. The stability circuit consists of a two stage RC network comprised of resistors R5, R6 and R16, capacitors C2 and C5 and a stability adjust potentiometer (R7). The parts comprising this circuit are shown on Figure 5-3.

SECTION 2
INSTALLATION

MOUNTING

The voltage regulator can be mounted vertically or horizontally. The voltage regulator is cooled by ambient air. Allow sufficient space about the unit for unobstructed flow of air and to permit servicing of the assembly and adjustment of the controls. Location of mounting holes and outside dimensions are shown on Figures 5-1 and 5-2.

ELECTRICAL CONNECTIONS

Connect interconnecting electrical wiring to the voltage regulator as shown on the wiring diagram provided with the generator set and the instructions that follow.

A. Sensing (Terminals E1, E2, and E3)

The voltage regulator is available with either single or three phase sensing at 208 or 240 VAC 400 HZ. Connect the sensing to terminal E1 and E3 for single phase sensing models. Internal wiring from terminals E2 and E3 to sensing transformers T1 and T2 determine the nominal sensing voltage.

1. 208V Sensing (For use from 200-220 VAC)

   The wire from terminal E3 should be connected to sensing transformer T1 terminal H2. On three phase sensing models the wire from terminal E2 should be connected to sensing transformer T2 terminal H2.

2. 240V Sensing (For use from 220-264 VAC)

   The wire from terminal E3 should be connected to sensing transformer T1 terminal H3. On three phase sensing models the wire from terminal E2 should be connected to sensing transformer T2 terminal H3.

CAUTION

Sensing must not be opened or grounded while unit is operating. Disregarding this instruction can result in equipment damage.

B. Voltage Regulator Input Power (Terminals L1 and L2)

Connect single phase, 120 VAC, 400 hertz power to the voltage regulator terminals L1 and L2 as shown on the wiring diagram provided with the generator. In application where one of these lines connects to the generator neutral line (N), the neutral should connect to terminal L2.

C. Fuse (F1)

A 5 ampere, 250 volt fuse is series connected in the regulator input power circuit as shown in Figure 5-2. Location of this fuse is shown on Figure 5-1. The fuse side of the regulator input power circuit should not be grounded. (See preceding paragraph).

D. Regulator DC Output (Terminals F+ and F-)

Connect to the generator exciter field leads as shown on the generator set wiring diagram. Be sure to maintain polarity F+ to + and F- to -).

CAUTION

Regulator dc output must not be opened, shorted, or grounded while unit is operating. Disregarding this instruction can result in equipment damage.

E. Regulator Chassis Ground

Grounding of the metal case is recommended. Where voltage regulator mounts solidly within a metal control cabinet, a ground wire connected to the control cabinet will provide satisfactory voltage regulator case ground.

F. External Voltage Adjust Rheostat

Refer to the wiring diagram supplied with the generator set and Figures 5-1 and 5-2.

The drawing shows terminal on the rheostat as observed from the back side of the unit. Interconnecting lines run from the left end terminal on the rheostat to regulator terminal R1 and from the right end terminal on the rheostat to regulator terminal R2. The rheostat must have a jumper wire from its center terminal to the end terminal that interconnects to regulator terminal R1.

SECTION 3
ADJUSTMENTS

EXTERNAL VOLTAGE ADJUST RHEOSTAT

This control permits adjustment of the generator output voltage. Adjust while unit is running at rated speed with no load applied (output circuit breaker open). If necessary, make final adjustment when load is applied. Voltage regulator should automatically keep generator voltage at the voltage selected by adjustment of the voltage adjust rheostat.

Turn rheostat clockwise to increase voltage, counter-clockwise to decrease voltage.

VOLTAGE RANGE ADJUST R3

This control extends the range of the external mounted voltage adjust rheostat. The voltage range adjust R3 is located on the circuit board section in the voltage regulator as shown on Figure 4. Adjustment is made using a small screwdriver. Adjustment may be made as described in either of the two methods that follow.

A. R3 Adjustment For Rated Voltage With Auto Voltage Adjust At Mid-Range

Where this setting is desired adjust as follows:

1. Open output circuit breaker. Adjustment is made with no-load applied.
2. Set external voltage adjust rheostat to mid-range (one-half between full counter-clockwise and full clockwise).
3. Start generator set and operate at rated speed.
4. Measure generator output voltage using ac voltmeter.
5. Turn the voltage range adjust as necessary to obtain required output voltage.

