IB 7.6.1.7-3
Issue C

INSTRUCTIONS

Negative Sequence Time-Overcurrent Relay

CIRCUIT SHIELD ®

Type 46Q	Catalog Series 227	Standard Case
Type 46Q	Catalog Series 427	Drawout Test Case

TABLE OF CONTENTS

INTRODUCTION

These instructions contain the information required to properly install, operate, and test the ABB Circuit-Shield™ Type 46Q Negative Sequence Time-Overcurrent Relay. The primary application of this relay is to provide protection against unbalanced loading for generators.

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. The 427F/G 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 contact is used in the application. The 227F/G 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 targets are 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. *Note especially that the connections for the 427F/G series units are not the same as for 227F/G units.*

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 227F/G series units this plug is located near the output relay, toward the middle of the relay. On 427F/G series units this plug is accessible (right rear of lower printed circuit board) without separating the upper and lower circuit boards.

4. These relays are shipped with an external resistor mounted on terminals 9 and 10. This resistor must be in place for proper operation.

5. 427F/G units have a movable link on the vertical rear circuit board (on the inside surface) to select the form of the contact between terminals 15 and 16. Withdraw the relay from its case to inspect the postion of this link.

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

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 techicians 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 Figure 2. *Note that the connections are DIFFERENT for the 427F/G units compared to the 227F/G units.* Also note that the 427F/G units provide a contact between terminals 15 and 16 that is convertible from normally open to normally closed. Withdraw the relay from its case to inspect the position of the *movable link* on the vertical rear circuit board (inside surface) that is used to set the contact form: the positions are marked "NO" for normally-open and "NC" for normally-closed. Typical external connections are shown in Figure 3.

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.* On 227F/G units this plug is located near the output relay toward the center of the circuit board. On 427F/G series units this plug is accessible (right rear of lower printed circuit board) without separating the upper and lower circuit boards.

These relays are shipped with an external resistor mounted on terminals 9 and 10. *The resistor must be in place for proper operation.*

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.

FAST-RESET terminals are provided for use during testing or for special applications. A momentary contact closure will fully reset the relay's "thermal" memory. **CAUTION:** the relay will be inoperative whenever terminals are connected; therefore, if a contact is used, it must provide only a momentary closure.

3. SETTINGS

TAP SETTING

The following taps are provided on standard units rated for use with 5 amp ct's: 2.5, 2.8, 3.1, 3.5, 4.0, 4.5 amperes. The tap should be set to equal the generator full load current, as seen on the secondary of the ct. It thereby sets the 1 per unit current for the relay. The tap pin may be removed with the relay in service. Upon removal the relay switches automatically to the highest tap.

NEGATIVE SEQUENCE PICKUP

This dial sets the relay's pickup current (I_2) in multiples of the tap setting. It is continuously adjustable from 0.1 to 0.4 times the tap setting. In other words, the negative sequence pickup can be set from 10 to 40 percent of generator full load current. A setting of 15% is typical.

TIME CURVE

This dial is used to set the I^2t characteristic of the relay to match the thermal capability of the generator. It is continuously adjustable from 1 to 4 times the rating given on the relay nameplate. The standard ratings are: 10, giving an adjustment range of 10-40 seconds; 5, giving a range of 5-20 seconds; and 2.5, giving a range of 2.5-10 seconds.

The time current characteristic curves are shown in the Application section of this instruction book.

DEFINITE MAXIMUM TIME (Internal Adjustment)

This internal adjustment sets the maximum operating time of the relay. It is factory set to approximately 250 seconds. It is continuously adjustable down to approx. 100 seconds by means of internal potentiometer R35. The setting must be made by test.

4. INDICATORS

TARGET

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

LED INDICATORS

A light-emitting-diode is provided to indicate when the input current is above the pickup setting.

A second led indicator is provided to indicate that the unit is timing. The led will flash on and off at a rate that is related to the current value: the higher above pickup, the faster the rate of flashing. On 427F/G series units, the led will light steadily without flashing if the negative-sequence current is in the region of the definite-time portion of the time-current curve.

IMPORTANT: the timing indicator led is not an operation target. Once a trip occurs the state of the indicating led is indeterminant. It may go out or it may remain continuously lighted. The led will remain in that state until secondary current is re-established into the input of the relay.

