

## SMART EVOLUTION, SIMPLICITY AND RELIABILITY IN THE MV DISTRIBUTION NETWORK WITH IEC 61850

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### ABSTRACT.

*During the last years the medium voltage world has seen a strong increase in demand of flexibility, simplicity and automation of the distribution networks. The Smart Grids concepts have changed network's needs and solutions with innovative design are required to satisfy these new demands. The standard IEC61850 is driving the innovation in the energy distribution devices enabling new functionalities and new architectures. An innovative automatic circuit breaker series has been specifically developed to enable easy, flexible and reliable medium voltage switchgear engineering and operation.*

*This new circuit breaker (CB) is a highly integrated device that combines measurement, protection and control capability with the primary power disconnection, switching and interruption technology. The CB embeds a protection and control Intelligent Electronic Device (IED) designed to unleash the full potential of the IEC 61850 standard for communication and interoperability.*

### INTRODUCTION

Recently, the medium voltage world has seen a strong trend towards technologies that bring new solutions to the needs of distribution networks.

Products featuring a higher degree of integration, component standardization and greater overall versatility have become available on the market, improving reliability while also reducing the time and effort needed for installation and maintenance. ABB is pioneering these new technologies by taking the opportunity to develop new products for the medium voltage primary distribution environment.

The eVD4, an innovative automatic circuit breaker series, has been developed specifically to enable easy, flexible and reliable medium voltage switchgear projects from the specification, tendering, engineering, production, installation, commissioning, testing and maintenance points of view.

The CB series combines innovative ABB technologies in the field of mechanics, electronics and sensors. The result is a highly integrated device that provides measurement, protection and control capability with the primary power disconnection, switching and interruption technology.



### ADDING INNOVATION ONTO A SOUND FOUNDATION OF PROVEN TECHNOLOGY

The new CB is derived from a mechanically actuated vacuum circuit breaker introduced to the market in 2003, over 250000 CBs have been installed all over the world demonstrating excellent reliability and a good level of versatility in a vast range of applications, with the addition of an integrated protection and control unit and sensor technologies.

The integrated protection and control unit based on ABB's Relion® technology is an Intelligent Electronic Device (IED) dedicated to protection, control, measurement and supervision of utility substations and industrial electrical systems. It is installed into the chassis of the new CB as a plug in device via a docking unit.

The integrated IED guarantees general protection of overhead lines, cable lines and distribution substation busbar systems and it is suitable for any radial distribution network regardless of the grounding principle.

The digital inputs and outputs (I/Os) and the communications channels are accessed through the circuit breaker plug and are made available within the switchgear's low voltage compartment by the socket/plug connection.

The sensors, mounted on the CB poles, are a new solution for measuring network primary currents and voltages needed for protection and control in medium voltage power systems. The sensor technology enables a reduction of equipment size, an improvement of equipment performance and of the standardization level, as a limited number of sensor sizes covers all CB ratings.

The combination of sensors and the integrated IED allows an accurate and reliable monitoring and registering of the network parameters while providing better safety protection

for both operating personnel and the substation equipment. The fully automatic CB offers specific advantages compared with a standard MV circuit breaker in all stages of the product life cycle.

### **Specification**

The high flexibility level of new CB series allows very easy specification:

- no need to define any parameters for the sensors, which derive from the rating of the circuit breaker and from the protection profile (only current or current and voltage protection)
- the IED pre-configurations can be customized to provide the best match for the network requirements.

### **Supply management**

The need for possibly three orders to different components suppliers for CB, instrument transformers and protection device is condensed to just one single order and one unique reference to ensure a complete MV switchgear solution. The time and effort needed for the ordering procedure is dramatically reduced.

### **Fast delivery**

The high technology production line and component standardization enable to guarantee the same delivery time for the new CB series as the standard circuit breaker.

### **Installation**

Delivering a ready to install solution, the sensors are on board and directly connected to IED inputs, all the relay wiring is instantaneously connected by the circuit breaker plug, so no wiring or additional work is needed.

### **Reduced effort and time for engineering and wiring**

With the integrated solution a large element of the switchgear wiring is built into the circuit breaker that is tested and guaranteed by production routine testing performed on each unit at factory site. As result the switchgear is much more standardized; the amount of wiring into the low voltage compartment is limited and the risk of wiring errors is reduced. This makes the complete switchgear solution faster and easier to engineer.

### **Reduced effort for SWG Factory Acceptance Test (FAT) while increasing safety and reliability**

The integrated and fully tested solution together with the lower amount of switchgear wiring reduces the effort needed to test the switchgear.

### **Easy maintenance, optimization of spare part stocks and reduced Mean Time To Repair (MTTR)**

The new CB is built from standard components that can be used across a wide range of applications, with just a few variations all models are covered so a smaller number of spare parts need to be kept in stock. All accessories are easy

accessible and they can be easily maintained. The integrated solution allows fast system recovery in case of failure; by replacing the CB all the core components of the switchgear will be replaced, minimizing Mean Time To Repair (MTTR).

The new CB series covers the most common MV circuit breaker ratings, with a nominal voltage up to 17,5 kV, nominal current up to 2500 A and breaking capacity up to 40 kA.