NOTE: Turn R3 clockwise to increase voltage, counter-clockwise to decrease voltage.

B. R3 Adjustment to Limit Maximum Voltage

This adjustment procedure may be used where it is desired to limit maximum voltage in the event the external voltage adjust is turned to its complete clockwise position. Adjustment procedure follows:

1. Open output circuit breaker and turn the external voltage adjust rheostat to maximum clockwise position.
2. Start generator and operate at rated speed.
3. Measure generator voltage using generator set ac voltmeter.
4. Turn range adjust R3 to position where meter indicates voltage is the maximum allowable voltage for the application.
5. Decrease voltage to nominal by turning the external voltage adjust rheostat counter-clockwise.

STABILITY ADJUSTMENT R7

This control is located on the circuit board section in the voltage regulator as shown on Figure 4.

This control injects a stabilizing signal into the voltage regulator circuitry which prevents oscillation of the generator voltage. Turning the control clockwise using a screwdriver increases the stabilizing signal. Excessive clockwise setting, however, may slow down the response time of the unit. In case adjustment of this control is required, the effect on output voltage should be measured using an oscilloscope. R7 must be adjusted to provide stable generator output at no-load and with load applied.

SECTION 4
TROUBLESHOOTING AND MAINTENANCE

PREVENTIVE MAINTENANCE

Periodic inspection should be made on this unit to ensure that it is kept free of dirt and moisture. Also, it is recommended that the wiring be checked for satisfactory condition (absence of frayed or broken insulation); all connections should be checked and tightened at this time.

TROUBLESHOOTING

Troubleshooting is the process of recognizing malfunctions of the system, intelligently analyzing the malfunctions, and making the necessary corrections to place the unit back into proper operation. The more common generator system malfunctions and the appropriate repair procedures are listed in the troubleshooting chart that follows.

TABLE 4-1 TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
No generator output voltage.	Defective flashing circuit.	Check flashing circuit. Repair defects, flash field.
	Open or shorted generator windings..	Test windings for shorts or opens. Replace defective parts.
Generator output drops to zero after flashing.	Regulator input power circuit fuses open.	Replace fuses.
	Open circuit between regulator output and exciter field.	Check wires and connections.
	Regulator input power open.	Check connections and wiring to regulator input power terminals (L1 and L2). Should be 1 phase, 120 VAC, 400 Hz.
	Open magnetic amplifiers.	Check for open windings. Replace defective magnetic amplifiers.
	Open rectifiers in BR1 or BR2.	Test rectifiers. Replace assembly if rectifiers are open or shorted.

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
Generator voltage low, but can be controlled by turning voltage adjust rheostat.	Voltage range adjust R3 requires adjustment.	Adjust potentiometer.
	Improper connections of sensing transformer.	Check wiring.
Generator output voltage low and uncontrollable.	Input power to regulator low.	Check circuit power to terminals L1 and L2. Should be 1 phase, 400 hertz, 120 VAC.
	Frequency low.	Increase speed to rated value.
	Improper connections of sensing transformer.	Check wiring.
	Excessive control current due to defective preamplifier, sensing or control windings.	Test components for open and short circuit. Replace circuit board 841-02053-77 or the voltage regulator.
Voltage high, regulator output full on.	Sensing transformer open or improperly connected.	Check sensing circuit wiring.
	Low or no control current due to defective preamplifier, sensing or control windings.	Test components for open and short circuit. Replace circuit board or the voltage regulator.
	Voltage adjust rheostat or voltage range adjust R3 open.	Check potentiometers. Replace if open. In addition, check wiring to remote mounted voltage adjust R1.
	Stability adjust potentiometer R7 open.	Check for open resistor. Replace if defective.
Voltage oscillates (hunts).	Prime mover speed fluctuating.	Refer to prime mover instructions.
	Stability control R7 adjustment.	Adjust clockwise for stable voltage at no load and also with load applied.

COMPONENT TEST PROCEDURE

CAUTION

Megger and other high potential test equipment should not be used. Incorrect use of such equipment could destroy the rectifiers, transistors, and capacitors in the regulator.

When testing insulation resistance of generator windings with a megger, first disconnect leads between regulator and generator.

A. PNP and NPN Transistor Test

Silicon transistors can be tested with a three-volt test light as detailed in the following chart. Testing by the test light method will normally indicate if a transistor is open or short circuited. Remove transistor from circuit to prevent other components in circuit from affecting readings. The light indications listed in Table 4-2 are those which should be observed if transistor is not shorted or open.

