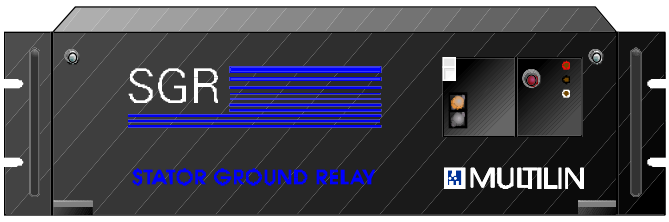
SGR
STATOR GROUND RELAY

Instruction Manual

Manual P/N: 1601-0043-A4



ISO9000 REGISTERED

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SECTION 1

INTRODUCTION

1.1 Protection Requirements Of Generator Stator Windings

In the past, protection of a generator's stator winding has been accomplished by grounding the neutral point through some type of impedance. A standard practice in many utilities is to ground all system generators through a distribution transformer with a resistance loaded secondary. This provides high resistance grounding in the generator circuit. As a result, ground fault currents are typically limited to less than 10 Amps, but the possibility of damaging ground currents occurring on the stator windings still exists.

At best a conventional 60 Hz relay, that uses finite voltage settings, measuring the neutral and the residual terminal voltage will leave about 2.5–10% of the winding near the neutral unprotected. Since stator grounds in this region do not cause a voltage above the threshold of the 60 Hz relay, there is a risk of one ground developing and remaining undetected over a period of time. In this scenario the stator is left vulnerable to damaging multiple grounds should a second fault occur.

In order to fully protect generator stator windings, a sensing scheme which covers the blind spot near the neutral must be implemented. The Multilin Stator Ground Relay covers this neutral end of the stator winding by utilizing the third harmonic voltage produced by generator non-linearities.

1.2 SGR Relay Features

- Provides 100% coverage of the generator stator windings under all loading conditions.
- Detects stator grounds, open neutral disconnect switches and shorted grounding resistors at no-load conditions prior to synchronizing the generator to the system.
- Designed on signal measurements made at a number of thermal units under various operating conditions.
- Sensitive to very low third harmonic voltage signals that may be encountered under either open circuit or loaded conditions of the unit.
- Fixed third harmonic trip criteria provides predictable coverage that does not require complicated setting procedures.
- Simple level settings for fundamental protection.
- Output alarm/trip relays with associated magnetic targets for ease of fault diagnosis.
- Alarm output for insufficient control voltage.

1.3 Typical Applications

The SGR relay is suited for the protection of nuclear, fossil, hydro and gas turbine main generators in utility/ industrial co-generation projects.

1.4 Order Code Information

SGR - 120 VAC / 60 Hz

1.5 Technical Specifications

Voltage Signal Inputs

3 Phase (VR_N,VW_N,VB_N) or Single-Phase from Open Corner Delta PT.

Nominal : 69 Vrms / 60 Hz Phase to Neutral
Continuous Overload : 1.5 x Nominal

Grounding Transformer Input

Continuous Overload :208 V_{rms} / 60Hz

Transformer Ratio Setting

Ratio 3 n_1/n_2 to be set with fixed resistor R16 on card SGR1. The adjustment range is infinite. Standard resistor values for 3 n_1/n_2 in the range 0.9 - 1.8 are recommended.

n1 = turns ratio of grounding transformer at generator neutral.

n2 = turns ratio of PT's on generator terminals.

Power Supply

120 V_{rms} / 60 Hz Station Service

Alarm feature for indicating loss of the +/- 15 VDC supply and protection features for overvoltage conditions.

Range of Operating Frequency

60Hz Pickup Level: +10% for 60 +/- 1Hz
+30% for 60 +/- 2Hz

180Hz Detector: 180 +/- 2Hz

Output Contacts

Output T & Output R: Form A dry contact
Break 0.15 A at 250 VDC with L/R < 40 mS
Break 5 A rms at 120 VAC

Power Supply Alarm: Form B dry contact
Break 0.025 A at 250 VDC with L/R < 5 mS
Break 3 A rms at 120 VAC

Output R

Output Relay R is activated when, for a set time, the following conditions apply:

Measurement at 180 Hz :

$$\frac{n_1 V'_N}{n_2 E'_3} < 0.15 \text{ AND } \frac{V'_P}{3\,E'_3} > 0.85 \text{ AND } E'_3 > 0.75\%$$

(Of The Generators Rated Phase-Neutral Voltage)

OR

Measurement at 60Hz

V'_N > setting level

180 Hz Setting : Fixed as per the Transformer Ratio
60 Hz Neutral Setting : 2.0 - 20 V rms (+/- 10 % accuracy)
Time Delay : 0.2, 1.0, or 2.0 seconds

Output T

Output Relay T is activated when, for a set time, the following conditions apply:

Measurement at 180 Hz :

$$\frac{n_1 V'_N}{n_2 E'_3} < 0.15 \text{ AND } \frac{V'_P}{3\,E'_3} > 0.85 \text{ AND } E'_3 > 1.5\%$$

(Of The Generators Rated Phase-Neutral Voltage)

OR

Measurement at 60Hz :

V'_P > setting level

180 HZ Setting : Fixed as per Transformer Ratio
60 Hz Residual Setting : 2.0 - 20 Vrms (+/- 10 %accuracy)
Time Delay : 0.2, 1.0, or 2.0 seconds

Indicators

Magnetic Targets for R and T outputs. Test points on each card for ease of troubleshooting and testing.

