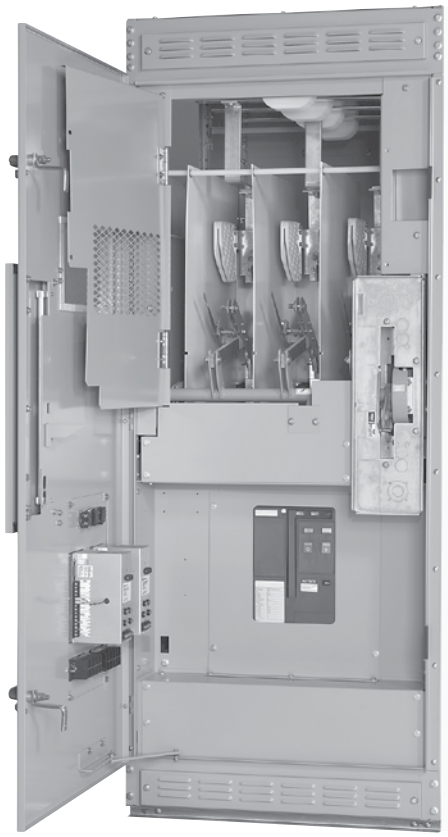
Medium-voltage power distribution and control systems > Switchgear >

Metal-enclosed switchgear, MSB utilizing medium-voltage switch and vacuum breakers

Contents



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General Description

Eaton's MSB assemblies (metal-enclosed switch and breaker) consist of a load interrupter switch (Type MVS) in series with a fixed mounted vacuum circuit breaker (Type VCP-TR for 5–15 kV) in a metal-enclosed cabinet. This combination has been designed primarily where a vacuum circuit breaker is required for higher interrupting capacities and a switch is required to provide a visible means of disconnect. As primary protection for single-ended substations, it can eliminate the need for a secondary main circuit breaker. It can also be applied as the primary main device and integrated with fused or unfused feeder switches in a lineup of MVS switchgear. Two and three breaker automatic transfer schemes are also available.

With the vacuum circuit breaker, Type MSB switchgear assemblies utilize an overcurrent protective device that provides increased system protection and increased coordination with upstream and downstream devices where these benefits cannot be achieved with a switch and fuse combination. Vacuum circuit breakers provide the following features:

- High interrupting capacity suitable for use with ground fault equipment and differential relay schemes
- Load Break Switch providing visible means of disconnect without opening the door
- High duty cycle
- Adjustable overcurrent protection
- Expanded protective relay functions, such as those provided in the EDR-5000
- Three-phase tripping; no single phasing on tripping
- Maintainable
- Long equipment life
- Special applications, such as capacitor switching, are possible with breakers

Eaton Type MSB switchgear provides a small footprint using vacuum breaker technology where the breaker rating does not exceed 1200 A continuous and interrupting ratings are not exceeded. All protective devices and meters are conveniently mounted on the switchgear structure door.

The VCP-TR vacuum breaker is a fully rated two-step stored energy circuit breaker with an "open-close-open" duty cycle. The interrupting rating is 25 kA or 40 kA from 4.76 kV to 15 kV and has a front access mechanism. Type VCP-TR circuit breakers can be supplied with an integral trip unit for phase and ground overcurrent protection.

The vacuum circuit breaker interrupter connections have been designed with a flex current transfer system that provides a unique non-sliding current transfer arrangement, which eliminates maintenance, excellent electrical and thermal transfer, and long vacuum interrupter life.

A visible disconnecting means is accomplished by the load break air interrupter switch and viewing window. Both indoor and outdoor non-walk-in enclosures are available. Applications include single unit lineups and transformer primary applications. Configurations with an automatic transfer control system can be easily accommodated. Fixed vacuum breakers are ideal for high duty cycle, as well as applications requiring rapid return to service after a fault.

Type MSB switchgear is the product of choice for ground fault interruption when air interrupters alone would be potentially hazardous if called on to operate above their assigned ratings. Capacitor switching is easily handled by MSB and avoids the restrike hazard presented by air switches.

Standardized designs cover most common applications, while custom designs are also available for custom requirements.

Type MSB vacuum switchgear meets or exceeds the following industry standards:

- ANSI/IEEE C37.20.3
- ANSI/IEEE C37.20.4
- ANSI C37.22
- ANSI C37.57
- ANSI C37.58
- NEMA SG5
- NEMA SG6
- CSA 22.2 No. 31
- EEMAC G8-3.3
- CSA listable for Canada and U.S. markets

MVS switch sections are easily combined with MSB sections in lineups. No bus transitions are required between them except where a bus transition is needed such as between main and feeder sections.

5/15 kV MSB Assembly

Construction

Eaton's Type MSB switchgear uses the same proven enclosure and air switch mechanism as MVS switchgear. It differs by using the fixed-mounted Eaton VCP-TR (5–15 kV) vacuum breaker in place of fuses. Current transformers associated with protection devices such as the EDR-3000 or EDR-5000 electronic protective relays are applied using the same ratings as drawout metal-clad switchgear. Integral overcurrent protective devices with the Arcflash Reduction Maintenance System™ such as DT 520MCV and DT-1150V trip units are also available. Devices are mounted on the single front-hinged door. The front door may be opened at any time to provide access to low-voltage components and the front of the circuit breaker without being exposed to medium voltage.

Eaton's Power Xpert and IQ family of electronic meters is normally used when metering functions are required.

The circuit breaker is bolted into position, but can be unbolted and removed from the enclosure. Routine maintenance can be performed on the circuit breaker mechanism in the enclosure.

Standard switch insulators are NEMA rated glass polyester or optional epoxy. Control power will be required as detailed below. AC can be supplied integrally if specified. DC control power, if required, must be furnished by others.

If AC control power is used, a capacitor trip device is provided.

Once the circuit breaker is closed and the closing spring is recharged, the breaker can open, close and open without spring recharge.

