IB 7.4.1.7-3
Issue C

INSTRUCTIONS

Phase Unbalance Relay

PHASE UNBALANCE RELAY

(Negative-Sequence Overvoltage Relay)

Type 60Q	Catalog Series 412J/412S	Test Case
Type 60Q	Catalog Series 212J/212S	Standard Case

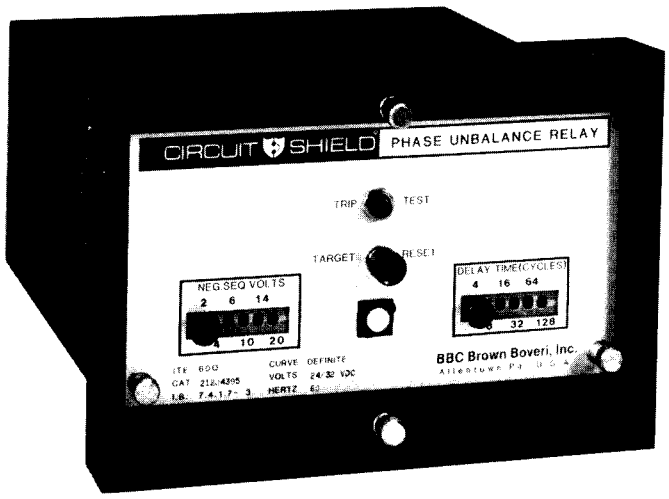


TABLE OF CONTENTS

INTRODUCTION

These instructions contain the information required to properly install, operate, and test certain three-phase voltage unbalance relays, type 60Q, catalog series 212J, 412J, 212S, and 412S. See the section on Testing for reference to earlier models of these relays, catalog series 211J, and 211S.

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 412J and 412S catalog series are similar to relays of the 212J and 212S series. Both series provide the same basic functions and are of totally drawout construction; however, the 412J and 412S series relays provide integral test facilities, and are preferred for new installations. Also, sequenced disconnects on the 412 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. On removal of a tap setting pin, the setting automatically switches to the following value/position: Pickup: highest voltage tap; Time Delay: longest time.

7. 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 the relay clean and dry.

2. INSTALLATION

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

Connections:
Typical external connections are shown in Figure 2.

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.

DC Control power must be connected in the proper polarity.

Control Voltage Selector Plug:
For relays with dual-rated control voltage: 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.)

3. SETTINGS

PICKUP (Negative Sequence Volts)
The pickup taps are labelled by the actual value of the negative-sequence voltage (on a line-to-neutral basis) which will cause the relay contacts to transfer.

TIME DELAY
Refer to the front panel markings for your relay. The time delay taps are calibrated in cycles or in seconds depending on the model. The delay time has a definite time characteristic; i.e., the delay is constant for any negative-sequence voltage above the pickup value.

4. TARGET INDICATOR

An operation target is provided. The target will retain its indication on loss of dc control power. In order to reset the target, normal control power must be present and a "normal" balanced ac voltage condition must exist.

APPLICATION DATA

The ABB Type 60Q is a negative-sequence overvoltage relay used to detect unbalance in a three-phase supply voltage.

The most common application is to protect motors against the effects of unbalanced voltage. If one fuse blows in the three-phase supply to a motor, the voltage does not collapse, due to the back emf. If the motor had been running at full load before the fuse opened, the negative-sequence component of the voltage (designated E_2) is equal to the ratio of the running to the starting current. This yields an E_2 of 16% for a typical motor with a starting current of 6 per unit. If the fuse opens when the motor is running lightly loaded, the resultant E_2 will be less; at no load typical values are 3 to 4%.

The Type 60Q is available with tap ranges of 1-10 volts E_2, and 2-20 volts E_2. On a percentage basis, the 1-10 volt model provides a sensitivity range of 1.45 to 14.5%. This range provides sufficient sensitivity to detect a blown fuse condition even for a motor running at no load. Selection of the most sensitive settings and faster time delays should be made with caution, to avoid nuisance tripping.

