

ADDENDUM TO IB 7.6.1.7-2B, Types 46D and 46H

The ABB Circuit-Shield solid-state protective relay identified below is hereby certified to be a direct replacement for the superseded model. This new version equals or exceeds the original model in fit, form, and function.

| <u>Product</u> | <u>Replacement Cat. no.</u> | <u>Superseded Catalog Number</u> |
|-----------------------------------|-----------------------------|----------------------------------|
| Current Balance Relay Type 46D | 427QXXX1 | 427QXXX0, 227QXXX0 |

The ABB Type 46D Current Balance relay is described by Bulletin DB 41-171S. The relay utilizes the Test Case design concept to provide a full drawout capability and easy field testing. Relays with catalog numbers starting with 427 are similar to relays of the 227 series, but offer totally drawout construction with integral test facilities. Current transformer shorting is accomplished by a direct-acting spring and blade assembly upon removal of the relay from its case. Units of the 227 series, which are now obsolete, are of partial drawout construction, with the input transformers remaining in the case upon withdrawal of the lower electronic circuit board.

Use of the Front Panel Test Jacks to Determine the Negative Sequence Current Level:

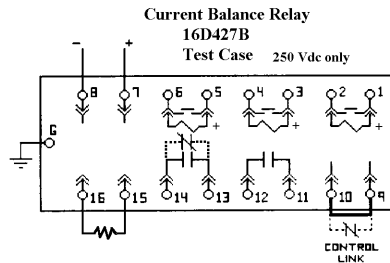
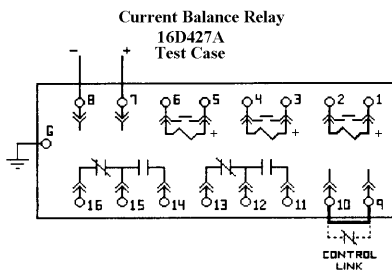
The 427QXXX1 series has test jacks on the front panel of the relay so that the negative sequence current level can be easily determined with the relay in service. This is done by making a measurement of the ac voltage signal from the negative sequence filter circuit within the relay. Use the following formulas:

$$I_2 = \frac{V_{sig} \text{ (AC RMS)}}{K}$$

K = 8.0 for 427QX1X1 models (0.1-0.4A range)
K = 1.6 for 427QX2X1 models (0.5-2.0A range)
K = 2.67 for 427QX4X1 models (0.3-1.2A range)

Mounting and Wiring:

The package size and mounting dimensions have been kept the same to provide mechanical interchangeability. The original rear terminal wiring arrangement has also been retained (see diagrams below). Mounting, wiring and operating information is shown in Instruction Book 7.6.1.7-2.



Contact 13-14 convertible
External resistor supplied with relay



INSTRUCTIONS

Current Balance Relays

CURRENT BALANCE RELAYS

(Negative Sequence Overcurrent Relays)

Type 46D Definite Delay
Type 46H Instantaneous

Catalog Series 227Q Standard Case
Catalog Series 427Q Test Case

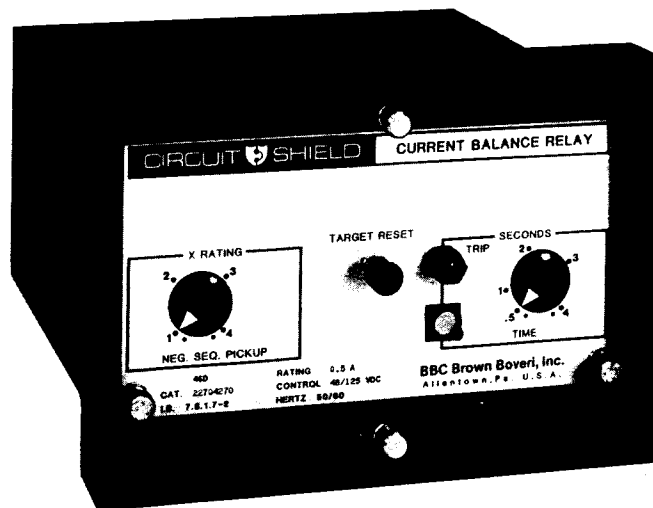


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INTRODUCTION

These instructions contain the information required to properly install, operate, and test the ABB Circuit-Shield™ Types 46D and 46H Negative Sequence Overcurrent Relays. The Type 46D relay has a definite delay timing characteristic, and its primary application is to provide protection for motors against unbalanced currents. The Type 46H has an instantaneous characteristic.

