



ABB North America

# Relion<sup>®</sup> protection and control For generation, transmission and sub-transmission applications

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# Our protection, control and automation offerings For generation, transmission and sub-transmission applications



**Relion® 670 series**  
Future-proof flexibility and performance



**Relion® 650 series**  
Compact and ready-to-use



**PCM600, IET600 & ITT600**

Software tools to optimize utilization



**COMBIFLEX® & COMBITEST**  
Proven and reliable interface



**System integration**  
Scalable migration and interoperability



**Services**  
Securing the full potential of your equipment

# ABB North America Power Systems Automation and Communication



ABB covers a wide range of products, systems, services and solutions for power systems automation and communication. In addition to Relion substation automation and protection, we provide Ventyx SCADA, EMS and DMS solutions and Tropos wireless communications. Based at the ABB Smart Grid Center of Excellence in Raleigh, NC we are the “one stop shop” for the digital substation and the Smart Grid - ready for the future, today.



Our products and systems cover all applications for generation, transmission grids and substations with:

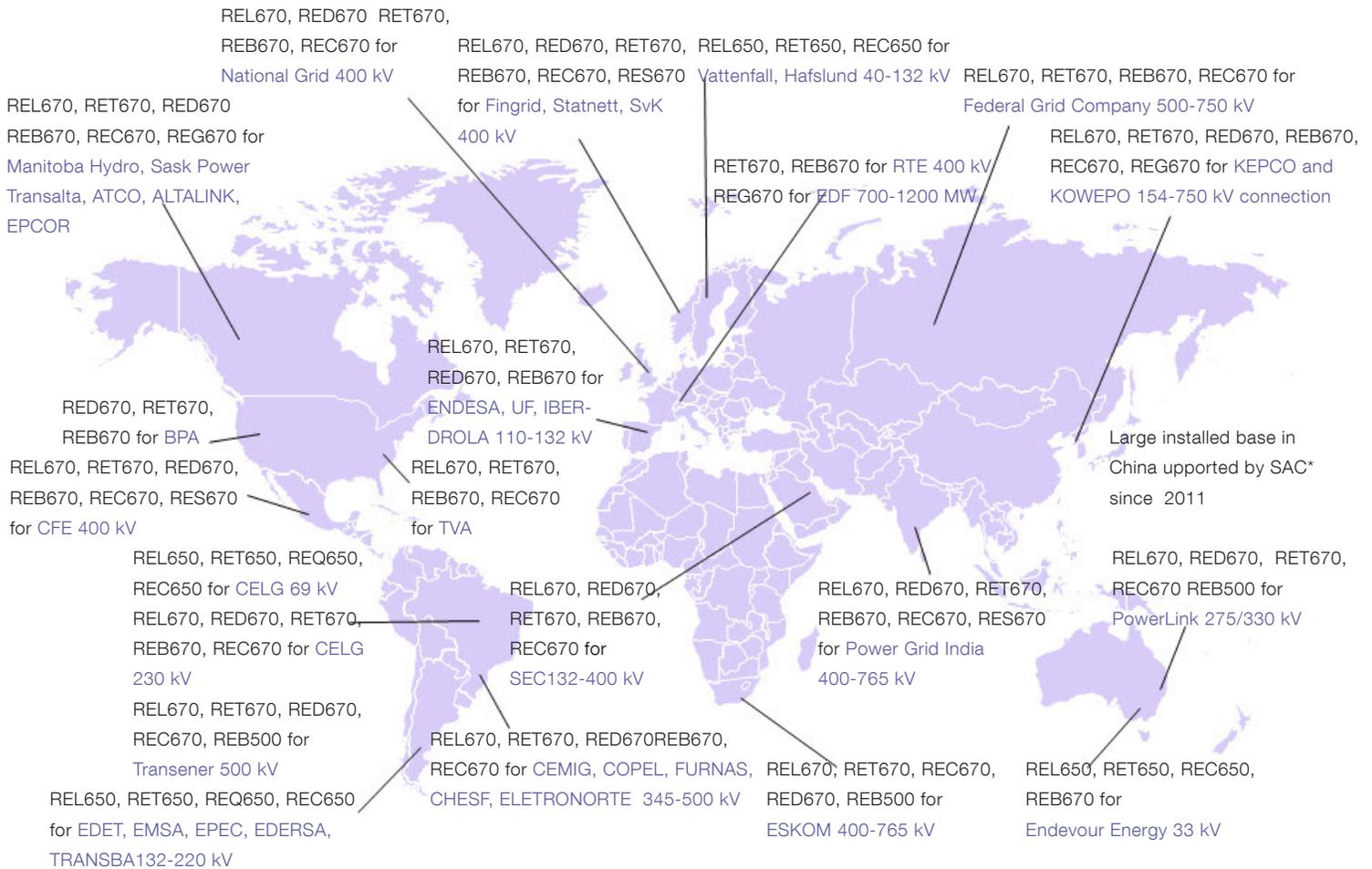
- Superior performance of protection and control functions
- Proven proficiency, both globally and locally
- Comprehensive digital communications capability
- Designed for IEC 61850 with full support for DNP 3.0
- Powerful software tool suite to make it happen

Additionally, we offer COMBIFLEX® modular auxiliary relays and COMBITEST test switches for high current solutions with proven reliability from more than 40 years experience in all environments. Further, we support our Westinghouse electro-mechanical products and Flexitest™ test switches out of our center for Relion distribution products in Coral Springs, FL. Finally bringing it all together, ABB can provide engineered system solutions with RTU560 and MicroSCADA with both Relion and third party products.



# Relion®

## Global protection and control



### Examples of Relion deliveries worldwide

#### Global experience for local perfection

ABB has the largest installed base of protection and control devices and systems for T&D applications. This includes electro-mechanical, static and digital design. The introduction of Relion 670 series was a new breakthrough in technology. Today, some of the world's dominant transmission companies use Relion to protect and control the most valuable assets in their 345–765 kV transmission systems. Hundreds of REG670 and RET670 are protecting large generators in South Korea, China and Brazil. The 650 series is installed around the world for sub-transmission and mid-sized generating stations, giving ABB and Relion unique experience to meet every application everywhere.

#### Stand-alone products and system integration migration

The 650 and 670 series are designed for IEC 61850 functionality, including parallel redundancy protocol (PRP), but fully support DNP 3.0 and other selected protocols. However, of all the 650 and 670 series devices we have delivered globally, more than 60,000 have been supplied with IEC 61850. Many of these

deliveries are for complete IEC 61850 based digital substation automation systems. Others are currently supporting other protocols, including DNP 3.0 today, but are ready to deploy an IEC 61850 architecture when you are.

The 650 and 670 series are a member of the Relion protection and control product family. Relion offers the widest range of products for the protection, control, measurement and supervision of power systems. To ensure interoperable and future-proof solutions, Relion products have been designed to implement the core values of the IEC 61850 standard, as well as support DNP 3.0. With ABB's leading-edge technology, global application knowledge and experienced support network, you can be completely confident that your system performs reliably – in any situation.

# Anything is possible For those thinking beyond the box



Not just a box, but rather a methodology. Designed to seamlessly consolidate functions, Relion is smarter, more flexible and more adaptable than any other “relay” in the market. Easy to integrate and with an extensive function library, Relion perform in ways others only dream of.

## Instead of 100 boxes

- ONE configurable protection and control concept with ONE software tool
- TWO optional hardware designs with large built-in HMI
- THREE TCP/IP ports and optional PRP redundancy
- FOUR hardware sizes for required I/O modules
- 28 pre-configured and type tested applications
- CUSTOMIZED for your unique application

## Increased reliability and optimized assets

Field tested multi-object capability is the next generation of protection and control - here today with Relion. Powerful enough to handle several protection and control applications within a single device, allowing you to do more with less, increasing reliability with fewer points of failure, minimizing supporting infrastructure, reducing engineering effort and lowering total cost of ownership with minimized O&M cost.

## Future-ready and smart grid enabled

The higher level systems required to deliver on the promise of a

smarter grid require access to real-time actionable information from the process level to the enterprise level. Built on a foundation of IEC 61850, interoperable, supporting multiple communication protocols including DNP 3.0, Ethernet compatible and network-centric, Relion supports the modern technologies and architectures required to provide the real time intelligence needed for the future grid, today

## Relion delivers performance and value

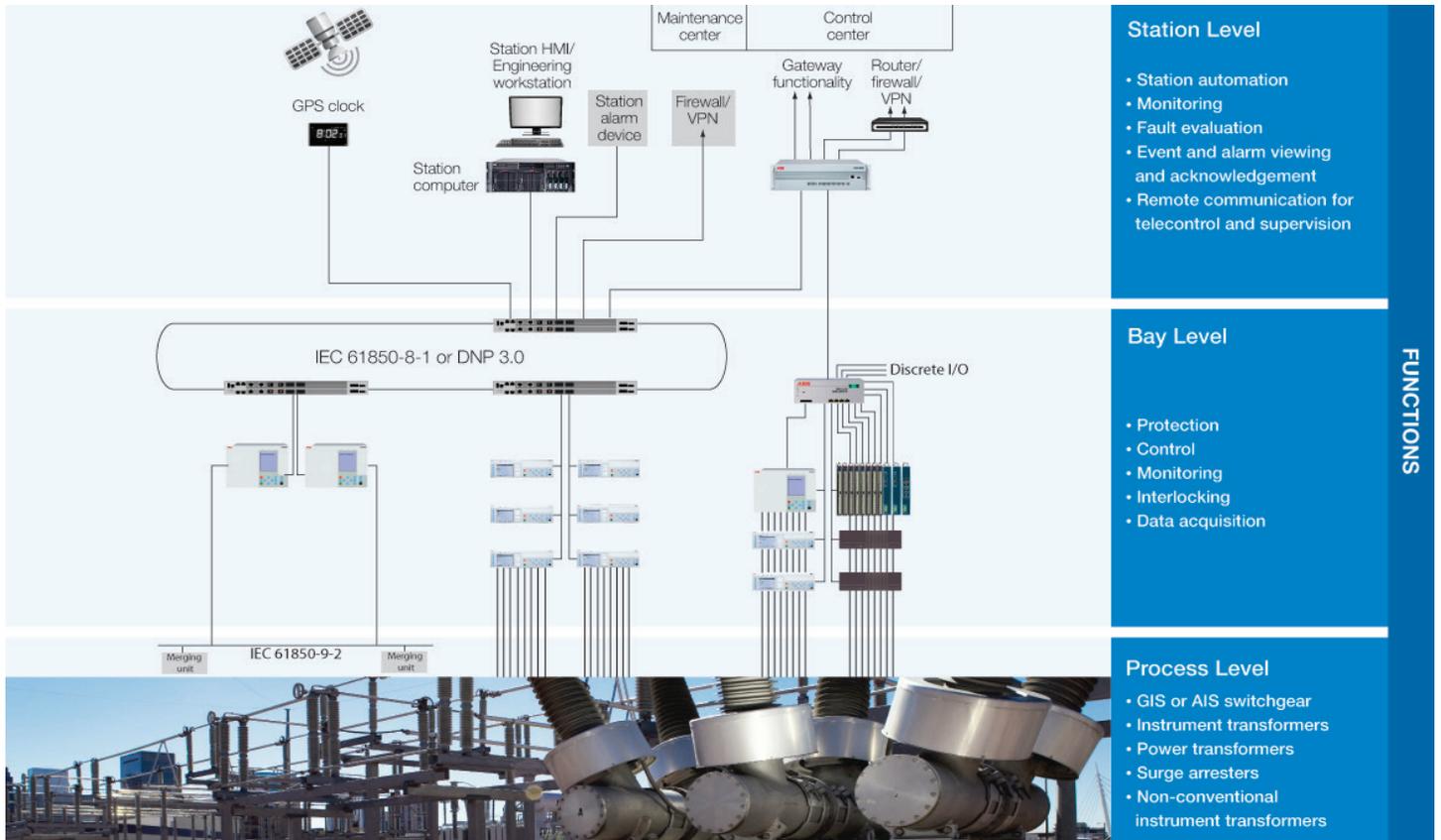
- Relion provides state-of-the-art building blocks including interoperability and advanced solutions for monitoring, protection and control of the digital substation.
- Functional consolidation allows you to design more compact and efficient solutions, reducing footprint, wiring and work.
  - Increased safety is achieved with digital optical communication and self supervision combined with state of the art redundancy and cyber security.
  - Enhanced reliability and less complexity is obtained with reduced number of boxes and connections
  - Simplicity is at hand when you learn one, you’ll know them all. One harmonized and open concept with one powerful tool for all applications reduces training, spare parts and maintenance.

## Step out of the box and into the future

Relion opens new possibilities. A sustainable investment able to competently support your protection and control needs today, and ready to seamlessly migrate to the efficiency of the optimized digital substation when you are.

# Relion®

## Designed to communicate



### Station Level

- Station automation
- Monitoring
- Fault evaluation
- Event and alarm viewing and acknowledgement
- Remote communication for telecontrol and supervision

### Bay Level

- Protection
- Control
- Monitoring
- Interlocking
- Data acquisition

### Process Level

- GIS or AIS switchgear
- Instrument transformers
- Power transformers
- Surge arresters
- Non-conventional instrument transformers

FUNCTIONS

Example of migration to the digital substation

### HMI, PCM600 and I/O

The 650 and 670 series have built-in large HMI display and function buttons which efficiently communicate locally with the technician or engineer. An additional PC can easily be connected to the front for communication with the PCM600 tool.

With PCM600 you can manage everything you need to read or write to the 650 and 670 series, but also other Relion products. You may configure and set your distance protection and then look at the graphical representation of the settings, or export the parameters as XRIO files to the test set. You may also extract events and disturbance recordings. Finally, you have access to all documentation directly when you need.

For IEC 61850 engineering and testing, the powerful IET and ITT tools not only support ABB hardware, but also others vendors' who comply with the IEC 61850 standard.

The 650 series has I/O modules for standard electrical analog connections. The 670 series have a large I/O library including static outputs as well as communication to remote I/O and digital communication for differential protection.

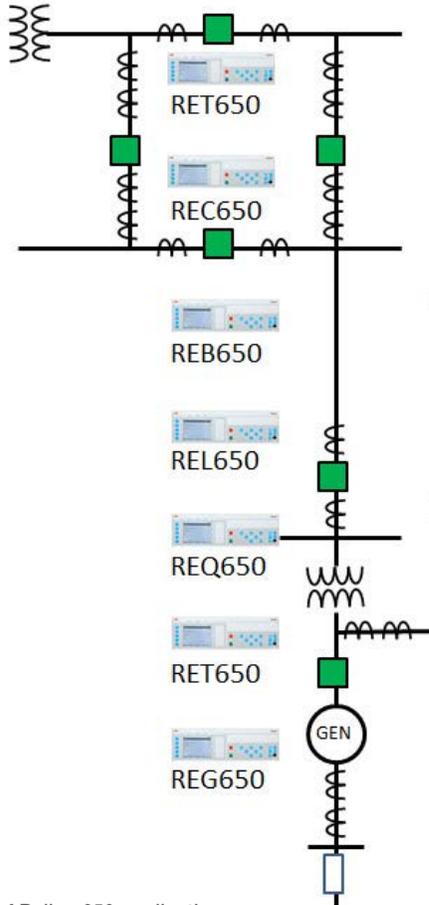
### RTU, MicroSCADA and SCADA

Communication within substations, between substations and to remote control centers is not new but has evolved from slower analog to faster digital communication. A large number of different serial SCADA and RTU protocols have been used by different utilities and manufacturers around the world resulting in costly and time consuming work with "protocol converters". The evolution to defacto and IEC standards like DNP and IEC 60870 improved this, but it is with the development and global acceptance of IEC 61850 that the realization of future-proof and seamless interoperability has been achieved.

The 650 and 670 series are designed for IEC 61850 and fully support IEC 61850-8-1 and GOOSE with two ports for redundancy (PRP). DNP 3.0 is supported both for serial and Ethernet communication. The 670 series supports IEC 61850 9-2 LE allowing connection to merging units and non-conventional instrument transformers. ABB can supply complete solutions with RTU560 or MicroSCADA for IEC 61850 and DNP 3.0 as well as selected other protocols. This can also be integrated with ABB Network Manager for enterprise-wide SCADA and EMS systems, as well as wide-area monitoring systems.

# Relion® 650 series

## Compact and ready-to-use



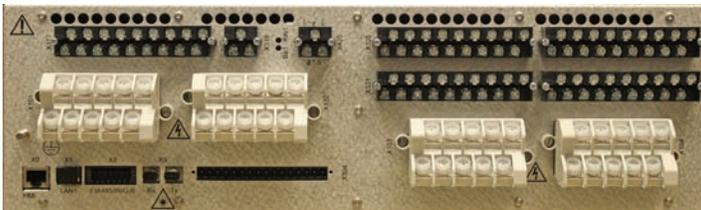
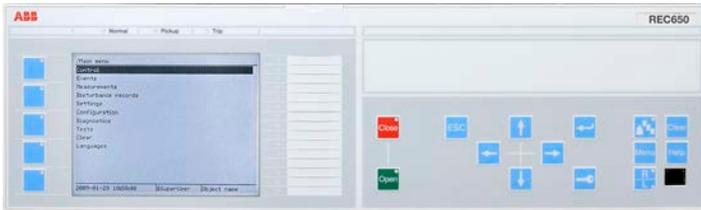
Example of Relion 650 applications

The 650 series was introduced in 2009, further evolving the technology from the 670 series and adapting the design for the sub-transmission and retrofit market as well as for mid-sized generators such as co-generation. The 650 is well suited as back-up protection for the 670 series, meeting a common preference that main and back-up protection shall have different designs and/or algorithms. The 650 series is primarily designed for the ANSI market in North America as a 3U rack mounted unit with ring lugs and DNP 3.0. Additionally, it is available with IEC 61850 and compression type connections, as well as in a 6U design for the global market. The same 6U design is being released for the decentralized bus protection REB500 version 8.0. This gives ABB a powerful and flexible range of differential protection for any application as part of one common concept with common tools - all enabled for the digital substation.

### Optimized and pre-configured

You may find little difference between the functionality of the 670 series and the 650 series. Many of the features and benefits in the 670 series are available in the 650 series, and you will find no difference in system integration using DNP 3.0 and IEC61850.

The 650 and 670 series can be combined when 670 series is needed for higher performance for certain applications. The main difference is that the 650 series offers off-the-shelf solutions with optimized functionality for each application as well as default settings. The 650 series, together with the PCM600 Quick Start Guide, provide a swift entry into the Relion universe and the possibilities available. The Relion 650 and 670 series may in the beginning seem more complex than conventional “relays”. However, replacing hundreds of different “boxes” and copper wires with one common Relion concept with a common PCM600 tool, leads to simplicity and efficiency. Learn one, know them all. Much like smart phone multi-functionality and “apps” revolutioned real-time personal communication.



The Relion 650 series IEDs provide optimum 'off-the-shelf', ready-to use solutions equipped and configured with complete protection functionality and default parameters to meet the needs of a wide range of applications within generation, transmission and sub-transmission networks.

#### The 650 series IEDs include:

- Pre-defined functionality optimized to meet different requirements of sub-transmission applications.
- Complete application configuration ready-made at the factory. To adapt the IED to your specific needs, you can easily modify the default I/O connections.
- Flexible system configuration through integrated protection and control in one IED.
- Support for user-defined names in the local language for signal and function engineering to enable easy understanding and user-friendliness when the protection and control system is in operation.
- Minimized parameter setting based on default values and ABB's new global base value concept. In addition parameter settings can be forced. This allows the IEDs to be taken into operation faster than ever before.
- Extended HMI functionality with 15 dynamic three-color indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions.
- Programmable LED text-based labels.
- Settable 1A/5A-rated current inputs.