Insulation

Insulation to ground and between circuits : 1.5 KVAC / 60 Hz for one minute

Surge Withstand Capability

SWC as per Ontario Hydro Standard Specification A-28M-82
(Exceeds requirements for ANSI C37.90a-1974 and IEC 255-5)

Radio Frequency Interference

As per Ontario Hydro Specification C5047-77

Operating Temperature

-20°C to +55°C

SECTION 2

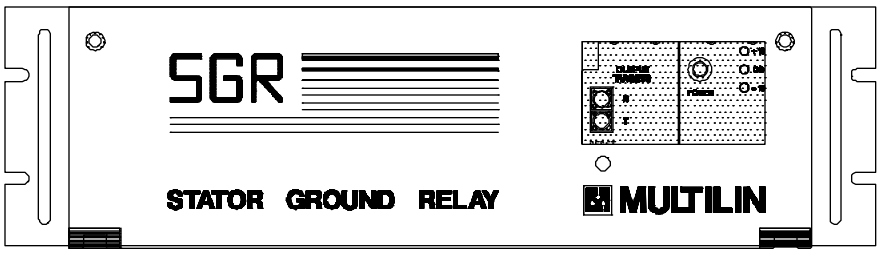
INSTALLATION

2.1 Physical Dimensions

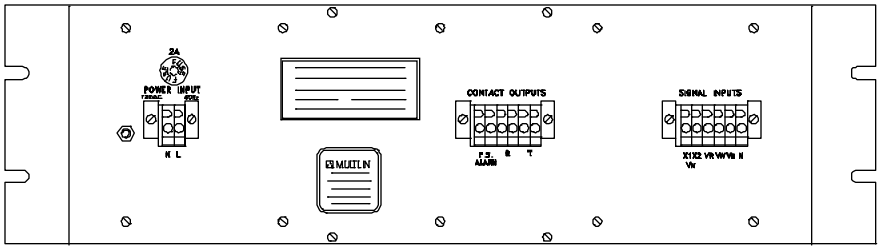
The SGR relay electronics are contained on printed circuit cards which are housed in an aluminum enclosure. Access to the cards is made by opening the hinged front panel door. From this point the test points and setting dials can be reached. With the front panel door closed, indicators can be viewed through the front door window and a reset may be performed via the switch extension shaft. The SGR relay is suitable for surface mounting and for mounting in a standard 19 inch rack. Dimensions of the SGR relay are shown in figure 2.1.

2.2 Mounting

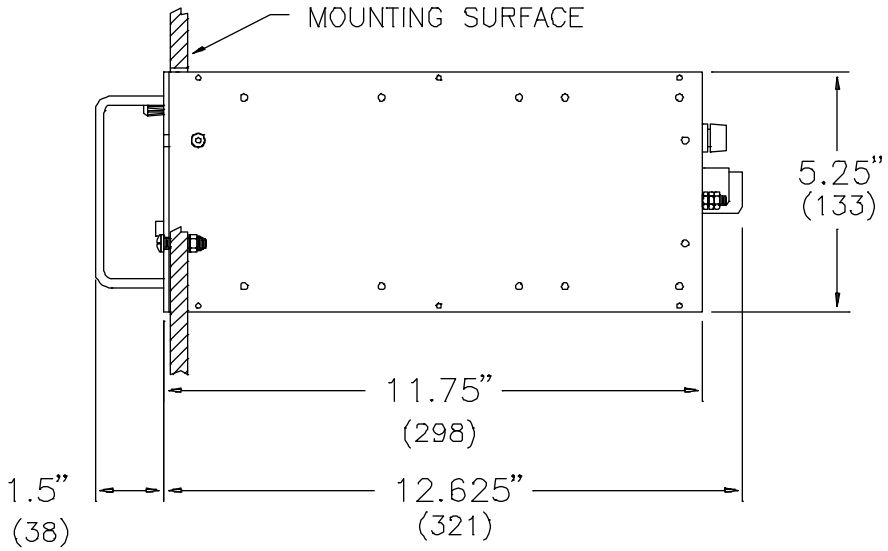
The SGR relay is designed to be rack or panel mountable and should be located so that the front panel controls are accessible and the indicators in view. If the relay is to be panel mounted, a rectangular cutout should be made in the panel as shown in figure 2.2. Also, in order to minimize noise pickup or interference, the SGR should be located as far as possible from high current sources or strong magnetic fields.



FRONT VIEW



REAR VIEW



SIDE VIEW

Inches
(mm)