The relay is housed in a case suitable for conventional semi-flush panel mounting. All connections to the relay are made at terminals at the rear of the case that are clearly numbered. The 427Q series relay provides totally drawout construction with integral test facilities. Current transformer shorting is accomplished by a direct-acting spring and blade assembly upon removal of the relay from its case. Sequenced disconnects prevent nuisance tripping during withdrawal or insertion of the relay if the normally open contacts are used in the application. The 227Q series relay is of partial drawout construction, with the input transformers remaining in the case upon withdrawal of the lower circuit board.

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 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 voltage marked on the relay front panel. For units rated for dc control power, the proper polarity must be observed.
3. For relays with dual-rated control voltage, the control voltage selector plug located on the lower circuit board must be placed in the correct position for the system control voltage. On 427Q series units the upper and lower circuit boards must be separated for easier access to the selector plug.
4. The 50 Hertz/60 Hertz selector plugs on the lower circuit board must be in the correct position for the system frequency. On 427Q series units the upper and lower circuit boards must be separated for easier access to the plug.
5. In most applications, the shorting link between terminals 9 and 10 must be in place for proper operation. See section on Connections for more information.
6. Drawout elements should insert in the case smoothly. Do not use excessive force.
7. High voltage insulation tests are not recommended. See section on Testing for additional information.
8. 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 competent 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 the nearest Asea Brown Boveri office. 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 Fig. 2. Typical external connections are shown in Figure 3.

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.

Internal selector plugs are provided to set up the relay for system frequency and dc control voltage. On 427Q series units, it will be necessary to separate the lower and upper printed circuit boards. See section on Maintenance, page 9 for the procedure.

Control Voltage Selector Plug:

Apply only the rated control voltage marked on the front panel of the relay. For units rated for dc control, proper polarity must be observed. For relays with dual-rated control voltage, *the control voltage selector plug located on the lower circuit board must be placed in the correct position* for the system control voltage. For units rated for use on 120 vac control, the plug must be placed in the 48 vdc position. For relays rated for use on 110 vdc, the plug must be placed in the 125 vdc position.

System Frequency Selector Plugs:

Two plugs are provided on the circuit board to set the relay for the system frequency. The plug positions are labelled for 60Hz and 50Hz operation.

External Control Link:

These relays are shipped with a shorting link between terminals 9 and 10. *The link must be in place for proper operation.* Alternately, in special applications the link may be removed and a controlling contact from another device connected. If the contact is closed the relay will be operable, with the contact open the relay is prevented from operating. Upon closure of the external contact, if the negative seq. current is above the pickup setting, the full time delay period will be obtained before the relay output contacts transfer.

3. SETTINGS

NEGATIVE SEQUENCE PICKUP

This dial sets the relay's pickup current (I_2) in multiples of the relay's rating. The rating is stamped on the front panel at the lower left. The dial is continuously adjustable from 1 to 4 times the rating. For example: a relay rated 0.3 amperes has a range of 0.3 to 1.2 amperes negative sequence. Typical settings for motor protection would be 10 to 20 percent of full load amps.

TIME DIAL (Type 46D only)

This continuously adjustable dial is used to set the operating time of the relay, and is marked in seconds. The timing characteristic is definite: the relay will operate in the time set on the dial, for any value of negative-sequence current greater than the pickup setting.

The time delay is usually set such that sufficient time is allowed to clear faults elsewhere on the system that would cause negative-sequence current at the relay's location.

Additional time delay, beyond the range of the front panel dial may be obtained by readjusting the internal calibration potentiometers. See section on Testing.

4. INDICATORS

A hand-reset operation target is provided. The target is electronically actuated at the time that the relay trip contacts transfer. Control power must be present and the relay must be in the non-trip condition to be able to reset the target.

APPLICATION DATA

The ABB Circuit-Shield™ Types 46D and 46H are negative-sequence overcurrent relays. The most common application is as a current balance relay for the protection of motors. The Type 46D is preferred for this application, as the built-in time delay allows time for faults elsewhere in the system to be isolated and cleared.

In motor applications, a blown fuse, open winding, or open conductor, produces a negative sequence component, I_2 , equal to the running current before the open occurred. Also, single-phase loads on the system can cause the phase voltages to be unbalanced. Since the negative-sequence impedance of the motor is so low, by a factor equal to the starting to running current ratio, a 5% voltage unbalance causes typically a 30% negative sequence current. This negative-sequence current causes overheating of the machine. The Type 46D provides fast, sensitive protection for these conditions.

Additional information is contained in the following Application Notes which are available on request: AN-18 "Type 46 for Motor Open Phase Protection" gives a typical calculation to determine the negative sequence currents; AN-13 "Capacitor Bank Protection with the Type 46D".