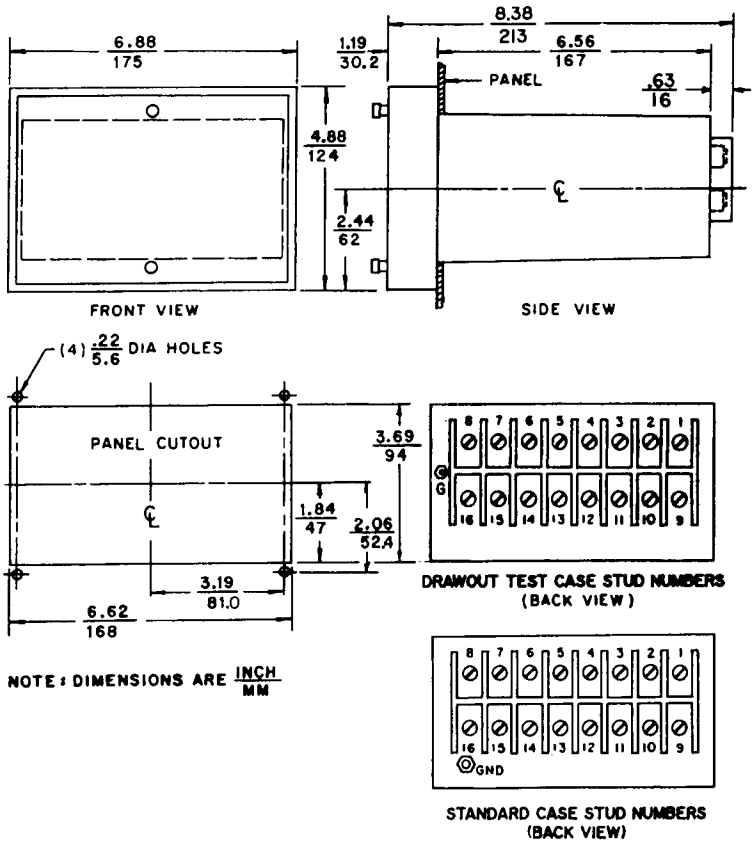


Figure 1: Relay Outline and Drilling

APPLICATION DATA

The ABB Circuit-Shield™ Type 46Q is designed for the protection of generators against the damage caused by prolonged unbalanced loads, open conductors, or persistant faults on the power system. The relay operates on the negative-sequence component of the line currents and ignores the balanced component caused by three-phase loads. The time-current characteristic is designed to match the generator's negative-sequence rating; that is, $I^2t = k$.

The relay is provided with taps which are used to set the one per unit relay current equal to the generator rated full load current (ct secondary quantity). A separate adjustment is used to set the relay's pickup current (I_2) from 10 to 40 percent of tap value.

The I^2t rating of the machine is specified by the manufacturer. The relay characteristic is matched to this requirement by selecting the correct model, and then by setting the TIME DIAL to a value equal or less than the machine rating, according to the user's practice and any other requirements that might be dictated by the system. The ITE-46Q is offered in 3 models of I^2t rating. The time-current characteristics are shown in the curves that follow in this instruction book.

In order to decrease tripping times for modest unbalances, a Definite-Maximum-Time characteristic is provided. This is continuously adjustable from 100-250 seconds, and is factory set at approximately 250 seconds.

Coordination with the primary and backup line relaying is assured by the Definite-Minimum-Time characteristic.

In order to protect the generator from damage due to recurring unbalances, the relay is provided with a "memory" function. This provides a linear reset of the I^2t accumulator when I_2 decreases to below the pickup setting. To assist in testing, and for unusual applications, the memory function may be fully reset by a momentary contact closure across the RESET input terminals.

An example of the typical time-current characteristic that results for a given set of settings is shown in Figure 4. For this example, pickup is set at 15%, I^2t at 30 seconds, and definite-maximum-time at 250 seconds.

If a pretrip-alarm function is required, a separate relay, the ABB Type 46D, a definite-time negative-sequence relay can be used. See IB 7.6.1.7-2 for the details of this unit.

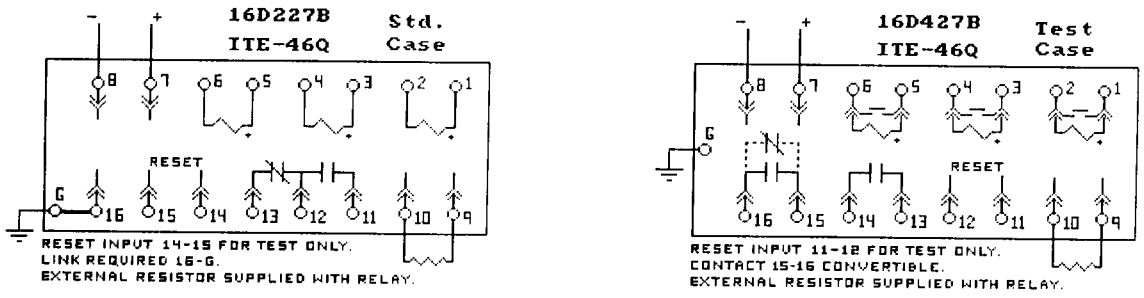


Figure 2 : Internal Connections

Important: connections for 427F/G units are not the same as for 227F/G units.

SPECIFICATIONS

INPUT CIRCUIT
Rating: 8 amperes - continuous
200 amperes - 1 second

Frequency: 227F/427F units: 60 Hz.; 227G/427G units: 50 Hz.

Burden: 0.04 ohms, resistive

Pickup Taps: 2.5, 2.8, 3.1, 3.5, 4.0, 4.5 amperes

TOLERANCES
Pickup: +/- 10% of setting.
Operating Time: +/- 10% of setting.

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

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:

Tripping:	30 amperes
Continuous:	5
Break:	0.3

CONTROL VOLTAGE
See relay nameplate for rating. Models available for:

48/125 vdc, 0.06 amp max. (ranges 38-58, 100-140)
48/110 vdc, 0.06 amp max. (ranges 38-58, 88-125)
24/ 32 vdc, 0.08 amp max. (ranges 19-29, 26- 38)

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

DIELECTRIC STRENGTH
227F/227G Series Units: 1500vac, 50/60Hz., 60 seconds, all circuits to ground.
427F/427G Series Units: 2000vac, 50/60Hz., 60 seconds, all circuits to ground.

CHARACTERISTICS OF COMMON UNITS

Type	Time-Current Curve (k)	Freq.	Control Voltage	Catalog Numbers Std Case	Catalog Numbers Test Case
46Q	10-40	60 Hz.	48/125 Vdc	227F1571	427F1571
			24/ 32 Vdc	227F1591	427F1591
		50 Hz.	48/125 Vdc	227G1571	427G1571
			48/110 Vdc	227G1501	427G1501
			24/ 32 Vdc	227G1591	427G1591
	5-20	60 Hz.	48/125 Vdc	227F2571	427F2571
			24/ 32 Vdc	227F2591	427F2591
		50 Hz.	48/125 Vdc	227G2571	427G2571
			48/110 Vdc	227G2501	427G2501
			24/ 32 Vdc	227G2591	427G2591
	2.5-10	60 Hz.	48/125 Vdc	227F3571	427F3571
			24/ 32 Vdc	227F3591	427F3591
		50 Hz.	48/125 Vdc	227G3571	427G3571
			48/110 Vdc	227G3501	427G3501
			24/ 32 Vdc	227G3591	427G3591

Note: Select 427 series units for new applications due to the improved test features. Consult factory on availability of other control voltage ratings.

