DESCRIPTIVE BULLETIN

Innovations in medium voltage switchgear

Solutions for the latest demanding requirements

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Innovations in MV switchgear
Overview

Digital switchgear, condition monitoring and advanced fault current protection are some of the innovations in medium voltage switchgear that can help achieve higher availability, increase safety, and reduce operational costs.

Digital switchgear
Digital switchgear offers many operational advantages and is an inherently safer design. When several new technologies are combined, the advantages of digital switchgear include:

- Increased safety
- Smaller footprint
- Reduced weight
- Energy savings
- Ability to easily handle last minute load changes
- Quicker delivery times

Condition monitoring
New sensor technology, intelligent circuit breakers and software are expanding the reach of asset health monitoring and reducing the total cost of ownership (TCO).

Flexible deployment options also allow a phased-in approach on existing ABB or non-ABB equipment.

Advanced fault current protection
The goal is always to take active measures to prevent an arc fault event from happening. Today's intelligent technologies like the Ultra-Fast Earthing Switch (UFES) immediately mitigate the effects of internal arc faults and raise safety standards to a whole new level.

The rising demand for energy requires larger or additional transformers and generators with increasing interconnection of individual supply-side networks. In comparison to conventional solutions, the I_s-limiter offers, both technical and economic advantages for solving short-circuit problems.

Digital medium voltage switchgear

Current and voltage sensors are key components

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01 Sensor-based technology is helping to enable the evolution of digital switchgear

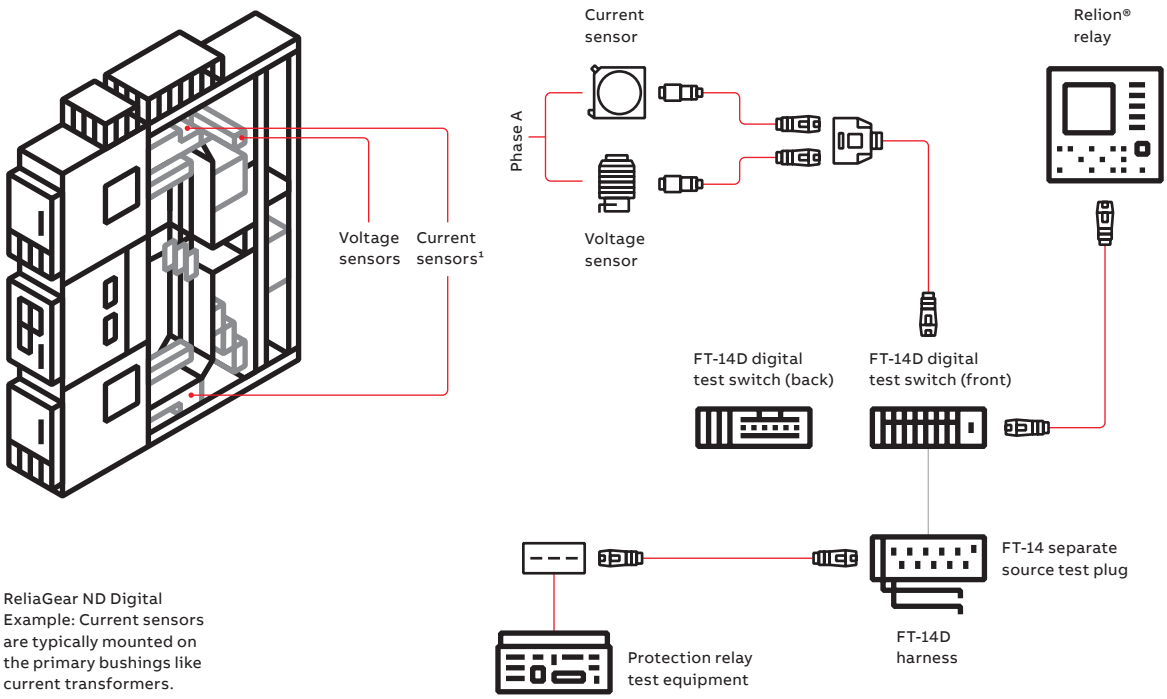
The transition to digital switchgear involves the optimized integration of sensors for current, voltage and asset health combined with advanced protection devices and efficient use of a common communication Ethernet bus with IEC 61850.