For the protection of generators against unbalanced loading, the Type 46Q with its I^2t inverse characteristic is preferred. See Instruction Book IB 7.6.1.7-3 for details. The Type 46D can be used as a pre-trip alarm relay in generator applications.

CHARACTERISTICS OF COMMON UNITS

| Type | Pickup Range I_2 | Operating Time | Catalog Numbers Std Case | ## Test Case* |
|------|-----------------------|----------------|-----------------------------|------------------|
| 46D | 0.5 - 2.0 A | 0.5 - 4 sec. | 227Q42x0 | 427Q42x0 |
| | 0.3 - 1.2 A | | 227Q44x0 | 427Q44x0 |
| | 0.1 - 0.4 A | | 227Q41x0 | 427Q41x0 |
| 46D | 0.5 - 2.0 A | 0.12- 1 sec | 227Q62x0 | 427Q62x0 |
| | 0.3 - 1.2 A | | 227Q64x0 | 427Q64x0 |
| | 0.1 - 0.4 A | | 227Q61x0 | 427Q61x0 |
| 46H | 0.5 - 2.0 A | High Speed | 227Q02x0 | 427Q02x0 |
| | 0.3 - 1.2 A | | 227Q04x0 | 427Q04x0 |
| | 0.1 - 0.4 A | | 227Q01x0 | 427Q01x0 |

* Test-case units preferred for new applications, due to the improved testing features.

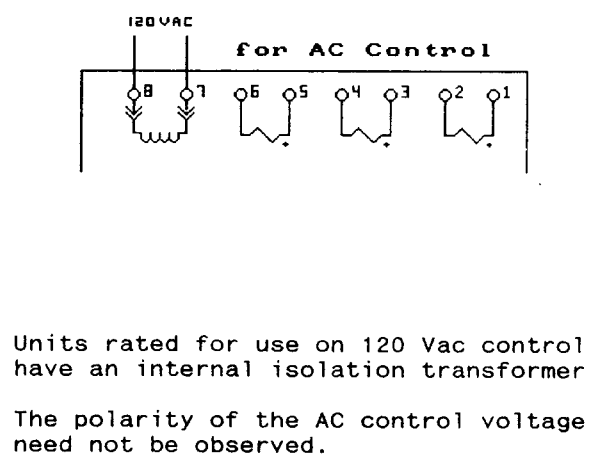
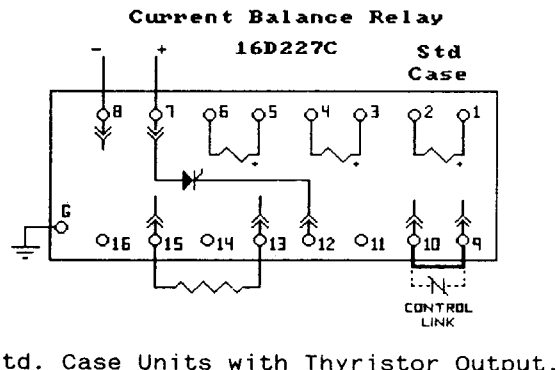
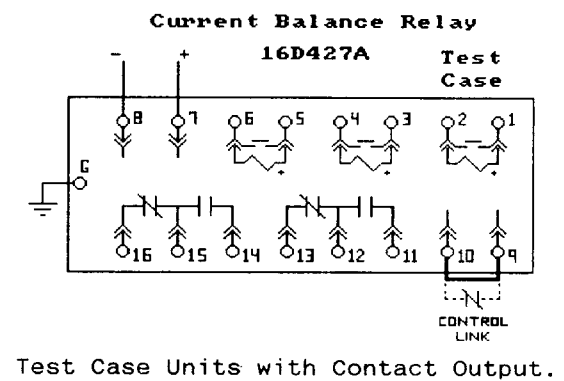
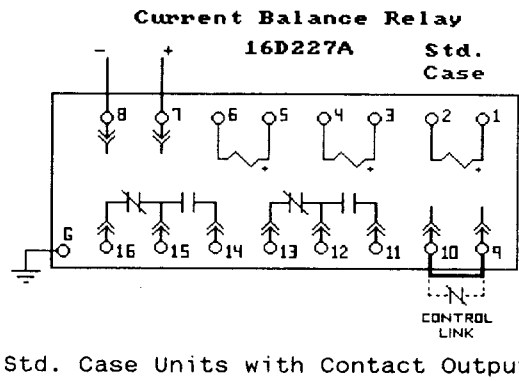
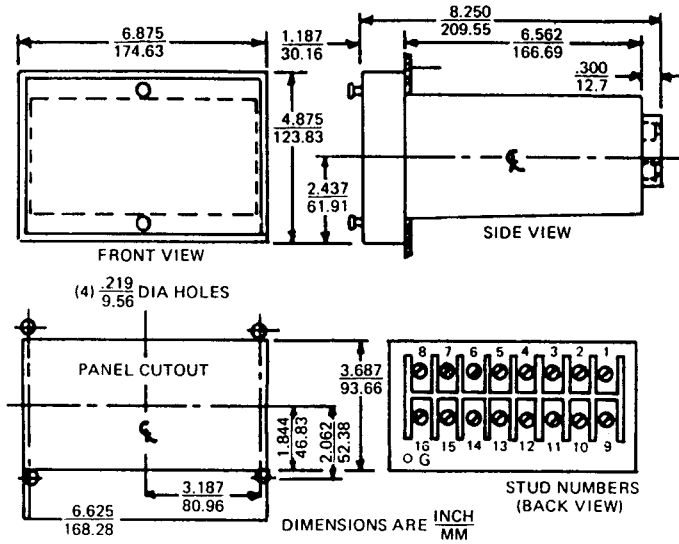
Each of the listed catalog numbers for the Type 46D and Type 46H contains an "x" for the control voltage designation. To complete the catalog number, replace the "x" with the proper control voltage code digit:

