Power Plant Electrical Technologies (Pty) Ltd



MV-FLEX RANGE

Medium Voltage Switchgear Solutions

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1. INTRODUCTION

Switchgear systems and their components rank among the most important facilities for electrical power transmission and distribution. Their versatile functions and the opportunities they provide contribute on the one hand to safety in general, and on the other hand they secure the availability of electrical energy.

The MV-Flex range offers a versatile and flexible solution to primary switchgear requirements up to 17.5 kV and 2500 A. Utilizing the ABB medium voltage range of circuit breakers and protection equipment a viable solution can be found for every situation.

TYPICAL INDUSTRIES & APPLICATIONS

- Infrastructure
- Mining and Metals
- Food and Beverage
- Water and Wastewater
- Utility and Power Generation
- Light and Heavy Industrial Processing

2.1. **SWITCHGEAR** CHARACTERISTICS

MV-Flex is front access, bottom entry, in-door, air insulated, metal clad, and free standing folded steel switchgear. It contains a single bus bar system, rear cable termination, integrated arc venting and incorporates fully extendible pattern cubicles. The switchgear is rated up to 15 kV, 50 Hz AC nominal, 17.5 kV max, with short duration withstand of 35 kV peak for 1 minute and with a BIL peak value of 95 kV.

The busbars are sized to a standard rating of 1250 A but can also cater for applications of up to 2500 A, with a fault withstand capability of up to 31.5 kA for 3 seconds. All panels are manufactured from 2.5 mm thick sheet steel using machine manufacturing processes, ensuring inter-changeability of all the components of the same type, between panels.

As standard the switchgear has integrated internal arc ducting and vents, allowing for the integration of the board into very confined spaces such as e-houses, container substations or under-ground areas. Bus bars are designed to minimize flash risk, and suitable rated electrical insulation is applied to all bus bar conductors (rated for 17.5 kV continuous). The switchgear is equipped with local and remote control for the circuit breakers.



2.1 **SWITCHING** DEVICES

The standard MV-Flex design can cater for radial or meshed network configurations and can be equipped with a range of primary switching devices including vacuum circuit breakers, SF6 circuit breakers, and vacuum contactors. The main components utilised are detailed below.

2.1.1 **VD4 CIRCUIT BREAKERS** (POWER DISTRIBUTION)

For standard applications the circuit breaker used is the ABB VD4 vacuum circuit breaker, with draw out pattern carriage, spring actuated mechanism and vacuum interrupters. The VD4 circuit breaker is provided at a standard voltage rating of up to 17.5 kV, with a BIL of 75 kV, and with a standard current rating of 1250 A or 2500 A at a short time withstand current rating of up to 31.5 kA. The circuit breakers are equipped with multi finger, self-aligning, spring tensioned isolating contacts and a spring tension operating mechanism.

The circuit breaker and control cubical access are front access only. Each circuit breaker is equipped with mechanical protective interlocking to prevent racking operation if the breaker is closed, and electrical interlocking to allow local closure in the test position only. The circuit breaker racking is only achieved through the closed front access door, and the front access door is provided with multi point mechanical locking and hinging to ensure complete arc flash protection from the front of the panel during circuit breaker racking operations. Although the MV-Flex range is marketed and sold with our standard VD4 with draw-out circuit breaker configuration rated at 17.5 kV, 1250 A, 25 kA, other voltage and current options are available on enquiry.

Table 1: Available VD4 models and specifications.

Model	Rated Voltage (U_r)	Rated Current (I_r)	Rated Short Time Withstand Current (3s) (I_k)
VD4 12	12 kV	630 - 2500 A	16 - 31,5 kA
VD4 17	17,5 kV	630 - 2500 A	16 - 31,5 kA
VD4 24	24 kV	630 - 2500 A	16 - 31,5 kA



Figure 1: ABB VD4 Withdrawable Circuit Breaker.

