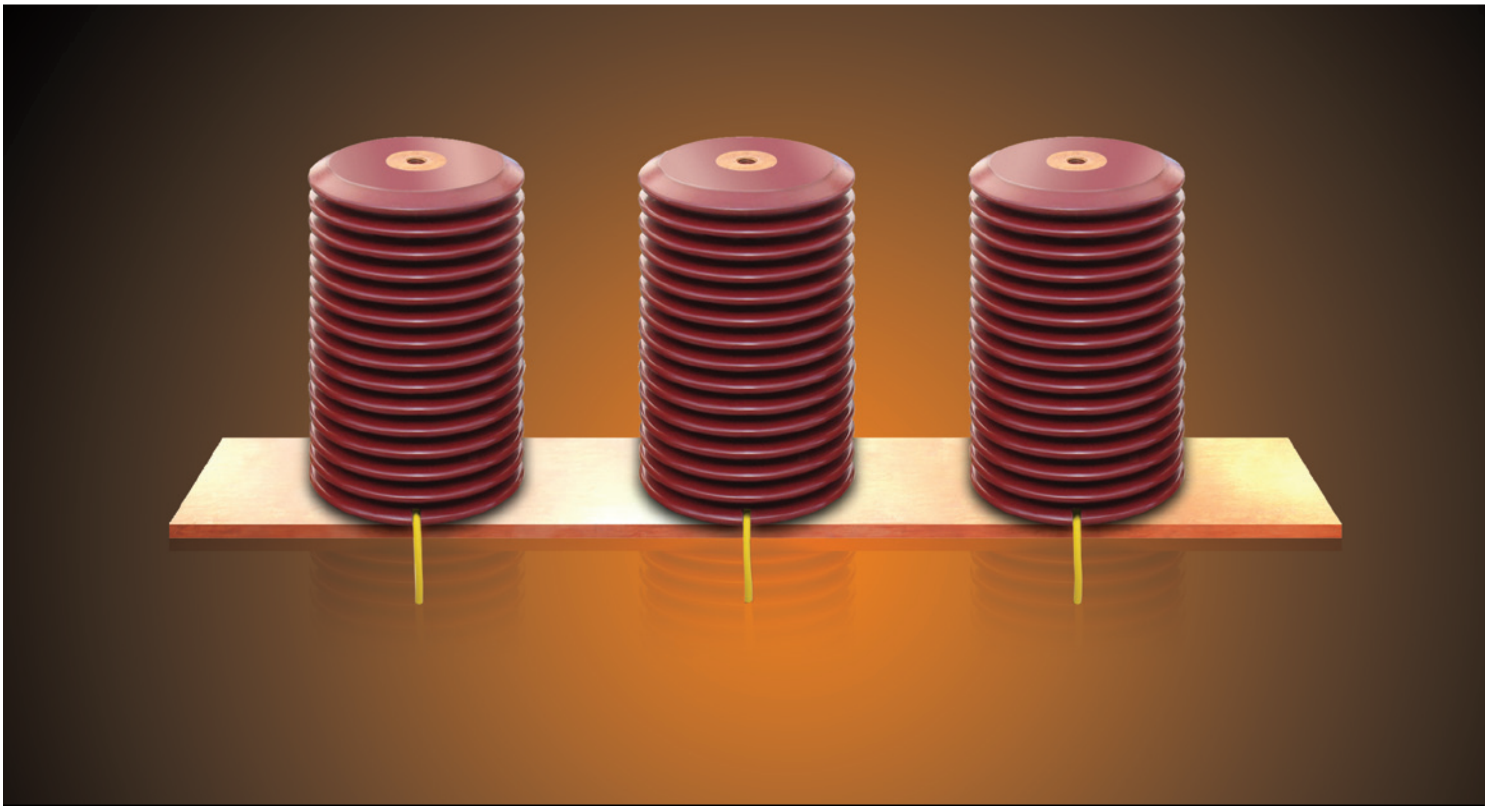


Medium voltage products – Catalogue TK 541/02

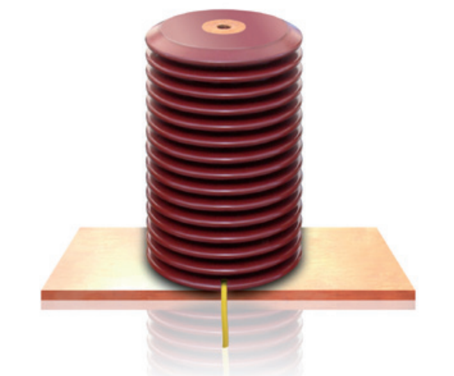
UFES™
Ultra-Fast Earthing Switch

Power and productivity
for a better world™

UFES – Benefits for a broad range of market segments









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Introduction
S^3 – Speed, Safety, Savings

The influence of high thermal and mechanical stresses in the event of an arc fault, the most serious fault possible in a switchgear system, can be drastically reduced by the use of an active arc fault protection system. In contrast to pure overcurrent protection, such a system specifically detects the occurrence of an internal arc fault within a minimum of time and can consequently initiate action on a higher level than the existing protection system, leading to rapid suppression of the fault. The faster an arc fault is suppressed when it occurs, the less damage can be expected in the switchgear system.

The Ultra-Fast Earthing Switch of type UFES is a combination of devices consisting of an electronic device and the corresponding primary switching elements which initiate a 3-phase short-circuit to earth in the event of a fault. The extremely short switching time of the primary switching element, less than 1.5 ms, in conjunction with the rapid and reliable detection of the fault, ensures that an arc fault is extinguished almost immediately after it arises (Extinguishing time < 4 ms after detection). This extension enables a passive protected switchgear to achieve the highest possible level of protection for persons and equipment.

With the extremely rapid intervention provided by the Ultra-Fast Earthing Switch, ABB has succeeded in increasing active arc fault protection for switchgear systems to a maximum. The compact system can in principle be used in any new or existing short-circuit proof switchgear system with rated voltages up to 40.5 kV and rated short time currents up to 63 kA (1s).

Unbeatable advantages:

- Increased system and process availability…
  …by avoidance of serious damage in the switchgear systems and the opportunity to restore service rapidly after a fault.
  …to preserve the greatest possible competitiveness.

- Increased operator safety…
  …for all switchgear systems.
  …especially during or after maintenance work.

- Drastic reduction in repair costs and consequential costs…
  …such as replacement of system components and the significant losses caused by long production stoppages.
  …by minimizing the effects of faults on the system.

- Minimization of pressure rise and gases…
  …in the faulty compartment and surrounding switchgear building.

1 Description of function

1.1 Function

The enhanced system and operator protection provided by the Ultra-Fast Earthing Switch is implemented by consciously creating a 3-phase short-circuit to earth in the event of an arc fault.

The tripping of the Ultra-Fast Earthing Switch first requires the rapid and reliable detection of an arc fault in a defined protection area of the switchgear system. The specific fault is detected either via an expandable UFES electronic detection and tripping unit type QRU1, or by external arc fault detection systems which are combined with a reduced UFES electronic tripping unit of type QRU100. If the criteria / conditions for a tripping are fulfilled, the UFES electronics issues a trip signal to the 3 primary switching elements (PSE), which then establish a 3-phase, metallic short-circuit at their point of installation.

As this short-circuit is of considerably lower impedance than the fault, the fault current commutates from the arc to the defined short-circuit created by the PSE, causing the arc fault voltage to break down and the arc to be extinguished almost immediately. The resulting controlled flow of earth fault current is then finally shut down by the feeder circuit-breaker.

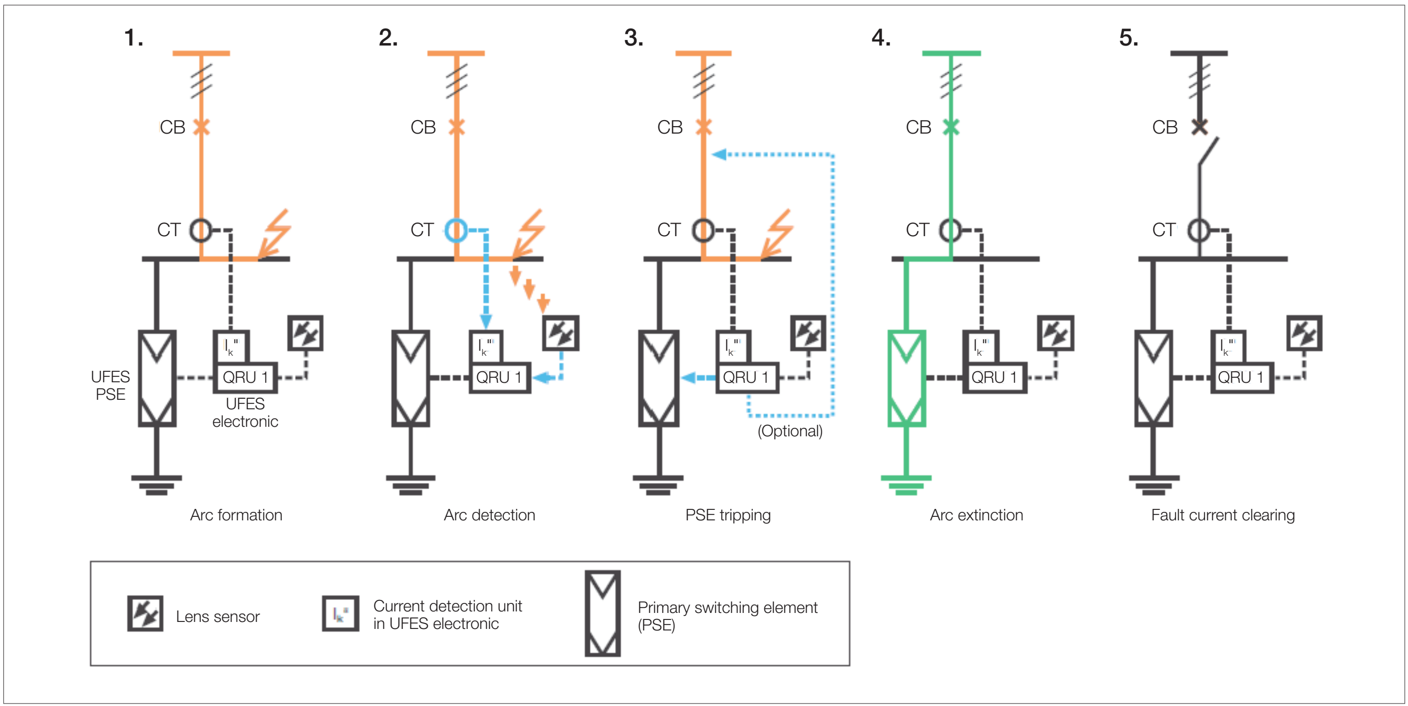
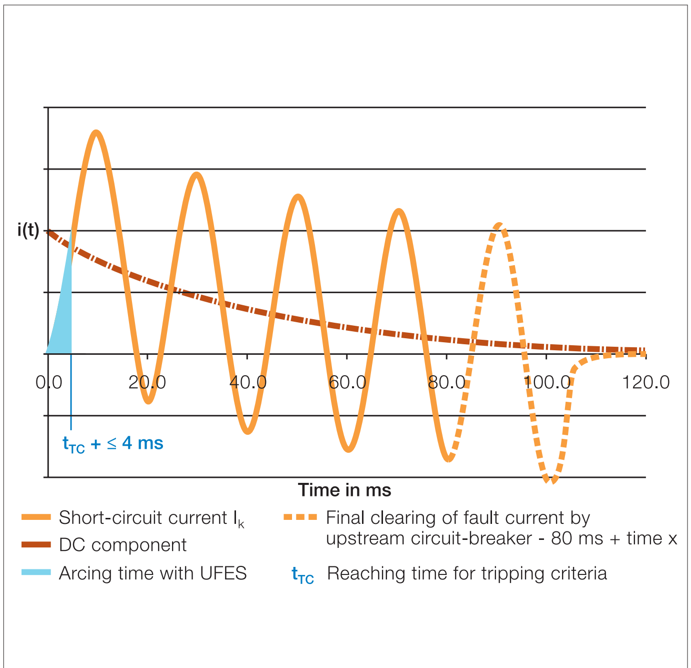
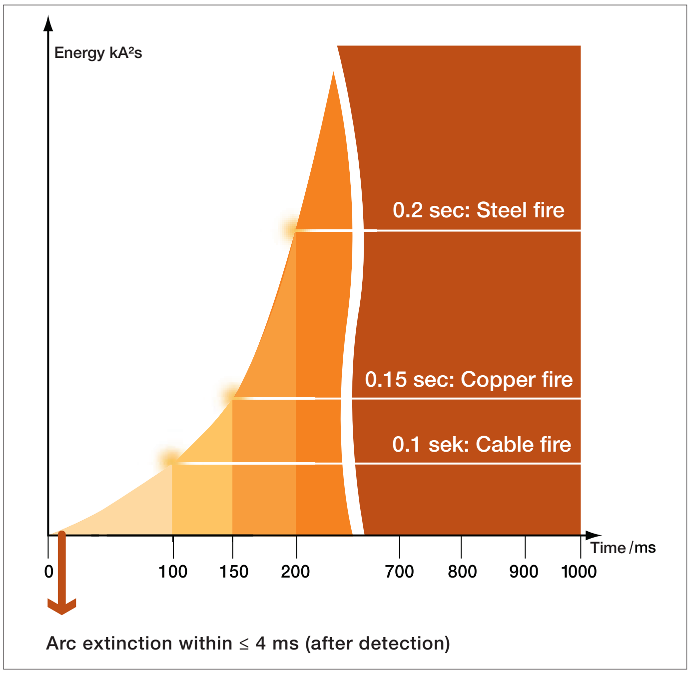


Fig. 1.1-1 **Diagrams showing the function sequence**





Figs. 1.1-2 – 1.1-3 **Drastic reduction in the possible energy input by extinguishing the arc fault before the first peak of the fault current (blue area).**

2 System components

2.1 Ultra-Fast Earthing Switch

The structure of the Ultra-Fast Earthing Switch type UFES consists of a device-specific electronics as well as the 3 primary switching elements (PSE). These elements, including made-up trip cables, form the UFES kit.

The UFES electronics is available in 2 designs. In this portfolio, the electronic detection and tripping unit (DTU) type QRU1 provides an expandable complete solution with internal light and current detection, which is able to protect small protection areas without any additional devices. The electronic tripping unit (TU) type QRU100 on the other hand, uses only external detection units for the monitoring of the protected area.

Fig. 2.1-1 **Electronic detection and tripping unit type QRU1**

Fig. 2.1-2 **Electronic tripping unit type QRU100**

Fig. 2.1-3 **Primary switching element type U1**

Fig. 2.1-4 **Trip cables (UFES electronics → PSE)**

2.2 Accessories and external components

2.2.1 UFES kit with DTU type QRU1

The optical detection of the individual switchgear system compartments is done by means of single lens sensors, which are directly connected to the DTU.

