ABB Power T&D Company Inc.
Relay Division
Coral Springs, FL
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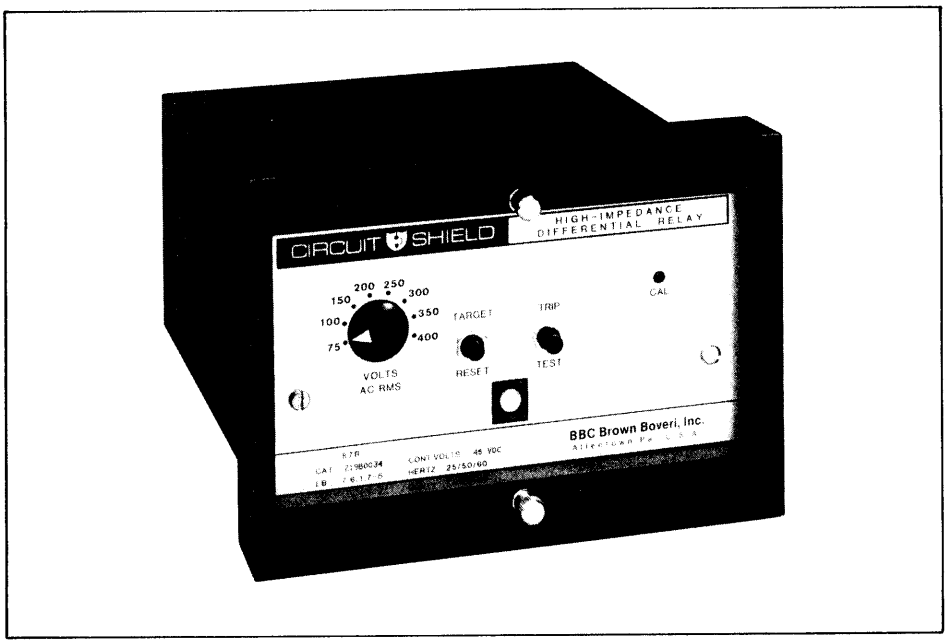
Single Phase
Device Number: 87B

CIRCUIT SHIELD ®

Type 87B High Impedance Differential Relay



Features

- Insensitive to CT saturation
- Definite voltage limiting
- Independent of the number of circuits
- High speed
- High sensitivity
- High seismic capability
- Accurate, repeatable characteristics
- Transient and EMI immunity
- 2 year warranty

Application

The Type 87B single-phase differential relay with high input impedance offers high-speed and sensitive protection against faults within the protected zone of substations or equipment. It is used in well known differential circuits with standard current transformers. The protection can be conveniently expanded to more CT's if breakers are added to the existing scheme.

The Type 87B is a high-speed or instantaneous differential voltage device intended primarily for bus differential protection. High current sensitivity also allows the relay to be used for differential protection of resistance grounded systems and machines or reactors.

The relay is a voltage calibrated device but its pick-up sensitivity is proportional to current magnitudes during internal faults. Its input presents high-impedance burden to current transformers (see Table 2) for secondary differential currents below 0.5 amperes and corresponding burden voltages below 1000 volts peak. Leakage current through the relay varistors at these levels is negligible.

The voltage across the relay input is practically zero in symmetrical circuits during normal operation. Moderate voltage may appear in the secondary circuits due to unequal performance or saturation of some CT's. However, due to relay high impedance and low leakage currents, these voltages will result in smaller differential currents (in percent) than in schemes with low impedance differential relays or high-impedance relays of other types. Thus, high differential impedance (usually several orders of magnitude higher than the shunt impedance of saturated CT's) leaves current transformers force-coupled through their secondaries and allows better discrimination between faults.

Internal faults lead to summation of all infeed secondary currents in the relay with some shunting effect of idle CT secondaries. Relay voltage and current rise rapidly during heavy internal faults. The signal, while being voltage-limited by varistors, causes the relays to operate and self-protect the input of 87B relay until circuit breakers trip.

The relay contains voltage-limiting resistors (varistors) which accurately limit voltage across its input terminals to a safe value during system faults.

The Type 87B relay is primarily designed to operate a fast lockout relay which, in turn, short circuits the relay inputs and trips associated circuit breakers.