MSB with Control Switches, Digitrip 3000® Overcurrent Relay with Optional Metering Shown

Standard MSB Switchgear and Assembly Ratings

Table 7.2-1. MSB Switchgear Assembly Ratings

Rated Maximum Volts kV	Rated BIL kV	Rated Main Bus Current Amperes	Rated Momentary Current kA rms Asymmetrical	Rated Short-Time (2 Seconds) Current kA Symmetrical
4.76 4.76	60 60	600, 1200, 2000 600, 1200, 2000	40 64	25 40
15 15	95 95	600, 1200 600, 1200	40 64	25 40

Circuit Breakers

Circuit Breaker Ratings

Type MSB assemblies can be supplied with Type VCP-TR (stored energy operator) or with Type VCP-TRL (electro-magnetic linear actuator operator) circuit breakers. Refer to **Table 7.2-3** for additional capacitor switching capability of the VCP-TR and VCP-TRL circuit breakers.

Table 7.2-2. Available Type VCP-TR and VCP-TRL Vacuum Circuit Breakers Rated per ANSI Standards (C37.04, C37.06, C37.09)

Circuit Breaker Type ①②	Rated Max. Voltage	Insulation Level		Rated Continuous Current	Rated Short-Circuit Current at Rated Maximum Voltage	Rated Voltage Range Factor	Maximum Symmetrical Interrupting & 2-Second Short-Time Current Carrying Capability	Closing and Latching Capability (Momentary)	Cable Charging Breaking Current	Three-Phase MVA at Rated Maximum Voltage (for Reference Only)	Mechanical Endurance No Load C-O Operations	
		Power Frequency Withstand Voltage 60 Hz, 1 Minute	Impulse Withstand Voltage (BIL) 1.2 x 50 microsec									
	V				I	K	K * I	2.6 * K * I		1.732 *V * I		
	kV rms	kV rms	kV Peak	Amperes	kA rms sym		kA rms sym	kA Crest	Amperes	MVA	Vacuum Interrupter	Mechanism
50 VCP-TR 25	4.76	19	60	600, 1200	25	1	25	65	10	210	30,000	10,000
50 VCP-TRL 25	4.76	19	60	600, 1200	25	1	25	65	10	210	30,000	100,000
50 VCP-TR 40	4.76	19	60	600, 1200	40	1	40	104	10	330	30,000	10,000
150 VCP-TR 25	15	36	95	600, 1200	25	1	25	65	25	650	30,000	10,000
150 VCP-TRL 25	15	36	95	600, 1200	25	1	25	65	25	650	30,000	100,000
150 VCP-TR 40	15	36	95	600, 1200	40	1	40	104	25	1040	30,000	10,000

① Rated interrupting time for all VCP-T circuit breakers is 3 cycle (50 ms).
② Operating duty for all VCP-T circuit breakers is O-0.3sec-CO-3min-CO.

Table 7.2-3. Capacitor Switching Capability of Type VCP-TR and VCP-TRL Circuit Breakers

Circuit Breaker Type	Rated Continuous Current	Cable Charging Current	Isolated Shunt Capacitor Bank Current	Back to Back Capacitor Switching		
				Capacitor Bank Current	Inrush Current	Inrush Frequency
	A	A	A	A	kA peak	kHz
50 VCP-TR 25	600, 1200	10	—	—	—	—
50 VCP-TRL 25	600, 1200	10	250 and 630	250 630	15 15	5.0 1.5
50 VCP-TR 40	600 1200	10 10	75–400 75–630	75–400 75-630	18 18	2.4 2.4
150 VCP-TR 25	600, 1200	25	—	—	—	—
150 VCP-TRL 25	600, 1200	25	250 and 630	250 630	15 15	5.0 1.5
150 VCP-TR 40	600 1200	25 25	75–400 75–630	75–400 75–630	18 18	2.4 2.4

Note: Type VCP-TRL 25 and VCP-TR 40 circuit breakers shown in this table are considered definite-purpose breakers per ANSI C37.04.

Breaker Control Ratings

Table 7.2-4. Breaker Stored Energy Mechanism Control Power Requirements

Rated Control Voltage	Spring Charge Motor ②		Close or Trip Amperes	Voltage Range	
	Run Amperes	Time Seconds		Close	Trip
48 Vdc	4.0	5	5.2	38–56	28–56
125 Vdc	3.0	5	3.6	100–140	70–140
250 Vdc	2.0	5	1.8	200–280	140–180
120 Vac	3.0	5	3.6	104–127	104–127
240 Vac	2.0	5	1.8	208–254	208–254

③ Inrush current is 4 times running amperes.

Protection Relays

Eaton's MSB breaker can be furnished with an Eaton Type EDR-3000 or EDR-5000 relay to provide overcurrent and fault protection. Optional zero sequence 50/51G ground fault protection is shown below. Other protective relaying options can be installed upon request — contact Eaton.

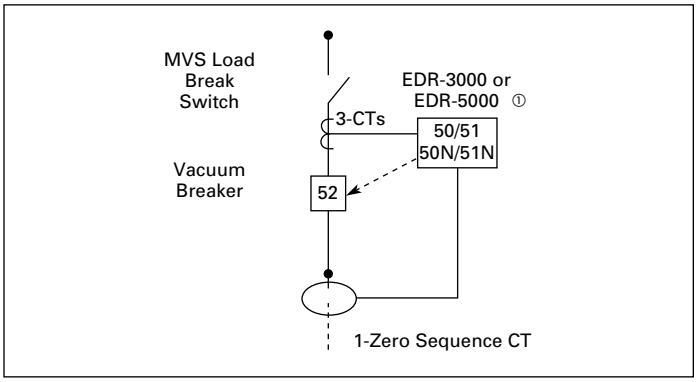


Figure 7.2-1. Typical MSB Single-Section One-Line Diagram

① Use of EDR-5000 requires VTs.

