Medium voltage products

UniGear 550
12 - 17.5 kV, arc-proof, air insulated switchgear for power applications
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1. Description

- Each UniGear 550 panel consists of a single unit which can be equipped with a vacuum circuit-breaker as well as with all the accessories available for conventional switchgear units.
- Approved to be used for special applications such as marine, navy and type tested for IEC, GB/DL and GOST standards.
- The panel incorporates a cubicle in its upper level to house auxiliary instrumentation.
- Units can be coupled together directly with the other products of the UniGear family.
- The switchgear does not require rear access for installation or maintenance, all the operations are carried out from the front.
Characteristics of UniGear 550

Range
- ...12-17.5 kV, ...1250 A, ...31.5 kA
- Standard IEC
- GOST and GB/DL Standards
- Highly customized versions

Safety
- Fitted with safety interlocks
- Internal arc classification IAC AFLR
- Classified LSC-2B, PM
- CB racking with closed door

Flexibility
- Wide range of applications
- Vacuum circuit-breaker
- Ring core, block type instruments transformers or sensors
- Wall and free-standing solution

Quality
- High quality
- Large installed base
- Installed in large number of Countries

Design includes
- Protection and control
- Earthing switch
- IS Limiter (coupled with IS Limiter panel)
- Load break switch (coupled with UniGear ZS1)
- Integrated capacitor banks
- Bay computer

Applications

Utilities and Power Plants
- Power generation stations
- Substations
- Main and auxiliary switchgear

Industry
- Pulp and Paper
- Cement
- Textiles
- Food
- Automotive
- Quarrying
- Petrochemical
- Oil and gas
- Metallurgy
- Rolling mills
- Mines

Marine
- Drilling platforms
- Off-shore oil rigs
- Container ships
- Tankers
- Cable ships
- Ferries

Transport
- Airports
- Ports
- Railways
- Underground transport

Infrastructure
- Shopping malls
- Hospitals
- Large infrastructure and civil works
UniGear 550 has undergone all the tests required by the International Standards (IEC) and local standards organizations (for example the Chinese GB/DL and Russian GOST standards).

In addition, UniGear 550 has completed the series of certifications required by the regulations of the major shipping registers (LR, DNV, RINA, BV and GL) for use of the switchgear in Marine and Navy installations.

The UniGear 550 reflects all the construction characteristics of the UniGear ZS1.
The circuit-breaker is the vacuum type Vmax/L in a withdrawable version.

The innovative feature of this panel is its size. In fact, it only measures 550 mm in width which makes it a very compact and versatile product that is ideal for applications where space is restricted.

UniGear 550 is designed so that it can be connected directly to the other versions of UniGear, such as ZS1, 500R and MCC. UniGear 550 has the same overall dimensions (height and depth) and the same main busbars arrangement as UniGear ZS1 with a maximum current of 4000 A.

For this panel, positioning against the wall is possible. In fact, the switchgear does not require access from the rear for installation or maintenance.

All the service operations are carried out from the front.
As a standard solution, it is possible to connect up to three single-core cables per phase (maximum cross-section of 185 mm²), or two cables per phase (maximum cross-section of 300 mm²). The connection height of the cables in relation to the floor is 600 mm.

UniGear 550 uses ring core current transformers as the standard solution, which are fixed onto “CT Rods”.
As an optional solution, block type current transformers are available.

The panel is designed to allow the insertion of fixed voltage transformers, positioned at the rear of the panel itself.
A deeper version of the panel also allows the use of a withdrawable VT truck.

The capacitive signal for indicating voltage presence is connected directly to the insulators which support the busbars on the cable sides.

The surge arresters can also be inserted in the cable area. The UniGear 550 switchgear is fitted with all the interlocks and accessories needed to guarantee a high level of safety for equipment and personnel, as well as reliable operation.
The UniGear 550 is designed to be equipped with the following instrument transformers:
• Ring core type current transformer (standard)
• Block type current transformer (optional)
• Bushing type current transformer (optional)
• Current sensor or combisensors (optional).

Ring core type current transformer
The current transformers are arranged on a support inside the switchgear (CT rod) and above the cable terminals so they are unaffected by: number of cables, cross section and type of terminations.
The CT rods are designed to be equipped with a maximum of two current transformers per phase (metering and protection) and with the following dimensional requirements:
• From 50 A to 200 A:
  - Minimum internal diameter: 59 mm
  - Maximum external diameter: 200 mm
  - Maximum height: 100 mm.
• From 250 A to 1250 A:
  - Minimum internal diameter: 69 mm
  - Maximum external diameter: 147 mm
  - Maximum height: 75 mm.

Block type current transformer or current sensor or combisensors
As an alternative to the above CT Rod CTs, the use of block type current transformers, current sensors and combisensors is possible.
Their use may be required in certain cases such as the need for fiscal metering on incoming feeders (Class 0.2), residual current protection on transformer feeders, etc.
The use of block type current transformers will in any case allow the application of ring core type current transformers on cables.

Bushing type current transformer
As an another alternative, UniGear 550 can also be furnished with bushing type current transformers, making this switchgear suitable for markets influenced by British Standards (BS).

Figure 2: Ring core type current transformers
Figure 3: Block type current transformers
Figure 4: Bushing current transformers
2. Air insulated switchgear

**ST-UG Earthing switch**

The UniGear 550 panel is equipped with the ST-UG type earthing switch. This device is a patented switch with rectilinear movement.

It is fitted with a snap action operating mechanism for positive high speed closing and it is dimensioned to conduct the rated short circuit making current when closed under load.

The speed of the snap action closing operation is independent of the controls.

The switch is equipped with an earthing blade which connects the three phases via the earthing pins mounted on the copper bars of the cable connecting system.

The earthing bar is electrically connected to earth by a stranded copper conductor.

The snap action closing mechanism of the earthing switch functions independently of the rotation of the drive shaft.

The switching speed and torque achieved are independent of the action of the operating mechanism.

A manual operating lever is provided for operation of the switch.

The earthing switch has been tested for two closing operations at 100% of the rated short-circuit making current.

The device is provided with auxiliary switches for signalling the open and closed positions, operated by the rod mechanism.

The following are available on request:
- Locking magnet
- Key locks for open and closed positions
- Padlock.

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<thead>
<tr>
<th>Earthing switch ST-UG</th>
<th>Rated voltage</th>
<th>Rated withstand impulse voltage</th>
<th>Rated short-time withstand current</th>
<th>Short-circuit duration</th>
<th>Short-circuit making current</th>
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<tr>
<td>Type</td>
<td>U(kV)</td>
<td>Uth(kV)</td>
<td>Ith(ka)</td>
<td>th(s)</td>
<td>Ith(ka)</td>
</tr>
<tr>
<td>ST-UG – 12-150</td>
<td>12</td>
<td>75</td>
<td>31.5</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>ST-UG – 17.5-150</td>
<td>17.5</td>
<td>95</td>
<td>31.5</td>
<td>1</td>
<td>80</td>
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*Figure 5: ST-UG Earthing switch*
## IEC Electrical characteristics

<table>
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<td>IAC AFLR</td>
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<tr>
<td>Rated voltage [kV]</td>
<td>12</td>
</tr>
<tr>
<td>Rated insulation voltage [kV]</td>
<td>12</td>
</tr>
<tr>
<td>Rated power frequency withstand voltage [kV 1 min]</td>
<td>28</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage [kV]</td>
<td>75</td>
</tr>
<tr>
<td>Rated frequency [Hz]</td>
<td>50/60</td>
</tr>
<tr>
<td>Main busbar rated current (40 °C) [A]</td>
<td>... 4000</td>
</tr>
<tr>
<td>Circuit-breaker rated current (40 °C) [A]</td>
<td>630</td>
</tr>
<tr>
<td>Rated short-time withstand current [kA x 3 s]</td>
<td>16/20/25/31.5</td>
</tr>
<tr>
<td>Internal arc withstand current (IEC 62271-200) [kA x 1 s]</td>
<td>16/20/25/31.5</td>
</tr>
<tr>
<td>Tested according to</td>
<td>IEC</td>
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</table>

1) GB/DL version is available with higher request in dielectric characteristics (42 kV) and short-time withstand current (4 s).