Filter and delay circuits are provided against system transients, RFI, and flux exchange between current transformers. The voltage pickup setting is made by means of a switch. Relay operation indicator is of the memory type. A built-in test push button is provided for operational trip test.

Typically, three Type 87B relays and a lockout relay are required in standard configuration for bus differential protection against phase-to-phase and phase-to-ground faults as shown in Figure 1.

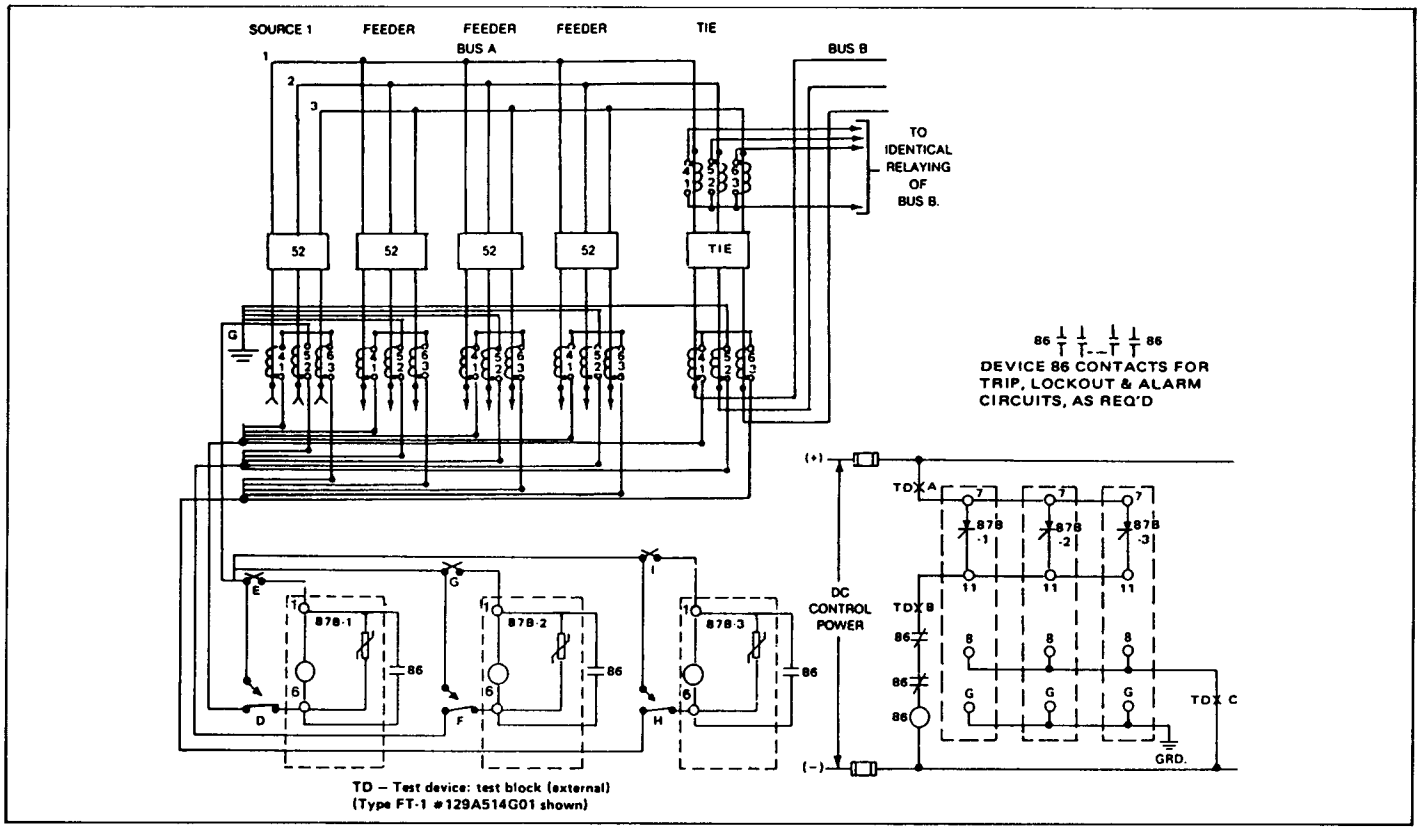


Figure 1. External Connections for Type 87B high-impedance, bus differential, voltage relay for protection of multiple bus sections with bus ties.