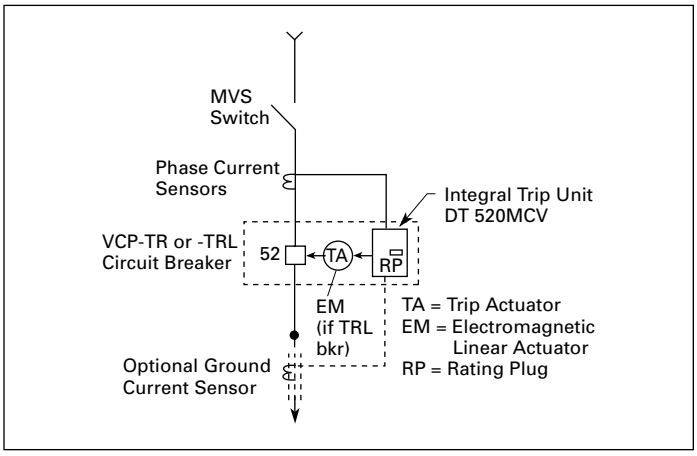


Figure 7.2-2. Typical MSB One-Line Diagram with DT 520MCV

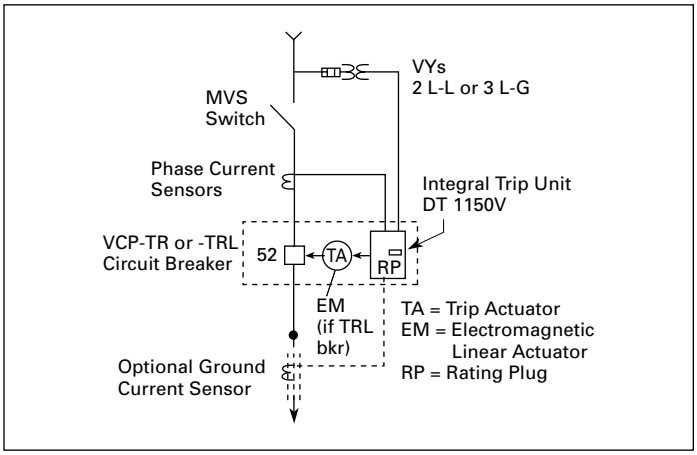


Figure 7.2-3. Typical MSB One-Line Diagram with DT-1150V

Table 7.2-5. Integral Protective Relays

Relay Type	Protective Relay IEEE Functions	Metering
DT 520MCV	50, 50T, 51, 50G, 51G	Amperes
DT-1150V	50, 50T, 51, 51G, 50G, 37, 46, 27, 59, 32, 47, 74, 81U, 81-0	Amperes,, VA, VAR, Watt, Wh, VAh, THD

Table 7.2-6. Protective Relays

Relay Type	Protective Relay IEEE Functions	Metering
EDR-3000	50/51; 50/51G	Amperes and ampere demand
EDR-5000	25, 27, 32, 46, 47, 50N/G, 51N/G, 50/51, 50BF, 51VR, 59, 67N, 67	Amperes; volts; pf, energy, power; THD; waveform

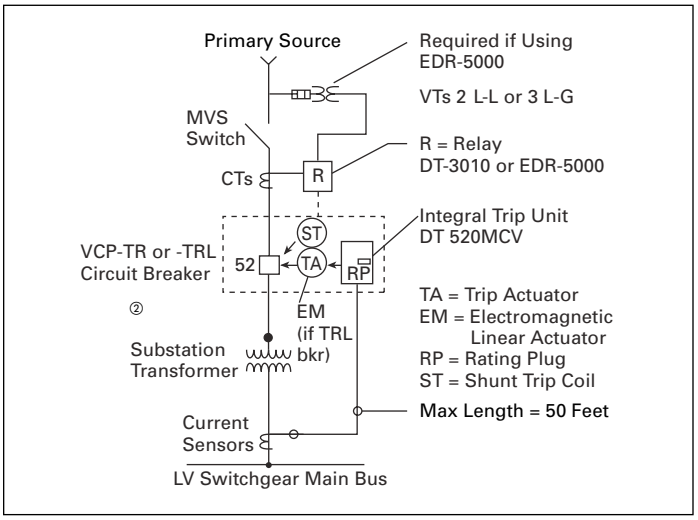
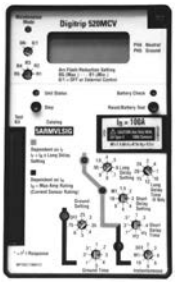


Figure 7.2-4. Transformer Primary Breaker with Secondary Bus Overcurrent Protection

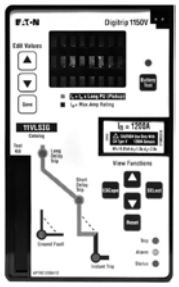
② Surge protection device, such as RC snubber, EHZ or Protec Z is highly recommended for transformer protection.

EDR-3000 Overcurrent Protective Relay

EDR-5000 Multifunction Protective Relay



Digitrip 520MCV



Digitrip 1150V

System Options

Surge Arresters

IEEE Standard C62.11 for metal-oxide surge arresters lists the maximum rated ambient temperature as 40 °C. The ambient temperature inside an MSB switchgear vertical section may exceed this temperature, especially in outdoor applications where solar radiation may produce a significant contribution to the temperature. **Table 7.2-7** lists the recommended minimum duty cycle rating for various system grounding methods based on switchgear temperatures not exceeding 55 °C.