- 250 vdc.....5 (Thyristor output)
- 120 vac.....6 (Contact output)
- 48/125 vdc.....7 (Contact output)
- 24/ 32 vdc.....9 (Contact output)
- 48/110 vdc.....0 (Contact output)

Internal Connections:

- Contact Output, Standard Case: 16D227A
- Contact Output, Test Case: 16D227B
- Thyristor Output, Standard Case: 16D227C

Figure 1
Relay Outline
and Drilling



Note: external resistor connected from terminal 13 to 15 is supplied mounted and wired on the relay and must be in place for relay operation.

Note for all units: the control link shown between terminals 9 and 10 must be in place for relay operation (or an external controlling contact used in its place).

Figure 2: Internal Connection Diagrams

SPECIFICATIONS

INPUT CIRCUIT

Rating: 8 amperes - continuous
200 amperes - 1 second

Frequency: 50 or 60 Hertz - internal links provided to select system frequency.

Burden:

| Pickup Range | Burden at 5A, three phase |
|--------------|--|
| 0.1 - 0.4 A | 1.0 VA, 1.0 P.F., terminals 1-2 & 5-6 2.0 VA, 1.0 P.F., terminals 3-4 |
| 0.3 - 1.2 A | 0.25 VA, 1.0 P.F., terminals 1-2 & 5-6 0.50 VA, 1.0 P.F., terminals 3-4 |
| 0.5 - 2.0 A | 0.25 VA, 1.0 P.F., terminals 1-2 & 5-6 0.50 VA, 1.0 P.F., terminals 3-4 |

TOLERANCES

Pickup: +/- 10% of setting.
Repeatability: @25°C +/- 1.5%
Operating Time: +/- 10% of setting.
Repeatability: @25°C +/- 1.5% or
+/- 25 milliseconds,
whichever is greater.

Note: tolerances shown are with respect to printed dial markings on the relay. Final operating values may be set by test using the pickup and time dials which are continuously adjustable.

TEMPERATURE RANGE

Nominal: 25 degrees C ambient
Additional +/-5% tolerance: -15 to +55 degrees C
Must operate: -30 to +70 degrees C

OUTPUT CONTACTS

| | | |
|--------------|-------------|-------------|
| Each contact | at 125 vdc: | at 120 vac: |
| Tripping: | 30 amperes | 30 amperes |
| Continuous: | 5 | 5 amperes |
| Break: | 0.3 | 1 ampere |

THYRISTOR OUTPUT (SCR)

(used only on certain units rated for 250 vdc control)

Thyristor at 250 vdc:
Tripping: 30 amperes
1 Second: 15 amperes
Continuous: 1 ampere

Note: once an SCR is turned on, it will remain in conduction until its anode current falls below its "holding current" which can be as low as 5 milli-amperes. Consequently, the output circuit must be interrupted with a 52/a circuit-breaker auxiliary contact.