Furthermore, the system can be expanded with the ABB arc guard type TVOC-2 for applications in which more than 9 switchgear system compartments are to be optically monitored. The DTU of the Ultra-Fast Earthing Switch provides 5 dedicated inputs for connection of these external devices. Herewith up to 150 lens sensors more can be integrated in the UFES protection system (see also chapter 4.2.1).

Detailed information regarding the characteristics of the TVOC-2 arc guard monitor units can be found in the corresponding technical catalogues.

2.2.2 UFES kit with TU type QRU100

The complete detection of an internal arc fault is done by means of external detection units. In this context, the TU suits ideal for the connection to the ABB arc protection system type REA. For this purpose compatible and accordingly tested interfaces are available.

Detailed information regarding the characteristics of the REA arc protection systems can be found in the corresponding technical catalogues.

2.3 Test plug

By usage of the test plug, the DTU / TU can be subjected to a functional testing in “Operation” mode. The test plug here conduces the optical and acoustic signalization of the 3 tripping pulses.

Fig. 2.2.1-1 Arc Guard type TVOC-2

Fig. 2.2.2-1 Arc protection system type REA

Fig. 2.2.1-2 Lens sensor

3 Functionality

3.1 UFES electronics

In the development of the electronics as a basic component of the Ultra-Fast Earthing Switch, the focus was consciously directed at the fundamental purpose of the application, namely the effective protection of the system by reliable detection of the fault and a short reaction time for initiation of measures against the fault. The circuit is completely implemented in fast analog technology, with exclusively hardware components responsible for the entire safety functionality.

3.1.1 Electronic detection and tripping unit (DTU) type QRU1

Functionality:
The DTU combines continuous light and overcurrent monitoring in a single unit. A configuration logic allows the two parameters to be set and combined in any way. In a test mode, the functions of the settings and detection components can be checked without tripping the primary switching elements (PSE). Inadvertent switchover into test mode is prevented by a lock switch.
The functions of the device relevant to safety are constantly self-monitored and can be polled via signals.

Light detection:
Light detection is implemented by means of individual lens sensors which are to be installed in the switchgear system compartments and which react to strong increases in light intensity. The light sensors are connected to the DTU by dielectrically sound optical fibre cables. A seven segment display indicates the activated sensor when a fault occurs, thus providing an opportunity for precise fault location. The lens sensors used are fully compatible with the ABB Arc Guard TVOC system.

Current detection:
Current detection is performed, for example, using the protection current transformers in the incoming feeder panel of the switchgear section, and these may have a secondary current of 1 A or 5 A. The inputs of this detection unit have a low burden of < 1 VA, and therefore this monitoring circuit can normally be looped into existing protection circuits without problems. If the instantaneous current measured is greater than the response level set, this constitutes the second criteria for reliable fault detection.

Note:
On selection of the current transformers to be used, it is to be ensured that they have a sufficiently high overcurrent factor to transmit the selected current threshold level accurately.

→ Detailed information on this aspect can be found in the Appendix A1.

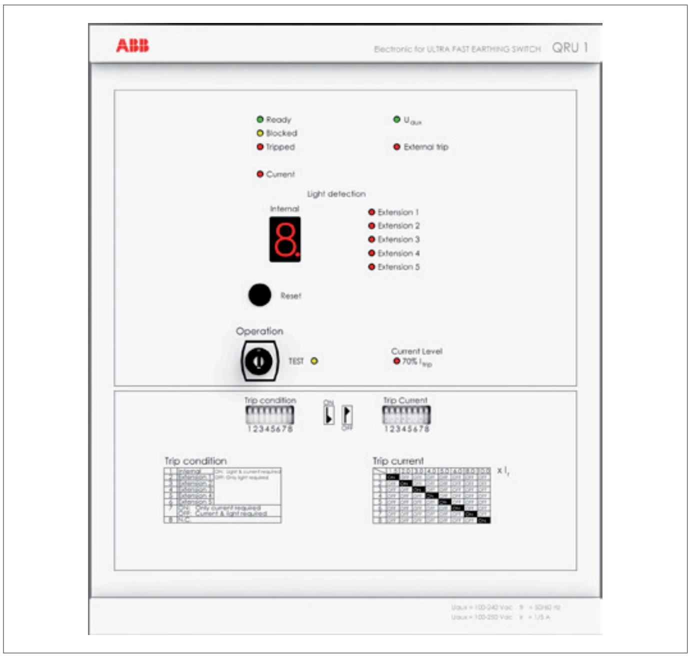


Fig. 3.1.1-1 DTU front view with controls and displays

Configuration:
All settings for implementation of the desired protection concept can be made in a user-friendly manner with DIP switches on the front of the DTU. This provides an opportunity to link the various detection units for the light and overcurrent parameters in AND/OR logic operations. The required response value for impermissible overcurrent can also be set with a second set of DIP switches.

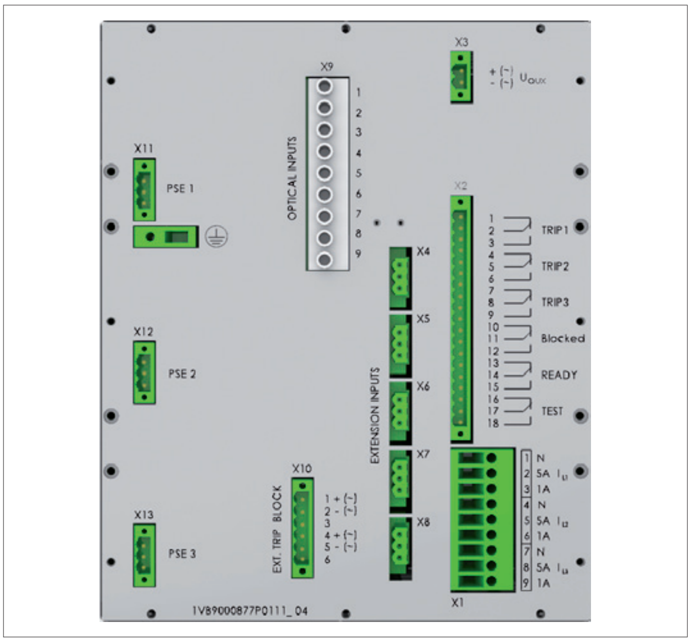


Fig. 3.1.1-2 DTU rear view
As far as possible, all connections are designed as plug-in terminal strips.
Available connections:

X1	3 current transformers (internal detection)
X2	6 floating signal contacts
X3	1 x Auxiliary voltage supply
X4 - X8	5 extension inputs
X9	9 optical sensors (internal detection)
X10	1 x external blocking
X10	1 x external trip
X11	3 x PSE

3.1.2 Electronic tripping unit (TU) type QRU100

Functionality:
The TU type QRU100 is the interface between external arc detection units and the UFES primary switching elements (PSE). For this purpose the electronics provides 2 Optolink and 2 high-speed input (HSI) terminals. While the HSI are universal interfaces, the optolink inputs are designed for the connection of the REA system only. In a test mode, the functions of the settings and detection components can be checked without tripping the PSE.

As for the DTU type QRU1, the test mode can be activated by means of a lock switch. The functions of the system relevant to safety are constantly self-monitored and can be polled via signals.

Optolink:
Via this signal transfer fiber connector the TU can be started by external detection units of the ABB arc fault protection system type REA. Besides of a very fast connection, this interface provides the additional advantage of continuous monitoring of the used fiber connection (optolink supervision).

Configuration:
The single inputs of the electronics can be enabled separately with DIP switches. Furthermore there is the possibility to combine specific inputs logically to a trip condition.

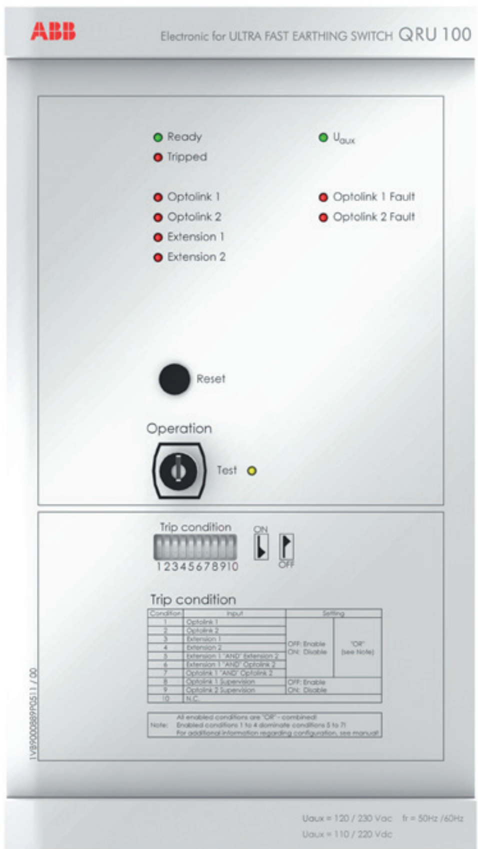


Fig. 3.1.2-1 **TU front view with controls and displays**

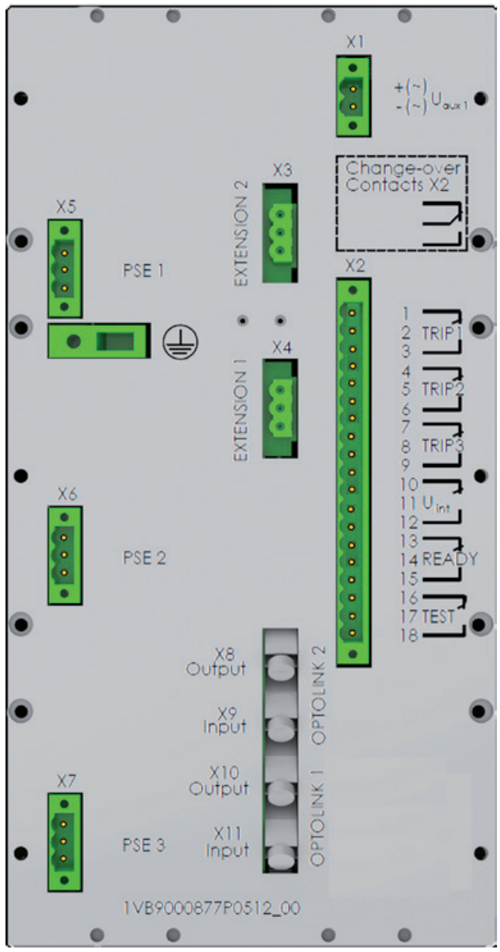


Fig. 3.1.2-2 **TU rear view**
As far as possible, all connections are designed as plug-in terminal strips.
Available connections:

X1	Auxiliary voltage supply
X2	6 floating signal contacts
X3, X4	2 x High-speed inputs (HSI)
X5 - X7	3 x PSE
X8 - X11	2 x Optolink interface

3.2 Primary switching element, type U1

Together with the fundamental requirement for serious arc faults to be rapidly and unequivocally recognized as such, the challenge consists in extinguishing them as quickly as possible. In the Ultra-Fast Earthing Switch, this is performed by three primary switching elements (PSE), which are installed between the live busbar system and earth. The PSE are available for various voltages and currents.

Speed:
The PSE provide a major time advantage over arc fault interruption by a circuit-breaker. A vacuum interrupter specially developed for this application in conjunction with a reliable, phase-independent micro gas generator mechanism for energy storage ensure that the switching operation is completed within 1.5 ms.

Switching principle:
When tripped, the micro gas generator causes an extremely rapid pressure rise in the piston chamber surrounding it. Propelled in this way, the piston penetrates the lid of the vacuum interrupter at the prepared rupture point, and drives the moving contact, which is at earth potential in its initial position, into the fixed contact socket which is at busbar potential. A firmly latched, undetachable connection is established.

Replacement:
As the processes described under "Switching principle" are irreversible, the tripped PSE are to be replaced with new ones after a switching operation.

Handling:
No special safety requirements have to be observed for proper handling of the PSE (installation, replacement, storage and dispatch). The installed micro gas generator is encapsulated in the PSE at the works and fitted with a special seal. In this condition, the switching device meets the requirements of the German Federal Institute for Materials Research, and has received a corresponding approval certificate.

Maintenance:
The PSE have a very low maintenance requirement. The external surface of the PSE with its switching contacts and operating mechanism completely embedded in epoxy resin only requires cleaning when heavily soiled, and a replacement of the micro gas generator should be planned after 15 years. This work is to be performed by the manufacturer.

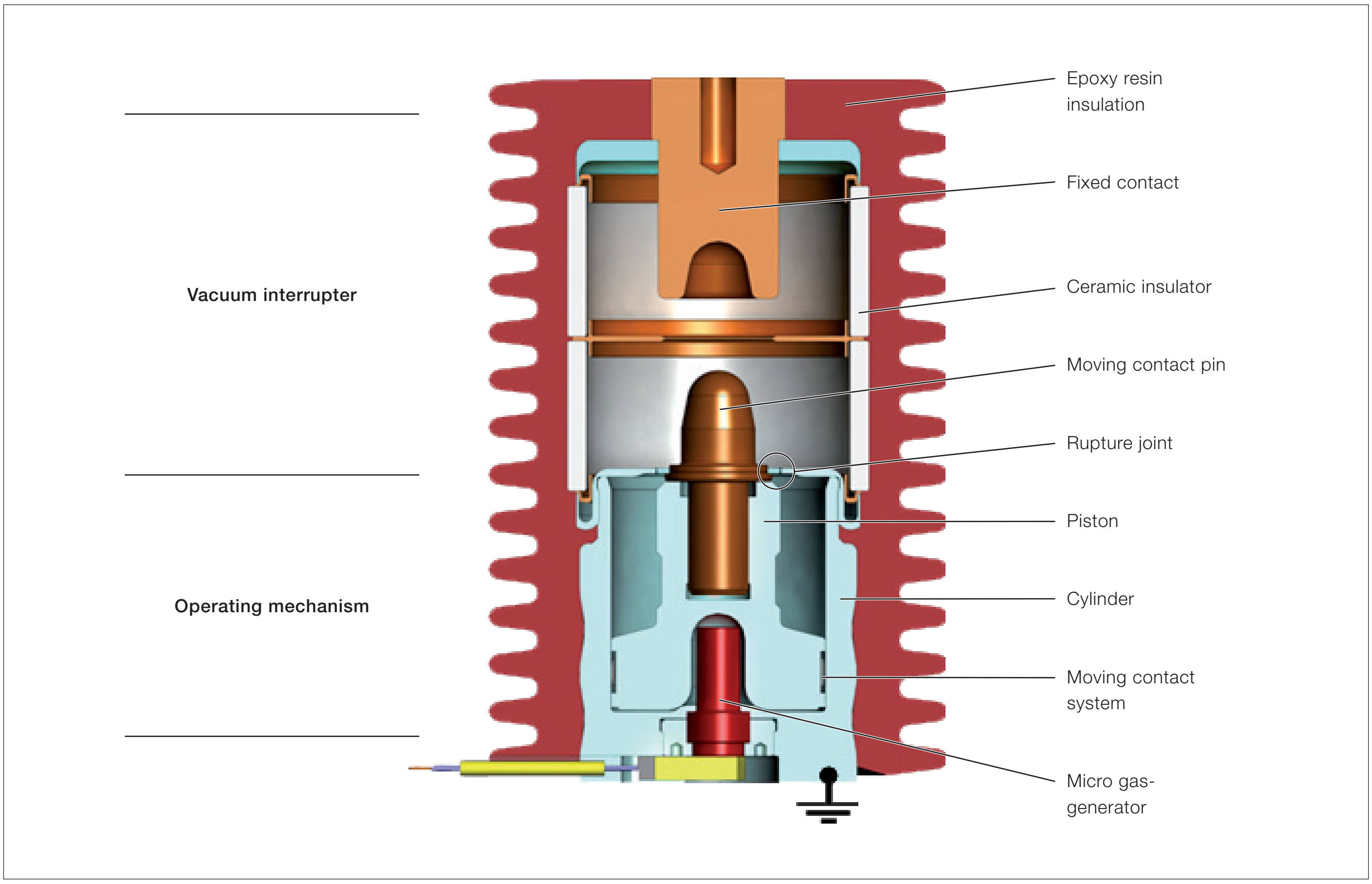


Fig. 3.2-1 **Sectional view of PSE**
Vacuum interrupter and micro gas generator integrated in a compact unit

Flexibility in installation:
The compact design of the PSE as individual units with autonomous operating mechanisms provides for flexibility in location and orientation for integration of these units in the switchgear system to be protected. With an overall height of 210 mm, the PSE of type U1 is dimensionally equivalent to a 24 kV pin-type insulator.

