DESCRIPTIVE BULLETIN

SafeGear®

5/15 kV, up to 50 kA arc-resistant switchgear

SafeGear® meets today’s challenge for improved safety and lower maintenance costs

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Medium voltage SafeGear®
Values and benefits

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SafeGear arc-resistant switchgear is available in Accessibility Types 2, 2B, and 2BC, in accordance with IEEE C37.20.7. The short circuit current duration is 0.5s, the preferred rating as per IEEEC37.20.7. Offering three different accessibility types for arc-resistant solutions brings high value to customers by offering a greater level of flexibility in the marketplace. This differentiates ABB from competitors who typically test to a single type of arc-resistant construction.

ABB provides solutions for both passive and active arc flash mitigation. SafeGear is a passive arc-resistant design. SafeGear, coupled with the REA101 arc detection relay and UFES, offers additional arc flash protection. Using arc detection through a fiber loop, coupled with overcurrent, to sense and extinguish an arcing event before it propagates, leads to increased personnel safety and lower downtimes.

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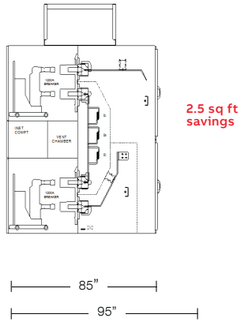
The 0.5s rating is available for service voltages of 5 through 15 kV and all continuous current ratings and fault current ratings for 50 kA and below. Arc-resistant accessibility for both Type 2 and Type 2B applications is applicable and remains unchanged for the SafeGear® configurations previously offered. The continued development of the SafeGear product line now enables two sets of PTs to be installed in a 38-inch compartment, reducing the number of frames needed, resulting in an overall smaller footprint. When only one set of PTs is required, the smaller 19-inch design allows the low voltage compartment to double in size.

SafeGear arc-resistant switchgear is available in standard depths of 85 and 92 inches, providing the smallest overall footprint in the industry. This smaller footprint results in lower project costs through reduced building and land costs.



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SafeGear®
Overview

SafeGear® meets today’s challenge for improved safety and lower maintenance costs

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01 Conventional switchgear 50 kA interruption at KEMA test lab
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02 Arc-resistant switchgear 50 kA interruption at KEMA test lab

No electrical system is foolproof. There’s always a chance that insulation system deterioration, equipment malfunction or human error will result in an arc fault, with potentially catastrophic consequences.

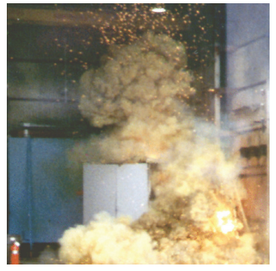
When an arc fault occurs in conventional switchgear, the heat of the arc (30,000° C), can melt and even vaporize, compartment materials and components. Flames and hot gases escape and ignite nearby materials. As air temperature increases in the enclosed space, so does the pressure. The rapid pressure build-up is explosive, hurling objects such as doors, panels, and components.

Disastrous arc faults cost managers of large-power installations hundreds of thousands of dollars in lost equipment and downtime, as well as needless deaths and injuries. The images below illustrate the consequences of an arc fault in conventional switchgear and the advantages of using SafeGear arc-resistant switchgear.

SafeGear not only meets conventional standards for metal clad switchgear, it goes beyond ANSI standards to provide the protection of arc-resistant construction. During an arc fault, expanding hot gases are carefully routed through a system of vents and flaps, generally through the roof and away from personnel at the front, rear or sides of the switchgear. Doors and panels are reinforced and sealed to withstand the temporary pressure surge until relief vents and flaps operate. Using techniques such as double sidewall and type 2/2B/2C or 2BC construction, damage is contained in the compartment of fault origination, rather than spreading to adjacent compartments. Equipment damage is greatly reduced, other circuits can often stay on line, and tragic injuries to employees are prevented.