Table 7.2-7. Suggested Minimum Ratings (kV) for Metal-Oxide Surge Arresters Located in Metal-Enclosed Switchgear

Service Voltage Line-to-Line kV	Distribution Class Arresters						Station Class Arresters					
	Solidly Grounded System		Low Resistance Grounded System		High Resistance or Ungrounded System		Solidly Grounded System		Low Resistance Grounded System		High Resistance or Ungrounded System	
	Arrester Ratings kV						Arrester Ratings kV					
	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV	Nominal	MCOV
2.30 2.40 3.30	3 3 3	2.55 2.55 2.55	3 3 3	2.55 2.55 2.55	3 6 6	2.55 5.10 5.10	3 3 3	2.55 2.55 2.55	3 3 3	2.55 2.55 2.55	3 6 6	2.55 5.10 5.10
4.00 4.16 4.76	3 6 6	2.55 5.10 5.10	6 6 6	5.10 5.10 5.10	6 6 9	5.10 5.10 7.65	3 6 6	2.55 5.10 5.10	6 6 6	5.10 5.10 5.10	6 6 9	5.10 5.10 7.65
4.80 6.60 6.90	6 6 6	5.10 5.10 5.10	6 6 6	5.10 5.10 5.10	9 9 9	7.65 7.65 7.65	6 6 6	5.10 5.10 5.10	6 6 9	5.10 5.10 7.65	9 9 9	7.65 7.65 7.65
7.20 8.32 8.40	6 9 9	5.10 7.65 7.65	6 9 9	5.10 7.65 7.65	10 12 12	8.40 10.20 10.20	6 9 9	5.10 7.65 7.65	9 9 9	7.65 7.65 7.65	10 12 12	8.40 10.20 10.20
11.00 11.50 12.00	9 9 10	7.65 7.65 8.40	9 10 10	7.65 8.40 8.40	15 18 18	12.70 15.30 15.30	9 9 10	7.65 7.65 8.40	10 12 12	8.40 10.20 10.20	15 18 18	12.70 15.30 15.30
12.47 13.20 13.80	10 12 12	8.40 10.20 10.20	12 12 12	10.20 10.20 10.20	18 18 18	15.30 15.30 15.30	10 12 12	8.40 10.20 10.20	12 12 15	10.20 10.20 12.70	18 18 18	15.30 15.30 15.30
14.40	12	10.20	12	10.20	21	17.00	12	10.20	15	12.70	21	17.00

Note: MCOV = Maximum Continuous Operating Voltage.

MSB Switchgear with Automatic Transfer Control

Application

Eaton's MSB switchgear with an automatic transfer control system is an integrated assembly of drawout VCP-W breakers, sensing devices and control components. Available in 5–15 kV classes.

It is typically applied where the continuity of service for critical loads from two power sources in either a two-breaker (one bus) or three-breaker (two bus) configuration is desired.

MSB switchgear with an automatic transfer control system can meet most automatic throwover requirements and has a wide variety of operational sequences embodied in one standard automatic transfer control system.

Typical Two-Breaker Automatic Transfer Using ATC Controller

Eaton's ATC-900 controller continuously monitors all three phases on both sources for correct parameters. Should the normal source be lost while the alternate source remains available, the sensing function in the ATC controller will change state starting the time delay function. If the of the normal source is not restored by the end of the time delay interval, the normal breaker will open and the alternate source breaker will close, restoring power to the load.

ATC Controller

Eaton's ATC-900 controller is equipped to display historical information via the front panel or over the power monitoring system. The ATC-900 controller stores 320 time stamped events. Oscillographic data for last 10 events can be downloaded via a USB port or displayed in the controller's display window. The controller allows communication via RS-232 or Modbus through an RS-458 port, Ethernet or via a USB interface.

ATC Controller

Standard Features

- Voltage sensing on both sources is provided by the ATC controller
- Lights to indicate status of switches, sources, and so forth
- Interlocking to prevent paralleling of sources via software
- Control power for the automatic transfer control system is derived from the sensing transformers
- Manual override operation
- Selectable closed with sync check or open transition on return to normal
- Programmable time delays on both sources, "OFF DELAY" and "ON DELAY"
- Four programmable digital inputs and outputs
- Single-source responsibility; all basic components are manufactured by Eaton

Optional Features

- Lockout on phase and/or ground overcurrents and/or internal bus faults
- Load current, power and PF metering with optional DCT module
- 24 Vdc control power input
- Up to four additional I/O modules each with four programmable digital inputs and digital outputs

Typical Three-Breaker (Two Mains and Normally Open Tie) Automatic Transfer Control

The automatic transfer switchgear assembly includes two main breakers and one tie breaker. An integrated automatic transfer control system containing sensing devices and low-voltage logic control and auxiliary equipment are also included. The transfer control system monitors both sources for correct parameters. A transfer selector switch is provided for selection between manual or automatic operating mode. In manual mode, all three breakers are manually operated. Electrical interlocking is provided in manual mode to prevent closing all three breakers at the same time. In automatic mode, the sequence of operation is based on two normally energized sources and operates as follows. Normal operation is: main breakers closed and the tie breaker open. Upon detecting an undervoltage(s) on the line side of a main breaker, and after a field-adjustable time delay, that main breaker opens. After an additional field-adjustable time delay, the tie breaker closes to restore power to the affected portion of the facility. Upon restoration of power to the line side of the main breaker, and after a field-adjustable time delay, the tie breaker opens. After a field-adjustable time delay, the opened main breaker closes.

Partial Discharge Sensing and Monitoring for Switchgear

Coupling Capacitor Type PD Sensor

RFCT Sensor

InsulGard Relay (PD Monitoring)

Partial Discharge in Switchgear

Partial discharge (PD) is a common name for various forms of electrical discharges such as corona, surface tracking and discharges internal to the insulation. It partially bridges the insulation between the conductors. These high-frequency discharges are essentially small arcs occurring in or on the surface of the insulation system when stress exceeds a critical value. With time, airborne particles, contaminants and humidity lead to conditions that result in partial discharges. Partial discharges start at a low level and increase as the insulation becomes deteriorated. Examples of partial discharges in switchgear are surface tracking across bus insulation, or discharges in the air gap between the bus and a support (such as where a bus passes through an insulating window between the sections of the switchgear). If partial discharge activity is not detected and corrected, it can develop into a full-scale insulation failure followed by an electrical fault. Most switchgear flashover and bus failures are a result of insulation degradation caused by various forms of partial discharges.