Current sensors
The current sensor is based on the principle of the Rogowski coil. The Rogowski coil sensor outputs voltage (Us = 180mV@60Hz) rather than current. This eliminates the open CT hazard. Output is proportional to the derivative of the primary current. The behavior of the sensor is not influenced by a magnetizing curve which results in a highly accurate and linear response across a wide dynamic range of measured quantities.

Varying loads can be accomodated without changing the current sensors unlike traditional CTs. Accuracy is up to class 0.5.

Voltage sensors
The voltage sensor uses the principle of a resistive voltage divider, is non-inductive and has no ferroresonance. The voltage sensor is typically 10,000:1 transformation ratio. No protective fuses are required. Accuracy is up to class 0.5.

Commissioning and testing
With digital test switches such as the FT-14D Digital Flexitest™ Switch, the testing process is the same but with added safety provided by the sensors.



ReliaGear ND Digital Example: Current sensors are typically mounted on the primary bushings like current transformers.

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01

Why digitize medium voltage switchgear?
Direct benefits

Cost-efficient
Complete PT compartments can be eliminated resulting in a smaller footprint without any loss in functionality. The reduced space requirements can lower switchgear housing costs and reduced weight can lower freight costs.

Safe and reliable
There are fewer wires to install, commission and maintain. Ethernet connectors replace many wire terminal lugs. There are fewer failure opportunities and improved safety with fewer live parts. There is no access to dangerous CT secondary signals.

Simple and accurate
The sensors have a wide and linear range. Current sensors do not saturate and varying loads can be accomodated without changing CTs (conventional switchgear).

Relion® relays monitor the sensors and provide error detection for troubleshooting. Compared to traditional instrument transformers, digital switchgear has reduced wattage loss because there are no core losses with sensors. The result is less energy is required to operate the switchgear.

Facilitate late design changes
Sensors facilitate late design changes such as changing loads within the same frame.

Specification	Conventional	Digital
Width (inches)	234	208
Estimated weight (lbs)	29,100	25,182
Wiring (feet)	~2,500	289
# of wire terminations	910	76
Manufacturing hours	135	24
# of shipping splits	3	2

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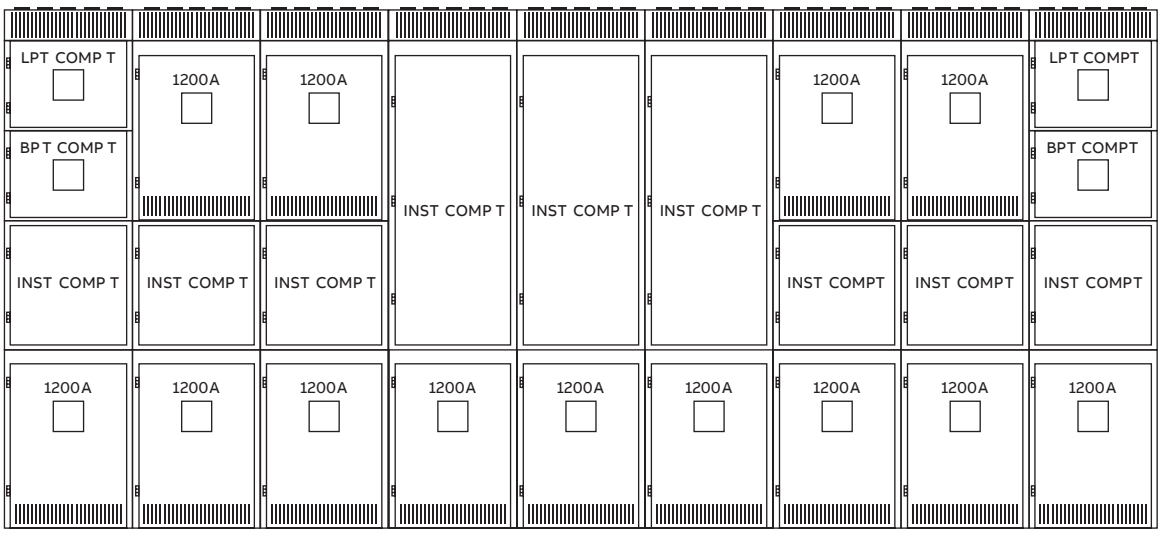
02a & 2b Comparison of like conventional switchgear (top) and digital switchgear (bottom)