CONTROL VOLTAGE

See relay nameplate for rating. Models available for:

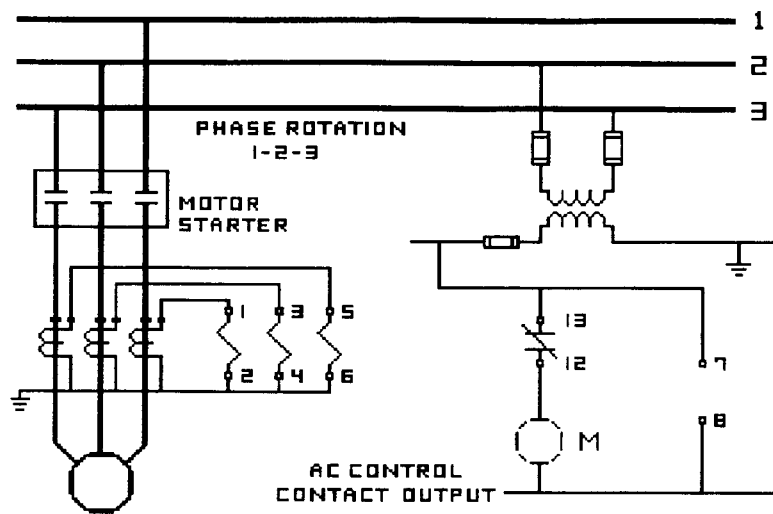
| | | |
|-----------------------------------|--------------------------|--------------------|
| 48/125 vdc, 0.05 amp max. | (ranges 38-58, 100-140v) | (Contact output) |
| 48/110 vdc, 0.05 amp max. | (ranges 38-58, 88-125v) | (Contact output) |
| 24/ 32 vdc, 0.08 amp max. | (ranges 19-29, 26- 38v) | (Contact output) |
| 120 vac, 50/60 Hz., 0.03 amp max. | (range 100-135v) | (Contact output) |
| 250 vdc, 0.05 amp max. | (range 200-280v) | (Thyristor output) |

HARMONIC FILTER

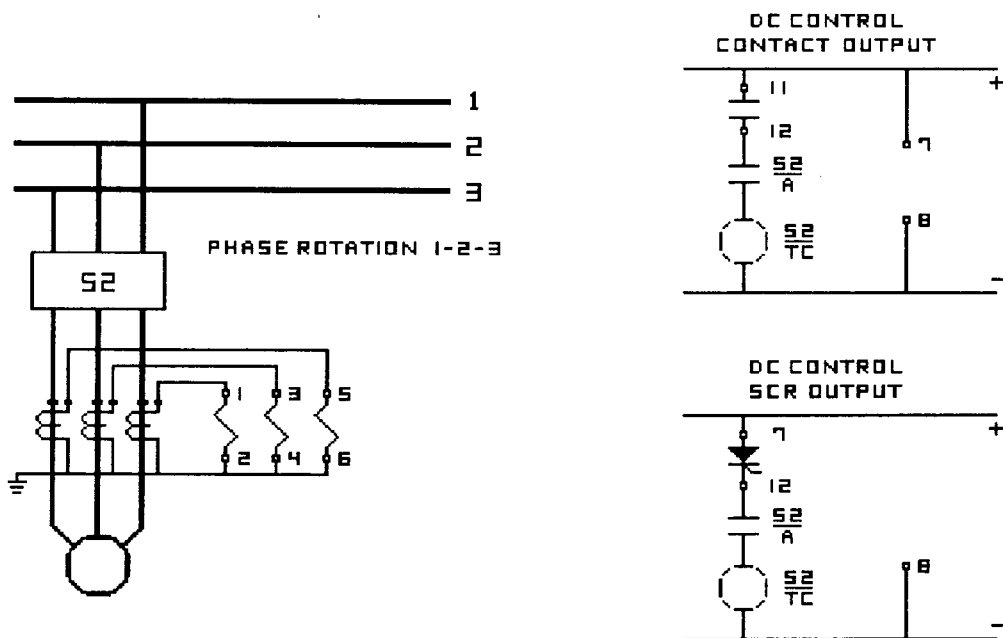
Built-in filter has minimum 10:1 rejection of third harmonic.

DIELECTRIC STRENGTH

1500 vac, 50/60 Hz., 60 seconds, all circuits to ground.



Motor Starter Application - AC Control Power - Contact Output



Circuit Breaker Application - DC Control Power

Figure 3: Typical External Connections

CT polarities and phase rotation must be as shown for proper operation.