2.1.2 **VM1 CIRCUIT** BREAKERS

The VM1 is a small footprint medium voltage vacuum circuit breaker, utilizing magnetic actuation technology to provide a more reliable and longer lasting solution to the industry. This is made possible by the simplicity of the magnetic actuator design features such as one moving part and built-in safety features. The vacuum circuit-breakers of type VM1 are intended for indoor installations in air-insulated switchgear.

VM1 circuit-breakers are used in systems where the switching frequency is high, such as auto recloser feeders, or large motor starters, where a standard vacuum contactor is not suitably rated. The VM1 provides this high switching frequency whilst having an extremely long service life with complete freedom from maintenance.

MECHANICAL OPERATING CYCLES

1. Operating mechanism: up to 100,000 cycles.
2. Operating cycles at rated short-circuit breaking current: up to 30,000 cycles.

Vacuum circuit-breaker with magnetic actuator mechanism advantages:

- Extremely high number of operating cycles.
- Virtually maintenance free.
- Electronic controller with sensor technology.
- Vacuum interrupters embedded in epoxy resin.

Although the MV-Flex range is marketed and sold with our standard VM1 with draw out circuit breaker configuration rated at 17.5 kV, 1250 A, 25 kA, other voltage and current options are available on enquiry.

Table 2: VM1 models and specifications available.

Model	Rated Voltage (U_r)	Rated Current (I_r)	Rated Short Time Withstand Current (3s) (I_k)
VM1 12	12 kV	630 – 2500 A	16 - 31,5 kA
VM1 17	17,5 kV	630 – 2500 A	16 - 31,5 kA
VM1 24	24k V	630 – 2500 A	16 - 31,5 kA



Figure 2: ABB VM1 Withdrawable Circuit Breaker.

2.1.3 **VSC MEDIUM VOLTAGE** VACUUM CONTACTORS (CONTROL)

The V-Contact (VSC) contactors are suitable for controlling medium voltage motor starting and medium voltage capacitor switching and certain transformer applications. Due to the breaking technique with vacuum interrupters, the V - Contact VSC can operate in particularly difficult environments. Fitted with suitable fuses, the V – Contact VSC can be used in circuits with fault levels up to 1000 MVA. Fuse holders (only VSC/F, VSC/P and VSC/PN contactors). The VSC/F or VSC/P contactor is fitted with fuse holders able to hold DIN or BS type fuses according to what is required.

When compared with a contactor fitted with a traditional operating mechanism, V-Contact VSC contactor allows energy saving which prevents emission into the atmosphere of about 7000 kg of carbon dioxide (CO_2). Although the MV-Flex range is marketed and sold with our standard V-Contact VSC/F contactors, with DCO control configuration at 12 kV, 400 A, with on carriage fuses, other voltage and current options are available on enquiry. The V-Contact VSC contactors are available in the following versions:

Table 3: VSC models and specifications available.

Fixed Contactor Carriage	Withdrawable Contactor Carriage
3.6 kV VSC 3	
7.2 kV VSC 7 - VSC 7/F	7.2 kV VSC 7/P - VSC 7/PN
12 kV VSC 12 - VSC 12/F	12 kV VSC 12/P - VSC 12/PN



Figure 3: ABB -VSC7/F 400 A -VSC12/F 400 A.

All the contactors mentioned above are available, on request, in one of the following two versions. SCO (Single Command Operated): closing takes place by supplying auxiliary power to the special input of the multi-voltage feeder. On the other hand, opening takes place when the auxiliary power is either voluntarily cut off (by means of a command) or involuntarily (due to lack of auxiliary power in the installation). DCO (Double Command Operated): closing takes place by supplying the input of the closing command of the apparatus as a pulse. On the other hand, opening takes place when the input of the opening command of the contactor is supplied as a pulse.