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02a

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02a & 2b Comparison of like conventional switchgear (top) and digital switchgear (bottom)

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03 Typical breaker cell of conventional switchgear

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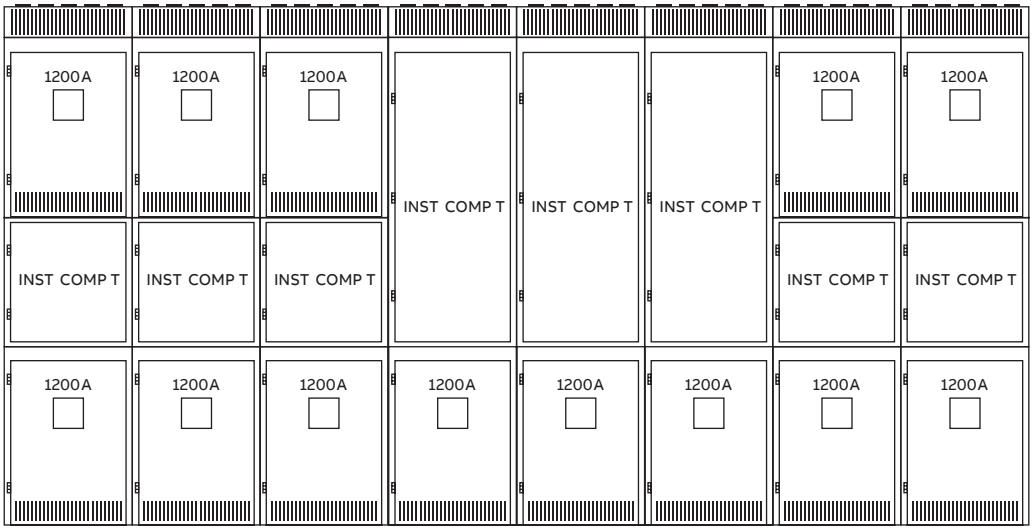
04 Corresponding breaker cell of digital switchgear



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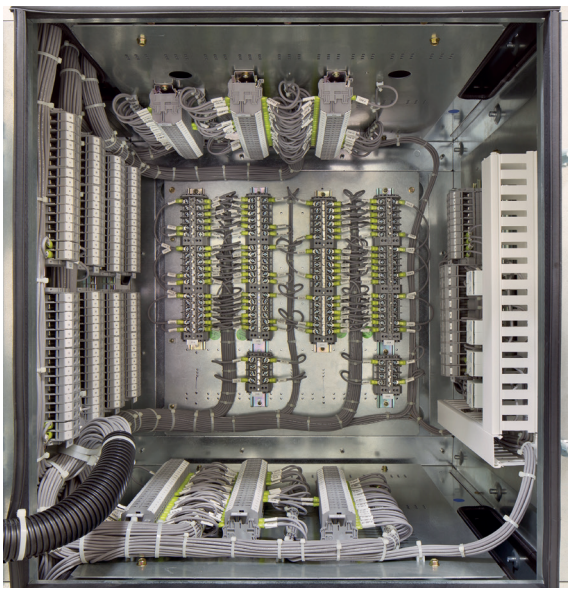

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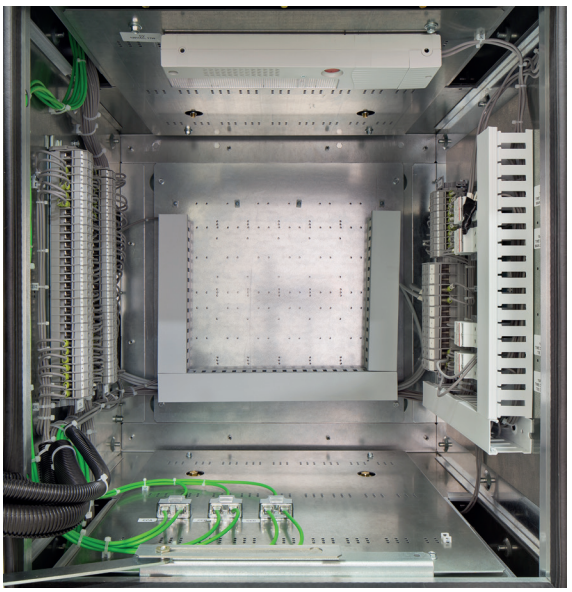

