Protection, control and monitoring

For transmission lines, substations, railways, power generation & renewables.

- Advanced protection, control and monitoring solutions
- At the forefront of IEC 61850 technology
- Future proof applications meeting digital substation requirements
Power and automation technology solutions from ABB support the digital transformation of your business from the field to the boardroom and everywhere in between. These solutions enable deep insight into the power network, asset performance management, energy efficiency and reduced operating costs.

ABB’s protection, control and monitoring portfolio provides interoperable and reliable solutions enabling a smarter, sustainable and future proof power system.

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Substation evolution.
From electro-mechanical relays to Digital Substation.

Evolution continues.

The main objective of the utilities is to provide affordable electric power of a good quality, continuously and preferably for profit. Reliability of the power system protection, as well monitoring, control and asset management have significantly improved from the early days of electromechanical relays to modern IEDs - leading to higher availability.

New challenges are arising for the customers, and it is the manufacturers task to facilitate usability of the equipment, in order to leverage the maximum of all assets in the power system. Digital substation is the way forward.

01 Substation evolution from classical to ABB Ability Digital Substation

01 Substation evolution from classical to ABB Ability Digital Substation
Grid evolution. Changes in the grid topology and business model.

Trends in modern power grids.

The trends that are having impact on transmission grid technology:
• Renewable penetration
• HVDC
• FACTS
• Phase-shifting transformers
• Micro-grids
• Nano-grids
• Electrical mobility
• Charging infrastructure for electric vehicles
• Digital transformation of transportation
• Digitalization of power grids

The requirements and expectations on substation protection and control will increase. Evolving grids have direct impact on protection and control systems.
Evolving grid and substation. Main challenges and expectations.

Requirements for a modern grid.

- **Fundamental requirements on protection and control IEDs**
  - High reliability
  - High availability
  - High operational performance
  - User friendliness and safety
  - Cost effectiveness
  - Interoperability

- **Cyber Security**
  - User access control
  - Secure communication
  - Protocol hardening
  - Security logging
  - Patch management

- **Product related expectations**
  - Scalability
  - Flexibility and robustness
  - Ability to facilitate conventional to digital substation transition

- **Life cycle requirements**
  - Safeguard investment over the entire life cycle
  - Backward compatibility
Relion® the power of one solution.
For protection, control and monitoring.

To cope with any situation, a modern protection IED needs to be configurable to fit within its intended application area. ABB’s solution to this requirement is the Relion® series of IEDs.

The Relion series offers a standardized library of functionality on a high performance, common hardware architecture, and provides the flexibility and configurability to suit any application area.

The Relion series of devices cover the complete protection, control and monitoring needs of your power infrastructure.

Advanced control capabilities and system modeling, according to IEC 61850 will give you new ways to design and dynamically operate your network. And in the smart grid, information is of vital importance, so advanced and accurate PMU (phasor measurement unit) functionality will present you with the information you need to make your smart grid truly smart.

With its proven reliability, high accuracy and high performance operation, the Relion family devices can be used for the most demanding applications for your power system network.

Relion 670 and 650 series.
The power of one.

ABB’s high performing series of intelligent electronic devices (IEDs)

Relion 670 series

- A flexible solution for every application
- Support for the most demanding requirements of protection and control applications
- Ordering as pre-configured or customized
  - Three different hardware casings (1/1, 3/4 and 1/2 19”)
  - Advanced protection and control features
  - Multiple objects
  - High level of functional integration

Relion 650 series

- Solution for the most common requirements of protection and control
- Pre-defined, ready-to-use solutions for all application areas
- Simple ordering, ready made applications for all application areas
  - Single breaker applications
  - One hardware casing (1/2 19”)
  - Always pre-configured
  - Few additional options
Relion® the power of one solution.
For line protection.

Overhead lines and cables tie the electrical grid together. Overhead lines are exposed and particularly vulnerable to everything from bad weather to flora and fauna.

It is an accident of geography that many power generation sites are situated far from the centers of power consumption, which means efficient ways of transporting large amounts of electricity over longer and longer distances is critically important.

Increasing voltage, reducing reactance and building more parallel lines using AC transmission is one answer. As primary power systems become more technically complex, secondary systems must keep up with improved algorithms, enhanced performance and rigorous control capability in order to ensure network stability and continuity.

From long, extremely high-voltage series compensated overhead lines deployed in rough, rural terrain to a short high-voltage underground cable link traversing a waterway, ABB grid automation has a protection solution for any line application, supported by 100 years of practical, real world experience.
Line protection solutions.
Relion® REL670, REL650, RED670 and RED650

Distance protection offers extensive protection application opportunities for overhead lines and cables, or combinations of overhead lines and cables.

Differential protection is easier to integrate and delivers more consistent performance compared to distance protection, at the cost of an increased hardware and communication dependency.

Distance protection is and remains by far the main protection principle for overhead lines and cables. It is reliable, fast and largely manages to eliminate the variable system quantities of load and supply out of the protection calculation.

Distance protection is in its core an impedance measurement, comparing a known line impedance against a measured system impedance.