TABLE 4-2 TRANSISTOR TEST CHART

TRANSISTOR TYPE	TEST LAMP NEGATIVE LEAD CONNECTED TO-	TEST LAMP POSITIVE LEAD CONNECTED TO-	LIGHT INDICATIONS
NPN	BASE BASE	EMITTER COLLECTOR	NO LIGHT NO LIGHT
	EMITTER COLLECTOR	BASE BASE	LIGHT LIGHT
PNP	BASE BASE	EMITTER COLLECTOR	LIGHT LIGHT
	EMITTER COLLECTOR	BASE BASE	NO LIGHT NO LIGHT

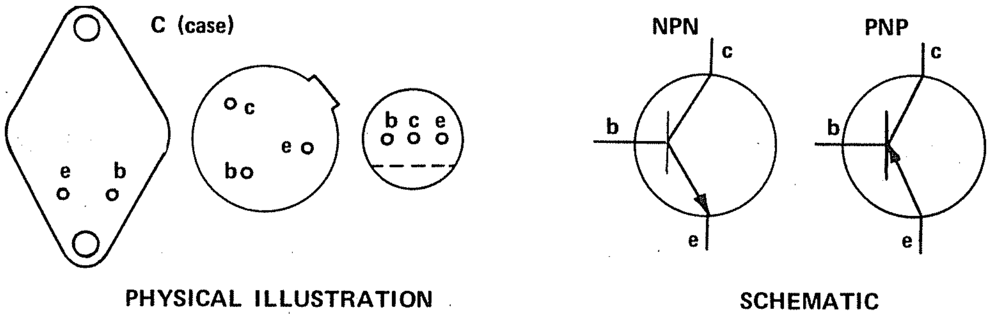


Figure 4-1 Transistors

B. Rectifier Test

Small brown surface marks, sometimes developed by rectifiers during normal operation, usually do not adversely affect rectifier operation.

Remove one lead from circuit.

NOTE: If the resistance is taken with rectifier leads connected in circuit, readings may reflect resistance of other components.

Test with ohmmeter or three-volt test light as follows:

1. Connect ohmmeter or test light leads across rectifier. Observe ohmmeter readings or, if test light is used, observe light bulb.
2. Reverse leads. Again observe ohmmeter readings or, if test light is used, observe light bulb.
3. A good rectifier will have high resistance in one direction and low resistance in the opposite direction. If a test lamp is used, the bulb should light in the direction where resistance is low, and should not light in the direction where resistance is high. If a low resistance is indicated in both steps 1 and 2, the rectifier is probably shorted. A high resistance in both steps 1 and 2 indicates an open rectifier.

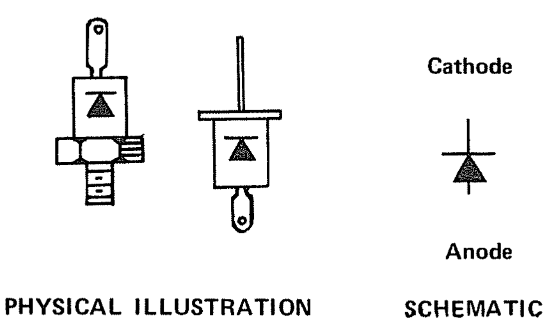


Figure 4-2 Silicon Rectifier

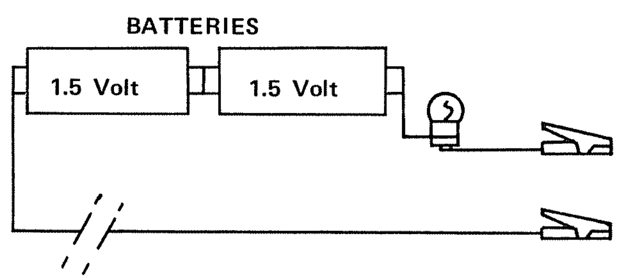


Figure 4-3 Three-Volt Test Lamp

C. Capacitor Test

1. Capacitors may be checked on a capacitor bridge to measure capacitance and leakage. Capacitance should not vary more than ± 10% of their rated values.
2. An approximate check may be made with an ohmmeter set to a high resistance scale. The meter should initiallv indicte low resistance and then gradually increase until capacitor is fully charged.