Sensing and Monitoring

Eaton's Type MSB metal-enclosed switchgear (2.4–15 kV) is corona-free by design. By making switchgear assemblies corona-free, Eaton has made its standard switchgear more reliable. However, as indicated above, with time, airborne particles, contaminants and humidity lead to conditions that cause partial discharges to develop in switchgear operating at 4000 V and above. Type MSB switchgear can be equipped with factory-installed partial discharge sensors and a partial discharge sensing relay for continuous monitoring under normal operation. Timely detection of insulation degradation through increasing partial discharges can identify potential problems so corrective action can be planned and implemented long before permanent deterioration develops. Partial discharge detection can be the foundation of an effective predictive maintenance program. Trending of partial discharge data over time allows prediction of failures, which can be corrected before catastrophic failure occurs.

The PD sensing and monitoring system consists of Eaton's InsulGard™ relay and PD sensors, specifically developed for application in the switchgear to work with the relay.

Partial discharges within the MSB switchgear compartments are detected by installation of coupling capacitor type sensor connected to the main bus or on the load side of the feeder breakers.

Partial discharges in power cables (external discharges) is detected by the installation of RFCTs around the ground shields of incoming or outgoing power cable terminations.

Output signals from sensors (coupling capacitor and RFCT) are wired out to terminal blocks for future or field use, or connected to the InsulGard relay. One InsulGard relay can monitor up to 15 input signals, as well as temperature and humidity. The temperature and humidity sensors are included with each InsulGard relay system. The relay continuously monitors the switchgear primary system for partial discharges and provides an alarm signal (contact closure) when high PD level is detected. Also, data analysis and diagnostics performed by Eaton engineers can be provided by remote communication with the InsulGard relay.

The sensors and InsulGard relay are optional in MSB switchgear.

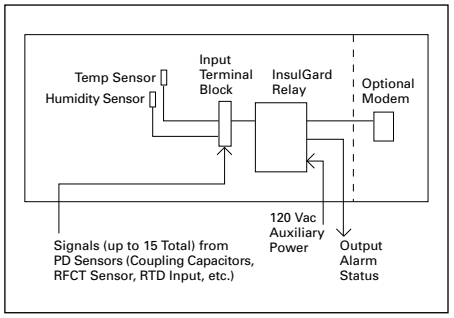
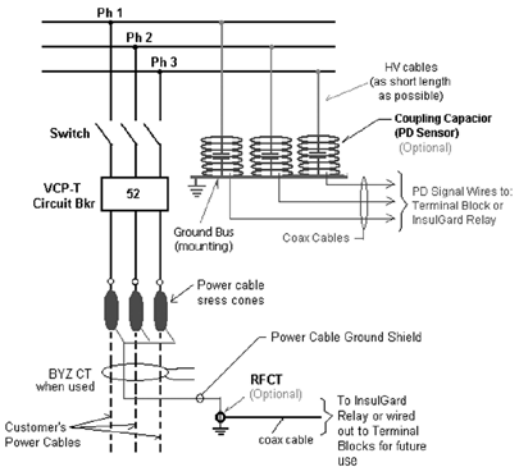


Figure 7.2-5. InsulGard Relay System



RFCT #1 detects partial discharges internal to switchgear compartment.

RFCT #2 detects partial discharges in customer's cables up to 100 ft from switchgear.

Figure 7.2-6. Typical Partial Discharge Sensor Connections in MSB Switchgear (5–15 kV)

Note: Use one set of PD sensing capacitors at every two vertical sections, or portion thereof. Use one RFCT at each incoming/outgoing cable circuit.

Standard

Typical Arrangements—5 kV and 15 kV

The sketches in this section represent the most common lineup arrangements. Many other configurations and combinations are available. The layouts shown are for rear-accessible equipment. Front-accessible designs are available—**refer to Eaton**. The depth of units will vary due to cable entrance and exit requirements, the addition of lightning arresters, instrument transformers, special cable terminators, etc.

Cables are shown as top and bottom entry only. Top or bottom must be selected for incoming and for outgoing cables. Cable sizing is based on two 500 kcmil XLP or EPR insulated cables per phase using preformed slip-on cable termination devices. Rear access is required for installation.