2.2 **INSTRUMENT TRANSFORMERS**

2.2.1 CURRENTTRANSFORMERS (CTS)

Each MV-Flex Circuit Breaker panel is equipped with a primary block type current transformer (CT). The current transformers are suitably rated for the panel operating voltage, load current and fault current rating. Each panel accommodates three multi winding current transformers, providing primary measurement for 3 phase protection and 3 phase metering CT inputs. Protection CT windings are dedicated for marshalling to the protection relay devices and the metering CT windings are available to be marshalled for local metering or remote metering, as may be required.

Protection and metering CT wiring is provided via their own respective 4-way test block, located on the panel front door. The incomer breaker current transformers can be optionally equipped with integrated capacitive voltage dividers for voltage presence indication.

CTs are wired to terminals in such a way that any ratio available can be selected to meet load specification. The MV-Flex CTs are typically supplied with multi tap windings to provide current sensitivity for a wide range of loads. The standard CT ranges available in stock for MV-Flex are:

Table 4: CT Specifications available

Components	High Range	Medium Range	Low Range
Protection CT Ratio	2500/2000/1600/1 A	1200/800/600/1A	400/250/100/1 A
Protection Class	10 P 10	10 P 10	10 P 10
Metering CT Ratio	2500/2000/1600/1 A	1200/800/600/1A	400/250/100/1 A
Metering Class	1.0	1.0	1.0
Burden	7.5 VA	7.5 VA	7.5 VA
Capacitive Divider	Yes	Yes	No

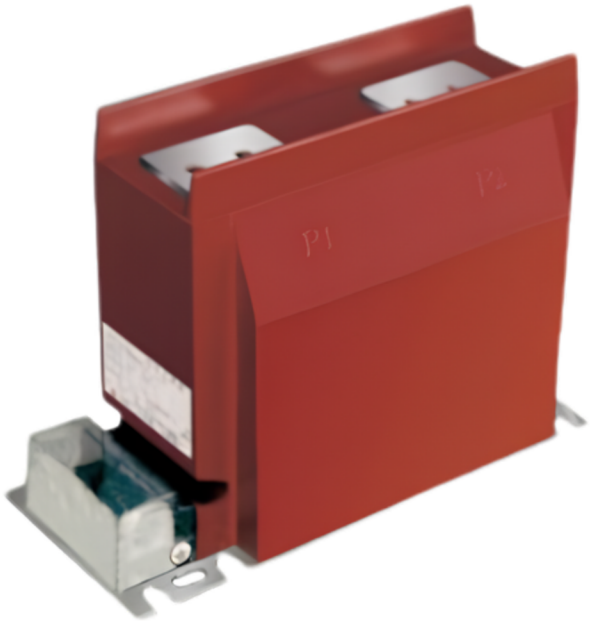


Figure 4: Typical Block Type Current Transformer.

2.2.2 **VOLTAGE TRANSFORMER** (VT) AND INDICATORS

The MV-Flex switchgear can be equipped with cable side or main bus VT's as may be required for the application. MV-Flex can accommodate one three phase VT on each incomer panel, for cable side voltage measurement for indication, metering, protection or synchronising control applications. The VT's can be three-limb or five-limb and can be configured in Y/Y or Y/D connections depending on the application or protection philosophy. The VT units can be fixed or draw out type with integrated primary fuses.

Bus VTs are installed in a separate panel, either as a fixed unit or in a draw out type configuration for ease of maintenance and primary fuse inspection. Cable side VTs are installed on top of the applicable panel, also as either as a fixed unit or in a drawer out type configuration, for cable side voltage metering or protection. This configuration also allows for synchronising or synchronism check functionality across bus sections etc.

Although the MV-Flex range is marketed and sold with our standard three limb Y/Y configuration rated at 6,6 kV, 11 kV or 15 kV, class 1, at 200 VA, other voltage and current options are available on enquiry.