997061A3.DWG

Figure 2.1 - Physical Dimensions

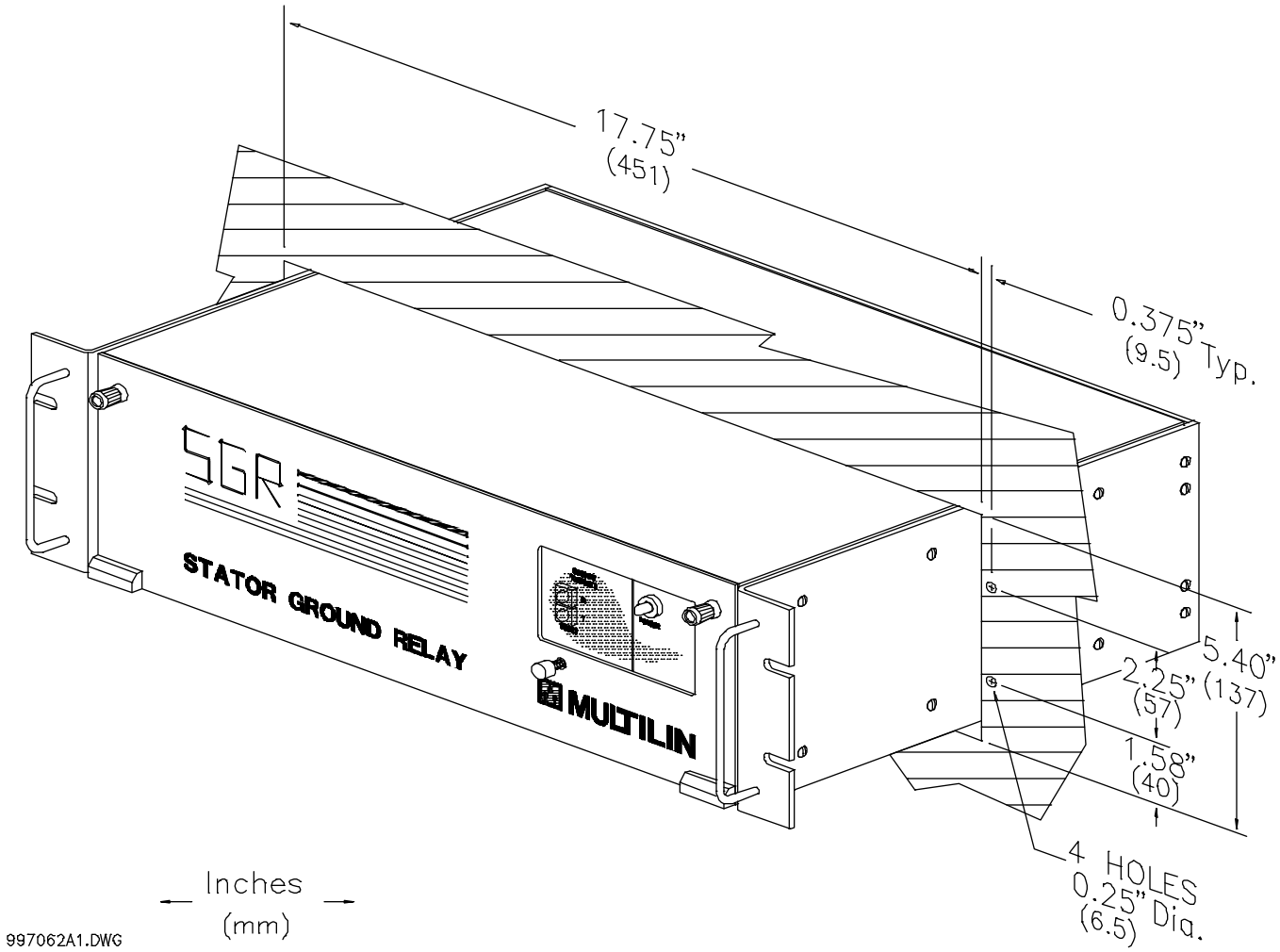


Figure 2.2 - Mounting

2.3 External Connections

All wiring connections to the SGR relay are made at the back of the unit and all terminals are identified in table 2.1 along with there functions. Figure 2.3 shows the connections for a SGR installation.

Power Supply

The SGR is designed to work with a 120 V_{rms} / 60 Hz station service. The power supply neutral connection is made at terminal 1 and the power supply live connection is made at terminal 2. The chassis ground stud must be connected directly to the dedicated system ground.

Power Supply Alarm

Terminals 3 and 4 provide an open relay contact for normal operating conditions. Closure of this contact indicates abnormal control voltage to the SGR.

Neutral Voltage

The voltage across the shunt resistor on the secondary side of the distribution transformer should be connected to V_N terminals 9 (X_1) and 10 (X_2) where terminal 9 is the low side.

Residual Terminal Voltage

The appropriate signals from the secondaries of the generator PT's should be connected directly to the SGR terminals 11 (VR), 12 (VW), 13 (VB), and 14 (VN).

Output Contact R

Terminals 5 and 6 provide a dry contact. This N/O relay closes when the appropriate fault criteria is satisfied. It is typically used in an alarm mode.

Output Contact T

Terminals 7 and 8 provide a dry contact. This N/O relay closes when its fault criteria is satisfied. This contact is typically used in a trip mode.

Table 2.1 - Terminal Identification

Terminal Number	Function
Ground Stud	Supply Voltage Ground
1	Supply Voltage Neutral
2	Supply Voltage Live
3	Power Supply Alarm
4	Power Supply Alarm
5	Output Contact R (+)
6	Output Contact R (-)
7	Output Contact T (+)
8	Output Contact T (-)
9	Voltage Neutral (X1)
10	Voltage Neutral (X2)
11	Voltage Red
12	Voltage White
13	Voltage Blue
14	Voltage Neutral