D. Power Transformer Test

1. With rated voltage on the primary windings, check the secondary voltages. Measured voltages, taken when a transformer is unloaded, run up to about 10 percent higher than those taken when the transformer is wired into its circuit.
2. Typical transformer defects are shorts between windings, open windings, and shorted turns. These usually may be detected by checking resistances and voltages. When the transformer overheats and the existence of shorted turns cannot be proved by resistance measurement, check the no-load alternating current in the primary winding. This excitation current will be excessive if there are shorted turns.

E. Current Transformer Test

Current transformers have a fixed ratio of current between the primary and secondary. The ratio between these currents is determined by the turns ratio. The following test should be made for shorted turns.

1. Load the generator to produce primary current in the transformer.
2. Measure the secondary current.

CAUTION

Do not open the secondary of a current transformer while the circuit is energized.

The ratio of primary to secondary current is approximately the same as the ratio of secondary turns to primary turns. If secondary current is considerably less than it should be, shorted turns are indicated.

F. Rheostats and Resistors

Check resistance values with an ohmmeter. Rheostats and adjustable resistors should be checked over their full range. Care should be taken to avoid damage to the fine wire when setting adjustment bands on adjustable resistors. The adjustment band should be loosened until it slides freely on the resistor tube.

SECTION 5
PARTS LIST AND DRAWINGS

Voltage regulator parts list and drawings are contained on the pages that follow. Because of the difficulty of making repairs to conformal-coated circuit boards, replacement of board or regulator rather than repair is recommended.

Parts List For Static Exciter Regulator

KEY NO.	DESCRIPTION	PART NUMBER	NO. REQ'D
AMP1	Circuit Board	841-02053-80	1
MA1, MA2	Mag Amp	857-42411-90	2
F1	Fuse Holder	516-30001-00	1
	Fuse, 5 amp. 250 volt	515-01205-31	1
T1, T2	Transformer, Sensing, 208-240V	855-62810-01	1
T3	Transformer, Power	855-52810-00	1
L1	Choke, E187	859-52010-00	1
TB1	Terminal Strip	531-30311-12	1
BR1	Bridge Rectifier Assembly	851-31616-10	2
	RFI Filter Assembly	514-00404-97	1
VAR	Voltage Adjust Rheostat 250 Ohm Use either of the following as listed on the panel bill of material 250 ohm, 25 watt rheostat or: 250 ohm, 2 watt, potentiometer	 867-32575-23 867-32522-80	