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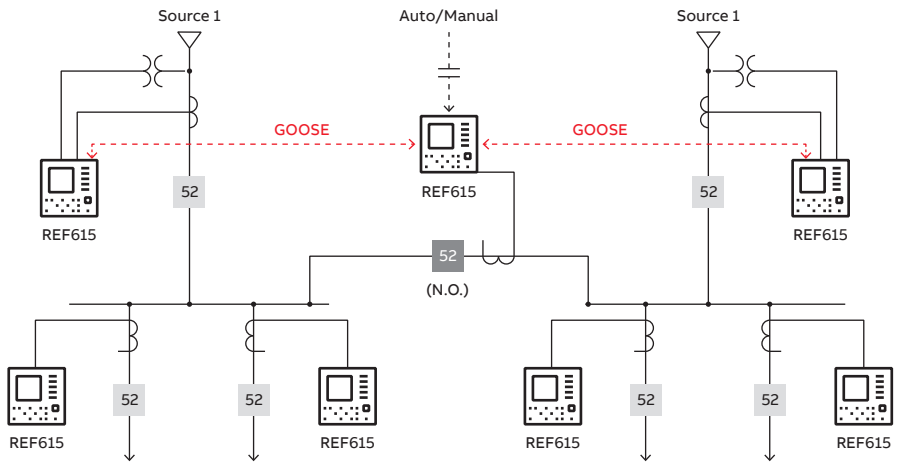
05 Single-line diagram to illustrate GOOSE messaging in automatic bus transfer schemes



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Standardized communication and redundancy
The Relion family of relays fully supports the IEC 61850 standards for communication and interoperability of substation automation devices.

The relays further support both parallel redundancy protocol (PRP) and the high-availability seamless redundancy (HSR) protocol. Both protocols are capable of overcoming a failure of a link or switch with near-zero switchover time.

Automatic transfer schemes (ATS)
The system can benefit from Generic Object Oriented Substation Event (GOOSE) messaging to enable the implementation of cost effective ATS. The Relion solution has an REF615 on each main providing current and voltage protection, breaker controls and the ATS. The tie relay is programmed to execute the ATS and sync-check functions. Integrators and Original Equipment

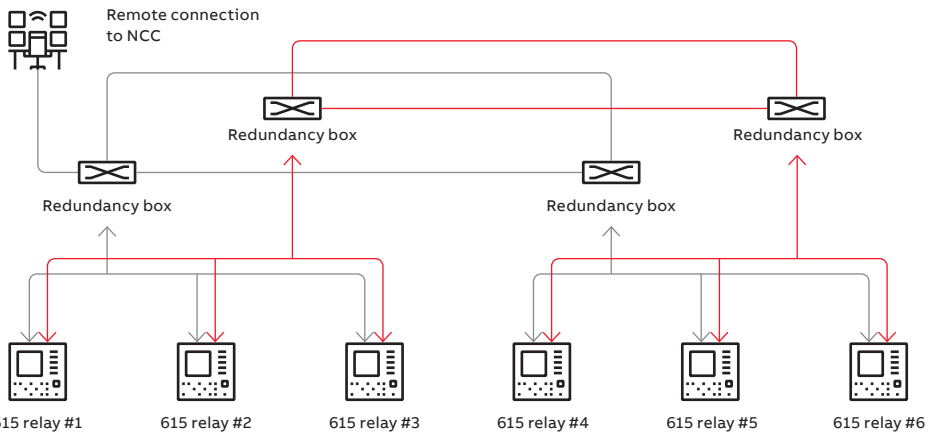
Manufacturers (OEMs) now have the flexibility of making functional changes much later in the production cycle.