#### Features

- Fully IEC 61850 compliant
- Protection and monitoring integrated in one IED
- Extensive self-supervision including analog channels
- Four independent parameter setting groups
- Large HMI for visualization of single line diagrams and on-line measurements
- Integrated or detachable HMI with 1-5 m cable for flexible panel mounting (only 6U)
- Ethernet interface for fast and easy communication with PC
- Accurate time synchronization via SNTP, DNP 3.0, IEC 60870-5-103 and IIRIG-B serial interface
- Signal matrix for easy configuration of binary and analog signals
- User management and authority handling

#### Control functions

- Apparatus control for up to 30 apparatus
- Synchrocheck, energizing check and synchronizing
- Selectable operator place allocation
- Versatile switch with two positions
- Selector switch with up to 32 position

#### Monitoring

- Disturbance recorder
  - Up to 3 seconds of data before the trigger
  - 100 disturbances
  - 40 analog channels (30 physical and 10 derived)
  - 96 binary channels

- Event list for 1000 events
- Disturbance report
- Event and trip value recorders
- Event counters
- Supervision of AC input quantities
- Indication of up to 135 binary signals via 15 three-color-state indication LEDs on up to three pages
- Insulation gas monitoring function
- Insulation liquid monitoring function
- Circuit breaker condition monitoring
- Station battery supervision

#### Communication

- IEC 61850-8-1 including GOOSE messaging
- DNP 3.0 slave protocol
- IEC 60870-5-103 serial communication
- 62439-3 standardized Parallel Redundancy Protocol (PRP)

#### Setting, configuration and disturbance handling

- Protection and control IED manager PCM600

#### Hardware

- Full 19", 3U and 1/2 x 19", 6U height case
- 20 analog inputs (10+1 CT and 9 VT inputs)
- Universal 1A/5A CT inputs
- Communication and processor module with 12 binary inputs, TCP/IP optical, galvanic RS485, and optical serial communication ports
- Binary input/output module with 9 inputs and 9 outputs
- Possibility to add one optional binary input/output module
- Power supply modules from 48 to 250 V DC or 100 to 240 V AC with 9 outputs, 3 of which with trip circuit supervision

# Relion® 670 series

## Maximum flexibility and performance

The 670 series was introduced 2005 for transmission applications and later extended for generation applications. This novel concept is based on the IEC 61850 architecture allowing a future proof design and interoperability between devices. The flexibility and high performance of the 670 series has made it the global standard for transmission and generation applications including UHV applications up to 800 kV and large hydro, thermal and nuclear power stations. This gives you ONE common solution provider for transmission and generation for protection and control. The 670 series is available with ANSI functionality and is supported, configured, tested and when needed verified in a multi-vendor test system in our Power System Communication and Automation center in Raleigh, NC.

The maximum flexibility and performance of the 670 series allows smarter, more reliable and more efficient solutions for the Digital Substation with fiber optics rather than the blue-print “box -and -wire” of the past. Multi-function, multi-algorithm and multi-object capability allows you to configure your optimized solution – if you are ready to think beyond the box.

### Perfecting protection

Reliable grids require reliable protection capable of operating correctly for normal and extreme conditions. Reliability requires dependability and security which means that speed and sensitivity has to be balanced with stability and selectivity. By using state-of-the-art algorithms in parallel, the 670 series can provide speed and sensitivity for internal faults and at the same time provide stability and selectivity for load, external faults and transients. Optimizing full scheme quadrilateral distance relaying for sub-cycle operation of series compensated lines, ¼ of a cycle operation for bus faults, 100% coverage of earth faults in generators and interturn faults in transformers, frequency scanning during islanding are just a few examples of the protection capabilities of the 670 series.

### Coordinating control

The 670 series has full SCADA control functionality as well as various interlocking, voltage control and on-load tap changer control functions. It has a large built-in HMI, modular I/O and various options for remote communication eliminating the need for conventional control panels and RTUs.

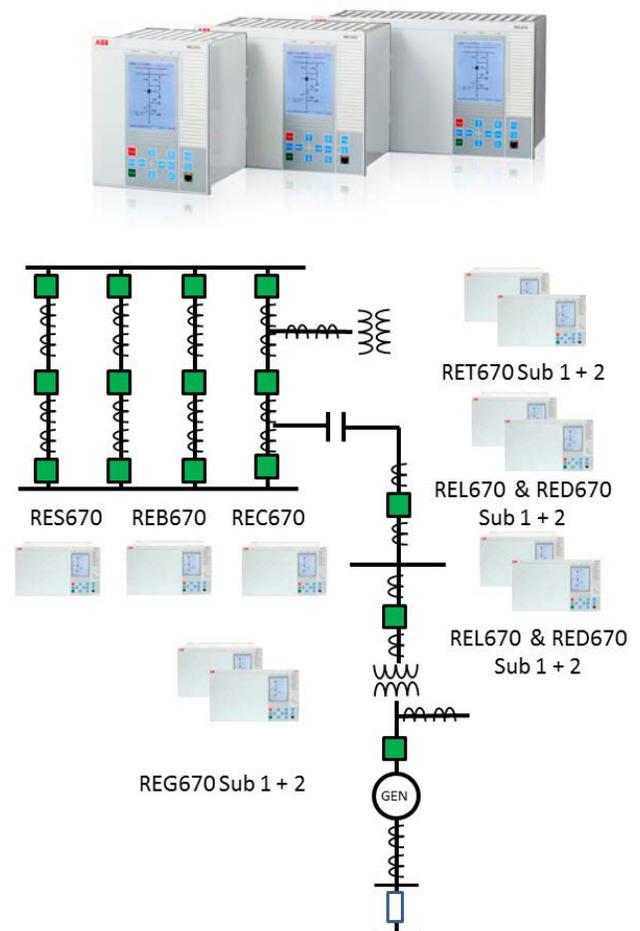
### Customizing communication

The 670 series has unique communication capabilities including legacy protocols, DNP for both serial twisted pairs and TCP/IP and IEC 61850 8-1 for client-server, bay-to-bay GOOSE, PRP redundancy and IEC 61850 9-2 capability based on your pre-

ference. The 670 series is backwards compatible and future ready. In addition station-to-station communication is provided for transfer trip and line differential protection. Finally, both the 650 series (1.3) and the 670 series (2.0) comply with the Cyber Security Deployment Guidelines published by ABB.

### Advancing automation

ABB has provided process automation and substation automation for utilities and industries for more than 30 years. Integration and coordination of measurement, protection and control using computers and optical communication is consequently a globally accepted technology with thousands of installations in service worldwide. With the introduction of Relion Intelligent Electronic Devices and MicroSCADA Pro, designed for IEC 61850 and fully supporting DNP 3.0, Substation Automation has evolved to a higher level of functionality, efficiency and interoperability. While ABB supplies conventional and optical solutions using our RTU560 concept, we also offer a path for full migration to the Digital Substation.



Example of Relion 670 applications

The Relion 670 series protection and control IEDs provide versatile functionality, as well as maximum flexibility and performance to meet the highest requirements of any application in generation, transmission and sub-transmission protection systems.

**The 670 series IEDs include:**

- Pre-configured and fully customized IEDs. As pre-configured, the IEDs are delivered type-tested and with default parameters to simplify ordering, engineering and commissioning. This shortens the time from delivery to operation. If needed, the IEDs can be easily adapted to meet specific power system requirements. The customized IEDs offer full flexibility in application engineering, allowing complete adaptation to your needs.
- Capability of handling several objects with a single IED and enable many other smart solutions based on functional integration. This multi-object capability has already been utilized by several utilities to increase availability and to optimize the cost-performance ratio while maintaining high grid reliability.
- Functionality required specifically in transmission applications, such as series compensation. They also feature both 1- and 3-phase tripping, voltage control for up to eight parallel transformers, an extended disturbance recorder, and binary and analog data transfer between IEDs.
- Powerful and flexible hardware.

**Features**

- Fully IEC 61850 compliant
- Protection, monitoring and control integrated in one IED
- Extensive self-supervision including analog channels
- Six independent parameter setting groups
- Signal matrix for easy configuration of binary and analog signals
- Ethernet interface for fast and easy communication with PC
- Large HMI for visualization of single line diagrams

**Control functions**

- Apparatus control for up to 30 apparatus
- Synchrocheck, energizing check and synchronizing
- Selectable operator place allocation
- Versatile switch with two positions
- Selector switch with up to 32 positions

**Monitoring**

- Disturbance recorder
  - Up to 10 seconds of data before the trigger
  - Up to 100 disturbances
  - 40 analog channels, 30 physical and 10 derived
  - 96 Binary channels
- Event list for 1000 events
- Disturbance report
- Event and trip value recorders
- Event counters
- Supervision of AC and mA input quantities
- Small and large HMI
- LED indications with 6 red and 9 yellow LEDs

**Communication**

- IEC 61850-8-1 including GOOSE messaging
- IEC 61850-9-2
- IEC 60870-5-103
- LON
- SPA
- DNP 3.0
- Remote end communication for transfer of 192 binary signals
- 62439-3 standardized Parallel Redundancy Protocol (PRP)

**Setting, configuration and disturbance handling**

- Protection and control IED manager PCM600

**Hardware**

- Full 19" case, 6U height with 24 analog inputs and up to 11 I/O modules
- 3/4 case, 6U height with 24 analog inputs and up to 8 I/O modules
- Half 19" case, 6U height with 12 analog inputs and up to 3 I/O modules
- Power supply modules from 24 to 250 V DC  $\pm$  20%
- Metering class input CTs
- Binary input module with 16 inputs
- Binary output module with 24 outputs
- Binary input/output module with 8 inputs and 12 outputs
- mA input module with 6 transducer channels
- GPS or IRIG-B time synchronization module
- Remote-end data communication modules
- Accessories

**New in release 2.0**

The 670 series is available as 1.2 and 2.0 versions. The main difference is that 2.0 supports IEC 61850 editions and 1 and 2 (selectable). In addition, the large HMI and cyber security implementation from the 650 series is now also available in the 670 series 2.0.

A high performing distance protection algorithm with quadrilateral characteristic and sub-cycle operating time, suitable for parallel, heavy loaded and/or series compensated lines, as well as conventional lines and cables, is available in REL670 2.0.

Finally, the fault locator accuracy has been significantly improved.

# Line and cable applications

## Line distance protection & control (REL670/650)

**REL670 and REL650 line distance protection IEDs (Intelligent Electronic Device) support extensive protection applications for overhead lines and cables, or combinations of overhead lines and cables. They feature full scheme distance protection with selective single-phase and three-phase tripping and autoreclosing with synchronizing and synchrocheck, power swing detection and a wide range of scheme communication logic. With five zone distance protection for phase-to-phase and phase-to-earth faults, the IEDs enable you to protect transmission and sub-transmission lines and cables in impedance or solidly earthed networks. They are also equipped with residual overcurrent protection functions and a wide range of scheme communication logic that enable detection and fault clearance of high resistive earth faults.**

### **REL670 – maximum flexibility and performance**

The REL670 IEDs provide versatile protection, monitoring and control functionality with maximum flexibility and performance optimized for transmission and sub-transmission overhead lines and cables. The powerful IED provides distance protection for double circuit, parallel operating and series compensated lines. This, together with flexible and expandable hardware, allows the IED to support your specific requirements. As a result, you can benefit from applications with multiple algorithms and comprehensive bay control functionality, including synchronizing, synchrocheck, dead line detection and autoreclosing.

Furthermore, REL670 IEDs are able to protect and control several objects, for instance a combination of a line and a shunt reactor with a single IED. As a result, this IED increases both the reliability and economy of your entire power system.



The REL670 IEDs provide both customized and pre-configured protection solutions. The pre-configured IEDs are equipped with complete functionality adapted for four different configuration alternatives: single pole breaker or multi-breaker arrangements with single or three-phase tripping. If needed, they can be adapted to meet your power system's specific requirements. With the customized REL670 IEDs you have the freedom to completely adapt the functionality according to your needs.

REL670 can operate as a full scheme distance protection with offset mho, quadrilateral or a combination of both. The quadrilateral characteristic provides optimized selectivity, maximum sensitivity and sub-cycle operating time even for long, heavy loaded, parallel and series compensated lines.

#### **REL650 – ease of use from ready-to-use solutions**

REL650 offers optimum 'off-the-shelf', ready-made application solutions for protection and control of single breaker or multi-breaker connected power lines and cables. The type-tested variants are delivered equipped and configured with complete protection functionality, and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation.

The 650 series IEDs introduce a number of innovations, such as a significantly reduced number of parameter settings and extended IED HMI functionality including 15 dynamic three-color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions. In the 650 series IEDs, most basic parameters are set before delivery from the factory. You only need to set the parameters specific to your application. The parameters related to line distance protection are mostly set as primary ohms, which significantly reduce the need to re-calculate the current and voltage values. This allows the IEDs to be quickly taken into operation. The application manual includes setting examples to support the protection engineer.

#### **Extensive protection for lines and cables**

REL670 and REL650 provide protection of power lines and cables with high sensitivity and low CT requirements. Measurements and setting of all five zones with several setting groups are realized completely independently to ensure high reliability. The distance protection function is available with both quadrilateral and mho impedance characteristics. This enables coordination with existing distance protection schemes in any power network.

The distance protection is further enhanced with load encroachment adaption, which increases the ability to detect high resistive faults on heavily loaded lines. The unique load current compensation in zone one prevents over-reaching during resistive faults and high power transfer on the line. Furthermore, an integrated power swing detection function prevents unwanted operation during power system oscillations caused by disconnection of parallel lines, heavy loads or tripping of large generators.

Versatile overcurrent functions provide additional back-up protection. The thermal overload protection will trip the line in overload situations to prevent more severe fault consequences. Breaker failure protection allows high-speed back-up tripping of surrounding breakers and re-tripping of the own breaker, for instance to avoid operational mistakes during testing. The distance, directional earth fault overcurrent and directional negative sequence overcurrent protection functions can communicate with the remote end in any communication scheme.

The autoreclosing functionality increases operation security and is an effective way to restore the network after arcing faults. In REL670 and REL650, autoreclosing can be made using synchrocheck to eliminate the risk of unwanted reclosing during unfavorable circumstances.

In addition to the wide range of overcurrent protection functions, REL670 and REL650 provide a negative sequence overcurrent protection. This function detects all unsymmetrical faults with or without earth connection. It features high sensitivity, which enables detection of faults with a low fault current. The negative sequence overcurrent protection can also be directional.

The multi-stage negative sequence overcurrent protection can serve as back-up protection for most faults. It can also serve as the main protection for earth faults and other unsymmetrical faults in radial applications.

REL670 IEDs can also provide additional logic in direct transfer trip schemes to minimize the risk of unwanted operation caused by a false signal in protection communication. Several different protection functions can be used as local criteria when configuring the logic for a specific application.

# Line and cable applications

## Line distance protection & control (REL670/650)



### Integrated protection and control

REL670 and REL650 IEDs are designed for IEC 61850, implementing all the aspects of this standard and therefore ensuring open, future-proof and flexible system architectures, with state-of-the-art performance. Their performance meets comprehensive communication tasks, for example, GOOSE messaging for horizontal communication. These IEDs provide you with wide application flexibility, which makes them an excellent choice for both new and retrofit installations.

The advanced interlocking functionality of REL670 allows you to avoid dangerous or damaging switchgear operations and to ensure personnel safety. REL670 performs secure bay- and station-wide interlocking using an easy-to-use reservation functionality. This prevents simultaneous operation of disconnectors and earthing switches and ensures that the interlocking information is correct at the time of operation. The control is based on the select-before-operate principle to ensure secure operation and to avoid human mistakes.

The integrated HMI of REL670 and REL650 provide you with a quick overview of the status of the line and service values as well as instant access to important data, such as settings. Using a library of symbols, you can easily configure the graphical display to correspond to your needs and to your substation. The built-in disturbance and event recorders provide you with valuable data for post-fault analysis and corrective actions to increase the security of your power system.

Furthermore, the HMI of REL670 allows secure and quick local control for stand-alone applications and provides

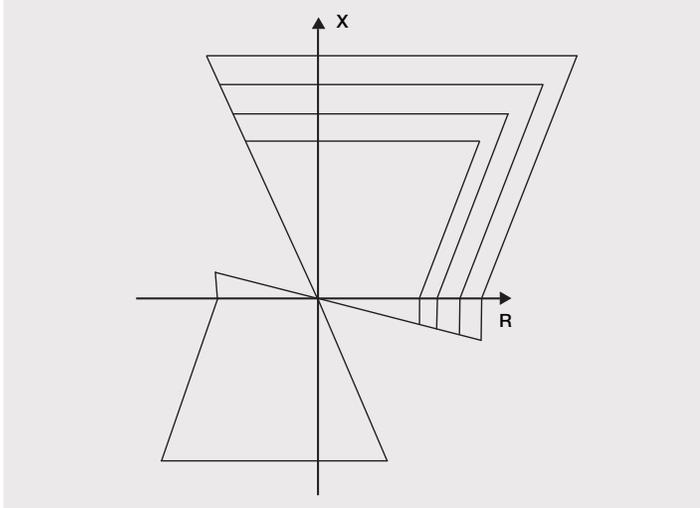
back-up control for substation automation systems, when control functionality is integrated in the IED. The two-position versatile switch and the 32-position selector switch functions in REL670/650 enable you to easily manage switching operations via an icon on the IED HMI. The versatile switch function allows you to directly change, for instance, the autorecloser function from On to Off, or vice versa, without changing the configuration. The function also presents an indication of the selected position.

The selector switch can replace an external mechanical selector switch and allows you to directly select the position you desire, for instance, to change the autorecloser mode between 1-pole, 3-pole or 1- and 3-pole modes in REL670/650. In addition to the IED HMI, these switch functions can be operated from a remote system.

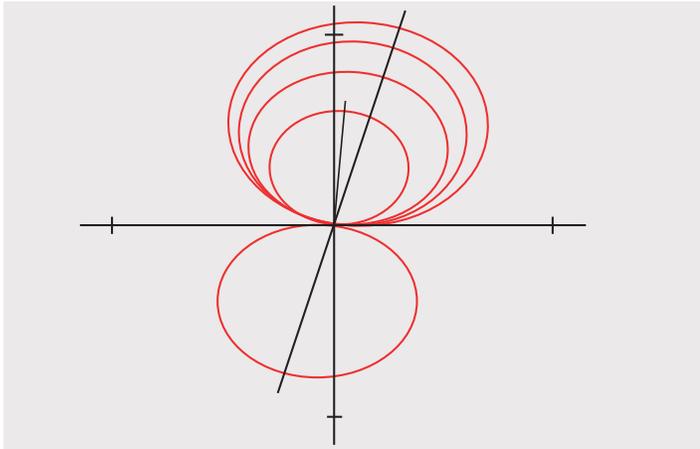
### Fast and efficient system integration

The IEC 61850 compliant REL670/650 IEDs utilize ABB's unique connectivity package concept, which simplifies the system engineering and reduces the risks of errors in system integration. A connectivity package contains a complete description of the specific IED, consisting of data signals, parameters, addresses and IED documentation. The signal data is configured automatically based on the information provided by the connectivity package to efficiently integrate the IEDs in ABB's MicroSCADA Pro automation system.

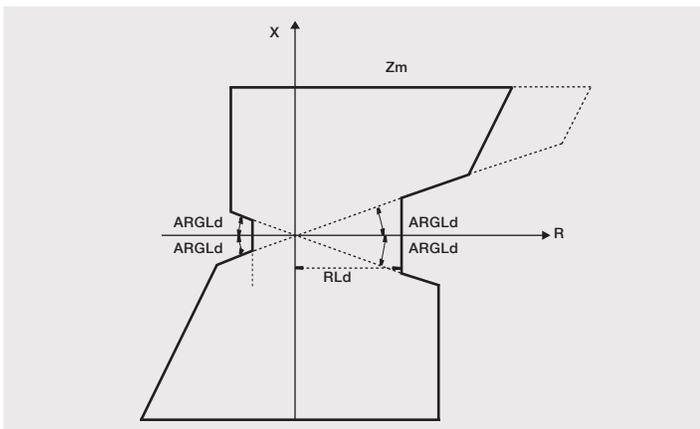
## Application examples



REL670/650 IEDs provide distance protection with quadrilateral characteristic.



