UniGear 500R
17.5 kV, arc-proof, air insulated switchgear for green applications
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1. Description

- 2000 A load current in a 500 mm wide panel - the famous UniGear family of switchgear is now extended with a highly space efficient solution, the UniGear 500R.
- Designed for the highest degree of safety and reliability, the UniGear 500R provides for maximum ease of use.
- All operations and maintenance actions are made from the front of the panel, which is equipped with mechanical safety interlocks between circuit-breaker and line disconnector. For ENA version, a cable testing device is also available.
- The vacuum circuit-breaker is the well-proven Vmax type in a removable arrangement.
- For optimal flexibility, the UniGear 500R is designed to be used in combination with other versions of UniGear switchgear, such as ZS1, 550 and MCC.
Characteristics of UniGear 500R

**Range**
- 17.5 kV, 2000 A, 31.5 kA
- IEC and ENA standards
- Standard and customized versions

**Features**
- 500 mm wide panel at 2,000 A load current
- Indoor wall and free-standing solution (IEC version)
- Cable testing facility (ENA version)
- Cable termination height up to 790 mm

**Safety**
- Fitted with safety interlocks
- Visible earthing connection (IEC version)
- Internal arc classification IAC AFLR (IEC) and IAC AF (ENA)
- Classified as LSC-2A, PM

**Flexibility**
- Wide range of applications
- Traditional and IEC 61850 based protection and control solutions
- Ring core, block type instruments transformers or sensors

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

**Transport**
- Airports
- Ports
- Railways
- Underground transport

**Infrastructure**
- Shopping malls
- Hospitals
- Large infrastructure and civil works
2. Air insulated switchgear

In order to extend the large and successful family of UniGear switchgear, ABB now proudly offers UniGear 500R for medium voltage power distribution.

The result is a very space efficient solution, designed to reduce the width of the switchgear and the panel design is 500 mm wide for up to 2000 A (please refer to below Figure 1).

Its compact design makes the UniGear 500R ideal for container installation (IEC version).

The panel has been designed with a dedicated three-position disconnector (connected, isolated and earthed) and with the well proven vacuum circuit-breaker Vmax in removable arrangement.

The UniGear 500R is a development of the proven UniGear ZS1 family of products.

Two versions are available:
- IEC version
- ENA version.

UniGear 500R has been completely tested according to IEC 62271-200 and for the United Kingdom according to ENATS 41-36.

According to the IEC standard, the UniGear 500R is defined as LSC2A and Partition Metallic.

Internal arc classification for IEC version is IAC AFLR and for ENA version it is IAC AF.

The UniGear 500R is completely accessible from the front; for this reason it is a back to wall mounted solution (IEC version) and ergonomically designed for front operations of all devices.

All the compartments are accessible directly from the front and top and all the maintenance and service operations do not require rear access.

The panel is fitted with a clear label on the front part with all the operating commands and indications of the main apparatus (disconnector, circuit-breaker, cable test cover for ENA version).

The IEC version is based on the UniGear ZS1 system, which means it has internal arc proof on front, lateral and rear (IAC AFLR) and the different gas duct types are located on the top of the panel.

The ENA version has been developed according the requirements of the main UK Utilities and ENA TS specification, with internal arc proofing of up to 25 kA on the front (IAC AF). This version is designed with the opening flaps located on the rear part of the panel and in case of an internal arc, they will open automatically.

Consequently, the accessibility of the lateral and rear part of the switchgear during service is restricted; only when the complete switchgear is out of service it is allowed to access in the lateral and rear part in a safe condition.

The ENA version require 600 mm clearance to the rear.

The ENA version is equipped with a front cable testing device as standard feature. This ergonomic front access simplifies cable testing during maintenance.

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**Figure 1:** Total saving of 14.5 m² surface area compared with a typical 14-panel switchgear systems.
One of the main characteristics of the UniGear 500R switchgear is the isolation of the circuit-breaker from the main busbars by means the three-position disconnector; this guarantees maximum personnel safety.