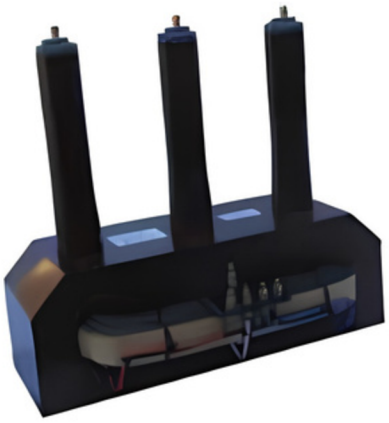


Figure 5: Typical 3-Limb Y/Y VT.

2.2.3 **PROTECTION**

The MV-Flex switchgear can be equipped with any selection from a range of electrical protection relays. As a standard offering the MV-Flex range is equipped with the ABB Relion® Range of protection relays, configured with our recommended protective and interlocking features.

All trip and close control circuits are marshalled and managed through the protection relays on each panel. The protection relays are provided with sufficient I/O for remote control interface to the control desk and for future PLC control purposes. This allows remote PLC monitoring and control interface through the relay for power monitoring, statusmonitoring, alarm monitoring and breaker/contactor control.

THE TYPICAL MV-FLEX DEFAULT PROTECTION RELAY CONFIGURATION INCLUDES THE FOLLOWING FEATURES:

- Trip circuit supervision, with close blocking circuit,
- Breaker Fail, with interlock back to incomers,
- Bus Blocking / reverse Interlocking Bus Differential,
- 50/51 Three-phase non-directional/directional overcurrent protection; (high, low & instantaneous stages),
- 50 N/51 N Three-phase non-directional/ directional earth fault protection; (high, low & instantaneous stages),

We also recommend the following improved protection features, especially for applications in confined spaces and where arc times are to be absolutely minimized, should a short circuit fault justified:

- Internal Arc interface, three arc sensors per panel and interlocked for zone protection, Bus wire connection between relays for zone protective interlocking,
- 50 L/51 NL Integrated arc sensing and protection functionality

Modbus communications or IEC 61850 network facility interface are also available as may be required for PLC interface or other such relay network control.

2.2.3.1 **TYPICAL** PROTECTION RELAYS:

The standard MV-Flex Protection relays are the ABB Relion® Series REX615 Protection and Control Relay. The typical relay supplied with this switchgear is the ABB REX615 due to its suitability in a wide variety of applications. Examples of configuration options are shown in Table 5 however the configuration can be fully customized to suite each specific applications needs.



Figure 6: ABB REX640 and REX615 Relays

Table 5: Typical REX 615 Configurations

Specification	Typical Configurations
Housing	Standard case Wide case (more I/Os) Wide case (more currents & voltages) (2 x AIM modules mandatory)
Communication module	COM: Ethernet 100 Base TX (2 x RJ45, 1 x MM LC) with HSR/PRP and IEC61850-9-2LE + Glassfibre ST + ARC detection 3 x lens sensors
Binary Input and Outputs	2x BIO: 8BI + 4BO
Analog Input and Outputs	2x AIM: 4CT (Io 1/5 A) + 3 VT
RTD Module (optional)	1x RTD2 - 2RTD + 1 mA (in) + 3BO
Power Supply	PSM3: 24-60 Vdc; 6BO PSM4: 48-250 Vdc; 100-240 Vac; 6BO
Application (in addition to base functionality)	APP1 - Current protection package APP2 - EF protection extension package APP3 - Feeder protection extension package APP4 - Fault locator package APP5 - Voltage protection package APP6 - Line differential protection package APP7 - Shunt capacitor protection package APP8 - Interconnection protection package APP9 - Machine protection package APP10 - Power Transformer protection package APP11 - Busbar protection package APP12 - OLTC control package APP13 - Line distance protection package
Protocols	CMP2: IEC 61850 and Modbus

2.2.3.2 **INTERNAL ARC** PROTECTION:

When MV-Flex switchgear is supplied with ABB Relion® Series REX615 relays on all Incomers and Feeders, the panels and relays are equipped with integrated internal arc sensors, and the relays are then configured through bus connections to differentiate between bus faults and feeder bay faults and the scheme reacts accordingly. Internal arc protection provides a significant advantage over standard "current-only" protection because it instantly isolates the exact fault location and cuts the breaker trip time down from roughly 100 milliseconds to under 1 millisecond. This results in much better damage limitations, reducing the cost of repairs and plant down time in the event of a fault.