REL670/650 IEDs provide distance protection with mho characteristic.



The load encroachment function allows the efficient detection of high resistive faults without interfering with the load impedance.

Relion® 670/650 series IEDs support IEC 62439 standard redundant communications on the station bus as per IEC 61850 standard. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds' recovery time in case of communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.

The supervision of communication links provides real-time status information about both communication links individually. If a failure occurs, an alarm is sent to the IED HMI and the substation automation system. This also allows for maintenance of the station bus while it is in operation. Thus, redundant communication further improves personnel safety and ensures that the necessary information about the system is available for operators in all situations.

Relion 670 series IEDs can also support synchronized sampled measured value communication over the process bus using IEC 61850-9-2 LE which replaces conventional wiring between the process and the secondary system. This enables new design of substations. For example, utilization of sensor technology eliminates problems caused by, for instance, CT saturation and EMC influence. Furthermore, extensions and maintenance of substations can be completed more efficiently as fiber-optic cables are used instead of copper wires.

670 series IEDs allow you to mix conventional wiring and fiber-optic communication with IEC 61850-9-2 LE in a single IED. This way you can shift from conventional wiring for analog data to fiber-optic-based communication for synchronized sampled measured values step by step.

# Line and cable applications

## Line differential protection & control (RED670)

The RED670 IED (Intelligent Electronic Device) is designed for protection, monitoring and control of overhead lines and cables with up to five line terminals. The phase segregated line differential protection of RED670 enables reliable single/two/three pole tripping and auto-reclosing with synchronizing and synchro-check. In addition, this IED is capable of handling transformer feeders, and generator and transformer blocks. It provides an extensive functionality with application opportunities and expandable hardware to meet your specific requirements.

RED670 provides absolutely selective protection without time grading. All line short circuits and earth faults can be cleared instantaneously. Additionally, the high sensitivity of RED670 allows for detection of small fault currents, which in turn allows high resistive phase to earth faults to be detected.

### Ready to use IEDs

The RED670 IEDs are delivered pre-configured, type tested and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation. These IEDs are equipped with complete functionality adapted for four different configuration alternatives: single pole breaker or multi-breaker arrangements with single or three phase tripping. If needed, they can also be easily adapted for your power system's specific requirements.

### Protection for up to five line terminals

RED670 provides phase segregated line differential protection for two to five line terminal applications in impedance or solidly earthed networks, including series compensated systems.

All individual phase currents in 1 $\frac{1}{2}$  and multi-breaker configurations can be connected to RED670 without external summation. Therefore, each current will always be correctly measured. This improves the stability of the line differential protection function and enables integration of a number of breaker related protection and control functions.

### Power transformer in the protected zone

RED670 is able to handle two or three-winding power transformer(s) in the protected zone. The line differential protection function handles all transformer winding vector groups and matches all transformer configurations with a simple parameter setting. This simplifies engineering since no auxiliary CTs or other protection equipment is needed.

Advanced stabilization methods are used for detection of transformer inrush current during energization to ensure



sensitive differential protection when a power transformer is included in the protected zone.

When a small transformer is connected as a tap on the line, the line differential protection can be used without an additional RED670 installed at the transformer tap. For low fault currents behind the tap transformer the line differential protection of RED670 includes a useful definite time or inverse time delayed characteristic. This enables selective operation of other protection functions located at the tapped transformer's high or low voltage side.

#### Extensive built-in protection for lines and cables

The RED670 features integrated distance protection to ensure fault clearance in case of communication failure. The full scheme distance protection provides independent phase selection, power swing detection and a wide range of scheme communication logics. The four-zone distance protection is further enhanced with load encroachment, which increases the ability to detect high resistive faults on heavily loaded lines.

Increase the functionality of your RED670 IEDs with optional back-up and multipurpose protection functions. Versatile overcurrent and thermal overload functions provide additional back-up protection. Breaker failure protection allows high speed back-up tripping of surrounding breakers and re-tripping of the own breaker, for instance, to avoid operational errors during testing. The distance directional earth fault overcurrent and directional negative sequence overcurrent functions communicate with the remote end in any communication scheme.

In addition to the wide range of overcurrent protection functions, RED670 provides a negative sequence overcurrent protection. This function detects all unsymmetrical faults with or without earth connection. It features high sensitivity, enabling detection of faults with low fault current. The negative sequence overcurrent protection can also be used as directional. This facilitates the coordination with protection for other objects.

The four-step negative sequence overcurrent protection can serve as back-up protection for most faults. It can also serve as the main protection for earth faults and other unsymmetrical faults.

#### Integrated protection and control

RED670 is designed for IEC 61850, implementing all the aspects of this standard, ensuring open, future-proof and flexible system architectures, with state-of-the-art performance. It features extensive functionality and expandable I/O. As a



result, you benefit from applications with multiple algorithms and comprehensive bay control functionality, such as synchronizing, synchro-check, dead-line detection and auto-reclosing in integrated and distributed architectures.

The advanced interlocking functionality of RED670 allows you to avoid dangerous or damaging switchgear operations, and therefore ensure personnel safety. The control is based on the select before operate principle to assure secure operation and to avoid human error.

The integrated HMI of RED670 allows secure and quick local control for stand-alone applications and provides back-up control for substation automation systems. It also enables instant access to important data, such as settings, events and disturbance information.

The two-position versatile switch and the 32-position selector switch functions enable you to easily manage switching operations via an icon on the IED HMI. The versatile switch function allows you to directly change, for instance, the autorecloser function from On to Off or vice versa without changing the configuration. The function also presents an indication of the selected position.

The selector switch can replace an external mechanical selector switch and allows you to directly select the position you desire, for instance, to change the auto-recloser mode between 1-pole, 3-pole or 1- & 3-pole modes. In addition to the IED HMI, these switch functions can be operated from a remote system.

# Line and cable applications

## Line differential protection & control (RED670)



The RED670 IEDs provide you with a future-proof concept based on wide application flexibility, which makes these IEDs an excellent choice for both new and retrofit installations.

### Protection communication according to the standards

Due to development in communication technologies and synchronization of measurements, line differential protection can be used in a wide range of applications. Consequently, you can also protect long lines using line differential protection and still maintain high security. RED670 can exchange phase current and binary signal information between up to five line terminals.

The RED670 IEDs are designed to communicate. They feature extensive supervision of communication channels and provide detailed information for fast restoration of the communication system. The built-in C37.94 interface of the RED670 enables easy and safe standardized optical connection to “off-the-shelf” communication equipment.

### You can:

- Choose either master-master or master-slave operating mode depending on your system’s functionality or your economic requirements.
- Connect RED670 to redundant channels to increase the dependability of the protection scheme.
- Use GPS or IRIG-B module for time tagging of samples, which allows RED670 to be used in switched networks with unequal channel delays.
- Use the echo-synchronization method for channels with stable and equal delays in both directions without time tagging of samples via GPS.

RED670 IEDs can also provide additional logic in the direct transfer trip schemes to minimize the risk of unwanted operation caused by a false signal in protection communication. Several different protection functions can be used as local criteria when configuring the logic for a specific application. Furthermore, the line differential protection function offers additional local criteria, such as phase-to-phase current variation. This ensures correct operation of the IED in case data is lost due to frequent failures in protection communication. Consequently, the protection system security is maintained, and the risk of interruption in electricity supply to customers is reduced.

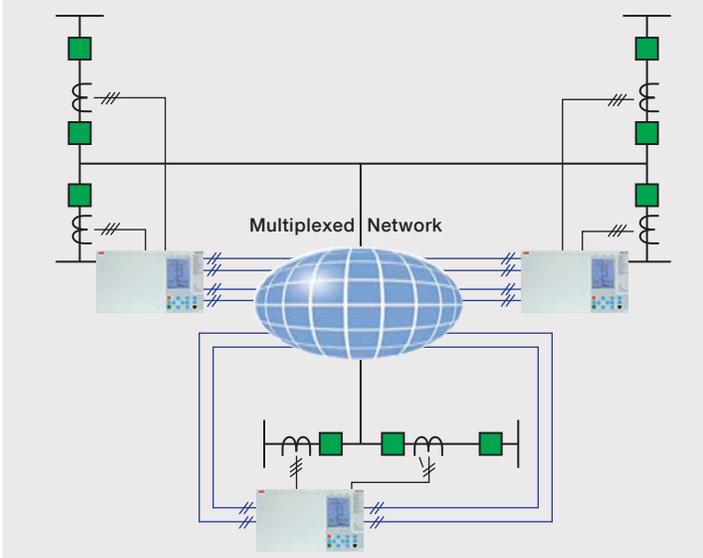
### Fast and efficient system integration

RED670 IEDs are more than just devices. They utilize ABB’s unique connectivity package concept, which simplifies the system engineering and reduces the risks of errors in system integration. This package contains a complete description of the specific IED, consisting of data signals, parameters, addresses and IED documentation.

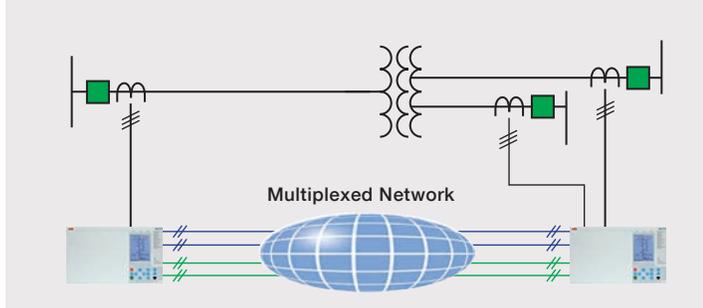
The signal data is configured automatically based on the information provided by the connectivity package to efficiently integrate the IEDs in ABB’s MicroSCADA Pro automation system.

Relion 670 series IEDs support IEC 62439 standard redundant communications on the station bus. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds’ recovery time in case of

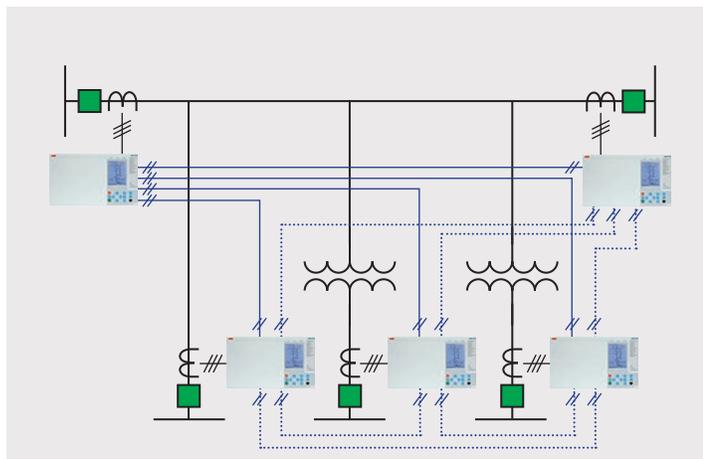
## Application examples



RED670 in three-terminal line application with individual phase current exchange.



RED670 for line and three-winding transformer application with individual phase current exchange and redundant communication.



RED670 for five-terminal line application in master-master or master-slave operating mode.

communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.

The supervision of communication links provides real-time status information about both communication links individually. If a failure occurs, an alarm is sent to the IED HMI and the substation automation system. This also allows for maintenance of the station bus while it is in operation. Thus, redundant communication further improves personnel safety and ensures that the necessary information about the system is available for operators in all situations.

Relion 670 series IEDs can also support synchronized sampled measured value communication over the process bus using IEC 61850-9-2 LE which replaces conventional wiring between the process and the secondary system. This enables new design of substations. For example, utilization of sensor technology eliminates problems caused by, for instance, CT saturation and EMC influence. Furthermore, extensions and maintenance of substations can be completed more efficiently as fiber-optic cables are used instead of copper wires.

670 series IEDs allow you to mix conventional wiring and fiber-optic communication with IEC 61850-9-2 LE in a single IED. This way you can shift from conventional wiring for analog data to fiber-optic-based communication for synchronized sampled measured values step by step.

# Transformer and substation applications

## Transformer protection & control (RET670/650)

The RET670/650 IEDs provide fast and selective protection, monitoring and control for all types of transformers, such as two and three-winding transformers and step-up transformers in power stations. In addition, RET670 offers state-of-the-art protection for autotransformers, phase shifting transformers and shunt reactors including switching control. With up to six three phase restraint current inputs into differential protection, it allows for multi-breaker substation arrangements on any transformer side. The advanced RET670 and RET650 communication capabilities allow you to integrate these IEDs into your substation automation system or use them as stand-alone multifunctional units.

The transformer protection IEDs offer several solutions for voltage control. Voltage control can be integrated in the same IED together with differential protection function and back-up protection functions, or as a separate stand-alone voltage control unit. The advanced voltage control functionality of RET670 is capable of handling single and up to eight parallel transformers in any combination of parallel groups. RET650 is capable of handling single and up to four parallel transformers.

Application flexibility ensures a future-proof investment and makes them an excellent choice for both new and retrofit installations. The integration of the main protection and a wide range of back-up protection functions within these IEDs improve

your power system performance. It also reduces engineering and installation time, space and spare parts requirements.

### RET670 – maximum flexibility and performance

The RET670 IEDs provide customized or pre-configured protection solutions for any type of transformer and shunt reactor application. The customized RET670 gives you the freedom to select functionality entirely according to your needs. The pre-configured RET670 variants simplify handling since the basic functionality is included and pre-configured. If needed, you can add optional functions to increase the functionality of the pre-configured RET670 IEDs to meet the specific requirements of your transformer or shunt reactor.

### Intelligent protection investment

You can also protect and control several objects with a single RET670 IED. For instance, a single RET670 IED can integrate complete protection and control functionality for a transformer and a connected transmission line. The distance protection function can also be used as back-up protection for faults. The four step negative sequence overcurrent protection can serve as back-up protection for most faults. It can also serve as the main protection for earth faults and other unsymmetrical faults.

The advanced logic capabilities and multipurpose protection function of the RET670 allow you to design special applications. These include automatic operation of disconnectors and



load transfer logic for a double busbar, and special protection applications. The logic can be easily generated, tested and commissioned with the help of the graphical engineering tool.

#### Advanced voltage control

Tap changer control functions include line drop compensation and a load shedding function based on voltage reduction. RET670 IED's tap changer position monitoring with mA- or BCD-signals enables supervision of the correct tap changer operation.

For parallel operating transformers, the RET670 and RET650 IEDs can utilize the minimum circulating current principle, ensuring the correct split of reactive power flow between each transformer in accordance with its rating. Using the average measured voltage between the IEDs within each group of transformers ensures the correct tap changer control. This also allows easy and efficient supervision of VTs. Alternatively the master-follower principle can be used for transformers with similar characteristics. Automatic control for a hot-stand-by transformer can also be included.

The RET670 IED can be equipped with integrated advanced voltage control functionality for single and up to eight parallel transformers in any combination of parallel groups. RET650 provides integrated voltage control for single/parallel transformers. The dedicated voltage control variant of RET650

is capable of handling two parallel operating transformers including back-up protection.

#### The right information for the right action

The integrated HMI of RET670 and RET650 provide you with a quick overview of the status of the substation with position indications and service values. Using a library of symbols, you can easily configure the graphical display to correspond to your needs and to your substation. The built-in disturbance and event recorders provide you with valuable data for postfault analysis and corrective actions to increase the security of your power system.

RET670/650 also features functions for local and remote apparatus control on all sides of the transformer. Secure bay- and station-wide interlocking allows you to avoid dangerous or damaging switchgear operations and to ensure personnel safety. The large HMI allows for local control and instant access of important data, such as settings, events and disturbance information. You can locally control and visualize up to 30 primary apparatus with one RET670/650 IED.

The two-position versatile switch and 32-position selector switch functions of RET670/650 enable you to easily manage switching operations via an icon on the IED HMI. The versatile switch function allows you to directly change, for instance, a voltage control function from manual to automatic mode. The



# Transformer and substation applications

## Transformer protection & control (RET670/650)



function also presents an indication of the selected position. The selector switch can replace an external mechanical selector switch and allows you to directly select the position you desire. In addition these switch functions can be also operated from a remote control system.

The HMI of RET650 features 15 dynamic three-color status indication LEDs on up to three pages, which is useful in maintenance and operation routines. It also has five configurable push-button shortcuts that can be used for different actions.

### Optimized utilization of transformers

The monitoring functionality of the RET670 and RET650 IEDs provides important information about the state of the transformers to an operator. The RET670 IEDs receive information about the transformer temperature and issue an alarm, log the event and trip if needed. This gives the operator time to disconnect the transformer in case of an overload during network emergency conditions. Early actions prevent forced ageing and prolong the transformer lifetime. The information about temperature can also be used to control the cooling system of the transformer.

### Fast and efficient system integration

The RET670 and RET650 IEDs are designed for IEC 61850, implementing all aspects of this standard and ensuring open, future-proof and flexible system architectures, with state-of-the-art performance. They utilize ABB's unique connectivity package concept, which simplifies the system engineering and reduces the risks of errors in system integration. A connectivity package contains a complete description of the specific IED, consisting

of data signals, parameters, addresses and IED documentation. The signal data is configured automatically based on the information provided by the connectivity package to efficiently integrate the IEDs into ABB's MicroSCADA Pro automation system.

Relion 670/650 series IEDs support IEC 62439 standard redundant communications on the station bus as per IEC 61850 standard. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds' recovery time in case of communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.

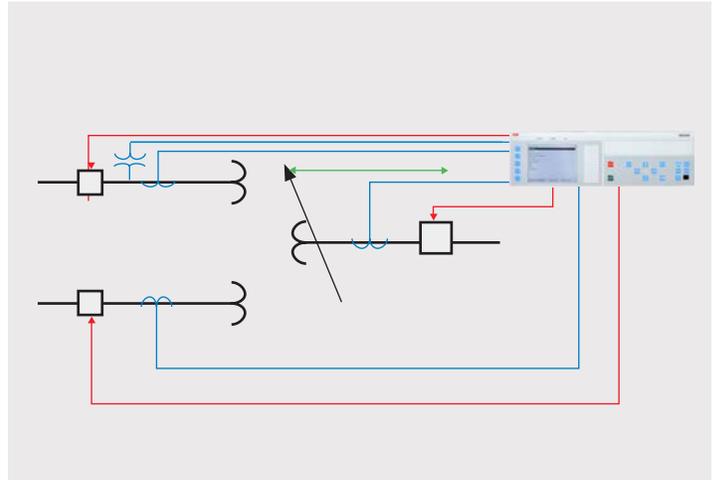
The supervision of communication links provides real-time status information about both communication links individually. If a failure occurs, an alarm is sent to the IED HMI and the substation automation system. This also allows for maintenance of the station bus while it is in operation. Thus, redundant communication further improves personnel safety and ensures that the necessary information about the system is available for operators in all situations.

Relion 670 series IEDs can also support synchronized sampled measured value communication over the process bus using IEC 61850 9-2 LE which reduces wiring between the secondary system. This enables new design of substations. For example,

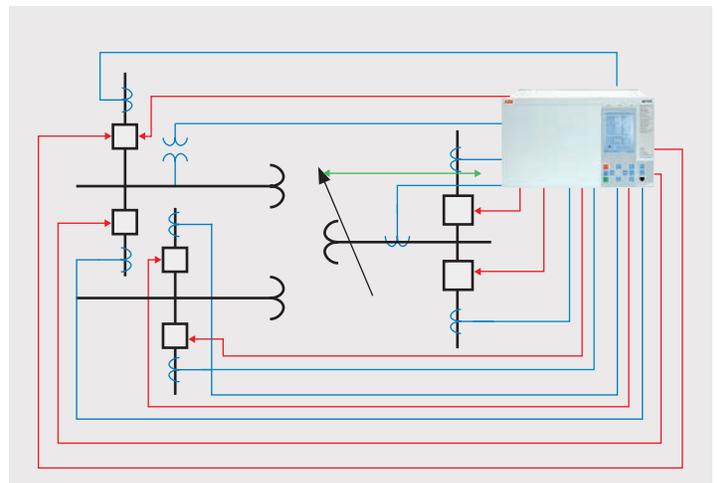
utilization of sensor technology eliminates problems caused by, for instance, CT saturation and EMC influence. Furthermore, extensions and maintenance of substations can be completed more efficiently as fiber-optic cables are used instead of copper wires.