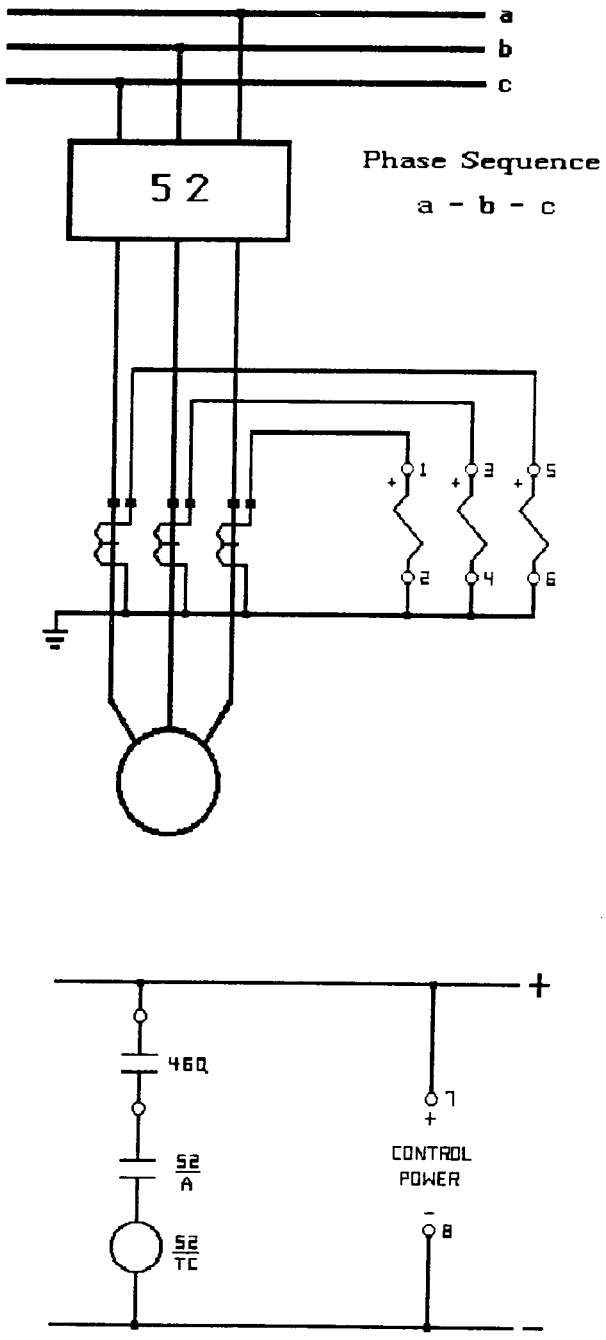
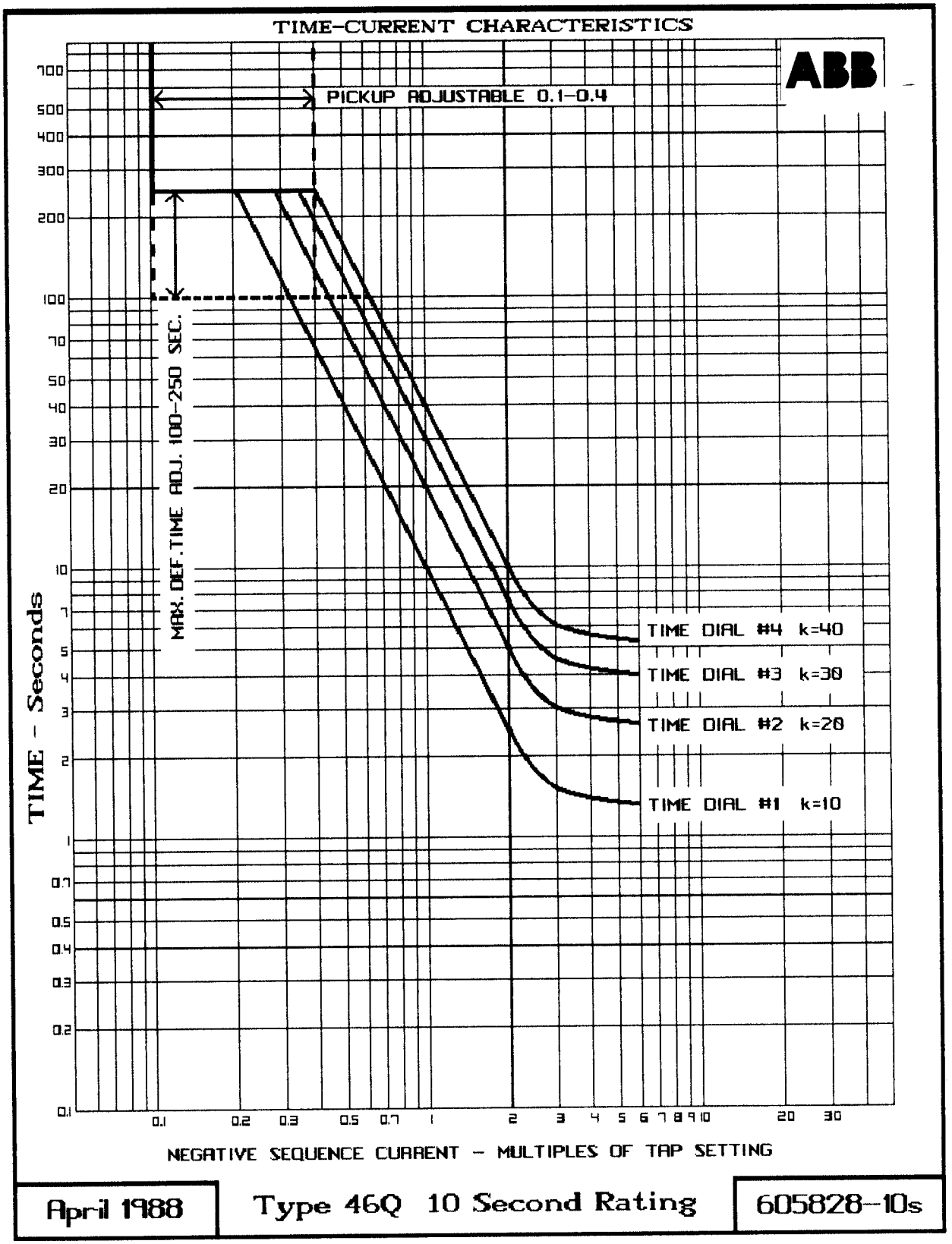