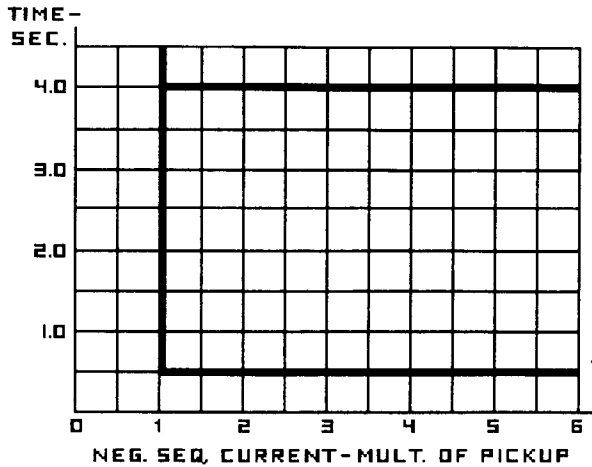


Fig 4: Definite Time Characteristic

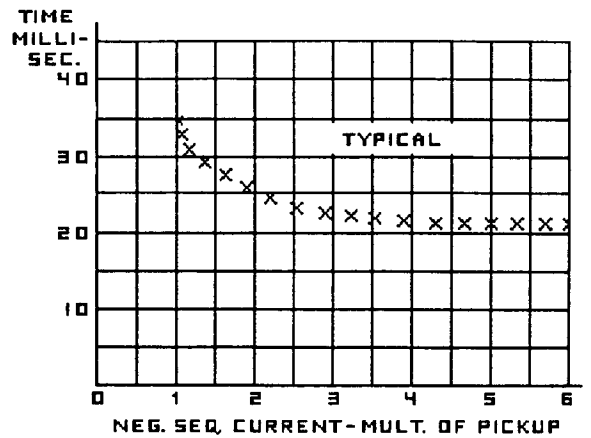


Fig 5: Type 46H Operating Time -Typical

Shown for Type 46D, 0.5-4 Second Model

Reset Time: Typically 30 milliseconds for both Type 46D and Type 46H.

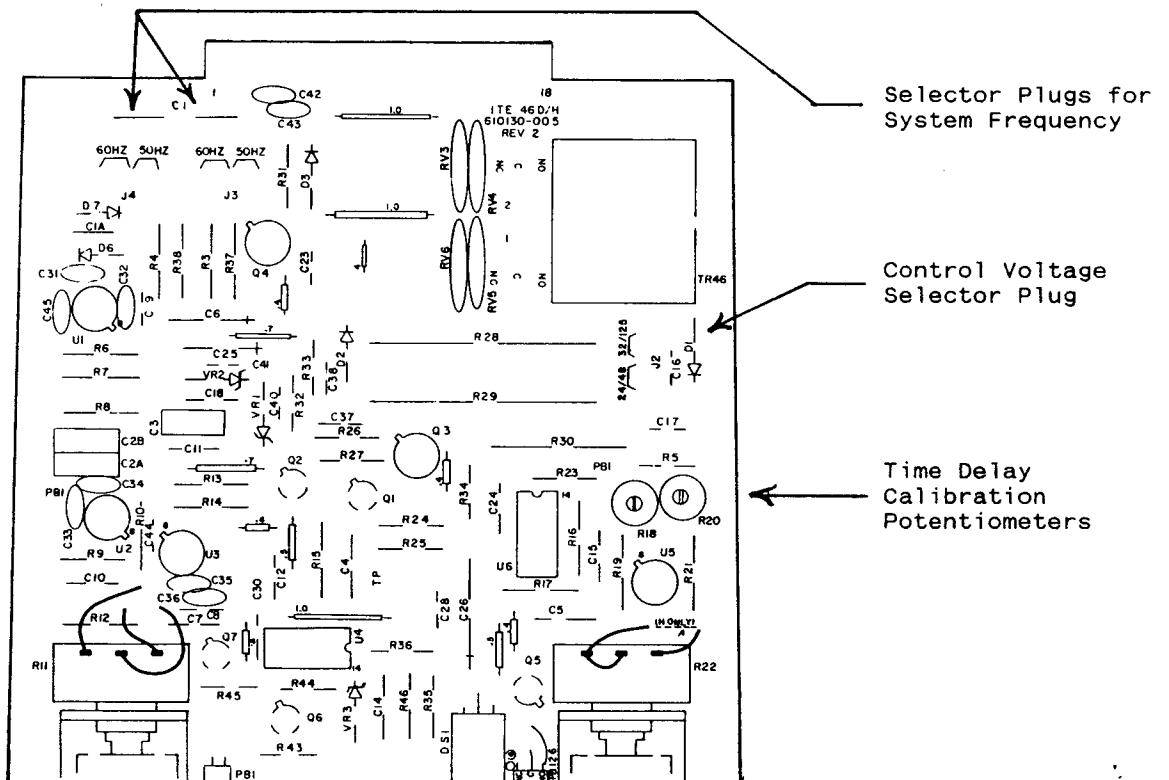


Figure 6: Typical Lower Circuit Board Layout Showing Location of Selector Plugs

TESTING1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on the Types 46D and 46H 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 circuit description will be provided on request. Renewal parts will be quoted by the factory on request.