670 series IEDs allow you to mix conventional wiring and fiber-optic communication with IEC 61850-9-2 LE in a single IED. This way you can shift from conventional wiring for analog data to fiber-optic-based communication for synchronized sampled measured values step by step.

### Application examples



RET650 provides complete protection and control for two- and three-winding power transformers.



RET670 ensures enhanced through-fault stability for multibreaker arrangements

# Bus and breaker applications

## Bus protection & control (REB670)

The REB670 IED features excellent application flexibility. It is designed for the protection and monitoring of busbars, T-connections and meshed corners from medium to extra high voltage levels. With its extensive I/O capability, REB670 protects single and double busbars with or without transfer bus, double circuit breaker or one-and-half circuit breaker arrangements.

The REB670 IED provides selective, reliable and fast fault clearance for all types of internal phase-to-phase and phase-to-earth faults in solidly earthed or low impedance earthed power systems. It can also handle all internal multi-phase faults in isolated or high-impedance earthed power systems.

REB670 features complete busbar protection, which in addition to differential protection includes flexible dynamic zone selection (disconnecter replica) integrated in one IED.

This enables dynamic CT connections to differential zones, as well as selective busbar and breaker failure tripping, disconnecter and circuit breaker status supervision. Due to its unique measuring principle, this IED has very low CT requirements compared to other numerical differential protection devices.

### In-depth busbar protection knowledge

The REB670 IED continues ABB's strong track record in busbar protection, starting from analog busbar protection relays INX2/5, RADSS, REB 101/103. So far, these relays have been successfully installed for over 40 years. ABB also has more than 10 years of experience of numerical busbar protection based on REB500 and RED521. All these devices have shown an impressive track record with no false operation due to incorrect IED functioning. Today, more than 20 000 zones equipped with ABB busbar protection are in service throughout the world.



### Always the correct behavior

REB670 is fast and stable simultaneously – such a unique combination is essential for effective busbar protection. This IED features extremely short operate time, typically 12 ms, for most internal faults, regardless of the number of connected feeders. At the same time, it maintains complete stability for external faults, even when heavy CT saturation occurs. It also has very low CT requirements compared to other numerical differential protection devices due to its unique measuring principle, which allows the sharing of CT circuits with other protection relays and thus saves costs. The low CT requirements guarantee stability and correct operation as long as the CT is not saturated for at least two milliseconds during each power system cycle. Furthermore, the REB670 provides superior sensitivity to internal faults, thus protecting your power system objects from extensive damage and long repair times. Additionally, it effectively recognizes and operates correctly for all types of evolving faults.

### Optimized performance

The REB670 IED features multiple algorithms in a single device. It features two differential protection functions: one basic and one with a sensitive operational level. The latter is able to detect internal busbar earth faults in low impedance earthed power systems, where a neutral point reactor or resistor limits the earth-fault current typically from 300A to 2000A. In addition, you can utilize the sensitive operation level when energizing the bus via long line, since this requires high sensitivity from busbar differential protection.

The innovative and fast measuring algorithm detects and prevents incorrect operation during open CT circuits. The supervision of open CTs of the IED allows you to design reset logic for the automatic re-start of the IED when the CT is re-connected. This supervision functionality can also generate alarms and trigger the disturbance recorder.

The integrated overall check zone feature can be used in double busbar stations to secure stability of the busbar differential protection in cases where status indication of a busbar disconnecter is entirely wrong in any of the feeder bays.

REB670 integrates zone selection functionality into a single IED and therefore no external equipment for CT switching and busbar protection trip routing is needed. The flexible zone selection allows automatic linking of CTs to the actual differential protection zone at any time.

REB670 provides maximum safety for your substation personnel in a fault situation. It also allows you to easily take a bay out of service for maintenance, and yet keep the busbar protection in operation during the maintenance period. You can disconnect the bay via the IED HMI or a selector switch. To sum up, REB670 is the most reliable solution for protecting the most precious assets of your power system: the most essential objects and your people.

REB670 is designed for IEC 61850, implementing all the aspects of this standard and thus ensuring open, future-proof and flexible system architectures, with state-of-the-art performance.

### Easy to handle

The REB670 IEDs are delivered pre-configured, type tested and with default parameters for easy handling of products– from ordering, engineering and commissioning to reliable operation. These IEDs are equipped with complete functionality adapted for three different configuration alternatives in three- and one-phase variants. They can be applied for differential protection of busbar sections from four up to 24 CT inputs. All variants have two low-impedance differential protection zones and check-zone. You can use the graphical configuration tool Protection and Control IED Manager PCM 600 to easily and intuitively adapt the pre-configured REB670 IEDs to your specific busbar arrangement. The integrated large HMI provides a quick overview of the magnitude and phase angle of all individual bay currents. It also presents the magnitude of differential and total through-load currents, bay CT connections towards two differential zones and check-zone. You can also access information about the actual status of primary switchgear objects, as well as trip signals and open CT indications. All this facilitates fast and efficient commissioning and consequently correct behavior of the busbar protection.

The two-position versatile switch and the 32-position selector switch functions enable you to easily manage switching operations via an icon on the IED HMI. The versatile switch function allows you to directly enable, for instance, the bay out of service feature or to directly disable a whole differential zone. The switch function also presents an indication of the selected position.

The selector switch can replace an external mechanical selector switch and allows you to directly select the position you desire. In addition to the IED HMI, these switch functions can be operated from a remote system.

# Bus and breaker applications

## Bus protection & control (REB670)

### Cost-efficient extensions

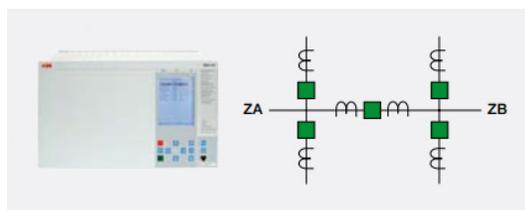
You can easily integrate extension bays into your existing REB670 IED. The station extensions can be done bay-by-bay without any software or hardware modifications within the protection IED. For instance, if you have a nine-bay station you can, by ordering a 12-bay variant, have everything included and prepared for all 12 bays. Thus, when extending your substation, all you need to do is to connect the wiring for the new bays and enable relevant functionality in the REB670 IED.

### Save space and money

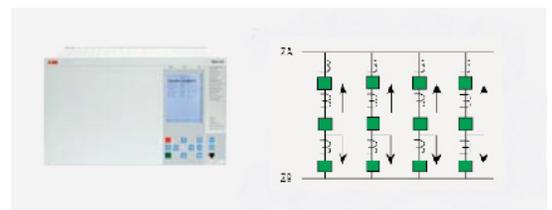
REB670 provides complementary integrated functionality in a single device. The integrated breaker failure protection for all breakers in any type of station layout allows easy implementation of complete back-up protection.



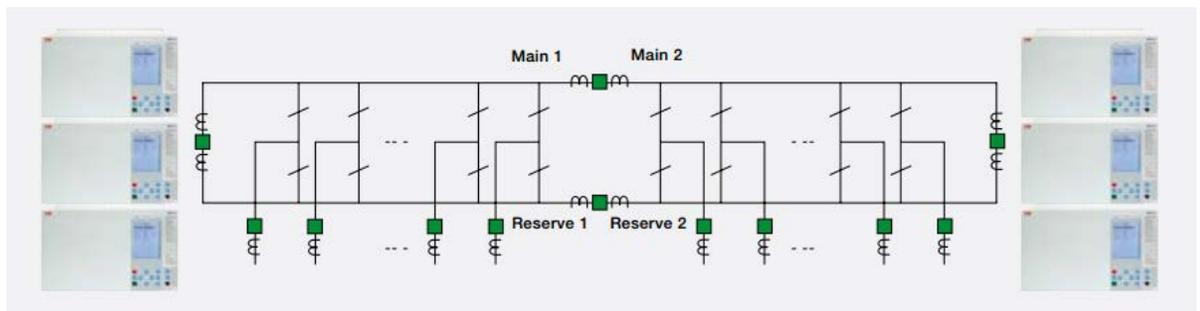
### Application examples



H-type station.



1 1/2 breaker stations.



Double busbar – single breaker station with two bus-coupler CBs and two bus-section CBs.



Furthermore, overcurrent protection provides back-up protection for feeders. This function can also be applied for end-fault protection, i.e. detecting short-circuits between the feeder circuit breaker and feeder CT when the circuit breaker is open. This functionality together with the communication capabilities of REB670 allows for the sending of a fast overcurrent trip signal to the remote end, thus preventing a trip from the busbar differential protection function.

The autoreclosing function provides delayed three-pole autoreclosing. This function can be used for delayed busbar restoration after busbar protection operation.

#### **Fast and efficient system integration**

Fast and efficient system integration REB670 IEDs are more than just devices. They utilize ABB's unique connectivity package concept, which simplifies system engineering and reduces the risk of errors in system integration. This package contains a complete description of the specific IED, consisting of data signals, parameters, addresses and IED documentation.

The signal data is configured automatically based on the information provided by the connectivity package to efficiently integrate the IEDs into ABB's MicroSCADA Pro automation system.

Relion 670 series IEDs support IEC 62439 standard redundant communications on the station bus. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds

recovery time in case of communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.

The supervision of communication links provides real-time status information about both communication links individually. If a failure occurs, an alarm is sent to the IED HMI and the substation automation system. This also allows for maintenance of the station bus while it is in operation. Thus, redundant communication further improves personnel safety and ensures that the necessary information about the system is available for operators in all situations.

REB670 is a member of the Relion protection and control product family and is suitable for most bus protection applications. It is also possible to utilize the high impedance differential schemes and the transformer differential protection for bus differential protection and T-connections in, for example, ring bus with a power transformer connection. Additionally, ABB can provide REB500, a distributed bus protection with extended capabilities for complex and large substation arrangements. REB500 version 8.0 will be based on the Relion 650 platform and utilize the same tools as the Relion family.

# Bus and breaker applications

## High impedance differential bus protection & control (REB650)

**ABB offers a unique and compact solution for high impedance differential protection. The numerical busbar protection REB650 IED provides its users with a wide variety of application opportunities. Designed primarily for the protection of single busbars with or without sectionalizers in high impedance based applications, it also offers high impedance differential protection for generators, autotransformers, shunt reactors and capacitor banks. Its I/O capability allows you to protect up to three 3-phase high impedance differential protection zones with a single IED.**

REB650 ensures fast fault clearance for all types of internal phase-to-phase and phase-to-earth faults in solidly earthed or low impedance earthed power systems. It can also handle all internal multi-phase faults in isolated or high impedance earthed power systems.

### **REB650 – ease of use from ready-to-use solutions**

REB650 offers an optimum 'off-the-shelf' ready-made solution for applications requiring high impedance differential protection.

The type tested REB650 is delivered equipped and configured with complete protection and control functionality, and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation.

The 650 series IEDs introduce a number of innovations, such as a significantly reduced number of parameter settings and extended HMI functionality, including 15 dynamic three-color indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions. In the 650 series, most basic parameters are set before delivery from the factory. You only need to set the parameters specific to your application. This allows you to quickly take your IEDs into operation. The application manual includes setting examples to support your protection engineers.

The REB650 IED continues ABB's strong track record in high impedance differential busbar protection applications, starting from analog relay RADHA and other similar relays from previous generations. To date, these relays have been successfully serving utilities for over 50 years.

### **Unique functional integration**

One REB650 is able to handle several high impedance differential protection zones. For instance, you can use it for one or up to three zones depending on your application. You can also utilize it to combine two main zones and a check zone in a single IED.

Among its top-notch features, REB650 incorporates complementary protection functionality consisting of versatile

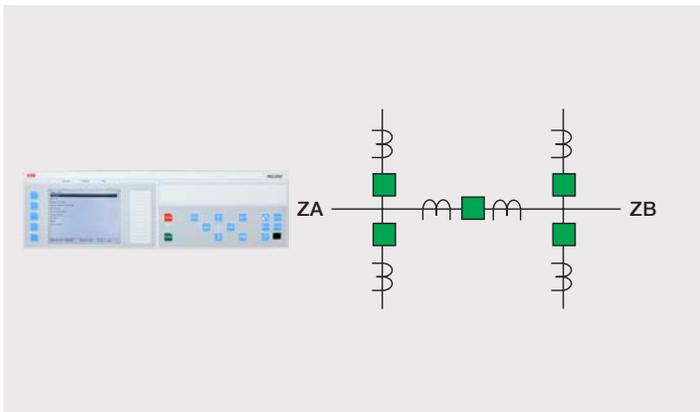




current and voltage protection functions. These functions can be used independent of the high impedance differential protection. Thus, one REB650 can integrate all protection functionality needed for a bus coupler. If required, the busbar protection operation can be released using the integrated phase undervoltage or residual overvoltage protection functions as an additional tripping criterion.

The users of REB650 will also benefit from the powerful integrated disturbance recorder that stores up to 100 disturbances. The pickup settings made directly in CT secondary volts reduce the need for re-calculating the current pickup and resistor values. This is another fact that contributes to taking the IED into operation faster than ever before.

### Application examples



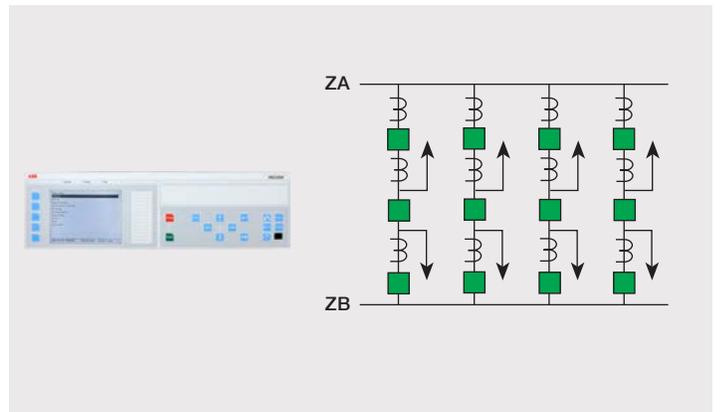
H-type station.



### Designed to communicate

Relion 650 series IEDs support IEC 62439 standard redundant communications on the station bus as per IEC 61850 standard. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). In addition, REB650 features several communication protocols, such as IEC 61850-8-1.

It utilizes ABB's unique connectivity package concept, which simplifies the system engineering and reduces the risks of errors in system integration. A connectivity package contains a complete description of the specific IED, consisting of data signals, parameters, addresses and IED documentation. The signal data is configured automatically based on the information provided by the connectivity package to efficiently integrate the IEDs in ABB's MicroSCADA Pro automation system.



1 1/2 breaker stations.

# Bus and breaker applications

## Breaker protection & control (REQ650)



**Breaker protection REQ650 provides a standalone solution for applications where the integration of the breaker failure protection or automatic reclosing function into the main line protection IED (Intelligent Electronic Device) is not preferred or suitable. This IED also offers local back-up protection, synchronizing, synchrocheck and energizing check functionality to enable well-structured and reliable protection for various applications.**

REQ650 provides you with an ideal protection and control solution for circuit breaker connected objects. The breaker failure protection allows for high speed back-up tripping of surrounding breakers, and re-tripping of the own breaker in any single breaker busbar arrangement, for instance to avoid operational mistakes during testing. This function is essential in substations that require local back-up protection. Breaker protection REQ650 is also the perfect choice for refurbishment projects where old protection relays need to be replaced.

### **Versatile application opportunities**

With its compact design and versatile functionality, REQ650 provides its users with a wide range of application opportunities.

For your existing protection systems, REQ650 enables an easy and cost-efficient way to replace remote back-up protection with local back-up protection. The original main protection can remain in operation, while one REQ650 IED installed in parallel offers the necessary back-up functionality. At the same time, the integrated disturbance recorder helps you improve your disturbance information handling.

In new substations, REQ650 enables cost-efficient back-up functionality when only basic protection and control is required. In a line bay, the phase overcurrent protection and residual overcurrent protection of REQ650 with voltage, current or dual polarization, based on zero sequence or negative sequence quantities delivers back-up for the line distance protection, provided by REL670 and REL650, for instance.

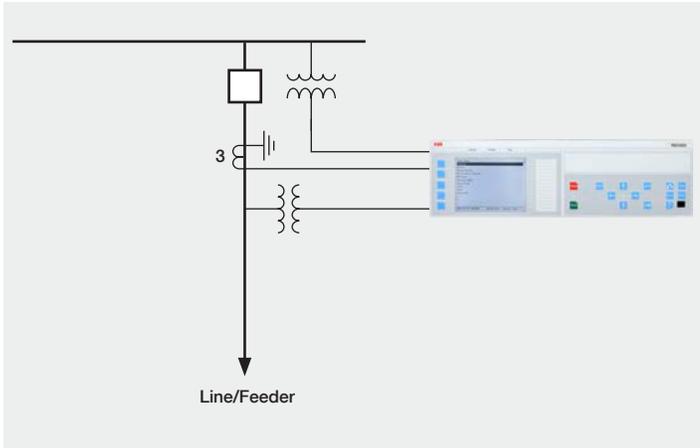
The breaker failure protection of REQ650 enables complete protection redundancy for the bay. Additionally, a number of other voltage- and current-based protection functions are available for applications where electricity supply within a specified voltage limit is critical, such as in industrial processes. With its automatic reclosing and synchrocheck functions, REQ650 provides independent back-up functionality for the main line distance protection IED. It also offers independent back-up for transformer and shunt capacitor bay applications.

In double-busbar configurations, REQ650 provides breaker failure protection as well as phase and residual overcurrent functions to split busbar sections in case of heavy and critical faults. This allows for fast fault clearance to minimize damage in the substation. In meshed networks with radial lines, REQ650 can provide main protection including control functionality for the radial lines.

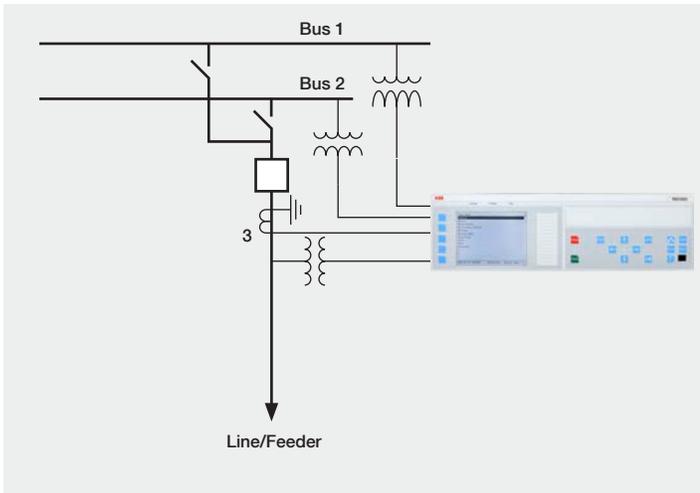
### **Long life with high availability**

In aging installations, the remaining lifetime of existing protection equipment often varies considerably. In such cases a partial replacement and retrofit can provide a solution that saves both time and money.