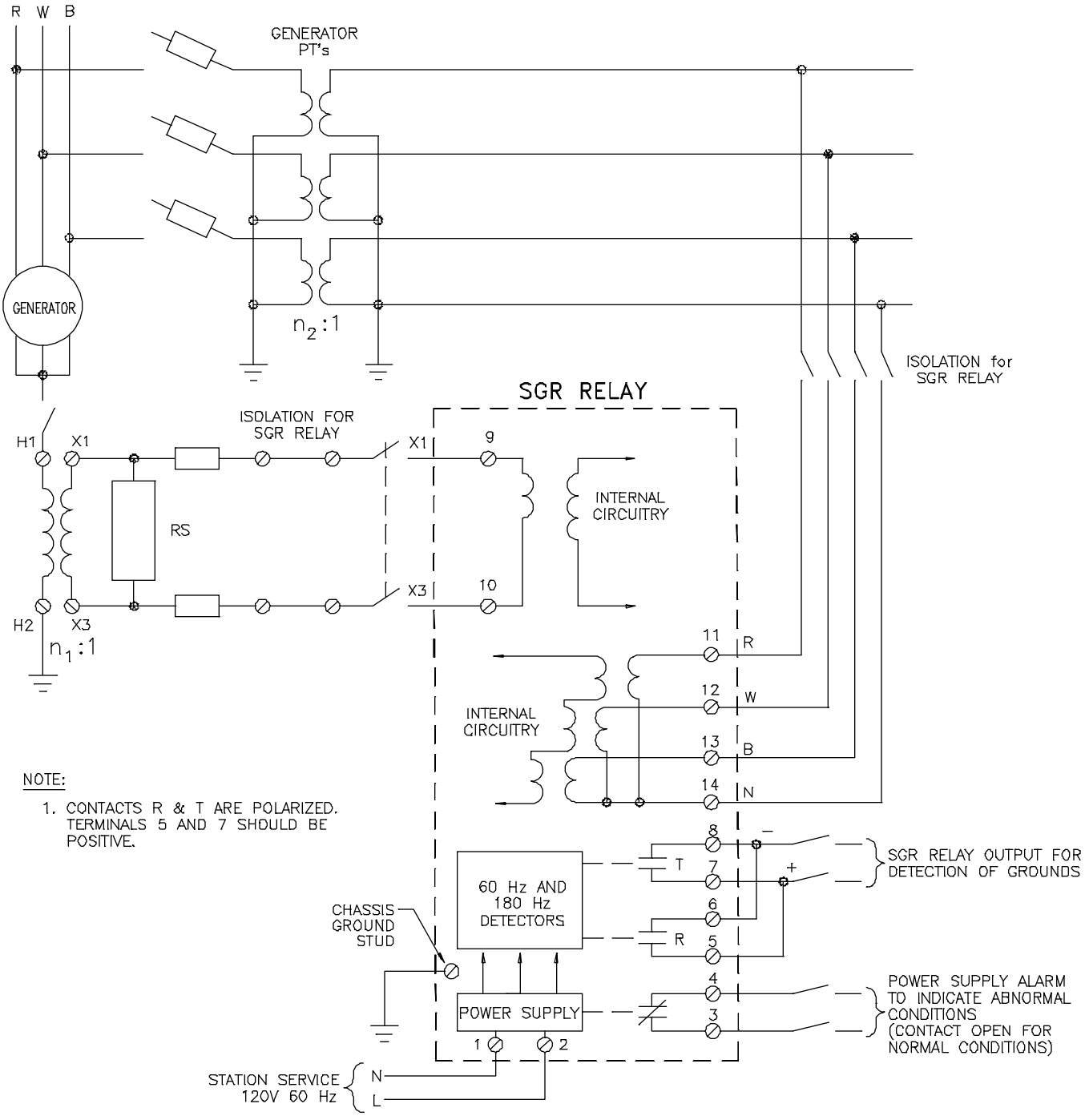


Figure 2.3 - External Wiring

SECTION 3

SETUP AND USE

3.1 Stator Ground Detection Signals

The Multilin Stator Ground Relay provides 100% coverage of the stator windings by implementing a third harmonic detector scheme and a fundamental frequency detector scheme. Figure 3.1 shows the voltage signals used to provide this protection. One signal is V_N', the voltage across the secondary side of a distribution transformer. The other signal is V_P', the residual terminal voltage. This is derived inside of the SGR by obtaining the secondary generator terminal voltages from a set of auxiliary PT's.

3.2 180 Hz Detector Scheme

The third harmonic scheme is used to detect ground faults in the neutral end zone of generator stator windings. This is accomplished through the measurement of the third harmonic components of VN' and VP'. Under fault conditions, the ratios of these voltages will change when compared to a derived generator third harmonic source voltage (E_3'). As a result, they can be used as a basis for relay operation. Coverage due to third harmonic detection is fixed to 15% of the winding near the neutral and based on the following trip criteria:

$$\text{Trip if } \frac{n_1 V_N'}{n_2 E_3'} < 0.15 \qquad \text{Trip if } \frac{V_P'}{3\,E_3'} > 0.85$$

where n_1 and n_2 are transformer turns ratios as per figure 3.1. Note that practical implementation also requires that E_3' is of sufficient magnitude for reliable measurement. The effective relay logic takes this into consideration.

3.3 60 Hz Detector Scheme

The magnitude of the fundamental frequency components of signals V_N' and V_P' are compared to their respective level detectors. Each detector is adjustable from 2 to 20 Vrms and when an input exceeds the detector level setting, the appropriate trip response is initiated. Fundamental frequency detection covers X - 100% of the stator windings where X is determined by the nominal secondary voltage of the potential transformers (Vo), the n_1/n_2 turns ratio, and the detector voltage levels (VS_N & VS_P) in rms.

3.4 Stator Ground Relay Logic

The SGR logic combines the results of the 180 Hz and 60Hz detectors to provide two outputs R and T. The output R closes its contacts if either the 60Hz signal at the neutral is above the threshold or the third harmonic signals satisfy both of the 180Hz conditions and the third harmonic source voltage E_3' exceeds 0.75% of the rated