When MV-Flex switchgear is not supplied with ABB Relion® REX615, or other brands of relays on the Feeders, we recommend an alternative internal arc protection scheme, based on the ABB Arc Guard TVOC-2 solution. The ABB Arc Guard TVOC-2 unit allows for the input of 30 fibre optic sensors of up to 60 m length, with instantaneous upstream tripping when an arc flash is detected within 3 m of the optic sensor. Discrimination and priority tripping schemes can be achieved by strategic sensor placement across the entire switchgear. The unit features a detachable display for arc detection time and location. Three sensors are provided per panel, providing arc sensing for the busbar ducting, device cubical and cable connection cubical.



Figure 7: ABB Arc Guard TVOC-2.

Table 6: ABB Arc Guard TVOC-2 Specifications

Specification	Rating
Control Voltage:	220/110 VDC/ VAC
Number of inputs:	Up to 30
Number of trip outputs:	3
Number of alarm outputs:	2

3. **CONTROLS** AND FEATURES

All MV-Flex switchgear panels are wired for local and remote control, metering and monitoring.

3.1 **LOCAL CONTROL, MONITORING AND METERING**

The MV-Flex Incomers and Feeders have local control features available. Facilities can be provided from each panel for local control and monitoring, which can include the following:

Table 7: Typical local control and indication

Local Control	Local Indication
Test / remote Selector Switch	Breaker/Contactor Open LED Lamp
Test Position Close Push Button Test	Breaker/Contactor Closed LED Lamp
Position Open Push Button Local	Breaker/Contactor Protection Fault LED Lamp
Protection reset Push button	Breaker racked In / Out Indication

For all circuit breakers panels, a Local / Test facility is provided on each panel for breaker open and close in the test position.

3.2 **REMOTE CONTROL,** MONITORING AND METERING FACILITIES

The MV-Flex Incomer and Feeder have remote control features available. It is anticipated that the switchgear will be locally controlled after initial commissioning, with either PLC interface or hard-wired interface to follow at some time in the near or far future.

Wiring is provided from each panel to a marshalling box on the rear of each panel, providing ease of access for top or bottom control cable entry. In this manner no additional wiring or trunking is required within the switchgear for such remote control and monitoring once the switchgear is delivered to site.

Table 8: Typical remote control and indication

Remote Control	Remote Indication
1 x Remote Close, potential free contact terminals	2 x Breaker/Contactor Open terminals
1 x Remote Open, potential free contact terminals	2 x Breaker/Contactor Closed terminals
1 x Remote Relay Reset, potential free contact terminals	1 x Breaker/Isolator/Protection Fault
	1 x Protection Tripped terminals

3.3 **ARC VENT** DUCTING

The MV-Flex switchgear has integrated arc vent ducting, allowing arc venting from each internally segregated area in the switchgear. This arc vent ducting can be taken away from the switchgear and away from the substation area by means of external ducting.

The MV-Flex Integrated arc ducting opens at the extremity of the switchgear, allowing easy interface of external with external arc ducting. This allows the end user to easily exhaust any potential arc gases through the rear wall of the substation or away from sensitive underground areas allowing the exhausting of any potentially hazardous arc products away from areas where personnel or equipment can be endangered.

The exhaust outlet of the ducting should have a suitable gravity held flapper to allow easy venting but so designed as to prevent ingress of vermin and birds etc. into the ducting during normal operation. Suitable safety signage is to be installed at the arc vent points outside the substation building.

3.4 **PANEL LABELLING** AND MARKINGS

Each panel is provided with screw fixed, traffolite marking and labels (in English or preferred language) for circuit designation. Such circuit designation is provided at the front top of the panel, rear top of the panel and from the bottom cable pit access to the panel.