SafeGear arc-resistant construction is design tested under actual arc-fault conditions and in conformance to IEEE C37.20.7 standard to verify:

- Cotton fabric test panels near the front, rear and sides and in the LV compartment or the adjacent do not ignite
- Doors and panels remain secure, except for minor distortion
- Components and molten materials are not ejected from the switchgear
- The arc does not burn through to the LV compartment (type 2B)
- The arc does not burn through to adjacent compartments (type 2C and type 2BC)
- Ground connections remain intact



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SafeGear ratings*

		Rated maximum voltage level		
Characteristic	Unit	5 kV	**8.25 kV**	**15 kV**
Rated nominal voltages	kV	2.4, 4.16, 4.8	4.8, 6.9, 7.2	6.9, 7.2, 8.4, 11, 12, 12.47, 13.2, 13.8, 14.4
Main bus continuous current	A		1200, 2000, 3000, 4000**	
Short term current (rms)	kA		25, 31.5, 40, 50	
Rated frequency	Hz		50, 60	
Low frequency withstand (rms)	kV	19	36	36
Impulse level (BIL,crest)	kV	60	95	95

* Ratings given are for service conditions within temperature and altitude limitations as defined by IEEE C37.20.2 metal-clad switchgear standard. All equipment is available with UL and CSA with type 2 or 2b construction
** 4000 A is forced-air cooled.

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01 Plenum interior

A system of chambers and tunnels inside the switchgear lineup serves as an exhaust system, venting gases in the case of an arc fault away from personnel and the affected compartment. Vents and flaps are located inside the chamber system and on top of the enclosure to release the pressure. ABB pioneered this design and holds patents on the construction details of this truly innovative con-

1. Each primary compartment – breakers, auxiliary transformers, main bus, and primary cable entrances – are designed with internal hinged flaps or vents to allow over-pressure and hot gases to escape in a carefully controlled manner through roof mounted plenum exhaust ducts – away from nearby personnel at the front, rear or sides of the switchgear.

2. Roof-mounted hinged flaps are engineered to open quickly as pressure increases in an arc fault condition.

3. Stationary primary contacts accept self-aligning tulip disconnects mounted on the breaker.

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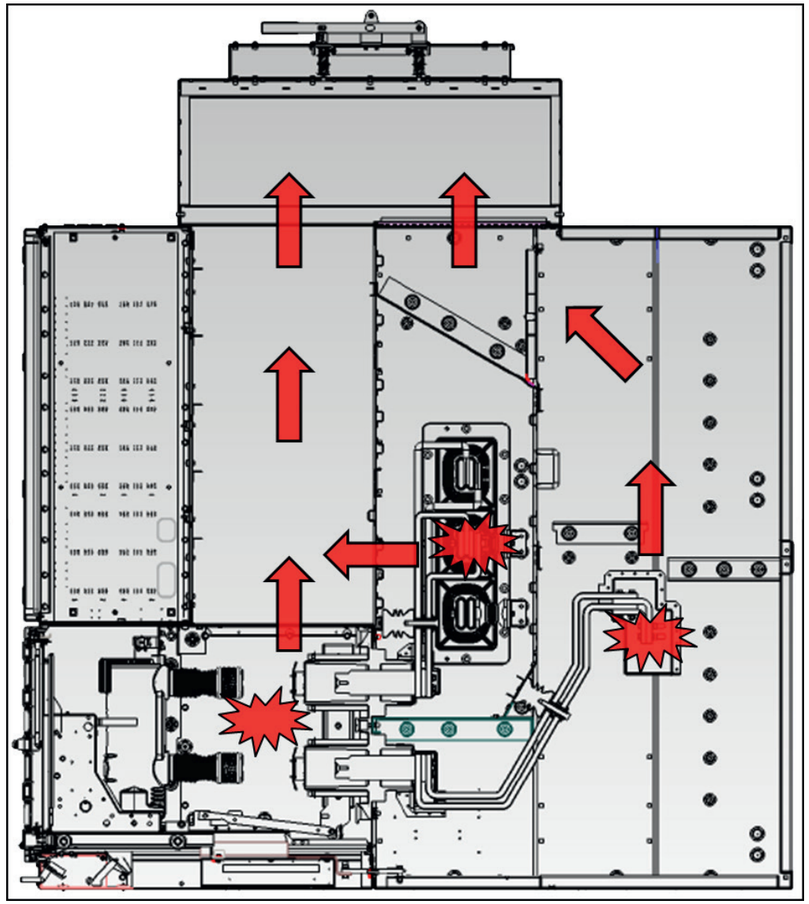
01 Venting flaps and chimneys release excessive pressure during an arc event. Front, side and rear structures maintain their integrity.



