IB 7.6.1.7-1
Issue C

INSTRUCTIONS

Machine Differential Relay

CIRCUIT SHIELD®

Type 87M

Catalog Series 219M	Three-Phase	Standard Case
Catalog Series 419M	Single-Phase	Test Case

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ALLENTOWN, PENNSYLVANIA USA

Errata to the Type 87M Instruction Booklet IB 7.6.1.7-1, Issue C

Issue C page 4, 3rd paragraph, 7th sentence
The reactor presents a high impedance (over 1000 ohms) to the flow of operate current.

Issue C page 4, 3rd paragraph, 7th sentence clarification
The reactor presents a high impedance to the flow of operate current. That impedance can be a value of either over 400 ohms or over 1000 ohms. For 219M three-phase units, the reactors are provided by a separate three-phase Reactor Assembly unit. Table 1 identifies the reactor impedance for each of the two three-phase reactor assemblies that have been sold. Note that as of October 1993, the reactor assembly unit #200C0004 was made inactive and was no longer available for sale.

Table 1 Reactor Assembly unit's reactor impedance used with 219M units

Reactor Assembly Catalog Number	Reactor Impedance (ohms)
200C0002	> 400
200C0004	> 1000

For 419M single-phase units, the reactor is included in the relay and Table 2 identifies the impedance of the reactors based upon the 419M unit's Catalog Number. For 419M units with a Catalog Number ending in "1" or "3", knowledge of the internal reactor's impedance requires removing in a safe and secure manner the inner chassis from its case and matching the reactor's description to the description provided in Table 2. The Catalog Number character "x" in Table 2 means "don't care".

Table 2 Reactor impedance internal to a 419M unit

419M unit Catalog Number	Reactor Impedance (ohms)	Reactor Description
419M65x0	> 400	-
419M65x1	> 400 (based on description)	Reactor has 200 turns of #18 wire.
419M65x1	> 1000 (based on description)	Reactor has 800 turns of #22 wire.
419M65x3	> 400 (based on description)	Reactor has 200 turns of #18 wire.
419M65x3	> 1000 (based on description)	Reactor has 800 turns of #22 wire.

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INTRODUCTION

These instructions contain the information required to properly install, operate, and test the ABB Circuit-Shield™ Type 87M Machine Differential Relay. The relay provides fast, sensitive differential protection for generators and motors.

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 419M 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. The 219M series relay is of partial drawout construction, with the input transformers remaining in the case upon withdrawal of the lower circuit board. The 219M series relay is supplied as a three phase unit, which is advantageous where panel space is limited.

The pickup current sensitivity setting dial is located on the front panel behind a removable clear plastic cover. A target indicator is also mounted on the front panel. The target is reset by means of a push-button extending through the relay cover.

PRECAUTIONS

The following precautions should be taken when applying the relay:

1. Incorrect wiring may result in damage. Be sure wiring agrees with the connection diagram before energizing. *Note that the connections for the 419M series and 219M series are different.*

2. Apply only the rated control voltage marked on the front panel. Control voltage must be applied in the correct polarity.

3. For relays with dual-rated control voltage, withdraw the relay from its case and check that the small movable link at the left rear of the lower circuit board is in the correct position for the system control voltage.

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

5. Only the lower circuit board of catalog series 219M relays is removable. Removing this board does not open circuit CT circuits. The board should insert smoothly. Do not use force.

6. When applying test currents to the relay, be sure to interrupt the current immediately upon relay operation to prevent thermal damage.

7. Follow test instructions to verify that the relay is in proper working order. If a relay is found to be inoperative, we suggest it be returned to the factory for repair.

8. When handling this relay, take all the necessary precautions to prevent damage from static electricity. This relay contains static sensitive components which could be damaged without proper grounding.

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 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 Figure 1. The external reactor assembly, catalog no. 200C0002 is recommended for use in most applications of the 219M series units. It is packaged in a surface mounted case, Figure 2.

Connections:

Internal connections are shown if Figures 3a, 3b, and 3c. Note the differences between catalog series 219M units and series 419M units. Typical connection diagrams are shown in Figs. 4a, 4b, 4c.

The Type 87M relay has a metal front panel which is connected through printed circuit board wiring to a terminal at the rear of the case. In all applications this terminal, marked "G", should be wired to ground.