The panel is intrinsically safe to operate due to mechanical interlocks between the main components:
- three-position disconnector
- circuit-breaker
- cable testing device (only for ENA version).

UniGear 500R switchgear provides maximum level of safety in the event of internal fault. It is able to withstand over-pressures caused by arcing and is fitted with exhaust flaps to evacuate the gases generated and therefore protecting both personnel and equipment.

The Vmax circuit-breaker used for UniGear 500R is the same as used for UniGear 550 panel, but a removable version. The very high reliability of the circuit-breaker enables it to be removable without compromising service continuity.

All the main components (opening and closing coils, spring charging motor, etc.) are located on the front of the panel and their replacement only requires the removal of the front cover. If in the unlikely event that the circuit breaker needs to be replaced, this can be carried out by trained technician in less than 90 minutes without the need of special tools. In this case a readily-available manual earthing device must be used in order to guarantee the earthing connection on cables.

UniGear 500R in IEC version has the same overall dimensions (height and depth) and the same main busbar arrangement as UniGear ZS1 with a maximum current of 4000 A. The result is that it is possible to connect this panel to UniGear ZS1, 550 and MCC without the use of adaptor panel making it a very flexible solution.

The UniGear 500R units are designed to be equipped with the following instrument transformers:
- Ring core type current transformer (standard)
- Block type current transformer (optional)
- Current sensor or combisensors (optional).

It is also possible to have a fixed voltage transformer with removable fuses on the cable side.

On request, the UniGear 500R can also be fitted with “Fault limiting systems” in order to further limit the effects of the internal arc (please refer to page 16).
2. Air insulated switchgear

Three-position disconnector

Every UniGear 500R, except the Measurement unit, is fitted with a manually operated off-load three-position disconnector on the main busbar side. The disconnector allows the circuit-breaker to be separated from the main busbars.

The disconnector has three defined positions:
- **ON**: circuit-breaker connected to the busbars system
- **OFF**: circuit-breaker isolated from the busbar and from earth
- **EARTH**: circuit-breaker connected to earth.

The disconnector is fitted with mechanical position indicators and dedicated auxiliary switches, to provide an immediate visual indication of which of the three positions the equipment is in.

All the safety and operating interlocks between the disconnector, circuit-breaker (and cable testing device for ENA version) are made mechanically.

The IEC version cubicle is fitted with a front inspection window to verify the correct position of the contacts of the disconnector.

The operating command of the disconnector is located on the front of the panel and the operations are performed in two steps:
- from ON position to OFF position
- from OFF position to EARTH position.

The operating lever can be removed only when the movement is completed.
In the incoming/outgoing feeder the disconnector and the circuit-breaker are used to earth the cable side.
In the bus-section unit it is possible to earth the main busbar side (busbar A and busbar B).

Figure 4: UniGear 500R in mixed configuration with withdrawable UniGear 550
Electrical characteristics

<table>
<thead>
<tr>
<th>Panel version</th>
<th>IEC version</th>
<th>ENA version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage [kV]</td>
<td>12</td>
<td>17.5</td>
</tr>
<tr>
<td>Rated insulation voltage [kV]</td>
<td>12</td>
<td>17.5</td>
</tr>
<tr>
<td>Maximum service voltage [kV]</td>
<td>12</td>
<td>15.4</td>
</tr>
<tr>
<td>Rated power frequency withstand voltage [kV 1 min]</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage [kV]</td>
<td>75</td>
<td>95</td>
</tr>
<tr>
<td>Rated frequency [Hz]</td>
<td>50 / 60</td>
<td>50 / 60</td>
</tr>
<tr>
<td>Rated main busbar current (40 °C) [A]</td>
<td>... 4,000 ...</td>
<td>... 4,000 ...</td>
</tr>
<tr>
<td>Rated feeder current (40 °C) [A]</td>
<td>630</td>
<td>630</td>
</tr>
<tr>
<td>Rated short-time current [kA x 3 s]</td>
<td>16 / 20 / 25 / 31.5</td>
<td>16 / 20 / 25</td>
</tr>
<tr>
<td>Arc proof withstand current (IEC 62271-200) [kA x 1 s]</td>
<td>16 / 20 / 25 / 31.5</td>
<td>16 / 20 / 25</td>
</tr>
<tr>
<td>Type of construction - Internal Arc Classification</td>
<td>IAC AFLR</td>
<td>IAC AF</td>
</tr>
<tr>
<td>Tested according to Standards</td>
<td>IEC</td>
<td>ENA / IEC</td>
</tr>
</tbody>
</table>

