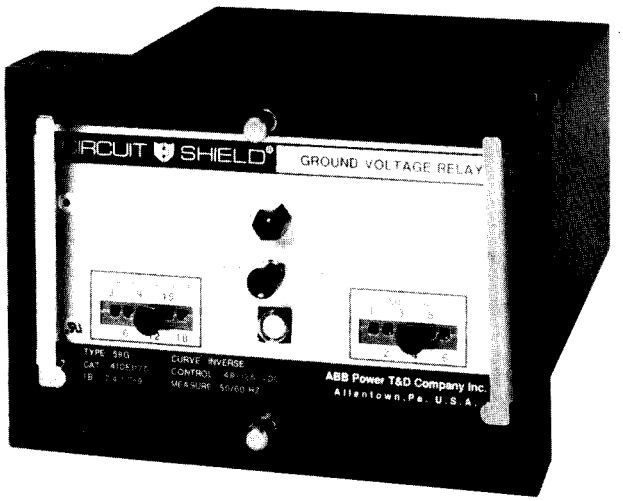
IB 7.4.1.7-9
Issue B

INSTRUCTIONS

Ground Voltage Relays

CIRCUIT SHIELD®

TYPE 27G	THIRD-HARMONIC UNDERVOLTAGE RELAY	
TYPE 59G	GROUND OVERVOLTAGE RELAY	
Type 27G	Catalog Series 210Q	Standard Case
Type 27G	Catalog Series 410Q	Test Case
Type 59G	Catalog Series 210E	Standard Case
Type 59G	Catalog Series 410E	Test Case



Type 59G

ABB POWER T&D COMPANY INC.
ALLENTOWN, PENNSYLVANIA, USA

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INTRODUCTION

These instructions contain the information required to properly install, operate, and test certain ABB Circuit-Shield™ single-phase undervoltage relays, Type 27G, catalog series 210Q and 410Q; and overvoltage relays, Type 59G, catalog series 210E and 410E. Earlier models of these relays, catalog series 211Q and 211E are covered by instruction book 18.4.7-2(D). Also see the section on Testing for reference to these earlier models.

The relay is housed in a case suitable for conventional semiflush panel mounting. All connections to the relay are made at the rear of the case and are clearly numbered. Relays of the 410Q, and 410E catalog series are similar to relays of the 210Q, and 210E series. Both series provide the same basic functions and are of totally drawout construction; however, the 410Q and the 410E series relays provide integral test facilities. Also, sequenced disconnects on the 410 series prevent nuisance operation during withdrawal or insertion of the relay if the normally-open contacts are used in the application.

Most settings are made on the front panel of the relay, behind a removable clear plastic cover. The target is reset by means of a pushbutton extending through the relay cover.

PRECAUTIONS

The following precautions should be taken when applying these relays:

1. Incorrect wiring may result in damage. Be sure wiring agrees with the connection diagram for the particular relay before energizing.

2. Apply only the rated control voltage marked on the relay front panel. The proper polarity must be observed when the dc control power connections are made.

3. For relays with dual-rated control voltage, withdraw the relay from the case and check that the movable link on the printed circuit board is in the correct position for the system control voltage.

4. High voltage insulation tests are not recommended. See the section on testing for additional information.

5. The entire circuit assembly of the relay is removable. The unit should insert smoothly. Do not use excessive force.

6. Follow test instructions to verify that the relay is in proper working order.

CAUTION: *since troubleshooting entails working with energized equipment, care should be taken to avoid personal shock. Only competant technicians familiar with good safety practices should service these devices.*

PLACING THE RELAY INTO SERVICE

1. RECEIVING, HANDLING, STORAGE

Upon receipt of the relay (when not included as part of a switchboard) examine for shipping damage. If damage or loss is evident, file a claim at once and promptly notify Asea Brown Boveri. Use normal care in handling to avoid mechanical damage. Keep clean and dry.

2. INSTALLATION

Mounting:
The outline dimensions and panel drilling and cutout information is given in Fig. 1.

Connections:
Internal connections are shown in Figure 2. Typical external connections are shown in Figures 3, 4, and 5. Control power must be connected in the proper polarity.

For relays with dual-rated control power: before energizing, withdraw the relay from its case and inspect that the movable link on the lower printed circuit board is in the correct position for the system control voltage. (For units rated 110vdc, the link should be placed in the position marked 125vdc.)

Relays rated for use with 120vac control power have an internal isolation transformer connected to relay terminals 7 and 8. Polarity of the ac control power to these terminals need not be observed.

Relays rated for use with 220 or 250 vdc control have an external resistor wired to terminals 1 and 9 which must be in place for normal operation. The resistor is supplied mounted on the relay.

These relays have metal front panels which are connected through printed circuit board runs and connector wiring to a terminal at the rear of the relay case. The terminal is marked "G". In all applications this terminal should be wired to ground.

3. SETTINGS

PICKUP (Type 59G)
The pickup voltage taps identify the voltage level at which the relay will operate (after the appropriate time delay).

DROPOUT (Type 27G)
The dropout voltage taps identify the voltage level at which the relay will operate on a decreasing input voltage (after the appropriate time delay).

Note: operating voltage values other than the specific values provided by the taps can be obtained by means of an internal adjustment potentiometer. See section on testing for calibration procedure.

On these relay models there is no adjustment for the differential between the operate and reset voltage values.

TIME DIAL
The time dial taps are identified as 1,2,3,4,5,6. Refer to the time-voltage characteristic curves in the Application section. Time dial selection is not provided on relays with an Instantaneous operating characteristic.

4. OPERATION INDICATORS

The Type 59G provides a target indicator that is electronically actuated at the time the output contacts transfer to the trip condition. The target must be manually reset. The target can be reset only if control power is available, AND if the input voltage to the relay drops below the pickup setting.

The Type 27G provides two led indicators. The yellow led lights when the input voltage falls below the dropout setting. The red led lights when the timer has timed out and the output contacts have transferred. Both led indicators are self-resetting when the voltage returns to normal.

The Type 27G also provides a target indicator which is actuated by the flow of current through the tripping contact (terminal 12). The trip current must be greater than 1 ampere to insure operation. The target must be manually reset. Control power must be available to reset the target.

APPLICATION DATA

GENERATOR PROTECTION:

The ABB Circuit-Shield™ Type 59G Ground Voltage Relay and the Type 27G Third-Harmonic Undervoltage Relay are used primarily to protect generators against ground faults. The combination of the two relays will provide 100 percent stator ground fault protection.

The Type 59G is a low pickup overvoltage relay which responds to 50 or 60 Hz voltages. The relay has a third harmonic blocking circuit which renders it insensitive to 180 Hz voltages. In addition, the relay is frequency compensated down to 5 Hertz. These characteristics allow the use of the relay for the primary, startup, and backup protection. The high sensitivity of the relay typically provides protection for over 95% of the generator winding. Inverse time delay is provided to allow for other relays to operate to remove ground faults elsewhere on the system.