Special care should be taken to connect control power in the proper polarity. For relays with dual-rated control voltage, the drawout unit must be inspected to see that the control voltage link at the left rear is in the correct position for the system control voltage. It may be necessary to separate the lower printed circuit board from the upper on 419M series units to make this inspection.

3. SETTINGS

The front panel PICKUP AMPERES control sets the relay's minimum operating current. It is adjustable from 0.1 to 0.5 ampere. See Figure 5 for the operating characteristic curve.

APPLICATION DATA

The Type 87M provides fast, sensitive differential protection for AC motors and generators. It is employed in the conventional scheme using (6) CT's. For "core balance" schemes using (3) current sensors, refer to the Type GRD relay, IB 7.1.1.7-4.

While their basic function is the same, important differences exist between catalog series 419M and series 219M units. The following must be understood to properly apply the relay: The 419M relays are single phase, so (3) units are required to protect a three phase machine. The 219M relays are three phase so only (1) unit is required, an advantage where panel space is limited. An external three phase reactor package is generally used with 219M units. The 419M relay has the reactor device built-in. The 419M units are totally drawout and provide built-in test facilities.

The relay has a non-linear percentage differential characteristic which allows operation for faults as low as 0.1 ampere, but provides security against misoperation on faults external to the zone of protection. This characteristic reduces the requirements on CT accuracy and transient response, since it requires more operating current as the restraint current magnitude becomes larger. This effect comes into play for restraint currents above 8 amperes. See Figure 5. In addition, an inductive reactance has been placed in series with the operate coil in 419M series units. (Supplied as an external device with 219M units.) The reactor presents a high impedance (over 1000 ohms) to the flow of operate current. The reactor is sometimes called a "stabilizing" impedance. It aids in the proper rejection of the differential protection scheme to high inrush load conditions, or the dc offset seen on motor starting. In other words, imbalances in CT secondary currents due to marginal CT performance will not cause significant operate current to flow. On the other hand, for faults in the zone of protection, the CT secondary voltage will rise to the reactor's saturation voltage and drive current through the operate coil. The reactor's saturation voltage is approximately 20 volts, therefore the CT secondary must be capable of at least this voltage. (C20 or higher, C50 preferred). CT secondary resistance and lead drop, if significant, must also be considered to add to the CT secondary voltage requirement.

Since the frequency response characteristic is fairly flat, the Type 87M may be used on 25 Hz. systems as well as at 50 or 60 Hz.

SPECIFICATIONS:

Restraint Circuit Ratings:

Continuous	12 amperes
One Second	300 amperes
Burden	0.25 VA at 5 A

Operating Circuit Ratings:

Continuous	5 amperes
One Second	200 amperes
Burden	1.0 VA at 5 A

Control Power:

Models available for:	Nominal Rating	Operating Range
48/125 Vdc at 0.035 A drain	24 Vdc	19 - 29 Vdc
48/110 Vdc at 0.035 A drain	32 Vdc	26 - 38 Vdc
24/ 32 Vdc at 0.050 A drain	48 Vdc	38 - 58 Vdc
220 Vdc at 0.035 A drain	110 Vdc	88 - 125 Vdc
250 Vdc at 0.035 A drain	125 Vdc	100 - 142 Vdc
	220 Vdc	176 - 246 Vdc
	250 Vdc	200 - 280 Vdc

Output Circuit:	(1) normally open contact, and (1) Selectable, normally open or normally closed Selection by movable link on lower board inside relay
Contact Output Rating:	at 125 Vdc 30 amperes for 0.1 second 5 amperes continuous 0.3 ampere opening
Temperature Range:	-30 deg C to +70 deg C
Dielectric:	2000 Vac rms, 1 minute, all circuits to ground.
Tolerances:	operating characteristic,+/- 25% (see Figure 5) operating time (maximum delay shown in Figure 6)
UL Recognized:	UL File Number E103204