Other methods of integration apart from direct installation of the switching device in the switchgear system are also possible. Using a type-tested ABB Service Box with built-in PSEs, it is for example possible to mount the primary part of the Ultra-Fast Earthing Switch on the outside of the switchgear and connect it to the busbar system (figure 3.2-2). When empty panels are available, a withdrawable PSE assembly variant can be used as a further retrofit option (figure 3.2-3).

Fig. 3.2-2 ABB Service Box with built-in PSE

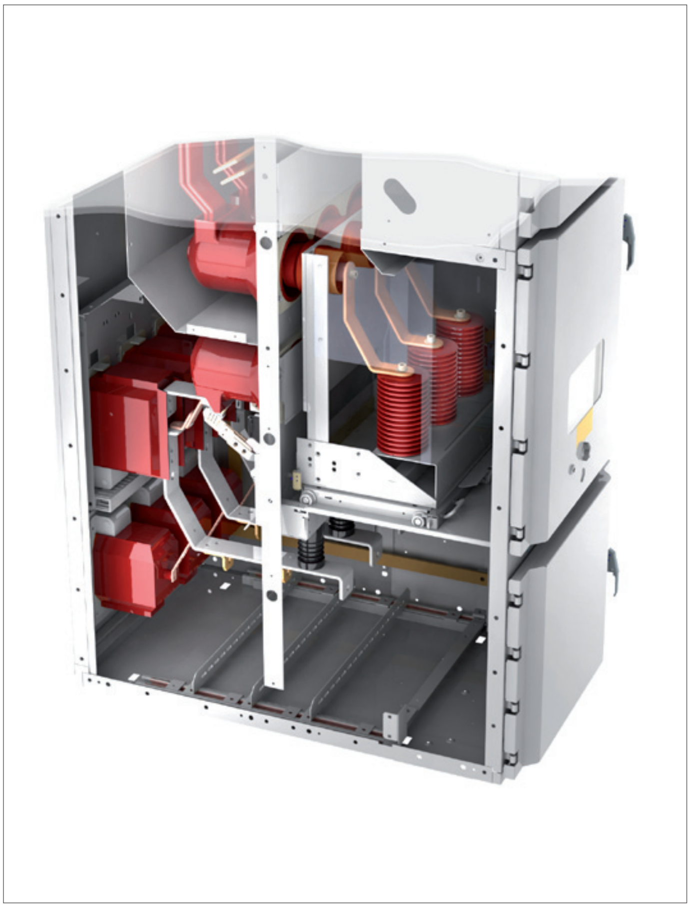


Fig. 3.2-3 Withdrawable assembly variant when empty panels are available

4 Applications

4.1 General

The following illustrations show various ways in which the Ultra-Fast Earthing Switch can be incorporated in a switchgear system. All the examples are described with the electronic detection and tripping unit type QRU1, but they can equally be designed with the electronic tripping unit type QRU100 and an external detection system like the ABB arc protection of type REA.

As there are a large number of customized variants, it is impossible to document every option for application of the Ultra-Fast Earthing Switch. Only the most frequently used applications are therefore presented as examples.

The transformers shown in the examples can also be replaced by generators or any other incoming feed to a switchgear system. Tripping of the primary switching elements (PSE) always takes place in all three phases.

The following characteristics are common to all example applications:

- In the event of an arc fault with exceed of the response values (light and current) / trip conditions the UFES electronics will trip.
- The three PSE create a 3-phase short-circuit to earth at the point of installation and the arc fault in the monitored protection area of the switchgear is extinguished immediately.
- The fault current is finally switched off by the feeder circuit-breakers. These circuit-breakers can also be triggered directly by the UFES electronics or by the external detection units to shorten the breaking time.

4.2 Example application 1 – Switchgear system with one incoming feeder and one protection area

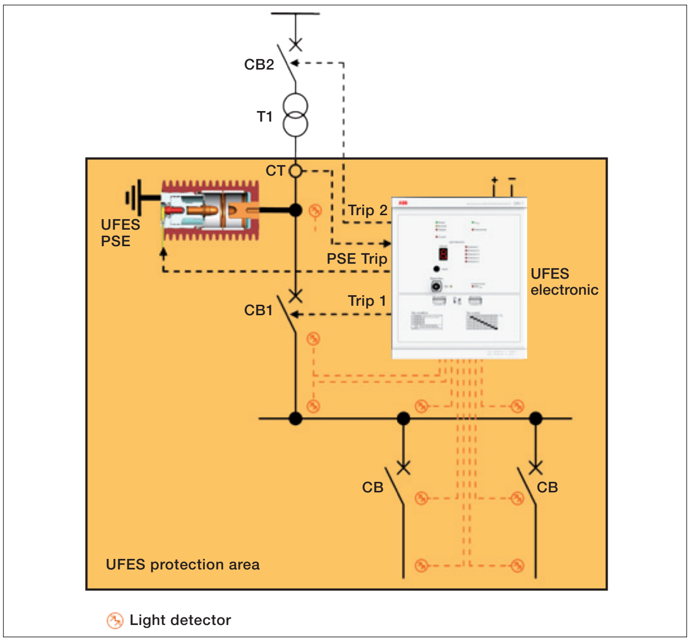
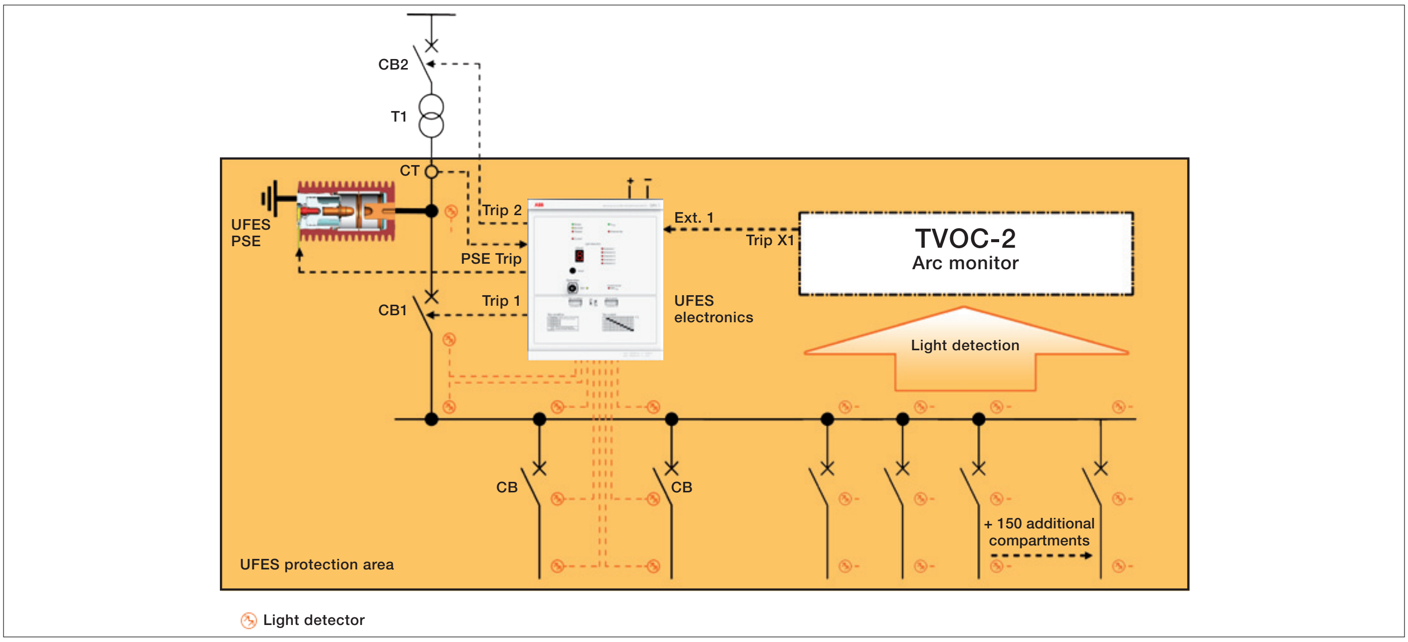


Fig. 4.2-1 System configuration
- 3-panel switchgear; triple partitioned per panel
- 1 incoming feeder; 1 UFES protection area
- PSE installed in cable termination compartment of the incoming feeder panel
- Optical monitoring of all 9 compartments by lens sensors
- Current monitoring by the current transformers installed in the cable termination compartment of the incoming feeder panel

If the fault is located behind circuit-breaker CB1 (as seen from the transformer) the faulty part is switched off by circuit-breaker CB1. Circuit-breaker CB2 then interrupts the three-phase short-circuit generated by the three PSE.

If the fault is upstream from circuit-breaker CB1 in the incoming feeder panel, circuit-breaker CB2 finally interrupts that fault.

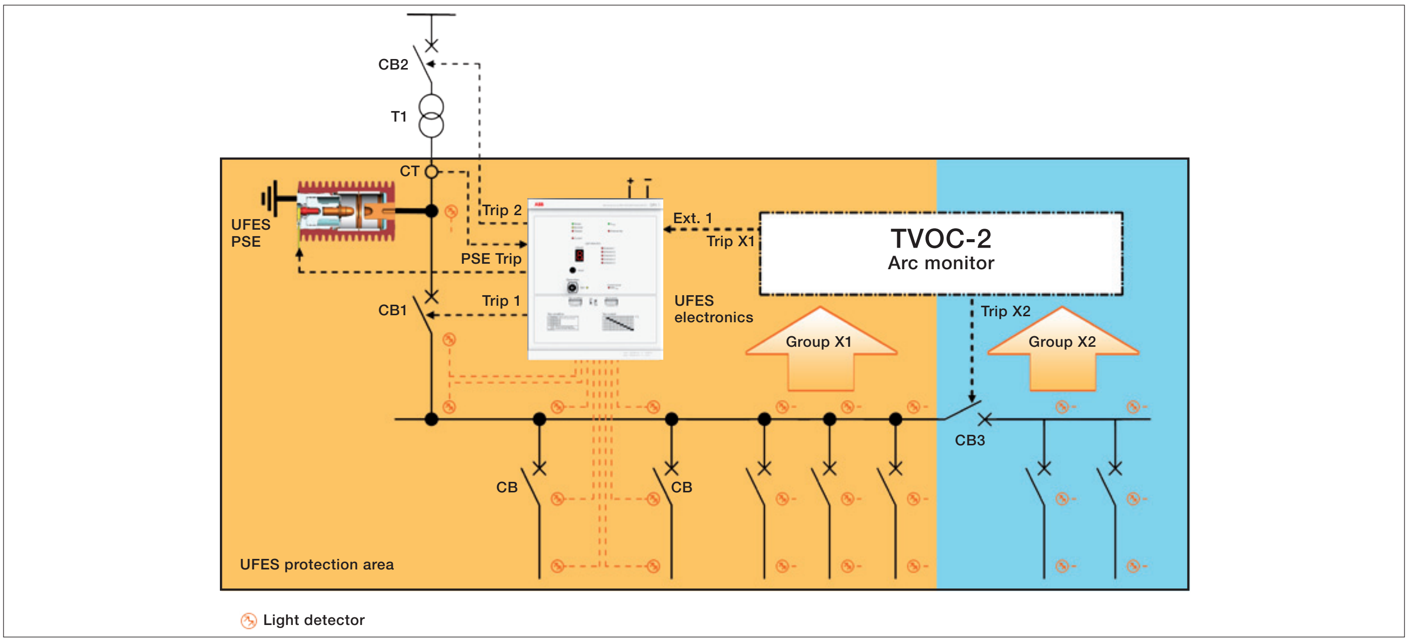
4.2.1 Example application 1 with optical extension by use of the ABB arc guard type TVOC-2



Using a maximum of 5 arc guard units of type TVOC-2, the UFES protection area can be extended by up to 150 additional optical lens sensors. The protection system can thus also be used for large switchgear installations with, for example, up to 53 panels with triple partitioning.

The processing time of the external TVOC-2 trip signal via the fast extension inputs of the DTU is approx. 250 μs and therefore has no significant influence on the effectiveness of the system as a whole.