Should 100% stator ground-fault protection be desired, the Type 27G may be added to the scheme. The Type 27G is applied to detect faults near the neutral end of the winding that would not be seen by the Type 59G. The relay is held in the picked-up condition by the 3rd harmonic voltage that is normally present across the generator neutral grounding resistor. During internal generator ground fault conditions the voltage is 60 Hz and the Type 27G will drop out. If the fault is exactly at the neutral, the relay sees zero volts and will drop out for this condition as well. In order to determine the dropout setting, the user should monitor the neutral voltage under various operating conditions of the generator prior to placing the relay in service. The Type 27G must be supervised by a voltage relay such as the Type 59D to block incorrect operation during startup or shutdown of the generator.

The Type 27G includes a 180Hz bandpass filter with approximately 30:1 rejection of 60 Hertz signals (150Hz for 50Hz.) To prevent a high magnitude 60 Hz input signal from picking up the relay, the filter is followed by a 60 Hz detection circuit that blocks relay operation. This insures the complete overlap of the protection provided by the Type 27G and the Type 59G.

Typical connections for the scheme are shown in Figure 3.

Both the Type 59G and the Type 27G have a high continuous rating of 208 volts, which permits omission of external relays usually required in these sensitive protective schemes to disconnect the relays from the source once a fault is detected.

For applications where sufficient third-harmonic does not exist, or where it is not practical to determine the minimum third-harmonic voltage, Asea Brown Boveri offers sophisticated injection schemes that do not rely on a third harmonic measurement. Contact your ABB representative or the factory for details of this equipment.

PROTECTION OF UNGROUNDED SYSTEMS:

The Type 59G may be applied for the detection of ground faults on ungrounded systems. Typical connections for this scheme are shown in Figure 4. The user should follow the recommendations of the potential transformer manufacturer and add an appropriate ballast resistor to prevent ferro-resonance effects.

The higher range version of the Type 59G, 20-70 volts pickup, is generally preferred for this application since the pt ratios are usually chosen to give 208v at the input of the relay for a solid ground on one phase. See additional notes on page 14.

CAPACITOR BANK PROTECTION:

The Type 59G relay finds application in capacitor bank protection schemes to monitor the difference in neutral voltages between banks or the neutral to ground voltage in a single bank. A shift in the neutral voltage occurs upon the failure of individual capacitors in the bank. Typical connections are shown in Figure 5. For additional information refer to ANSI C37.99 "Guide for Protection of Shunt Capacitor Banks".

The Type 59G used for this application requires a 60 Hertz bandpass-filter module rather than the third-harmonic blocking filter supplied on versions used for generator protection. *To properly specify the relay for capacitor bank protection add the suffix "-HF" to the catalog number.*

SPECIFICATIONS

Input Circuit:

Rating: 208v continuous.
480v, 10 seconds.

Burden: 59G: 1.2 VA, 1.0 P.F. at 120 volts.
27G: 0.1 VA, 1.0 P.F. at 120 volts.

Taps: available models include:

Type 27G: 0.5, 0.8, 1, 1.5, 2, 3 v (180 Hz/150Hz.)
1, 2, 3, 6, 8, 12 v (180 Hz/150Hz.)

Type 59G: 1, 2, 3, 4, 5, 6 v
3, 6, 9, 12, 15, 18 v
20, 30, 40, 50, 60, 70 v

Operating Time: See Time-Voltage characteristic curves that follow.
(Type 59G, instantaneous unit: less than 65 ms. at 2 times pickup)

Output Circuit:

Each contact

@ 120 vac	@ 125 vdc	@ 250 vdc	
30 amps.	30 amps.	30 amps.	tripping duty.
5 amps.	5 amps.	5 amps.	continuous.
2 amps.	0.3 amp.	0.1 amp.	break.

Series Target Coil: (Type 27G only) 1 ampere or more trip circuit current will insure target operation. Withstand: 30 amperes, 1 second. Coil resistance: negligible.

Operating Temperature Range: -30 to +70 deg. C.

Control Power:

Models available for 48/125 vdc @ 0.05 A max.
48/110 vdc @ 0.05 A max.
220 vdc @ 0.05 A max.
250 vdc @ 0.05 A max.

additionally for the Type 59G: 24/ 32 vdc @ 0.05 A max.
250 vdc @ 0.05 A max.
120 vac 50/60 Hz. @ 0.05 A.

Allowable variation:

24vdc	nominal:	19- 29 vdc
32vdc	"	25- 38
48vdc	"	38- 58
110vdc	"	88-125
125vdc	"	100-140
220vdc	"	176-246
220vdc	"	200-280
120vac	"	95-135 vac

Tolerances:

At 25°C:
Operating Voltage: +/- 5% or +/- 0.5 volts, whichever is greater.
Time Delay: +/- 10% or +/- 0.05 seconds, whichever is greater.

Note: the above tolerances are with respect to the printed dial marks. By using calibration procedures, the relay may be set more precisely to the desired operating values.

Pickup or dropout voltage variation over temperature range -20 to +55°C: +/-5% or +/-0.1 volt, whichever is greater.

Time delay variation over temperature range -20 to +55°C: +/-10% or +/- 0.05 second, whichever is greater.

Dielectric Strength:
2000 vac, 50/60 Hz., all circuits to ground.

Seismic Capability:
More that 6g ZPA biaxial broadband multifrequency vibration without damage or malfunction. (ANSI C37.98-1978)

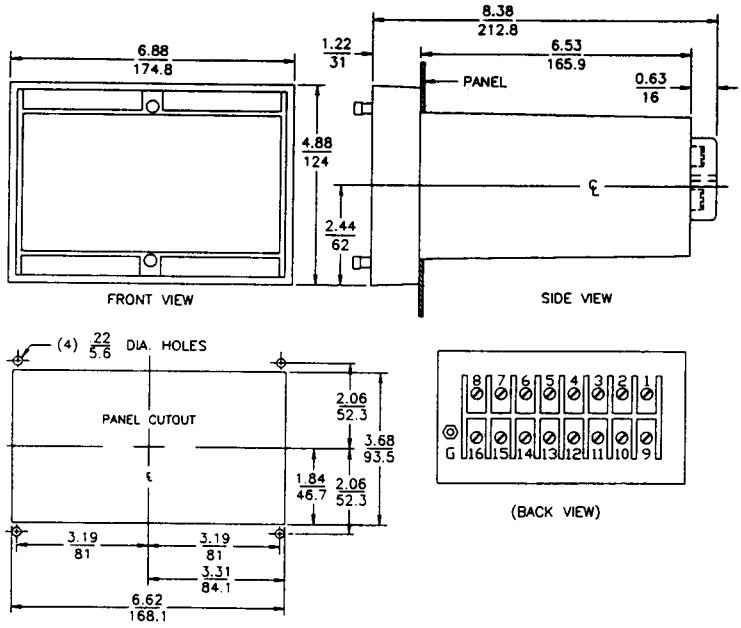


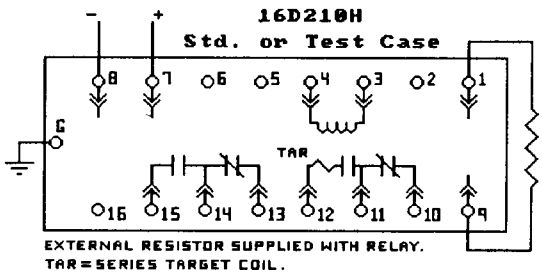
Figure 1: Relay Outline and Panel Drilling