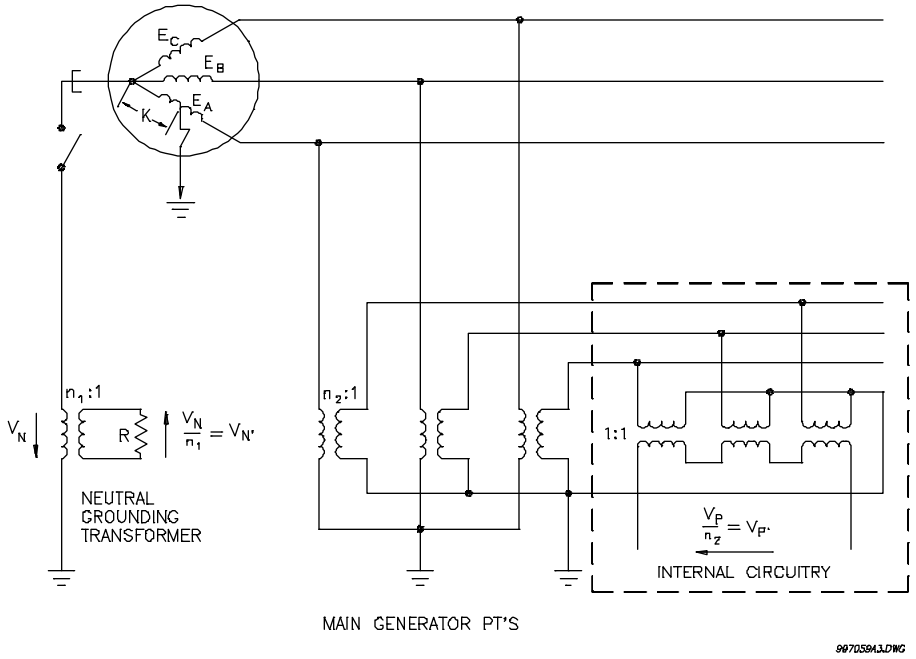


Figure 3.1 - Signal Used for Stator Ground Protection

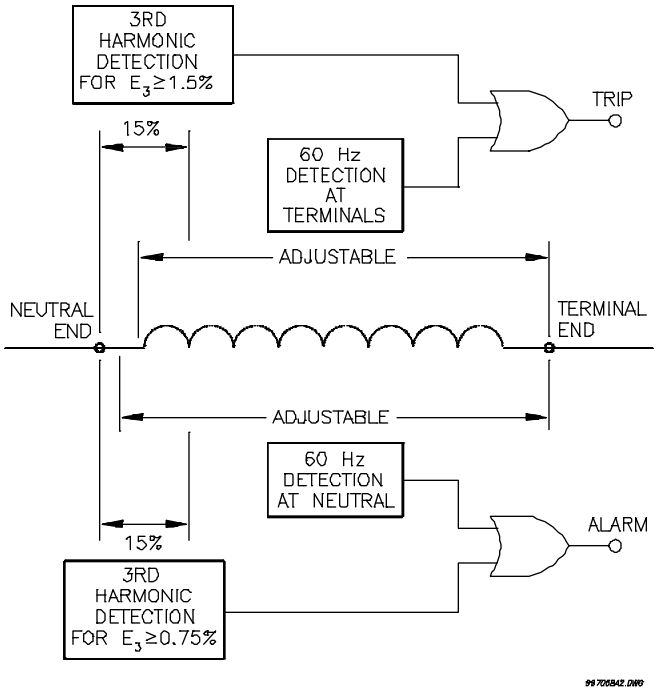


Figure 3.2 - Stator Ground Relay Winding Coverage

phase-neutral voltage. This defines the maximum sensitivity of the third harmonic detection. The output T closes its contacts when either the 60Hz residual terminal voltage exceeds the threshold setting or one of the third harmonic conditions are satisfied and the third harmonic source voltage E_3' exceeds 1.5% of the fundamental phase-neutral voltage.

These two outputs allow the flexibility of using one in the alarm mode and the other in the trip mode. For example, the output R could be in the alarm mode with the associated VS_N' 60 Hz detector set to a sensitive 97.5% coverage, while output T could be in the trip mode with the associated 60Hz detector set to a less sensitive 95% coverage.

3.5 Power Supply Alarm

When the power supply voltage to the SGR is reduced from the nominal to less than 50 V_{rms}, the output and power supply alarm relays drop out. Under normal operating conditions, the power supply alarm contacts are open and when supply conditions become abnormal the contacts close. At this point the plus and minus supplies are less than 10 volts to common.

3.6 180 Hz Scheme Settings

Coverage due to third harmonic detection is a fixed 15% of the winding near the neutral. The only setting required for the 180Hz scheme relates to the ratios of the grounding transformer at the neutral and the potential transformers at the terminals. The setting is made by adjustment of the gain in the neutral signal which is done by soldering in the appropriate value of resistor R16 on circuit card SGR1. This resistor is soldered on posts for ease of replacement. A standard resistor size is to be selected from Table 3.1 according to the ratio $3\,n_1/n_2$. The factory placed resistor value corresponds to $3\,n_1/n_2 = 1.2$ (R16 = 22.1K). The location of Resistor R16 is shown in figure 3.4.

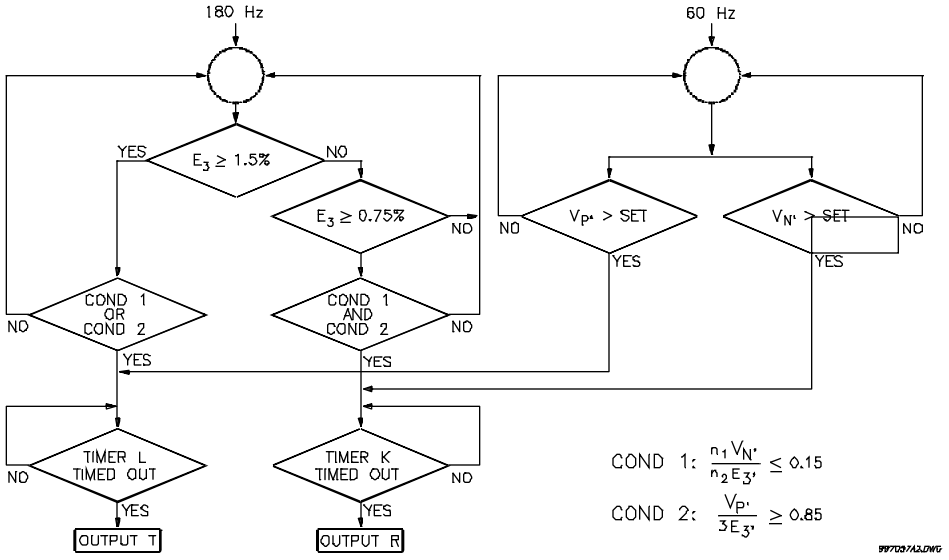


Figure 3.3 - Stator Ground Relay Logic

Table 3.1 - Selection Of Resistor R16

3n1/n2	Resistor R16
0.90	11.3 K
0.95	12.7 K
1.00	14.0 K
1.05	15.8 K
1.10	17.4 K
1.15	19.6 K
1.20 *	22.1 K*
1.25	24.9 K
1.30	28.0 K
1.35	31.6 K
1.40	36.5 K
1.45	42.2 K
1.50	49.9 K
1.55	60.4 K
1.60	73.2 K
1.65	93.1 K
1.70	124 K
1.75	187 K
1.80	340 K