Figure 3: Typical External Connections

The output contact terminals are left un-numbered in this diagram due to differences between units of the 227F/G and 427F/G series. Refer to Figure 2, internal connections, for your particular unit.

The external resistor supplied mounted and wired to terminals 9 and 10 must be in place for proper operation.

Phase rotation and ct polarities must be observed for proper operation. Connections shown are for a-b-c phase rotation. If the system is a-c-b, interchange the wires on terminals 3 and 5, and on terminals 4 and 6.


TIME-CURRENT CHARACTERISTICS
ABB
PICKUP ADJUSTABLE 0.1-0.4
MAX. DEF. TIME ADJ. 100-250 SEC.
TIME DIAL #4 k=40
TIME DIAL #3 k=30
TIME DIAL #2 k=20
TIME DIAL #1 k=10
TIME - Seconds
700
500
400
300
200
100
70
50
40
30
20
10
7
5
4
3
2
1
0.7
0.5
0.4
0.3
0.2
0.1
0.1 0.2 0.3 0.5 0.7 1 2 3 4 5 6 7 8 9 10 20 30
NEGATIVE SEQUENCE CURRENT - MULTIPLES OF TAP SETTING
April 1988
Type 46Q 10 Second Rating
605828-10s

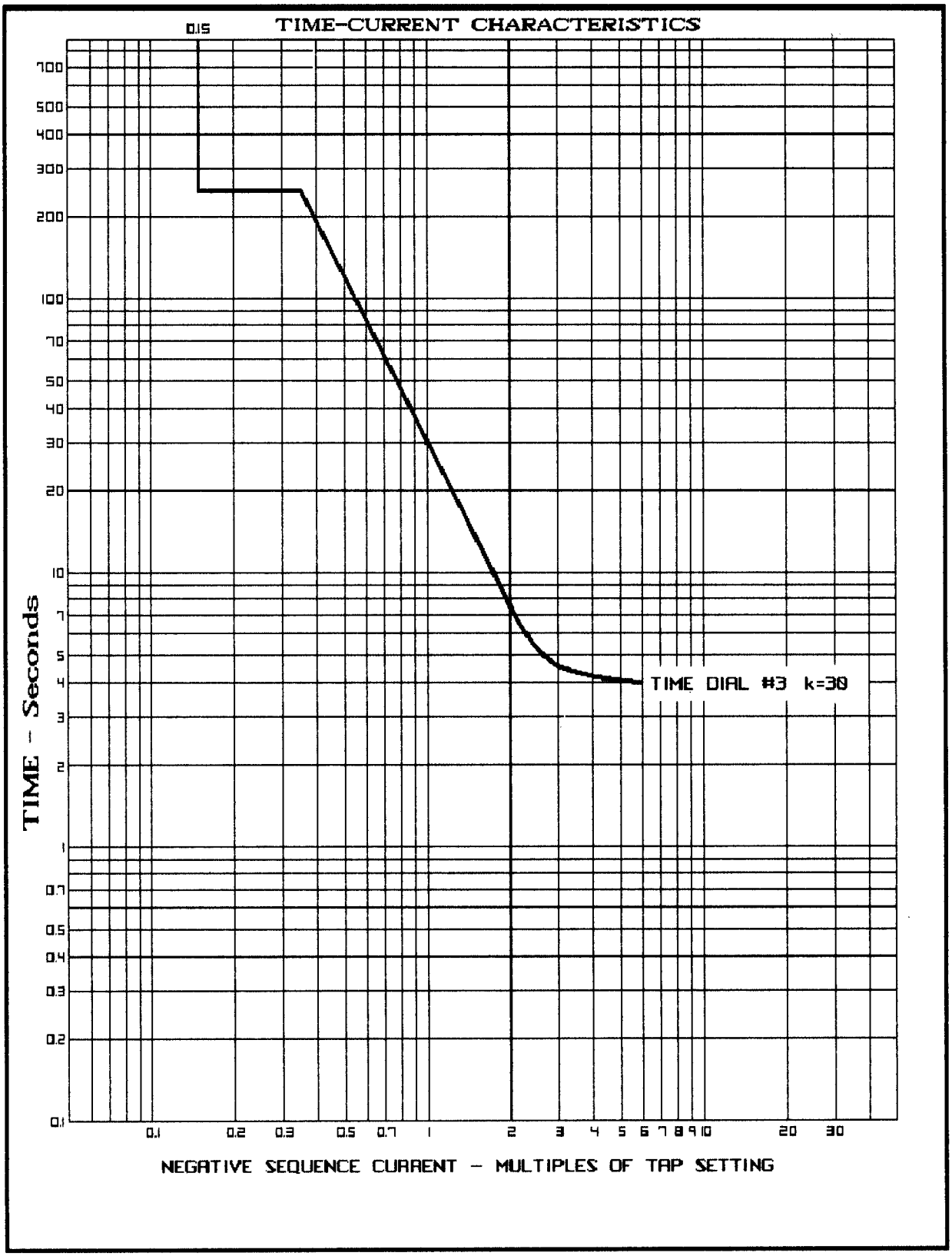
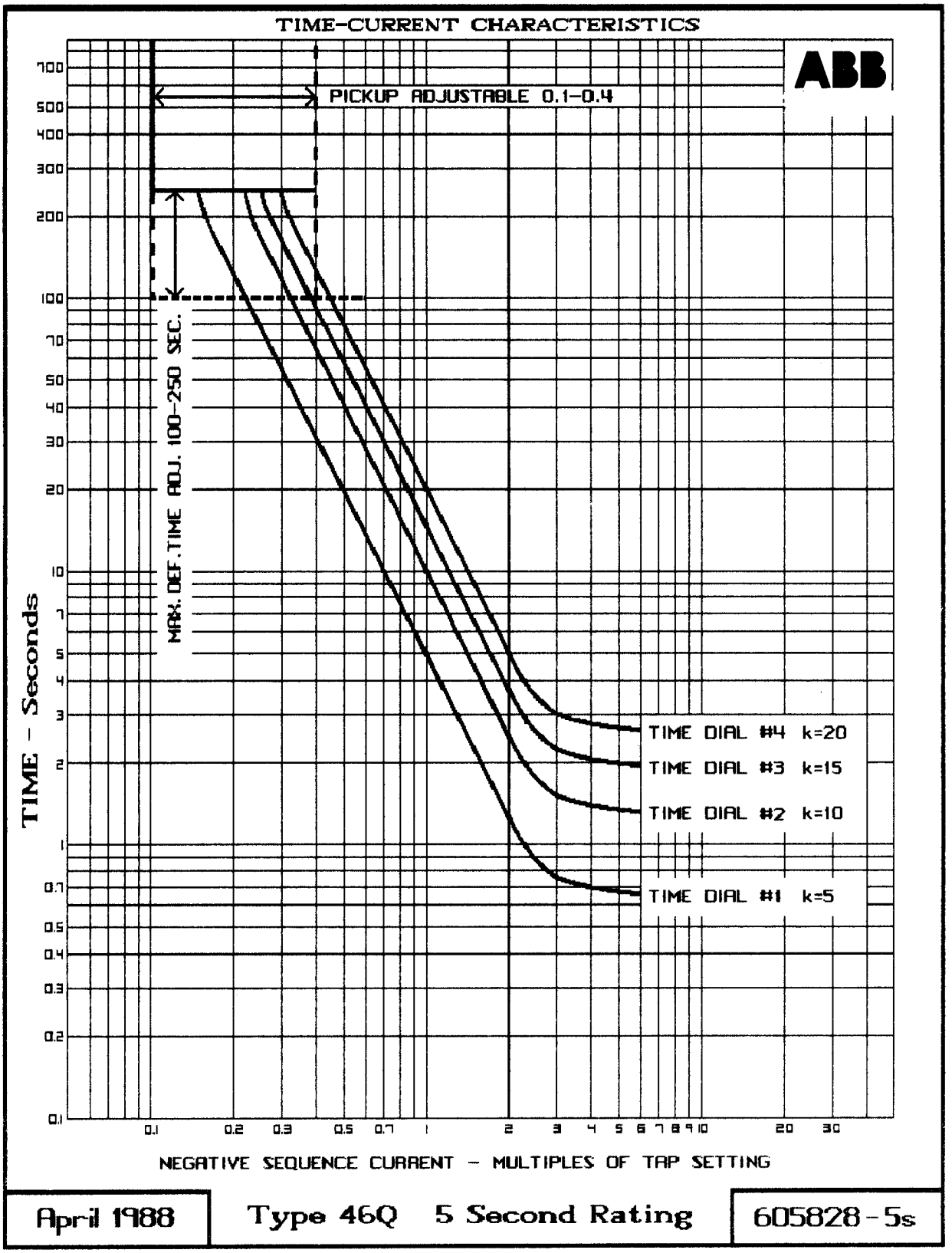


Figure 4: Example: Time-current Characteristic Shown for a Particular Selection of Settings for a Relay with a 10 Second Rating

Pickup = 15% of Tap Setting Time Dial = #3 (k=30 seconds)
Definite Maximum Time = 250 seconds


TIME-CURRENT CHARACTERISTICS
ABB
PICKUP ADJUSTABLE 0.1-0.4
MAX. DEF. TIME ADJ. 100-250 SEC.
TIME DIAL #4 k=20
TIME DIAL #3 k=15
TIME DIAL #2 k=10
TIME DIAL #1 k=5
TIME - Seconds
NEGATIVE SEQUENCE CURRENT - MULTIPLES OF TAP SETTING
April 1988
Type 46Q 5 Second Rating
605828-5s