A modern distance protection IED (Intelligent Electronic Device) must deal with many more features though: phase selection, load encroachment, power swing detection, scheme communication, phasor measurement, monitoring, control and backup protection – a wide variety of tasks are performed, differing from installation to installation and customer to customer.

Relion REL670 and REL650 offer line distance protection. REL670 offers pre-configured solutions while it is also a highly configurable device that delivers superior protection, control and monitoring in any high-voltage application; REL650 provides a pre-defined, pre-configured variant with a small form factor and standardized solution.

An alternative principle for line protection that is quickly becoming the norm is differential protection. Differential protection is based on Kirchhoff’s laws, stating that all current into a network node shall add up to zero in an ideal system. What this practically means for a line protection application is that the current that is measured to flow into the line should also be measured to come out.

Differential protection is easier to integrate into a protection philosophy than distance protection, as it is a unit protection. It delivers more consistent performance, at the cost of an increased hardware and communication dependency. Some form of high bandwidth, low latency communication is required in between the line ends to exchange analog information for the line differential algorithm to process. Typically, this is a direct fiber optic cable, but communication over MPLS-TP, SDH, PDH or SONET network is also possible.

Relion RED670 and RED650 offer either a dedicated line differential protection IED, or a so called multi-function device, whereby distance protection is integrated in the same IED as well.

<table>
<thead>
<tr>
<th></th>
<th>REL670</th>
<th>REL650</th>
<th>RED670</th>
<th>RED650</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance protection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>&lt; 1 cycle</td>
<td>1 1/2 cycle</td>
<td>&lt; 1 cycle</td>
<td>1 1/2 cycle</td>
</tr>
<tr>
<td>Additional Functions</td>
<td>Power swing blocking</td>
<td>Out of step and pole slip detection</td>
<td>Phase preference logic</td>
<td></td>
</tr>
<tr>
<td>Series compensated lines</td>
<td>X</td>
<td>Not available</td>
<td>X</td>
<td>Not available</td>
</tr>
<tr>
<td><strong>Differential protection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>Not available</td>
<td>&lt; 1 cycle</td>
<td>1 1/2 cycle</td>
<td></td>
</tr>
<tr>
<td>Maximum line ends</td>
<td>S</td>
<td>3</td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>In-zone transformer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Short range communication to multiplexer</td>
<td>Not available</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Communication speed</td>
<td>64 kbit/s or 2 Mbit/s</td>
<td>64 kbit/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct Fiber communication range</td>
<td>Up to ~ 130 km</td>
<td>Up to ~ 60 km</td>
<td></td>
<td></td>
</tr>
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</table>

05
Line protection performance characteristics
Line distance protection.
Relion® REL670 and REL650

Line distance protection offers extensive protection application opportunities for overhead lines and cables, or combinations of overhead lines and cables.

The REL670 can offer more integrated functionality compared to the REL650, such as full bay control functionality and synchrophasors (PMU) functionality. In order to facilitate this additional functionality, there is a larger and more flexible choice in available hardware compared to the REL650 as well.

REL670 and REL650 include features such as:
- Distance protection with 6 independent zones, for quadrilateral and mho characteristics
- Power swing detection and blocking, out-of-step and pole slip detection
- Phase preference logic for the correct tripping of multiple phase-to-earth faults in compensated networks
- Back-up current, voltage and frequency protection
- Switchgear control functionality

REL670 comes in four different variants
- REL670-A41 offers a 6 zone distance protection function with mho and quad characteristic, sub cycle tripping times, load encroachment, phase preference logic, power swing detection. Overcurrent, overvoltage, undervoltage, frequency and thermal overload protection are available as backup protection functions and included as basic or optional functionality. It also includes breaker failure protection, autoreclose and synchrocheck functionality. This variant is used in isolated or high-impedance earthed systems. All other variants are intended for directly earthed systems.

- REL670-A42 offers everything included in REL670-A41, except the phase preference logic
- REL670-B42 is equal to the REL670-A42, but is intended for 1 ½ or double breaker configurations.
- REL670-D42 is equal to REL670-A42, and in addition includes synchrophasors (PMU) functionality by default

REL650 comes in two different variants
- REL650-A11 offers a 6 zone distance protection function with mho and quad characteristic, load encroachment, power swing detection, out of step protection, overcurrent, frequency and thermal overload protection. It also includes breaker failure protection, autoreclose and synchrocheck functionality
- REL650-A12 offers everything included in REL650-A11, and additionally phase preference logic. This functionality is required for a correct phase selection in high impedance or resonance earthed networks