The ABB type 60Q includes a built-in timer, which should be set sufficiently long to allow faults on the system to be cleared by other devices.

The type 60Q also includes a harmonic filter which allows the relay to operate properly even if the voltage waveform is not a pure sine-wave.

For applications requiring detection of the negative-sequence content of the load current, refer to the ABB types 46D (IB 7.6.1.7-2) and 46Q (IB 7.6.1.7-3).

The pickup taps of the Type 60Q are calibrated in negative-sequence volts, on a line-to-neutral basis. The relationship to line-to-neutral voltages is given as follows:

$E_2 = 1/3 * (V_a + a^2 V_b + a V_c)$ by the definition of negative-sequence voltage,

where $a = e^{j240}$ $a^2 = e^{j120}$

With the 3 phase voltages separated by 120^0

$E_2 = 1/3 * (|V_a| + e^{j240}|V_b|e^{j240} + e^{j120}|V_c|e^{j120})$

$= 1/3 * (|V_a| + |V_b|e^{j120} + |V_c|e^{j240})$

For the case where $|V_b| = |V_c|$

$E_2 = 1/3 * (|V_a| + |V_b|(e^{j120} + e^{j240}))$

$= 1/3 * (|V_a| + |V_b|(-1))$

$= 1/3 * (|V_a| - |V_b|)$

$= 1/3 * V_{difference}$

The above analysis shows that the reduction in one phase-to-neutral voltage results in a negative-sequence voltage component equal to 1/3 the value of the reduction.

Notes on the Use of AC Control Power

In general the use of a station battery to provide a reliable source of tripping and control power is preferred. However, the type 60Q can be arranged for use with 120 vac control power by using a separate type 96 three-phase power supply. This supply provides a nominal 175vdc output to provide control power to the 60Q relay. Sufficient voltage is developed to keep the 60Q relay operating even on the loss of one phase.

The output contacts of the 60Q relay may be used in a 120 vac control circuit or in a capacitor trip circuit where the capacitor voltage is no more than 170 vdc nominal. (If a higher rating is required add the suffix "-CAP" to the catalog number of the 60Q relay.) The control power for these relays should never be taken directly from the capacitor trip circuit, as the relay will drain the capacitor in the event of loss of AC supply.

See Figure 4 for the control connections for the combination of the types 60Q and 96.

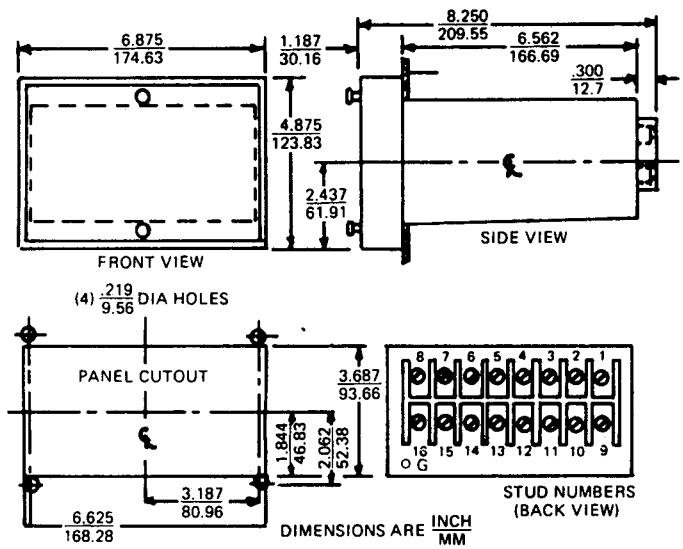


Figure 1:

Relay Outline and

Panel Drilling.