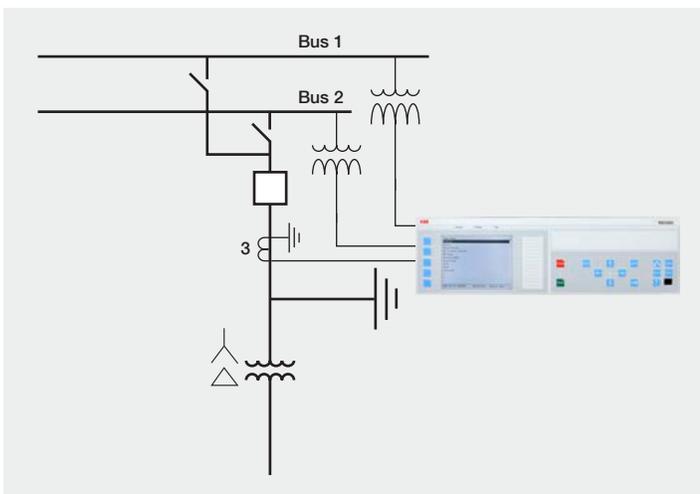
## Application examples



Line bay in solidly earthed network, connected to single busbar switchyard.



Line bay in solidly earthed network, connected to double busbar switchyard.



Transformer bay in solidly earthed network, connected to double busbar switchyard.

In partial replacement the old, unreliable relays in line protection applications can be replaced with one REQ650 and combined with your well-functioning existing relays. You can also replace the breaker failure protection relay – often the weakest link in a well-functioning busbar protection system – with one REQ650 per bay. A number of valuable additional functionalities are now available, including extensive back-up protection functionality, basic control functionality and a disturbance recorder.

The communication capabilities of REQ650 allow transfer of data to your control center. REQ650 supports IEC 62439 standard redundant communications on the station bus as per IEC 61850 standard. This ABB solution utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). The REQ650 increases both availability and life of an aging protection system.

REQ650 offers optimum 'off-the-shelf', ready-made application solutions for the protection and control of circuit breaker connected objects. The type-tested variants are delivered equipped and configured with complete protection functionality, and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation.

The 650 series IEDs introduce a number of innovations, such as a significantly reduced number of parameter settings and extended HMI functionality including 15 dynamic three color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions. In the 650 series IEDs, most of the basic parameters are set before delivery from the factory. You only need to set the parameters specific to your application. The parameters related to the protected object are set as primary values, which significantly reduces the need to recalculate the current and voltage values, allowing the IEDs to be quickly put into operation. The application manual includes setting examples to support the protection engineer.

# Generating station applications

## Generator protection & control (REG670/650)

Based on ABB's extensive experience, REG670 and REG650 IEDs (Intelligent Electronic Device) take generator protection to a new performance level that ensures unrivalled selectivity and sensitivity. REG670/650 provide protection and monitoring for generators, prime movers and step-up transformers in hydro, pump-storage, gas, diesel, combined-cycle, steam, nuclear, cogeneration and renewable power stations. With excellent performance, flexibility and scalability, they fulfill the demanding requirements of both new and retrofit installations – in every corner of the world.

A generator protection system with REG670/650 meets the requirements for maximum dependability and availability. The differential protection internal/external fault discriminator is based on negative sequence current values, enabling fast and selective decision to operate. The unique main protection functions are able to selectively detect and clear all fault types

over 100% of the stator winding. The detection criteria can be used to create intelligent, application-specific functions to enhance your protection system, enabling it to meet very specific requirements, for instance, when the operating conditions of the plant change.

REG670/650 place low requirements on instrument transformers, which, together with the fast and accurate protection functions, reduces primary equipment demands and investment costs.

### REG670 – for any type and size of generator and generator-transformer unit

REG670 IEDs provide customized and pre-configured protection solutions for any type of generator and block connected generator-transformer unit. Due to its unique capabilities it is especially suitable for protecting large turbo and hydro units including pump-storage power plants.



The pre-configured and type-tested IEDs simplify the handling of products – from ordering, engineering and commissioning, to reliable operation. If needed, additional I/O boards, communication options or application functions can easily be added to meet the specific requirements of your generating station. Furthermore, several instances of protection functions are readily included in the REG670 IEDs, and you only need to set parameters related to the power system objects during commissioning.

The pre-configured REG670 variants simplify handling since the basic functionality is included and pre-configured. If needed, you can add optional functions to increase the functionality of the pre-configured REG670 IEDs to meet the specific requirements of your power plant. The customized REG670 gives you the freedom to select functionality entirely according to your needs.

The generator differential protection of REG670 features extremely fast detection criteria, with a typical operate time of 15 ms – and yet the IED maintains high security. The transformer differential protection integrated in REG670 provides extremely fast differential protection with automatic ratio matching and vector group compensation. Additionally, it takes the tap-changer position into consideration for optimized sensitivity. Utilizing the same transformer differential protection used in Transformer protection RET670 allows REG670 to be a complete protection solution for generator-transformer units.

#### Unique functional integration

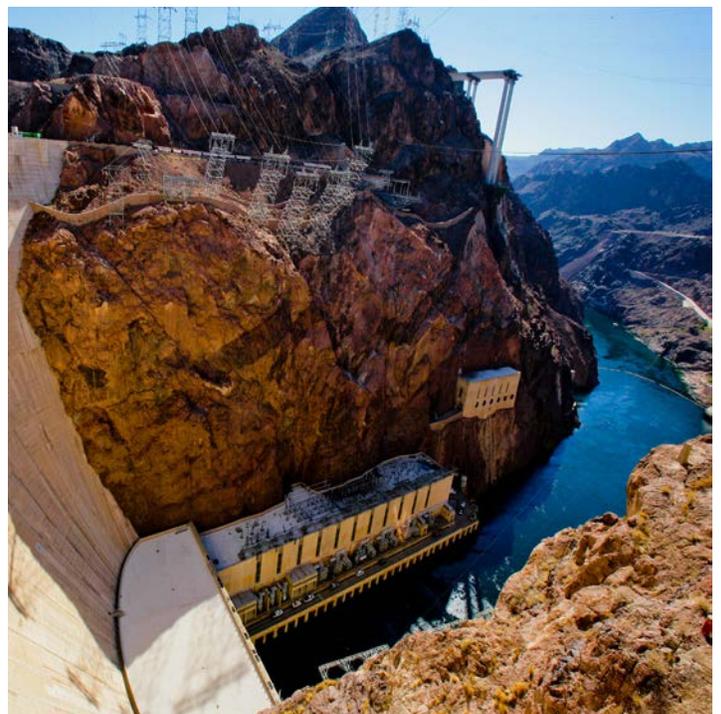
REG670 integrates parallel algorithms with advanced logic and communication. Up to 24 analog inputs permit integration of main and back-up protection in one IED. This allows you to protect several objects with a single REG670 IED. For instance, by integrating several differential protection functions, one single REG670 IED can protect a complete generator-transformer unit. The under impedance protection function can also be used as back-up protection for faults within the unit or external faults in the power network.

Alternatively, additional objects, such as transformers, can be included in the generator protection scope. This enables full duplication of the protection in main one and main two. All this reduces the number of IEDs needed to protect the entire generating station, increasing availability at the same time. The selector switch can replace an external mechanical selector switch which allows you to directly select the position you desire. In addition, these switch functions can be operated from a remote control system.

#### Versatile communication capabilities

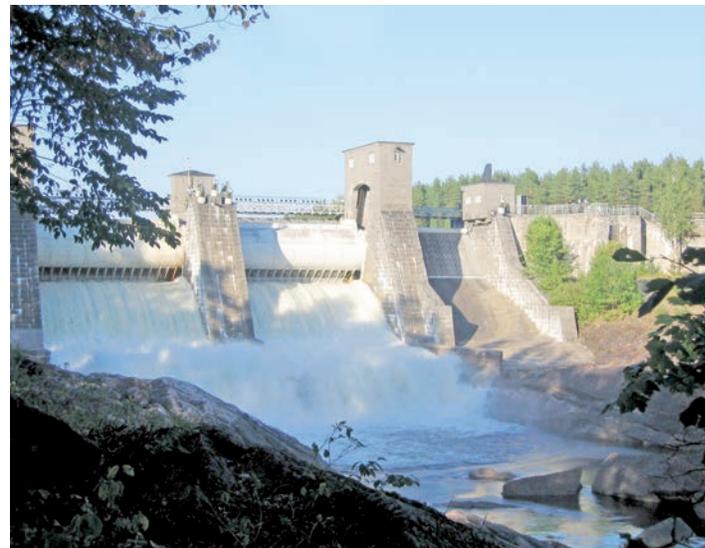
REG670/650 IEDs allow you to use several communication protocols in parallel to communicate with the plant control system, monitoring system or relay protection engineering office. They are designed for IEC 61850, implementing all aspects of this standard and thus ensuring open, futureproof and flexible system architectures, with state-of-the-art performance. These capabilities also provide new opportunities for utilizing signalling and tripping schemes in generator protection. Additionally, they enable the transfer of binary and analog data to any subscriber.

Relion 670/650 series IEDs support IEC 62439 standard redundant communications on the station bus as per the IEC 61850 standard. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds' recovery time in case of communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.



# Generating station applications

## Generator protection & control (REG670/650)



The dedicated measurement class input current transformers of REG670 enable detection of power level down to 0.5% of the unit rated power, which ensures accurate reverse power protection in steam-turbine applications.

In demanding applications, such as pump-storage plants, the unit has several operating modes: generating, pumping, starting or breaking. In such applications, the protection IED needs to adapt to the actual operating mode. The logical programming capability of the REG670 allows it to automatically detect the actual operating mode of the unit and adapt its operation accordingly. The selected operating mode can be shown on the built-in IED HMI, which is useful especially during commissioning and testing.

The distance between the generator and the high voltage substation can in many cases be substantial and yet many binary signals need to be exchanged between the two locations. REG670 features a dedicated fiber optic communication link to exchange binary signals with another 670 series IED located in the high voltage substation. Up to 192 binary signals for indication, alarming and tripping purposes can be sent to both directions simultaneously.

REG670 also features injection-based 100% stator earth-fault protection and 3rd harmonic based 100% stator earth fault protection. These solutions enable a new way to optimize the cost-performance ratio of the protection system in relation to the importance or size of the generating station. The 3rd harmonic based 100% stator earth-fault protection utilizes the differential principle, which provides high sensitivity and security.

This ensures correct operation even during low load conditions.

### Stator and rotor windings protected under all operating modes

When the injection-based protection of REG670 is used, 100% of the machine stator winding, including the star point, is protected under all operating modes, even at machine standstill. The innovative filtering technique ensures high sensitivity for both stator and rotor protection, which enables early detection of faults.

Additionally, ABB's innovative implementation of the injection principle does not require any changes in the plant primary circuit because injection is always done on the secondary side of the voltage or grounding transformer irrespective of the actual grounding method used. This enables very cost-efficient design of the injection unit, and makes it very easy and fast to take the protection system into operation. Thus REG670 offers an optimum solution for large hydro and turbo machines.

A special tool module accessed via Protection and control IED manager PCM600 significantly simplifies the commissioning and operation of the injection-based stator and rotor earth-fault protection functions. Additionally, the tool module guides the user through the installation and calibration procedure to achieve sensitive protection.

At the end of the calibration process the tool verifies the

validity of the calibration parameters which ensures proper operation of the installation taking into account all the characteristics of the installation.

### **REG650 – your best choice for small and medium-sized generators**

REG650 offers optimum 'off-the-shelf', ready-made solutions, including all the required functionality for protection and control of small and medium-sized generators. With its 20 analog inputs, REG650 is one of the most compact generator protection devices on the market. This allows, for instance, the integration of overcurrent protection for excitation or auxiliary transformer, in addition to generator protection. The 3rd harmonic based 100% stator earth-fault protection utilizes the differential principle, which provides high sensitivity and security. This ensures correct operation even during low load conditions.

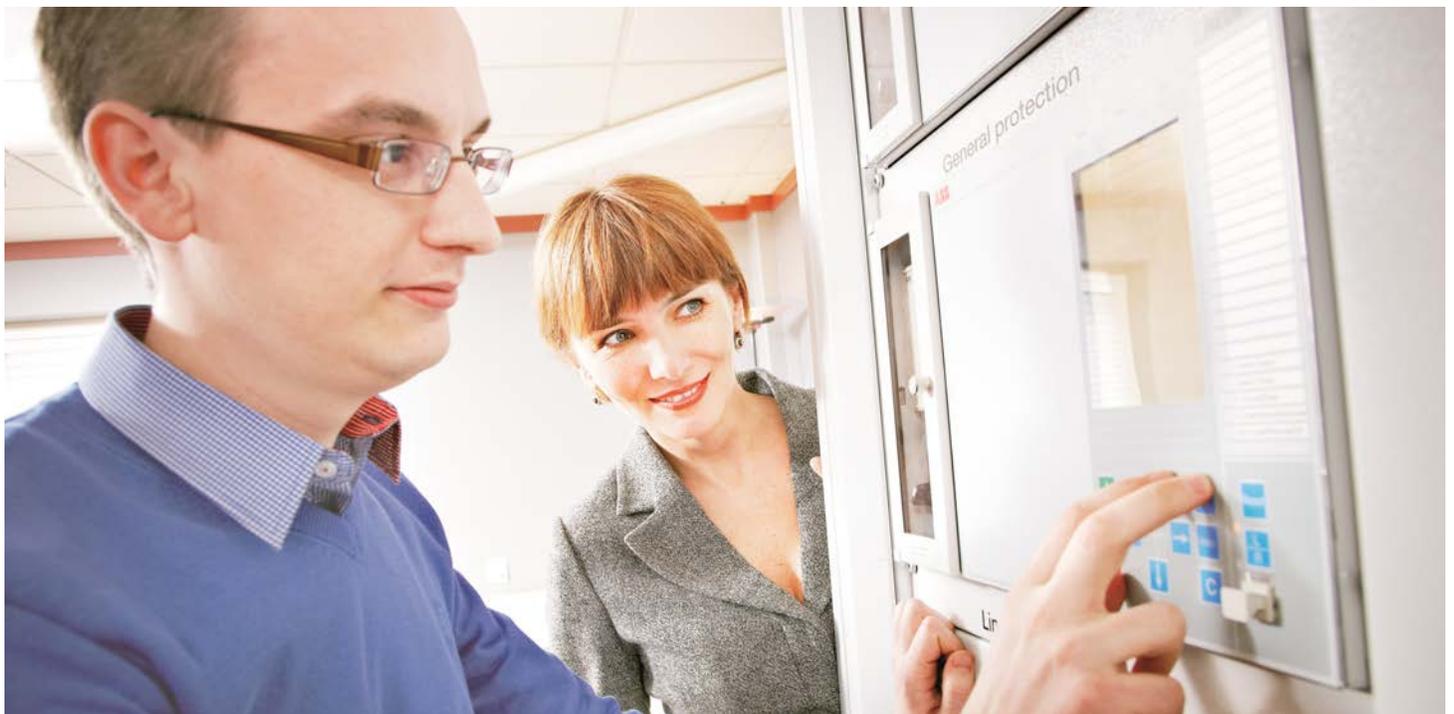
The type-tested variants of REG650 IEDs are delivered equipped and configured with complete functionality and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation. Depending on the selected variant, either low impedance generator differential protection or three winding transformer differential protection is included. Other generator protection functions are always included.

The 650 series IEDs introduce a number of innovations, such as a significantly reduced number of parameter settings and extended IED HMI functionality, including 15 dynamic three color-indication LEDs per page, on up to three pages, and five configurable push-button shortcuts for different actions. In the 650 series IEDs, most basic parameters are set before delivery from the factory. You only need to set the parameters specific to your application.

### **The right information for the right action**

The integrated HMI of REG670 and REG650 provides you with a quick overview of the status of the power plant with position indications and service values. Using a library of symbols, you can easily configure the graphical display to correspond to your needs and to your station. The built-in disturbance recorder, capable of storing data in COMTRADE format, provides you with valuable data for post fault analysis and corrective actions to increase the security of your power plant.

The two-position versatile switch and 32-position selector switch functions of REG670/650 IEDs enable you to easily manage switching operations via an icon on the IED HMI. The functions also present an indication of the selected position.



# Generating station applications

## Generator protection & control (REG670/650)

### Fast and efficient system integration

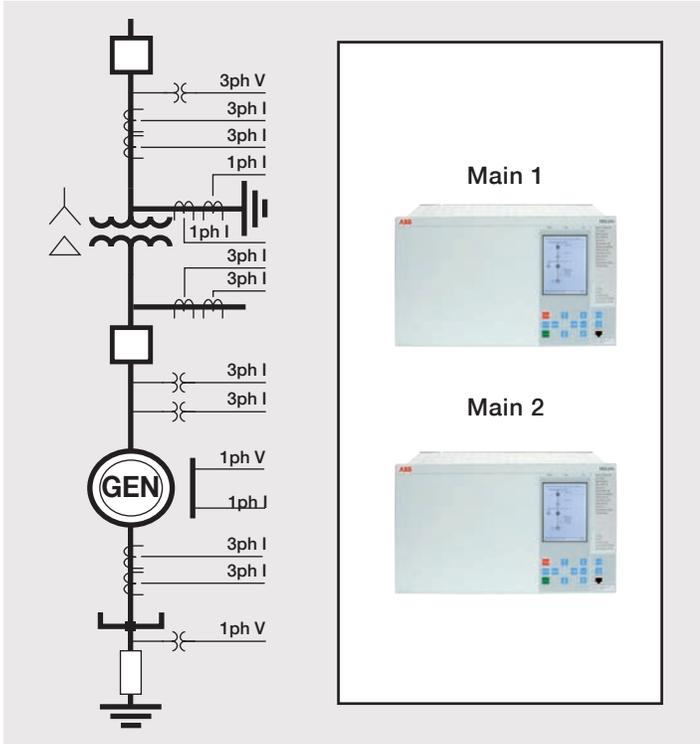
REG670/650 IEDs are more than just devices. They utilize ABB's unique connectivity package concept, which simplifies the system engineering and reduces the risks of errors in system integration. An IED connectivity package contains a complete description of the specific IED, consisting of data signals, parameters, addresses and IED documentation. Being designed for IEC 61850, it can easily be integrated in any power plant control system that is compliant with this standard.

### Relion® – Complete confidence

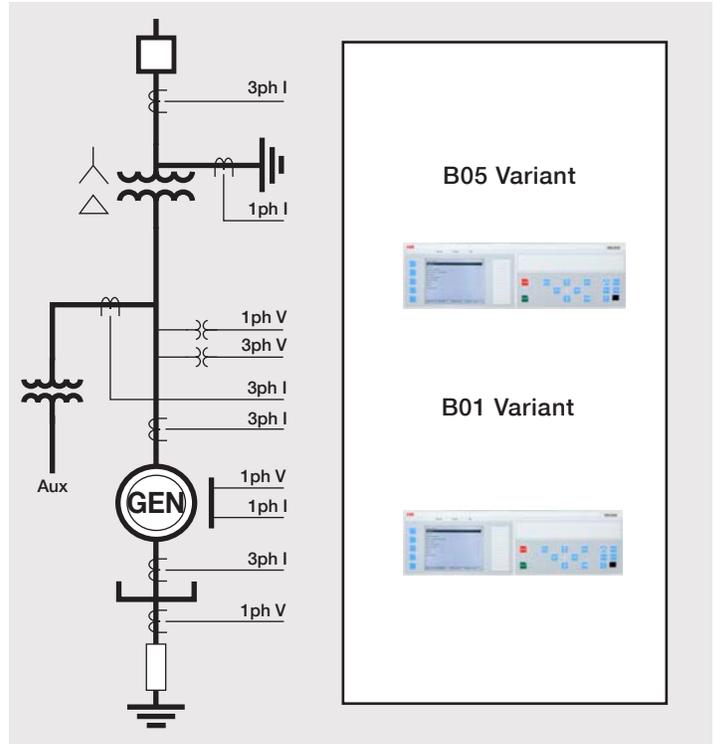
Generator protection REG670/650 IEDs are members of the Relion protection and control product family. The Relion product family offers the widest range of products for the protection, control, measurement and supervision of power systems. To ensure interoperable and future-proof solutions, the Relion products have been designed to implement the core values of the IEC 61850 standard. With ABB's leading-edge technology, global application knowledge and experienced support network, you can be completely confident that your system performs reliably – in any situation.