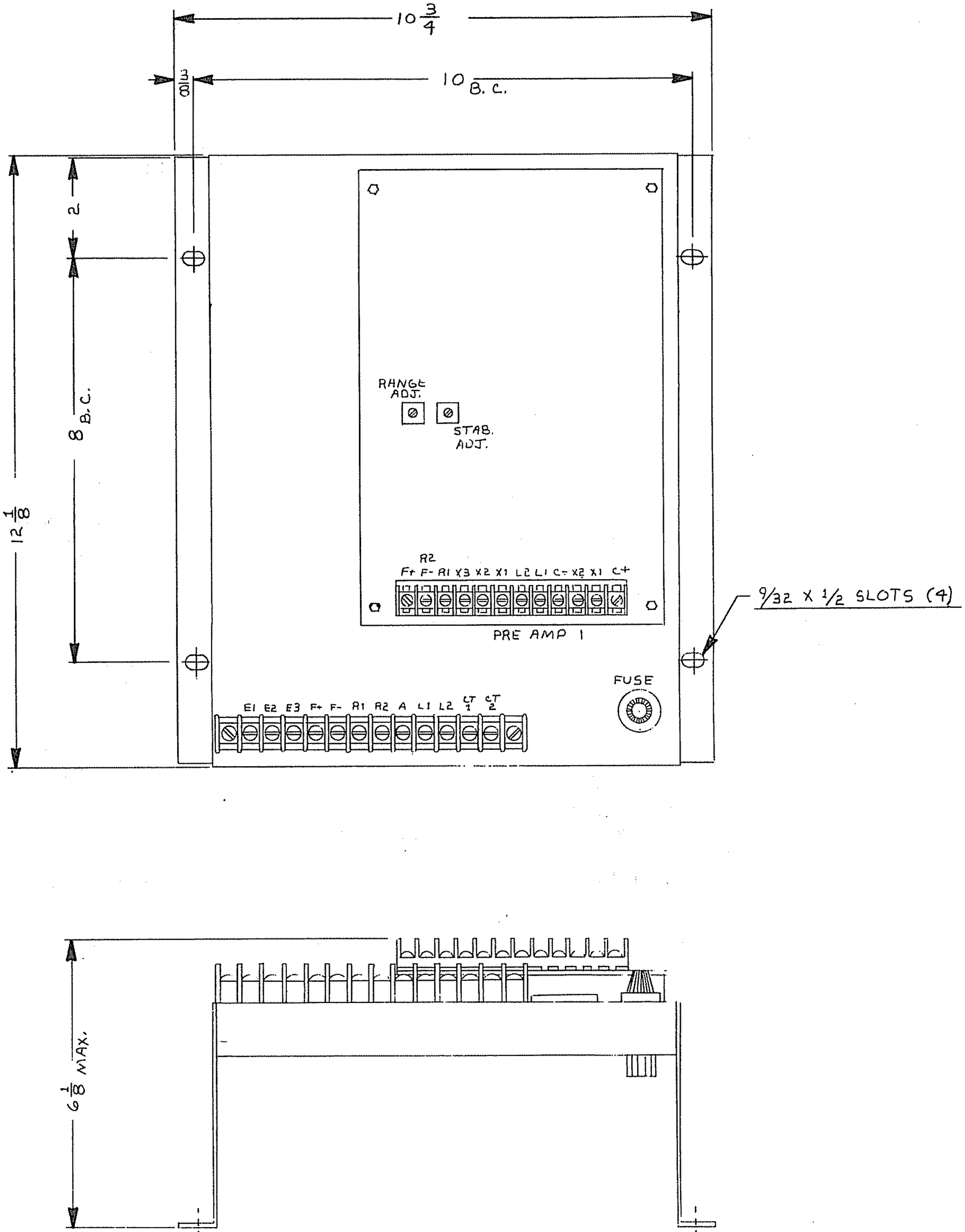