ABB freely publishes documentation and relay configuration files for the following ATS:
- MTM closed transition
- MTM open transition
- MTM good line seeking
- MTM universal
- MM preferred source closed transition
- MM preferred source open transition
- MM preferred source universal
- MTTM closed transition
- MTTM good line seeking
- MTTM universal
- MG closed transition
- MG open transition

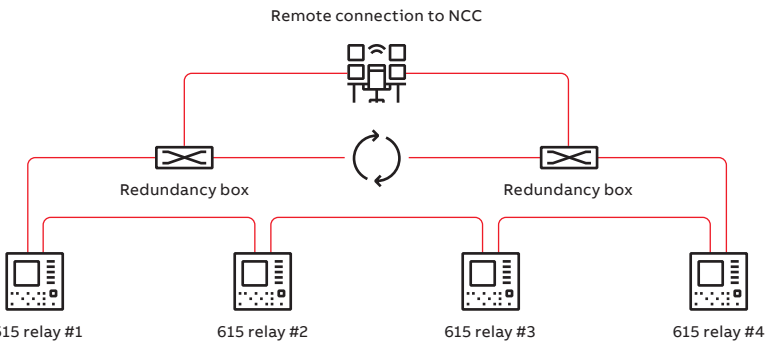
Sampled values (SV)
Complimenting GOOSE, SV is a protocol for acquiring digitized samples of analog information - typically from instrument transformers. According to IEC 61850-9-2 LE, an SV packet will contain eight instantaneous values (3 phase current + 1 ground current and 3 phase voltage + 1 ground voltage) at a programmable sampling rate.

The REF615 relay can not only send sampled values to the process bus, it can also receive sampled values of voltages. This allows a networked feeder relay shown above to measure power even though it's only connected to a current transformer.

The sampled values can also be used for sync-check purposes or be integrated with the SSC600, ABB's centralized automation, protection and control system.



06 PRP has two redundant standard Ethernet networks (dual LAN)



07 HSR uses a ring topology for a redundant LAN

Relion protection and control relay ANSI portfolio

Selection table	ANSI Code	REF601	REJ601	REM601	RED615*	REF615*	REF615R	REG615	REM615*	RET615	REF620	REM620	RET620	REX640*	SSC600*	SMU615*
Application																
Arc fault protection						○	○	○	○	○	○	○	○	○	○	○
Busbar						●								○	●	
Back-up		●	●			●	●				●			●	●	
Capacitor bank														○		
Feeder		●	●		●	●	●				●			●	○	
Generator								●						○		
Motor				●					●			●		○	○	
Petersen coil control														○	○	
Transformer					●					●			●	○	○	
Line differential					●											
Functionality																
Autorecloser	79	●			●		●				●			●	●	
Circuit breaker control	52	●		●	●	●	●	●	●	●	●	●	●	●	●	
Condition monitoring	CM	●		●	●	●	●	●	●	●	●	●	●	●	●	●
Current-based protection	50, 67	50	50	50	●	●	●	●	●	●	●	●	●	●	●	