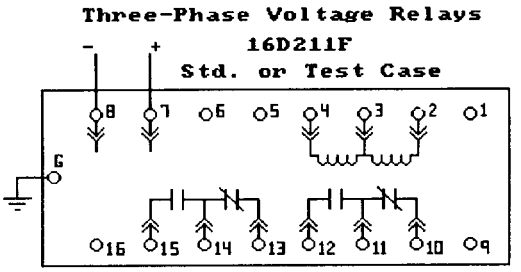


Figure 2: Internal Connection Diagrams

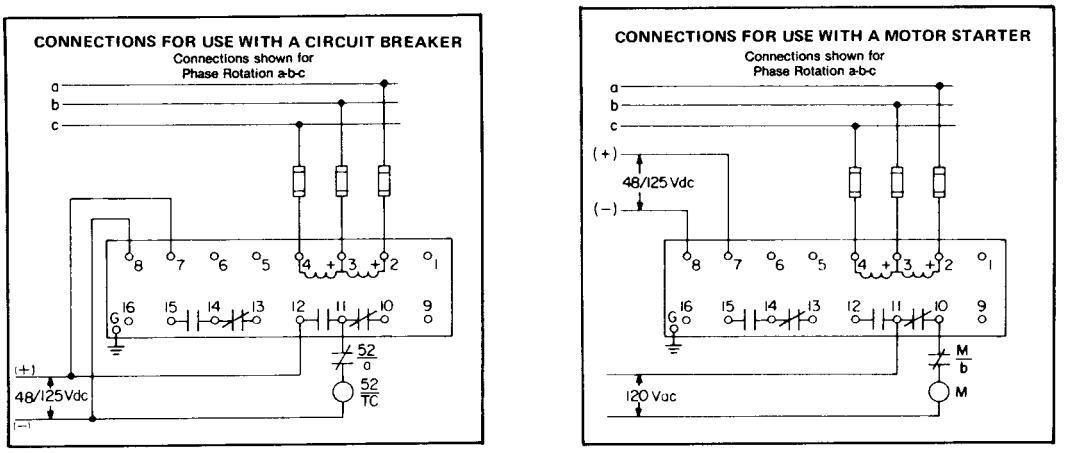


Figure 3: Typical External Connections for Type 60Q Units Rated for DC Control.