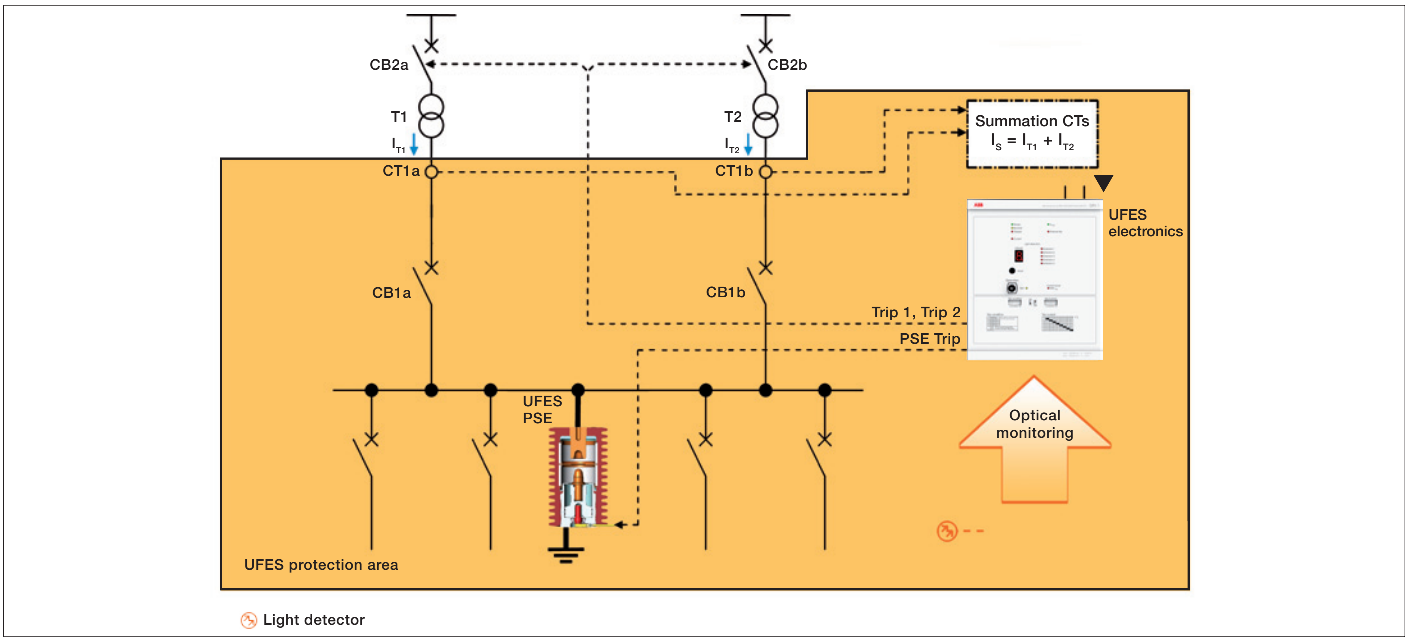
4.2.2 Example application 1 with optical extension by use of the ABB arc guard type TVOC-2 and light selective detection and disconnection



Selectivity can be established via the optical extension units for individual sections within the protection area. This makes it possible, for example, to detect an arc fault purely optically in less relevant outgoing feeders or groups of panels and to interrupt it using a circuit-breaker without involving the PSE.

In the example above, there is no tripping of the DTU when an arc fault is detected by the lens sensors of Group X2, but merely an OFF signal to the tie breaker CB3.
The current in this protection area is not assessed.

4.3 Example application 2 – Switchgear system with two incoming feeders and one protection area

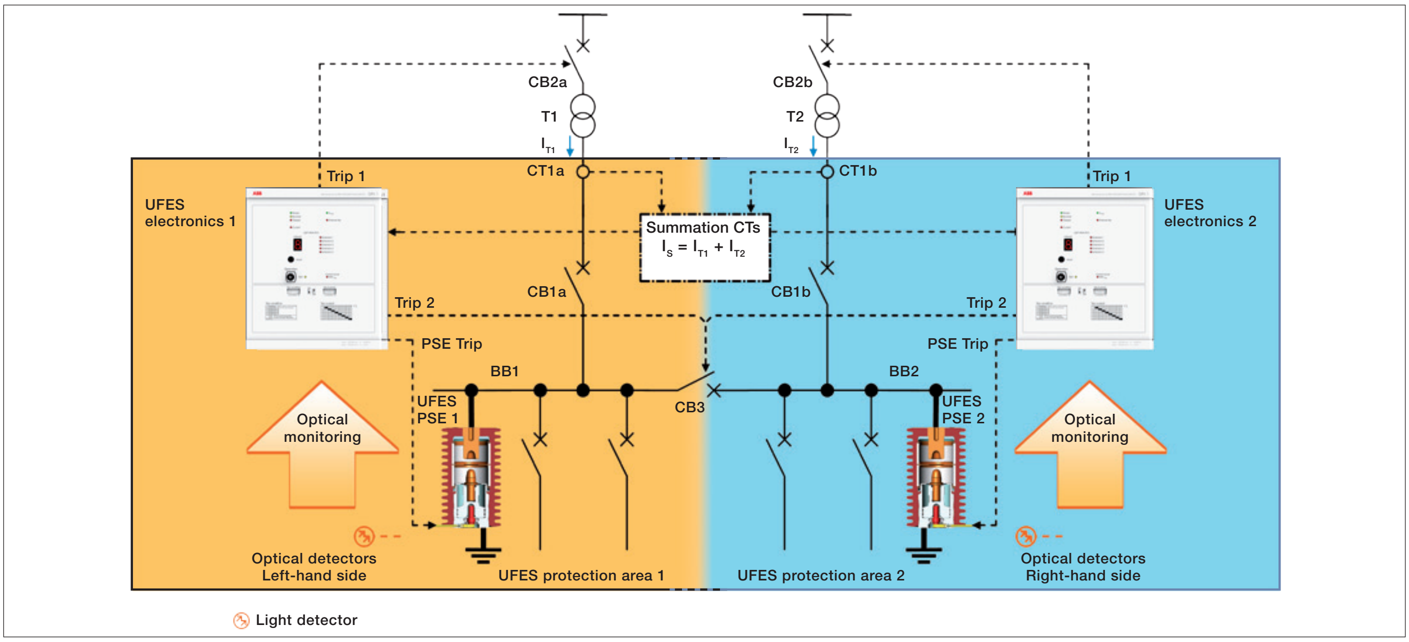


In this example, the switchgear system is supplied by two transformers. In order to implement arc fault protection with one Ultra-Fast Earthing Switch only, the three PSE are, in contrast to example application 1, connected directly to the busbar. This ensures that the Ultra-Fast Earthing Switch remains effective even after a transformer feeder has been shut down.

The current transformers required for current monitoring are located in the relevant incoming feeder panels in the system. In order to monitor the currents of both incoming feeders (current transformers CT1a and CT1b), the currents are added by summation CTs and the result fed to the DTU.

If the fault is located behind circuit-breakers CB1a and CB1b (as seen from the transformer), the three-phase short-circuit generated by the three PSE and the faulty part of the switchgear are switched off by the circuit-breakers CB1a and CB1b. If the arc fault occurs upstream from circuit-breaker CB1a (CB1b), it is switched off by circuit-breaker CB2a (CB2b).

4.4 Example application 3 – Switchgear system with two incoming feeders and two coupled protection areas



This switchgear system is supplied by two transformers. It has two separate busbar sections BB1 and BB2, which can be connected together via longitudinal bus coupler (CB3).

Since each busbar section can also be operated independently, one Ultra-Fast Earthing Switch has to be considered for each bus bar section. The respective three PSE are connected directly to the left hand side busbar and right hand side busbar.

Tripping of the Ultra-Fast Earthing Switches is selective, i.e. UFES 1 is only activated when there is a fault in the left-hand switchgear system with BB1, and UFES 2 only protects the right-hand switchgear system with BB2.

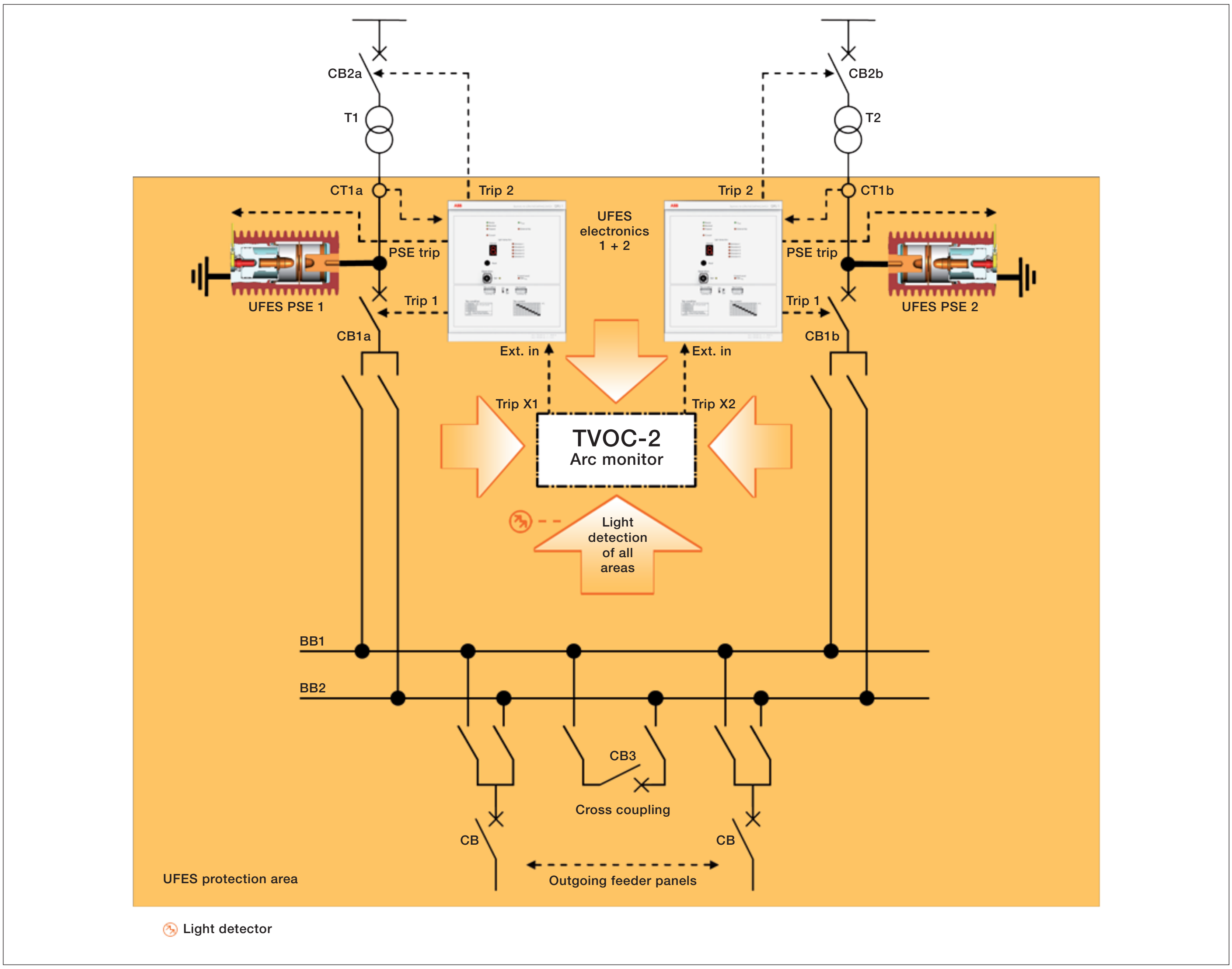
Light selective protection:
UFES 1 is activated by the light sensors in the left-hand switchgear system with BB1 and by the summation current I_S. The summation current I_S is the total of the currents I_{T1} and I_{T2} flowing through both feeders of the system. These two currents are totalized in the current transformer. Similarly, UFES 2 is activated by the light sensors in the right-hand switchgear system with BB2 and also by the summation current I_S.

In the event of an arc fault in the area of switchgear system BB1 which exceeds the setpoints for summation current I_s and light in switchgear system BB1, UFES 1 trips. The three PSE on busbar BB1 short-circuit the three phases to earth and the arc in the area of switchgear system BB1 is extinguished immediately. At the same time, circuit-breakers CB2a and CB3 receive an OFF command from the DTU.

If the fault is located behind circuit-breaker CB1a (as seen from the transformer), the three-phase short-circuit generated by the three PSE and the faulty part of the switchgear are switched off by the circuit-breakers CB1a and CB3. If the arc fault occurs in the termination area of the incoming feeder panel for BB1, it is switched off by circuit-breaker CB2a.

The same applies accordingly to the right-hand switchgear system with BB2.

4.5 Example application 4 – Open switchgear system with two incoming feeders and double busbar system



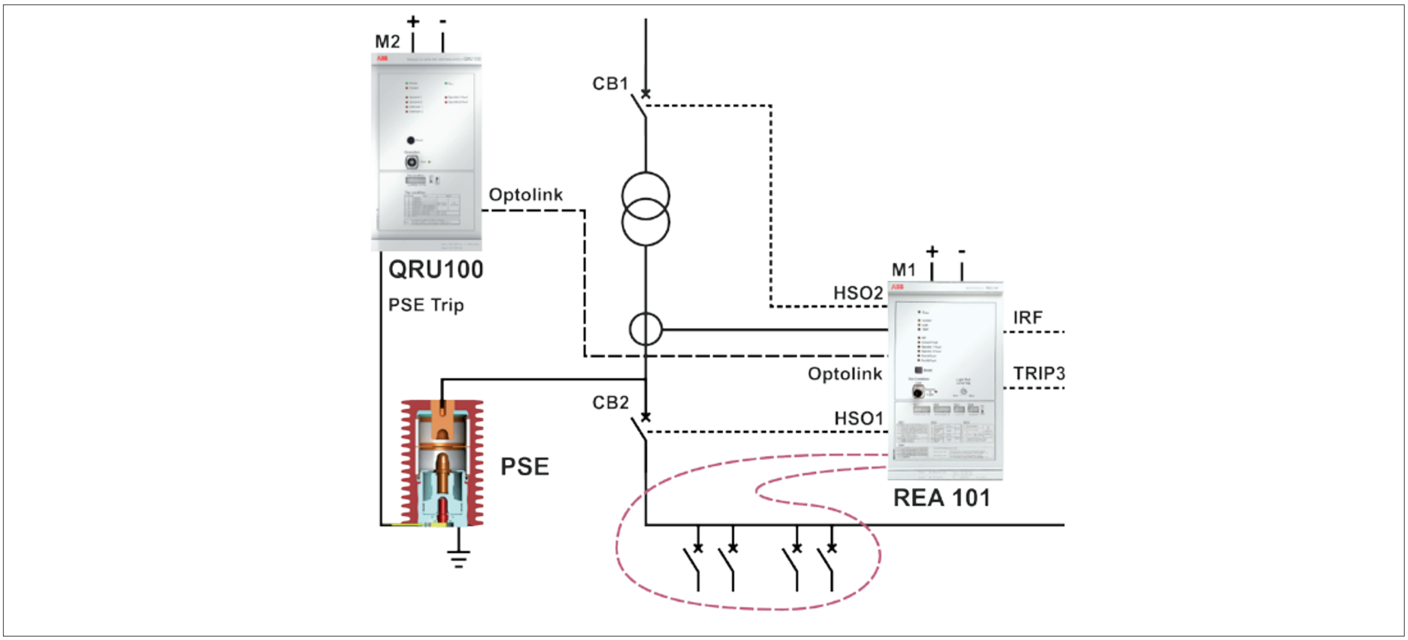
The example here shows a switchgear system with an open design. The switchgear system has two incoming circuit-breakers, which can be connected via disconnector to either BB1 or BB2. Same applies to the circuit-breakers of the outgoing feeders. Furthermore the busbar sections of BB1 and BB2 can be operated in parallel via transverse coupling.