The integrated IED is available with five different license levels, each license level enables the customer to use a particular set of protection functions and depending on requirements current only or both current and voltage measurements. Thanks to the integration of the IED into the CB, the design of the relay has been optimized specifically to perform the monitoring, control and diagnostic functions of the CB operation.

## **CB STRUCTURE OVERVIEW**

The new vacuum circuit-breaker has been designed for simplicity and safety. The structure of the breaker is composed of a sturdy metal frame, the poles and the operating mechanism.

This CB is characterized by a small number of components with high reliability and can be customized with a wide range of easily and rapidly installed accessories, the majority being common to the well proven VD4 line.

### **Operating mechanism**

The operating mechanism contains the spring for the mechanical stored energy opening and closing releases and dedicated interlocks. Taking advantage of the very limited mass of the vacuum interrupter contacts and the reduced travel for switching, the operating mechanism only has to supply a low operating energy, this means that there is very limited wear on the system and practically makes the circuit breakers maintenance-free. Up to 30000 close-open operations are possible over the CB's life time.

### **Proximity sensors**

Proximity sensors detect open/closed status, the spring's charged/discharged state and the position of the truck and send this information to the integrated IED via a dedicated wired link into the circuit breaker. This allows the IED to self-detect the status of the CB with high reliability, providing increased safety and no bouncing.

### **Enhanced auxiliary circuit plug.**

The CB plug has to provide reliable connections for not only the circuit breaker's auxiliary circuits but also the relay connections: the communication channels, the input and output (I/O) signals and the residual current sensor connections. To achieve this, the CB features an enhanced plug comprising 58 pins plus separate communication channels (in the right side of the picture two 100 Mbit electrical Ethernet ports are shown).

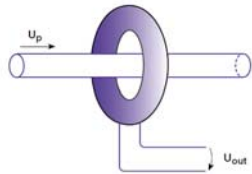


on the primary side during a short-circuit or transients in the network

Coverage of the whole range of currents and voltages is assured with just three sizes of sensors up to the maximum rated current and voltage of the circuit-breaker. Both measurements are in class 1. A broken circuit or short-circuit in the signal cable will cause no hazard or damage.



The current sensor consists of a Rogowski coil: a uniform winding on a closed circular support with a constant cross section and without a ferromagnetic core. The voltage induced in the winding (the transmitted signal) is directly proportional to the variation in the let-through current. The current sensors are characterized by the absence of saturation and hysteresis phenomena thanks to the absence of iron in the Rogowski coil. The measure of the current, therefore, is linear up to the maximum setting value for the protection thresholds.



The transmitted signal is a voltage:

$$U_{out} = M \frac{di_p}{dt}$$

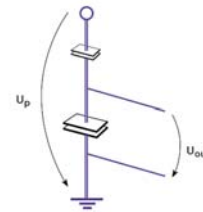
For a sinusoidal current under steady state conditions the voltage is:

$$U_{out} = M * j * \omega * I_p$$

The signal is a sinusoidal voltage, proportional to the current, with 90° phase shift (lead).

In all cases, even if the primary current is non-sinusoidal, a signal reproducing the actual primary current waveform is obtained by integrating the transmitted signal.

The voltage sensor consists of a capacitive divider realized by a cylindrical metal electrode moulded in the sensor and facing the circuit-breaker bushing. The output signal is a voltage directly proportional to the primary voltage. The voltage sensors are characterized by absence of ferroresonance phenomena and insensitivity to the effects of DC components.



Transmitted signal from a voltage divider is:

$$U_{out} = \frac{C_1}{C_1 + C_2} U_p$$

In all cases, the transmitted signal reproduces the actual primary voltage waveform.

The integrated sensors provide several advantages for MV switchgear in terms of performance and safety:

#### Linearity of measurement and versatile protection

Thanks to the absence of resonance and hysteresis phenomena the sensors are linear up to the highest currents and voltages with a good dynamic performance. As a result, the sensors enable high protection performance and many-sided disturbance analysis.

#### Safety

The nominal value of the transmitted signal is low enough to be harmless to people and to secondary equipment, even when the highest currents and voltages occur on the primary side. A broken circuit or short-circuit in the signal cable will cause no hazard or damage.

#### Small power consumption

The efficiency of a sensor is high compared with instrument transformers. In addition, there are no losses in the secondary cabling. These savings add up to a long lifespan of the equipment and at a utility level these savings could be significant.

#### Environmentally friendly

The construction of the sensors uses less raw material and their power consumption is negligible.

### THE SMART EVOLUTION THAT TAKES MV SWITCHGEAR INTO THE FUTURE.

The new automatic circuit breaker is a key element for the creation of simple, reliable and safe medium voltage switchgear. Full compliance with the new IEC61850 standard and GOOSE functionality assure the compatibility with new substation communication systems. The entire switchgear life cycle is optimized by its adoption. Starting from the easier specification and ordering, to the drastically reduced complexity of the switchgear in terms of engineering, wiring and testing, to the commissioning and maintenance of the panel, this new network component is a major step-forward in terms of performance, simplicity, reliability, safety and cost effectiveness.