<table>
<thead>
<tr>
<th></th>
<th>REL670</th>
<th>REL650</th>
</tr>
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<tbody>
<tr>
<td>Distance protection</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Speed</td>
<td>&lt; 1 cycle</td>
<td>1 ½ cycle</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Mho, Quad</td>
<td>Mho, Quad</td>
</tr>
<tr>
<td>Zones</td>
<td>2 instances, 6 zones each</td>
<td>1 instance, 6 zones</td>
</tr>
<tr>
<td>Tripping</td>
<td>1ph/3ph</td>
<td>1ph/3ph</td>
</tr>
<tr>
<td>Load encroachment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Power swing blocking</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Back-up protection</td>
<td>Optional</td>
<td>Basic</td>
</tr>
<tr>
<td>Control of entire bay</td>
<td>Optional</td>
<td>Circuit breaker only</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>REL670-A41</th>
<th>REL670-A42</th>
<th>REL670-B42</th>
<th>REL670-D42</th>
<th>REL650-A11</th>
<th>REL650-A12</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed distance protection</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phase preference logic</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Back-up protection</td>
<td>Optional</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>Control of entire bay</td>
<td>Optional</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
</tr>
<tr>
<td>Configuration</td>
<td>Single breaker</td>
<td>Double breaker</td>
<td>Single breaker with PMU</td>
<td>Circuit breaker only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Line differential protection.

Relion® RED670 and RED650

Differential protection is easier to integrate and delivers more consistent performance as distance protection, at the cost of an increased communication dependency.

Line differential protection offers an easy, accurate and secure alternative to line distance protection in line protection applications, but requires communication between the line ends.

Relion RED670 and RED650 offer line differential protection and the option for line and cable distance protection in the same device. With its high performance, high bandwidth and low latency communication channel, RED670 delivers subcycle trip times in both its differential and distance protection functions.

RED650 provides a predefined, preconfigured variant with a small form factor and a standardized application solution.

RED670 and RED650 can either be outfitted with their own dedicated long/medium-range communication module, or use a short-range communication channel to a multiplexer so that an independent communication network can be used.

RED670 and RED650 include such features as:
- Differential protection from 3 to 5 line ends, with up to two in-zone transformers
- Dedicated IED communication, or multiplexer support
- Back-up current, voltage and frequency protection

In addition, RED670 can include all the functionality available in REL670, resulting in a single device capable of both line differential and line distance protection.

RED670 comes in four variants
- RED670-B33 offers 2 – 5 line ends differential protection with the possibility for increased performance over a 2 Mbit data link, improving trip time performance.
- RED670-A42 offers a high speed differential protection with sub-cycle trip times, and includes overcurrent, voltage, frequency and thermal overload protection. These are included as basic or optional functionality. It also includes breaker failure protection, autoreclose and synchrocheck functionality.
- RED670-B42 is equal to the RED670-A42, but is intended for 1 ½ or double breaker configurations.
- RED670-C42 is equal to RED670-A42, and includes the high speed, sub cycle distance protection as the backup functionality to the existing high speed line differential protection.

RED650 comes in one variant
- RED650-A11 offers a 3 ended line differential protection function, with an option for an in-zone transformer. It also offers a 6 zone distance protection function with mho and quad characteristic, load encroachment, power swing detection, out of step protection, overcurrent, frequency and thermal overload protection. It includes breaker failure protection, autoreclose and synchrocheck functionality.

**RED670 and RED650**

<table>
<thead>
<tr>
<th>Feature</th>
<th>RED670</th>
<th>RED650</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential protection</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Speed</td>
<td>&gt; 1 cycle</td>
<td>1/4 cycle</td>
</tr>
<tr>
<td>Communication speed</td>
<td>64 kbit/s or 2 Mbit/s</td>
<td>64 kbit/s</td>
</tr>
<tr>
<td>Line ends</td>
<td>2-5</td>
<td>2-3</td>
</tr>
<tr>
<td>In-zone transformer</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tripping</td>
<td>3ph/3ph</td>
<td>3ph/3ph</td>
</tr>
<tr>
<td>Distance protection</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Back-up protection</td>
<td>Basic and additions as options</td>
<td>Basic</td>
</tr>
<tr>
<td>Control of entire bay</td>
<td>Optional</td>
<td>Circuit breaker only</td>
</tr>
<tr>
<td>Time synchronisation</td>
<td>PPS, IRIG-B, GPS/IEEE 61850-9-3</td>
<td>PPS, IRIG-B, IEEE 61850-9-3</td>
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**RED670 and RED650**

<table>
<thead>
<tr>
<th>Art. No</th>
<th>Description</th>
<th>RED670-B33</th>
<th>RED670-A42</th>
<th>RED670-B42</th>
<th>RED670-C42</th>
<th>RED650-A11</th>
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<tbody>
<tr>
<td>Function</td>
<td>High speed differential protection</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Differential protection</td>
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<td>X</td>
<td>X</td>
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<tr>
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<td>Optional</td>
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<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>Back-up protection</td>
<td>Basic and additions as options</td>
<td>Basic and additions as options</td>
<td>Basic and additions as options</td>
<td>Basic and additions as options</td>
<td>Basic</td>
</tr>
<tr>
<td></td>
<td>Control of entire bay</td>
<td>Optional</td>
<td>Optional</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
<td>Circuit breaker only</td>
</tr>
</tbody>
</table>

**RED670 and RED650**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>RED670-B33</th>
<th>RED670-A42</th>
<th>RED670-B42</th>
<th>RED670-C42</th>
<th>RED650-A11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single breaker, 2-5 line ends</td>
<td>Single breaker, 2-3 line ends</td>
<td>Double breaker, 2-3 line ends</td>
<td>Single breaker, 2-3 line ends</td>
<td>Single breaker, 2-3 line ends</td>
</tr>
</tbody>
</table>
Relion® the power of one solution.
For substations.