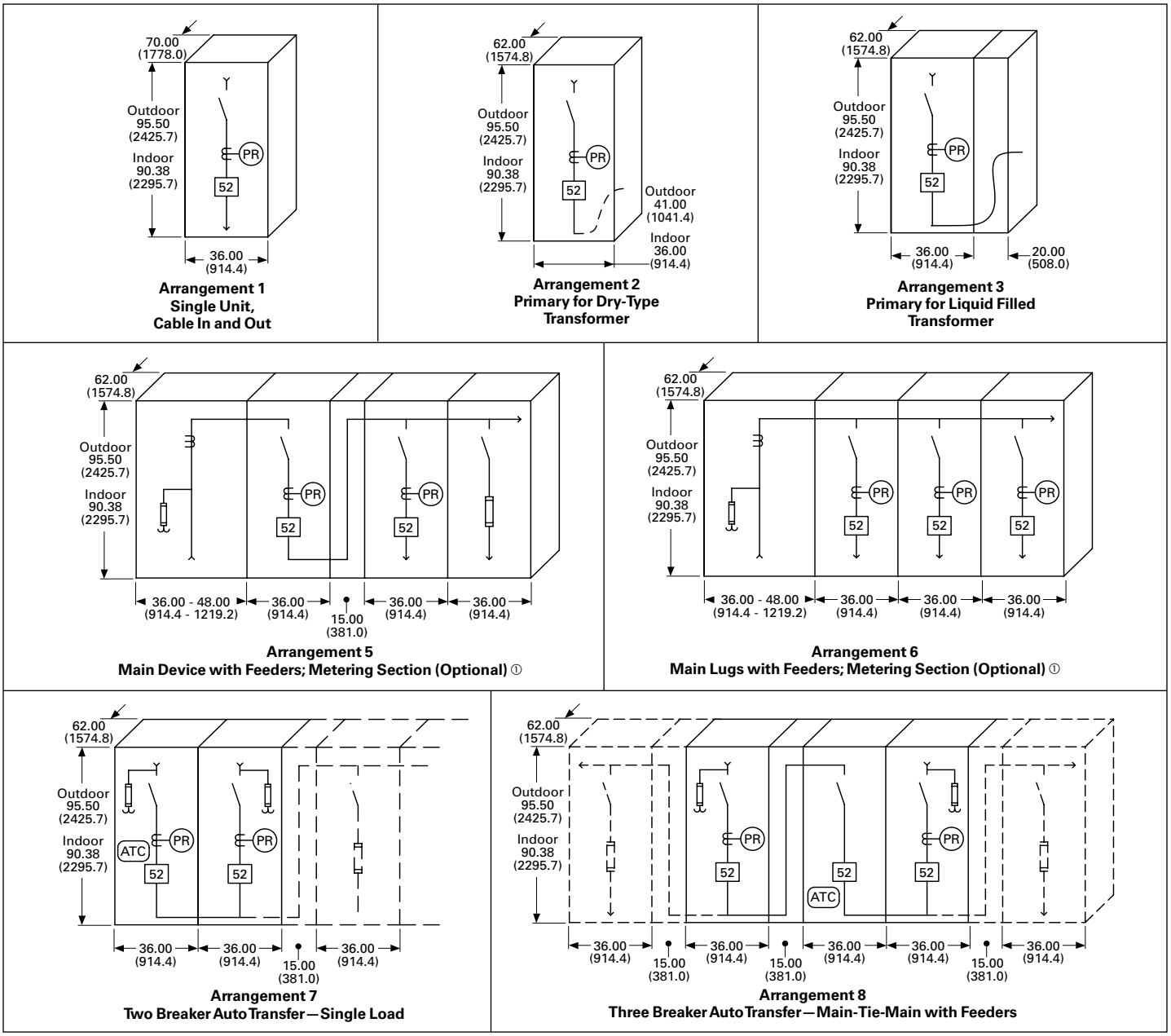


Figure 7.2-7. Layouts and Dimensions in Inches (mm)

① Width of metering compartment may vary depending on utility requirements.

Note: PR—Overcurrent protective relay, typical functions—50/51, 50/51N or 50/51G. Eaton's EDR-3000 or EDR-5000.

Dimensions not to be used for construction purposes unless approved.

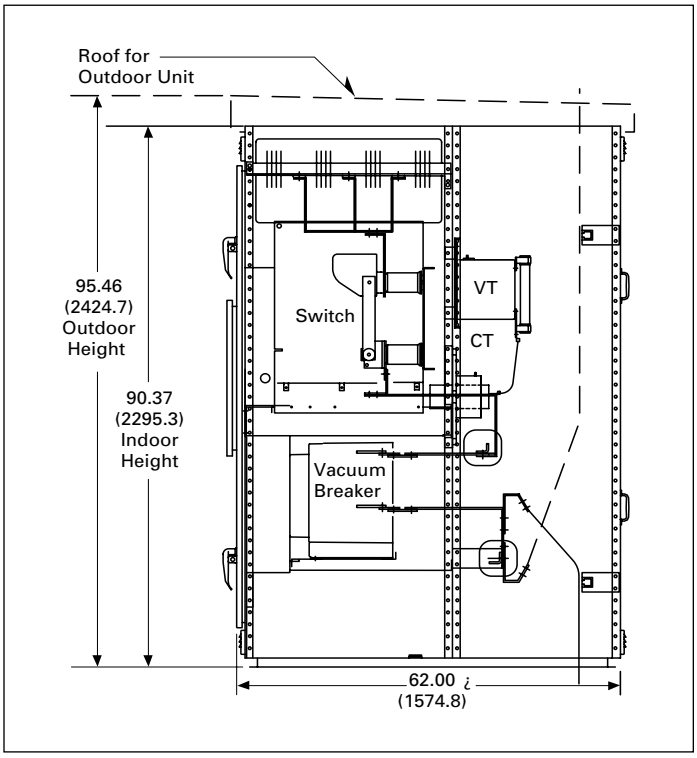


Figure 7.2-8. 5, 15 kV MSB with Main Bus

① Minimum depth 70.00 inches (1778.0 mm) if two sets of CTs are required.

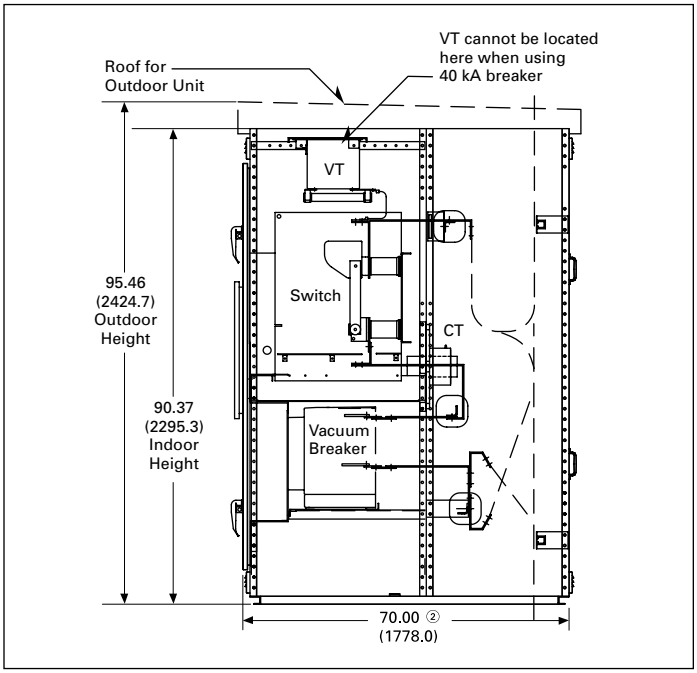


Figure 7.2-9. 5, 15 kV MSB without Main Bus

② Minimum depth 80.00 inches (2032.0 mm) if two sets of CTs are required.