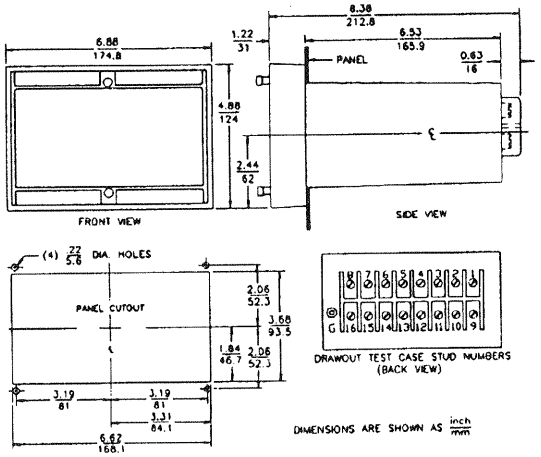

Figure 1: Relay Outline

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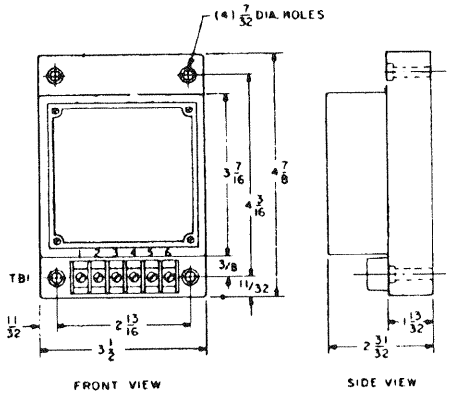