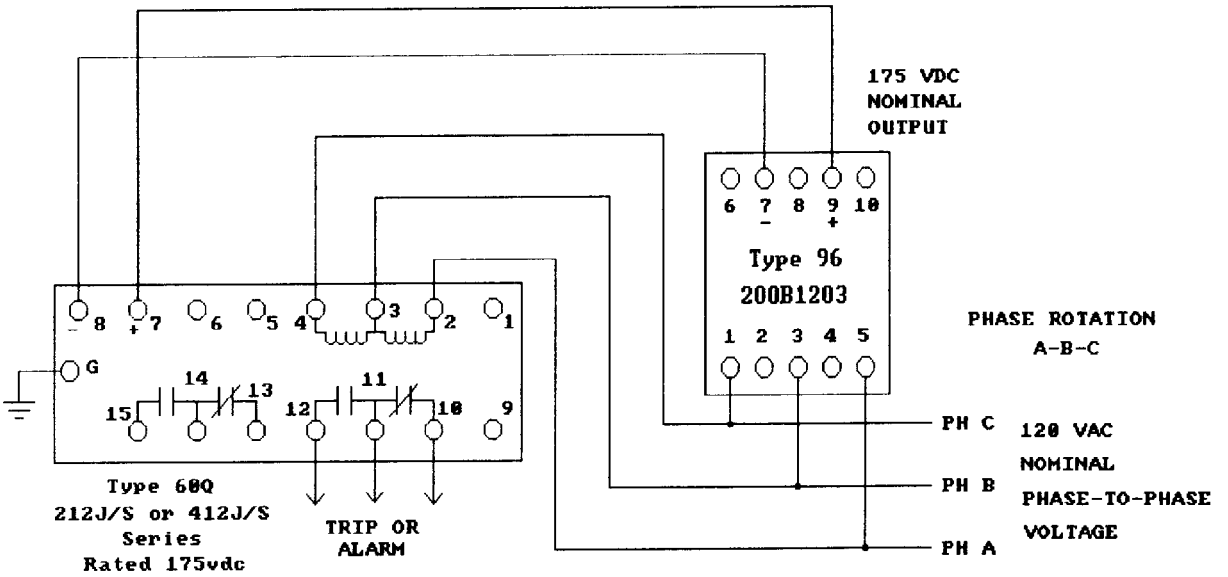


Figure 4: Typical Control Connections for Types 60Q and 96
(AC Control)

SPECIFICATIONS

Input Circuit:

Rating: 120v models: 160vac, continuous, 50 or 60 Hz.
208v models: consult factory.

Burden: 120v models: less than 1 VA, 1.0 PF at 120 volts, per phase.

Taps: available models include:
E_2 Pickup: 1, 2, 3, 5, 7, 10 volts; or,
2, 4, 6, 10, 14, 20 volts.
Dropout: approximately 95% of pickup.

Operating Time:

Taps: available models include:
4, 8, 16, 32, 64, 128 cycles; or,
0.32, 0.63, 1.25, 2.5, 5, 10 seconds.

Output Circuit:

Each contact	@ 125 Vdc:	@ 250 Vdc:	
	30 amperes	30 amperes	tripping duty.
	5 amperes	5 amperes	continuous.
	0.3 ampere	0.1 ampere	break.

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.
24/ 32 vdc @ 0.08 A max.
220 vdc @ 0.05 A max.
250 vdc @ 0.05 A max.
175 vdc @ 0.05 A max. (for use with type 96 converter 200B1203)

Allowable variation:		
24vdc	nominal:	19- 29 vdc
32vdc	"	25- 38
48vdc	"	38- 58
110vdc	"	88-125
125vdc	"	100-140
220vdc	"	176-250
250vdc	"	200-280
175vdc	"	140-200

Tolerances:

Operating Voltage:
+/-10% or +/-0.5 volts E_2, whichever is greater.

Operating Time:
+/-10% or +/-2 cycles, whichever is greater.

These tolerances are based on the printed dial markings. If required by the application, the relay may be set more precisely to the desired values of operating voltage and delay by means of the internal calibration adjustments.

Repeatability: variation in operating voltage for a +/-10% variation in control voltage: +/-0.25%, typical.

variation in operating voltage over the temperature range -20 to +55 deg C: +/-5%, typical.

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)

CHARACTERISTICS OF COMMON UNITS

ABB Type 60Q — **Test Case**

Tap Range Volts E_2	Time Delay Range	Control Voltage	Connection Diagram	Cat. Numbers 60 Hertz	Cat. Numbers 50 Hertz
1-10	4-128 cycles	48/125 vdc	16D211F	412J4275	412S4275
		48/110 vdc		412J4205	412S4205
		24/ 32 vdc		412J4295	412S4295
		175 vdc		412J4215	412S4215
		250 vdc		412J4255	412S4255
1-10	0.32-10 sec.	48/125 vdc	16D211F	412J5275	412S5275
		48/110 vdc		412J5205	412S5205
		24/ 32 vdc		412J5295	412S5295
		175 vdc		412J5215	412S5215
		250 vdc		412J5255	412S5255
2-20	4-128 cycles	48/125 vdc	16D211F	412J4375	412S4375
		48/110 vdc		412J4305	412S4305
		24/ 32 vdc		412J4395	412S4395
		175 vdc		412J4315	412S4315
		250 vdc		412J4355	412S4355
2-20	0.32-10 sec.	48/125 vdc	16D211F	412J5375	412S5375
		48/110 vdc		412J5305	412S5305
		24/ 32 vdc		412J5395	412S5395
		175 vdc		412J5315	412S5315
		250 vdc		412J5355	412S5355

Note: "Standard Case" units have catalog numbers beginning with "212", and have the same electrical characteristics as 412 series units. 412 series units are preferred for new applications due to their improved test features.