Standards

The switchgear and main apparatus contained in it 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 60137 – for insulated bushings.
- IEC 60529 – for degree of protections.

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
- Normal operational altitude is 1000 m above sea level. For higher altitude applications, please contact an 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 500R switchgear is normally supplied with the following standard degrees of protection:

- IP4X for the enclosure of IEC version
- IP3X for the enclosure of ENA version
- IP2X for the partition between compartments.

On request, the external housing can be supplied with higher degrees of protection; in this case, please contact an 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.
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 chosen as a fundamental parameter for the user.

According to the IEC 62271-200, UniGear 500R switchgear can be defined as follows:

1. **LSC-2A**
   The main busbar and circuit-breaker/cable compartments are physically and electrically segregated.
   This is the category for equipment that enables access to the circuit-breaker/cables compartment with the main busbars energized.

2. **Partition Metallic PM**
   This covers switchgears with continuous metallic partitions intended to be earthed, between opened accessible compartments and live parts of the main circuit.
   Metallic partitions or metallic parts of them shall be connected to the earthing point of the switchgear.

3. **Tool-based accessible compartment**
   This contains high-voltage parts, that may be opened, but not for normal operation and maintenance. Special procedures are required. Tools are necessary for opening.
Internal arc classification

UniGear 500R switchgear is classified IAC AFLR for IEC version and IAC AF for ENA version

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 5: UniGear 500R in ENA version
4. Design features

Compartments

Each switchgear unit consists of two power compartments for busbars [B] and circuit-breaker/cables [A], please refer to figure 6.

The closing of the circuit-breaker front cover and cables doors is done with screws.

Each unit is fitted with a low voltage compartment [C], where all the auxiliary instruments are housed.

Arc-proof switchgear, for the IEC version, is normally provided with a duct [D] 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 top and maintenance operations can properly carried out with the switchgear back to wall installed.

The compartments are segregated from each other by metallic partitions.

Earthing

The earthing of the power cables is performed by the earthing position of the disconnector and the closure of the circuit-breaker.

In addition each switchgear can be fitted with an earthing switch 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.

Main busbars

The busbar compartment contains the main busbar system connected to the fixed upper isolating contacts of the three-position disconnector by means of branch connections.

The main busbars are made of electrolytic copper.

For ratings up to 1250 A, the busbars are made of flat bars; while for higher currents up to 4000 A, a special D-shape busbar is used.

The busbars are covered with insulating material at 17.5 kV.

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Unit compartment

A Circuit-breaker and cable compartment
B Busbar compartment
C Low voltage compartment
D Gas duct channel

Figure 6: UniGear 500R section view
There is a single busbar compartment along the whole length of the switchgear.

**Cable connections**

The circuit-breaker/cables compartment contains the branch system for connection of the power cable to the lower contacts of the circuit-breaker.

The feeder connections are made of electrolytic copper and they are made with flat busbars for the whole range of currents. For 17.5 kV they are covered with insulating material.

**Earthing busbar**

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

**Insulating bushings**

The insulating bushings contain the contacts for connection of the circuit-breaker with the busbar compartment via the three-position disconnector.

The insulating bushing is three-pole type and are made of epoxy resin.

**Cables**

Single- and three-core cables up to a maximum of three per phase can be used depending on the rated voltage and the cable cross-section (please refer to page 29).