## Standards

The switchgear and main apparatus contained within comply with the following Standards:
- IEC 62271-1 for general purposes.
- IEC 62271-200 for the switchgear.
- IEC 62271-102 for the earthing switch.
- IEC 60071-2 for the insulation coordination.
- IEC 62271-100 for the circuit-breakers.
- IEC 60529 for degree of protection.

## Normal operation conditions

The rated characteristics of the switchgear are guaranteed under the following ambient conditions:
- Minimum ambient temperature: – 5 °C
- Maximum ambient temperature: + 40 °C

For different temperature ranges, please contact your ABB sales representative.

- Ambient humidity:
  - Maximum 24 h average of relative humidity 95% RH
  - Maximum 24 h average of water vapour pressure 2.2 kPa
  - Maximum monthly average of relative humidity 90% RH
  - Maximum monthly average of water vapour pressure 1.8 kPa

- The normal operational altitude is up to 1000 m above sea level. For higher altitude applications, please contact your ABB sales representative.
- Presence of normal, non-corrosive and uncontaminated atmosphere.

## Degrees of protection

The degrees of protection of the switchgear conform with IEC 60529 Standards.

UniGear 550 switchgear is normally supplied with the following standard degrees of protection:
- IP4X for the enclosure
- IP2X for the partition between compartments.

On request, the external housing can be supplied with higher degrees of protection; in this case, please contact your ABB sales representative.

The electrical characteristics of the switchgear can vary for ambient conditions other than those described in the previous section and also if a higher degree of protection is used.

## Colour of the external surfaces

RAL7035 - light grey. (Front doors and side sheets). Other colours available on request.
3. IEC Classification

With the release of the IEC 62271-200 standard, new definitions and classifications of Medium Voltage switchgear have been introduced. One of the most significant changes is that classification of switchgear into metal-clad, compartmented and cubicle types has been abandoned. The revision of switchgear classification rules has been based on the user’s point of view, in particular on aspects like service and maintenance of the switchgear, according to the requirements and expectations for proper management, from installation to dismantling. In this context, Loss of Service Continuity (LSC) has been selected as a fundamental parameter for the user. According to the IEC 62271-200, UniGear 550 switchgear can be defined as follows.

Loss of service continuity -LSC-2B
The various LSC categories describe the possibility of keeping other compartments and/or panels energized while a compartment in the main circuit is opened. The defined categories are:
• LSC-1: The whole switchgear shall be put out of service for opening a main circuit compartment for normal operation and/or normal maintenance or for gaining access to any switchgear components.
• LSC-2A: The same as LSC-1 with the exception that the main busbars and the functional units adjacent to the one under maintenance can remain energized.
• LSC-2B: The same as LSC-2A with the exception that the cable compartment can remain energized.
UniGear 550 is classified as LSC-2B because the busbar, circuit-breaker and cable compartments are physically and electrically segregated. This is the category that defines the possibility of accessing the circuit-breaker compartment with the busbars and cables energized.

Partition Metallic -PM
With regard to the type of partitions or shutters between live parts and an open compartment, a distinction is made between two partition classes:
• Class PM (Partition made of Metal);
• Class PI (Partition made of Insulating material).
UniGear 550 is defined with PM partition class having the segregation between compartments made of metallic sheets/shutters.

Interlock-controlled accessible compartment
The front side of UniGear 550 is classified interlock-controlled because the access of the compartments containing high-voltage parts, intended to be opened for normal operation and/or normal maintenance, is controlled by the integral design of the switchgear.

Tool-based accessible compartment
The rear part of the UniGear 550 is classified tool-based because it is possible to open the compartment containing high-voltage parts, that may be opened, but not for normal operation and maintenance, only using a tool. Special procedures are required.

Internal arc classification – IAC AFLR
UniGear 550 switchgear is classified IAC AFLR
When the switchgear is specified and installed, some fundamental points must be taken into consideration:
• Level of the fault current (16...31.5 kA).
• Duration of the fault (0.1...1s).
• Escape routes for the hot and toxic gases produced by combustion of materials.
• Dimensions of the room, with special attention to the height.
Please consult your ABB representatives for detailed information.
Figure 6: UniGear 550
Compartments
Each switchgear unit consists of three power compartments: circuit-breaker [A], busbars [B] and cables [C]; please refer to figure 7. Each unit is fitted with a low voltage compartment [D], where all the auxiliary instruments are housed. Arc-proof switchgear is normally provided with a duct [E] for evacuation of the gases produced by an arc; different types of gas ducts are available. All the compartments are accessible from the front and maintenance operations can correctly carried out with the switchgear installed up against a wall. The compartments are segregated from each other by metallic partitions.

Main busbars
The busbar compartment contains the main busbar system connected to the upper isolating contacts of the circuit-breaker by means of branch connections. The main busbars are made of electrolytic copper. For ratings up to 2500 A, the busbars are flat bars; while for currents between 3150 A and 4000 A, a special D-shape busbar is used. The busbars are covered with insulating material at 17.5 kV. There is a single busbar compartment along the whole length of the switchgear, which optionally can be divided into compartments.

Cable connections
The cable compartment contains the branch system for connection of the power cables to the lower contacts of the circuit-breaker. The feeder connections are made of electrolytic copper and they are flat bars for the whole range of currents. For 17.5 kV they are covered with insulating material.

Earthing switch
Cable compartment can be fitted with an earthing switch for cable earthing. The same device can also be used to earth the busbar system (measurements and bus-tie units). It can also be installed directly on the main busbar system in a dedicated compartment (busbar applications). The earthing switch has short-circuit making capacity. Control of the earthing switch is from the front of the switchgear with manual operation. The position of the earthing switch can be seen from the front of the switchgear by means of a mechanical coupled indicator and from the front window.

Earthing busbar
The earthing busbar is made of electrolytic copper and it runs longitudinally throughout the switchgear, thereby guaranteeing maximum personnel and installation safety.

Insulating bushings and shutters
The insulating bushings in the circuit-breaker compartment contain the contacts for connection of the circuit-breaker with the busbar compartment and cable compartment respectively. The insulating bushings are of three-pole type and are made of epoxy resin. The shutters are metallic and are activated automatically during movement of the circuit-breaker from the racked-out position to the operation position and vice versa.

Cables
Single and three-core cables up to a maximum of three per phase cn be used depending on the rated voltage, and the cable cross section (please refer to page 24). The switchgear can be back to wall installed as the cables are easily accessible from the front.
Gas exhaust duct
The gas exhaust duct is positioned above the switchgear and runs along its whole length. Each power compartment is fitted with a flap on its top surface. The pressure generated by the fault makes it open, allowing the gas to pass into the duct. Evacuation from the room of the hot gases and incandescent particles produced by the internal arc must normally be carried out. The UniGear 550 switchgear can be fitted with a complete range of solutions to satisfy all requirements, either in the case where evacuation is possible directly at the end of the switchgear, or when solutions from the front or rear are requested. Some installations, such as marine applications, do not allow evacuation of the gases to the outside of the room and therefore a dedicated solution has been developed to guarantee personnel safety and conformity with the Standards, such as longitudinal evacuation chimneys. Please contact your ABB sales representative for more information.

Busbar applications
Each switchgear unit can optionally be fitted with an accessory busbar application:
- current or voltage transformers for busbar measurements.
- busbar system earthing switch.
- top entry duct or cables to make interconnections between different sections of switchgear.

Unit compartments
A  Circuit-breaker compartment
B  Busbar compartment
C  Cable compartment
D  Low voltage compartment
E  Gas exhaust duct

Figure 7: UniGear 550 section view
5. Fully type-tested

The UniGear 550 switchgear has undergone all the tests required by the international (IEC) Standards and local Standards organizations (for example, the Chinese GB/DL and Russian GOST standards).

In addition, the tests required by the main shipping registers (LR, DNV, RINA, BV and GL) have been carried out for use of the switchgear in marine installations. As indicated in these standards, the tests were carried out on the switchgear units considered most sensitive to the effects of the tests and therefore the results were extended across the whole range.

Each switchgear unit is subjected to routine tests in the factory before delivery. These tests are intended to provide a functional check of the switchgear based on the specific characteristics of each installation.