We deliver essential substation automation, high-voltage protection, control and monitoring solutions for today’s power networks, ensuring they are ready for tomorrow’s challenges.

As urban centers grow ever larger and the demand for electricity accelerates, power generation itself has entered a transitional phase.

Traditional methods such as large-scale thermal or hydro generation still dominate, but a new era of decentralized electricity generation is developing. Decentralized generation is characterized by small islands of balanced power supply and demand. But the intermittent nature of this kind of generation, for example small wind turbine or solar photovoltaic installations, makes a stable traditional electrical grid more important than ever, and this is driving the development and increased complexity of modern power networks.

It is an accident of geography that many power generation sites are situated far from the centers of power consumption, which means efficient ways of transporting large amounts of electricity over longer and longer distances is critically important.

As primary power systems become more technically complex, secondary systems must keep up with improved algorithms, enhanced performance and rigorous control capability to ensure network stability and continuity.

Substation solutions
Substations are integral parts of a power network, built to ensure grid infrastructure operates safely, reliably and efficiently. Statistically, the number of faults in a substation is substantially lower than in the more exposed overhead power lines, but the strategic importance of a substation as a point where everything in a power network comes together makes the consequences of electrical failure even more severe. Reliability and capacity to minimize equipment damage is therefore vital.

ABB grid automation delivers an extensive portfolio of protection, control and monitoring solutions to keep substations safe and secure.

Control applications
Advanced and ready made control solutions for interlocking and reservations

Busbar protection
- Low impedance busbar protection for up to six bus bar zones
- Capability of using conventional hard wired measurements and IEC 61850-9-2 sampled values in the same IED

Transformer protection and voltage control
- Capability of protection transformer with differential protection and restricted earth fault
- Performing voltage regulation with the same IED
Circuit breakers and disconnectors
Relion® REC670, REC650 and REQ650

Circuit breakers and disconnectors
Circuit breakers, disconnectors and earthing switches typically comprise the bulk of the components inside a substation. There are many types of breakers and switches, and many ways of configuring the connections between them.

Circuit breaker and disconnector control
Driven and controlled by the substation automation system, IEDs reserve, interlock and actuate the circuit breakers and disconnectors that enable the electrical grid to operate.

Circuit breaker protection
Circuit breakers typically combine failure protection with autoreclose, synchro-check and system back-up protection of functions related to current, voltage and frequency. In ABB Relion protection IEDs this functionality is basic or optional, and also available in a product specifically designed for this purpose – the REQ650 breaker protection Intelligent Electronic Device (IED).

The REQ650 provides ideal breaker failure protection, enabling high-speed back-up tripping of surrounding breakers, and retripping of the target breaker. REQ650 breaker protection is the ideal choice for refurbishment projects, where old protection relays need to be replaced.

ABB’s REC650 and REC670 offer various pre-configured variants to cover the different switchgear configurations that exist in substations around the world.

Interlocking and reservations
REC670 and REC650 have ready made logic function blocks for bay and station wide interlocking.

IEC 61850 based reservation philosophy prevents multiple operations of more than one apparatus in the substation.

Breaker backup protection may also be included in ABB’s REC670 bay control unit. REC670 offers an extensive back-up protection function library, which it shares with all other protection products in the 670 and 650 series. REC670 delivers the same high-performance protection functionality as a dedicated protection device.

<table>
<thead>
<tr>
<th>REC670*</th>
<th>REC650**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control, disconnector and earthing switch control</td>
<td>Up to 6 circuit breakers and 24 switches</td>
</tr>
<tr>
<td>Up to 1 circuit breaker and 9 switches</td>
<td></td>
</tr>
<tr>
<td>Generic switch control</td>
<td>Up to 150 double point objects</td>
</tr>
<tr>
<td>Up to 30 double point objects</td>
<td></td>
</tr>
<tr>
<td>IEC 61850</td>
<td>Edition 1 and 2</td>
</tr>
<tr>
<td>Edition 1 and 2</td>
<td></td>
</tr>
<tr>
<td>Reservation</td>
<td>With or without confirmation</td>
</tr>
<tr>
<td>Interlocking</td>
<td>Pre-defined or user defined</td>
</tr>
<tr>
<td>Operation</td>
<td>Direct or select before operate, with or without enhanced security</td>
</tr>
</tbody>
</table>

* Control functionality can be optionally integrated in all Relion 670 series products, except for REC670
** All Relion 650 series products include basic control for 1 circuit breaker