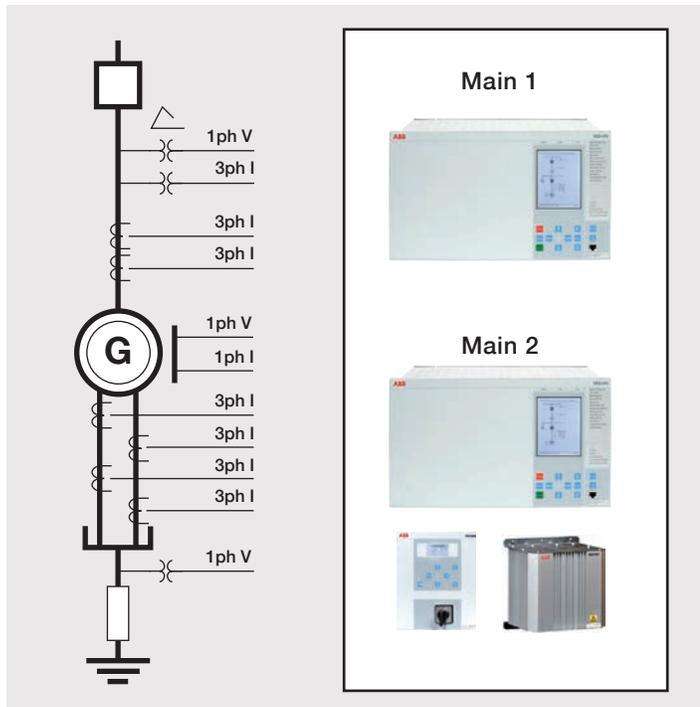
Application examples



REG670 IED with 24 analog inputs is able to protect the entire generator-transformer unit including generator differential and transformer/overall differential protection. Redundancy is obtained by duplication.



REG650 based protection scheme for medium-sized generator-transformer unit connected to a solidly earthed high voltage system.



REG670 IED with 24 analog inputs for advanced generator protection including overall differential protection, split-phase differential protection and 100% stator earth-fault protection based on injection principle. Redundancy is obtained by duplication.

# Wide area applications

## Phasor measurement unit (RES670)



For real-time and efficient wide area power system monitoring, protection and control

The RES670 IED provides power system AC voltages and currents as phasors - up to 8 analog phasors with the possibility to send positive, negative, zero sequence values or all of them. Reference for the phase angle is the Global Positioning System - GPS or IRIG-B. The high measurement accuracy of voltages and currents eliminates the need for external measurement transducers. This makes RES670 ideal to use in all types of Phasor Measurement Unit (PMU)-based applications.

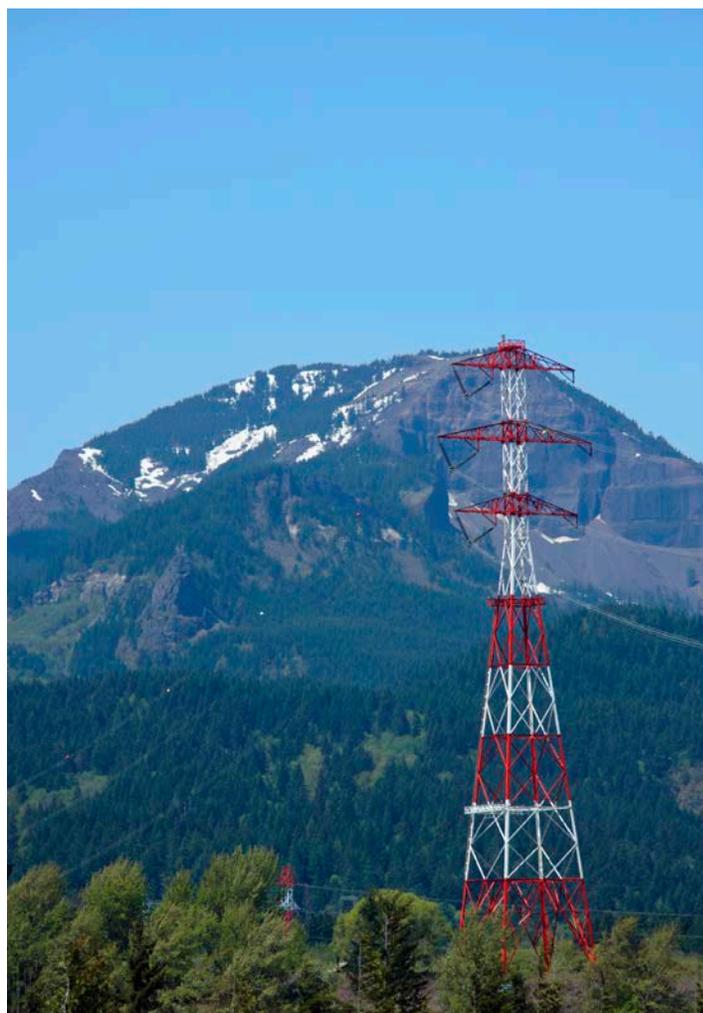
The communication capabilities of RES670 including IEEE C37.118, IEC 61850-8-1 and DNP3.0 enable easy integration of RES670 in an existing substation automation system. Further, along with the phasor data measurement functionality, several protection and control functions of the Relion® 670 series IEDs are available in RES670.

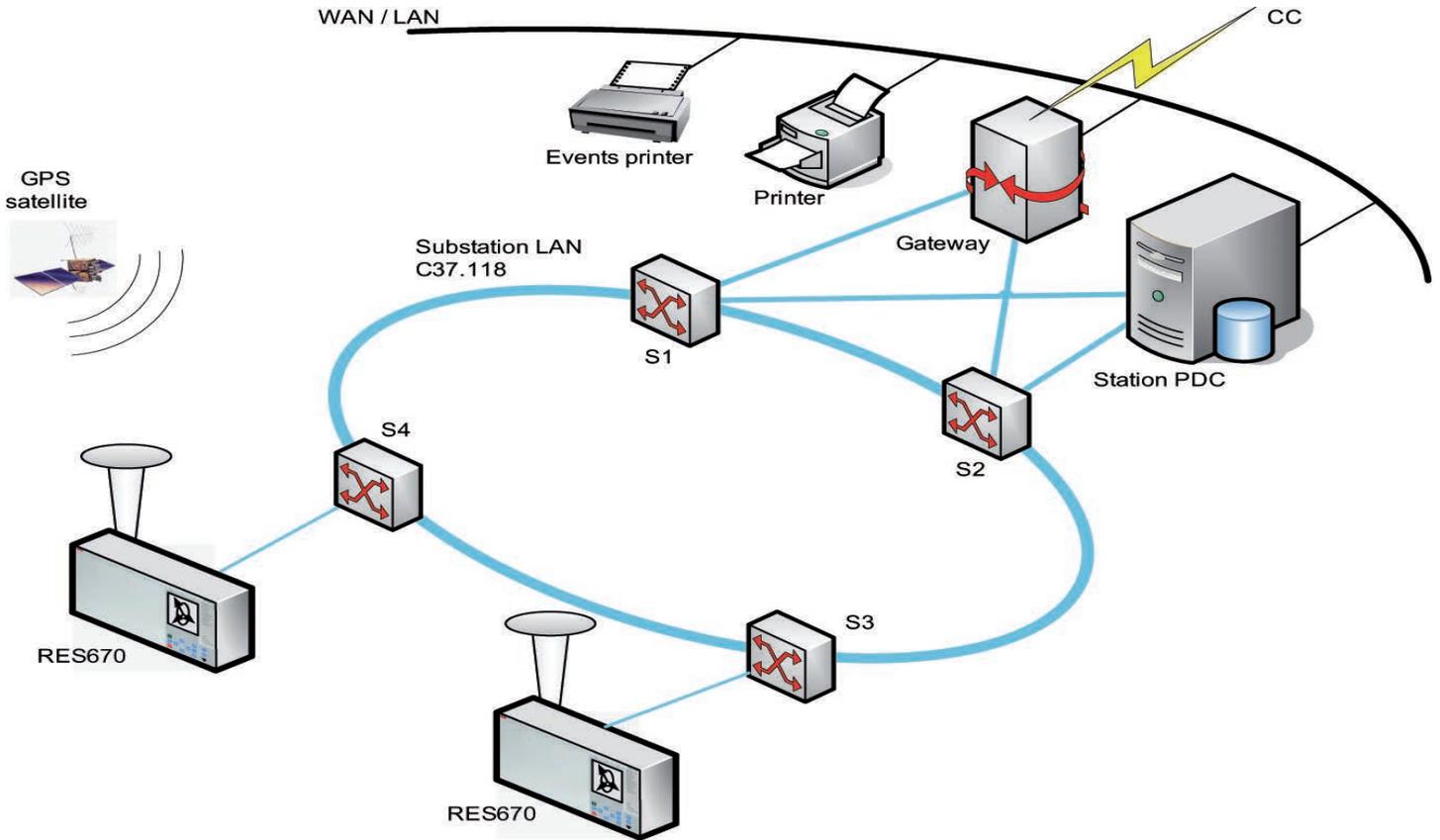
The RES670 also offers the operational flexibility for the challenges imposed by the Smart Grid applications of tomorrow.

RES670 IEDs provide customized or pre-configured measurement solutions applicable for any type of substation and substation configuration. The customized RES670 gives you the freedom to select functionality entirely according to your needs. The pre-configured RES670 variants simplify handling since the basic functionality is included and pre-configured.

### Application

RES 670 is a Phasor measurement unit that provides power system AC voltages and currents as phasors, that is as real and imaginary parts or as magnitude and phase angle. The reference for the phase angle is the NavStar Global Positioning System – GPS that also supplies highly accurate time and date. The accurate time tagging of measurements taken at different geographical locations make it possible to derive the phasor quantities. Based on phasors a number of power system applications are available. Phasor Measurement Units (PMUs) have so far been mainly used for recording and on-line supervision of Wide Area Measurement System (WAMS) applications. In a typical setup, 10-20 PMUs at different locations in a synchronized power network, streams phasor





data together with power flow data and frequency, to a data concentrator.

The data concentrator is usually a mass storage with capacity for about one week of data in a FIFO buffer. In case of any disturbance it should be very easy to access the data recorded to support the disturbance analysis process. The phasor data is normally sent from the PMU to the data concentrator at a speed of 25/30 or 50/60 samples per channel and second. The number of sampled channels is typically 10-20. Phasor data is normally understood as the magnitude and phase angle of the positive sequence voltage or current. The common reference for the angle measurement is the GPS system, which provides precise time reference. Since every measurement sent to the data concentrator is time tagged, any angle difference between power system AC quantities can be derived.

### Relion® – Complete confidence

Phasor measurement unit RES670 IED belong to the Relion protection and control product family. The Relion product family offers the widest range of products for the protection, control, measurement and supervision of power systems. To

ensure interoperable and future-proof solutions, Relion products have been designed to implement the core values of the IEC 61850 standard. With ABB's leading-edge technology, global application knowledge and experienced support network, you can be completely confident that your system performs reliably – in any situation.

# Bay control applications

## REC670/650

The REC670 and REC650 Bay control IEDs are designed for the control, monitoring and protection of circuit breakers, disconnectors, and earthing switches in different switchgear configurations. Providing extensive application options, both these IEDs are designed for IEC 61850. They implement the core values of the standard, ensuring open, future-proof and flexible system architectures, with state-of-the-art performance. The IEDs are ideal for refurbishment and extension of existing installations as well as for new installations.

### REC670 – maximum flexibility and performance

REC670 IEDs provide customized or pre-configured control solutions for any type of switchgear and for different switchgear configurations. The customized REC670 gives you the freedom to select functionality according to your needs. The REC670 variants simplify handling as the basic functionality is included and pre-configured. If needed, you can add optional functions to easily increase functionality to meet the specific requirements of your switchyard.

REC670 enables the manual control of a tap-changer from a Substation Automation system. It can also integrate advanced voltage control for transformers in a substation in a single IED. This eliminates the need for dedicated voltage control devices in

cases where the transformer protection is not equipped with voltage control.

### REC650 – ease of use from ready-to-use solutions

REC650 offers optimum 'off-the-shelf' solutions for control applications in single breaker applications in single and double busbar arrangements. For double busbar arrangements, control of a bus coupler bay is also available. The type-tested variants are equipped and configured with complete functionality, and with default parameters for easy handling of products – from ordering, engineering and commissioning to reliable operation.

The 650 series IEDs introduce a number of innovations, such as significantly reduced parameter settings and extended IED HMI functionality including 15 dynamic three-color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions. In the 650 series IEDs, all basic parameters are set before delivery from the factory. You only need to set the parameters specific to your application, such as line data. This allows the IEDs to be quickly taken into operation.

### Outstanding control capabilities

The bay control IEDs feature a large HMI for local control and instant access to important data, such as settings, events and disturbance information. It also provides a quick overview of the



status of the bay with position indications and service values. You can freely select which of the measurements available in the IEDs should be shown on the HMI of the IEDs.

You can control and visualize locally up to thirty primary apparatus in up to six bays with REC670, and up to eight primary apparatus in one bay with REC650. The control is based on the select-before-operate principle, which ensures secure operation and helps avoid human error. By selecting the control screen as a default screen in REC650, you can quickly execute control commands, and see the most important values. REC650 features three pages of alarm indications and each page consists of 15 dynamic three-color indication LEDs. These three-color LEDs can present the status of any binary input signal on the HMI of REC650 IEDs.

The Protection and control IED manager PCM600 tool offers a symbol library according to IEC and ANSI standards. You can use this tool to easily configure the graphical display of the IEDs to correspond with your needs and to your substation. The built-in disturbance and event recorders provide you with valuable data for post-fault analysis and corrective actions to increase the security of your power system.

The outstanding I/O capability of REC670 enables the control of several bays with complete measurement with only one IED. For instance, one REC670 IED is capable of handling the control of all apparatus in one entire diameter in an 1 1/2 breaker arrangement, including breaker failure protection for all breakers. REC670 therefore simplifies system design and ensures extremely cost-efficient solutions for any substation at any voltage level supporting different protection and control philosophies.

Additionally, REC670/650 features the two-position versatile switch and the 32-position selector switch functions, which enable you to easily manage switching operations via an icon on the IED HMI. The versatile switch function allows you to directly change, for instance, the autorecloser function from On to Off, or vice versa, without changing the configuration. This function also presents an indication of the selected position. The selector switch can replace an external mechanical selector switch and allows you to directly select the position you desire, for instance to change the autorecloser mode between 1-pole, 3-pole or 1- and 3-pole modes in REC670. In addition to the IED HMI, these switch functions can be operated from a remote system.

### Secure interlocking

The advanced interlocking functionality of REC670 and REC650

IEDs allows you to avoid dangerous or damaging switchgear operations and to assure personnel safety. Both IEDs perform secure bay- and station-wide interlocking using easy-to-use reservation functionality. Reservation prevents simultaneous operation of apparatus and ensures that the interlocking information is correct at the time of operation.

Ready-made and tested interlocking modules are available for almost any type of switchgear arrangement. The interlocking scheme based on these modules can also be adapted to your specific interlocking conditions. These powerful IEDs support interlocking both via a station bus and hardwired signals. The bay control IEDs utilize GOOSE messaging based on the IEC 61850 standard to perform horizontal communication and interlocking. This provides a cost-efficient solution for the interlocking.

### Operational reliability

In addition to interlocking, the output relays of the REC670 and REC650 IEDs feature an integrated continuous supervision function to ensure high security against unwanted operation. The Bay control IEDs are designed with the same technology as ABB's other 670 and 650 series protection and control IEDs. Meeting the stringent EMC requirements set for protection relays, these bay control IEDs provide secure control of your primary equipment.

### Cost savings through integrated functionalities

Both REC670 and REC650 bay control IEDs feature breaker failure protection. This provides cost savings and improves availability since no separate breaker failure protection relays are needed. REC650 integrates breaker failure protection for one breaker in each device, and REC670 for breakers in any type of breaker arrangement in a single device. Integrated synchronizing functions, autoreclosing and back-up protection functionality save both space and money. In addition, the integrated local HMI eliminates extensive cabling as the traditional mimic board with related interposing relays is not needed.

# Bay control applications

## REC670/650



The capacitor bank protection in REC670 detects dangerous operation situations and trips before any damage occurs in capacitor units that are vulnerable to different phenomena in power systems.

The capacitor bank protection in REC670 IEDs consists of overcurrent protection, undercurrent protection, harmonic overload protection, reactive power overload protection and a reconnection inhibit function. These, together with other protection functions that can be included in REC670 IEDs, such as unbalance protection based on overcurrent protection, provide complete protection for capacitor banks.

In addition to the wide range of overcurrent protection functions, REC670 and REC650 provide a negative sequence overcurrent protection. This function detects all unsymmetrical faults with or without earth connection. It features high sensitivity, which enables detection of faults with low fault current. The negative sequence overcurrent protection can also be used as directional. This facilitates the coordination with protection for other objects.

The four step negative sequence overcurrent protection can serve as back-up protection for most faults. It can also serve as the main protection for earth faults and other unsymmetrical faults.

The REC650 features extensive circuit breaker condition monitoring and monitoring of the station battery supply. The three trip circuit supervision outputs of the IED eliminate the need for an external trip circuit supervision unit.

### Fast and efficient system integration

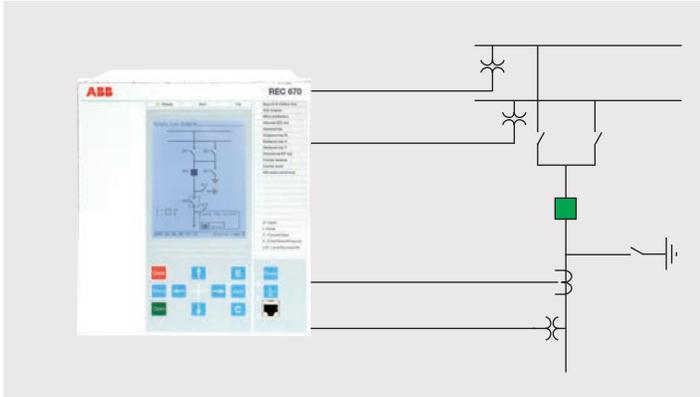
The REC670 and REC650 IEDs provide a compact, bay-oriented control solution with communication capabilities replacing conventional control circuits. Due to their IEC 61850 compliance, they can be easily integrated with any IEC 61850 compliant system. In addition, they can exchange information and cooperate with other vendors' IEC-61850-compliant IEDs.

Relion 670/650 series IEDs support IEC 62439 standard redundant communications on the station bus as per IEC 61850 standard. The solution from ABB utilizes the IEC 62439-3 standardized Parallel Redundancy Protocol (PRP). PRP improves the communication system reliability and features a unique capability of zero seconds' recovery time in case of communication failures. This means that there will be no interruption in communication if one link fails as the other link instantaneously takes over the communication. As a result, there is no data lost when communication failures have occurred.