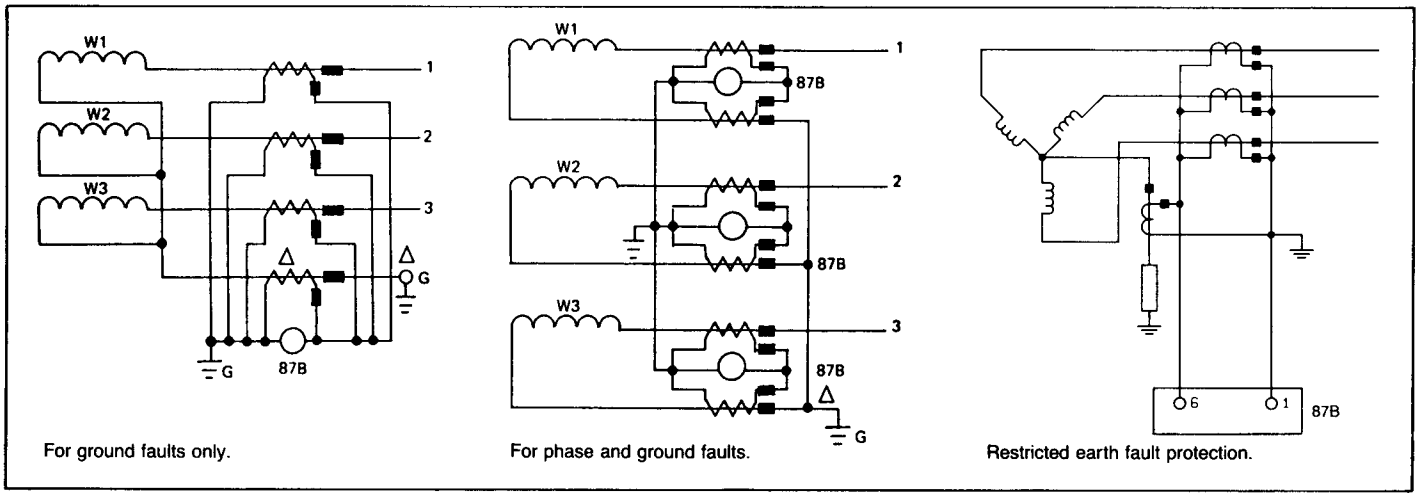


Figure 2. Protection of motors, reactors and generators.

NOTE: Δ - delete grd. conn. and (1) CT if for motor protection.

Application Considerations

Differential protection schemes with high-impedance relays require consideration of certain points. In general and to provide optimum performance, attention is recommended to: proper selection of current transformers and wiring, voltage settings above voltages and transients expected under external fault or inrush conditions, sensitivity to internal faults and relay withstand at maximum fault magnitudes.

A properly set relay will discriminate between external (through feed) and internal system faults.

For example, the following selection procedures can be adapted for a given bus differential protection scheme:

Voltage Settings — External Faults

The relay should be set above maximum secondary circuit voltage which will appear during external faults.

Assume that the CT of a faulted feeder or load breaker is completely saturated and one or more source CT's are forcing current through its secondary winding.

1. Identify ratio and location of CT's.
2. Obtain or calculate DC resistance of the secondary winding of the CT and two-way lead length from the junction point to the farthest CT. Correct resistance values to the highest ambient or operating temperature.
3. Obtain interrupting rating of the largest circuit breaker (symm. A RMS) referred to secondary side of CT's.
4. Product of this current and resistance sum obtained above is symmetrical AC RMS voltage.
5. To obtain minimum relay setting, multiply this value by a factor (e.g. 2.5 or 2.8) which will account for safe margins, DC offset, resistance tolerances and current transfer between CT's.

The voltage thus calculated represents the minimum safe setting of the delay. If the value is between set points, use the next higher pickup setting.

Withstand — Internal Faults

The thermal withstand of the relay is controlled by internal dissipation limits. Energy depends on the speed of the differential and lockout relay operation, maximum available fault current, and CT saturation characteristics.

In general, the wattsecond rating of high-impedance relays of any type should be checked against expected energy.

For convenience, one could use a simplified method as reflected in Table 1 that is based on limits of CT saturation voltages with respect to relay currents and a total operating time of 40 milliseconds (from inception of the fault to closing instant of the lockout relay contacts).