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1. Dedicated instrument compartments isolate low voltage circuits and instrumentation from compartments with primary circuits.

2. Doors on breaker, PT and CPT compartments are reinforced with channel steel. Special hinges and multiple-point latches add to compartment security, preventing flames from escaping and igniting nearby materials in arc fault conditions.

3. Double sidewall construction provides superior resistance to burn-through. A small air gap between compartments enables heat dissipation from an arc that would otherwise burn through equivalent single wall thickness.

4. Breaker compartment doors have large windows that enable viewing of breaker status indicators, including open/closed flags, spring charged status, and the operations counter. The windows can be omitted for customers who prefer solid steel door construction.

5. All front doors have a multi-point latch to facilitate operations and ensure integrity of the arc-resistant rating.

6. Closed-door racking capability maintains the integrity of arc-resistant construction by allowing the breaker to be inserted or withdrawn while the arc-resistant compartment door remains closed.

7. Arc resistance and closed-door racking significantly reduces operator risk during the handling and operation of the equipment. Installation, maintenance and operations personnel recognize the sturdiness and benefit of the design. Insurance companies recognize the reduced operational risk with lower contract rates. Owners realize the gain from reduced loss of revenue due to improved reliability of the power system.

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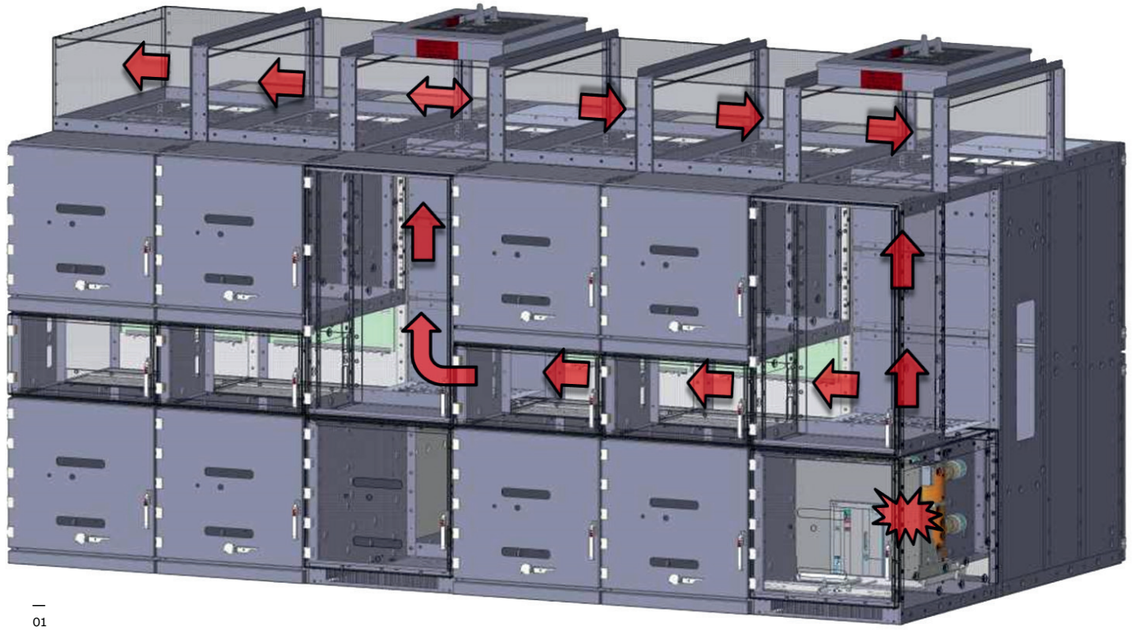
01 Venting chamber system allows arc-resistant construction with two-high arrangements for safe and compact power distribution equipment.