Figure 2: Reactor Outline

Figure 2: Reactor Outline

INTERNAL CONNECTIONS

16D219B Type 87M
Machine Differential Relay
Three Phase: Standard Case

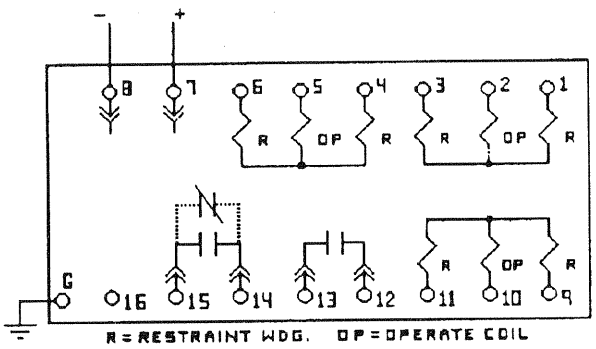


Fig. 3a: Type 87M 219M Series

16D419C Type 87M
Machine Differential Relay
Single Phase: Drawout Test Case

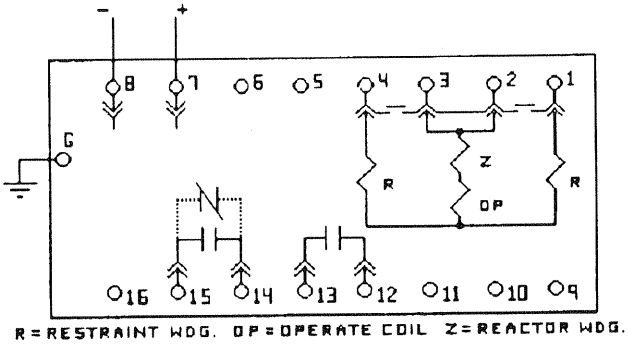


Fig.3c: Type 87M 419M Series

6S219M

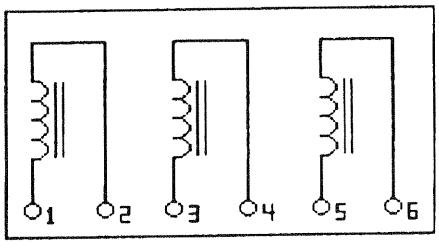


Fig. 3b: Reactor Package

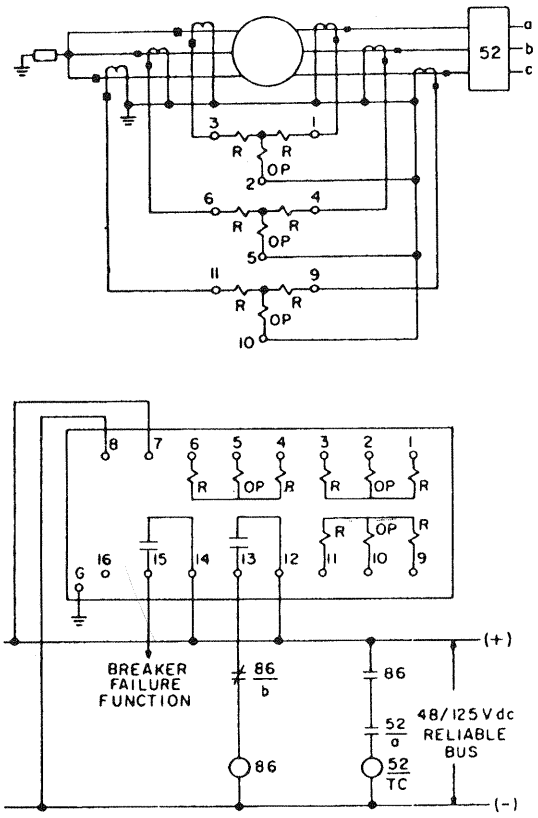


Fig 4a: Typical Connections
219M without Reactor Pkg.

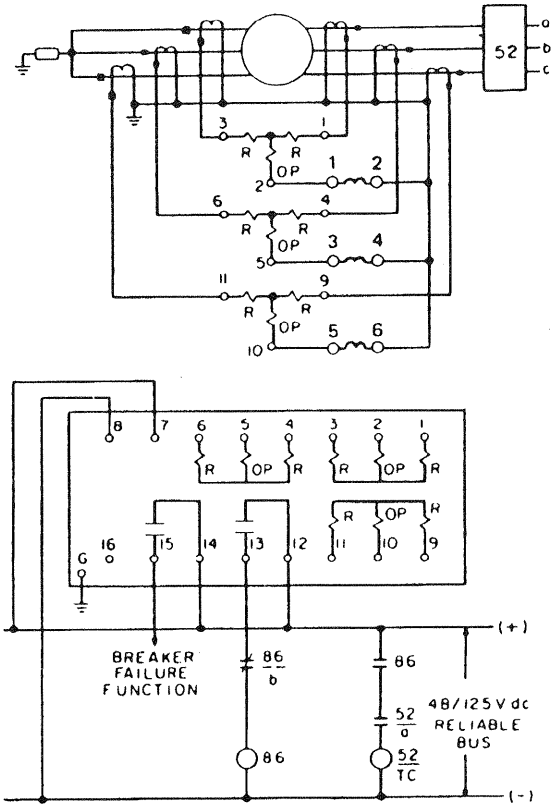


Fig 4b: Typical Connections
219M with Reactor Pkg.

CHARACTERISTICS OF COMMON UNITS

TYPE	PHASES	CONTROL POWER	CATALOG NUMBER
Standard Case	3	48/125 Vdc	219M2570
		48/110 Vdc	219M2500
		24/32 Vdc	219M2590
		220 Vdc	219M2520
		250 Vdc	219M2550
Test Case	1	48/125 Vdc	419M6570
		48/110 Vdc	419M6500
		24/32 Vdc	419M6590
		220 Vdc	419M6520
		250 Vdc	419M6550