Table 1 — Typical Input Current and Energy Limits

Max. Relay Current (Symm. RMS)	Current Transformers		Max. System Fault Current (Symm. RMS)	Max. Relay Current (Symm. RMS)	Current Transformers		Max. System Fault Current (Symm. RMS)	Max. Relay Current (Symm. RMS)	Current Transformers		Max. System Fault Current (Symm. RMS)
	Max. Satur. Voltage	Minimum Ratio			Max. Satur. Voltage	Minimum Ratio			Max. Satur. Voltage	Minimum Ratio	
				170A	240V	1500:5 1200:5 800:5	50 KA 37.5 KA 25 KA	100A	350V	2500:5 2000:5 1500:5	50 KA 37.5 KA 25 KA
300A	170V	1000:5 800:5 500:5	50 KA 37.5 KA 25 KA	150A	260V	2000:5 1500:5 1000:5	50 KA 37.5 KA 25 KA	90A	360V	3000:5 2500:5 1500:5	50 KA 37.5 KA 25 KA
250A	200V	1000:5 800:5 500:5	50 KA 37.5 KA 25 KA	135A	280V	2000:5 1500:5 1000:5	50 KA 37.5 KA 25 KA	75A	400V	4000:5 2500:5 2000:5	50 KA 37.5 KA 25 KA
220A	210V	1200:5 1000:5 600:5	50 KA 37.5 KA 25 KA	125A	290V	2000:5 1500:5 1000:5	50 KA 37.5 KA 25 KA	62.5A	440V	4000:5 3000:5 2000:5	50 KA 37.5 KA 25 KA
200A	220V	1500:5 1000:5 800:5	50 KA 37.5 KA 25 KA	110A	310V	2500:5 2000:5 1200:5	50 KA 37.5 KA 25 KA	40A	600V	① ① 4000:5	50 KA 37.5 KA 25 KA

① CT's in this range are not widely available due to limited window area. Consult factory.

Current Sensitivity — Internal Faults

Since the varistor current within the pickup range of the relay is negligible, minimum fault current to trip is controlled only by the relay burden current and the magnetizing currents of current transformers. Obtain relay current from Table 2 and add to the sum of magnetizing currents of all CT's in the circuit at selected pickup voltage (consult CT magnetizing curves).

If all CT's are identical, one could also check the approximate number of circuits or breakers, that can be connected to the relay at a desired current sensitivity and voltage setting. To obtain the number, subtract the relay current from the required fault current sensitivity and divide by the magnetizing current of one CT.

Current Transformers — Wiring

The relay is designed for use with dedicated CT's. Toroidal or bushing type current transformers with low leakage impedance are preferred. All current transformers should be of the same ratio. Highest available CT tap is recommended to assure that the secondary winding is fully distributed around the core.

The best sensitivity will be obtained if CT lead resistances to the junction point are minimized and the junction is equidistant in lead length from all CT's.

If CT secondaries are additionally protected by gaps or varistors, their trigger or threshold voltage should not be less than 1600-2000 volts.

Specifications

Ratings (Δ) for: 75-400 VRMS, 1500 Wsec. Type 87B Relay.

Burden: See Table 2.

Voltage Pickup: 75-400 Volts AC RMS, settable by means of a front panel switch at 75, 100, 150, 200, 250, 300, 350 or 400 volts.

Tolerance: Voltage Pickup ±5% of setting

Operating Time: Total trip time: 23-40 milliseconds (includes 20-30 msec. time of the lockout relay and 3-10 msec. operating time of 87B relay).

Input Withstand: 150 Volts RMS continuous
400 Volts RMS for 5 minutes
1500 Wattsec. max. at voltage—limiting conditions (internal system faults).

Frequency: 25/50/60 Hz

Voltage Limiting: 1200-1500 Volts instantaneous at input currents in excess of 0.5-1.0 ampere.

Control Power: 48, 125 or 250 Vdc + 20% −50%
Battery drain — 10 mA (stand-by)
24/32 Vdc + 20% −50%
Battery drain 12-20 mA (stand-by

Output Circuit: Thyristor (SCR) output
30 amps RMS for 0.033 seconds (trip duty)
12.5 amps RMS for 0.25 seconds
7.5 amps RMS for 1 second
1 amp RMS continuous

Temperature: Minus 20°C to Plus 70°C

Seismic Capability: More than 6g ZPA either axis biaxial broadband multifrequency vibration without damage or malfunction (ANSI/IEEE C37.98)

Transient Immunity: More than 2500V 1 MHz bursts at 400 Hz repetition rate, continuous (ANSI C37-90.1 SWC); FAst Transient Test; EMI immunity.