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ADVAC® breakers

General overview

The ADVAC® breaker is a spring mechanism breaker with modular, easy to maintain design. Fully compliant with IEEE Standards C37.04, C37.06 and C37.09, the ADVAC breaker is a great fit for many applications.

Features

- Mechanical operations counter
- Open, closed, ready/not ready lights and push-buttons
- Mechanical anti-pump
- Back-to-back C2 cap switch ratings
- 3-cycle operation

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Available ADVAC breaker ratings

Voltage class	Nominal voltages	Continuous current	Short circuit/ withstand (2 sec)	Close and latch	BIL (lightning impulse withstand)	Power frequency withstand (Hi-Pot)
kV	kV	A	kA, rms	kA, peak	kV, crest	kV, rms
5	2.4, 4.16, 4.8	1200, 2000, 3000	25	65	60	19
			31.5	82		
			40	104		
			50	130		
8.25	4.8, 6.9, 7.2	1200, 2000, 3000	40	104	95	36
15	6.9, 7.2, 8.4, 11, 12, 12.47, 13.2, 13.8, 14.4	1200, 2000, 3000	25	65	95	36
			31.5	82		
			40	104		
			50	130		

ADVAC® G40 breaker

General overview

The ADVAC® G40 vacuum generator circuit breaker is available at 15 kV, 4000 A, 40 kA in compliance with IEEE/IEC 62271-37-013. The withdrawable ADVAC G40 offers a small footprint and full protection for power generation applications.

Features

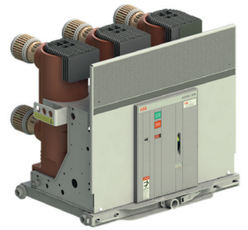
- Suitable for demanding conditions, including out-of-phase condition and island mode
- Safety enhanced, tested solution for DC-component up to 130%; no need to add time delay
- Optimum interface with different ratings available
- Available as a UL listed product