IEC type tests
- Short-time and peak withstand current
- Temperature rise
- Internal arc capability
- Dielectric test
- Making and breaking capacity of circuit-breaker and contactors
- Earthing switch making capacity
- Mechanical operations of circuit-breaker and earthing switch
- IP degree

IEC routine factory tests
- Visual inspection and check
- Mechanical sequence operations
- Cabling check
- Electrical sequence operations
- Power frequency withstand voltage
- Measurement of the resistance of the main circuits
- Secondary insulation test

Special type tests required by shipping registers for marine/navy application
- High ambient temperatures (+45 °C)
- Inclination
- Vibration
- Shock test

Description of IEC type tests
- Short-time and peak withstand current
  The test shows that the main power and the earthing circuits resist the stresses caused by the passage of the short-circuit current without any damage. It should also be noted that both the earthing system of the withdrawable circuit-breaker and the earthing busbar of the switchgear are subjected to the test. The mechanical and electrical properties of the main busbar system and of the top and bottom branch connections remain unchanged even in the case of a short-circuit.

- Temperature rise
  The temperature rise test is carried out at the rated current value of the switchgear unit and shows that the temperature does not become excessive in any part of the switchgear unit. During the test, both the switchgear and the circuit-breaker or contactor it may be fitted with are checked.

- Internal arc capability
  Please refer to page 16.
Type tests required by the shipping registers and navies

• **High ambient temperatures**
The service conditions for the electrical apparatus in marine installations are generally more severe than those in normal land applications.
Temperature is a main factor and for this reason the shipping register regulations require the switchgear to be able to operate at higher ambient temperatures (45 °C or higher) than those stated in the IEC Standards (40 °C).

• **Inclination**
The test is carried out by inclining the switchgear for a defined time up to 25° alternately on all four sides and operating the apparatus.
The test proves that the switchgear is able to resist these extreme service conditions and that all the apparatus it contains can be operated without any problems and without being damaged.

• **Vibration**
The reliability and sturdiness of the UniGear ZS1 switchgear has been definitively proved by the result of the withstand test to mechanical stresses due to vibration. The service conditions on shipping installations and marine platforms require the switchgear to work in environments strongly affected by vibrations, such as those caused by the motors on large cruise ships or the drilling plants of oil rigs.
– 1 mm amplitude in the frequency range between 2 and 13.2 Hz.
– 0.7 g acceleration amplitude in the frequency range between 13.2 and 100 Hz (see picture on the previous page).

• **Shock test**
This verifies the capability of the UniGear 550 to withstand the effect of the shock wave generated by an explosion of a bomb under the surface of the sea.
This test has been performed by Cetena-Fincantieri using Cetena’s high impact for medium weight equipment installed in the Riva Trigoso workshop.

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• **Dielectric test**
These tests verify that the switchgear has sufficient capability to withstand the lightning impulse and the power frequency voltage.
The power frequency withstand voltage test is carried out as a type test, but it is also a routine test on every switchgear unit manufactured.

• **Circuit-breaker making and breaking capacity**
The circuit-breaker is subjected to the rated current and short-circuit current breaking tests.
Furthermore, it is also subjected to the opening and closing of capacitive and inductive loads, capacitor banks and/or cable lines.

• **Earthing switch making capacity**
The earthing switch of the UniGear 550 switchgear can be closed under short-circuit. Although, the earthing switch is normally interlocked to avoid being operated on circuits which are still live.
However, should this happen for any reasons, personnel safety will be fully safeguarded.

• **Mechanical operations**
The mechanical endurance tests on all the operating parts ensures the reliability of the apparatus. General experience in the electro-technical sector shows that mechanical faults are one of the most common causes of a fault in an installation.
The circuit-breaker is tested by carrying out a high number of operations - higher than those which are normally carried out by installations in the filed.
Furthermore, the switchgear components are part of a quality control program and samples are regularly taken from the production lines and subjected to mechanical life tests to verify that the quality is identical to that of the components subjected to the type tests.

• **IP degree**
The IP protection degree is the resistance offered by the UniGear 550 against penetration of solid objects and liquids.
This degree of resistance is indicated by the prefix IP followed by two characters (i.e. IP4X).
The first number identifies the degree of protection against the entrance of solid objects, the second one is related to liquids.
6. Safety

When developing modern medium voltage switchgear, personnel safety must necessarily take priority. This is why the UniGear 550 switchgear has been designed and tested to withstand an internal arc due to a short-circuit current of the same current level as the maximum short-time withstand level.

The tests show that the metal housing of UniGear 550 switchgear is able to protect personnel near the switchgear in the case of a fault which evolves as far as striking an internal arc.

An internal arc is a highly unlikely fault, although it can theoretically be caused by various factors, such as:

- Insulation defects due to quality deterioration of the components. The reasons can be adverse environmental conditions and a highly polluted atmosphere.
- Overvoltages of atmospheric origin or generated by the operation of a component.
- Inadequate training of the personnel in charge of the installation.
- Breakage or tampering of the safety interlocks.
- Overheating of the contact area, due to the presence of corrosive agents or when the connections are not sufficiently tightened.
- Entry of small animals into the switchgear (i.e., through cable entrance).
- Material left behind inside the switchgear during maintenance activities.

The characteristics of the UniGear 550 switchgear notably reduce the incidence of these causes for faults, but some of them may not be eliminated completely. The energy produced by the internal arc causes the following phenomena:

- Increase in the internal pressure.
- Increase in temperature.
- Visual and acoustic effects.
- Mechanical stresses on the switchgear structure.
- Melting, decomposition and evaporation of materials.

Unless suitably protected, these phenomena have very serious consequences for the personnel, such as wounds (due to the shock wave, flying parts and the doors opening) and burns (due to emission of hot gases).

The internal arc test verifies that the compartment doors remain closed and that no components are ejected from the switchgear even when subjected to very high pressures, and that no flames or incandescent gases penetrate, thereby ensuring safety of the personnel near the switchgear. The test also ensure that no holes are produced in external accessible parts of the housing, and finally, that all the connections to the earthing circuit remain intact, hence guaranteeing the safety of personnel who may access the switchgear after the fault.

The IEC 62271-200 Standard describes the methods to be used for carrying out the test and the criteria which the switchgear must conform to.

The UniGear 550 switchgear fully conforms to all the five criteria indicated by the IEC standards.

The IAC classification is proved by the test according to the following designations:

- General: classification IAC (Internal Arc Classified)
- Accessibility: A, B or C (switchgear accessible to authorized personnel only (A), to all (B), not accessible due to installation (C))
- F, L, R: access from the front (F – Front), from the sides (L – Lateral) and from the rear (R – rear).
- Test values: test current in kiloamperes (kA), and duration in seconds (s).

The parameters of each specific plant mean that evacuation of the hot gases and incandescent particles must be checked very carefully in order to ensure and maintain personnel safety.

Fault limiting systems

The structure of the UniGear 550 switchgear offers complete passive type protection against the effects of a fault due to an internal arc for a time of 1 second up to 31.5 kA. ABB has also developed excellent active protection systems which allow very important objectives to be achieved:

- Detection and extinction of the fault, normally in less than 100 ms, which improves network stability.
- Limitation of damage on the apparatus.
- Limitation of outage time for the switchgear unit.

For active protection against an internal arc, devices consisting of various types of sensors can be installed in the various compartments, which detect the immediate outburst of the fault and carry out selective tripping of the circuit-breakers.

The fault limiting systems are based on sensors which use the pressure or light generated by the arc fault as trigger for fault disconnection.

16
ITH
The ITH sensors consist of micro-switches positioned on the top of the switchgear near the gas exhaust flaps of the three power compartments (busbars, circuit-breaker and cables). The shock wave makes the flaps open and operate the micro-switches connected to the shunt opening release of the circuit-breaker. Total tripping time is 75 ms (15 ms ITH + 60 ms circuit-breaker).

FRD (Fast Recovery Device)
This system consists of pressure sensors located in the low voltage compartment and connected to the three power compartments by means of small tubes. The sensors detect the rising front of the pressure wave which develops on the outburst of the arc and react by making the circuit-breakers open. The sensors are protected against the external environment and they can be checked even with the switchgear in operation. Total tripping time is 75 ms (15 ms FRD + 60 ms circuit-breaker).