The cables are easily accessible from the front.

**Gas exhaust duct (IEC version)**

The gas exhaust duct is positioned above the switchgear and runs along its whole length.

Each power compartment is fitted with a flap positioned on the top of it. The pressure generated by the fault opens the flap, 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 500R switchgear can be fitted with a complete range of solutions to meet all requirements, either 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 realised to guarantee personnel safety and conformity with the Standards, such as longitudinal evacuation chimneys.

Please contact ABB sales for more information.

**Busbar applications**

Each switchgear unit can optionally be fitted with an accessory busbar application:

- voltage transformers for busbar measurements
- busbar system earthing switch
- top - entry duct to make interconnections between different sections of switchgear (available in 2012).

Figure 7: ENA version rear view (2000 A left, 1250 A right)
5. Fully type-tested

The UniGear 500R switchgear has undergone all the tests required by the international (IEC) Standards and local Standards organizations as ENA for UK market.

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
- Earthing switch making capacity (top application)
- Mechanical operations of circuit-breaker and line disconnector
- IP degree and impact test

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

Figure 8: UniGear 500R during internal arc 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.

• **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 UniGear 500R switchgear can be supplied with a dedicated earthing switch only for main busbar earthing.
  This earthing switch can be closed under short-circuit. In actual fact, the earthing switch is normally interlocked to avoid being operated on circuits which are still live.
  However, should this happen for any one of several reasons, safety of the personnel operating the installation would 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 field.
  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.

• **Partial discharge**
  UniGear 500R switchgear has been tested against partial discharge in order to find dielectric breakdown of a small portion of a solid electrical insulation system under high voltage stress.

• **IP degree and impact test**
  The IP protection degree is the resistance offered by the UniGear 500R 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 protection degree against the entrance of solid objects, the second one is related to liquids.
When developing modern medium voltage switchgear, personnel safety must necessarily take priority. This is why the UniGear 500R 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 500R 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 500R 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 500R 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 500R 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 for IEC version and 25 kA for ENA version.

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.
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 two 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 39. 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
6. Safety

The UniGear 500R switchgear is fitted with all the interlocks and accessories needed to provide the highest level of safety and reliability for both installation and personnel.

Interlocks

The safety mechanical interlocks are standard ones [1-6] please see the dedicated table at page 19. They are specified by the IEC standards and they guarantee the correct operation sequence. The presence of ABB safety interlocks provides 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 realizing the interlocking logics between panels of the same switchgear, or of other medium-, low- and high- voltage switchgear. The logics are realized by means of distributors or by ringing the keys. The disconnector can be locked in disconnected [7] or earthed position [8] and the relevant lock key can only be removed with the disconnector in the defined positions. When the UniGear 500R is fitted with front voltage transformers with fuses (ENA version) the cable door is interlocked [9] with the earthing position of the disconnector; only when this apparatus is in that position it is possible access the cables side. The closing [10] and opening [11] operations of the main busbars earthing switch can be locked by means of keys.
Padlocks
The opening and closing of the circuit-breaker can be prevented by applying the padlocks to the relevant push-buttons [12-13] on the front panel. The padlock can also be applied to the connected [14] and earthed [15] position of the disconnector. In the ENA version the cable test cover it is interlocked with disconnector positions and can also be padlocked [16]. The UniGear 500R switchgear is preset for using padlocks with a 4 to 8 mm diameter.

Locking magnets
The locking magnets enable automatic interlocking logics without human intervention. The operation with disconnector [17] and the circuit-breaker [18] can be prevented. This magnet can also be applied to the earthing switch [19] of busbar applications; also in this case it can prevent operation. The locking magnets operate with active logics and therefore the lack of auxiliary voltage leaves interlocking system active (in safety condition).