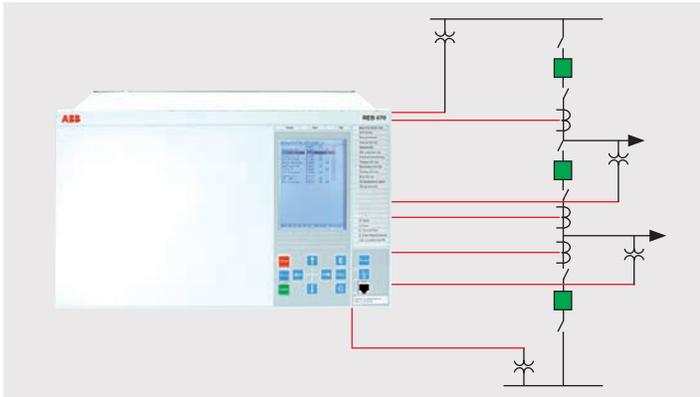
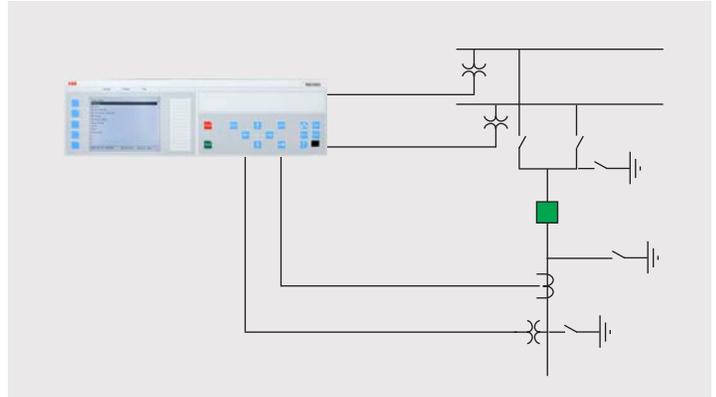
The supervision of communication links provides real-time status information about both communication links individually. If a failure occurs, an alarm is sent to the IED HMI and the substation automation system. This also allows for maintenance of the station bus while it is in operation. Thus, redundant communication further improves personnel safety and ensures that the necessary information about the system is available for operators in all situations.

Relion 670 series IEDs can also support synchronized sampled measured value communication over the process bus using IEC

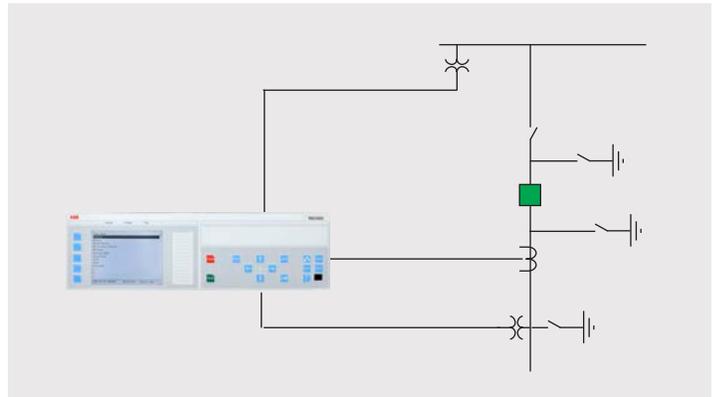
## Application examples



REC670/650 in a double busbar single circuit breaker arrangement.



One REC670 is capable of handling control of all apparatus in one entire diameter in 1 1/2 breaker arrangement.



REC650 in a single busbar single circuit breaker arrangement.

61850-9-2 LE which replaces conventional wiring between the process and the secondary system. This enables new design of substations. For example, utilization of sensor technology eliminates problems caused by, for instance, CT saturation and EMC influence. Furthermore, extensions and maintenance of substations can be completed more efficiently as fiber-optic cables are used instead of copper wires.

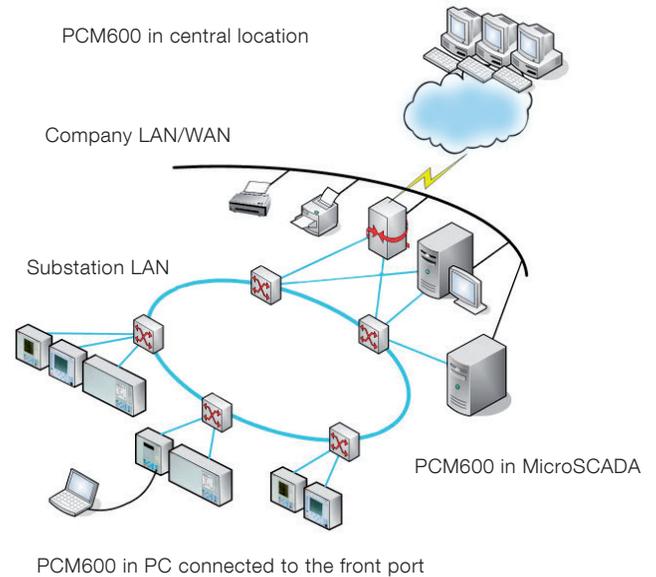
670 series IEDs allow you to mix conventional wiring and fiber-optic communication with IEC 61850-9-2 LE in a single IED. This way you can shift from conventional wiring for analog data to fiber-optic-based communication for synchronized sampled measured values step by step.

# Protection and control IED manager PCM600

PCM600 provides versatile functionalities for the entire life-cycle of Relion® protection and control IED applications. This easy-to-handle tool helps you manage your protection and control equipment all the way from application and communication configuration to disturbance handling, including automatic disturbance reporting.

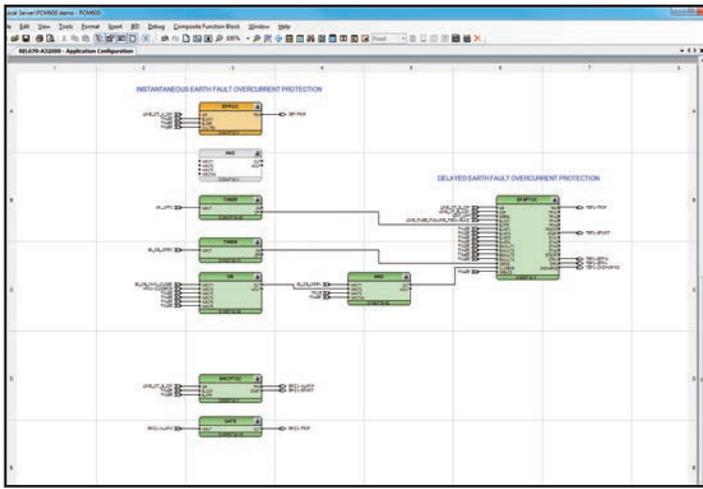
PCM600 interacts with IEDs over the fast and reliable TCP/IP protocol via a corporate LAN or WAN, or alternatively directly through the communication port at the front of the IED. It is able to read and write all configuration and setting data of an IED with a single command. The user interface, workflow and the IEC 61850-based data model in the PCM600 are designed according to the same philosophy as the Relion protection and control IEDs, ensuring smooth and seamless integration between the tool and the IEDs.

PCM600 is freeware, downloadable from the ABB Library. The connectivity package needed for each Relion series is provided with each order as a CD or can be downloaded. From the online Update Manager you will always have the latest versions.

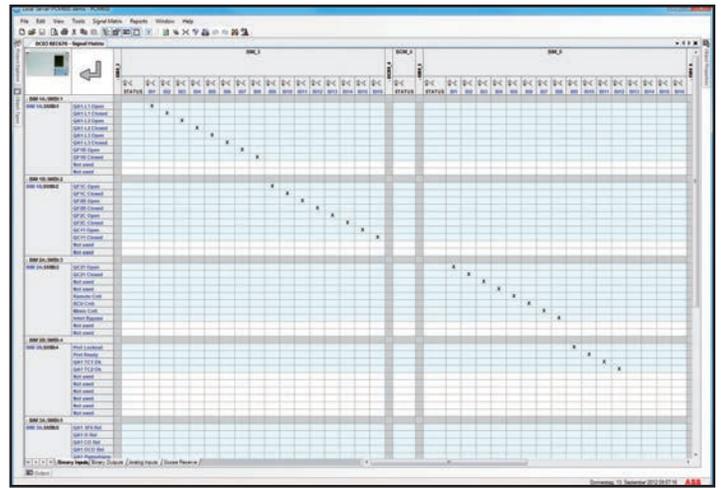


## Top 10 features of the protection and control IED manager PCM600

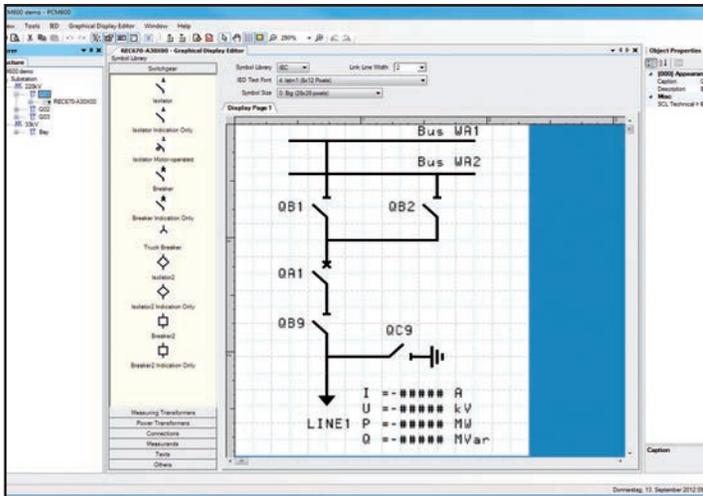
- Powerful application configuration for creation and monitoring of application configuration.
- Graphical representation of parameters simplifies setting of protection function parameters.
- Configuration of IED hardware and IED display.
- Communication management.
- Signal matrix for efficient and flexible connection of CTs, VTs and binary input and output signals, as well as connection of the GOOSE (Generic Object Oriented System-Wide Events) signals between IEDs.
- Comparison of configuration between IEDs and PCM600, and as well as SCL (substation configuration description language) files at SCD (substation configuration description) import.
- Monitoring of IED signals and events.
- Integrated disturbance recording functionalities for scanning and analysis of disturbance information.
- Copy/paste and export/import functions to allow efficient reuse of existing IEDs, bays or substations.
- Utilizes ABB's unique Connectivity Package concept which contains a comprehensive description of the IED, consisting of data signals and parameters as well as the IED documentation.



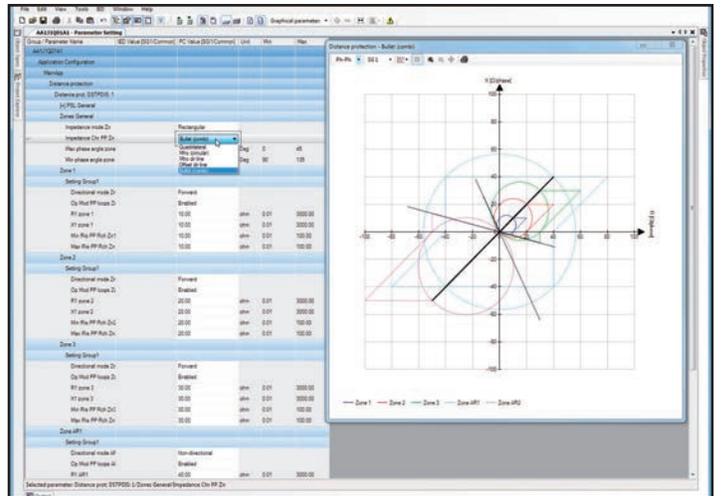
Application configuration allows you to easily create, change or view an IED configuration. The colors of the function blocks relate to the function status in the configuration: unconnected (gray), partially connected (yellow) or fully connected (green).



With the signal matrix, you can connect the process termination with any I/O connection point in the configuration in the same way as the traditional trip matrix.

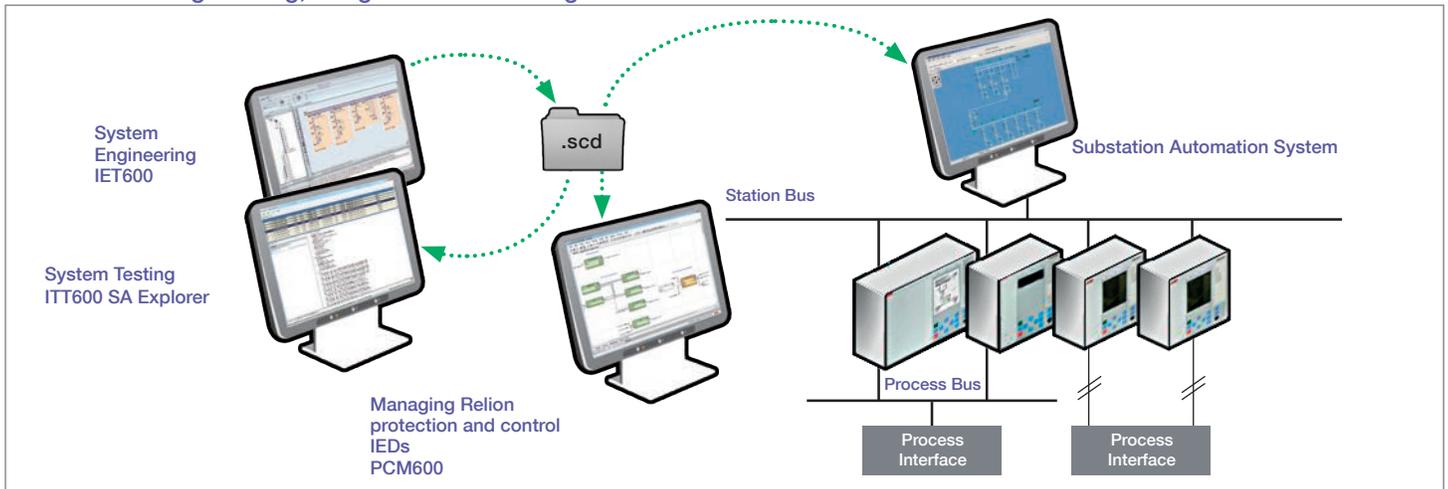


With the graphical display editor, you can easily engineer the single line diagram according to the switchgear arrangement for the IED HMI.



The parameter setting tool allows you to change or view all the parameters that an IED has, for all the setting groups. When reading the parameters from the IED, you can easily compare the values in the PC with the ones in the IED. The graphical representation of protection characteristics supports you in visualizing, for example, distance protection parameter setting.

### Tool suite for engineering, integration and testing



ABB's comprehensive suite of tools for engineering, integration and testing supports you throughout the complete lifecycle of protection and control IEDs and IEC 61850-based substation automation systems. With many advanced features, the tools allow you to manage your installation efficiently in all situations from engineering and commissioning to operation and maintenance.

# Integrated engineering tool IET600

**Integrated engineering tool IET600 is designed for configuring IEC 61850-based substation automation systems and applications with IEC 61850 compliant IEDs from ABB and other vendors. IET600 allows system engineers and integrators to define and configure the complete substation automation system according to IEC 61850. It features powerful graphical interfaces to design the substation topology, manage the communication between all IEC 61850-compliant IEDs in the substation and generate a complete description of the substation in an SCD file.**

IET600 provides a simplified, consistent and flexible approach to SA system engineering enabling substation engineers to design the complete system engineering of an IEC 61850-based substation with a single tool.

IET600's combination of powerful engineering editors and built-in IEC 61850 intelligence allows engineers to integrate protection and control IEDs easily and effectively, including

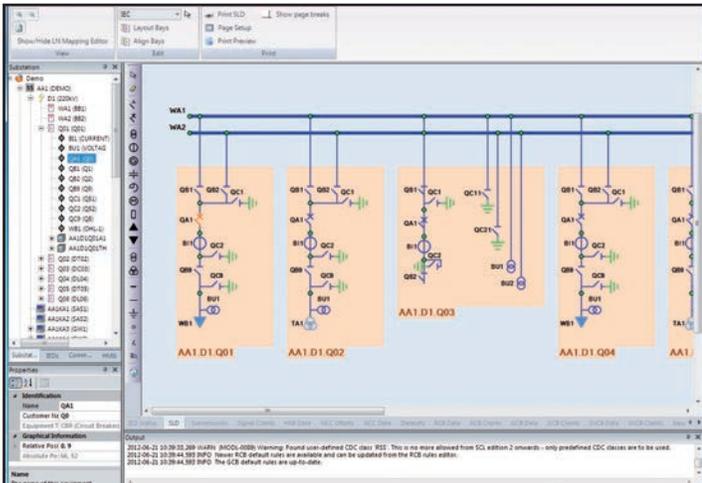
devices from third-party vendors. IET600 performs consistency checks at every step of the engineering process, which can significantly reduce the amount of errors not only during system engineering, but also subsequently during the system integration, testing and commissioning phase.

Centralized configuration and maintenance of substation signals for ABB's MicroSCADA platform ensures that data consistency is assured throughout the lifecycle of the substation. The modern and intuitive user interface allows engineers to easily navigate through large amounts of data to find exactly what they need.

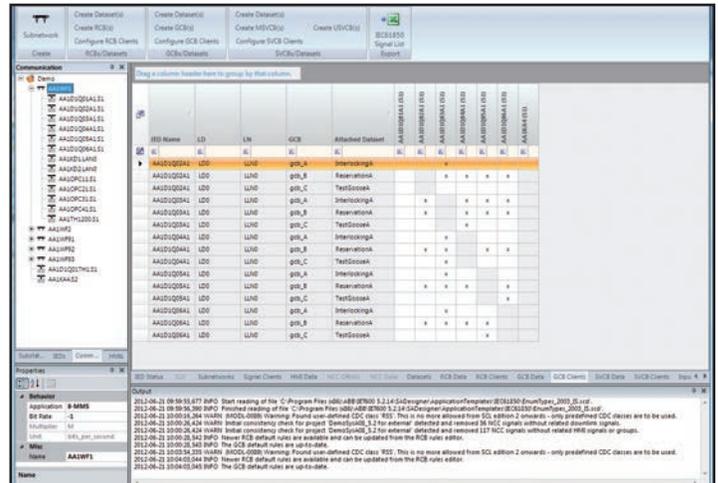
With over a thousand deployed systems worldwide, IET600 integrates ABB's long-term IEC 61850 expertise. ABB's UCA International certified in-house System Verification Center continuously ensures that IET600 meets the integration and system performance requirements of ABB and third-party protection and control devices.

## Top 10 features of the integrated engineering tool IET600

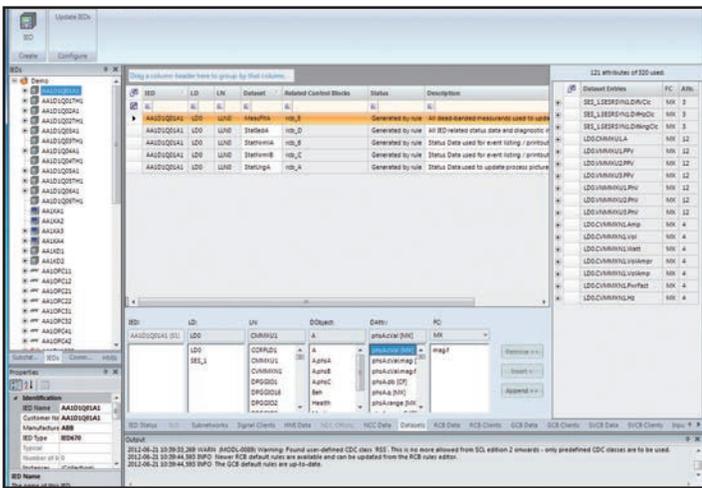
- Design and specification of the substation topology in a graphical Single Line Diagram editor.
- Consistent configuration of the complete dataflow communication between all IEC 61850 IEDs in the substation.
- Configuration of a wide range of IEC 61850 communication services, including MMS, GOOSE and sampled values.
- Flexible configuration of communication networks to adapt to various substation layouts and system size.
- Definition of complete substation configuration in an SCD file according to IEC 61850, including substation topology and communication structure and dataflow.
- Import, utilize and create SCL conform files for usage with any IEC 61850-compliant devices and tools in the market.
- Management and comparison functions for SCL-based files allow engineers to manage changes and ensure consistency during project execution.
- Export project data and graphics in Excel and PDF for documentation.
- Centralized management of station and gateway-level signals that ensures data consistency throughout the substation.
- Reuse of previously engineered station and gateway-level signals between multiple IET600 projects.