Each panel component is provided with clear and concise component labelling to IEC standards and where possible, to IEC number symbol codes. These match and correspond to numbering in the drawings.

All terminal rails have a terminal rail number, and all terminals have terminal numbers. These justify and correspond to numbering in the drawings. All wire markers have sleeve type wire marking at all termination points.

The remote termination for signal and control have terminals divided per panel and per circuit type and clearly indicating the terminal groupings for CT and VT signals, inputs and output form the panel.

3.5 **ANTI-CONDENSATION** HEATERS

The MV-Flex switchgear can be supplied with anti-condensation heaters in areas with high humidity to prevent condensation build up inside the equipment. The heaters are strategically installed in the circuit breaker and cable side cubicles of the switchgear. Heaters can be switched on or off via local control circuit breakers in the control cubicle.

The standard anti-condensation heaters are rated at 150 W, 220 VAC, and are supplied by means of an auxiliary AC supply. Other alternatives are available on request.

3.6 **WIRING TERMINALS** AND LUGS.

As a standard the MV-Flex uses a specific range of terminals, each specific to the requirements of the different circuits in the control cubicle.

- All CT circuits are terminated using spring loaded 4.0mm² terminals and hook lugs to prevent accidental discontinuity of CT circuits.
- All control wiring is terminated and secured using 2.5 mm² screw clamp terminals with blade lugs to ensure connectivity and trip functionality.
- Disconnect terminals are installed for ease of maintenance and protection testing.
- Screw clamp earth terminals are utilised throughout to ensure key earth connections and bonding.

3.7 **PANEL WIRING AND** COLOUR CODING.

The panel wiring follows the IEC convention for panel wiring and colour coding.
The following basic notes apply:

- Current Transformer circuits are wired with 2.5 mm² Conductor, colour coded Red, White, Blue and Black.
- Voltage Transformer circuits are wired with 1.5 mm² conductor, colour coded Red, White, Blue and Black.
- All auxiliary wiring is provided with grey panel wire conductor of at least 1.5 mm², unless otherwise required.
- All 110 V DC Bus wiring is provided with grey panel wire conductor of at least 2.5 mm², unless otherwise required.



Figure 8: Typical Control Wire Layout of MV-Flex

4. **GENERAL** SPECIFICATIONS

Table 9: Standard MV-Flex Specifications

Specification	Rating
Busbar Arrangement	Single bus bar system
Configurations	Incomer/Feeder Circuit breakers
Delivery Version	Complete Panels
Standard	IEC 62271
Packing	Road-freight wooden case
FAT	Standard inspection, functional testing
Altitude of installation m	Less than 1000 m

4.1 **PRIMARY ELECTRICAL** PARAMETERS

Table 10: Standard Electrical Parameters

Parameter	Rating
Rated voltage	17.5 kV
Service voltage	Up to 15 kV
Rated frequency	50 Hz
Power frequency withstand voltage (altitude <= 1000 m) BIL	28 kV rms
(1.2/50 us. wave)	95 kV peak
BIL (derated) at altitude <= 1000 m	75 kV peak
Short time withstand current	31.5 kA rms / 3 s
Peak withstand current	63 kA peak
Internal arc withstand current	25 kA rms / 1 s
Bus bar rated current	1250 A
Electromagnetic compatibility	Conforming to IEC62271-1

4.2 **MECHANICAL** PARAMETERS

Table 11: Mechanical Parameters

Parameter	Rating
Protection degree outer cover (IEC 60529)	IP4X
Protection degree inner partitions (IEC 60529)	IP20
Ambient temperature (IEC 60694)	-5 ˚C to +45 ˚C
Tropicalisation	EC 60068-2-30, IEC 60721-2-1
Painting colour	RAL 7023
Painting treatment	Powder Coated as standard
Floor fixing	Expansion bolts
Anti-condensation heaters	Yes (if required due to environmental conditions)

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