Technical characteristics ADVAC® G40

System-source short-circuit breaking current Isc	kA	40							
Rated voltage Ur	kV	5				15			
Enclosure		Advance and SafeGear				Advance and SafeGear			
Rated current Ir	A	1200	2000	3000	4000*	1200	2000	3000	4000*
Generator-source short breaking current Iscg [kA] @ 110% DC (Class G1)	kA	25	25	25	25	25	25	25	25
Generator-source short circuit breaking current Iscg [kA] @ 130% DC (Class G2)	kA	25	25	25	25	25	25	25	25
90° Out-of-phase Making and Breaking Current Id	kA	20	20	20	20	20	20	20	20
Short-time withstand current Ik	kA	40	40	40	40	40	40	40	40
Duration of short circuit tk	s	2	2	2	2	2	2	2	2
Peak withstand current Ip	kA	115	115	115	115	115	115	115	115
Lightning impulse withstand voltage Up	kV	60	60	60	60	95	95	95	95
Power frequency withstand voltage Ud	kV	20	20	20	20	38	38	38	38
System-source fault prospective TRV									
Peak Uc	kV	9.2	9.2	9.2	9.2	27.6	27.6	27.6	27.6
RRRV	kV/µs	1.17	1.17	1.17	1.17	3.5	3.5	3.5	3.5
Rise time t3	µs	2.65	2.65	2.65	2.65	7.95	7.95	7.95	7.95
Time delay td	µs	1	1	1	1	1	1	1	1
Generator-Source fault prospective TRV									
Peak Uc	kV	9.2	9.2	9.2	9.2	27.6	27.6	27.6	27.6
RRRV	kV/µs	0.53	0.53	0.53	0.53	1.6	1.6	1.6	1.6
Rise time t3	µs	5.75	5.75	5.75	5.75	17.25	17.25	17.25	17.25
Time delay td	µs	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Out-of-phase fault prospective TRV									
Prospective TRV - Peak Uc	kV	13	13	13	13	39	39	39	39
Prospective TRV - RRRV	kV/µs	1.1	1.1	1.1	1.1	3.3	3.3	3.3	3.3
Rise time t3	µs	3.95	3.95	3.95	3.95	11.85	11.85	11.85	11.85
Time delay td	µs	1	1	1	1	1	1	1	1
Closing time [ms]	ms	50-80	50-80	50-80	50-80	50-80	50-80	50-80	50-80
Opening time [ms]	ms	30-50	30-50	30-50	30-50	30-50	30-50	30-50	30-50
Contact resistance	µΩ	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15
Mechanical endurance class		M2	M2	M2	M2	M2	M2	M2	M2
Standard operating sequence		CO - 30 min - CO							

ADVAC® G50 breaker

General overview



The ADVAC® G50 vacuum generator circuit breaker is available at 15 kV, 4000 A, 50 kA in compliance with IEEE/IEC 62271-37-013. The withdrawable ADVAC G50 offers a small footprint and full protection for power generation applications.

Features

- Suitable for demanding conditions, including out-of-phase condition and island mode
- Safety enhanced, tested solution for DC-component up to 130%; no need to add time delay
- Optimum interface with different ratings available

Technical characteristics ADVAC® G50

System-source short-circuit breaking current Isc	kA	50							
Rated voltage Ur	kV	5				15			
Rated current Ir	A	1200	2000	3000	4000*	1200	2000	3000	4000*
Generator-Source short breaking current Iscg [kA] @ 110% DC (Class G1)	kA	50	50	50	50	50	50	50	50
Generator-Source short circuit breaking current Iscg [kA] @ 130% DC (Class G2)	kA	37	37	37	37	37	37	37	37
90° Out-of-phase Making and Breaking Current Id	kA	25	25	25	25	25	25	25	25
Short-time withstand current Ik	kA	50	50	50	50	50	50	50	50
Duration of short circuit tk	s	2	2	2	2	2	2	2	2
Peak withstand current Ip	kA	137	137	137	137	137	137	137	137
Lightning impulse withstand voltage Up	kV	60	60	60	60	95	95	95	95
Power frequency withstand voltage Ud	kV	20	20	20	20	38	38	38	38
System-source fault prospective TRV									
Peak Uc	kV	9.2	9.2	9.2	9.2	27.6	27.6	27.6	27.6
RRRV	kV/µs	1.17	1.17	1.17	1.17	3.5	3.5	3.5	3.5
Rise time t3	µs	2.65	2.65	2.65	2.65	7.95	7.95	7.95	7.95
Time delay td	µs	1	1	1	1	1	1	1	1
Generator-Source fault prospective TRV									
Peak Uc	kV	9.2	9.2	9.2	9.2	27.6	27.6	27.6	27.6
RRRV	kV/µs	0.53	0.53	0.53	0.53	1.6	1.6	1.6	1.6
Rise time t3	µs	5.75	5.75	5.75	5.75	17.25	17.25	17.25	17.25
Time delay td	µs	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Out-of-phase fault prospective TRV									
Prospective TRV - Peak Uc	kV	13	13	13	13	39	39	39	39
Prospective TRV - RRRV	kV/µs	1.1	1.1	1.1	1.1	3.3	3.3	3.3	3.3
Rise time t3	µs	3.95	3.95	3.95	3.95	11.85	11.85	11.85	11.85
Time delay td	µs	1	1	1	1	1	1	1	1
Closing time [ms]	ms	50-80	50-80	50-80	50-80	50-80	50-80	50-80	50-80
Opening time [ms]	ms	30-50	30-50	30-50	30-50	30-50	30-50	30-50	30-50
Contact resistance	µΩ	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15	11 - 15
Mechanical endurance class		M2	M2	M2	M2	M2	M2	M2	M2
Standard operating sequence		CO - 30 min - CO							