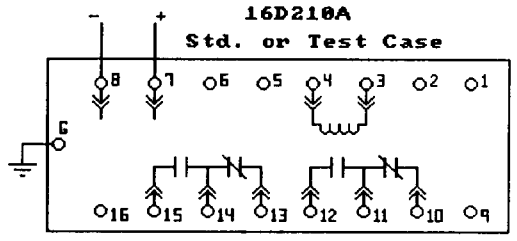
Dimensions are inches / mm

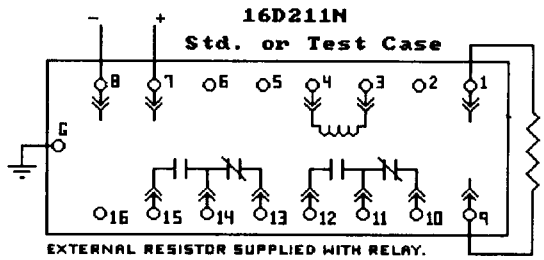
Figure 2: INTERNAL CONNECTION DIAGRAMS AND OUTPUT CONTACT LOGIC

The following tables and diagrams define the output contact states under all possible conditions of the measured input voltage and the control power supply. "**AS SHOWN**" means that the contacts are in the state shown on the internal connection diagram for the relay being considered. "**TRANSFERRED**" means the contacts are in the opposite state to that shown on the internal connection diagram.

Condition	Contact State	
Type:	Type 27G	Type 59G
Normal Control Power AC Input Voltage Below Setting	Transferred	As Shown
Normal Control Power AC Input Voltage Above Setting	As Shown	Transferred
No Control Voltage	As Shown	As Shown







Type 27G: diagram 16D210H.

Type 59G: see table, page 10.