227Q Series Units:

Drawout circuit boards of the same catalog number are interchangeable. A unit is identified by the catalog number stamped on the front panel and the 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 in service does not open circuit the ct's; however, *a trip may result*.

An 18 point extender board (cat 200X0018) is available for use in troubleshooting.

427Q Series Units:

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

Test connections are readily made to the drawout relay unit by means of standard banana plugs. Current connections are made to the vertical posts at the blade assemblies. Control power and output connections are made at the rear vertical circuit board. This rear board is marked for easier identification of the connection points.

Should separation of the upper and lower circuit boards be necessary, remove (2) screws that attach the left and right handle assemblies to the upper printed circuit board. The lower circuit board can then be withdrawn forward from the printed circuit connector. (Some units may require the removal of two additional screws on the rear underside of the lower circuit board.) An 18 point extender board (catalog 200X0018) is available from the factory if access to this assembly is required for troubleshooting.

Test Plug:

A test plug assembly, catalog 400X0001 is available for use with the 427Q 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, withdraw the draw-out element from the case before applying the test voltage.

3. BUILT-IN TEST FEATURE

A built-in trip test feature is provided as a convenient means of testing the operation of the relay and the associated trip circuit.

Tests should be made with the main circuit de-energized.

When the TRIP test button is depressed, a signal is applied to the relay's pickup circuitry, causing the relay to pick up and time out. The button, which is recessed to prevent accidental operation, must be held down continuously for the time delay set on the relay to obtain a trip. The target should set when the trip contacts transfer.

4. ACCEPTANCE TESTS

Typical test circuits for use with a single-phase test current source are shown in Figure 7. Note the differences in connections between units with contact output and units with thyristor output. Apply proper control power per the nameplate rating of the relay (also check internal control voltage selector link position).

The test current connections must be as shown. A test current correction must be made for single-phase testing: the test current source must be set to 1.73 times the desired negative sequence current to obtain the correct response:

$$\begin{aligned} \text{By definition } I_2 &= 1/3(I_a + a^2 I_b + a I_c) \\ \text{and the connection causes } I_b &= -I_a \quad I_c = 0 \\ \text{therefore } I_2 &= 1/3(I_a - a^2 I_a) = 1/3(1 - a^2)I_a = \sqrt{3}/3 I_a \\ \text{consequently } I_a &= 3/\sqrt{3} I_2 = \sqrt{3} I_2 \end{aligned}$$

Pickup Test: set the desired pickup dial settings (if no setting is specified use the 4X dial position). For the Type 46D, set the time dial to minimum. Increase the test current slowly until the output contacts transfer. Note the test current (remember the 1.73x factor if single-phase testing is used). Pickup should be within +/-10% of the set point. For Type 46D relays with a minimum time setting of 0.5 second, be sure to slowly increase the current so that you do not "overshoot" the pickup current value while the relay is timing-out.

Operation through relay terminals 5 and 6 can be verified by moving the test leads connected to terminals 3 and 4 to terminals 5 and 6 respectively, and repeating the test.

If the setting required for the application is known, pickup may be set exactly to the desired value since the pickup dial is continuously adjustable.

Timing Test (Type 46D): set the test current equal to 2 times the pickup setting (remember the 1.73x factor if single-phase testing is used). Set the time-dial to the desired setting. (Use maximum setting if none specified.) Apply the test current. The relay should time out within +/-10% of the time dial setting. The target should set. If the setting required for the application is known, the final timing adjustment may be made using the time-dial and retesting.

Internal Time-Delay Calibration Potentiometers: additional time delay beyond the range of the front panel dial can be obtained if required for the application. Set the front panel dial to maximum, then adjust internal potentiometer R18. A further adjustment by means of R20 may also be made. Verify each adjustment by repeating the timing test.

Timing Test (Type 46H): since the Type 46H is a high-speed relay, point-on-wave switching effects and inherent limitations of the test equipment can make accurate measurements difficult. Repeatability should be within +/- 2 cycles. The internal calibration potentiometers R18 and R20 can be used to increase the delay somewhat from the factory setting.

Security Test: if an accurate three-phase source is available, a check can be made to see that the relay does not respond to balanced (positive-sequence) currents. Connect the phase A current to terminals 1 and 2 and set at 0° phase angle; apply the phase B current to terminals 3 and 4 and set at 120° lagging; connect the phase C current to terminals 5 and 6 and set at 120° leading. Set the relay pickup and time dials to minimum. Simultaneously apply the tests currents at a magnitude of 10 amps. The relay should not trip. (Note: any inaccuracies in the three-phase source will likely result in a negative sequence component.) A more accurate test method is described in Application Note AN-16, however, a phase-angle meter is required to perform the test.