AMVAC™ breakers
General overview

The AMVAC™ breaker is a magnetically actuated and latched breaker capable of a high number of operations due to its simplified design. Fully compliant with IEEE Standards C37.04, C37.06 and C37.09, the AMVAC breaker is a great fit hen maintenance is a key concern.

Features
- Mechanical operations counter
- Optional roll-on-floor design
- Open, closed, ready/not ready lights and push-buttons

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Available AMVAC breaker ratings

Voltage class	Nominal voltages	Continuous current	Short circuit/ withstand (2 sec)	Close and latch	BIL (lightning impulse withstand)	Power frequency withstand (Hi-Pot)
kV	kV	A	kA, rms	kA, peak	kV, crest	kV, rms
5	2.4, 4.16, 4.8	1200, 2000, 3000	25	65	60	19
			31.5	82		
			40	104		
			50	130		
8.25	4.8, 6.9, 7.2	1200, 2000, 3000	40	104	95	36
15	6.9, 7.2, 8.4, 11, 12, 12.47, 13.2, 13.8, 14.4	1200, 2000, 3000	25	65	95	36
			31.5	82		
			40	104		
			50	130		

Distribution protection and control

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01 Relion 615 series
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02 Relion 620 Series
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03 COM600 Grid automation controller

ABB's Relion® family of protection and control relays for distribution applications provides the performance, safety, and ease-of-use that switchgear specifiers and users demand. The Relion 615 and 620 series offer complete protection and control for feeders, motors, and transformers in switchgear applications and are characterized by their flexibility and performance in today's and future distribution schemes.

The IEC 61850 implementation in Relion includes fast peer-to-peer communication over the substation bus. GOOSE (Generic Object Oriented Substation Events) communication is used between Relion devices in switchgear to form a stable, reliable, and high-speed busbar protection system, provide fast and dependable auto transfer schemes and zone interlocking. Separate hard-wiring is not needed for the horizontal communication between the switchgear cubicles.

Relion relays for feeder protection offer an optional cable fault detection function that can detect extremely short duration underground faults. These faults are typically undetectable by conventional protection where there is no operation of the breaker. This feature helps users to learn of these events faster, resulting in reduced down time.

Relion 615R, 615 and 620 series relays include:
- Comprehensive set of protection and metering functions for feeders, transformers, and motors
- Draw-out design
- Integrated Open/Close push buttons and Local/ Remote selector with indicating lights
- Protection and control for one and two breakers as well as breaker-and-a-half schemes
- Enhanced safety with optional arc fault protec- tion in all 615 and 620 series relays
- Web browser based user interface accessible through an RJ45 front port
- Trip coil monitoring
- Monitoring of breaker health parameters such as travel time, number of operations, wear and tear, and spring charging time
- DNP3 and Modbus protocols included standard in all relays
- Relion relays are fully IEC 61850 compliant for communication and interoperability of substa- tion automation devices
- Fully ANSI and RoHS compliant as well as UL listed

ABB's COM600 Grid Automation Controller can be used as a local HMI to display switchgear single line diagrams and the status of devices such as breakers and protection relays. COM600 also provides gateway functionality to enable switchgear integration into SCADA systems. It can be easily installed as part of the switchgear control devices.