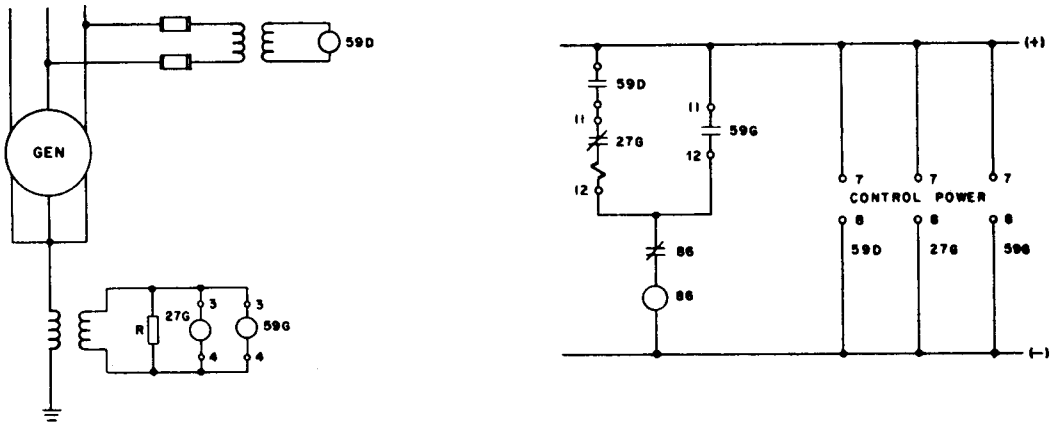


Figure 3: Typical Connections - Generator Stator Ground Protection

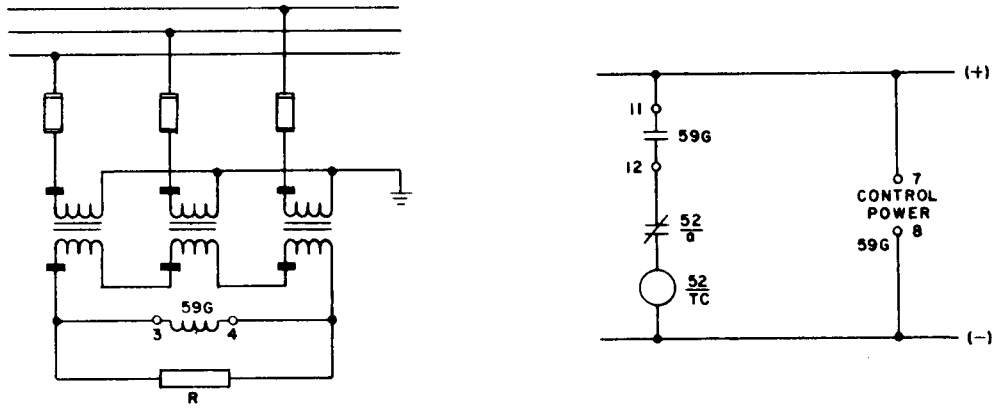


Figure 4: Typical Connections - Ground Fault Detection on Ungrounded Systems

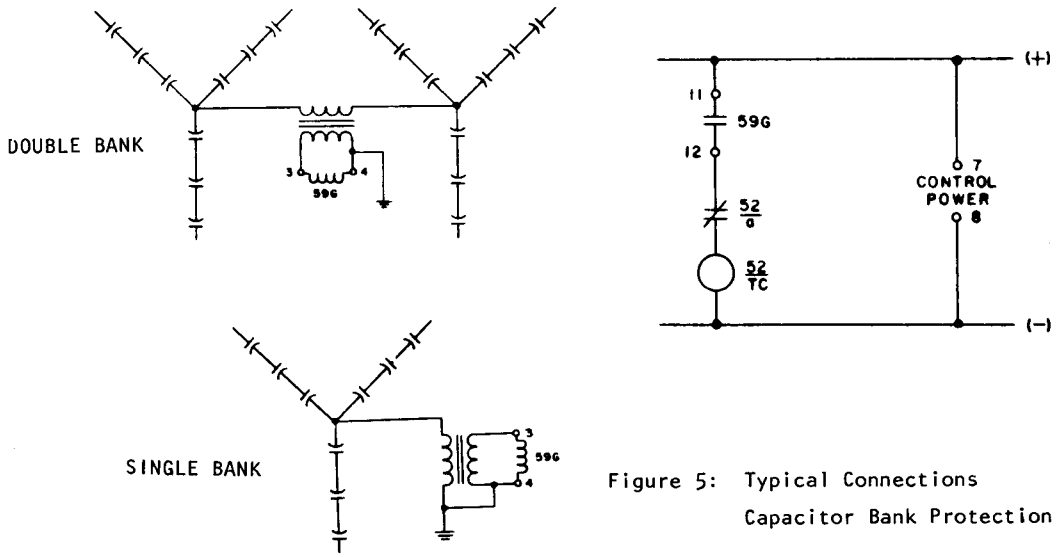
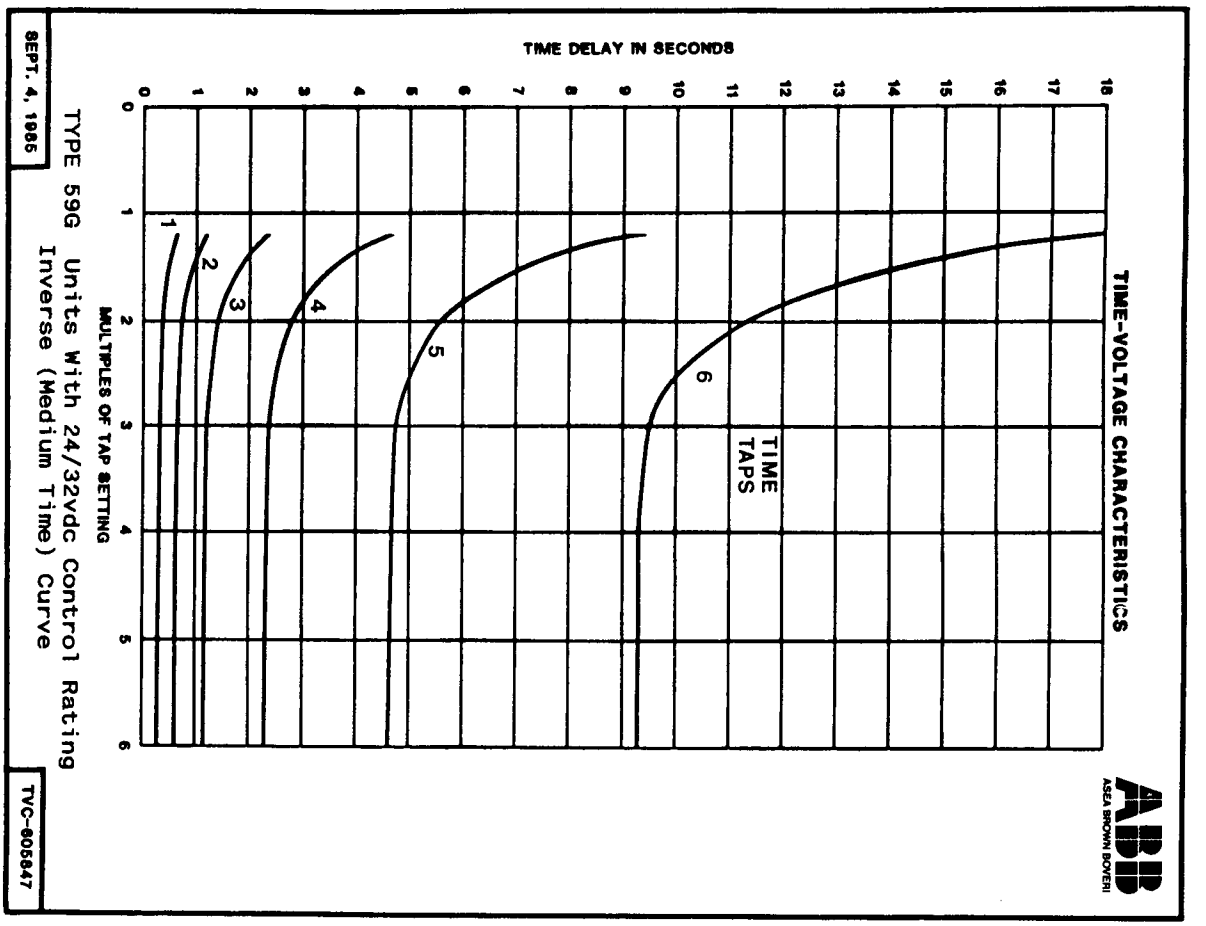
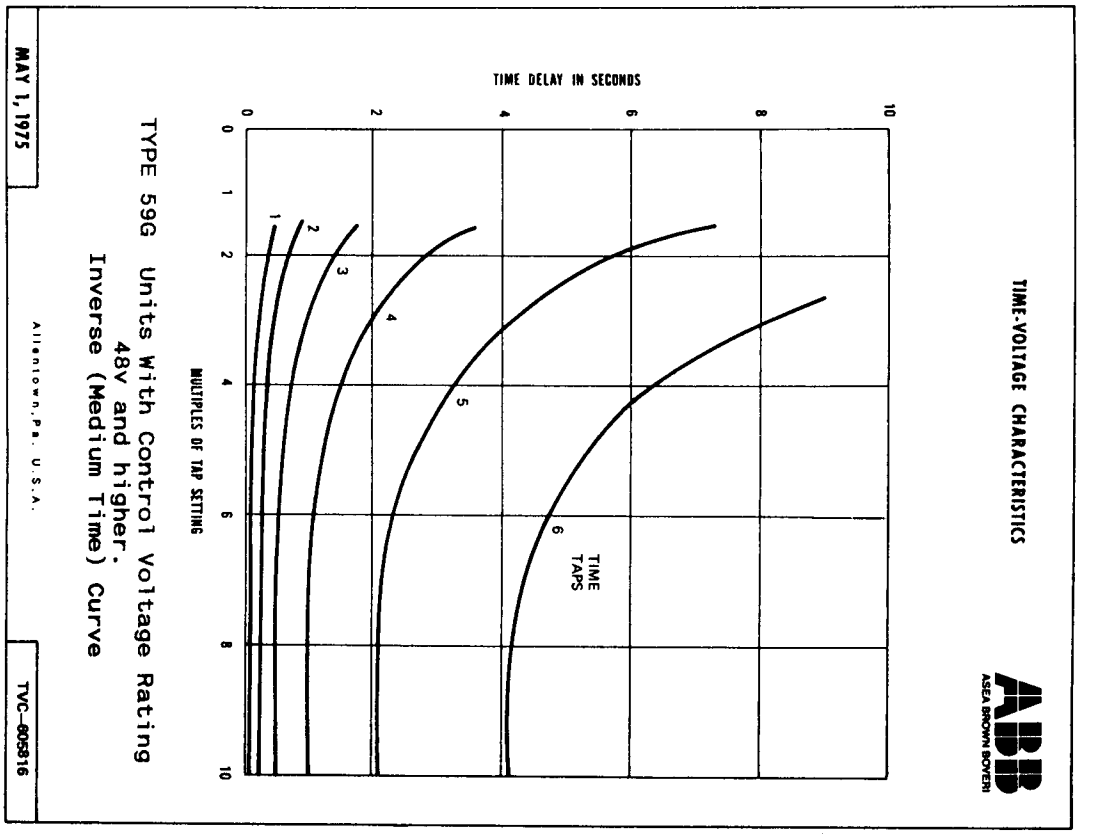