3.7 60 Hz Scheme Settings

The settings of the level detectors that measure the 60Hz components of V_N' and V_P' are made by adjustable potentiometers (with dials) on the front panel of card SGR2. The location of which is illustrated in figure 3.5. Setting VS_N is for V_N' and setting VS_P is for V_P' in rms volts.

$$V'_N = 2.4\left[\frac{n_2}{3\,n_1}\right] \text{ (dial setting)}$$

$VS'_P = 2$ (dial setting)

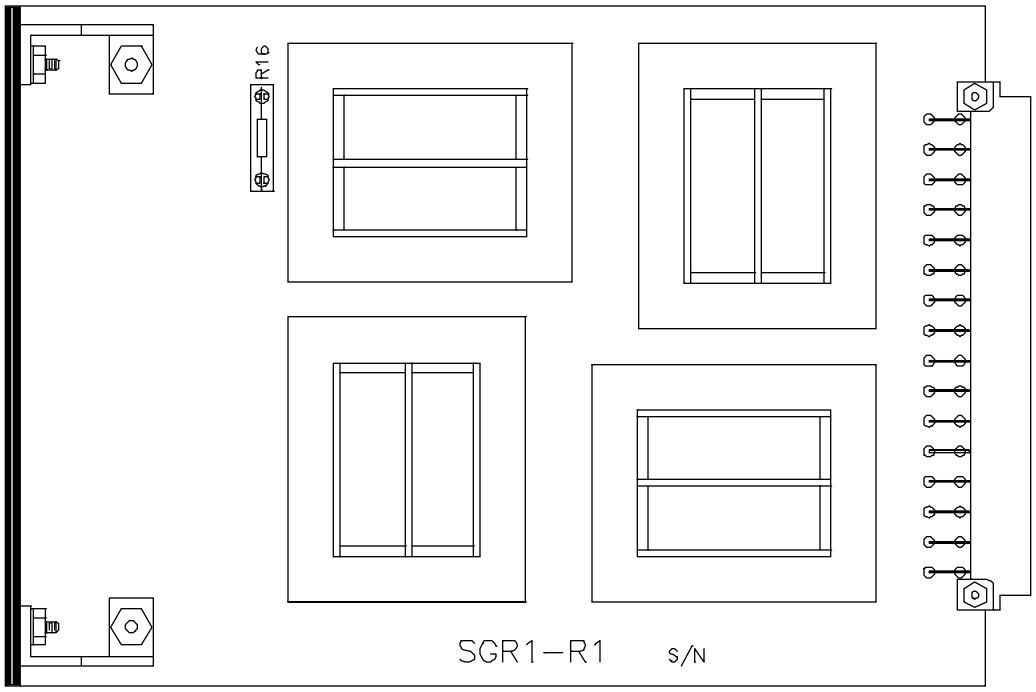
3.8 Output Delay Settings

There are two timer settings for delaying the output up to 2 seconds. The timer settings are made by soldering-in appropriate value of resistors RX1 and RX2 on circuit card SGR5. RX1 sets the time delay for output “T” and RX2 set the time delay for output “R”. The standard value of resistors for various time delays are listed in Table 3.2. The factory-made setting is 2 seconds (RX1 and RX2 are open).

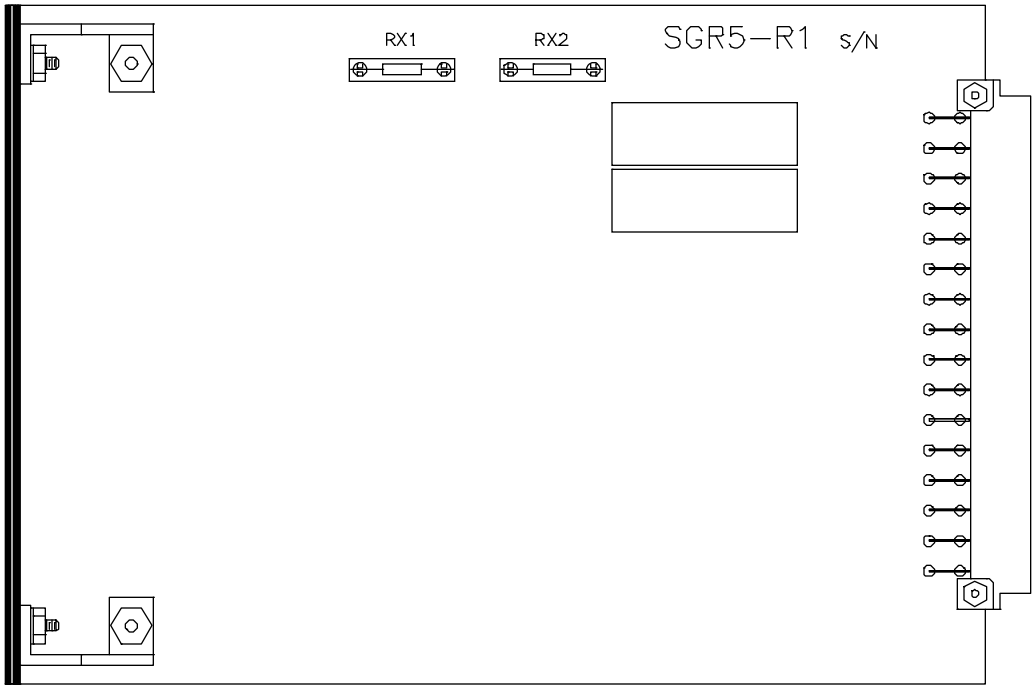
Table 3.2 - Selection Of Resistor Values For RX1 And RX2