TVOC
This system consists of an electronic monitoring device located in the low voltage compartment which is connected to optic sensors. These are distributed in the power compartments and are connected to the device by means of optic fibres. When a certain pre-set light level is exceeded, the device opens the circuit-breakers. To prevent the system from intervening due to light occasionally generated by external phenomena (flash of a camera, reflections of external lights, etc.), current transformers can also be connected to the monitoring device. The protection module only sends the opening command to the circuit-breaker if it receives the light and short-circuit current signal simultaneously. Total tripping time is 62 ms (2 ms TVOC + 60 ms circuit-breaker).

REA
This system offers the same functionality as TVOC. The REA system consists of the main unit (REA 101) and optional extension units (REA 103, 105, 107) which make it possible to create customized solutions with selective tripping. For more information, please see the dedicated chapter at page 38. Total tripping time is 62,5 ms (2,5 ms REA + 60 ms circuit-breaker).

Arc protection in IED
The REF615, RET615, REM615 and REF610 IEDs (Intelligent Electronic Device) can optionally be fitted with a fast and selective arc flash protection. It offers a two-to three-channel arc-fault protection system for arc flash supervision of the circuit breaker, cable and busbar compartment of switchgear panels. Total tripping time is 72 ms (12 ms IED + 60 ms circuit-breaker).

Figure 9: Arc duration and damage caused
The UniGear 550 switchgear is fitted with all the interlocks and accessories needed to guarantee the highest level of safety and reliability for both installation and personnel.

Interlocks
The safety mechanical interlocks are standard ones [1÷5], please see the dedicated table at page 19. They are set out by the IEC standards and are therefore necessary to guarantee the correct operation sequence. ABB safety interlocks guarantees the highest level of reliability, even in the case of an accidental error, and enables highest operator safety system of interlocks.

Keys
The use of key interlocks is very important in realising the interlocking logics between panels of the same switchgear, or of other medium, low and high voltage switchgear. The logics are realised by means of distributors or by ringing the keys. The apparatus truck [6] can be locked in the racked-out position and the relevant lock key can only be removed with the apparatus in this position. The earthing switch closing [7] and opening [8] operations can be locked by means of keys, key logic is explained in the table at page 19. The circuit-breaker racking-in/out operations [9] and earthing switch opening/closing [10] can be prevented by means of key locks, which prevent insertion of the relevant operating levers. The key lock can also be applied to the earthing switch of busbar applications. The keys can always be removed.

Padlocks
The circuit-breaker [11] and cable [12] compartment doors can be locked in the closed position by means of padlocks. These can be applied to both door closing versions –with central handle (standard) or screws (optional). The operations for apparatus racking-in/out [13] and earthing switch opening/closing [14] can be prevented by applying the padlocks to the insertion slots of the relevant operating levers. The padlock can also be applied to the earthing switch of busbar applications.

Figure 10: Double key lock on earthing switch

The metallic segregation shutters [15] between circuit-breaker, busbars and cable compartments can be locked by means of two independent padlocks in both the open and closed position. Padlocks from 4 to 8 mm diameter can be accommodated.

Locking magnets
The locking magnets enable automatic interlocking logics without human intervention. The circuit-breaker racking-in/out [16] and the earthing switch closing/opening [17] operations can be interlocked. This magnet can also be applied to the earthing switch of busbar applications. The magnets operate with active logics and therefore the lack of auxiliary voltage leaves the interlocking system active (in safety condition).
### Standard safety interlocks (mandatory)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Condition to be fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 A</td>
<td>Apparatus racking-in</td>
<td>Apparatus in OFF position</td>
</tr>
<tr>
<td>1 B</td>
<td>Apparatus closing</td>
<td>Defined truck position</td>
</tr>
<tr>
<td>2 A</td>
<td>Apparatus racking-in</td>
<td>Defined truck position</td>
</tr>
<tr>
<td>2 B</td>
<td>Apparatus multi-contact plug unplugging</td>
<td>Truck in test position</td>
</tr>
<tr>
<td>3 A</td>
<td>Earthing switch closing</td>
<td>Truck in test position</td>
</tr>
<tr>
<td>3 B</td>
<td>Apparatus racking-in</td>
<td>Earthing switch in OFF position</td>
</tr>
<tr>
<td>4 A</td>
<td>Apparatus compartment door opening</td>
<td>Truck in test position</td>
</tr>
<tr>
<td>4 B</td>
<td>Apparatus racking-in</td>
<td>Apparatus compartment door closed</td>
</tr>
<tr>
<td>5 A</td>
<td>Feeder compartment door opening</td>
<td>Earthing switch in OFF position</td>
</tr>
<tr>
<td>5 B</td>
<td>Earthing switch opening</td>
<td>Cable compartment door closed</td>
</tr>
</tbody>
</table>

Note: Apparatus is circuit-breaker.

### Keys (on request)

| 6    | Apparatus racking-in lock           | Can only be removed with the truck in the racked-out position |
| 7    | Earthing switch closing lock         | Can only be removed with the earthing switch open             |
| 8    | Earthing switch opening lock         | Can only be removed with the earthing closed                  |
| 9    | Insertion of the apparatus racking-in/out crank lever | Can always be removed |
| 10   | Insertion of the earthing switch operating lever | Can always be removed |

### Padlocks

| 11   | Apparatus compartment door opening  |
| 12   | Cable compartment door opening      |
| 13   | Insertion of the apparatus racking-in/out crank lever |
| 14   | Insertion of the earthing switch operating lever |
| 15   | Shutters opening or closing         |

### Locking magnets (on request)

| 16   | Apparatus racking-in/out            |
| 17   | Earthing switch ON/OFF               |

### Accessory devices

| 20   | Shutters fail-safe                  |
| 21   | Apparatus-switchgear unit compatibility matrix |
| 22   | Circuit-breaker mechanical operating mechanism |

The device locks the shutters in the closed position when the apparatus is removed from the compartment. The operator cannot open the shutters manually. The shutters can only be operated by the apparatus truck.

The apparatus multi-contact plug and relative switchgear unit socket are equipped with a mechanical matrix, that disables apparatus racking-in into a switchgear unit with an inappropriate rated current.

The apparatus compartment is equipped with a mechanical device, that enables circuit-breaker closing and/or opening directly by means of the front operating mechanism pushbuttons, keeping the door closed. The controls can be operated with the circuit-breakers in the operation and racked-out position.
The Vmax medium voltage circuit-breakers combine ABB’s state-of-the-art technology in designing and constructing vacuum interrupters with its excellence in the design, engineering and production of the circuit-breakers. They find their ideal use in UniGear 550.

The ratings are up to 17.5 kV, 1250 A and 31.5 kA. Vmax circuit-breakers are used in electrical distribution for control and protection of cables, overhead lines, transformer and distribution substations, motors, transformers, generators and capacitor banks.

Insulating monobloc
The structure of Vmax is particularly innovative since instead of have three distinct separate poles, it has a single insulating monobloc where the three vacuum interrupters are housed. The monobloc and operating mechanism, of the mechanical type with a spring for operating energy storage, are fixed to a sturdy metallic frame.

Operating mechanism
The Vmax series is fitted with a simple mechanical operating mechanism, derived from the same mechanical operating mechanism used on the VD4 series. The stored energy operating mechanism with free trip allows opening and closing operations independent of the operator. The spring system of the operating mechanism can be recharged both manually and by means of a geared motor. Opening and closing of the apparatus can take place both by means of the push-buttons located on the front of the panel, and by means of the electric releases (shunt closing, shunt opening and undervoltage).

The circuit-breaker is always fitted with a mechanical antipumping device to prevent repeated sequences of opening and closing operations following simultaneous and maintained opening and closing commands (both local and/or remote).
Apparatus-operator interface
The front part of the circuit-breaker provides the user interface.

It features the following equipment:
• OFF pushbutton.
• ON pushbutton.
• operation counter.
• indicator of the circuit breaker open and closed state.
• indicator of the charged and discharged state of the operating mechanism springs.
• manual charging device for the operating mechanism springs.
• override selector of the undervoltage release (optional).

Standards
IEC 62271-100 for the circuit-breaker.