The open design of the switchgear and therewith, the typically associated local mixing of the individual systems in the busbar or disconnectors area, does not allow a clear optical triage of the faulty system. To trip only the necessary Ultra-Fast Earthing Switch(es) for the extinguishing of the arc, a protection concept with current selectivity has to be applied.

Current selectivity:
One Ultra-Fast Earthing Switch is installed in each terminal area of the incoming feeder. The individual Ultra-Fast Earthing Switches measure the current at their point of installation only. Light, as the second criteria, will be detected by a TVOC-2 arc guard, which sends a trip signal to all installed Ultra-Fast Earthing Switches in the event of an internal arc.

In the event of an arc fault in the UFES protection area, only the Ultra-Fast Earthing of the incomer, which is feeding the fault, will operate

4.6 Ultra-Fast Earthing Switch with electronic tripping unit type QRU100



With the electronic tripping unit type QRU100, the Ultra-Fast Earthing switch suits for the connection of external arc protection systems. In such an application, the complete detection of an arc will be covered by the external system, which will send a trip signal to the Ultra-Fast Earthing Switch in case of an arc fault.

This results in additional opportunities for the creation of new protection concepts with other arc fault protection systems and for the retrofit of existing systems.

The 2 available interfaces on the QRU100, High-speed input (HSI) and Optolink, suit ideal for the connection of the ABB arc protection system type REA.

The REA arc protection system is a fast and flexible configurable system for switchgear. Just like the UFES electronic detection and tripping unit type QRU1, the REA system detects an arc based on light and current monitoring. For the optical monitoring 2 types of sensors are used:

1. Line sensors, which detect the light over the complete length of a fiber

2. Lens sensors, typically to be installed in each individual switchgear compartment

As soon as an arc is identified as such, the REA system sends a disconnect signal to the circuit-breakers which are feeding the fault. In combination with the Ultra-Fast Earthing Switch, a trip signal of the REA system can be send directly to the Ultra-Fast Earthing Switch via the optolink interface.

The individual modules of the REA system:

1. Main module REA101 – Stand-alone relay, providing optical detection by means of a line sensor and internal current detection.

2. Extension module REA103 – Extension of the optical detection with additional line sensors.

3. Extension module REA105 – Extension of the optical detection with an additional line sensor. Furthermore equipped with own high-speed outputs for applications where higher selectivity is required.

4. Extension module REA107 – Extension of the optical detection with additional 8 lens sensors.

Detailed information regarding the characteristics of the REA arc protection system, as well as further example applications can be found in the corresponding technical catalogues.

All example applications of the Ultra-Fast Earthing Switch with electronic detection and tripping unit type QRU1, mentioned in this chapter 4, can be equally realized with an external system like the REA in combination with UFES and QRU100.

5 General notes on installation

5.1 Primary switching elements (PSE)

The possible short circuit earthing area and therewith the protection area within the switchgear system to be monitored is defined by the location at which the PSE are installed. The choice of installation point, in turn, is dependent on the intended protection concept. The protection area within the switchgear system in principle is given upwards (opposite feeding direction) from the point of installation of the PSE to the outgoing terminals of the incoming feeder circuit-breaker(s). The downward areas are automatically included and so protection is ensured down to the outgoing terminals of the outgoing feeder circuit-breakers. Special configurations reflecting this definition, in which the standard protection concept is modified, are not mentioned here and should be considered as individual cases where required. It is in principle advisable to locate the PSE in the area of the busbars or cable terminations, as close as possible to the incoming feeder of the defined protection area.

5.2 UFES electronics (Type QRU1 or type QRU100)

The UFES electronics can be installed at any point in a low voltage compartment of the switchgear system, or also outside the switchgear system. It should however be remembered that the maximum cable length between the UFES electronics and the PSE must not exceed 10 m.

The standard method is door mounting. If required, however, the UFES electronics can also be installed in the switchgear or outside on a wall using a surface mounting set which is available as an optional extra.

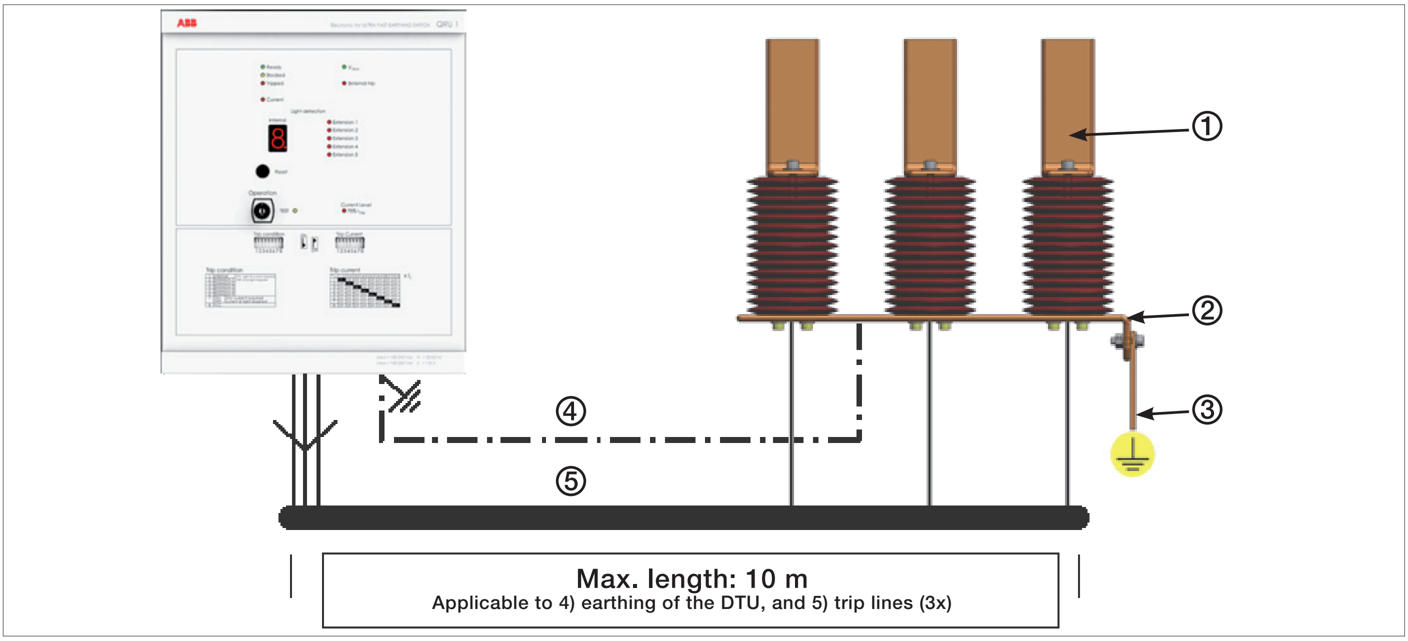


Fig. 5.2-1 **System configuration**

1 Customized, live bar system
2 PSE earthing bar
   Material: Copper
   Width: Min. 80 mm (depending on design)
   Cross-section: Min. 400 mm²; 800 mm² (80x10 copper bar) recommended
3 Earthing bar system (connection to station earth)
   Material: Copper
   Cross-section: Min. 240 mm²; 30x8 copper bar (240 mm²) recommended
4 Earthing of the DTU
   Cu cable (min. 2.5 mm² flexible or 4.0 mm² rigid)
5 Trip lines (DTU → PSE)
   Made-up, screened Cu cable with special system plug connectors, 2-core, twisted, included in the UFES kit supply.

5.3 Light detectors for connection to the QRU1

Detector cables are available in standard lengths (see ordering data). They may not be shortened or spliced. Sharp kinks or pinching during installation of the cables are to be avoided. The plastic fibre consists of polymethyl methacrylate (PMMA) with a PVC jacket. Each detector consists of an optical cable and a lens, which are tested and calibrated together at the works so as to achieve identical sensitivity independently of the cable length. The lens admits light from all directions with the exception of a small screened-off area behind the detector (cf. distribution diagram).

Practical trials have shown that the light from an arc reflected between metallic surfaces is normally sufficient for a trip. This has to be tested in each particular case.

5.3.1 Detector positioning

When positioning the sensors, it is to be ensured that all the switchgear system compartments or areas to be monitored in accordance with the selected protection concept are covered. Every panel should be monitored if possible.

Detectors shall not be positioned in such a way that they react to the normal switching arc of a circuit-breaker. The sensor can detect arcing at a distance of 3 metres (see illustration 5.3-2). In order to increase the level of safety even further, the sensors can be installed at distances of 1.5 metres, thus creating redundancies.

Fig. 5.3-1 Lens sensor

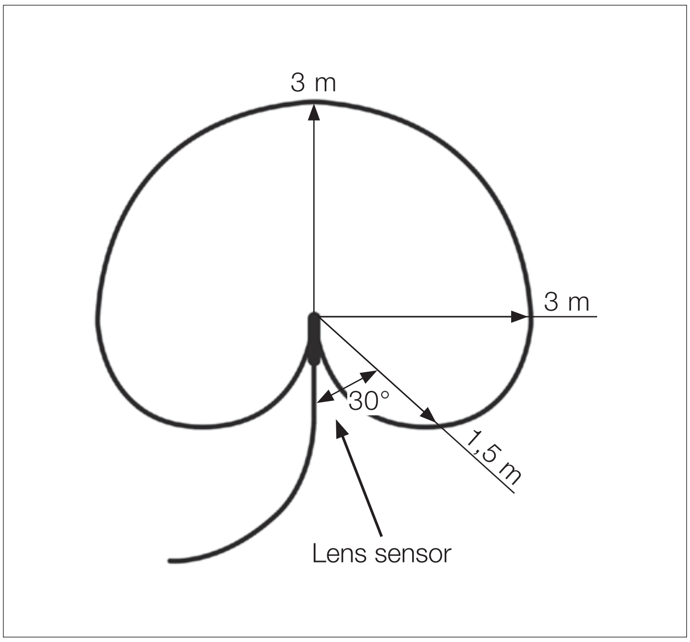


Fig. 5.3-2 Detection range of a lens sensor

6 Technical data

6.1 Primary switching element

6.1.1 Electrical properties

		Type											
		U1-14-063	U1-14-100	U1-175-25	U1-175-40	U1-175-50	U1-175-63	U1-270-25	U1-270-40	U1-360-25	U1-360-40	U2-405-25[1]	U2-405-40[1]
Rated voltage (rms)	kV	1.4	1.4	17.5	17.5	17.5	17.5	27	27	36	36	40.5	40.5
Rated short-time withstand current (rms)	kA	63	100	25	40	50	63	25	40	25	40	25	40
Rated short duration power-frequency withstand voltage (rms)	kV	5	5	42	42	42	42	60	60	70	70	95	95
Rated lightning impulse withstand voltage (peak)	kV	12	12	95	95	95	95	150	150	170	170	200	200
Rated frequency	Hz	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60
Rated peak withstand current	kA	140	220	65	104	130	165	65	104	65	104	65	104
Rated short-circuit duration	s	1	0.5	3	3	3	1	3	3	3	3	3	3
Rated short-circuit making current	kA	140	220	65	104	130	165	65	104	65	104	65	104

[1] On request

6.1.2 Mechanical properties (all types)

Dimensions (diameter x height)	mm	137 x 210 [2]
Weight	mm	max. 5.5 kg
Operating time	ms	< 1.5
Contact bounce time	ms	0

[2] Different dimension for 40.5 kV, on request

6.1.3 Service life expectation

At rated voltage and under the ambient conditions stated

Number of making operations		1
Mechanical	Years	up to 30
Micro gas generator (SMGG)	Years	up to 15

6.1.4 Ambient conditions

Operating temperature range	-5 bis +70 °C [3]
Transport temperature range	-25 bis +70 °C (max. 48 Stunden)
Storage temperature range	-5 bis +40 °C
Ambient humidity (storage)	max. 65 %, non-condensing
Site altitude	1000 m above NN

[3] Different conditions on request

6.2 Electronic detection and tripping unit type QRU1

6.2.1 Mechanical properties

Degree of protection, front (flush mounted)	IP 4X
Degree of protection (enclosure as a whole)	IP 2X
Weight	~5.5 kg

6.2.2 Auxiliary power supply

Rated voltage	120 V & 230 V AC (50/60 Hz) 110 V & 220 V DC
Tolerance range of rated voltage	85 % - 110 % U_r (AC) 70 % - 120 % U_r (DC)
Rated insulation voltage	2 kV
Power consumption	< 25 VA

6.2.3 Detection and control inputs (overview)

Optical (light detection)	9 x
Current transformer	3 x
External tripping	1 x
External blocking	1 x
External detection units	5 x

6.2.4 Current transformer inputs

Rated input current I_r	1 A and 5 A
Rated frequency	50 / 60 Hz
Continuous load current	4 x I_r
Rated short-time current, 1 s	100 x I_r
Rated peak withstand current	250 x I_r
Burden	< 0.5 VA

6.2.5 Control inputs: Ext. Trip / Ext. Blocked

Rated voltage AC	24 V to 250 V
Rated voltage DC	24 V to 250 V
Reaction time “Ext. Blocked”	< 30 ms
Reaction time “Ext. Trip”	< 15 ms

6.2.6 Signal/control contacts

Signals	3 x Tripped 1 x Blocked 1 x Ready 1 x Test
Type	Changeover, floating
Rated voltage	250 V (AC or DC)
Rated current	5 A
Rated making current (0.5 s)	10 A
Rated making current (3 s)	8 A
Breaking capacity (L/R < 40 ms), 48 V DC	2A
Breaking capacity (L/R < 40 ms), 110 V DC	0.4 A
Breaking capacity (L/R < 40 ms), 220 V DC	0.25 A

6.2.7 Extension inputs

Output voltage	approx. 12 V DC
Output current	approx. 5 mA DC

6.2.8 Optical sensors for the QRU1

Type	Lens sensor
Max. length of optical fibre cable	30 m [1]
Min. permissible bending radius	50 mm
Ambient temperature	-25 to +70 °C
Ambient temperature (short time)	-25 to +85 °C
Ambient light intensity without tripping	3000 lux

[1] Greater lengths on request

6.2.9 Setting range for current detection

Current settings x I_r	1.5 / 2.0 / 3.0 / 4.0 / 5.0 / 6.0 / 8.0 / 10.0
Error in operating value 1.5 - 6.0 x I_r	+/- 5 % of setting
Error in operating value 8.0 - 10.0 x I_r	+/- 12 % of setting