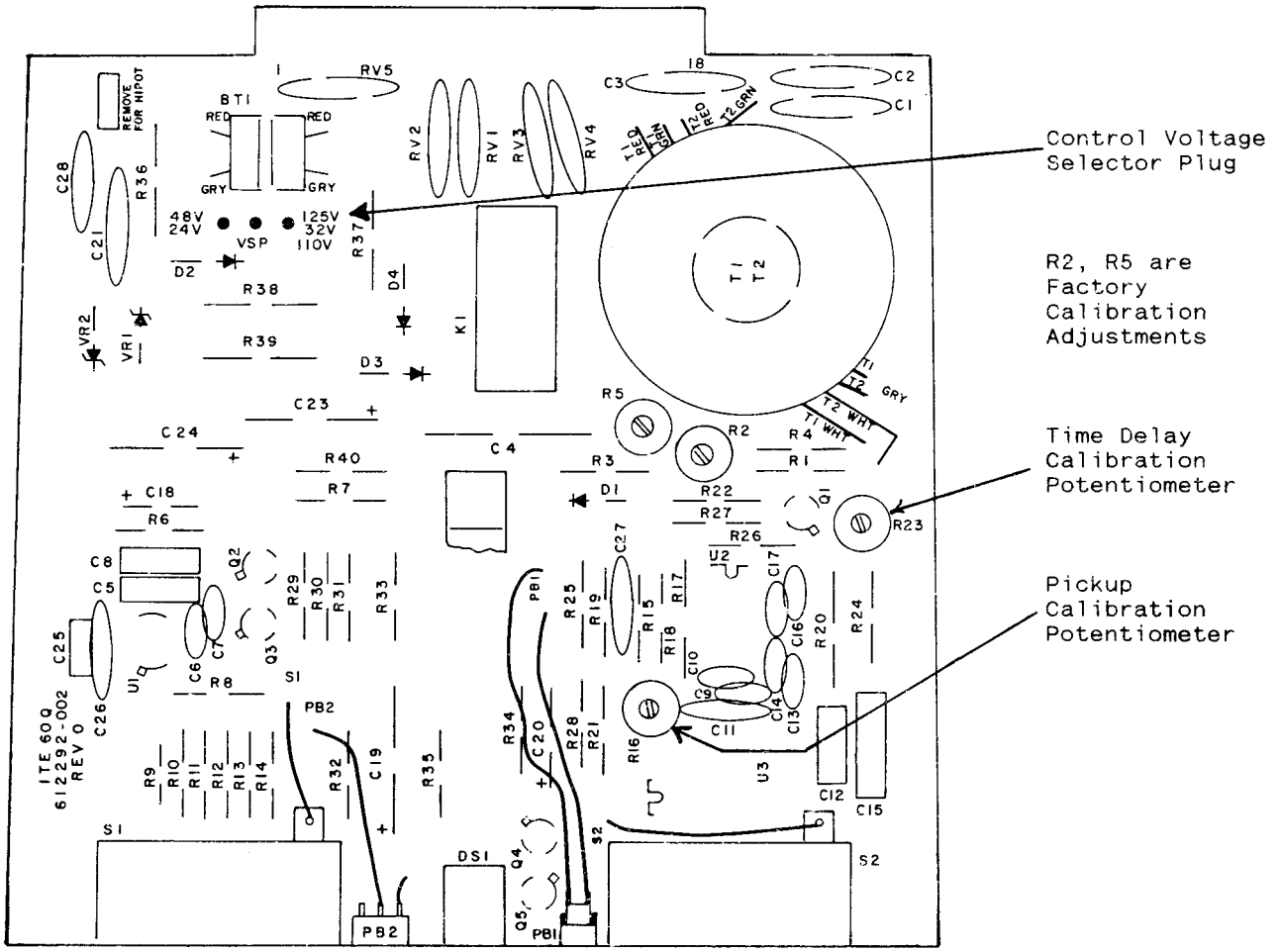


FIGURE 5: TYPICAL PRINTED CIRCUIT BOARD LAYOUT

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 can be provided on request. Renewal parts will be quoted by the factory on request.