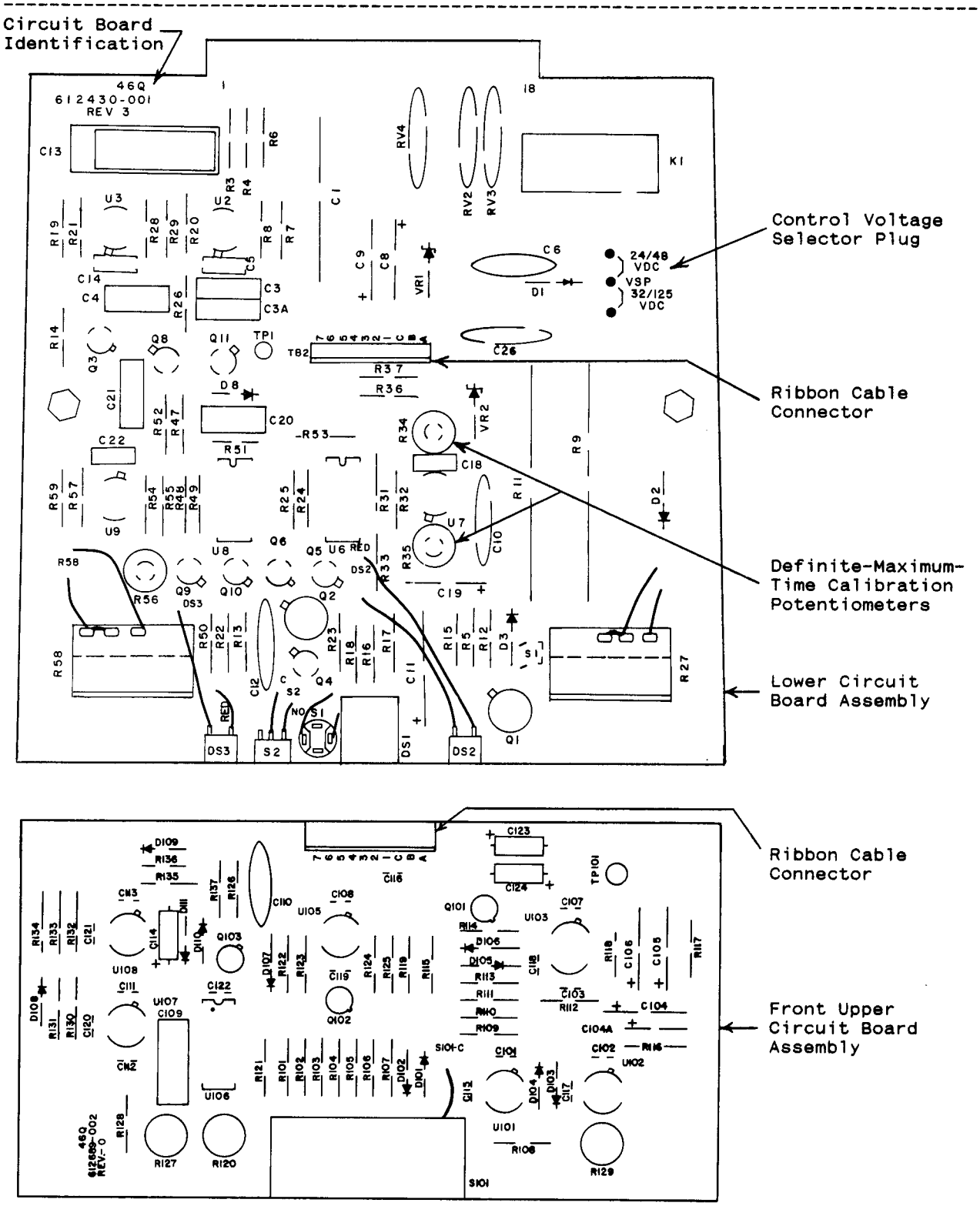


Figure 5: Typical Circuit Board Layouts

Lower Circuit Board 612430
Front Upper Circuit Board 612689

Notes:

1. If disassembling the circuit boards, be sure to inspect for wires connected to lugs under the support posts, and return to original position when re-assembling the unit. (Not used on all units)

2. For calibration of the Definite-Maximum-Time use potentiomenter R35. If R35 has insufficient range to obtain the value you want, then use potentiometer R34. (See test procedure on page 14.)

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on the ABB Circuit-Shield™ Type 46Q relay. 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 will be provided on request. Renewal parts will be quoted by the factory on request.

227F/G 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 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, in applications using the normally closed contact, ***a trip will result.***

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

427F/G 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 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.

IMPORTANT: in order to test the drawout unit, a resistor must be connected temporarily between terminals 9 and 10 on the rear vertical circuit board. The value of this resistor depends on the the control voltage rating of the relay. The control voltage rating is stamped on the front panel, and is also dependent on the position of the internal control voltage selector plug. The value of the required resistor is usually printed on the rear vertical circuit board. A 25 watt resistor is sufficient. If no resistor is readily available, the resistor assembly mounted on the rear of the case could be removed and used. *Be sure to remount the resistor on the case at the conclusion of testing.*

Should separation of the upper and lower circuit boards be needed, remove (2) screws that attach the left and right handle assemblies to the upper printed circuit board. Some units may also require the removal of (2) screws from the underside of the unit near the rear vertical circuit board, and the removal of (2) brackets that tie the front and rear upper boards together: refer to the notes with the circuit board layouts in this book. The lower board may then be withdrawn forward from the printed circuit connector. When reassembling, be sure to restore all connections and hardware as originally configured.

A test plug assembly, catalog 400X0001 is available for use with the 414 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 drawout element from the case before applying the test voltage.

On 427F/G series units, a link provided on the upper rear 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". On 227F/G series units this function was provided by the link on the rear terminal block between terminals 16 and G.

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 associated trip circuit.

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

When the TRIP test button is depressed, a signal equivilent to approximately 1.3 amps (+/-20%) of negative-sequence current is applied to the relay's pickup circuitry, causing the relay to pick up and time out. The button must be held continuously until a trip is obtained. When the button is pressed and held, the pickup indicator should light and the timing indicator should flash. The target should set when the trip contacts transfer. (Measurement of the time delay should not be made for this functional test.)

Note that combinations of ampere tap and pickup dial settings can be made that result in a pickup setting that is above the simulated test current; therefore, if the tap setting x pickup dial setting is greater than 1 ampere, the tap setting should be lowered temporarily to perform the trip test. *Be sure to return the tap pin to the correct setting at the conclusion of the test.*

4. ACCEPTANCE TESTS

Typical test circuits for use with a single-phase test current source are shown in Figure 8. Note the differences in connections between 227F/G series and 427F/G series units. Apply proper control voltage per the nameplate rating of the relay (also check the internal 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:

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

Thermal memory considerations: when control power is initially applied to the relay, the thermal memory is set at approximately half-way to the trip point. The application of dc control power simulataneously with the application of the ac test current will result in large timing errors. Therefore, during testing the following sequence of actions must be followed: #1: apply control voltage to the relay; #2: reset the thermal memory by momentarily shorting the RESET terminals; #3: apply test current and determine the operating time.