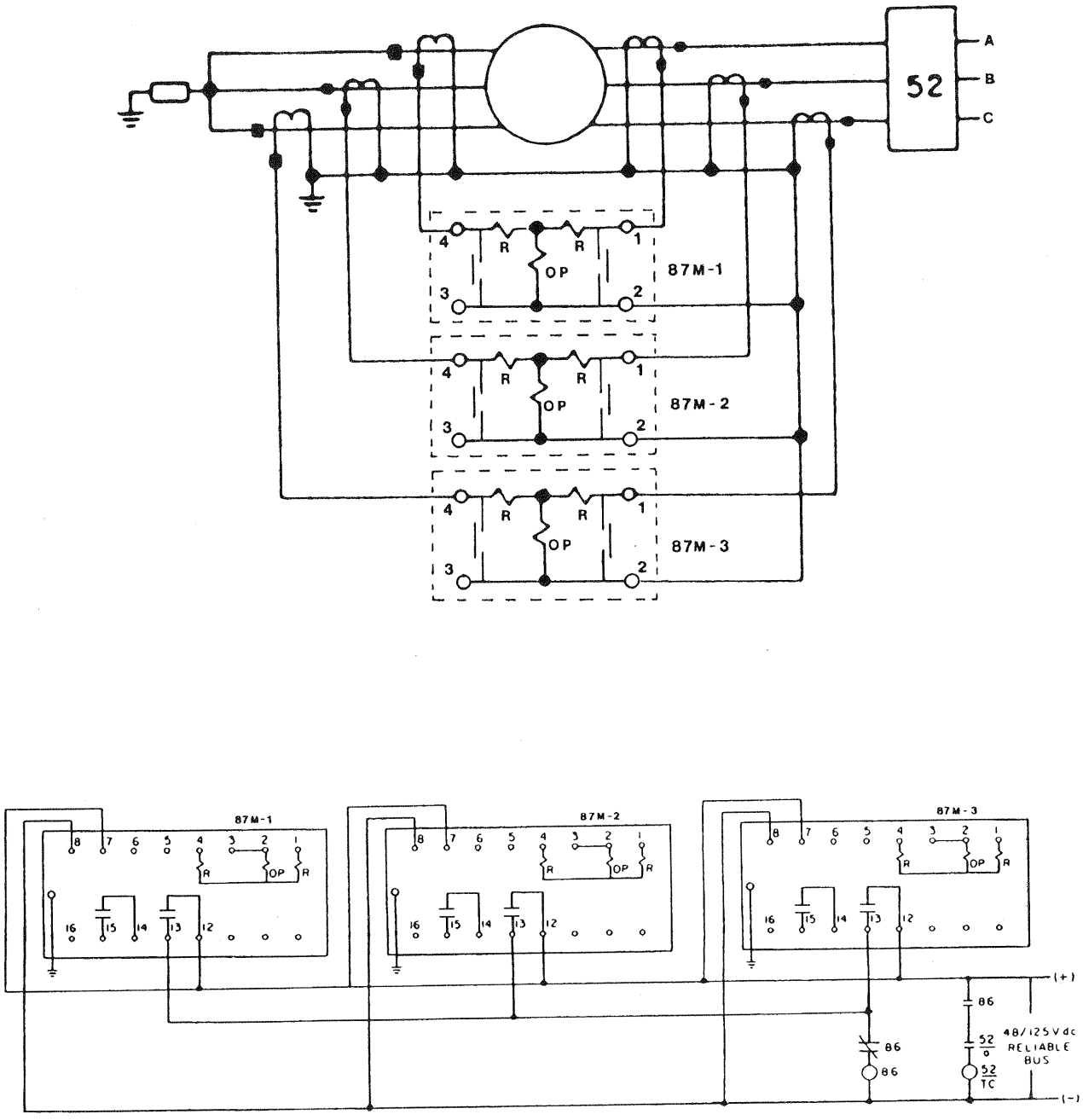


Figure 4C: Typical Connections 419M Series Units

Note: Consult factory for typical connections for generators with delta connected windings.