The earlier versions of these three-phase voltage relays, catalog series 211J, 211S, are obsolete and have been superseded by the improved relays described by this book. See paragraph 7 for a reference to these obsolete relays.

412J and 412S 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.

A test plug assembly, catalog 400X0002 is available for use with the 412 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.

212J and 212S 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.

Circuit boards of the 212J/212S series are *not interchangible* with 211J/211S units.

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.

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.

3. BUILT-IN TEST FUNCTION

Be sure to take all necessary precautions if tests are run with the main circuit energized. *A normal, balanced, three-phase ac input voltage, as well as the dc control voltage must be present at the relay terminals for the built-in test to be operable.* When you depress the button labelled TRIP, an unbalanced condition is simulated, and 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, for the time delay set on the relay, until operation is obtained.

4. ACCEPTANCE TESTS

A typical test circuit is shown in Figure 6, with the ac voltage sources connected to provide negative-sequence voltage (reverse phase sequence). Connect the relay to a proper source of control voltage to match its nameplate rating (and internal plug setting for dual-rated units).

Set the 60Q pickup voltage tap to 10v. Set the time delay tap to the minimum setting. Raise all three voltage sources equally in small increments to maintain a balanced three-phase source. Relay operation should be obtained at 9.0 to 11.0 volts: the output contacts should transfer and the target set to orange.

Reduce the source voltages to zero. Reset the target.

Set the time delay tap to the maximum position. Check the timing by switching the voltage sources suddenly and simultaneously from 0 to 20 volts. Operating time should be within +/-10% of the expected time.

If the final tap settings have been selected for the application, these may be verified by repeating the above tests for those particular operating values. The pickup voltage should be within +/-10% (or +/-0.5 volts, whichever is greater). The time delay should be within +/-10% (or +/-2 cycles, whichever is greater). Time delay tests should be made with the voltage sources set to approximately 2 times the pickup voltage setting.

5. CALIBRATION

A typical test circuit is shown in Figure 6 with the ac voltage sources connected to provide negative-sequence voltage (reverse phase sequence). Connect the relay to a proper source of control voltage to match its nameplate rating (and internal plug setting for dual-rated units). For 212 series units the 18 point extender board provides easier access to the internal pots. For calibration purposes, the ac sources should be accurate in phase and magnitude, and varied equally to provide balanced three-phase voltage.

The *pickup voltage* may be varied between the fixed tap values by adjusting the internal pickup calibration potentiometer. Place the PICKUP VOLTAGE tap pin in the nearest value and adjust the internal pot R16, repeating the test until the desired operating voltage is obtained.

The *time delay* may be adjusted by means of internal calibration potentiometer R23. When making timing measurements, the sources voltages should be applied suddenly and simultaneously at a value of approximately 2 times the pickup tap setting.

Internal potentiometers R2 and R5 are for factory calibration of the negative-sequence filter and should not be adjusted.

We suggest the relay be tagged with the final operating values for reference purposes.

6. IN CASE OF DIFFICULTY

The most common problem experienced with this relay is incorrect wiring, resulting in incorrect phase-sequence being applied to the input terminals 2, 3, and 4. The relay will pick up with incorrect phase-sequence, since the applied voltage is essentially 100% negative-sequence to the relay.

Also, the wiring diagrams in this book are based on A-B-C phase rotation. Some systems operate with A-C-B rotation and the connections to the relay must be modified accordingly: swap the leads to terminals 3 and 4.