Types of interlocks

### 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</td>
<td>Closing of the circuit-breaker</td>
<td>Line disconnector operating lever removed</td>
</tr>
<tr>
<td>2</td>
<td>Movement of the line-disconnector</td>
<td>Circuit-breaker in OFF position</td>
</tr>
<tr>
<td>3</td>
<td>Opening of the line-disconnector from EARTH position</td>
<td>Circuit-breaker in OFF position</td>
</tr>
<tr>
<td>4</td>
<td>Opening of the line-disconnector from EARTH position</td>
<td>Test cable door closed (ENA version only)</td>
</tr>
<tr>
<td>5</td>
<td>Opening of the test cable cover (ENA version only)</td>
<td>Line disconnector closed (ENA version only)</td>
</tr>
<tr>
<td>6</td>
<td>Opening of the earthing busbar line-disconnector</td>
<td>Circuit-breaker in EARTH position and CB in ON position</td>
</tr>
</tbody>
</table>

### Keys (on request)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>OFF position of line-disconnector</td>
</tr>
<tr>
<td>8</td>
<td>EARTH position of line-disconnector</td>
</tr>
<tr>
<td>9</td>
<td>Cable door with front VTs (ENA version only)</td>
</tr>
<tr>
<td>10</td>
<td>Earthing switch ON lock (top busbar application)</td>
</tr>
<tr>
<td>11</td>
<td>Earthing switch OFF lock (top busbar application)</td>
</tr>
</tbody>
</table>

### Padlocks

<table>
<thead>
<tr>
<th>Lock</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>12</td>
<td>ON circuit-breaker push-button</td>
</tr>
<tr>
<td>13</td>
<td>OFF circuit-breaker push-button</td>
</tr>
<tr>
<td>14</td>
<td>Line-disconnector in ON position</td>
</tr>
<tr>
<td>15</td>
<td>Line-disconnector in EARTH position</td>
</tr>
<tr>
<td>16</td>
<td>Cable testing device (ENA version only)</td>
</tr>
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</table>

### Locking magnets

<table>
<thead>
<tr>
<th>Lock</th>
<th>Condition to be fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Line-disconnector operation</td>
</tr>
<tr>
<td>18</td>
<td>Circuit-breaker operation</td>
</tr>
<tr>
<td>19</td>
<td>Earthing switch operation (top busbar application)</td>
</tr>
</tbody>
</table>
7. Vmax removable vacuum circuit-breaker

The Vmax medium voltage circuit-breakers are the synthesis of ABB technology in designing and constructing vacuum interrupters and of the excellence of design, engineering and production of the circuit-breakers. They find their ideal use in UniGear 500R.

The ratings are up to 17.5 kV, 2000 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 having 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.

The compact structure ensures the same sturdiness and mechanical reliability as a traditional circuit-breaker consisting of an operating mechanism/pole base cover and three separate poles.

The low speed of the contacts together with the reduced run of the contacts, limit the energy required for operation, resulting in extremely limited wear on the circuit-breaker. This means the circuit-breaker requires limited maintenance.

The interrupters of the Vmax medium voltage circuit-breakers are the same as those used in the VD4 and VM1 series. The Vmax series therefore provides the same characteristics as the vacuum series mentioned above, that is, interruption of the currents without arc chopping and overvoltages and extremely rapid recovery of the dielectric properties after the interruption.

Operating mechanism

The Vmax series is fitted with a mechanical operating mechanism of simple conception and use, derived from the same mechanical operating mechanism which equips 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 anti-pumping device to prevent repeated sequences of opening and closing operations following simultaneous and maintained opening and closing commands (local and/or remote).
Apparatus-operator interface

The front part of the circuit-breaker represents the interface of the apparatus with the operator.

It is provided with the following accessories:
• OFF pushbutton.
• ON pushbutton.
• operation counter.
• indicator of the OFF and ON state of the circuit breaker.
• indicator of the charged and discharged state of the operating mechanism springs.
• manual device for charging the operating mechanism springs.
• selector for exclusion of the undervoltage release (optional).

Standards

IEC 62271-100 for the circuit-breaker.
ENA TS 41-36 UK Energy Network Association technical specification for distribution switchgear.