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Switchgear monitoring

SafeGear can be provided with integrated IR windows, from multiple manufacturers, on the rear door to facilitate thermal monitoring of the cable connections.

For users wanting a greater peace of mind, SafeGear also comes with a 24x7 monitoring solution for temperature, humidity, and partial discharge activity.

The temperature monitoring is done using either IR sensor technology or SAW sensor technology. The PD activity is monitored with UHF antennas and specialized signal processing.

The monitored data is available locally, as well as remotely in the user's SCADA or historian systems.

SafeGear® Digital
An ABB Ability™ solution

SafeGear® Digital is an advanced medium voltage switchgear solution — reliability and simplicity are it’s hallmarks. Digitalization of the protection and control system simplifies construction while increasing safety and versatility. ABB is taking the next dramatic leap forward in advancing the technology of switchgear solutions.

Next Level Cost Efficiency

Reduced footprint
Sensors are more compact than traditional instrument transformers

Bus/line potential transformer compartments can be eliminated

up to 25% less space needed

Optimized weight
Conventional instrument transformers weigh 40-60 lbs

Sensors weigh 1.5-4.5 lbs

Up to 25% weight reduction

Faster delivery to site
More efficient engineering versus conventional protection and control

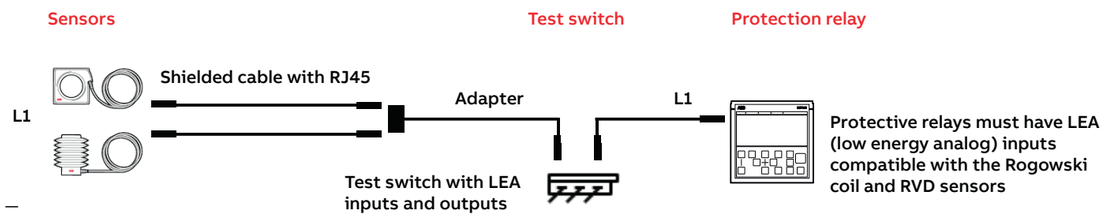
Late customization possible

Up to 30% faster delivery

Faster installation/commissioning
Fewer frames to install and fewer inter-frame connections

Fewer components to test and reduction of inventory

25% reduction



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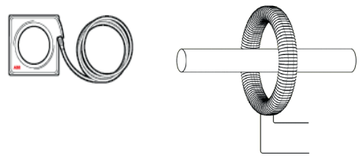
01 Minimized analog wiring in the switchgear increases reliability

Next level safety
- Minimizes the amount of operator interaction while troubleshooting and servicing
- No potential exposure to open secondary CT circuits
- Minimizes potential for high voltage exposure with closed door racking

Next level sustainability
- Reduces resource consumption in manufacturing
- Significant savings of CO2 over lifetime
- Energy loss is minimized

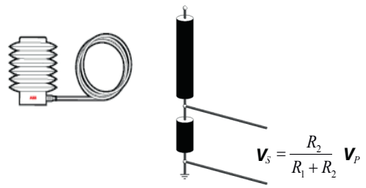
Next level reliability
- Sensors are immune against grid disturbances such as Ferro resonance phenomena
- Less wiring required – Decreased risk of potential operator error
- IEC 61850 + Ethernet-based GOOSE messaging digital communication enables fast and precise actions in case of malfunction

Current sensors
- Rogowski coil
- Output voltage is proportional to the derivative of primary current
- Output voltage is integrated by protective relay
- No saturation (air core)
- Open CT hazard eliminated
- Linear through the entire measuring range



$$v_s(t) = M\frac{di_p(t)}{dt}$$

Voltage sensors
- Resistive voltage divider (RVD) sensors
  - Passive elements
  - No fuses required
- No Ferro resonance (non-inductive)
- Inherently safe as they fail open



$$V_S = \frac{R_2}{R_1 + R_2} V_P$$

SafeGear® meets today’s challenge for improved safety and lower maintenance costs

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