5. ADDITION OF TEST JACKS

Some users have added test jacks to the front panel of the relay so that the negative sequence current level can be easily determined with the relay in service. This is done by making a measurement of the voltage signal from the negative sequence filter circuit within the relay. Contact the factory for the details of this simple modification.

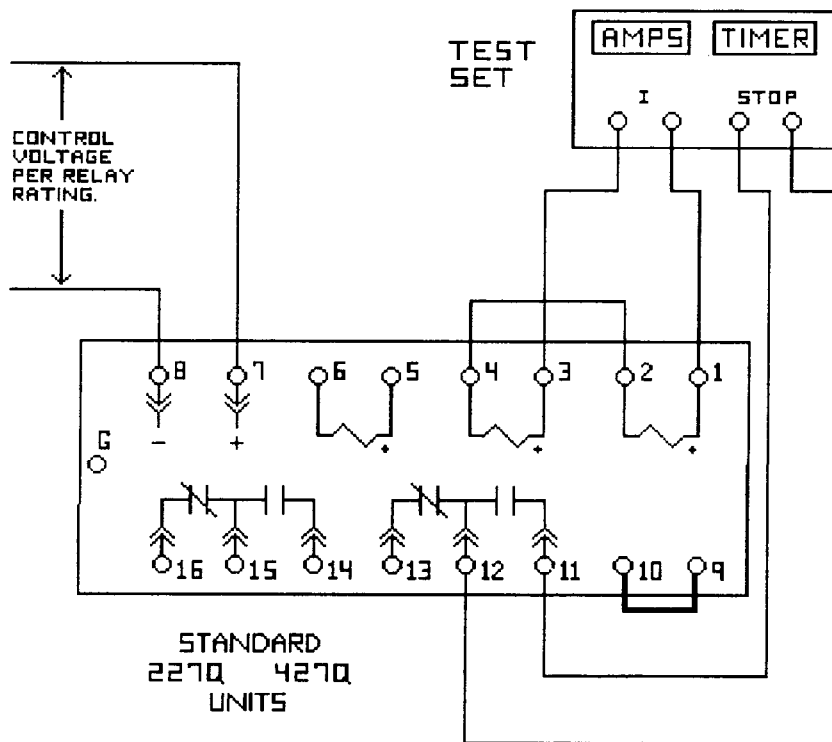
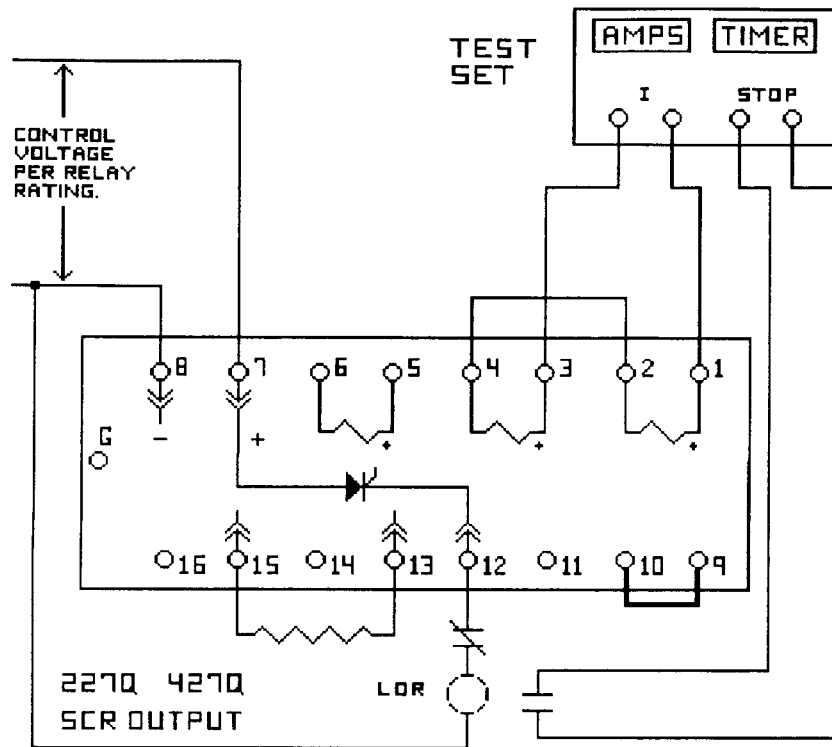


Figure 7: Typical Test Circuit Connections