Selection table	ANSI Code	REF601	REJ601	REM601	RED615*	REF615*	REF615R	REG615	REM615*	RET615	REF620	REM620	RET620	REX640*	SSC600*	SMU615*
Distance protection	21P, 21N													○	○	
Disturbance recording	DFR				●	●	●	●	●	●	●	●	●	●	●	
Fault locator	FLOC				●		●							○	○	
Frequency protection	81				○			●						●	●	
Generator differential protection	87G							●							○	
High impedance restricted earth-fault protection	87NHI														●	
Display with single-line diagram					●	●	●	●	●	●	●	●	●	○		
Line differential protection (in-zone xfmr support)	87L				●									○		
Load-shedding	81LSH					●	●		●	●	●	●	●	●	○	
Motor differential protection	87M											●		○		
On-load tap changer control	90V													○	○	
Power quality	PQ				●	●	●	●						●	○	
Self-powered protection relay (available in IEC)																
Syncro-check	25				○	●	●	●			●			●	○	
Gen/non-gen CB synchronizing (25AUTOSYNCG)	25													○		
Transformer differential protection	87T				●					●			●	○	○	
Voltage-based protection	27, 59				●	●	●	●	●	●	●	●	●	●	●	
Withdrawable release mechanism					●	●	●	●	●	●	●	●	●			●
Hardware																
Analog inputs (CT/VT)		4/0	4/0	4/0	4/5	7/6	4/5	7/5	7/4	7/6	7/8	7/4	10/4	12/10		4/3
Analog inputs (current sensor, voltage sensor, CT)		3/0/1	3/0/1	3/0/1	3/3/1	3/3/1	3/3/1		3/3/1					6/6/2		3/3/1
Binary inputs/outputs		4/6	4/6	4/6	16/10	18/13	11/7	16/10	18/13	14/13	32/18	14/13	16/17	56/42		8/9
RTD/mA inputs					2/1			2/1	6/2	2/1		14/5	2/1	20/4		
mA outputs														4		
Objects (controlled/monitored)																
Circuit breaker		1/0		1/0	1/0	2/0	1/1	1/0	1/0	1/0	2/2	1/1	2/2	3/0		1/1
Disconnector, 3 states (DC)														6/6		
Disconnector (DC)					2/3	2/2		2/2	2/2	2/2				8/8		2/2
Earthing switch (ES)					2/2	1/2		1/2	1/2	1/2				3/3		1/1
Communication protocols																
DNP 3.0					●	●	●	●	●	●	●	●	●	●	●	●
IEC 61850 Ed. 1					●	●	●	●	●	●	●	●	●	●	●	●
IEC 61850 Ed. 2 (including sampled values)					●	●	●	●	●	●				●		●
Modbus		●	●	●	●	●	●	●	●	●	●	●	●	●		
Profibus						○				○	○	○		○		
Communication media																
Ethernet (RJ-45)					●	●	●	●	●	●	●	●	●	●	●	●
Ethernet (LC)					●	●	●	●	●	●	●	●	●	●	○	○
Ethernet redundant solutions (HSR/PRP)					●	●	●	●	●	●	●	●	●	●	●	○
Front communication					RJ45	RJ45	RJ45	RJ45	RJ45	RJ45	RJ45	RJ45	RJ45	RJ45		RJ45
Serial (RS 232/485, ST connector)		●	●	●		○		○	○	○				○		

● Function supported
○ Function supported as option
⋆ Support current and voltage sensor connections

Condition monitoring

Adding value by reducing total cost of ownership

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08 Surface Acoustic Wave (SAW) sensor

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09 Example condition monitoring screens for switchgear lineup (left) and individual breaker (right)

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10 Infrared (IR) sensor

Asset health monitoring
Monitoring of critical assets provides end users with peace of mind that the equipment will perform as required, when required. Digital switchgear can facilitate condition-based maintenance, the best approach to electrification management by monitoring variables such as:

- Trip/close coil health
- Breaker timing
- Contact wear
- Bolted joint temperatures
- Internal humidity
- Partial discharge activity

Monitoring can be an on-premises software solution or more localized with touchscreen HMIs mounted to the switchgear. The system can be scaled to the cloud and leverage the internet of things, services and people (IoTSP) infrastructure where data can be converted to actionable intelligence.

SwitchgearMD™ temperature and partial discharge monitoring is available on low voltage, medium voltage and motor control center (MCC) products with the following sensor packages:

- Wireless for temperature and partial discharge monitoring (SAW sensors and UHF measurements)
- Wired for temperature monitoring (IR sensors)
- Wired for humidity monitoring

Surface Acoustic Wave (SAW) sensing system

- SAW sensors are wireless passive components directly coupled to conductors
- No battery or power source required
- Equipped with quartz (piezoelectric) material that contracts/expands when subjected to change in temperature

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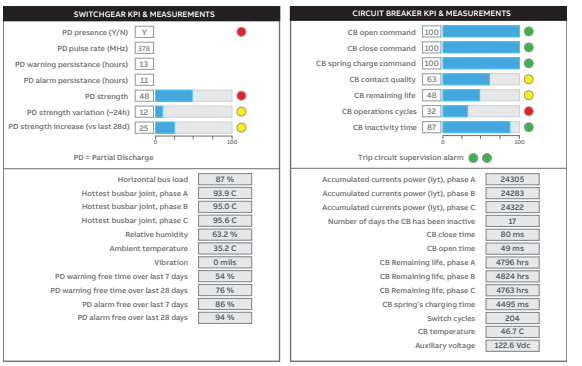
Partial discharge (PD) monitoring