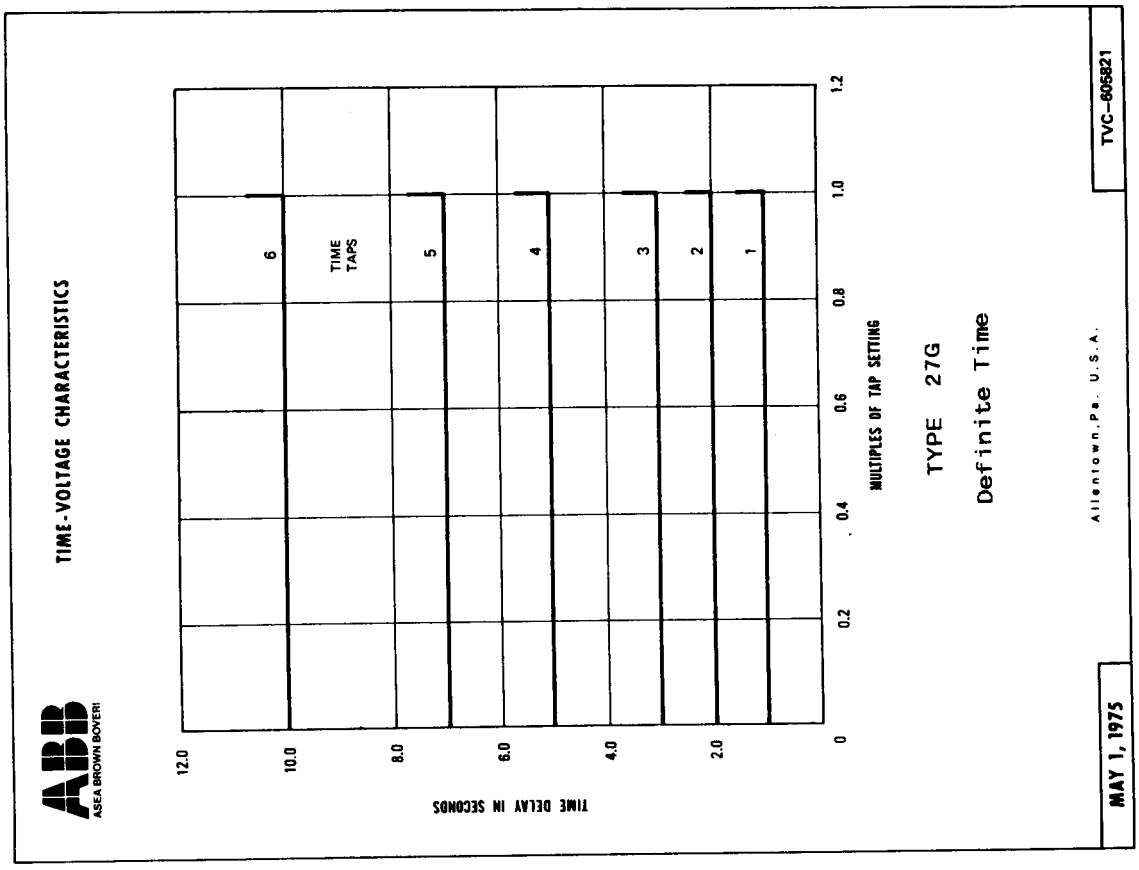
Figure 5: Typical Connections
Capacitor Bank Protection

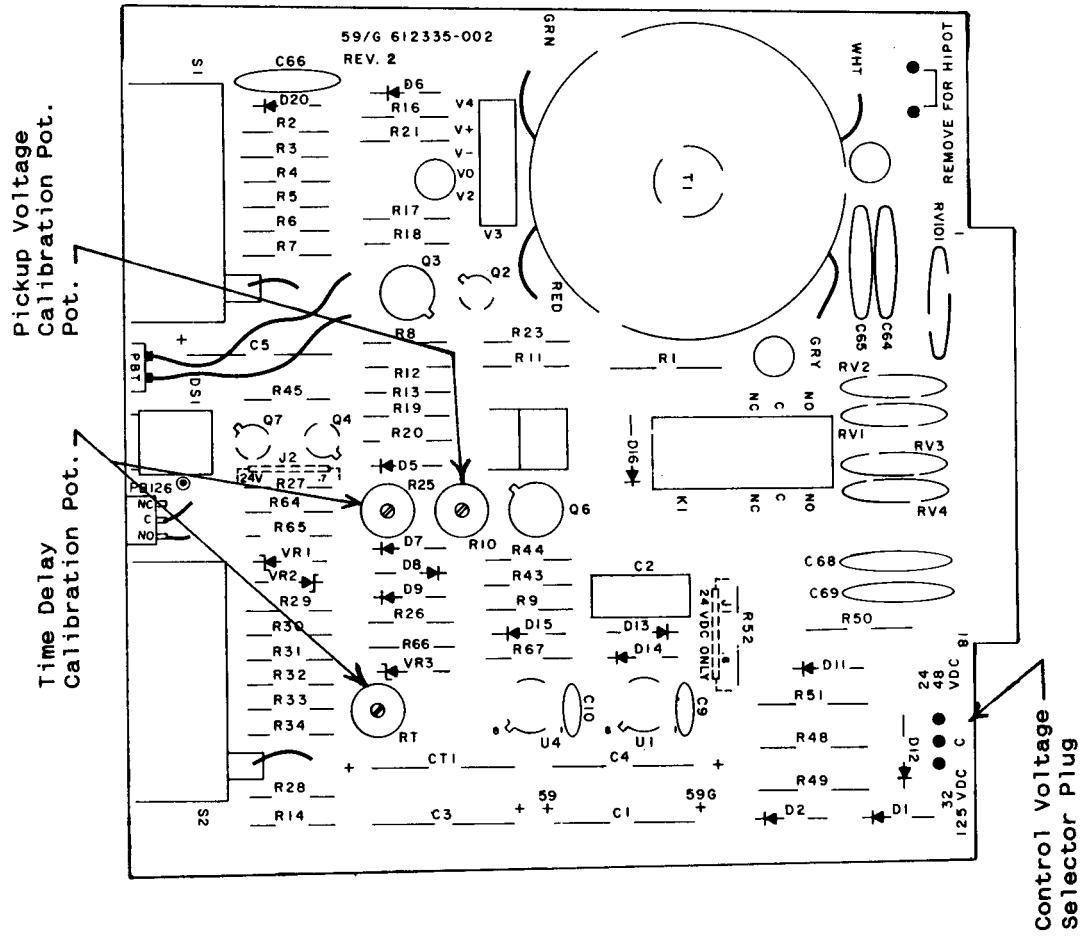


TYPE 59G Units With 24/32vdc Control Rating
Inverse (Medium Time) Curve



TYPE 59G Units With Control Voltage Rating
48v and higher.
Inverse (Medium Time) Curve