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

- **50 A - 200 A:** Block type CTs or sensors.
- **250 A - 1250 A:** Ring core, block type CTs or sensors.
- **1250 A - 2000 A:** 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 have either a closed or split core. The ring core transformer with split core is used for detecting earth fault currents and can be easily used around the incoming cables. Air insulated ring core transformers are used for measuring the phase current and are placed over insulated CT rod. These transformers comply with IEC 60044-1 and ENA TS 41-36 standards.
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 and ENA TS 41-36 Standards. Their dimensions are in accordance with the DIN 42600 Narrow Type Standard, in the Medium and Long Size versions up to 2000 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. The ABB range of current transformers is designated TPU.

Voltage transformer

The voltage transformer is epoxy resin insulated and used to supply metering and protection devices. The transformer can be designed as single or double pole insulated. The single pole insulated design is available in fused solution with the fuse accessed from the front and top. The design complies with IEC 60044-21 and ENA TS 41-36 standards and its dimensions with DIN 42600 standard. They are available for fixed assembly (rear arrangement).
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 500R 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 personell. 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.

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.
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

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 is phase shifted of 90° from the primary current waveform.

Therefore, for simple and rough information about the measured current signal, it is possible to use voltmeters with high input impedance. Nevertheless, more exact and precise information under transient conditions, content of different frequency components or current waveform distortions that appears in electric power network requires integration of voltage signal comming out of Rogowski Coil. This functionality is already available inside of IEDs provided by ABB, so very precise measurement of the primary current is available.

Output voltage of Rogowski Coil linearily 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.
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 Kabeldon</th>
<th>Diameter over insulation mm</th>
<th>Conductor size mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2 kV</td>
<td></td>
<td></td>
<td>7.2 kV 12 kV 17.5 kV</td>
</tr>
<tr>
<td>1 - 7.2</td>
<td>SOT 101</td>
<td>10.5 - 15</td>
<td>10 - 35</td>
</tr>
<tr>
<td>1 - 7.2</td>
<td>SOT 102</td>
<td>12.9 - 25.8</td>
<td>50 - 150</td>
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<tr>
<td>1 - 7.2</td>
<td>SOT 103</td>
<td>21.4 - 34.9</td>
<td>185 - 300</td>
</tr>
<tr>
<td>12 - 17.5</td>
<td>SOT 241 A</td>
<td>11 - 15</td>
<td>-</td>
</tr>
<tr>
<td>12 - 17.5</td>
<td>SOT 241</td>
<td>15 - 28</td>
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</tr>
<tr>
<td>12 - 17.5</td>
<td>SOT 242</td>
<td>24 - 39</td>
<td>-</td>
</tr>
<tr>
<td>12 - 17.5</td>
<td>SOT 242 B</td>
<td>38 - 54</td>
<td>-</td>
</tr>
<tr>
<td>12 - 17.5</td>
<td></td>
<td></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.
11. Distribution automation

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
• **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.
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.
- 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.

Figure 32: Transformer protection and control RET615
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 intended 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.

Figure 38: Typical setup with REA 101 and subunits 103
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 straightforward 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

<table>
<thead>
<tr>
<th>Application</th>
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<td>Voltage based protection</td>
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**Communication Protocols**

- IEC61850-8-1: o (off) • • • • • • •
- IEC60870-5-103: • • • • • • • • •
- DNP 3.0: • • • • • • • • • • • • •
- SPA: • • • • • • • • • • • • •
- LON: • • • • • • • • • • • • •
- Modbus: • • • • • • • • • • • • •
- Profibus: o (off) • • • • • • • • • • • • •