<table>
<thead>
<tr>
<th>REC670-A30</th>
<th>REC670-B30</th>
<th>REC670-C30</th>
<th>REC670-D30</th>
<th>REC650-A02</th>
<th>REQ650-B11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 circuit breaker, double busbar</td>
<td>2 circuit breakers, double busbar</td>
<td>1 ½ circuit breaker, double busbar, with PMU</td>
<td>1 circuit breaker, double busbar, with PMU</td>
<td>1 circuit breaker, double busbar</td>
<td></td>
</tr>
<tr>
<td>1 circuit breaker, double busbar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage regulation and OLTC control</td>
<td>Optional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection</td>
<td>Optional</td>
<td></td>
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<tr>
<td>Synchro-check</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Autoreclose</td>
<td>X</td>
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<td>X</td>
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</tr>
<tr>
<td>IEEE 1344 / C37.118 (PMU)</td>
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<tr>
<td>IEC 61850-9-2</td>
<td>8 SV streams (Optional)</td>
<td>4 SV streams (Optional)</td>
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</tr>
</tbody>
</table>
Transformer protection, control and monitoring.
Relion® RET670, RET650

Transformers
Electrical transformers are key pieces of equipment common throughout an electrical grid. They are typically high-value, difficult to replace assets that can also become key weak points in electrical infrastructure as stresses on the grid increase, and safeguards are overwhelmed. Unnecessary transformer outages and undue equipment stresses should be avoided at all costs and a solution should be adopted that help keep these high-value assets in peak operating condition.

Voltage control
Voltage regulation and tap changer control are required for any transformer with an on load tap changer (OLTC), but it needn’t be a separate control device.

RET670 and RET650 both include voltage regulation and tap changer control for a single transformer, while RET670 can also be configured for voltage regulation and tap changer control of up to 8 parallel transformers.

Transformer protection
Relion RET670 or RET650 Intelligent electronic devices (IEDs) provide fast, reliable protection, monitoring and control solutions for all types of transformers. In addition, RET670 offers state-of-the-art protection for autotransformers, phase-shifting transformers and shunt reactors. These IEDs provide extremely fast differential protection with automatic CT ratio matching and vector group compensation, and are ideal solutions for the most demanding transformer protection applications.

RET650 delivers complete protection for two- or three-winding transformers, while RET670 can also provide control for up to 30 switching objects.

One RET670 IED can be extended to contain two differential protection functions to protect the most advanced system configurations, providing increased functional integration and more cost-effective protection and control solutions.

Transformer monitoring
Advanced transformer monitoring functions are included. These enable preventive maintenance of the equipment thereby avoiding outages and saving significant costs. Monitoring functionalities include estimation of transformer insulation loss of life based on top oil temperature measurement/calculation and monitoring of transformer through faults.

Voltage regulation
For single transformer or up to 8 parallel transformers
Tap changer control
IEC 61850 Edition 1 and 2 Edition 1 and 2
HMI
Full graphic display with circuit breaker, disconnector and tap changer position indications

RET670 comes in 2 pre-configured variants:
• RET670-A01 is intended for 2 winding transformers and RET650-A05 for three winding transformers. Both devices are 6U ½ 19" devices, offering a lot of functionality in a small package

RET670-A10 RET670-A25 RET670-B30 RET670-B40 RET650-A01 RET650-A05
Differential protection X X
Three winding differential protection X X
Back-up protection X Optional X X X X
Apparatus control Optional
Voltage regulation and OLTC control Optional X Optional Single transformer
IEEE 1344 / C37.118 (PMU) Optional
Apparatus control Optional Circuit breaker only
IEC 61850-9-2 streams Optional 5 SV streams (Optional) 4 SV streams (Optional)
Busbar protection.
Relion® REB670, REB650 and REB500

The heart of a substation is its busbar configuration. Although typically designed in single or double busbar systems, there are many other designs, each with specific advantages. ABB’s Relion family of IEDs provides the flexibility to adjust to any busbar configuration, and delivers unrivaled reliability and performance.

Traditional busbar differential protection employs a high impedance system. This relatively simple overvoltage or overcurrent function requires several supporting functions in a modern substation, such as advanced disturbance recording and communication capabilities.

REB650 is a dedicated, high performance, high impedance differential protection IED that fills this application space.

The performance and reliability of high impedance differential protection systems is hard to match using alternative methods, but they are also more costly, complex, and require the use of dedicated current transformers. High impedance differential protection schemes must also deal with potentially very high voltages near commissioning and maintenance personnel. Instead, low impedance differential protection is much easier to incorporate into modern protection systems, is considerably safer and considered the best solution by utilities all over the world.

ABB grid automation provides products for two different approaches to low impedance differential protection applications: REB670 for centralized and REB500 for distributed busbar protection solutions.

A centralized solution puts all process inputs and outputs in a single place - the busbar protection IED. This reduces IED hardware costs substantially, because it eliminates the need for additional hardware in all bays, unlike a distributed solution.

Centralized busbar protection is also generally faster because different IEDs do not have to communicate, eliminating delays. However, this does impact the size and extendibility requirements of the protection IED – each bay requires a certain number of IOs, which must fit in a single device and be wired from the bay to the centralized IED. This can be difficult from a station topology point of view, particularly in large, open-air substations.

REB670 offers an easy to configure centralized busbar protection for up to 24 feeders, and can cover up to 6 independent busbar zones.