Circuit-breaker operating mechanism
A OFF/ON auxiliary contacts
B Geared motor for spring charging
C Built-in spring charging lever
D Mechanical signalling device for circuit-breaker ON/OFF
E Mechanical operation counter
F Plug-socket connectors of electrical accessories
G Signalling device for springs charged/discharged
H Service releases
I ON pushbutton
L OFF pushbutton

Figure 12: internal view of Vmax circuit-breaker operating mechanism
Selection of the current transformer type must take into account the level of primary current as follows:

- 50 A - 200 A: Ring core, block type CTs or sensors.
- 250 A - 1250 A: Ring core, block type CTs or sensors.

**Ring core current transformer**

The ring core current transformer can be air or resin insulated and is used to supply metering and protection devices. The transformer can feature either a closed or split core. The ring core transformer with split core is used for detecting earth fault currents and can be easily mounted around the incoming cables. An air insulated ring core transformer is used for measuring the phase current and it is placed over the insulated CT rod.

These transformers comply with IEC 60044-1 standard.

**Block type current transformers**

The block type current transformers are epoxy resin insulated and used to supply the measurement devices and protection instruments. These transformers have a wound core with one or more cores, with performance and accuracy classes suitable for the installation requirements. They conform to the IEC 60044-1 Standards.

Their dimensions are in accordance with the DIN 42600 Narrow Type Standard, in the Medium and Long Size versions up to 1250 A.

The current transformers can also be provided with a capacitive socket for connection to voltage signalling devices. The current transformers are normally fitted on the load side of the apparatus compartment for measurement of the phase currents of the switchgear unit. Fitting on the supply side of the apparatus compartment is also possible (busbar applications) for measuring the busbar currents or for realising particular protection schemes. The ABB range of current transformers is designated TPU.
Voltage transformers

The voltage transformers are of the epoxy resin insulated type and are used to supply measurement and protection devices. They are available for fixed assembly or for installation on removable and withdrawable trucks. They conform with the IEC 60044-2 Standards. Their dimensions are in accordance with the DIN 42600 Narrow type Standard.

These transformers can have one or two poles, with performance and precision classes suited to the functional requirements of the instruments connected to them. When they are installed on removable or withdrawable trucks they are fitted with medium voltage protection fuses. The withdrawable trucks also allow replacement of the fuses with the switchgear in service. Truck racking-out with the door closed automatically operates closure of a metallic segregation shutter between the live parts of the switchgear and the instrument compartment.

Fixed voltage transformers can be installed directly on the main busbar system in a dedicated compartment (busbar applications). The ABB range of voltage transformers is designated TJC, TDC, TJP.
9. Measurement sensors

Electronic instrument transformers
Future for measuring currents and voltages in intelligent UniGear is a low-power instrument transformer (according to present IEC standards they belong to the group of Electronic instrument transformers) called a “sensor” for short. These products replace conventional instrument transformers of both block and ring core types.
The characteristic feature of advanced ABB sensors is the level of output signal, which is fully adapted to fit new microprocessor-based equipment without the need of having unnecessary power.
The analogue output signal level depends on the principle used and can be:
- In the range of mV for current sensor (typical value is 150 mV at rated primary current).
- In the range of volts for voltage sensors where the division ratio is 1:10000 (e.g. output 1/√3 V for 10 000/√3 kV nominal system voltage at primary/input side).
The UniGear 550 can be fitted with two sensor types:
- KEVCD is block type sensor with shape that conforms to DIN size standard. Two versions could be selected: one providing current measurement together with voltage indication capability or second one, providing, in addition to these, also voltage measurement possibility. All measurements/sensings for each phase is realized within a single body, so there is no need for additional devices.
- KECA is ring type current sensor.

Characteristics of the sensors
Construction of current and voltage sensors is done without the use of ferromagnetic core. This fact results in several important benefits for the user and the application:
- sensor behavior is not influenced by non-linearity and width of hysteresis curve; that results in accurate and linear response over a wide dynamic range of measured quantities.
- single device/sensor could be used for both protection and for measurement purposes (no need for a separate design/product).
- there are no hysteresis losses, so sensors are having excellent frequency response also at frequencies different from the rated one, thus providing very precise input to protection functions, allowing more precise fault analysis and efficient fault location.
- sensors do not have dangerous states in operation (no problem to keep output short-circuited or left open), resulting in high safety for surrounding devices and personnel. The output signal remains very low even in fault situations of the network.
- the use of sensors disable the possibility of related ferroresonance phenomena, thus even more increasing the safety and reliability of the power network; furthermore, there is no need for additional protection equipment, special burden or wiring.

![Diagram](image_url)

Figure 20: Linearity of advanced ABB sensors and example of output signal waveforms compared to conventional saturated CT
ABB sensors are connected to the measurement and protection evaluation devices by means of shielded cables and connectors, providing a high degree of immunity to electromagnetic disturbances.

Accuracy of these sensors is verified and tested including the cabling, so precise information is assured up to the evaluation device. Furthermore, the use of ABB sensors and ABB relays enables to guarantee the overall system accuracy, i.e. to guarantee the accuracy of full measurement chain = sensors together with IED, to be better than 1%.

Benefits of the sensors

Due to the linear response and wide dynamic range, sensors are much more standardized devices (compared to a number of different designs of CTs and VTs). Therefore, it is much easier to select the appropriate design (it simplify engineering tasks) and there could be also reduction in spare parts on user side.

Significantly decreased power consumption during operation of sensors due to negligible losses introduced by sensors (no iron = no hysteresis losses; less winding and negligible output current = small losses in sensor winding) results in huge savings for lost energy and minimized temperature rise (thus improving temperature conditions and ageing within application). It also results in significantly lighter devices, having weight only a fraction of that provided by conventional CTs or VTs. Therefore, no special machines/tools are needed to carry them and transport costs can be smaller.

Fast connection of sensors to IEDs without any tools and material needed simplify and reduce assembly effort.

Figure 21: KEVCD block type current and voltage sensor

Figure 22: KECA ring core type sensor
9. Measurement sensors

Current sensor

The current sensor is based on Rogowski Coil principle. Rogowski Coil work in the same manner as conventional iron-core current transformers (CTs). The main difference between Rogowski Coils and CTs is that Rogowski Coil windings are wound over a non-magnetic core, instead of over an iron core. As a result, Rogowski Coils are linear since the non-magnetic core cannot saturate. Rogowski Coils produce output voltage \( U_s \) that is a scaled time derivative of the measured primary current \( I_p \).

\[
U_s(t) = M \frac{di_p(t)}{dt}
\]

![Figure 23: Working principle of Rogowski Coil](image)

Integration of the current sensor output signal is performed within the connected IED in order to obtain the information about actual current value.

In case of purely sinusoidal primary current \( I_p \) at rated frequency defined as:

\[
i_p(t) = \sqrt{2}I_p \sin(\omega t)
\]

the output voltage from the Rogowski Coil is

\[
U_s(t) = \sqrt{2}I_p M \cos(\omega t)
\]

For this case, r.m.s. value of the output signal could be easily measured even without integrator, using a voltmeter or oscilloscope, observing a phase shift of 90° from the primary current waveform.

Output voltage of Rogowski Coil linearly depends on frequency, therefore rated value of output voltage is 150mV at 50Hz and 180mV at 60Hz. Once the rated frequency is set in the IED, sensor provides precise information about the measured primary current signal even for different harmonics (no hysteresis losses and no saturation applies) and thus correct performance for all protection functions is assured. In theory, response of Rogowski coil output is linear in unlimited dynamic range of the measured primary current. Constraints in their use originates from other limitations, e.g. application size, fixations etc. Only single coil is sufficient to cover whole range of primary currents needed, e.g. KECA 250B1 type has been successfully tested up to 2000A continuous thermal current. KEVCD sensor type contains a primary conductor and due to this fact just two types are needed to cover the primary current range from 0 to 3200A. They conform to the IEC 60044-8 standard.
Voltage sensor

The voltage sensor is based on a principle of resistive voltage divider. It consists of 2 resistive elements which divide the input signal to the level that is possible to connect to a standard LV measuring devices.

The main difference between resistive voltage divider and conventional voltage transformer (VT) is their working principle. In case of VTs, voltage is induced in the winding. In case of voltage divider, voltage is simply divided in relation to resistances of the resistive elements thus no induction takes place.

\[ U_s = \frac{R_2}{R_1 + R_2} U_p \]

Figure 24: Working principle of resistive voltage divider

Used resistors consists of a rod made of stable ceramic material on which the special non-inductive resistive pattern is applied.