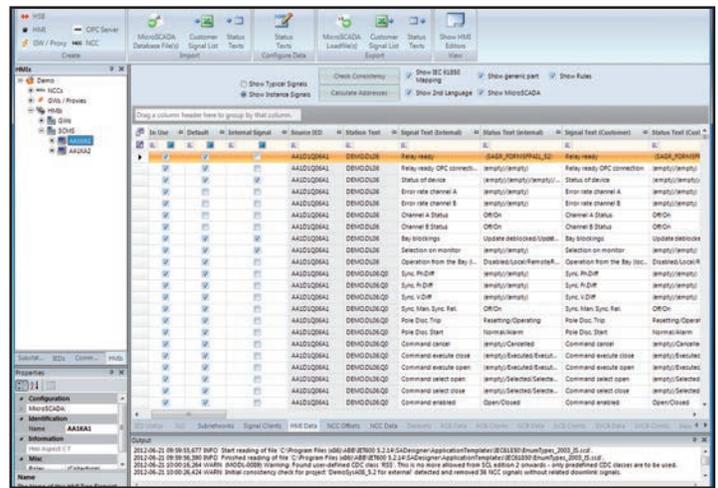
IET600 provides powerful graphic editors to design and configure the substation topology according to IEC 61850. System engineers can easily define the substation layout using the built-in Single Line palette of primary equipment, assign internal and customer-specific names to the devices, and print the configuration for documentation.



IET600's communication editors allow fast and easy configuration of the dataflow between all IEC 61850-compliant IEDs in the substation. Built-in consistency checks and clear representation of information reduces errors during the engineering process.



IET600 provides engineers with a complete and transparent overview of all communication data in the substation. Datasets, GOOSE reports and sampled value control blocks can be created and configured quickly and easily.



Configure and manage station and gateway-level signals for ABB's MicroSCADA SYS600 platform from IET600 to ensure data consistency throughout the station. Automatic calculations and easy reuse of engineered signals give engineers a powerful means to configure the station computers.

# Integrated testing tool

## ITT600 SA Explorer

**Integrated testing tool ITT600 SA Explorer is designed for easy diagnosis and troubleshooting of IEC 61850-based substation automation systems and applications. It features convenient navigation, comprehensive presentation of application data, and support for system consistency check both on-line and off-line. This allows anybody to use the same tool to analyze and debug substation automation applications regardless of their level of knowledge of IEC 61850 communication.**

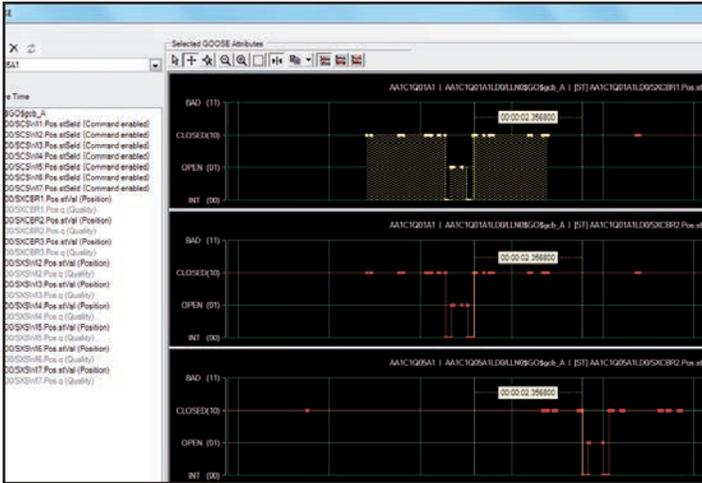
The ITT600 SA Explorer tool offers facilities for exploring and analyzing the communication configuration of the protection and control IEDs (Intelligent Electronic Devices) and IEC 61850 communication in substation automation systems, including GOOSE messages. Its versatile functionality eliminates the need for multiple testing tools for different purposes, such as MMS browsers, and protocol and Ethernet analyzers.

The powerful features of ITT600 SA Explorer provide test engineers with access to any IEC 61850-compliant IED. The tool's various functions allow efficient testing of the IED application and isolate the root cause of system communication problems. This significantly reduces testing and commissioning time.

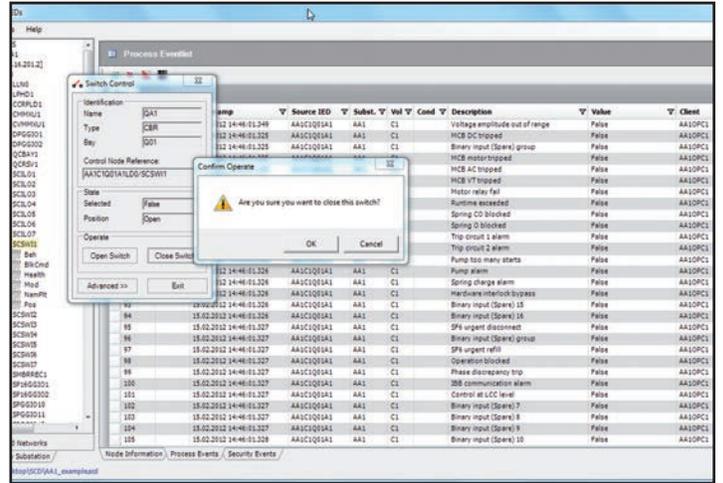
ITT600 SA Explorer is easy to use, and does not require the skills of a data communication specialist. By translating the complex terminology of communication protocols into the standardized IEC 61850 language, it makes the essential information available to all users.

### Top 10 features of the integrated testing tool ITT600 SA Explorer

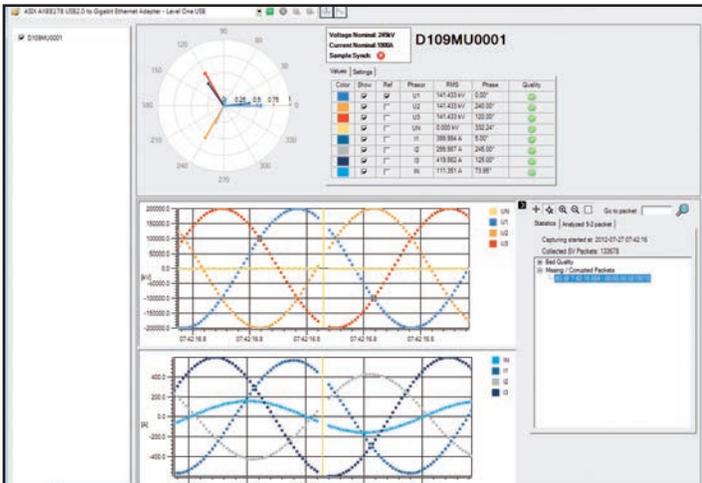
- Exploration of the complete IEC 61850 communication configuration of ABB's Relion protection and control IEDs and third-party IEDs.
- Process event list with filtering and exporting capabilities to support testing and commissioning of the IEDs.
- Many advanced functionalities, such as creation of dynamic datasets and editing of setting group values.
- Manual and automatic comparison of the system configuration description (.scd) and the deployed IED configurations to ensure data consistency.
- Documentation of the system configuration revisions and IED firmware versions to keep track of the changes in the system.
- Unique graphical visualization of the data flow within an IEC 61850-based system to verify and, if needed, optimize the data flow.
- Visualization of GOOSE data in an Oscilloscope style view simultaneously for several IEDs showing correlations and time measuring. This enables faster debugging and troubleshooting.
- Support for decoding and analysis of substation automation-related Ethernet-based communication protocols, such as IEC 61850-8-1, IEC 61850-9-2, IEC 60870-5-104, DNP 3.0/TCP and Modbus/TCP.
- Comparison of any two SCL-based (substation configuration description language) files at the same time; for instance, comparison of two .icd files to identify the differences between them.
- Visualization of IEC61850-9-2 LE sampled value streams in a phasor and Oscilloscope style view.



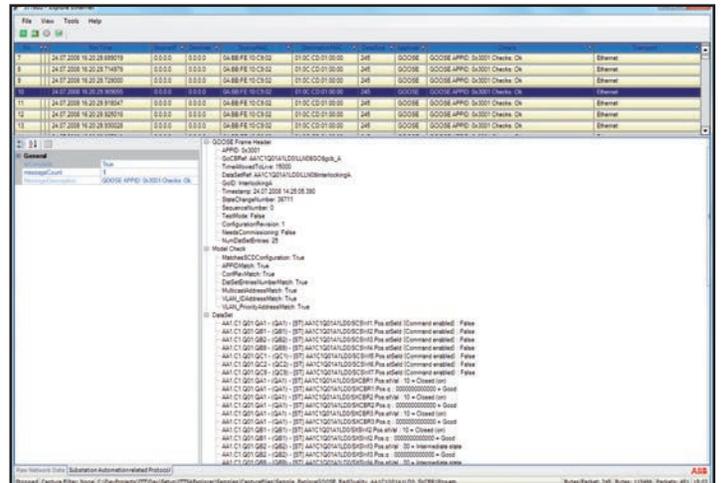
ITT600 SA Explorer makes GOOSE messages visible, and presents the transmitted GOOSE values both on-line and off-line. The tool allows you to focus on the application behavior and verify the traffic instead of searching for specific values in GOOSE frames.



ITT600 SA Explorer allows you to connect to any IEC 61850-compliant IED, browse the IED configuration, subscribe to IEC 61850 reports, send Select-before-operate commands and review the IED's response in the built-in event list.



ITT600 SA Explorer visualizes up to two IEC61850 9-2 LE streams in a phasor diagram and as RMS values to allow engineers to evaluate primary currents and voltages sent by a merging unit on-line. Off-line analysis for one stream includes an Oscilloscope style view of the sampled values.



When analyzing communication within a substation automation system, ITT600 SA Explorer allows you to focus on the transmitted payload instead of protocol details. You only need to concentrate on the application values important to you while the tool's unique built-in consistency check functionality takes care of the details.

# COMBIFLEX® and COMBITEST

## Proven and reliable solutions for protection and testing



The proven COMBIFLEX® relay family and modular building system offer flexible and reliable protection solutions for a range of applications. You can also combine COMBIFLEX auxiliary relays with Relion® protection and control family products, or other protection relays, to add functionalities such as lock-out, lock-out reset or external contact reinforcement. Using the COMBITEST test system together with, for instance, the Relion family IEDs, provides a safe, secure and easy-to-use method of secondary injection testing of a protection system when performing commissioning and maintenance.

### Flexible and safe

The COMBIFLEX building system features unique flexibility for designing various protection schemes. The wide range of different mounting and casing alternatives allows the COMBIFLEX-based protection system to adjust to any space and functionality requirements.

The COMBIFLEX mounting system has been shaped from decades of practical experience of the assembly of complete relay and control systems. The system is based on the 19-inch rack standard which permits a simple combination of products using the same international standard. Every part of COMBIFLEX integrates perfectly forming well-functioning panel designs. The combination of Relion IEDs and COMBIFLEX relays allows you to utilize the space in a cubicle in an optimum way.

The connections in the COMBIFLEX building system, for instance between the relays and test switches, are easy and fast to make using pre-crimped wires – no tools are needed.

Additionally, all the connection points in the COMBIFLEX building system are insulated from human contact, which prevents human injuries during installation.

### Auxiliary relays for every need

The COMBIFLEX family provides a wide range of auxiliary relays for performing tripping, blocking, interlocking and signaling tasks. They are available with various ratings and contact configurations. The relays, which have a long mechanical life, feature up to 15 contacts. The contacts are suitable for heavy, medium or light duty operation.

The COMBIFLEX auxiliary relays are especially suitable in protection and control circuits, including in highly corrosive atmospheres or seismic areas. This allows you to easily design tripping, interlocking and multiplying functions and logic using a single relay or combinations of relays.



### Increase personnel safety with COMBITEST

The COMBITEST relay test system provides a wide range of testing capabilities. Using secondary injection tests allows you to inject signals to an isolated protection device to test its performance and operation limits. This helps you ensure that the protection device operates according to your specifications before an actual protection operation is called for.

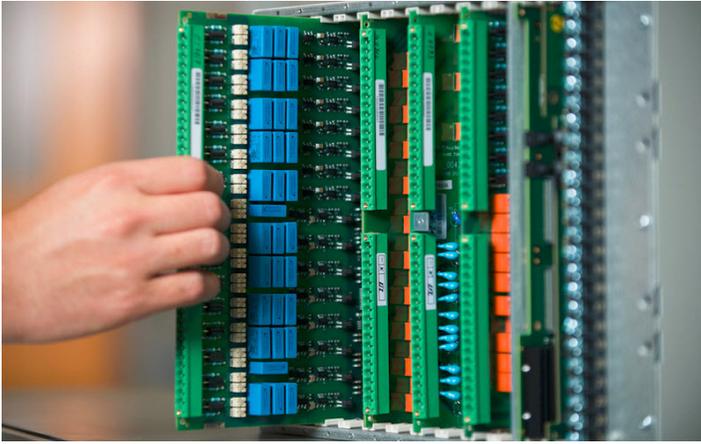
The COMBITEST test system allows you to perform secondary injection testing of any protection and control IED and protection relay without disconnecting secondary instrument transformers, for instance CTs, from the protection devices. No external shorting links are needed on the test handle. When the test-plug handle is inserted into the test switch, the preparations, such as blocking of tripping circuits, short-circuiting of CTs, and opening of voltage circuits, are automatically carried out in the correct sequence. This eliminates the risk of accidental opening of the CT secondary, and tripping a circuit breaker during testing. This makes the secondary injection testing of the protection devices safe for both personnel and equipment.

When the test-plug handle is withdrawn after testing has been completed, the protection device automatically returns to its reset position before the connection to trip circuits is restored.

The COMBITEST test system contains all components required in secondary injection testing. The RTXP test switch and RTXH test-plug handle are available in various sizes, which makes it easy to adjust the test system to your specific needs.

COMBIFLEX and COMBITEST have an excellent track record in a large global installed base, including North America. COMBIFLEX high current and heavy duty contacts for tripping and latching relays can be installed jointly with Relion 670 or 650 series IEDs in a shielded, separate compartment to avoid transient and other disturbances which may occur if these are integrated with the electronics directly. Together with the COMBITEST test switch, this provides reliable and safe solutions to guarantee tripping and simplified testing.

# Our services



Relion hardware configuration



Relion function configuration



Product support and testing of Relion 670 series



Product support and testing of Relion 650 series

## What we can offer

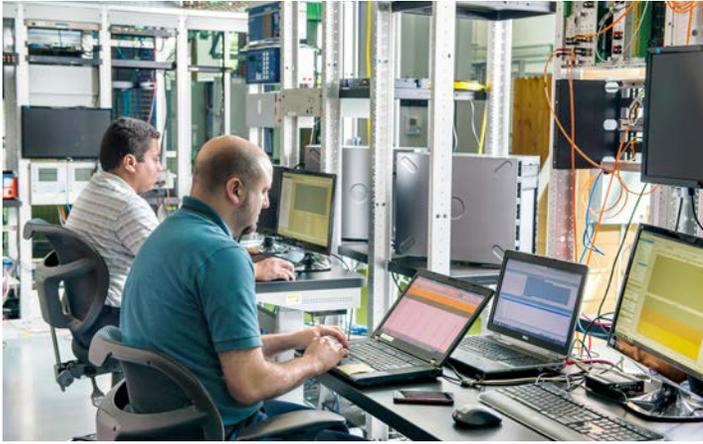
- Visit, listen, educate and offer you Relion to evaluate
- Demonstrate our powerful substation automation tool suit
- Deliver your optimized Relion products and systems
- Respond to emergency/urgent customer needs
- World-class 10 year product warranty
- Advanced knowledge of ABB primary equipment and systems
- Regional support for relay applications and settings
- Regional support for system architectures
- Expert IEC 61850 implementation
- Relay school and fundamentals webinars
- Skilled local application and product support specialists
- Access to ABB global domain experts
- Configuration, testing and training
- Access to ABB global Product Verification Center
- Engineering, acceptance testing and verification
- Access to ABB global System Verification Center

## Where you can find us

ABB Power System Automation and Communication together with the Smart Grid Center of Excellence are at the same location creating an ABB Power T&D hub for North America. This includes the engineering and support center for Substation Automation Products with Relion protection and control of transmission and generation applications as well as engineered Substation Automation Systems.

Additionally, substation automation, protection and control solutions are supported from regional support centers throughout North America as well as by the ABB network of regional sales and technical managers. Ventyx Network Management solutions are supported from Ventyx local offices.

# Regional support, testing and verification



Smart Grid COE verification lab



Relion smart grid integration



Systems verification lab



Interoperability testing



Example of REB670 panel with COMBITEST

# Global product verification center

ABB has a long history of real time power system simulations for the verification of protection, control and monitoring products. This methodology was originally developed together with BPA in the 1980's. The first delivery of high speed protection to the series compensated 500kV lines in northwestern U.S. was verified using EMTP files for simulation. By connecting IEDs to the Real Time Digital Power system Simulator (RTDS), your network can be simulated, allowing you to determine how your protection system will react to particular disturbances and enabling you to take the necessary measures to eliminate the risk of serious power failure.

## Increased complexity calls for verification

The increasing complexity of power systems and the diversity of new protection, control and monitoring products have increased the demand for power systems simulation. Some factors that call for customer specific simulation and verification include:

- Network topology, such as parallel and multi terminal line
- Increasing diversity of components in power network, such as HVDC line and FACTS devices.
- High speed protection
- Multi terminal protection
- Long lines with load encroachment
- Introduction of new numerical techniques in protections, such as adaptive algorithms and fuzzy logic.

## A copy of your own power network

Power system simulation services will help you study possible disturbance and know their effects on your power system.

ABB provides simulation tests for the following:

- Faults analysis in different locations in the power system
- Breaker operations as opening, closing and re-closing
- Short term network stability variation
- Power swing analysis
- Different load conditions

The ABB RTDS offers an advanced and effective means for verifying protection and control equipment for specific applications. Since the simulation runs in real time, the physical protection equipment can be connected in closed-loop with the power system model. In the open-loop testing, calculated voltages and currents or playback of COMTRADE files from the simulator can be used. Moreover, the closed-loop interaction of the protection system with the network model provides insight on both the performance of the IED scheme as well as its effect on the power system.

The flexibility in topology, model and automatic test sequences allows protection equipment to be subjected to virtually all possible faults and operating conditions.



Global Product Verification Center

# Global systems verification center

When the IEC 61850 standard was introduced, ABB not only implemented it in its product portfolio, but also established a system verification and validation center (SVC) to verify correct implementation. In this test center, each and every product, system component, application and tool is tested in a real-life system environment to demonstrate its specified functionality and performance. Complete systems are verified to ensure that they fully meet the requirements in terms of communication, integration, functionality, security and performance.

UCAIug has qualified ABB's SVC as an IEC 61850 test facility and competence center. ABB's SVC is thereby officially qualified to test and certify the IEC 61850 conformity of products and confer the users' group label to them. The SVC's purpose is to ensure the high quality of ABB's system automation system solutions and provide a platform for the exchange of experience between IEC 61850 experts within ABB. All actions of ABB's SVC are focused on the following targets:

- Ensure a common understanding for the system integration  
Ensure a common understanding for the engineering process.
- Target a consistent philosophy within ABB systems and products
- Identify and initiate the closing of gaps between system requirements and product features

- Improve the quality of the system solution in architecture, integration and performance
- Decrease demand for specialized expertise within a customer system project
- Build up integral know how in testing and system integration of third party products
- Reduce cost and execution time of customer projects

## System verification and validation

The fact that products from different suppliers or different products from the same supplier conform to the standard is in itself no guarantee for interoperability. Systems verification and validation looks at the dynamic interaction of at least two IEDs in a substation automation system (SAS) covering, to the extent possible, all potential configurations. This is especially important for their interaction in executing distributed functions. Furthermore, it permits the verification of the performance of services provided by communication equipment such as switches.

It is not possible to consider the lifecycle of any SAS without taking into account the lifecycles of all integrated products. The process of creating a substation automation system involves numerous tests, from the development and production of an individual IED to the completion of the system. Testing improves the quality and reduces costly risks.



Global Systems Verification Center

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