Type 59G Circuit Board Layout
(typical for models with dc control voltage)

CHARACTERISTICS OF COMMON UNITS

Type	Tap Range	Frequency	Control Voltage	Connection Diagram	Catalog Numbers Std Case	Test Case
27G	0.5-3 v	180 Hz.	48/125 vdc	16D210H	210Q4575	410Q4575
			48/110 vdc		210Q4505	410Q4505
			220 vdc		210Q4525	410Q4525
			250 vdc		210Q4555	410Q4555
	1-12 v	180 Hz.	48/125 vdc	16D210H	210Q4275	410Q4275
			48/110 vdc		210Q4205	410Q4205
			220 vdc		210Q4225	410Q4225
			250 vdc		210Q4255	410Q4255
	0.5-3 v	150 Hz	48/125 vdc	16D210H	—	410Q4775
			48/110 vdc		—	410Q4705
			220 vdc		—	410Q4725
	1-12 v	150Hz	48/125 vdc	16D210H		410Q4875
			48/110 vdc		—	410Q4805
			220 vdc		—	410Q4825
59G	3-18 v	50/60 Hz.	48/125 vdc	16D210A	210E1175	410E1175
			48/110 vdc	16D210A	210E1105	410E1105
			24/ 32 vdc	16D210A	210E1195	410E1195
			220 vdc	16D211N	201E1125	410E1125
			250 vdc	16D211N	210E1155	410E1155
			120 vac	16D210A	210E1165	410E1165
	1- 6 v	50/60 Hz.	48/125 vdc	16D210A	210E1275	410E1275
			48/110 vdc	16D210A	210E1205	410E1205
			24/ 32 vdc	16D210A	210E1295	410E1295
			220 vdc	16D211N	210E1225	410E1225
			250 vdc	16D211N	210E1255	410E1255
			120 vac	16D210A	210E1265	410E1265
	20-70 v	50/60 Hz.	48/125 vdc	16D210A	210E1375	410E1375
			48/110 vdc	16D210A	210E1305	410E1305
			24/ 32 vdc	16D210A	210E1395	410E1395
			220 vdc	16D211N	210E1325	410E1325
			250 vdc	16D211N	210E1355	410E1355
			120 vac	16D210A	210E1365	410E1365
	20-70 v	50/60 Hz.	48/125 vdc	16D210A	210E0375	410E0375
			120 vac	16D210A	210E0365	410E0365

Important Notes:

1. If Type 59G is to be used in a capacitor-bank protection application, add the suffix "-HF" to the catalog number: eg 410E1175-HF.

2. All Type 27G listed above have 1-10 second definite-time delay.

3. All Type 59G listed above have inverse timing characteristic, except catalog number 410E03x5 which is instantaneous.

   Instantaneous unit 410E03x5 is designed to be applied as a supervising relay in a directional ground scheme.

4. "Test Case" units preferred for new applications due to their improved testing features.

Consult factory for units not listed in the above table.

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on these relays. Follow test instructions to verify that the relay is in proper working order. We recommend that an inoperative relay be returned to the factory for repair; however, a schematic diagram, and in some cases a circuit description, can be provided on request. Renewal parts will be quoted by the factory on request.

210 Series Units:

Drawout circuit boards of the same catalog number are interchangible. A unit is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom side of the drawout circuit board.

The board is removed by using the metal pull knobs on the front panel. *Removing the board with the unit in service may cause an undesired operation.*

An 18 point extender board (cat 200X0018) is available for use in troubleshooting and calibration of the relay.

211 Series Units (obsolete):

Type 59G, catalog series 211E, and Type 27G, catalog series 211Q, are obsolete. 210 series units are NOT directly interchangible with the older 211 series units. To replace a 211 series unit with a 210 or 410 series unit, the entire relay including the case assembly must be changed. The case assemblies are mechanically interchangible. External connections for the Type 27G are identical for both series (except the trip circuit should be connected to terminal 12 in order to obtain target operation). For the Type 59G, some connections must be rewired; see Figure 7 for reference.

410 Series Units:

Metal handles provide leverage to withdraw the relay assembly from the case. Removing the unit in an application that uses a normally closed contact will cause an operation. The assembly is identified by the catalog number stamped on the front panel and a serial number stamped on the bottom of the circuit board.

Test connections are readily made to the drawout relay unit by using standard banana plug leads at the rear vertical circuit board. This rear board is marked for easier identification of the connection points.

Important: for units which have an external resistor mounted on rear terminals 1 and 9 (such as the Type 59G rated for 250 vdc control): in order to test the drawout unit an equivilent resistor must be connected to terminals 1 & 9 on the rear vertical circuit board of the drawout unit. The resistance value must be the same as the resistor used on the relay (10000 ohms for the 59G rated 250vdc). A 25 or 50 watt resistor will be sufficient for testing. If no resistor is available, the resistor assembly mounted on the relay case could be removed and used. *If the resistor from the case is used, be sure to remount it on the case at the conclusion of testing.*

Test Plug:

A test plug assembly, catalog number 400X0002 is available for use with the 410 series units. This device plugs into the relay case on the switchboard and allows access to all external circuits wired to the case. See Instruction Book IB 7.7.1.7-8 for details on the use of this device.

2. HIGH POTENTIAL TESTS

High potential tests are not recommended. A hi-pot test was performed at the factory before shipping. If a control wiring insulation test is required, partially withdraw the relay unit from its case sufficient to break the rear connections before applying the test voltage.

On these relays, a link on the circuit board is removed temporarily when high potential tests are conducted at the factory. After testing, the link is restored to its position to connect certain surge suppression components to ground for normal operation. The link is labelled "remove for hipot".

3. BUILT-IN TEST FUNCTION

Be sure to take all necessary precautions if tests are run with the main circuit energized.

The built-in test is provided as a convenient functional test of the relay and associated circuit. When you depress the button labelled TRIP, the measuring and timing circuits of the relay are actuated. When the relay times out, the output contacts transfer to trip the circuit breaker or other associated circuitry, and the target is displayed. The test button must be held down continuously until operation is obtained. For the Type 59G an overvoltage condition is simulated when the button is depressed. For the Type 27G relay, an undervoltage condition is simulated (therefore the relay must be picked up with 180Hz voltage to run the trip test).