**Additional Functionality**

- Fault locator: • • • • • • •
- Auto re-closure: 3 shots 5 shots 2 shots 5 shots 5 shots o(5 shots)
- On load tap changer control: • • • • • • •
- Disturbance recording: • • • • • • •
- Withdrawable release mechanism: • • • • • • •
- Single line diagram HMI**: • • • • • • •
- Local control: • • • • • • • • •
- Remote control: • • • • • • • • •
- Condition monitoring: • • • • • • •
- Power quality monitoring: •
- Analog inputs (VT/CT): -/4 9/8 -/5 -/5 32/27 42/24**** 18/13
- Sensor inputs: • • • • • • • • •
- Binary inputs / Outputs: 5/8 18/13 32/27 42/24**** 18/13
- RTD*** / mA inputs: 8 / 6 5 / 6 mA outputs o(4) o(4)

* With interface protocol converter
** HMI - Human Machine Interface
*** RTD - Resistive Temperature Detector
**** 27 if outputs are static outputs
1) REU615 with A configuration, for voltage and frequency based protection
2) REU615 with B configuration, for tap changer control
o = optional
s = secondary application
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**Voltage based protection**

- **Feeder application (Incomming and/or Outgoing)**
- **High requirement feeder application**
- **Transformer application**
- **High requirement transformer application**
- **Motor protection**
- **High requirement motor protection**
- **Generator & synchronous motor protection**
- **Distance protection**
- **Line differential protection**
- **Back-up Protection**
- **Arc protection**

**Communication Protocols**

- **IEC61850-8-1**
- **IEC60870-5-103**
- **DNP 3.0**
- **SPA**
- **LON**
- **Modbus**
- **Profibus**

**Additional Functionality**

- **Fault locator**
- **Auto re-closure**
- **On load tap changer control**
- **Disturbance recording**
- **Withdrawable release mechanism**
- **Single line diagram HMI**
- **Local control**
- **Remote control**
- **Condition monitoring**
- **Power quality monitoring**
- **Analog inputs (VT/CT)**
- **Sensor inputs**
- **Binary Inputs / Outputs**
- **RTD/mA inputs**
- **mA outputs**

**5 shots**

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</table>
12. Typical units

**Single-line diagram of typical units**

- **IF** – Incoming/outgoing feeder
- **M** – Measurements
- **BS** – Bus section

**Single-line diagram of busbar applications**

- **Voltage transformers**
- **Earthing switch**
Graphical symbols

- Circuit-breaker
- Disconnector
- Switch
- Socket and plug
- Voltage transformers

- Current transformers
- Fuse
- Earth
- Cable entry

Key to components

- Standard components
- Accessories
- Alternative solutions
### IEC version

<table>
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<tr>
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<th>Value</th>
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<tr>
<td>Depth (mm)</td>
<td>1,320</td>
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<tr>
<td>Height (mm)</td>
<td>2,200/2,595</td>
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<tr>
<td>Height with gas exhaust duct (mm)</td>
<td>2,500</td>
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<tr>
<td>Width (mm)</td>
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<tr>
<td>Rated current (A)</td>
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### ENA version

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<td>Height with gas exhaust duct (mm/inch)</td>
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<tr>
<td>Width (mm/inch)</td>
<td>500-1,000 / 19.7-39.4</td>
</tr>
<tr>
<td>Rated current (A)</td>
<td>630, 1,250, 2,000</td>
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</table>

(1) The height of the unit is a function of the height of the Low Voltage compartment, available in the 586, 981 mm versions.
(2) In the ENA version on the rear part of the panel there are located the flaps; no gas duct solution is applicable.
(3) 1000 mm/39.4 inch is relevant to bus-section unit.
(4) Others solutions are available, please contact ABB representative.

### Typical feeder unit

**UniGear 500R IEC version**
- **Single busbar system**
  - A Low voltage compartment
  - B Busbar compartment
  - C Circuit-breaker and cable compartment
  - D Gas duct channel

**UniGear 500R ENA version**
- **Single busbar system**
  - A
  - B
  - C
Contact us

Your sales contact: www.abb.com/contacts
More product information: www.abb.com/productguide

The data and illustrations are not binding. We reserve the right to make changes without notice in the course of technical development of the product.

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