Time Delay	Resistors RX1 and RX2
2.0 sec	open
1.0 sec	402 K
0.2 sec	43.2 K

The location of the above resistors on card SGR5 are shown in figure 3.4



Location of R16 on Card SGR1



Location of RX1 and RX2 on Card SGR5

Figure 3.4 - Location of Resistors on Cards SGR1 and SGR2

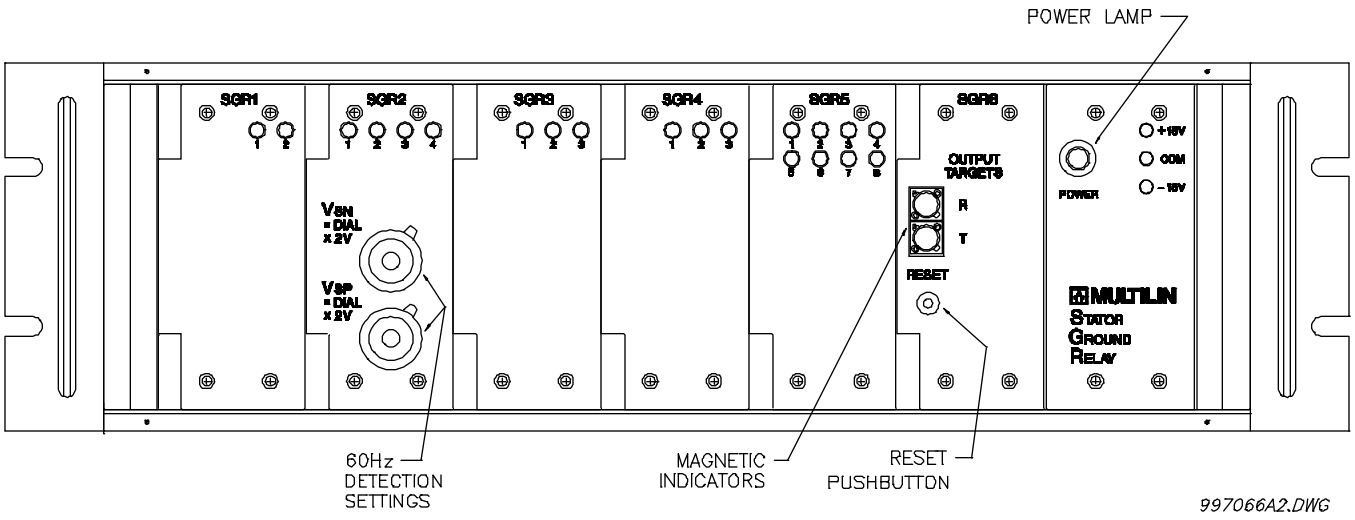


Figure 3.5 - SGR Front Panels

3.9 Front Panel Controls And Indicators

Two magnetic targets are located on the front panel of circuit card SGR6. One target is labeled R and the other is labeled T with each indicating the status of the corresponding output relay. When an output relay is dropped out, the corresponding relay contact will be open with the magnetic indicator displaying black. When an output relay is picked up, the corresponding relay contact will be closed with the magnetic indicator displaying yellow. This latter case indicates a fault condition.

The front panel of SGR6 also contains a reset pushbutton for clearing the magnetic indicators when a fault has occurred, but is no longer present. Resetting may also be performed with the SGR front door closed. This is accomplished by pushing the switch extension shaft which is mounted on the chassis door.

The power supply front panel holds a neon lamp which is connected directly to the 120 V_{rms} / 60 Hz rear power input terminals number 1 and 2. As a result, it indicates the presence of input power being applied to the relay.

SECTION 4

TESTING

4.1 Primary Injection Testing

Complete system operation can be checked by applying voltage across the primary of the potential transformers and thus provide the three phase input. The grounding transformer input can be made directly with a potential source. In order to do this a primary (high voltage) test set is required. With this method the entire system including the PT's can be checked.

If this equipment is not available,secondary injection tests can be performed to check everything except the PT's. This procedure is described in the following section.

4.2 Secondary Injection Testing

Secondary injection testing can be performed using the test setup of figure 4.1. The tests described here apply to the SGR with the factory installed resistor value for R16 of 22.1K and the RX1 and RX2 resistors open.

Power Supply

Apply 120V_{rms} / 60 Hz to the Power Input terminals and measure that the DC supply voltages on the front panel of the fixed power supply card. These voltages should be +15 and -15 VDC with respect to common. Also note that the power lamp illuminates when control power is applied.

V_N' > VS_N Detector Level

Set the VS_N dial on the front of the SGR2 circuit card to 5. Now increase the 60 Hz voltage across terminals 9 and 10 with 11, 12, 13 and 14 grounded. When the input voltage reaches 10.0 V_{rms}, the R contacts should close and the R magnetic indicator should turn yellow. Note that there is a two second delay in the output response. This is due to output delay resistors being the factory value; open. Remove the input voltage and the R contacts should open. Now press the SGR6 reset pushbutton. The R magnetic indicator will return to it's original black colour.

V_P' > VP_N Detector Level

Set the VS_P dial on the front of the SGR2 circuit card to 7. This time increase the 60 Hz voltage across the terminals 11 and 14 with terminals 9, 10, 12 and 13 grounded. When the input voltage reaches 14.0 V_{rms}, the T contacts should close and the T magnetic indicator should turn yellow. Once again note that there is a two second delay in the output response. Remove the input voltage and the T contacts should open. When the reset pushbutton is pressed, the T magnetic indicator will return to its original black colour.

Neither Of The 180 Hz Conditions Satisfied And E_3 > 1.5%

Inject 5 V_{rms} / 180 Hz across terminals 9 and 10, 2 V_{rms}/ 180 Hz across terminals 12 and 14 with terminals 11 and 13 tied to ground. With the following input conditions applied, both the R and T output contacts remain open with the front panel indicators remaining black. Now measure the following test points on the front panel of the SGR5 circuit card. The measurements here indicate that there is a sufficient amount of third harmonic source voltage to enable the 180 Hz detection scheme, but neither of the 180 Hz fault conditions are satisfied.