6.2.10 Ambient conditions

Operating temperature range	-25 to +55 °C
Transport and storage temperature range	-25 to +70 °C
Ambient humidity	max. 65 %, non-condensing
Site altitude	2000 m above NN

6.2.11 Reaction times

Start time of electronics	1 s
Input signal to trip signal (extension)	~ 250 µs

6.3 Electronic tripping unit type QRU100

6.3.1 Mechanical properties

Degree of protection, front (flush mounted)	IP 4X
Degree of protection (enclosure as a whole)	IP 2X
Weight	~ 4.5 kg

6.3.2 Auxiliary power supply

Rated voltage	120 V & 230 V AC (50/60 Hz) 110 V & 220 V DC
Tolerance range of rated voltage	85 % - 110 % U_r (AC) 70 % - 120 % U_r (DC)
Rated insulation voltage	2 kV
Power consumption	< 25 VA

6.3.3 Extension inputs for external detection units

Optolink	2 x
Extension (HSI)	2 x

6.3.4 Signal / control contacts

Signals	3 x Tripped 1 x U_{int} 1 x Ready 1 x Test
Type	Changeover, floating
Rated voltage	250 V (AC or DC)
Rated current	5 A
Rated making current (0.5 s)	10 A
Rated making current (3 s)	8 A
Breaking capacity (L/R < 40 ms), 48 V DC	2A
Breaking capacity (L/R < 40 ms), 110 V DC	0.4 A
Breaking capacity (L/R < 40 ms), 220 V DC	0.25 A

6.3.5 “Extension” inputs (High-speed input – HSI)

Output voltage	~ 22 V DC
Output current	~ 10 mA DC

6.3.6 “Optolink” – Signal transfer fiber to REA system

Max. length of plastic fiber	40 m
Max. length of glass fiber	2,000 m
Operating temperature range	-35 to +80 °C
Min. permissible bending radius	50 mm

6.3.7 Ambient conditions

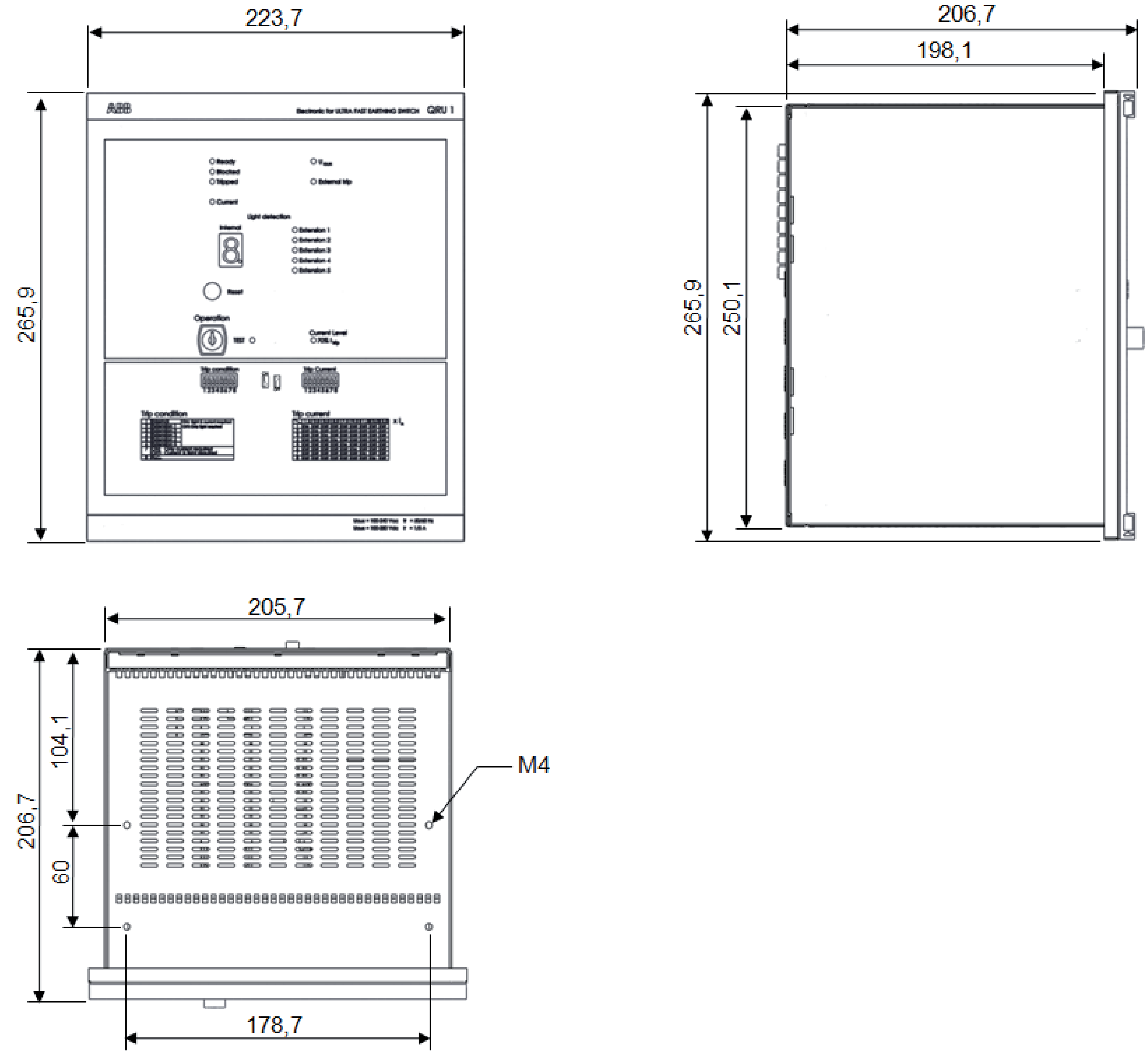
Operating temperature range	-25 to +55 °C
Transport and storage temperature range	-25 to +70 °C
Ambient humidity	max. 65 %, non-condensing
Site altitude	2000 m above NN

6.3.8 Reaction times

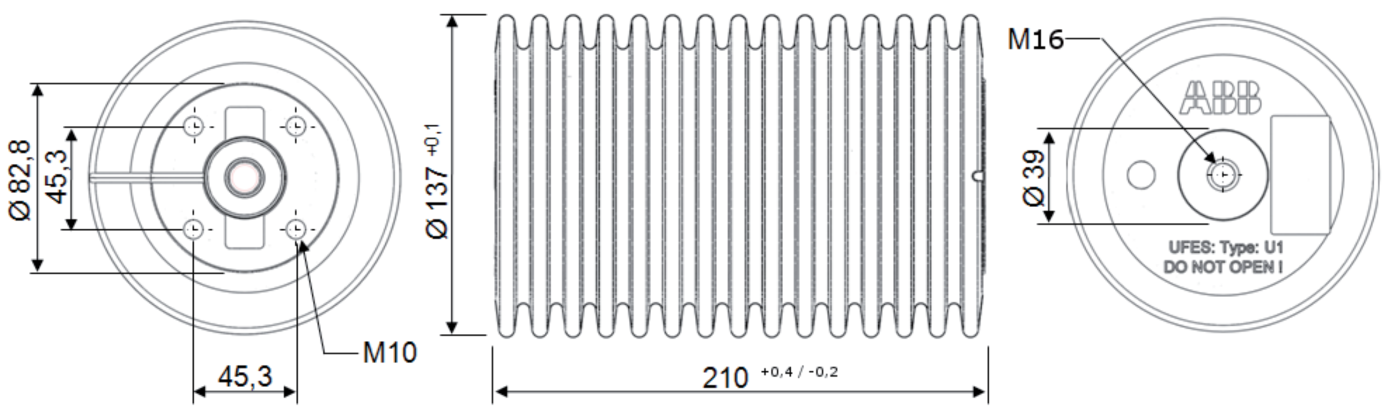
Start time of electronics	1 s
Input signal to trip signal (Optolink)	~ 400 µs
Input signal to trip signal (Extension)	~ 400 µs

7 Dimensions

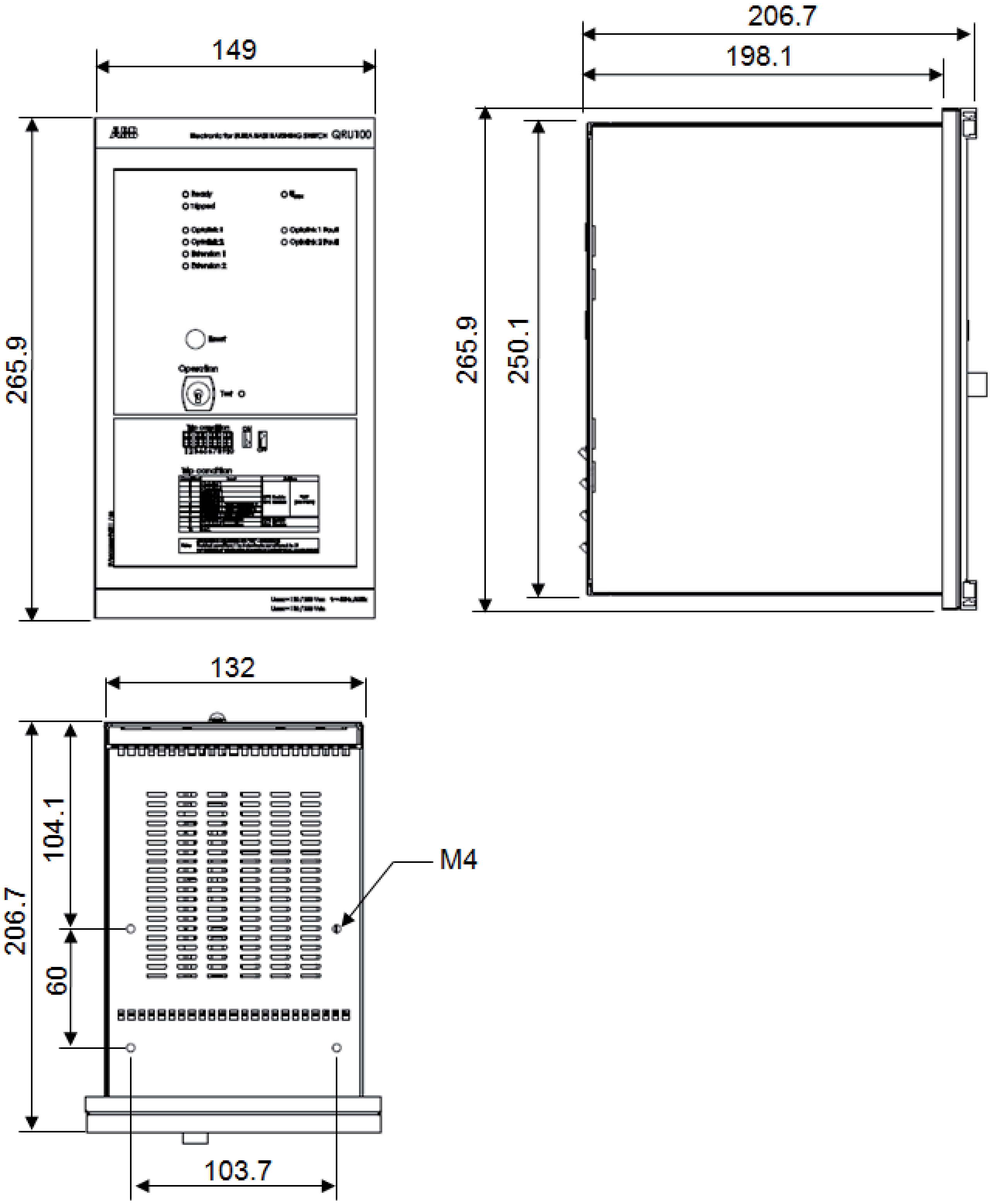
7.1 Electronic detection and tripping unit type QRU1