- UHF (300 MHz to 3 GHz) measurements
- Detects extent of PD activity above a set threshold

IR: Infrared temperature sensing system

- IR sensors have a non-conductive plastic body
- Sensors do not require external power
- Sensors provide rise over ambient reading
- Sensors have lifetime calibration



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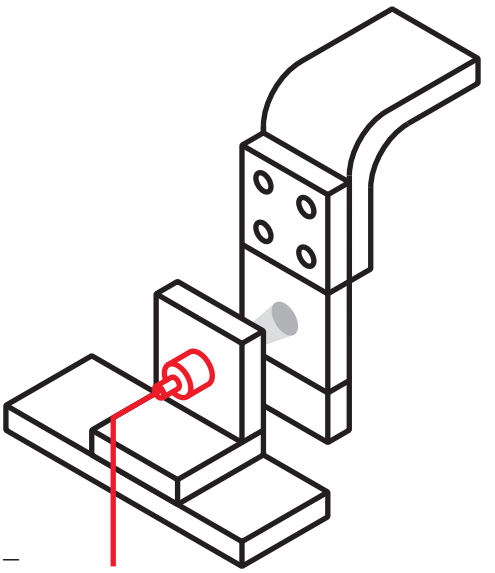

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— 11 Ultra-fast earthing switch and REA relay

— 12 I_s-limiter

Arc flash mitigation

The Ultra-Fast Earthing Switch (UFES) provides innovative arc fault protection, offering the highest possible level of safety for personnel and equipment, the maintenance of secure power supply and the reduction of production outages.

- Arc fault extinction in less than 4 ms
- Arc detection by means of optical sensors and current measurement
- Available for switchgear ratings up to 40.5 kV and 100 kA
- Easy integration into new and existing low and medium voltage systems
- Combinable with different arc protecting devices, including light detection relay and I_s-limiter

Fault current mitigation

The world's fastest current limiting and switching device rated up to 40 kV, the I_s-limiter is capable of detecting and limiting a short-circuit current during the first current rise, i.e., in less than a millisecond. It can be applied in early system design stages or to increase ratings in existing systems thereby reducing capital costs and improving system functionality.

One of many uses is shown in Figure 12. Switchgear dimensioned for 2 x Ik can be used on a system with total short circuit current of 4 x Ik and without losses.

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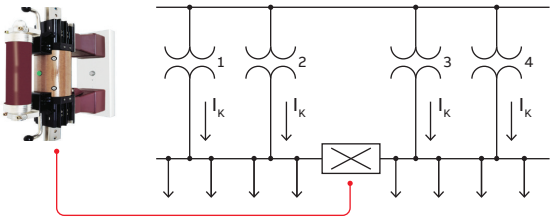

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Medium voltage ANSI metal-clad air insulated switchgear

Feature	Advance®	Advance® 27	ReliaGear® ND	SafeGear®	SafeGear® HD
Maximum voltage - 15kV	•		•	•	•
Maximum voltage - 28.5kV		•			
Maximum short circuit - 31.5kA			•		
Maximum short circuit - 50kA	•			•	
Maximum short circuit - 63kA					•
UL labeled	•	•	•	•	•
CSA/cUL labeled	•			•	•
Arc-resistant type 2, 2B				•	•
Arc-resistant type 2C, 2BC				•	
Reduced width (26")			•		
AMVAC breaker (magnetic)	•	•		•	
ADVAC breaker (spring)	•			•	•
Vmax/A breaker			•		
Outdoor non-walk-in	•	•	•		
Outdoor sheltered aisle	•	•	•	•	•
PDC (Power Distribution Center)	•	•	•	•	•

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Cary, NC 27511 USA
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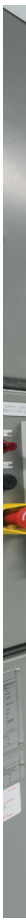
abb.com/mediumvoltage



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