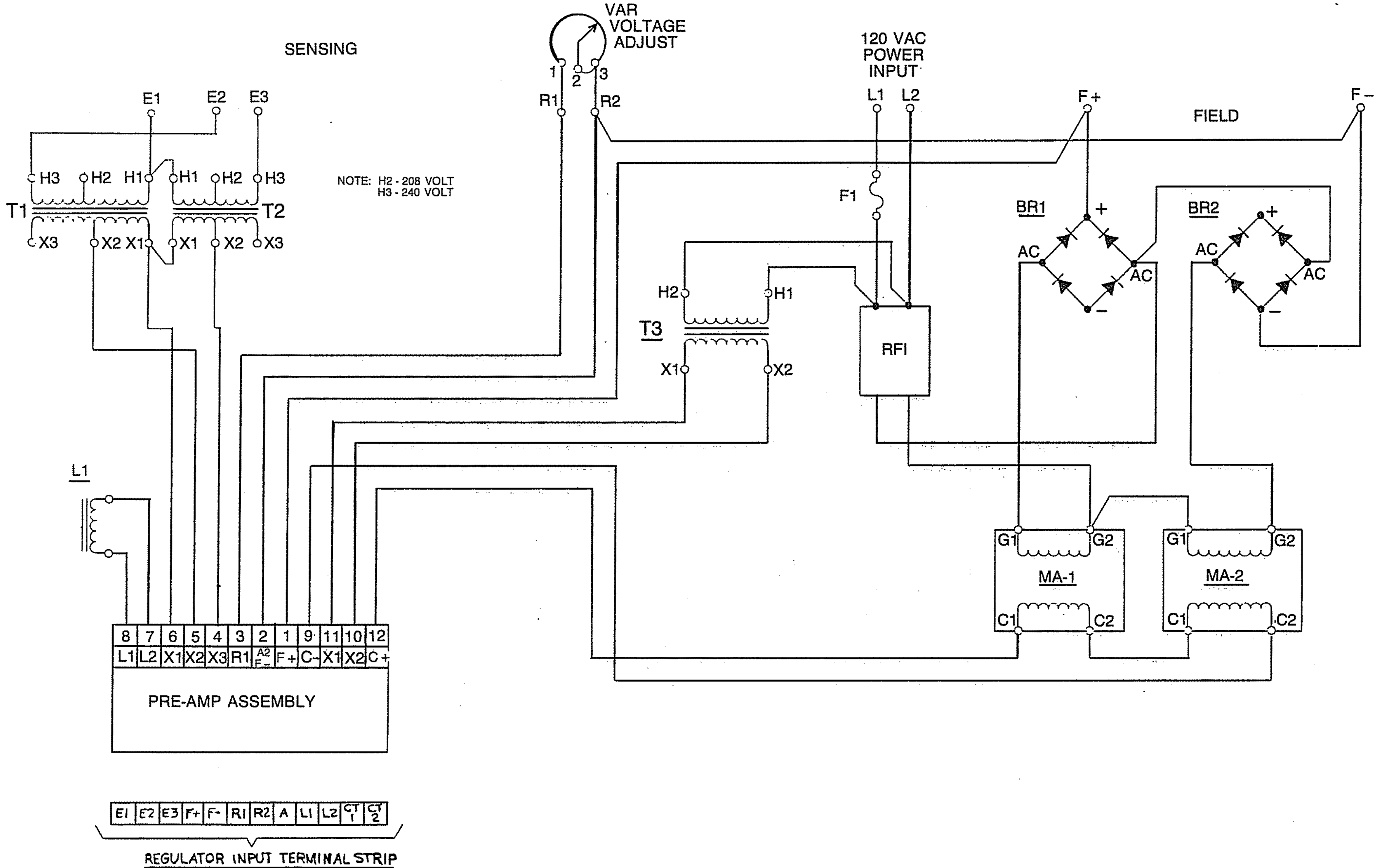