7.2 Primary switching element type U1

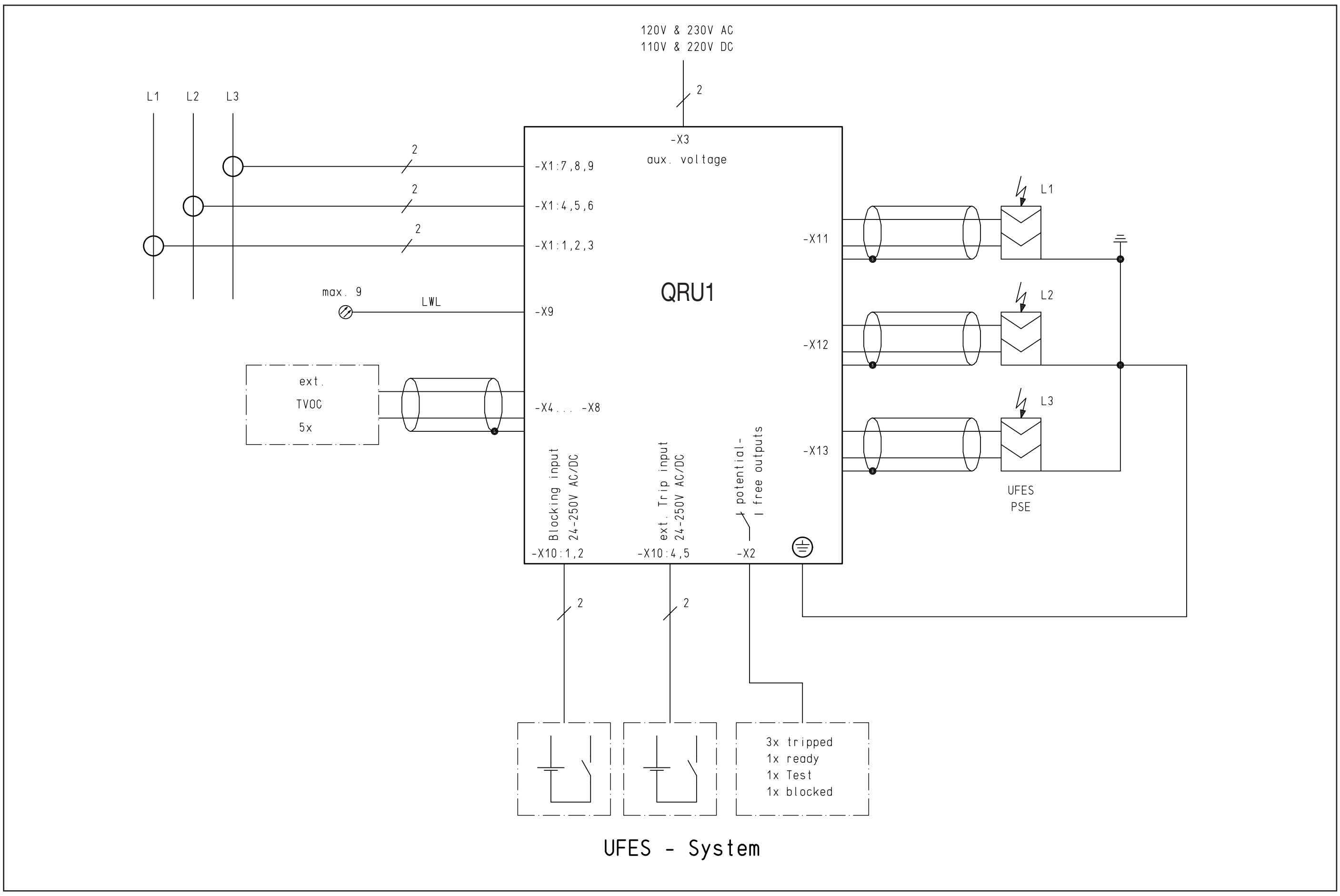


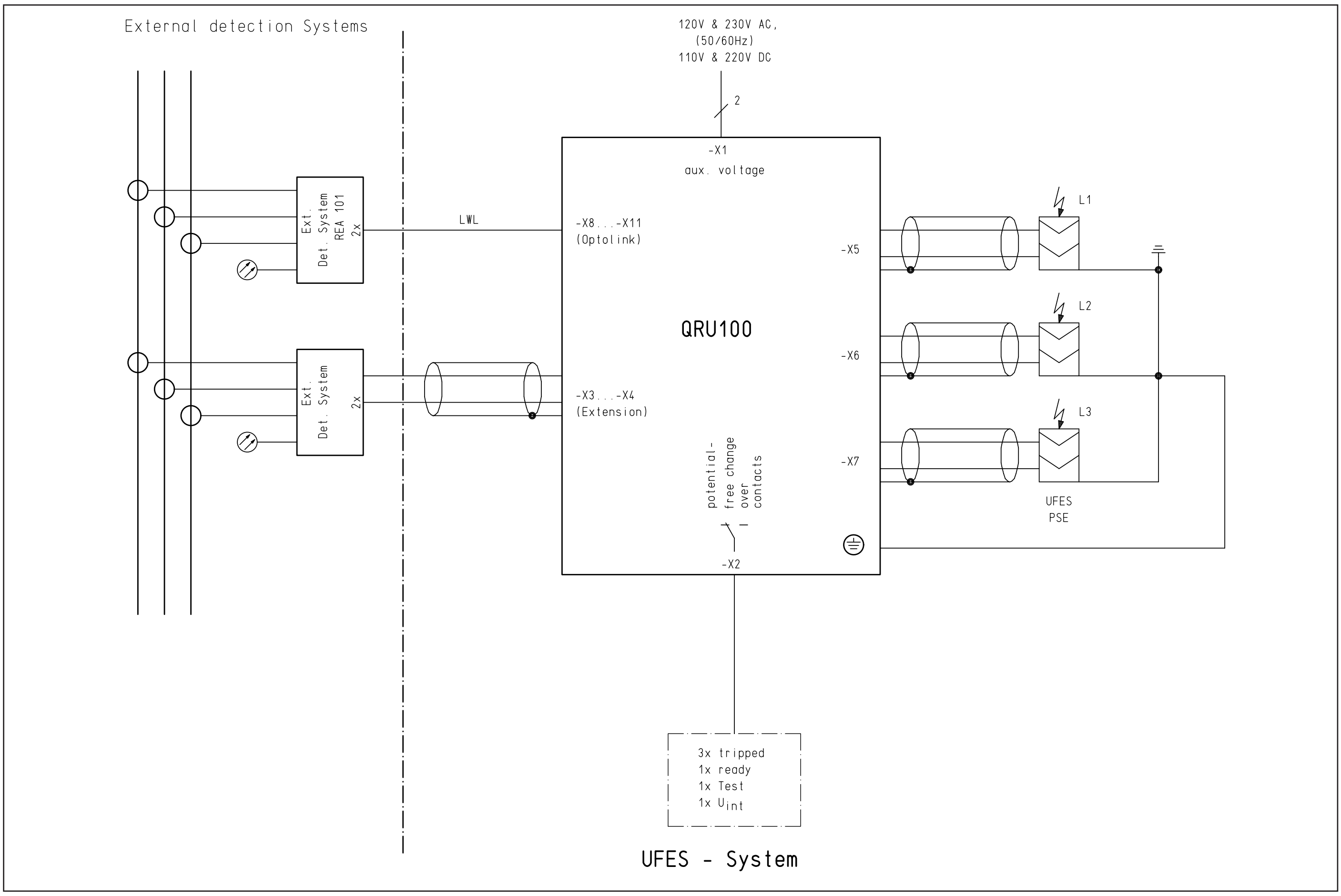
7.3 Electronic tripping unit type QRU100



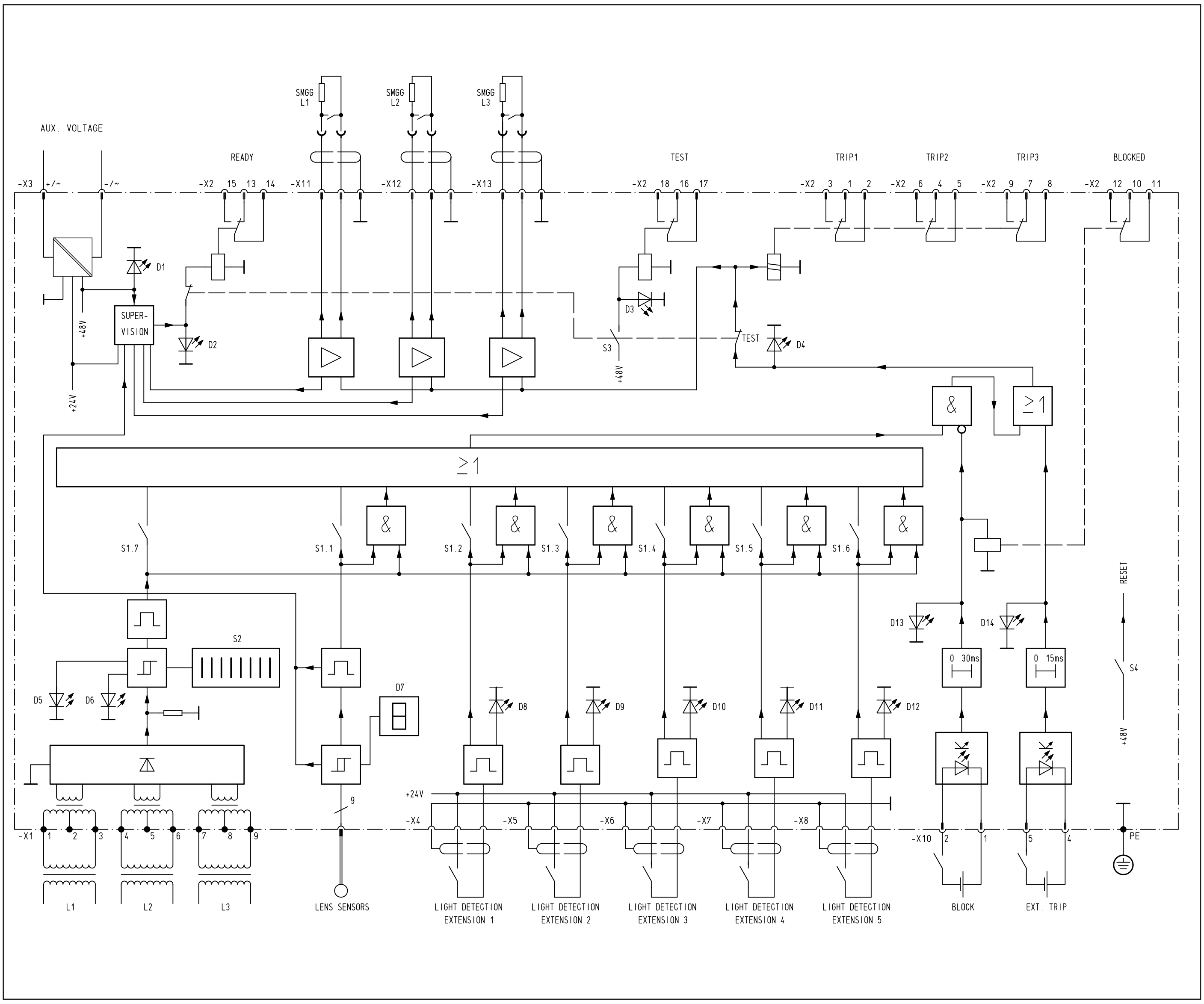
8 Circuit diagrams

8.1 Block diagram of Ultra-Fast Earthing Switch



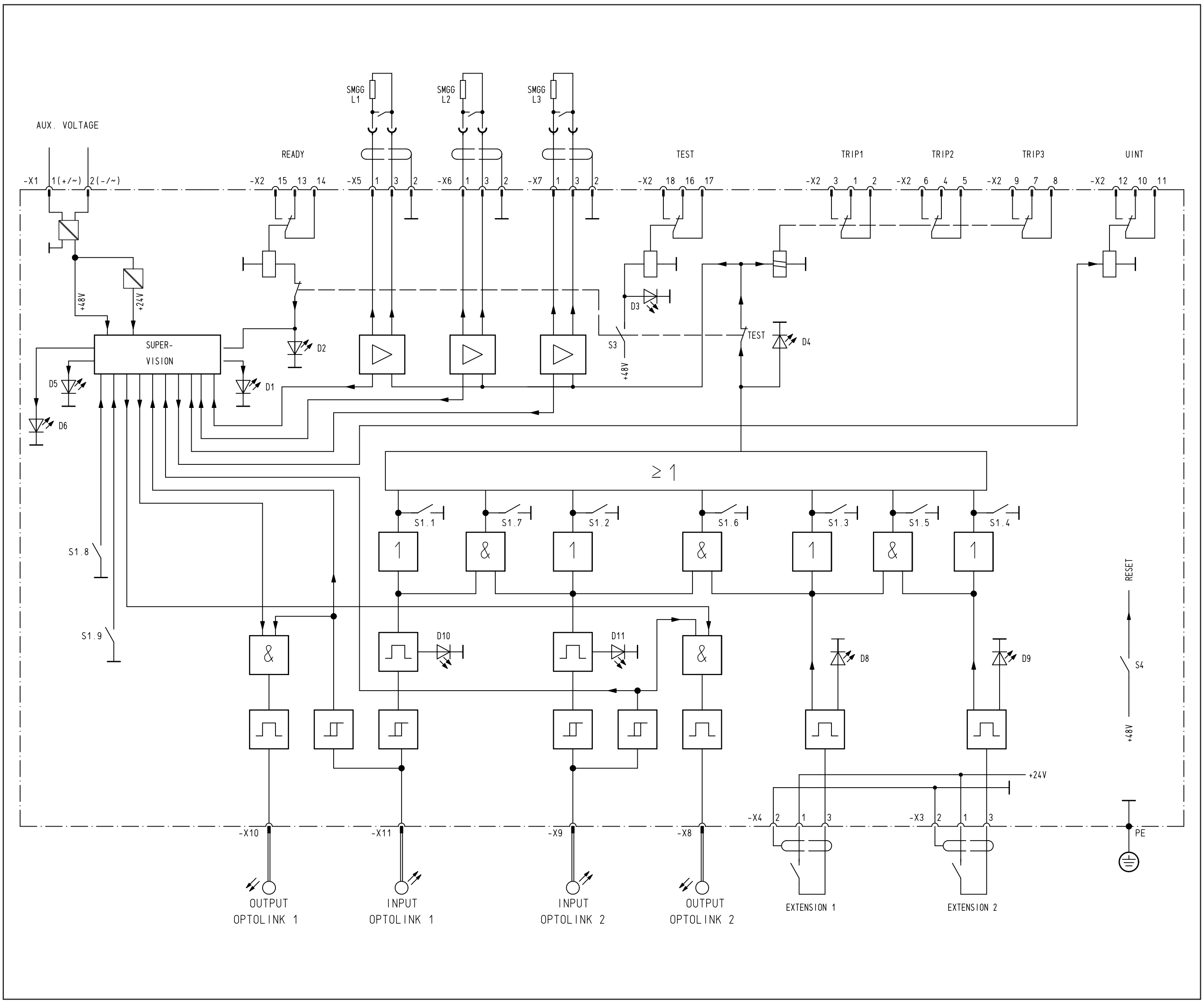


8.2 Terminal and single line diagram of the electronic detection and tripping unit, type QRU1



Legend to QRU1 operator controls and displays		
In circuit diagram	On front panel	Colour
D1	U_{aux}	green
D2	Ready	green
D3	Test	yellow
D4	Tripped	red
D5	70 % I_{trip}	yellow
D6	Current trip	red
D7	Internal	red
D8	Extension 1	red
D9	Extension 2	red
D10	Extension 3	red
D11	Extension 4	red
D12	Extension 5	red
D13	External trip	red
D14	Blocked	yellow
S1	Trip Condition	
S2	Trip Current	
S3	Test	
S4	Reset	

8.3 Terminal and single line diagram of the electronic tripping unit, type QRU100



Legend to QRU100-operator controls and displays		
In circuit diagram	On front panel	Colour
D1	U_{aux}	green / yellow
D2	Ready	green
D3	Test	yellow
D4	Tripped	red
D5	Optolink Fault 1	red
D6	Optolink Fault 2	red
D8	Extension 1	red
D9	Extension 2	red
D10	Optolink 1	red
D11	Optolink 2	red
S1	Trip Condition	
S3	Test	
S4	Reset	

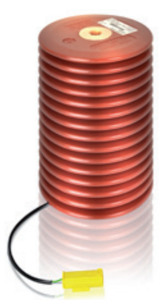
9 Ordering details

Item 1.1a - 1.8a. 1.11a. 1.12a

Item	Description	Type design.	Part number	
1a	**UFES Kit 100**			
	consisting of: - 1 pc. Electronic Tripping Unit (TU). type QRU100 - 3 pcs. Primary Switching Elements (PSE) - 3 pcs. Trip lines. UFES electronics → PSE. 10 m (without picture) - 1 pc. Door mounting kit (without picture)		1VB9001025…	
			POF [2]	GOF [1) 2)]
1.1a	UFES Kit 100 - 17.5 kV / 25 kA	Kit100-175-25	…R1133	…R1143
1.2a	UFES Kit 100 - 17.5 kV / 40 kA	Kit100-175-40	…R1233	…R1243
1.3a	UFES Kit 100 - 17.5 kV / 50 kA	Kit100-175-50	…R1333	…R1343
1.4a	UFES Kit 100 - 17.5 kV / 63 kA	Kit100-175-63	…R1433	…R1443
1.5a	UFES Kit 100 - 27 kV / 25 kA	Kit100-270-25	…R2133	…R2143
1.6a	UFES Kit 100 - 27 kV / 40 kA	Kit100-270-40	…R2233	…R2243
1.7a	UFES Kit 100 - 36 kV / 25 kA	Kit100-360-25	…R3133	…R3143
1.8a	UFES Kit 100 - 36 kV / 40 kA	Kit100-360-40	…R3233	…R3243
1.9a	UFES Kit 100 - 40.5 kV / 25 kA [1)]	Kit100-405-25	…R4133	…R4143
1.10a	UFES Kit 100 - 40.5 kV / 40 kA [1)]	Kit100-405-40	…R4233	…R4243
1.11a	UFES Kit 100 - 1.4 kV / 63 kA	Kit100-14-63	…R0433	…R0443
1.12a	UFES Kit 100 - 1.4 kV / 100 kA	Kit100-14-100	…R0533	…R0543