In a distributed solution, a single, central IED connects many satellites (bay units), which are connected to the process. Typically, a distributed solution scales much better, as the IO is not concentrated on a single IED, which also drastically reduces the wiring needed between different parts of the installation. Instead of many cables coming from every feeder to a central location, a single optical fiber cable between the bays and the central IED suffices.

Although communication delays and the synchronization of many measurement points from different places reduces performance to some extent, it is still well within acceptable (and accepted) levels. While the additional hardware increases initial costs of a distributed installation compared to a centralized solution, subsequent installation costs can be reduced due to the reduction of wiring throughout the installation. REB500 delivers a high-performance solution, with industry leading reliability and sub cycle performance that scales up to very complex system topologies and many connected feeders.

<table>
<thead>
<tr>
<th>REB670-A20</th>
<th>REB670-A31</th>
<th>REB670-B20</th>
<th>REB670-B21</th>
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<tr>
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<td>High impedance</td>
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<tr>
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<th>REB670</th>
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</tr>
<tr>
<td>Number of zones</td>
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<th>REB670-Customized</th>
<th>REB500</th>
<th>REB505-A03</th>
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<td>Low impedance, distributed</td>
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<td>Measurement</td>
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<td>Single-phase</td>
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<td>Bays</td>
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<tr>
<td>Voltage and current backup protection</td>
<td>Optional</td>
<td>X</td>
</tr>
<tr>
<td>Breaker failure protection</td>
<td>Optional</td>
<td>X</td>
</tr>
<tr>
<td>Circuit breaker monitoring</td>
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</table>
Phasor measurement unit.
Relion® RES670

The Relion 670 series of protection and control intelligent electronic devices (IEDs) can provide power system AC voltages and currents as phasors.

Enhanced monitoring enables power network operators to take fast remedial action and use existing power systems more efficiently. Better information supporting fast, reliable emergency actions reduces the need for relatively high transmission margins made necessary by potential power system disturbances.

Depending on the product, these devices can transmit up to 32 analog phasors in two different data streams. The high accuracy of voltage and current measurements eliminates the need for any external measurement transducers, which makes the 670 series ideal for use in all types of Phasor Measurement Unit (PMU)-based applications.

RES670 comes in 2 preconfigured variants:
- RES670-A20 is intended for up to 3 bays and a single busbar. Although it can handle two distinct PMU reports, meaning it can handle 2 separate system frequencies, it is configured for a single frequency (busbar) system.
- RES670-B20 is intended for up to 6 bays and a double busbar. It can handle two distinct PMU reports, meaning it can handle differing frequency rates on both busbars and still report the frequency accurately. It features automatic configuration of the correct frequency system based on the status indications of the disconnector inputs of the bay.
Relion® the power of one solution.
for railways.

ABB delivers a comprehensive range of rail and urban transport infrastructure solutions for AC systems that ensure safe, reliable power delivery to all essential rail assets.

Rapid urbanization plus the urgent need to reduce carbon dioxide emissions are driving substantial new interest and investment in the transportation sector. Because of their specialized nature, traction power protection and control systems can be challenging.

With the Relion RER670, ABB offers a single solution encompassing the entire scope of railway power delivery; transmission, transformation and delivery. In a single device it supports single and two phase systems in isolated, compensated or solidly earthed networks.

Relion RER670 applications include protection, control and monitoring of AT and BT catenary systems, single and double phase power transformers, single and double phase transmission lines, and incorporate control and communication functionality based on IEC 61850 edition 2. The RER670 is designed to be used on 16.7 Hz, 50 Hz and 60 Hz networks.

With over 150000 Relion devices installed globally, RER670 has a robust family history and is a testament of the trust that has enabled numerous users to secure their power infrastructure.
Relion® RER670

RER670 is used for the protection, control and monitoring of transmission lines or transformers in 16.7 Hz, 50 Hz and 60 Hz railway applications.

**Line protection**

Line protection is covered by the distance protection function with quadrilateral or circular starting characteristics. The six zones have fully independent measurements and settings from each other which gives high flexibility for all types of lines. Load encroachment and adaptive reach compensation are included. Communication to remote ends can be used for even more selective protection, via traditional tele protection equipment or through direct IED to IED communication.

Backup functions like directional earth fault or overcurrent as well as breaker failure protection are available, as well as autoreclose and synchrocheck functions. A line fault locator for up to 10 line segment supports efficient remedial actions after faults on the transmission line.

**Transformer protection**

The transformer differential protection function covers different traction power transformer configurations and a wide range of current and voltage backup functions are available, including restricted earth fault protection.

A very fast transformer tank protection helps to avoid damages in case of short circuits to the transformer tank.

**Catenary protection**

Catenary distance protection package is similar to the line protection package, but is used as a distance protection for catenary feeders, which supply the moving locomotive through a pantograph. The function is applicable for single-phase booster transformer (BT) railway supply systems and can be used as a simplified distance protection for auto transformer (AT) catenary systems.