Testpoint	Voltage
TP1	0 VDC
TP2	15 VDC
TP3	15 VDC
TP4	0 VDC

Both Of The 180 Hz Conditions Satisfied And E_3 > 1.5%

Inject 5 V_{rms} / 180 Hz across terminals 11, 12 and 13 with respect to terminal 14. At the same time, apply 2 V_{rms} / 180 Hz across terminals 9 and 10. After a 2 second delay both the R and T contacts will close and both of the magnetic indicators will turn yellow. Once again remove the input conditions and reset the trips with the SGR6 front panel reset pushbutton.

Both Of The 180 Hz Conditions Satisfied And 1.5% > E_3 > 0.75%

Inject 0.9 V_{rms} / 180 Hz across terminals 11, 12 and 13 with respect to terminal 14. Also tie terminals 9 and 10 to ground. With these input conditions only the R contact will close and R magnetic indicator will turn yellow. Remove the input conditions and perform a front panel reset.

Power Supply Alarm

Inject 5 V_{rms} / 180 Hz across terminals 11, 12 and 13 with respect to terminal 14. At the same time, connect terminals 9 and 10 to ground. Note that both the output contacts close and that both of the magnetic indicators

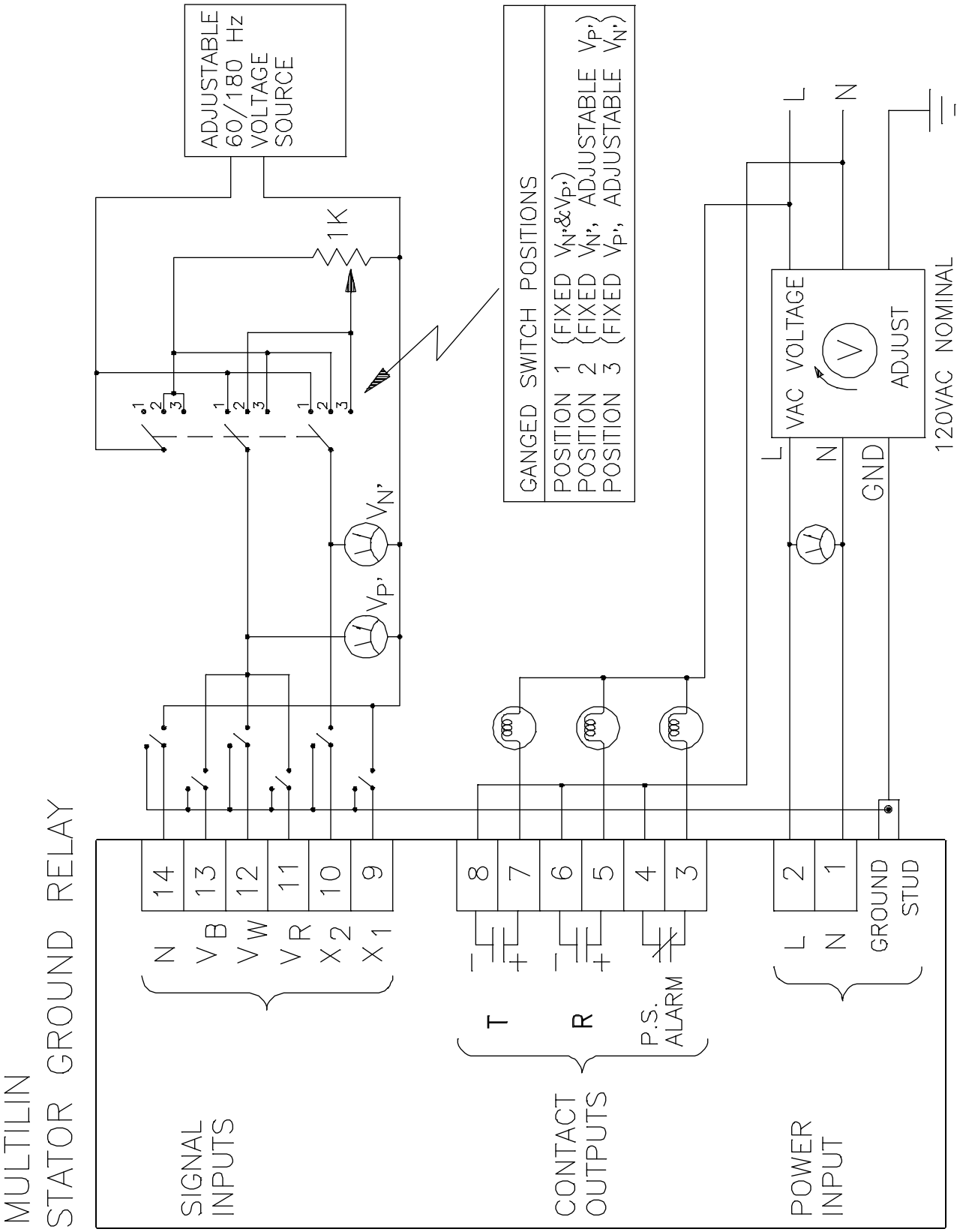


Figure 4.1 - Secondary Injection Test Setup

indicate a fault condition by turning yellow. At this point also pay attention to the power supply alarm contacts. They should be open and therefore indicating that the power input to the SGR is healthy.

Now reduce the control voltage applied to the SGR Power Input terminals from the nominal 120 V_{rms}. Observe that the output relays R and T open and the power supply alarm relay closes when the plus and minus supplies are less that 10 volts to common.

LIST OF FIGURES

LIST OF TABLES

MULTILIN RELAY WARRANTY

Multilin warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a Multilin authorized factory outlet.

Multilin is not liable for contingent or consequential damages or expenses sustained as a result of a relay malfunction, incorrect application or adjustment