The output signal is a voltage directly proportional to the primary voltage so no integration or any extra processing is needed.

In case of purely sinusoidal primary voltage \( (U_p) \) at rated frequency defined as:

\[ u_p(t) = \sqrt{2} U_p \sin(\omega t) \]

the output voltage from resistive voltage divider is

\[ u_s(t) = \frac{R_2}{R_1 + R_2} \sqrt{2} U_p \sin(\omega t) \]

Also for this case, value of the output signal could be easily measured using a voltmeter or oscilloscope

Standard division ratio used in ABB sensors is 10000/1. This assures the output signal to be sufficient and safe for further processing within IED.

For information about the measured voltage signal, it is possible to use voltmeters with high input impedance, nevertheless the use of ABB IEDs is recommended as this connection has been tested and verified.

Resistive voltage divider has no ferromagnetic core and no winding. Therefore, there is no risk of ferroresonance phenomena as in case of VTs and no additional damping devices are needed for that purpose. The use of such dividers significantly increase safety and reliability of the network as well as enhance safety towards the personnel under all circumstances. There is also no problem or danger in case the secondary terminals are short-circuited. Furthermore, the sensor can remain connected even during switchgear voltage tests at power frequency.

The resistive divider correctly operates even during transients where DC as well as other frequency components are present (no ferromagnetic core inside of the divider means no possibility for saturation at different frequencies). This enable undistorted evaluation of transients and precise analysis of protection functions. Apart from the possibility to measure DC components during transients, resistive voltage divider enables also precise continuous DC voltage measurement at steady-state.

Due to linear response and no possibility of saturation a single divider is sufficient to cover the range of voltages from 0 to 24kV. Nevertheless, in case of overall voltage sensor body, other mechanical requirements or dimensions/distances for different voltage levels may need to be taken into account. For that case, two different heights of KEVCD sensor are available, fitting to standard DIN dimensions. Selected sensor version could then be used also for voltage levels lower then maximum rated primary voltage.

They conform to the IEC 60044-7 Standards.
10. Cable terminations

Terminations for polymer insulated cables 1 – 17.5 kV

It is crucial that power cables connecting the switchgear are terminated properly, and for this purpose, ABB has developed an excellent range of easy-to-use products for preparation and termination of cables.

MV power cables are normally designed with a conductor of aluminium or copper, polymer insulation, an extruded insulation screen, a metallic screen, armouring (optional) and a polymer outer jacket.

To enable safe and reliable current carrying properties, it is necessary to achieve sufficient mechanical connection between the cable conductor and the busbar. ABB offers mechanical cable lugs designed to fit the cable conductor by bolting. It is also essential to guide the electrical field of the cable correctly, and ABB offers Cold Applied terminations, made of rubber, that create an active pressure around the cable. Furthermore, if the cable is designed with another type of metallic screen than copper wires, special earthing kits must be used to achieve proper handling of possible fault currents. The armouring of the cable must have the same earth potential as the cable screen, so it might be necessary to use additional connection accessories that are also available. Detailed information can be found in separate technical information for cable accessories.

Applications and features

Depending on the cable design, it is necessary to use the correct type of cable accessory. When single core cables are designed with copper wire screen only, it is sufficient to use just a cable lug and a termination that fits the actual size of the cable.

The benefit of Cold Applied accessories is that no heat or open flame is necessary for installation (except for branch seals on 3-core cables). After the cable is prepared, the termination is simply slid on without any tools. If a three core cable is used, or a cable with copper tape screen, or aluminium foil screen, or a cable with armouring; then additional material is required.

Another very important factor is correct cable preparation and ABB also offers excellent cable preparation tools.

Recommended cable termination products

The pre-moulded cable termination type Kabeldon SOT can be used on any polymer cable irrespective of design or conductor size. Type SOT 10 is designed for 7.2 kV cables, while type SOT 24 covers 12 and 17.5 kV. A few variants of terminations fit a wide range of cable sizes. Extra material such as earthing kits, crutch seals for 3-core cables and screen potential material for cable armouring is also covered by the ABB range of products. Please contact your ABB Sales Representative for more information.
### Designation and sizes

<table>
<thead>
<tr>
<th>Voltage level</th>
<th>Designation</th>
<th>Diameter over insulation mm</th>
<th>Conductor size mm²</th>
<th>7.2 kV</th>
<th>12 kV</th>
<th>17.5 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 7.2</td>
<td>SOT 101</td>
<td>10.5 – 15</td>
<td>-</td>
<td>10 – 35</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1 – 7.2</td>
<td>SOT 102</td>
<td>12.9 – 25.8</td>
<td>-</td>
<td>50 – 150</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1 – 7.2</td>
<td>SOT 103</td>
<td>21.4 – 34.9</td>
<td>-</td>
<td>185 – 300</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 – 17.5</td>
<td>SOT 241 A</td>
<td>11 – 15</td>
<td>-</td>
<td>10 – 35</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 – 17.5</td>
<td>SOT 241</td>
<td>15 – 25</td>
<td>-</td>
<td>50 – 185</td>
<td>50 – 150</td>
<td></td>
</tr>
<tr>
<td>12 – 17.5</td>
<td>SOT 242</td>
<td>24 – 39</td>
<td>-</td>
<td>240 – 500</td>
<td>185 – 300</td>
<td></td>
</tr>
<tr>
<td>12 – 17.5</td>
<td>SOT 242 B</td>
<td>38 – 54</td>
<td>-</td>
<td>630 (**)</td>
<td>630 (**)</td>
<td></td>
</tr>
</tbody>
</table>

(*) Can be mounted on cables with 800 and 1000 mm² by using silicone rubber tape 2342 as top seal.
ABB’s Power Protection Philosophy

With deliveries of protection IEDs (Intelligent Electronic Devices) to more than 70 countries, ABB best understands the requirements of diverse protection needs as a result of wide ranging local legislation, safety requirements and engineering practices. Therefore, ABB has developed a power protection philosophy that not only serves the specific needs and requirements of diverse power systems, but also creates a feeling of confidence and peace of mind for both power system owners and users alike.

The main purpose of an ABB IED power protection system is to recognize any abnormal power system conditions, or abnormally operating components within the power system. Then, based on the information gathered by the IED, the power protection system will initiate corrective actions to return the power system to its normal operating state, or, isolate the fault to limit damage to the power system and injury to personnel. This provides a safe environment for all. Power protection systems do not prevent power network faults from arising, but it will be activated only when an abnormality has occurred in the power system. However, carefully matching the available protection functionality offered by ABB IEDs to the specific power protection requirements of the power system and its components not only provides the best power protection for the power system, but also improves the performance and the reliability of the power protection system within it, thus minimizing the effects of power network faults and preventing the abnormalities or disturbances from spreading to the healthy parts of the power network.
Advantages of a complete power protection system

Operating speed, sensitivity, selectivity and reliability are the integral elements of the power protection system and need mentioning. There is a strong correlation between the operating speed of the power protection system and the damage and danger caused by a power network fault. Substation automation provides remote control and monitoring capabilities, which speeds up the location of faults, and therefore the restoration of the power supply after a fault. Fast operation of the power protection IEDs also minimizes post-fault load peaks, which together with voltage dips increase the risk of the power disturbance spreading to healthy parts of the power network. The sensitivity of the power protection must be adequate to detect relatively high resistance earth faults and short circuits in the most distant parts of the power network. Reliable selectivity is essential in order to limit the loss of power supply to as small an area as possible, and to allow the abnormal or faulted part of the power network to be reliably located. Corrective actions can then be directed to the abnormal or faulty part of the network, and the supply can be restored as rapidly as possible.

The power protection system must also have a high degree of reliability. This also means that if for example a CB (circuit-breaker) fails to operate, the backup power protection will identify the fault and react. Substation Automation (SA) puts the operator in perfect control of the substation. In addition to the SA system improving the power quality of the power transmission and distribution network under normal operation, it especially improves the quality of the power transmission and distribution network's available power in a situation of disturbance and during substation maintenance. A SA system or SCADA (supervisory control and data acquisition) system brings the full benefits of numerical technology into protection and control of power networks. The terminals are easily set and power protection parameters configured to the specific needs of the power system through easy and safe access via the operator’s workplace.