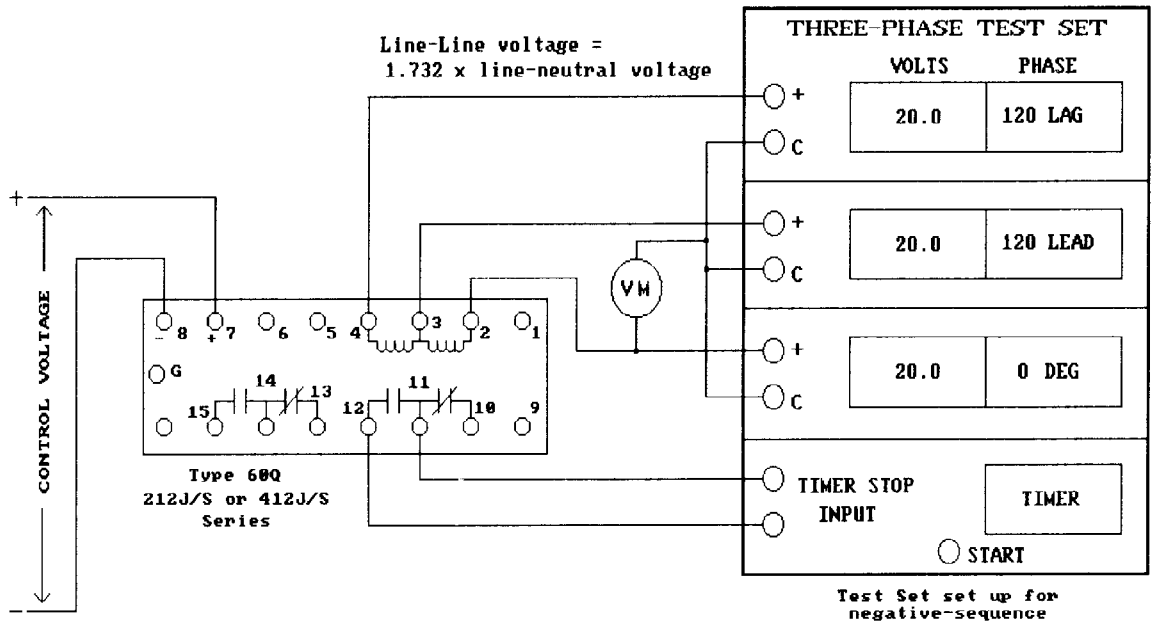


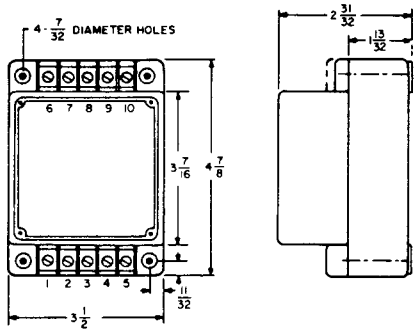
Figure 6: Typical Test Circuit Connections

7. OBSOLETE UNITS, Catalog Series 211J, 211S

Type 60Q relays of catalog series 211J and 211S are obsolete. Equivilent 412J and 412S units are recommended for new installations and as replacements for the earlier models. Drawout circuit boards are *not interchangible* between the 211J/S, 212J/S, or 412J/S series. However, the rear terminal connections are the same for all three series; therefore, the entire relay including the case assembly may be replaced with no change in the external wiring.

The following is a list of recommended replacement units for the earlier models:

"Old" Catalog Numbers		Recommended Replacement
211J4275, 211J6275	----------	412J4275
211J4375, 211J6375	----------	412J4375
211S4275, 211S6275	----------	412S4275
211S4375, 211S6375	----------	412S4375



Type 96 Converter
Catalog 200B1203
Input Voltage: 120 Vac, 3 phase.
Output Voltage: 175 Vdc, unregulated.
Output Current: 100 ma. maximum.

Figure 7: Type 96 Converter

(See pages 4 and 5 for application)