**Control and Interlocking**

This IED can also be provided with full bay control and interlocking functionality. The autorecloser includes priority features for multi breaker arrangements. It cooperates with the synchrocheck function with high-speed or delayed reclosing.

**Communication**

RER670 provides extensive IEC 61850 support, and incorporates such functions as MMS, GOOSE, SV, FTP, HSR and PRP, as well as IEC 60870-5-103 communication.

Binary signals can be exchanged with the Line Data Communication Module (LDCM). Communication between IEDs in different substations is supported using the IEEE C37.94 standard.

RER670 can be ordered with these functional packages:

- The A51 package is intended for transformer protection. It includes transformer under impedance, differential, restricted earth fault and tank overcurrent protection functionality.
- The B60 package is intended for line protection. It includes distance and switch onto fault protection, scheme communication and multi section fault location functionality.
- The B70 package is intended for catenary protection. It includes catenary distance and switch onto fault protection, scheme communication and multi section fault location functionality.
- The H37 and H38 packages offer apparatus energization control, transformer tap changer control, and current and voltage harmonic monitoring.
- Further options include transformer energization control, transformer tap changer control, and current and voltage harmonic monitoring.
- The number and type of analog inputs and binary inputs and outputs as well as mA input and communication modules can be selected when ordering.
Relion® the power of one solution.
For power generation and renewables.

We deliver secure power generation solutions by continuously adapting to the active system situation, guaranteeing reliability and performance.

Thermal power plants
Burning natural gas, coal, diesel oil, biomass or using nuclear fission to create steam, which in turn drives turbines and generators is how most electrical power on earth is presently produced, and thermal power generation will remain an integral part of the energy mix for a very long time. As the grid and the machinery connected to it become ever larger and more complex, reliable sources of quality power are crucial for its stability.

Hydroelectric power plants
Moving water is the oldest green technology, which has produced energy for mankind for thousands of years, and electricity for more than a century. Hydro generation continues to play a significant role in modern power networks as a load balancer and as a source of cheap, renewable energy. Although in many regions many of the most accessible hydro locations have been developed, pumped storage upgrade solutions are breathing new life and interest in existing installations. In regions with untapped renewable generation potential, hydro helps to integrate other renewable sources such as wind and solar power into the network, by providing stability and storage capacity.

Renewable generation
Sustainable power, such as solar photovoltaic, large and small hydroelectric and wind turbines deployed either onshore or offshore are part of the power generation future. Their deployment in our electrical networks is steeply on the rise and only expected to increase in the future, but this is not always an easy process.

Utility-scale renewable generation is typically situated in remote, difficult to access locations, such as far out to sea, in a desert or on a mountaintop, which means they require advanced protection and control equipment to ensure a reliable connection to the grid.

Generator
A generator is one of the most complex and essential pieces of electrical equipment in a power station. Without it no electricity will be produced, so unnecessary outages and undue stress on the generator are to be avoided at all cost.

Transformer
Step-up and auxiliary transformers are high value, difficult to replace assets that are as much a part of a generator protection solution as the generator protection device itself. Step-up transformers can potentially be exposed to a much larger frequency range than conventional transformers, and may also face very different conditions during fault and through fault incidents because of their proximity to the generator.

A protection solution for every component
ABB’s Relion family of IEDs delivers control, protection and monitoring solutions that protect these vital generating assets. With its proven reliability, high accuracy and high performance operation, the Relion series can be used for the most demanding applications.

Advanced control capabilities and system modeling, such as given by IEC 61850 will give you new ways to design and dynamically operate your network or power plant. And in the smart grid, information is of vital importance, so advanced and accurate PMU (phasor measurement unit) functionality will present you with the information you need to make your smart grid truly smart.

Technology may change, but safety, quality and reliability remain the top requirements of any power generation source. Whether the generation solution is large or small, centralized or distributed. In the end, every minute not spent producing energy has tremendous financial and social consequences. ABB is at the forefront of the digitalization that is sweeping over the power generation space. Our digital substation portfolio enables customers to build for the future - today, while still enjoying the long-term ABB know-how and support of the existing market.
Generator protection, control and monitoring.
Relion® REG670

Relion REG670 Intelligent Electronic Device (IED) is a protection and monitoring solution for generators, prime movers and step-up transformers in hydro, pumped storage, gas fired, combined cycle, steam, and cogeneration power plants.

Supported by ABB’s extensive experience in generator protection solutions, REG670 achieves a new level of performance with up to 24 analog inputs, and the availability of IEC61850-9-2 process bus technology. Main and back-up protection can be integrated into one IED, and additional components like transformers can be included in the scope of protection. This reduces the number of IEDs needed to protect the generating station. It also increases availability, simplifies installation and reduces lifecycle costs relating to commissioning, maintenance and spare parts.

Using an advanced and innovative filtering technique, REG670 can provide integrated sub synchronous resonance protection for turbo generators.