Single-function and multi-function terminals

Correct power protection methods and comprehensive functionality increase the performance of the power protection system.

The definition of comprehensive functionality varies with the requirements of the protected power network or system. While single-function power protection IEDs are sufficient for some network applications, more complex power networks and systems need advanced multi-functional power protection IEDs. Single-function Power protection IEDs include a set of power protection functions for, for instance, a specific feeder application type.

The main advantages of these power protection IEDs are redundancy and price. One or more single-function power protection IEDs would provide sufficient protection in most power protection application areas.

Figure 27: Comparison between standard and high requirement feeders
**Feeder protection**

The power protection applications can be roughly divided into two categories, namely standard applications (utilizing basic current based protection) and high requirement applications (utilizing current and voltage based protection) and then also the combinations of the two.

The selected power protection scheme or system has to fulfill the application-specific requirements regarding sensitivity, selectivity and operating speed of the power protection.

The power protection requirements are mainly determined by the physical structure of the power network or system and in most cases the requirements can be fulfilled with non-directional/directional over-current protection IEDs.

In power networks or systems with a more complex structure more advanced power protection functions like distance protection or line differential protection may have to be introduced.

The purpose of the over-and under-voltage power protection system is to monitor the voltage level of the network. If the voltage level deviates from the target value by more than the permitted margin for a set time period, the voltage protection system is activated and it initiates actions to limit the duration of this abnormal condition and the resulting stresses caused to the power system or its components.

To prevent major outages due to frequency disturbances, the substations are usually equipped with under-frequency protection IEDs, which in turn control various power load-shedding schemes. These are just a few examples of the major power protection functions for power feeders.

**Applications and features**

Depending on the requirements a suitable IED type can be selected and configured in such a way that an overall solution can be found for different feeder types.

Generally, the required power protection functionality of these feeder types differ greatly depending on, amongst other things, the characteristics of the source of the fault current and the type of advanced functions that may be additionally needed to fulfill the basic requirements of the power protection application.

**Recommended products**

The recommended products for feeder protection are part of ABB’s Relion® product family of power protection IEDs. These IEDs have been developed after many years of experience gathered from wide ranging application and functionality requirements of ABB customers globally. The popular RE500 series IEDs also played a big part in ABB’s success in this area.

Relion® products have been designed to implement the core values of the IEC 61850 standard. The genuine implementation of the IEC 61850 substation communication standard covers vertical as well as horizontal communication between IEDs.

![Figure 28: Feeder protection and control REF630](image)
• **Feeder Protection and Control REF630** provides main protection for overhead lines and cable feeders of power distribution networks. REF630 fits both isolated neutral networks and power networks with resistance or impedance earthed neutral. Four (4) pre-defined configurations to match typical feeder protection and control requirements are available. The pre-defined configurations can be used as such, or the IED can easily be modified or functionally extended with freely selectable add-on functions to help fine-tune the IED to meet even the most demanding individual application requirements - exactly.

• **Feeder Protection and Control REF615** is a dedicated feeder IED perfectly aligned for the protection, control, measurement and supervision of utility and industrial power distribution systems. It provides mainly protection for overhead lines, cable feeders and busbar systems of power distribution substations. It fits both isolated neutral networks and power networks with resistance or impedance earthed neutrals. Furthermore, making use of the IED’s advanced inter-station communication facilities, REF615 can also be applied for protection of ring-type and meshed distribution networks as well as radial networks. As of now, the REF615 suite consists of eight standard configurations to suit the most common feeder protection and control applications as well as your current and forthcoming feeder protection requirements.

• **Feeder Protection REF610** is primarily intended for the protection of incoming and outgoing feeders in power distribution substations of resistance earthed and solidly earthed power systems. REF610 is suitable for employment in marine and off-shore environments. Supplied with an optional arc protection function REF610 also provides fast substation busbar arc-fault protection. The REF610 is also used for back-up protection of motors, transformers and generators to increase protection redundancy in critical utility and industrial applications.

Figure 29: Feeder protection and control REF615
Figure 30: Feeder protection REF610
Transformer protection
The power transformer is one of the most important components, as well as one of the most valuable individual units in the power distribution network. Therefore, the particular importance of preventing disturbances in the power distribution system is almost completely dependent on a functioning power transformer. Although high-quality power transformers are highly reliable, insulation breakdown faults occasionally occur. These faults, appearing as short circuits and/or earth faults generally cause severe damage to the windings and transformer core. The damage is proportional to the fault clearing time so the power transformer must be disconnected as quickly as possible. The power transformer has to be transported to a workshop for repair, which is a very time-consuming process. The operation of a power network where the power transformer is out of service is always cumbersome. Therefore, a power transformer fault often constitutes a more severe power system fault than a line fault, which usually can be rectified rather quickly. It is extremely important that fast and reliable protection IEDs are used to detect transformer faults and initiate tripping.

The size, voltage level and importance of the power transformer determine the extent and choice of monitoring and protection devices to be used to limit the damage at a possible fault. When compared to the total cost of the power transformer and the damages caused by a power transformer fault, the cost of the power protection system is negligible.

Recommended products
The recommended products for feeder protection are part of ABB’s Relion® product family of power protection IEDs. These IEDs have been developed after many years of experience gathered from wide ranging application and functionality requirements of ABB customers globally. The popular RE500 series IEDs also played a big part in ABB’s success in this area.

Relion® products have been designed to implement the core values of the IEC 61850 standard. The genuine implementation of the IEC 61850 substation communication standard covers vertical as well as horizontal communication between IEDs.

Figure 31: Transformer protection and control RET630
• Transformer Protection and Control RET630 is a comprehensive transformer management IED for protection, control, measuring and supervision of power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industry power distribution networks. It provides main protection for two-winding power transformers and power generator-transformer blocks. Two (2) predefined configurations to match your typical transformer protection and control specifications are available. The pre-defined configurations can be used as such, or the IED can easily be modified or functionally extended with freely selectable add-on functions to help fine-tune the IED to meet even the most demanding individual application requirements exactly.

• Transformer Protection and Control RET615 is a dedicated transformer protection and control IED for two-winding power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industrial power distribution systems. RET615 offers eight (8) standard configurations to match applied transformer neutral earthing principles with either high impedance or numerical low impedance restricted earth-fault protection schemes. CT ratio differences and phase shifts of all commonly employed power transformer vector groups are numerically compensated for. RET615 features also local or remote control of the transformer HV side circuit-breaker.
11. Distribution automation

Motor protection
Motor protection is generally expected to provide overcurrent, unbalance, earth-fault and short-circuit protection. However, the fundamental issue for motors is thermal protection, as overheating is the worst threat to the motor. Motors need to be protected not only against electrical faults but also against any improper usage. ABB’s solutions focus on advanced thermal protection that prevents improper use of the motors. The thermal overload protection is needed to protect the motor against both short-time and long-time overload and so it is of great importance for the performance of the motor. Overload conditions of short duration mainly occur during motor start-up. Improper use of a running motor does not necessarily damage the equipment but shortens its lifespan. Therefore, a reliable and versatile motor protection system not only protects the motor but it also prolongs the motor’s life-cycle, which contributes to improving the return on investment of your motor drive.

Recommended products
The recommended products for feeder protection are part of ABB’s Relion® product family of power protection IEDs. These IEDs have been developed after many years of experience gathered from wide ranging application and functionality requirements of ABB customers globally. The popular RE500 series IEDs also played a big part in ABB’s success in this area. Relion® products have been designed to implement the core values of the IEC 61850 standard. The genuine implementation of the IEC 61850 substation communication standard covers vertical as well as horizontal communication between IEDs.
• Motor Protection and Control REM630 is a comprehensive motor management IED for protection, control, measuring and supervision of medium and large asynchronous motors in medium voltage industrial power systems. REM630 is a member of ABB’s Relion® product family and a part of its 630 product series characterized by functional scalability and flexible configurability. It also features necessary control functions required for the management of industrial motor feeder bays. REM630 provides main protection for asynchronous motors and the associated drives. The motor management IED is intended for circuit-breaker and contactor controlled medium sized and large asynchronous motors in a variety of drive applications, such as motor drives for pumps, fans, compressors, mills, crushers, etc. The pre-defined configuration can be used as such or easily customized or extended with add-on functions, by means of which the motor management IED can be fine-tuned to exactly satisfy the specific requirements of your present application.