Pickup test: set the desired tap and pickup settings (if none specified use 2.5 amp tap, and 0.1x pickup dial). Increase the test current slowly until the pickup lamp lights. Note the test current (remember the 1.73x factor if single-phase testing is used). Pickup should be within +/-10% of the set point (2.5 x 1.732 x 0.1 = 0.433 amperes if using the referenced settings). If the setting for the application is known, pickup may be set exactly to the desired value since the pickup dial is continuously adjustable.

Timing Test (I^2t characteristic): set the test current equal to the tap value (remember the 1.732x factor if single-phase testing is being used). Set the time-dial to the desired setting (use #1 time-dial if none specified). Reset the thermal memory. Apply the test current. The timing indicator should flash and the relay should time-out within +/-10% of the time-dial setting x the time rating stamped on the front panel. (For a 10 second rated relay set on time-dial #1, the expected operating time would be 9-11 seconds.) The target should set. If the setting required for the application is known, the final timing adjustment may be made using the continuously adjustable time-dial, and retesting to verify.

Be sure to follow the testing sequence discussed in the paragraph above titled "thermal memory considerations".

Timing Test (Definite Maximum Time Characteristic): internal adjustments on the printed circuit board are used to set this timing function. The range of adjustment is approximately 100 - 250 seconds. It is factory set at 225 to 275 seconds (250 sec nominal +/-10%).

To check this function, set the pickup dial to 0.1 and the test current just above the pickup point where the pickup led comes on. If the 2.5 amp tap is used, a test current of 0.52 amps (2.5 x 0.1 x 1.732 x 1.20) would be appropriate. Reset the thermal memory. Apply the test current. The pickup light should come on. On 427F/G series units the timing light should come on steady. On 227F/G units the timing led will be off. The relay should trip and set its target in 225 to 275 seconds.

If the delay is to be set to another value of time, adjust the DEF MAX TIME internal calibration pot, reset the thermal memory, and repeat the test as necessary to obtain the desired operating time. Refer to the lower-printed-circuit-board layouts on pages 11 and 15 to find the location of the potentiometer.

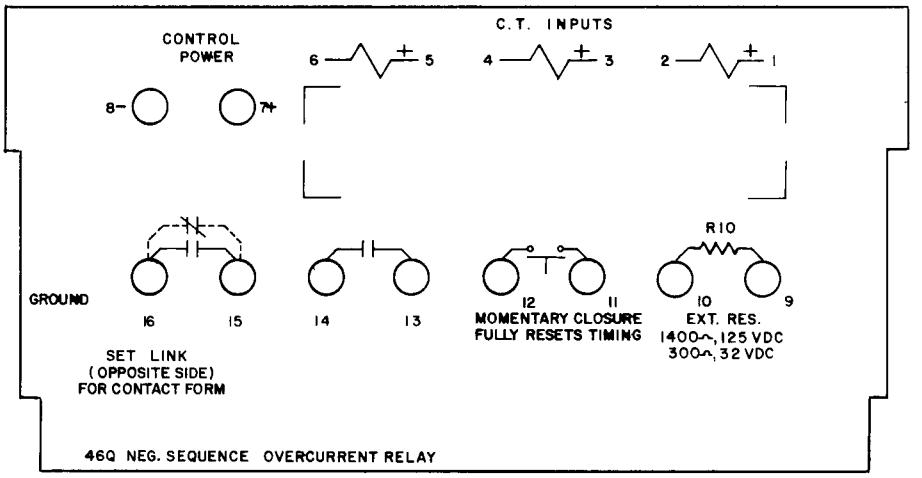


Figure 6 Typical Vertical Backplane Board - 427F/427G Series

Notes:
1. Contact between terminals 15-16 is convertible. Selector link is on the inside rear surface of the board. N.O. = normally open; N.C.= normally closed.
2. When testing, use "dry" momentary contact between terminals 11-12 to reset thermal memory.
3. External resistor required between terminals 9-10. See text, pg 12.
4. Connections are different for 227 series units, see diagrams pg 16.