4. ACCEPTANCE AND CALIBRATION TESTS

A typical test circuit is shown in Figure 6. Apply control voltage to match the relay's nameplate rating. For dual-rated units check the position of the control voltage selector link on the circuit board first. The Type 59G requires a 50 or 60 Hz source. The Type 27G requires a 180 Hz. source. (150 Hz. for units applied to 50 Hz systems.)

The operating voltage should be within +/-5% or +/-0.5 volt (whichever is greater) of the tap setting. To check the time delay: for the Type 59G switch the input voltage from 0 volts to 2X the tap setting; for the Type 27G switch the voltage from 2X the tap setting to zero volts. The operating time should be within +/-10% of the value read from the time-voltage curve for the unit for the time-dial used. (or +/-0.05 sec whichever is greater)

Pickup or dropout may be varied somewhat from the fixed taps by adjusting the internal calibration potentiometers. For 210 series units, use of an extender board will make the procedure easier. With the tap pin in the setting nearest the desired operating value, adjust the calibration potentiometer to obtain the desired operation. If the calibration potentiometer has insufficient adjustment range, try placing the tap pin in the next closest position on the opposite side of the desired setting. Similarly, the operating time may be adjusted by using the time delay calibration potentiometer.

Internal Calibration Potentiometers:

Relay Type	Pickup Adjustment	Time Adjustment
Type 59G	R10	R25
Type 27G	R12	R37

To check target operation on the Type 27G, wire the output contact (terminals 11-12) to trip a lockout relay. The lockout relay will insure sufficient trip current flow to set the target.

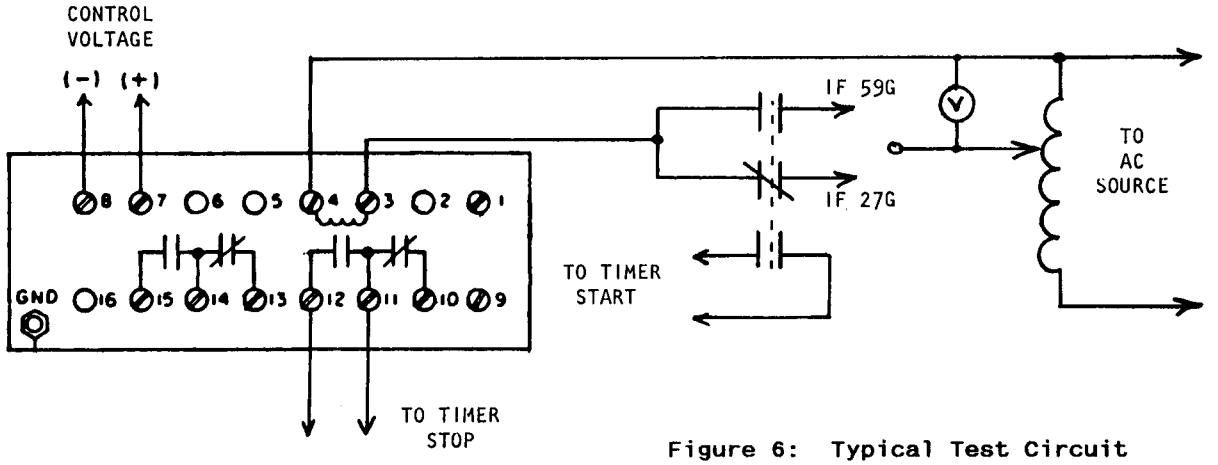


Figure 6: Typical Test Circuit

The following information is for use when replacing a 211E series unit with a 210E series unit:

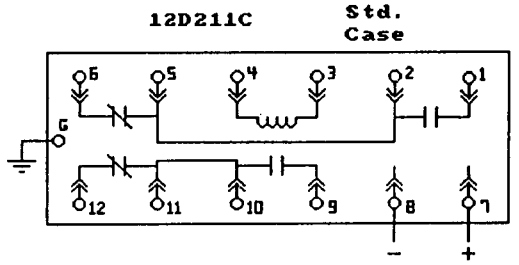
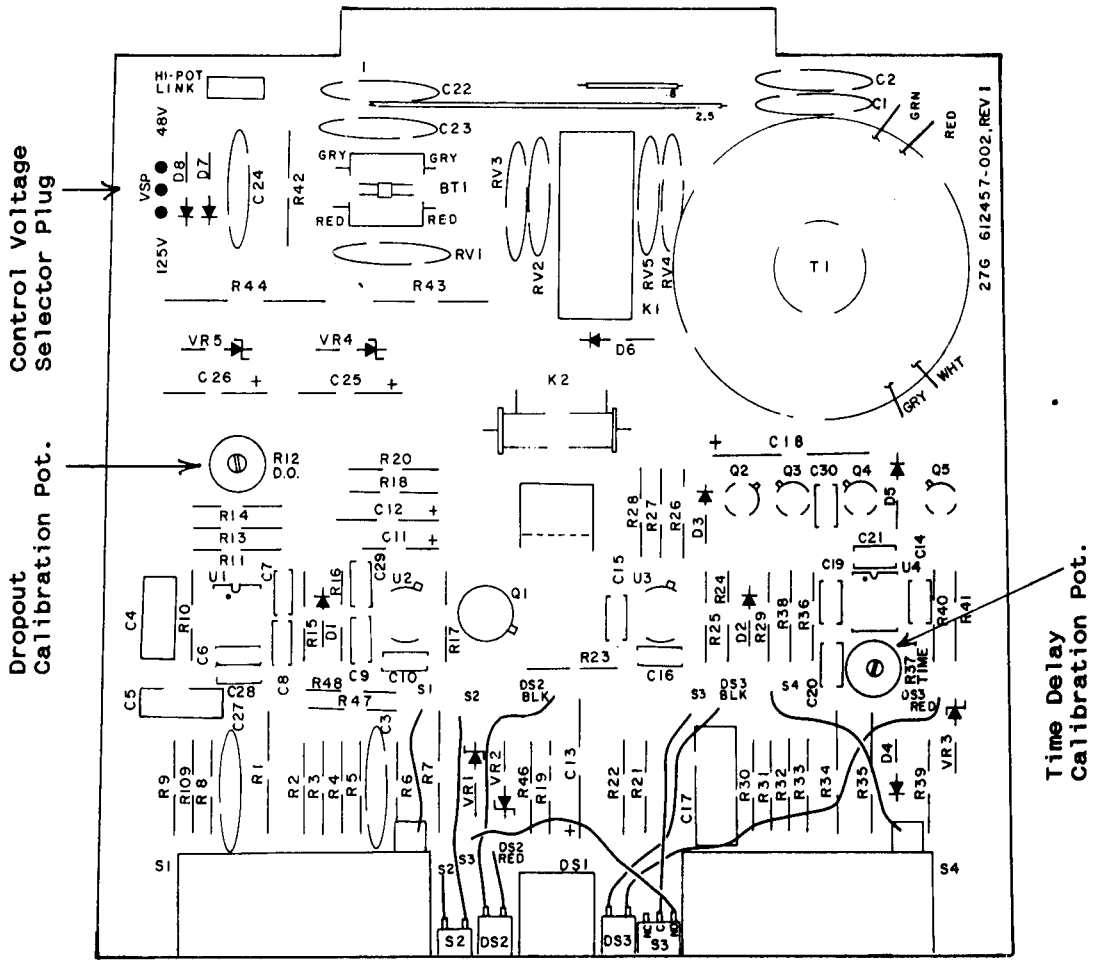