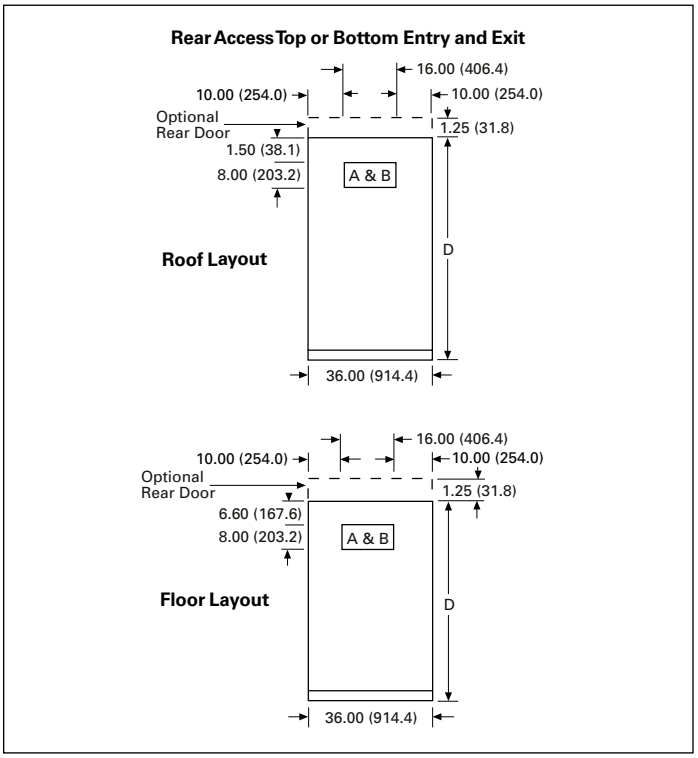


Figure 7.2-10. 5 kV and 15 kV Roof Layouts and Floor Layouts

③ Cable location B not available with main bus.

Note: A = Power cable to load, B = Power cable from source.

Dimensions not to be used for construction purposes unless approved.

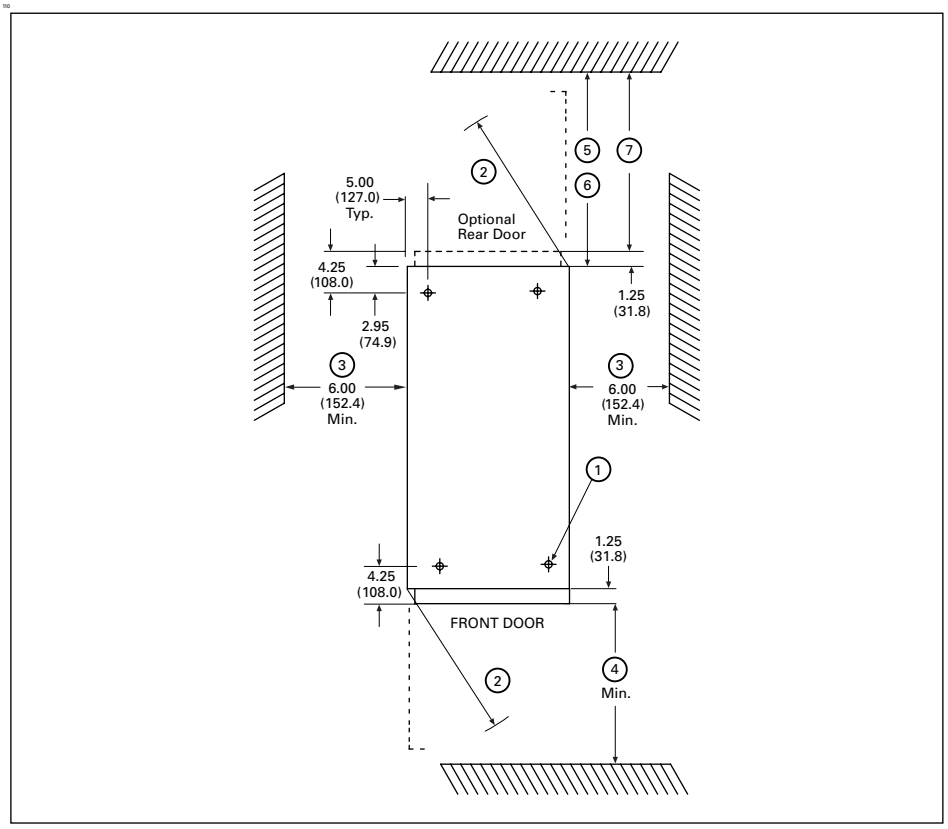


Figure 7.2-11. Typical Anchor Plan for MSB, Indoor or Outdoor

① Locations for tie-down 0.65 inches (16.5 mm) diameter holes for four places. Customer provided bolts for anchoring should be 0.50–13 min. (M12 x 1.75 min. CL 10.9) and tightened to 75 ft-lb (101.7 Nm).

② Door swing equals unit width at 90°.

③ The standard minimum clearances on side. The authority having jurisdiction may require a larger distance.

④ Minimum clearance in front is the width of the widest vertical section plus 1.00 inch (25.4 mm). The authority having jurisdiction may require a larger distance.

⑤ The standard minimum recommended distance is 30.00 inches (762.0 mm) for assemblies requiring rear access for installation and maintenance. The authority having jurisdiction may require a larger distance.

⑥ For MVS only. If the application is specifically provided by contract as not requiring rear access as stated in 5, then the minimum recommended distance is 6.00 inches (152.4 mm).