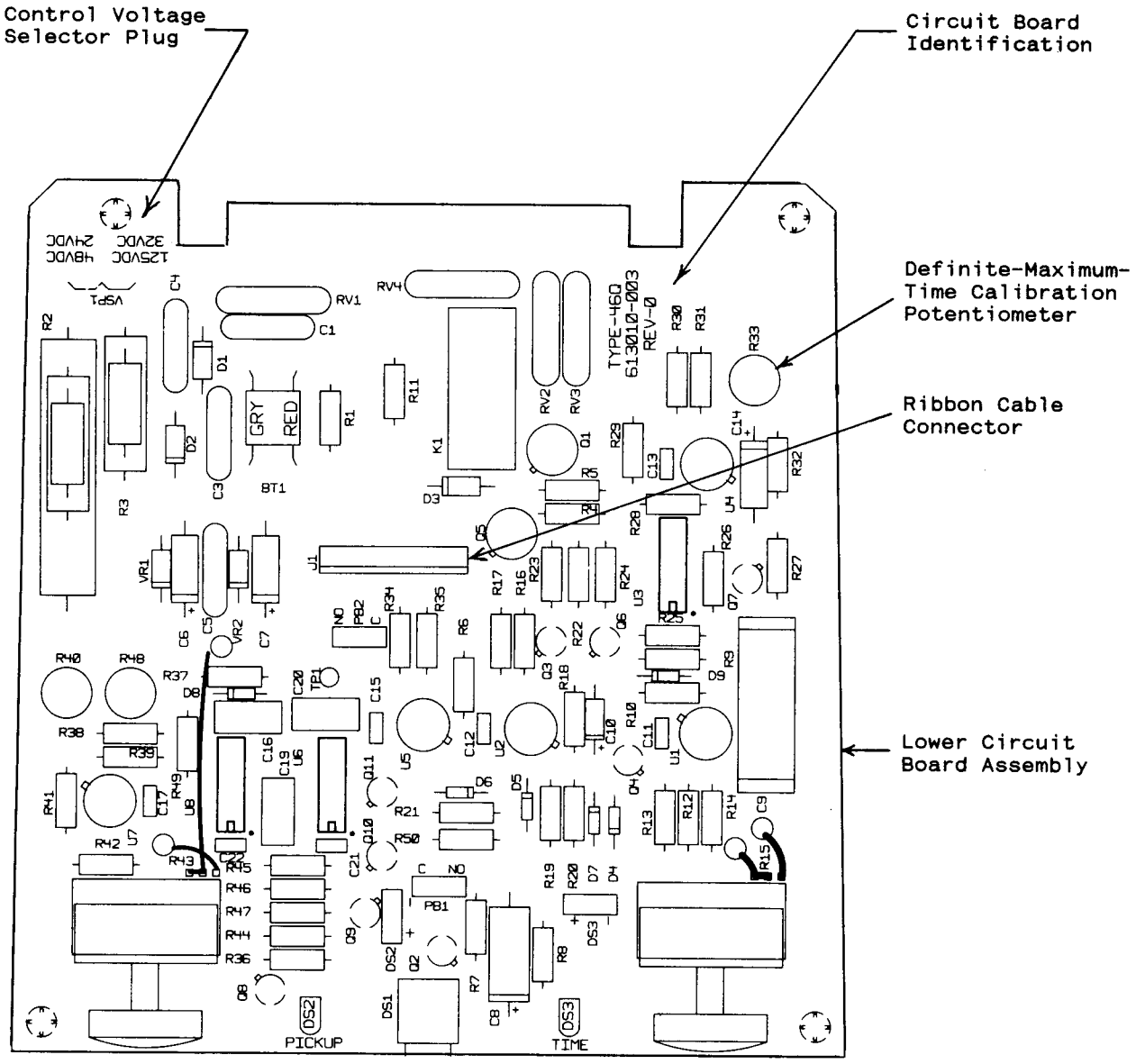


Figure 7: Typical Circuit Board Layout

Lower Circuit Board 613010

Notes:
1. If you disassemble the upper and lower circuit board units, be sure to reconnect the ribbon cable at both ends upon reassembly.
2. For calibration of the Definite-Maximum-Time use potentiometer R33. (See test procedure on page 14.)

ABB Power T&D Company Inc.
Protective Relay Division
7036 Snowdrift Rd.
Allentown, PA 18106

Issue C (6/91)
Supersedes Issue B

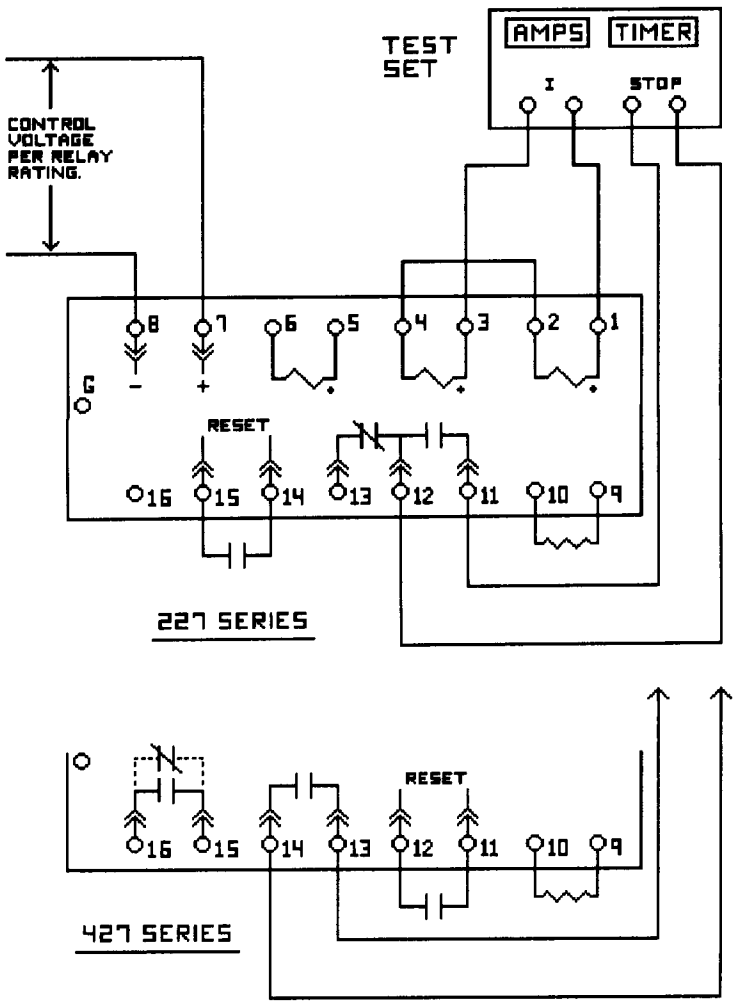


Figure 8: Typical Test Connections

Notes:
1. For single-phase testing shown in diagram, test current correction factor required. See procedures on pages 12, 13, 14.
2. Note difference in output contact arrangement for 227F/G series vs. 427F/G series units.
3. To check all inputs, change connections shown above:
   lead on terminal 1 moves to terminal 5, and
   lead on terminal 2 moves to terminal 6; then
   repeat pickup current test.

These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in conjunction with installation, operation, or maintenance.