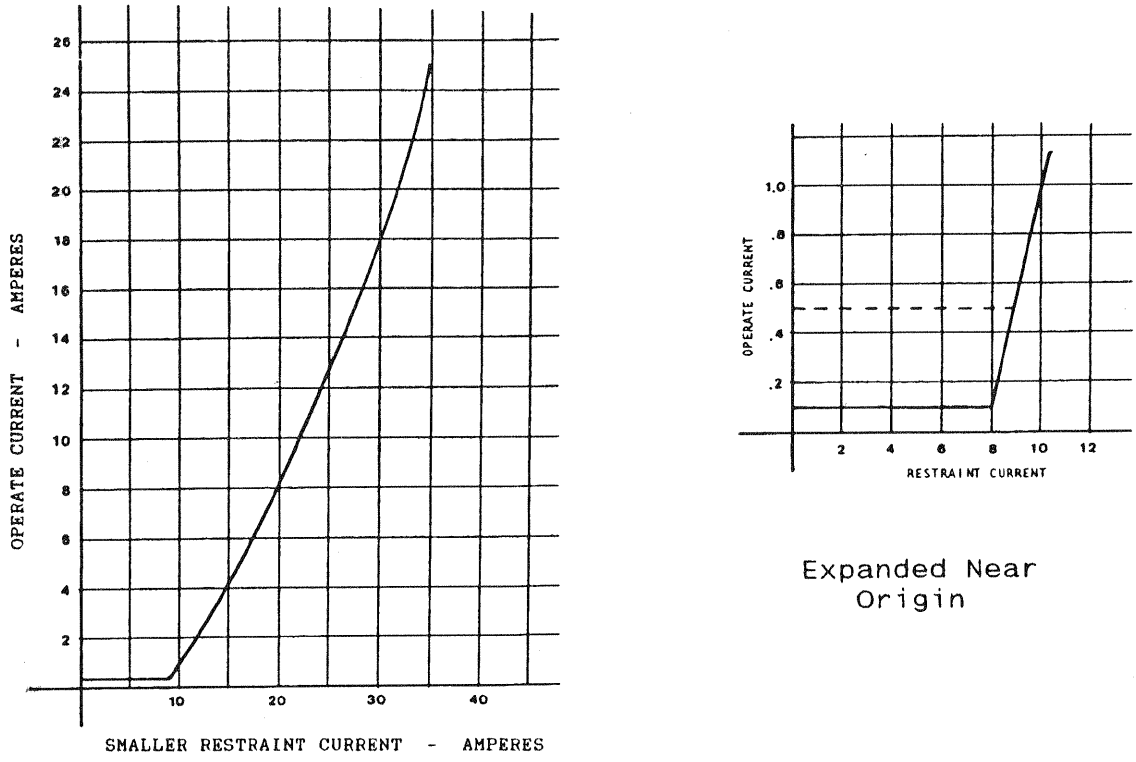


Figure 5: Operating Characteristic

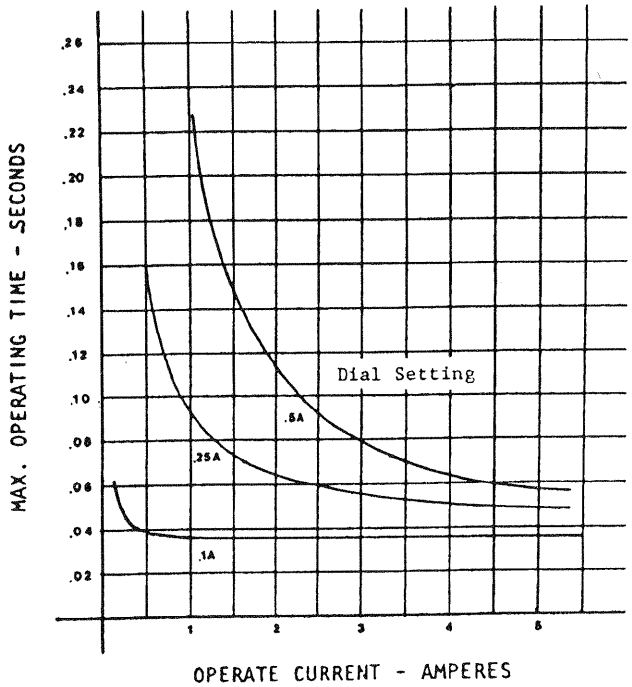


Figure 6: Operating Time Characteristic

TESTING

1. MAINTENANCE AND RENEWAL PARTS

No routine maintenance is required on the Type 87M 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 supplied on request. Renewal parts will be quoted on request by the factory.

219M Series:

Drawout circuit boards of the same catalog number are interchangeable. The board is removed by using the metal pull knobs on the front panel. The relay is identified by the catalog number on the front panel and a serial number stamped on the underside of the circuit board. Removing the circuit board does not open circuit the current transformers connected to the relay.

Note: *Mechanical interlocking has been provided on the 219M series relay cases to prevent insertion of an old style lower circuit card cat # ending in 3. Also the lower removable circuit card of the 219M series relay cannot be inserted into an older style case. Do not attempt to alter or remove these interlocking features since damage or loss of protection can occur.*

419M Series:

Metal handles provide leverage to withdraw the relay assembly from the case. Removing or installing a drawout unit with the relay in service will not cause an undesired operation. The assembly is identified by a catalog number on the front of the unit and a serial number stamped on the bottom of the board.

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 and (2) screws which secure the lower board to the backplane assembly. The lower board may then be withdrawn forward from the printed circuit connector. An 18 point extender board is available from the factory if access to the lower circuit board is required during testing or troubleshooting.