Item 1.1b - 1.8b. 1.11b. 1.12b

Item	Description	Type design.	Part number
1b	**UFES Kit 1**		
	consisting of: - 1 pc. Electronic Detection and Tripping Unit (DTU). type QRU1 - 3 pcs. Primary Switching Elements (PSE) - 3 pcs. Trip lines. UFES electronics → PSE. 10 m (without picture) - 1 pc. Door mounting kit (without picture)		
1.1b	UFES Kit 1 - 17.5 kV / 25 kA	Kit1-175-25	1VB9001014R1103
1.2b	UFES Kit 1 - 17.5 kV / 40 kA	Kit1-175-40	1VB9001014R1203
1.3b	UFES Kit 1 - 17.5 kV / 50 kA	Kit1-175-50	1VB9001014R1303
1.4b	UFES Kit 1 - 17.5 kV / 63 kA	Kit1-175-63	1VB9001014R1403
1.5b	UFES Kit 1 - 27 kV / 25 kA	Kit1-270-25	1VB9001014R2103
1.6b	UFES Kit 1 - 27 kV / 40 kA	Kit1-270-40	1VB9001014R2203
1.7b	UFES Kit 1 - 36 kV / 25 kA	Kit1-360-25	1VB9001014R3103
1.8b	UFES Kit 1 - 36 kV / 40 kA	Kit1-360-40	1VB9001014R3203
1.9b	UFES Kit 1 - 40.5 kV / 25 kA [1)]	Kit1-405-25	1VB9001014R4103
1.10b	UFES Kit 1 - 40.5 kV / 40 kA [1)]	Kit1-405-40	1VB9001014R4203
1.11b	UFES Kit 1 - 1.4 kV / 63 kA	Kit1-14-63	1VB9001014R0403
1.12b	UFES Kit 1 - 1.4 kV / 100 kA	Kit1-14-100	1VB9001014R0503



Item 2.1 - 2.8. 2.11. 2.12

Item	Description	Type design.	Part number
2	**Primary switching element**		
2.1	Primary switching element - 17.5 kV / 25 kA	U1-175-25	1VB9001016R1110
2.2	Primary switching element - 17.5 kV / 40 kA	U1-175-40	1VB9001016R1120
2.3	Primary switching element - 17.5 kV / 50 kA	U1-175-50	1VB9001016R1130
2.4	Primary switching element - 17.5 kV / 63 kA	U1-175-63	1VB9001016R1140
2.5	Primary switching element - 27 kV / 25 kA	U1-270-25	1VB9001016R1210
2.6	Primary switching element - 27 kV / 40 kA	U1-270-40	1VB9001016R1220
2.7	Primary switching element - 36 kV / 25 kA	U1-360-25	1VB9001016R1310
2.8	Primary switching element - 36 kV / 40 kA	U1-360-40	1VB9001016R1320
2.9	Primary switching element - 40.5 kV / 25 kA [1)]	U2-405-25	1VB9001016R2410
2.10	Primary switching element - 40.5 kV / 40 kA [1)]	U2-405-40	1VB9001016R2420
2.11	Primary switching element - 1.4 kV / 63 kA	U1-14-63	1VB9001016R1040
2.12	Primary switching element - 1.4 kV / 100 kA	U1-14-100	1VB9001016R1050

1) On request
2) Design of Optolink interface on TU:
- POF: Plastic optical fiber
- GOF: Glass optical fiber

Item	Description	Type design.	Part number
3	**Lens sensors for UFES electronic detection and tripping unit (DTU) type QRU1**		
3.1	Cable length 1 m	TVOC-1-DP1	1SFA663 003 R1010
3.2	Cable length 2 m	TVOC-1-DP2	1SFA663 003 R1020
3.3	Cable length 4 m	TVOC-1-DP4	1SFA663 003 R1040
3.4	Cable length 6 m	TVOC-1-DP6	1SFA663 003 R1060
3.5	Cable length 8 m	TVOC-1-DP8	1SFA663 003 R1080
3.6	Cable length 10 m	TVOC-1-DP10	1SFA663 003 R1100
3.7	Cable length 15 m	TVOC-1-DP15	1SFA663 003 R1150
3.8	Cable length 20 m	TVOC-1-DP20	1SFA663 003 R1200
3.9	Cable length 25 m	TVOC-1-DP25	1SFA663 003 R1250
3.10	Cable length 30 m	TVOC-1-DP30	1SFA663 003 R1300

Pos. 3.1 - 3.10

Item	Description	Type design.	Part number
4	**Accessories**		
4.1.1	UFES electronic tripping unit (TU), POF [2]	QRU100	1VB9001015R0530
4.1.2	UFES electronic tripping unit (TU), GOF [2]	QRU100	1VB9001015R0540
4.2	UFES Electronic detection- and tripping unit (DTU)	QRU1	1VB9001015R1000
4.3	Trip cable UFES electronics → PSE, 10 m		1VB9000978R0101
4.4	Connecting cable, UFES electronics → REA / TVOC, 10 m		1VB9000979R0101
4.5	Wall installation kit for UFES electronics		1MRS050240
4.6	Door installation kit for UFES electronics		1MRS050209
4.7	Test plug		1VB9001023R0101

Item	Description	Type design.	Part number
5	**TVOC-2 [4]**		
5.1	**Arc monitor (10 optical inputs)** including HMI and accessories for door installation	TVOC-2-240	1SFA664001R1001
5.2	**Extension (Plug-in unit)** 10 optical inputs	TVOC-2-E1	1SFA664002R1001
5.3	**Erweiterungen (Plug-in unit)** 10 optical inputs for 60 m detector cable [1]	TVOC-2-E3	1SFA664002R3001

Pos. 5.1

Item	Description	Type design.	Part number
5.4	**Lens sensors for TVOC-2 [4]**		
5.4.1	Cable length 1m	TVOC-2-DP1	1SFA664003R1010
5.4.2	Cable length 2m	TVOC-2-DP2	1SFA664006R1020
5.4.3	Cable length 4m	TVOC-2-DP4	1SFA664003R1040
5.4.4	Cable length 6 m	TVOC-2-DP6	1SFA664003R1060
5.4.5	Cable length 8 m	TVOC-2-DP8	1SFA664003R1080
5.4.6	Cable length 10 m	TVOC-2-DP10	1SFA664003R1100
5.4.7	Cable length 15 m	TVOC-2-DP15	1SFA664003R1150
5.4.8	Cable length 20 m	TVOC-2-DP20	1SFA664003R1200
5.4.9	Cable length 25 m	TVOC-2-DP25	1SFA664003R1250
5.4.10	Cable length 30 m	TVOC-2-DP30	1SFA664003R1300
5.4.11	Cable length 60 m [1]	TVOC-2-DP60	1SFA664003R3600

POS. 5.4.1 - 5.4.10

Item	Description	Type design.	Part number
6	**Optolink [3]**		
6.1	Connecting cable POF, AE → REA101, 2 m		SPA-ZF AA 2
6.2	Connecting cable POF, AE → REA101, 5 m		SPA-ZF AA 5
6.3	Connecting cable POF, AE → REA101, 10 m		SPA-ZF AA 10
6.4	Connecting cable POF, AE → REA101, 20 m		SPA-ZF AA 20
6.5	Connecting cable POF, AE → REA101, 40 m		1MRS 120517

1) On request
2) Design of Optolink interface on TU:
- POF: Plastic optical fiber
- GOF: Glass optical fiber
3) Extract of REA catalogue. Information to other system components can be found in the dedicated product catalogue.
4) Extract of TVOC-2 catalogue. Information to other system components can be found in the dedicated product catalogue.

A 1 Appendix
Determination of the tripping current

A 1.1 General

The three current inputs for phases L1, L2 and L3 in the electronic detection and tripping unit (DTU) of type QRU1 are generally supplied by three existing current transformers in the incoming feeder panel. How the tripping current to be set is determined is explained in the following section.

A 1.2 Introduction

For the determination of the tripping current, the smallest short-circuit current which flows through the Ultra-Fast Earthing Switch via the current transformer in the direction of the switchgear in the case of a fault in the area of the switchgear system to be protected is to be identified in the short-circuit current calculation.

This smallest short-circuit current is reduced by the arc voltage when faults occur in the switchgear system. For the purposes of setting the tripping current on the DTU, we therefore recommend reducing the smallest calculated short-circuit current by 30% (this applies to medium voltage switchgear systems).

The maximum current which the current transformer supplying the DTU can transmit until the DTU trips is then to be ascertained.

The smaller of these two currents is the maximum current which can be set on the DTU.

A 1.3 Determining the current transmitted by the current transformer

The current which the existing current transformer transmits without discernible saturation effects up to the tripping of the DTU is dependent on the:

- technical data of the current transformer, and
- loads (burdens) connected to the current transformer

A 1.3.1 Explanatory notes on the technical data of a current transformer

The DTU may only be activated by current transformers for protection purposes. These are identified by the letter P following the class designation.

Example:
2000/1 20VA 5**P**10

Key:

2000 A	Rated primary current
1 A	Rated secondary current
20VA	Rated burden
5**P**	Accuracy class (Table 14)
10	Accuracy limit factor

Accuracy class	5 P	10 P
Measurement deviation for rated primary current	± 1 %	± 3 %
Phase displacement angle for rated primary current		
- Minutes	± 60	–
- Centiradians	± 1.8	–
Total measurement deviation at rated accuracy limit current (rated current x accuracy limit factor)	5 %	10 %

Table 14: Accuracy limits for protection current transformers

The current transformer used as the example may have a maximum total error of 5 % at 10 times the rated primary current (10 x 2000 A = 20.000 A) and a connected rated burden of 20 VA. If, for example, the secondary burden of 20 VA is reduced, the accuracy limit factor increases, i.e. the current transformer transmits a greater overcurrent before saturation takes place.

The following sections show how these relationships can be determined.

A 1.3.2 Determination of the resistances (burdens)

In principle, three resistances (burdens) are to be determined for the secondary circuit of the current transformer:

1. Internal resistance (internal burden) of the current transformer (secondary side!) – R_{CT}

   The internal resistance can be taken from the measuring record of the current transformer or is to be determined using a measuring instrument (resistance measurement), and must be extrapolated to a temperature of +75°C.

   Caution:
   Resistance measurement with a meter may only be performed when the primary current of the current transformer is zero, i.e. this measurement must not be performed during operation!

2. Resistance of the connecting conductors – R_{wire}

   The lengths (l) and cross-sections (A) of the connecting conductors are to be determined and used to calculate the resistances, which are then to be extrapolated for +75°C.

   R = ρ *x l/A*

   R = Ohmic resistance

   ρ = Resistivity (normally stated for +20 °C)

   ρ = 0,0178 u Ohm (for copper at +20 °C)

   ρ = 0,0216 u Ohm (for copper at +75 °C)

   l = Length of the conductor

   A = Cross-sectional area of the conductor

Table 15 states the resistances per metre of copper conductors of various cross-sectional areas at +75°C.:

Material	2.5 mm²	4 mm²	6 mm²
Copper	0.00865 Ω/m	0.00541 Ω/m	0.00360 Ω/m

Table 15

3. Input resistance of the connected relay

   The input resistances (burdens) of the connected relays can be found in the relevant data sheets.

   Alternatively, the resistances of the connecting conductors (R_{wire}) and the input resistances of the relays (R_{relay}) can be determined by current and voltage measurement at the current transformer terminals (secondary side!): ((R_{relay} + R_{wire}) = U/I). We recommend the use of a clip-on ammeter for the current measurement, as the transformer terminals must on **no** account be opened during operation.

   The input resistances (burdens) of the DTU are as follows:

   - Rated secondary current 1A: < 0,5 VA (500 m Ω)
   - Rated secondary current 5A: < 0,5 VA (20 m Ω)

   The total resistance R_{tot} is calculated as follows:

   $R_{tot} = R_{ct} + R_{wire} + R_{relais}$

   where:

   R_{tot} = Total resistance

   R_{ct} = Internal resistance (internal burden) of the current transformer (secondary side!)

   R_{wire} = Resistance of the connecting conductors

   R_{relais} = Input resistances of the connected relays

A 1.3.3 Determination of the accuracy limit factor

The accuracy limit factor of a current transformer indicates the maximum multiple of the rated current at which the current is still transformed with a specified accuracy. Above this accuracy limit factor, the secondary current may be distorted as a result of transformer saturation.

The actual accuracy limit factor is calculated as follows:

$$F_A \approx F_r \times \frac{|S_{ct} + S_r|}{|S_{ct} + S_A|}$$

where:

F_A = Actual accuracy limit factor

F_r = Accuracy limit factor (rated)

S_{ct} = Internal burden of the secondary winding
$S_{ct} = I_r^2 \times R_{ct}$

S_r = Rated burden (see technical data of the current transformer)

S_A = Actual connected burden
$S_A = I_r^2 \times (R_{wire} + R_{relais})$

Calculation of the actual accuracy limit factor using the example provided:

Current transformer data:	2000 / 1 A	20 VA	5P10
Internal burden of the secondary winding:	S_{ct}	=	17.5 VA
Rated burden of the current transformer:	S_r	=	20 VA
Actual connected burden:	S_A	=	13.5 VA

$$F_A \approx F_r \times \frac{|S_{ct} + S_r|}{|S_{ct} + S_A|}$$

$$F_A \approx 10 \times \frac{|17.5\ \text{VA} + 20\ \text{VA}|}{|17.5\ \text{VA} + 13.5\ \text{VA}|}$$

$F_A \approx 12.1$

For safety reasons, we recommend that the accuracy limit factor of 12.1 calculated here be multiplied by 0.8. This results in a maximum tripping current to be set of:

10 x rated current of the supplying current transformer,

provided that the smallest calculated short-circuit current is not the determining variable.

Note:
These calculations have been simplified for ease of application.

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