A REG670 generator protection scheme delivers maximum dependability and availability, featuring extremely fast detection criteria (typically 15 milliseconds) for generator differential protection, while maintaining a high level of security with DC offset functionality. Among the REG670’s many functions, is injection-based 100 percent stator and rotor earth fault protection, as well as third harmonic-based 100 percent stator earth fault protection. These solutions optimize the protection system’s cost-performance ratio in relation to the importance or size of the generating station. ABB’s innovative solution enables injection via a neutral point VT, or even an open-delta VT located at the generator terminals.

No changes are necessary in the primary circuit or grounding resistor, so the design, installation and commissioning of the protection system is simple and fast. The third harmonic-based 100 percent stator earth fault protection utilizes the differential principle, providing high sensitivity and security to ensure proper operation even in low load conditions.

REG670 comes in 3 different pre-configured variants, as well as a completely customizable solution:

- REG670-A20 offers a solution for a typical generator protection application with generator differential and back-up protection including 12 analog inputs transformers in a half 19” case size
- REG670-B30 offers enhanced generator protection application with generator differential and back-up protection, including 24 analog inputs in a full 19” case size. Optionally, pole slip protection, 100% stator earth fault protection and overall block differential protection can be added
- REG670-C30 offers complete unit protection, including generator and generator transformer protection with 24 analog inputs in a full 19” case size. Optionally pole slip protection and 100% stator earth fault protection can be added

<table>
<thead>
<tr>
<th></th>
<th>REG670-A20</th>
<th>REG670-B30</th>
<th>REG670-C30</th>
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<tbody>
<tr>
<td>Generator differential protection</td>
<td>x</td>
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<td>Two winding transformer differential protection</td>
<td>Optional</td>
<td></td>
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</tr>
<tr>
<td>Three winding transformer/block differential protection</td>
<td>Optional</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Backup protection</td>
<td>Extensive function selection included, and additional functionality available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparatus control</td>
<td>Optional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEEE 1344/C37.118 (PMU)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>IEC 61850-9-2</td>
<td>8 SV streams (Optional)</td>
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</table>
Protection and control manager for IEDs. 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.

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

- Powerful application configuration for creating and monitoring 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, 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

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.

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 (PCM600, IET600 and ITT600) 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.

Features
- IEC 61850 oriented project explorer for fast navigation within a project / substation
- Primary objects view
- Communication subnetworks view
- IED view
- HMI view
- Default support for primary and secondary equipment naming scheme according IEC 61846
- Station wide consistent IEC 61850 dataflow configuration
- View or engineer dataset and dataflow configuration, for vertical or horizontal IEC 61850 communication
- Comprehensive matrix for efficient and flexible configuration of:
  - IEDs
  - Communication subnetworks
  - Primary objects
  - Secondary objects
  - MMS client server reporting
  - GOOSE publisher/subscriber
  - Sampled values publisher/subscriber
- Configuration of IEC 61850 substation to substation communication
- Configuration of IEC 61850 functions & sub-functions
- Freely adaptable tool behavior for handling IEC 61850 IED capabilities for higher engineering tool interoperability
- Transparent IEC 61850 configuration comparison when importing SCL files
- Graphical editor for single line diagram
- Bay oriented
- Voltage level oriented
- Including IEC 61850 logical node mapping to primary equipment & functions
- Graphical editor for network configuration diagram covering and supporting:
  - IEDs, HMIs, Gateways
  - Ethernet switches
  - Switch configuration according to IEC 61850-90-4
- Graphical editor for network configuration diagram covering and supporting:
  - IEDs, HMIs, Gateways
  - Ethernet switches
  - Switch configuration according to IEC 61850-90-4
- Integral communication address configuration tables
- HMI database maintenance for ABB MicroSCADA Pro SYS600/C based substation automation systems
- Powerful copy/paste functions for:
  - Single or multiple HMI signals
  - IEC 61850 IEDs
  - Graphical bay single line diagram
  - Fully engineered bays including IEDs, single line diagram, logical node mapping, ABB MicroSCADA Pro SYS600/C database signals
  - Seamless migration of projects from the predecessor versions
- Supported file exchange formats for ABB MicroSCADA SYS600/C
  - "xml" file database load file
  - "csv" database load file (complete)
  - "csv" file database load file (changes only)
  - "txt" gateway configuration files
  - "xml" database documentation
- SCL import
- SCD, ICD, CID, IID
- SED (SCL version 2007 Rev.B)
- SCD, ICD, IID
- SED (SCL version 2007 Rev.B)
- "xml" export for documentation of complete IEC 61850 dataflow
- Supported IEC 61850 file formats
  - SCL import
  - SCD, ICD, CID, IID
  - SED (SCL version 2007 Rev.B)
  - SCL export
  - SCD, ICD, IID
  - SED (SCL version 2007 Rev.B)
- Supported IEC 61850 SCL scheme versions
  - 2003 Rev.A
  - 2007 Rev.B

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 diagram and as RMS values to allow engineers to evaluate primary currents and voltages sent by merging unit on-line. Off-line analysis for one stream includes an oscilloscope style view of the sampled values.
- 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 visualizes up to two IEC 61850 9-2 LE streams in a phasor diagram and as RMS values to allow engineers to evaluate primary currents and voltages sent by 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.