A test plug assembly, catalog no. 400X0001 is available for use with 419M 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 circuit board from its case sufficient to break the connections, before applying the test voltage.

3. ACCEPTANCE TESTS

Connect the relay in the test circuit as shown in Figure 7. Apply the correct dc control voltage. Do not connect the reactor assembly when making these tests. On 419M series units, a post, is provided on the upper printed circuit board for a jumper to be temporarily installed to bypass the reactor (Ll) (See Fig. 7). The reason for this is that many test sources do not have the voltage capability to drive current through the reactor, or if they do, the waveform distortion that may result affects the calibration. Continuity of the reactor can be checked with an ohmmeter. The dc resistance should be less than 2 ohms. Check each of the 3 elements if the external reactor package is used.

CAUTION: do not allow high currents to persist longer than necessary.

a. Depress the TARGET RESET button. The target should show black.
Actuate the TRIP TEST button. The relay should operate and display an orange target.

b. Set the relay's PICKUP dial to 0.1 ampere. Set, variable transformer #1 for zero restraint current in branch 1.
Increase the operate current in branch 2 until the relay operates. The operate current should be 0.08 to 0.12 A.

c. Set the restraint current on the #1 variable transformer to 10.0 amperes. Adjust the current on the #2 transformer until the relay operates. (Check restraint current and readjust as necessary if there is interaction.) The operate current should be between 0.8 and 1.2 amperes.

d. For 219M series units, repeat (b) and (c) for the other two phases.

4. BUILT-IN TEST FEATURE

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

A built-in trip test feature is provided as a convenient means of testing the operation of the relay and the associated trip circuit. When the test button is pressed, the pickup circuit of the relay is activated, causing the relay to operate, tripping the breaker or associated auxiliary.

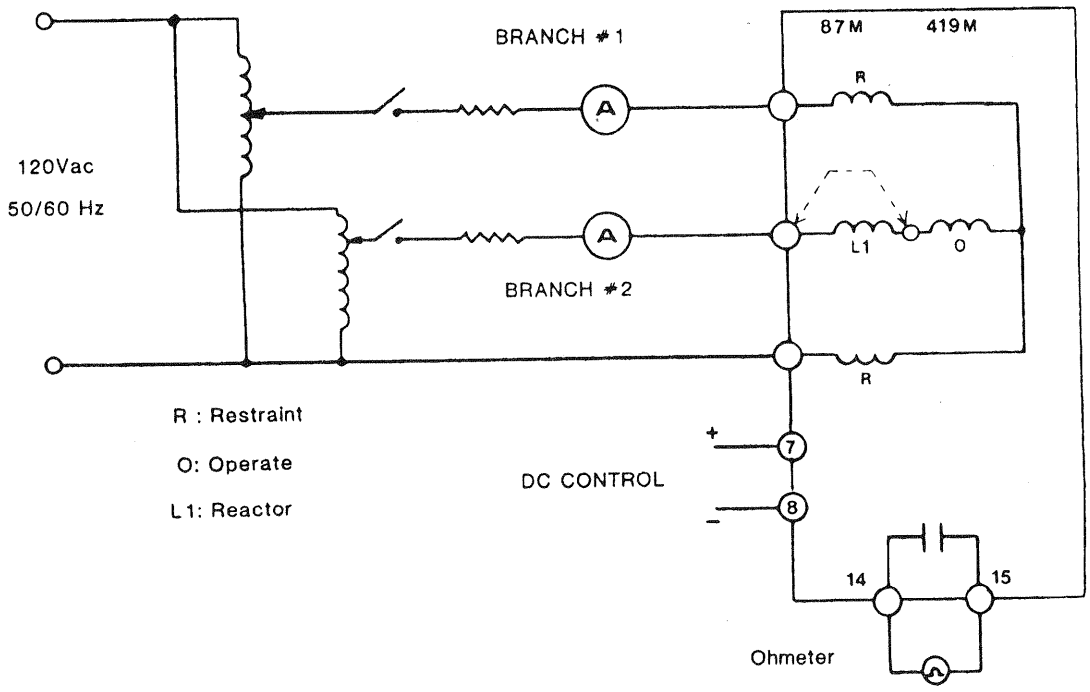


Figure 7: Typical Acceptance Test Circuit

OBSOLETE RELAYS

The Type 87M relay 219M and 419M series with catalog numbers ending with the digit "3" (digit "1" for the 250 Vdc control) have been obsoleted and superseded by catalog numbers ending with the digit "0". The obsoleted models used a Thyristor (SCR) output device (terminals 12-13). The operating times, output ratings, and external wiring have not been altered by this modification.