• Motor Protection and Control REM615 is a dedicated motor IED perfectly aligned for the protection, control, measurement and supervision of asynchronous motors in manufacturing and process industry. Typically, REM615 is used with circuit-breaker or contactor controlled HV motors, and contactor controlled medium sized and large LV motors in a variety of drives. REM615 is available in three (3) standard configurations including all the basic motor protection functions, voltage protection functions and power and energy measurements. Local or remote start/stop control of the motor is also facilitated.

• Motor Protection Relay REM610 is a motor IED for the protection, measuring and supervision of medium sized and large asynchronous LV motors and small and medium-sized asynchronous HV motors in manufacturing and process industry. The REM610 IED can be used with both circuit-breaker and contactor-controlled motor drives in a variety of applications. Enhanced with an optional add-on card for RTD sensors or thermistor elements, the IED can be used for direct temperature measurement of critical motor items, such as bearings and windings. It is also used for the protection of cable feeders and distribution transformers benefiting from thermal overload protection besides phase overcurrent protection, earth-fault protection and phase unbalance protection.
11. Distribution automation

Voltage Protection

REU615 is available in two predefined, off-the-shelf configurations, denoted A and B, targeted for two of the most common applications of the IED. The A configuration of REU615 is pre-adapted for voltage and frequency based protection applications in utility and industrial power systems and distribution systems including networks with distributed power generation. The A configuration of REU615 is indented to be used in medium voltage switchgear systems with a separate voltage measuring cubicle. The A configuration of REU615 provides busbar overvoltage and undervoltage supervision, network residual voltage and frequency supervision. The B configuration is pre-adapted for automatic voltage regulation. Both configurations also allow CB control and provide measuring and supervising functions. The B configuration of REU615 featuring voltage regulation capability is targeted for automatic and manual voltage regulation of power transformers equipped with a motor driven on-load tap-changer.

REU615 is a member of ABB’s Relion® protection and control product family and its 615 product series. The 615 series IEDs are characterized by their compactness and withdrawable-unit design. Re-engineered from the ground up, the new 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

Arc protection

An electric arc short-circuit in a switchgear installation is normally caused by a foreign object entering the cubicle or a component failure. The arc causes an explosion-like heat and pressure effect usually causing vast damage to the switchgear and the operation personnel.

An adequate arc protection system protects your substation against arc faults by minimizing the burning time of the arc, thus preventing excessive heat and damage. It minimizes material damage and allows power distribution to be smoothly and safely restored. The system can also bring cost benefits even before an arc fault occurs. As older switchgear is more prone to arc faults, an arc protection system will effectively extend the life of your switchgear and make more of your investment. But what is even more important, this technology can help save lives.
Applications and features
Sources of arcing may be insulation faults, maloperating devices, defective bus or cable joints, overvoltage, corrosion, pollution, moisture, ferro-resonance (instrument transformers) and even ageing due to electrical stress. Most of these arc fault sources could be prevented by sufficient maintenance. However, in spite of the precautions taken, human errors can lead to arc faults.
Time is critical when it comes to detecting and minimizing the effects of an electric arc. An arc fault lasting 500 ms may cause severe damage to the installation. If the burning time of the arc is less than 100 ms the damage is often smaller, but if the arc is extinguished in less than 35 ms its effect is almost unnoticeable.
Generally applied, protection IEDs are not fast enough to ensure safe fault clearance times at arc faults. The operation time of the overcurrent IED controlling the incoming circuit breaker may, for instance, have to be delayed hundreds of milliseconds for selectivity reasons. This delay can be avoided by installing an arc protection system. The total fault clearance time can be reduced to max 2.5 ms plus the circuit breaker’s contact travel time.
Furthermore, at cable compartment faults, auto-reclosures can be eliminated by employing arc protection.

Recommended products
• Arc protection system REA 101 with its extension units REA 103, REA 105 and REA 107 are designed to be used for the protection of medium and low-voltage air-insulated switchgear.
The central unit type REA 101 operates independently or together with other REA 101 units. REA is the fastest arc protection system on the market, providing tripping times down to 2.5 ms.
REA is equipped with a fast integrated overcurrent-sensing element and is thus working independently from other feeder protection units.
The REF615 and REF610 feeder protection IEDs include an optional arc protection function for the feeder cubicle.
11. Distribution automation

Station automation COM600

COM600, ABB’s station automation device, is an all-in-one communication gateway, automation platform and user interface solution for utility and industrial distribution substations. The gateway functionality provides seamless IEC61850 connectivity between substation IEDs and network-level control and management systems. The automation platform with its logic processor makes COM600 a flexible implementation platform for substation level automation tasks. As a user interface solution COM600 accommodates web technology based functionalities providing access to substation devices and processes via a web browser based human machine interface (HMI).

Product

The Station Automation COM600 offers web server functionality, providing a human machine interface (HMI) for local substation monitoring and control. Secure communication enables the access of the substation HMI over the internet or LAN/WAN for any authorized user with a standard PC and a web browser. By connecting a laptop computer to the unit locally, an HMI for full monitoring and control functionality is obtained on the substation level. The Station Automation COM600 also provides gateway functions for mapping data and signals between substation and higher-level systems such as SCADA, DSC. The COM600 is designed for smooth system integration and interoperability based on pre-configured solutions utilizing connectivity packages for ABB IEDs.

Figure 39: Station Automation COM600
Application and features

With their compact and robust design, the COM600 is well adapted for harsh environments. It meets the IP4x degree of protection by enclosure and contains no moving parts subject to wear and tear. The COM600 is based on embedded technology for durability and maximum availability. The features and compact dimensions of the COM600 enable it to be easily installed in the Low Voltage Compartment of most Unigear panels. COM600 is suitable for both industrial and utility applications.

The COM600 incorporates OPC Server functionality, which provides one entry point to all the information of a substation, and the IEC 61850 support enables connectivity and seamless communication with application-specific equipment.

The COM600 is fully compliant with the IEC 61850 standard for distribution automation. Thus it provides full interoperability with any IEC 61850 compliant IEDs, tools and systems, which simplifies system design and commissioning.

The commissioning of ABB IEDs is straight forward due to the support of ABB’s unique connectivity package concept, which simplifies system configuration and reduces the risk of errors in the system integration, minimizing device configuration and set-up times.

For more detailed information, the technical and product guides for COM600 are available at http://www.abb.com/substationautomation

Figure 40: Overview of a system using Station Automation COM600
11. Distribution automation

Selection table of relays

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<td>*** RTD - Resistive Temperature Detector</td>
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<td>1) REU615 with A configuration, for voltage and frequency based protection</td>
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## Application

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## Additional Functionality

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<tr>
<th>Fault locator</th>
<th>Auto Reclosure 3 shots</th>
<th>Auto Reclosure 5 shots</th>
<th>Auto Reclosure 2 shots</th>
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<th>mA Outputs</th>
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12. Typical units

Single-line diagram of typical units

IF - Incoming/Outgoing feeder
BT - Bus-tie
R - Bus Riser
RM - Riser with measurements

M - Measurements
IFD - Direct Incoming/outgoing
IFDM - Direct incoming/outgoing feeder with measurements
Single-line diagram of the busbar applications

![Diagram showing Voltage transformers and Earthing switch]

Graphical symbols

![Symbols for Circuit-breaker, Socket and plug, Voltage transformers, Current transformers, Fuse, and Earth]

![Symbols for Cable entry and Busbar entry]

Key to components

- **Standard components**
- **Accessories**
- **Alternative solutions**
13. Technical data

Units: ...12 kV - 17.5 kV, ...31.5 kA

| Depth (mm) | 1340 |
| Height (mm) | 2200/2595 (1) |
| Height with gas exhaust duct (mm) | 2675 (2) |
| Width (mm) | 550 |

| Rated current (A) | 630 | 1250 |
| IF | Incoming/outgoing |
| M | Measurements |
| BT | Bus Section |
| R | Riser |
| RM | Riser with measurements |
| IFD | Direct incoming/outgoing |
| IFDM | Direct incoming/outgoing with measurement |
| DF | Switch-disconnector unit |

(1) The height of the unit is a function of the height of the low voltage compartment, available in the 705, 1100mm versions.
(2) Others solutions are available, please contact ABB representative.