Figure 5-1 Regulator Outline Drawing



NOTE: Transformer T2 is used only on regulators with three phase sensing

Figure 5-2 Regulator Electrical Schematic

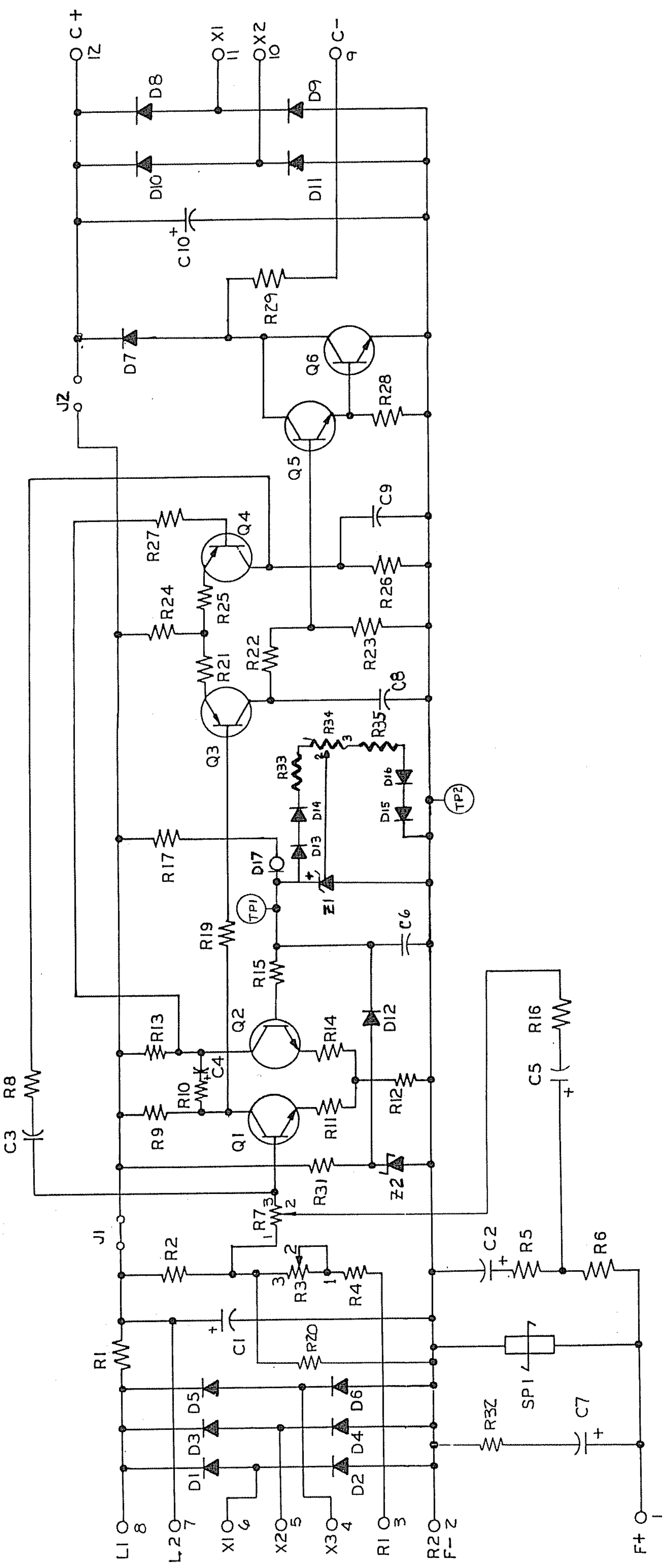


Figure 5-3 Circuit Board Schematic

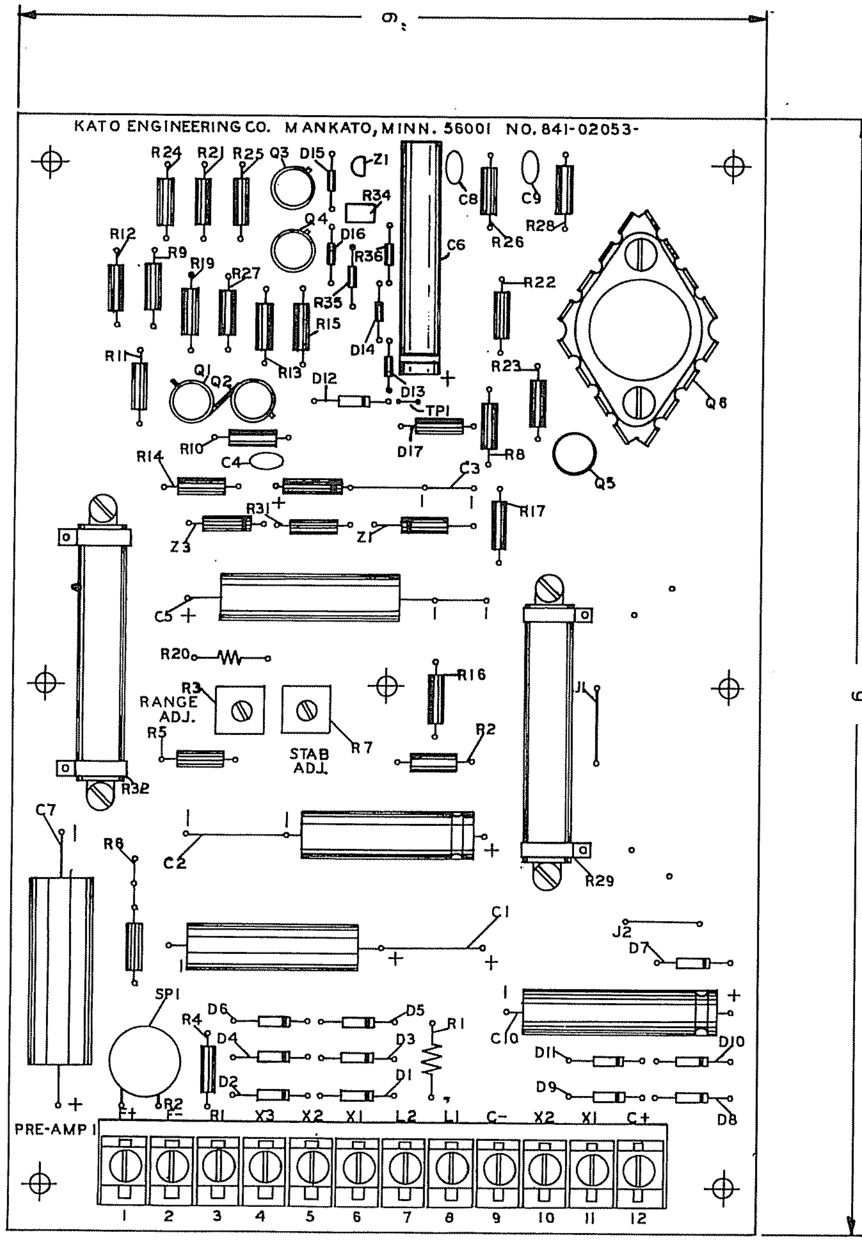


Figure 5-4 Circuit Board Outline Drawing

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Warranty/Quality Assurance	KatoWarranty@mail.nidec.com

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