Impulse: IEC Class III ± 5kV

Weight: Unboxed — 4.5 lbs. (2 Kg)
Boxed — 5 lbs. (2.3 Kg)
— 0.26 cubic feet

How To Specify

Differential relays shall be Asea Brown Boveri Type 87B or equal. Relays shall have high input impedance and fast speed operation. The relay shall contain metal-oxide varistors for voltage limiting. Relay shall be capable of withstanding 6g ZPA seismic stress without malfunctioning. Built-in means shall be provided to allow operational tests without additional equipment.

Table 2 — Relay Input Data

Input Impedance and Sensitivity						
Pickup		Input	Current Sensitivity ②			
Dial Setting V. RMS	Peak Volts (Sine)	Resistance (burden) Ohms ± 10%	Pickup Current A. RMS ± 10%	Primary Amps 4000:5 CT	2000:5 CT	1200:5 CT
75	106.1	1430	0.05	40	20	12
100	141.4	1600	0.06	48	24	14
150	212.1	1820	0.08	64	32	19
200	282.8	1950	0.10	80	40	24
250	353.6	2050	0.12	96	48	29
300	424.3	2120	0.14	112	56	34
350	495	2170	0.16	128	64	38
400	565.7	2210	0.18	144	72	43

② System current values are listed for reference only and represent contribution of all power sources. Magnetizing current of CT's is not included.

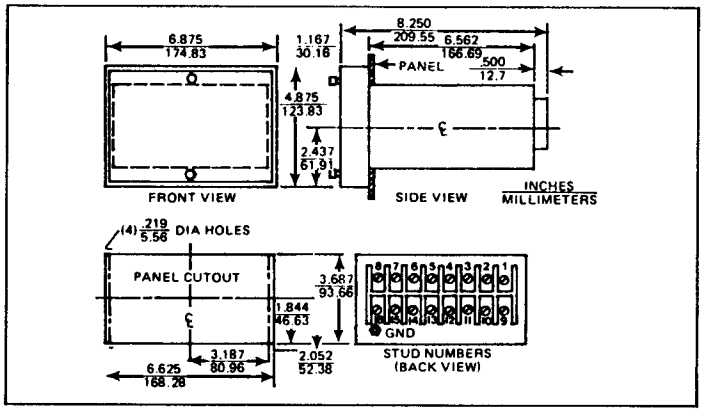


Figure 3—Relay Outline and Drilling.

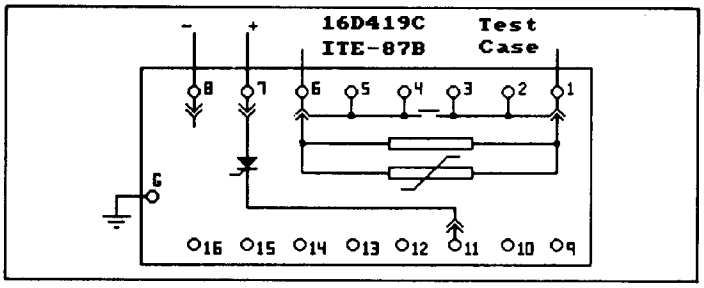


Figure 4— Basic Connections of 87B.

Further Information

List Prices: PL 41-020
Technical Data: TD 41-025
Instruction Book: IB 7.6.1.7-7③
Other Protective Relays:
Application Selector Guide, TD 41-016

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Single Phase
Bus Differential
Drawout Test Case

CIRCUIT SHIELD ®

Type 87B High Impedance Differential Relay

Type	Application	Sensitivity	Internal Connections	Control Voltage	Catalog Number
87B	Bus, Machine, Restricted-earth-fault.	75-400 Volts (0.05-0.18 A) 25/50/60 Hz.	16D419C	48 Vdc	419B0032
				125 Vdc	419B0042
				250 Vdc	419B0052
				24/32 Vdc	419B0092
				110 Vdc	419B0002

Internal Connection Diagram

16D419D Type 87B
Bus Differential Relay
Drawout Test Case