Note: Mechanical interlocking has been provided on the new 219M25X0 series relay cases to prevent insertion of an old style lower circuit card cat # ending in 3. Also the lower removable circuit card of the new 219M series relay cannot be inserted into an older style case. Do not attempt to alter or remove these interlocking features since damage or loss of protection can occur.

Drawout assemblies of the new 419 series units are interchangeable with old 419 series models, except, the 250 Vdc control voltage unit of the older style case is not provided with terminals 14 and 15 (spare contact).

The following apply to the Thyristor (SCR) output circuit:

1. Be sure the trip circuit is interrupted by an "a" contact to remove high current from the output circuit. A Thyristor output has an inherently high momentary current rating and a low continuous current rating. Do not exceed the rating.

2. Thyristors require a minimum current to remain conducting after triggering. Load (trip coil) must draw at lease 0.1 amp to insure operation. Place resistance in parallel with a low current coil if necessary to guarantee the current, or use the output contact instead (terminal 14 & 15).

The specification for the SCR and the spare output contact are as follows:

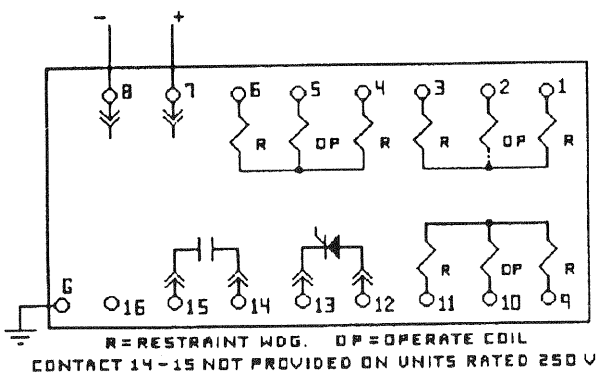
Thyristor output rating:	Contact output rating at 125 Vdc:
30 amperes for 0.1 second	30 amperes for 0.1 second
5 amperes for 1.0 second	5 amperes continuous
1 ampere continuous	0.3 ampere opening

Notes on 24/32 Vdc and 250 Vdc applications.

Relays rated 24/32 Vdc do not include a control voltage link. They can be operated at both voltages with no change. Relays rated 250 Vdc are provided with an SCR trip output only and no spare contact. Terminals 14 & 15 are not provided with these units. See internal connection diagram below.

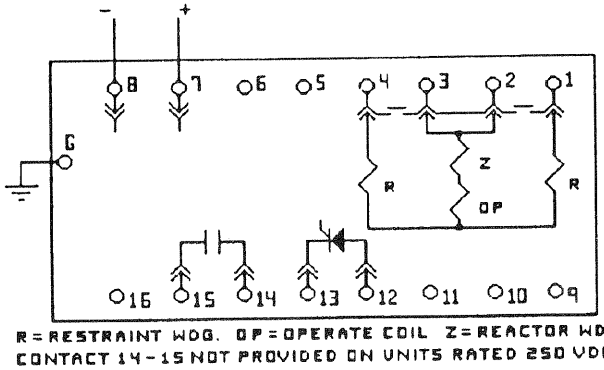
INTERNAL CONNECTIONS

16D219A Type 87M
Machine Differential Relay
Three Phase: Standard Case



R = RESTRAINT WDG. OP = OPERATE COIL
CONTACT 14-15 NOT PROVIDED ON UNITS RATED 250 VDC.

16D419A Type 87M
Machine Differential Relay
Single Phase: Drawout Test Case



R = RESTRAINT WDG. OP = OPERATE COIL Z = REACTOR WDG.
CONTACT 14-15 NOT PROVIDED ON UNITS RATED 250 VDC.

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Supersedes Issue B
Minor Revisions 2-98

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. Should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to Asea Brown Boveri.