⑦ If optional rear door is supplied, the minimum is the width of the widest vertical section plus 1.00 inch (25.4 mm). The authority having jurisdiction may require a larger distance.

⑧ Finished foundation's surface shall be level within 0.06-inch (1.5 mm) in 36.00 inches (914.4 mm) left-to-right, front-to-back and diagonally, as measured by a laser level.

Application Examples

Low Resistance Ground Schemes

Medium-voltage low-resistance ground schemes are typically used for 5 kV class systems feeding 5 kV class motor loads. The resistor affords both full selectivity in tripping on ground faults, while limiting ground fault magnitudes to low values (typically 50–400 A). Reducing the current levels to a faulted motor greatly reduces damage and subsequent rewind and repair costs.

System tripping during ground faults on the line side of the secondary main breaker must be cleared by sending a trip signal to the transformer primary side protective device. Fusible switches on the primary side of the step-down transformer (typically rated 5–15 kV) may not be used for this purpose. Any ground fault sensed may escalate as the switch is being signaled to trip thereby exceeding its typical 600 A maximum current breaking capacity.

Eaton's MSB breaker, being a fully rated interrupting device, may be tripped regardless of fault level up to its interrupting rating (for example, 28 kA). Only this type of overcurrent device or a metal-clad switchgear drawout breaker may be safely used.

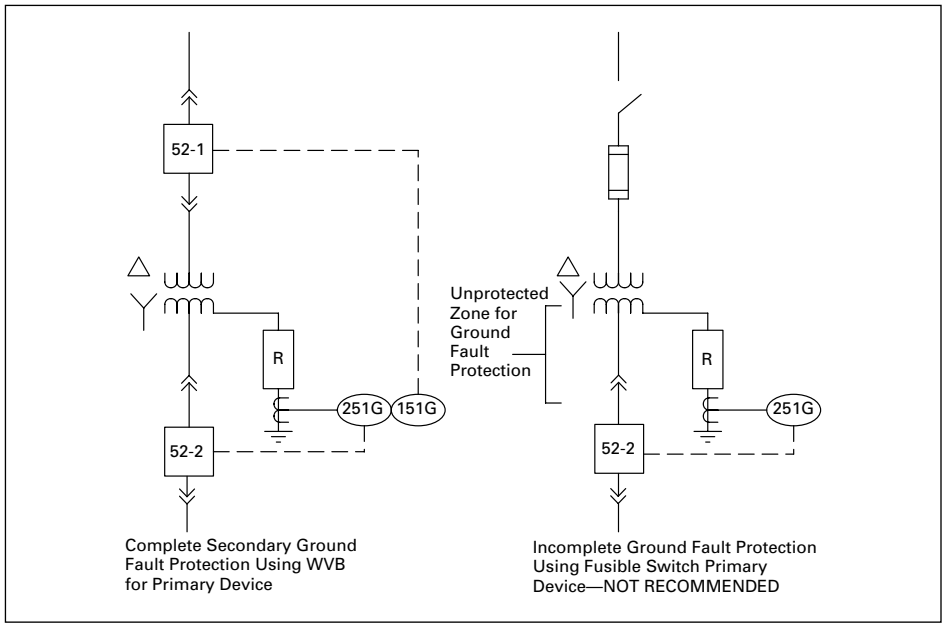


Figure 7.2-12. Low Resistance Ground Scheme (Phase and Primary Ground Fault Protection not Shown)

Single-Ended Substation Designs

In this configuration, the MSB serves as both primary and secondary protection for the transformer. Savings in both floor space and cost result, due to elimination of the secondary main device.This scheme is only recommended where cost and space prevent the use of secondary main device.

Two sets of current transformers are used to protect against secondary ground faults, overloads and short circuits, as well as primary winding faults.

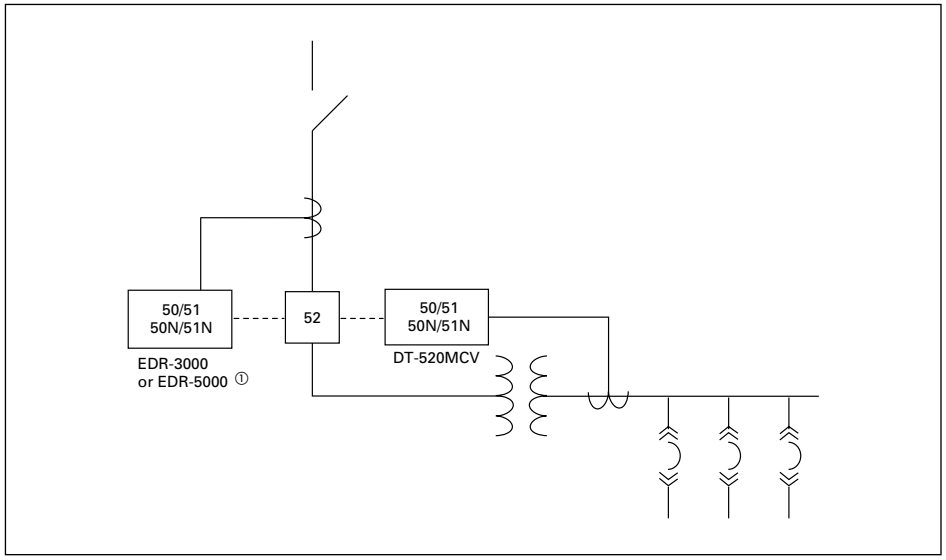


Figure 7.2-13. Single-Ended Unit Substations Using Primary Breaker Protection (MSB)

① Use of DT-1150V or EDR-5000 requires VTs.

Weights

Table 7.2-8. Approximate Weights in Lb (kg)

5 or 15 kV Class	Indoor	Outdoor
MSB section	1700 (773)	2000 (909)
MVS section (non-fused)	1500 (681)	1800 (817)
Fuses (three) add	200 (91)	200 (91)
Transition section	300 (136)	—

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