Figure 7: Internal Connections for Type 59G, 211E Series Units

For reference only.
Do not use for 210E series units.

Re-wiring Table:

Wire on 211E unit terminal	MOVES to 210E unit terminal
1	12
2	11
3	3
4	4
5	11
6	10
7	7
8	8
9	15
10	14
11	14
12	13
G	G



Type 27G Circuit Board Layout (typical)

ADDITIONAL NOTES ON THE APPLICATION OF THE ITE-59G FOR GROUND DETECTION ON UNGROUNDED SYSTEMS:

Grounds on ungrounded systems should be detected and cleared promptly to achieve continuity of service and also to protect equipment and personnel from high voltages. More serious line-to-line faults resulting from a second ground can be caused by insulation breakdown initiated by an uncleared ground.

Figure 4 shows the scheme typically used to detect grounds on three-phase ungrounded systems. Figure 8 below shows the same basic scheme with an alternate location for the ballast resistor. Indicating lamps or voltmeters are often connected across the pt secondaries to indicate which phase is grounded.

Under normal system conditions, the phase-to-ground voltages are balanced. The pt and relay voltages are as shown in Figure 9. The sum of the 60 Hz secondary voltages is zero. However, the third-harmonic voltages will appear in phase with each other and the 59G will see three times the third-harmonic component of the phase-to-neutral voltages. The 59G is a low-pickup overvoltage relay, but is designed to ignore third harmonic voltages. Thus, the 59G will protect the system against insulation deterioration or grounds without nuisance alarms caused by variations in the primary voltage waveshape.

When a ground occurs, the balance of the phase voltages relative to ground is altered as shown for phase A grounded in Figure 10. The equivilent circuit in the grounded condition is also shown.

For phase A grounded the relay voltage is $V_R = V'_{CA} - V'_{AB} = V'_C - V'_A - V'_A + V'_B$

and since $V'_B + V'_C = -V'_A$ then $V_R = -3\ V'_A$.

As an example, assume a 2400/4160Y system, with 35:1 potential transformers rated 4200v primary/ 120v secondary. (The pt's must be rated for line-to-line potential.) The resulting voltages are shown below:

		No Ground Present	Ph A Ground Present
Primary	V_{AN}	2400	0
	V_{BN}	2400	4160
	V_{CN}	2400	4160
Secondary	V'_{AN}	69	0
	V'_{BN}	69	119
	V'_{CN}	69	119
Relay	V_R	0	208

The solid ground on phase A produces a relay voltage of 208 volts and the 59G will close its contacts to alarm, or in some applications to trip the circuit. The ABB Circuit-Shield™ Type 59G has a continuous rating of 208 volts in order to withstand this condition.

Provision against false alarms due to unbalanced system charging currents is made by adjusting the 59G pickup voltage setting. The 20-70 volt tap range is preferred.

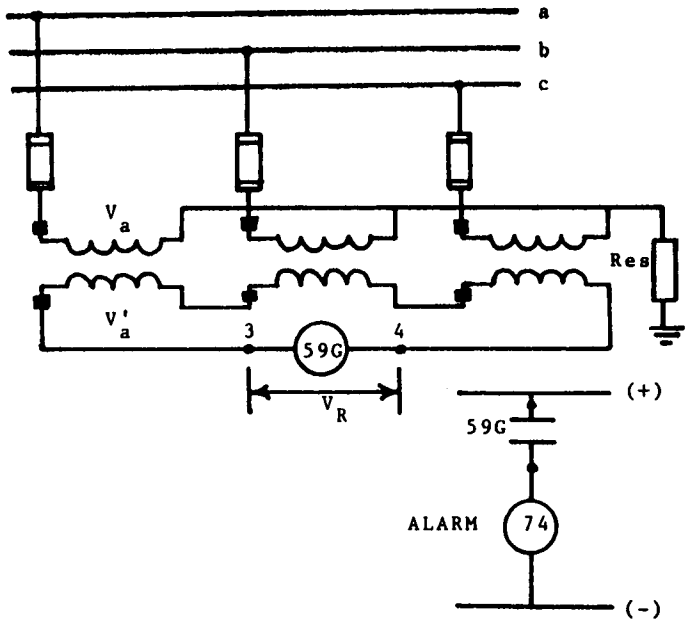


Figure 8: Ground Detection on Ungrounded Systems

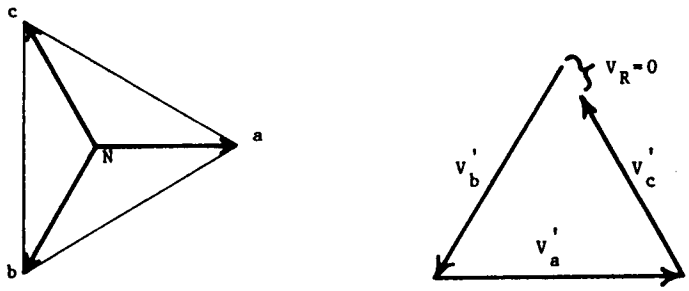


Figure 9: Voltages Under Normal System Conditions

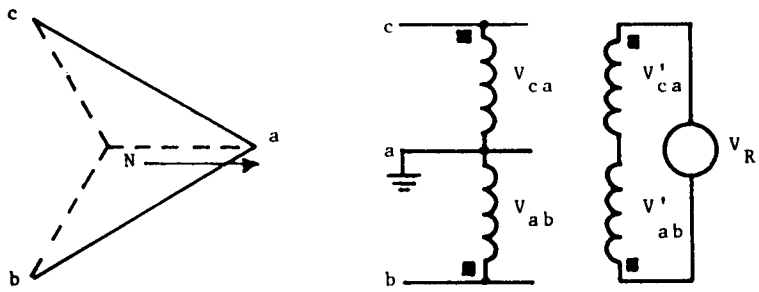


Figure 10: Voltages With Ground On Phase A