The IED shall support the following communication and time synchronization options:

- IEC 61850-8-1 including GOOSE and client-server MMS communication, with the possibility of changing from Edition 1 to Edition 2, or vice versa.
  - MMS communication shall be supported for up to eight different clients
  - GOOSE, MMS, SV and FST shall be available on every Ethernet port on the IED, with the possibility of enabling or disabling each of them by a parameter setting

- IEC 61850-9-2 LE process bus, with the possibility of mixing conventional analog channels with IEC 61850-9-2 LE in the same device; if a 9-2LE stream is lost, the IED shall block the functions dependent on the lost stream, while all other functions dependent on streams that are still available shall remain in operation.

- IEC 62439-3 parallel redundancy protocol (PRP) with zero seconds recovery time in case of communication failure; PRP shall be supported for the engineering tool, MMS, GOOSE, DNP3.0, FTP, SNTP, and PTP services.

- IEC 62439-3 high-availability seamless redundancy (HSR) shall be supported for the engineering tool, MMS, GOOSE, DNP3.0, FTP, SNTP, and PTP services.

- IEC 60870-5-103 communication protocol
- DNP 3.0 communication protocol
- SPA communication protocol
- LON communication protocol

- The IED shall support IEC 62351-8, and provide a full NERC-CIP level 5 cybersecurity compliance, including:
  - user authority and password management
  - centralized user authority and password management support
  - cybersecurity-related logged events (user login; login unsuccessful; password changes, etc.)

- The IED shall include the IEEE 1588-2008/IEC 61850-9-3 precision time protocol (PTP), and the possibility of being synchronized by a master clock, or of acting as a master clock, and shall also be able to serve as an IEEE 1588-2008/IEC 61850-9-3 boundary or transparent clock.

- Time-synchronization through GPS, SNTP, DNP 3.0, IEC 60870-5-103, IRIG-B, or PPS
- The IED shall be capable of serving as a SNTP server.
- The IED shall have an Ethernet interface for communication with the engineering tool.

The IED shall support the following communication interfaces:

- An RJ-45 Ethernet interface on the front LHMI of the IED that can be used to connect the software engineering tool, and also support DHCP and the IEC 61850 standard.
• Up to four Ethernet interfaces according to IEEE 802.3u 100BASE-FX or IEEE 802.3u 100BASE-TX with 100 Mbit/s communication speed, freely configurable for single or redundant (HSR or PRP) communication for any protocol via Ethernet; it shall be possible to connect the software engineering tool to the IED via the mentioned Ethernet channels; the connector for each port shall be selectable between optical connector, or connector type RJ45.

• A serial communication interface used for SPA, IEC 60870-5-103 and DNP3.0; this module shall be optical, supporting glass fiber: 62.5/125 mm or 1 mm plastic fiber.

• An optical communication module used for LON; this module shall be optical, supporting glass fiber: 62.5/125 mm or 1 mm plastic fiber.

• A galvanic RS485 communication module with communication speed of 2400–19200 bauds shall support a RS-485 6-pole connector, or soft ground 2-pole connector.

The local HMI of the IED shall meet the following criteria:
• A graphical display capable of showing a user-defined, single-line diagram and provide an interface for controlling switchgear; the graphical display shall have up to 12 different pages, used for monitoring and controlling one or several bays, or for customized functionality like displaying measurements.

• A graphical display capable of showing virtual push-buttons and dynamic texts linked to the internal logic of the IED.

• A backlit HMI to ensure readability under dark conditions.

• Navigation buttons, virtual keyboard and configurable command buttons; the command buttons shall be freely configurable for shortcuts in the HMI tree, or for simple commands.

• User-defined dynamic three-color LEDs for indications and alarms; the IED shall be capable of configuring up to 135 different LED indications.

• Ethernet communication port for commissioning and test purposes.

• Access to the various menus through the LMHI shall be protectable by password.

• Control of the primary apparatus using a two-step select operate command.

The IED shall be able to display the following quantities on the LHMI and on the substation automation system:
• Measured voltages, currents, frequency, active, reactive and apparent power and power factor.

• Measured analog values from merging units.

• Primary phasors

• Positive, negative and zero sequence currents and voltages.

• Pulse counters

The IED shall have the following monitoring capabilities:
• Disturbance recorder with disturbance report:
  o non-volatile memory capable of storing up to 100 disturbance recordings
  o 40 analog channels (30 physical and 10 derived) with 1000 Hz sampling rate for 50 Hz systems and 1200 Hz sampling rate for 60 Hz systems
  o 352 binary channels
  o disturbance recorder shall have a post-fault retriggering option
  o recordings shall be stored in the device in COMTRADE format

• Event list for 1,000 process events and 2,048 security events.
- Event and trip value recorders.
- Self-supervision with an internal event list function; the IED shall be capable of flagging error signals from time synchronization and individual error signals from I/O modules.
- Adjustable breaker monitoring shall be capable of handling multiple breaker types; breaker monitoring function shall comprise the following:
  - travel time of the CB during opening operation
  - travel time of the CB during closing operation
  - the number of CB operations
  - CB remaining life of respective phase
  - the number of days CB has been inactive
  - the CB charging time of the
  - the accumulated energy (Iyt) based on current samples
- Temperature and pressure insulation supervision for gas medium for circuit breakers.
- Fault locator
- Event counters
- Running hour meter
- Elapsed time integrator with limit transgression and overflow supervision.
- Supervision of AC input quantities.
- Limit counter for four independent limits for binary signals with overflow indication.
- Ethernet access point diagnostics for all Ethernet ports on the IED, including diagnostics for redundant communication; Ethernet access point diagnostics shall be able to indicate denial of service.
- IEC 61850 quality monitor, detailing the quality of an IEC 61850-9-2LE analog channels.

The IED shall support the following logic functions:
- A substantial number of logic functions that are freely configurable and can be combined with the protection, control and monitoring functions inside the IED; the logic functions shall be available in different execution cycles to match those of protection, control and monitoring functions, and shall be:
  - starting and tripping logic, with settable pulse time and tripping program (single-phase, double-phase or three-phase), and with testing and simulation capabilities as per IEC 61850
  - basic configuration function blocks, such as AND, OR, XOR, INVERTER, TIMER, flip-flop function blocks, Boolean to integer conversion, and integer to Boolean conversion
  - comparator for integer inputs
  - comparator for real inputs

The IED shall be able to support the following hardware:
- Test switch in connection with the IED, including a solution for mounting the test switch in the same 19” rack as the IED to ensure a clear station layout.
- 1/2 x 19” 6U height case selected according to the required number of I/O modules, and with up to 12 analog input channels.
- The power supply modules shall support DC voltages ranging from 24 V DC to 60 V DC, or from 90 V DC to 250 V DC.
- All modules used in the IED shall be conformal coated.
- It shall be possible to choose between compression type and ring-lug type connector types.
- One of the following mounting alternatives shall be available: flush, rack, and wall mounting.
- The water and dust protection level shall be according to IEC 60529, with at least:
  - front IP40 (IP54 with sealing strip)
  - sides, top and bottom IP40
  - rear side IP20
- All above-stated specification shall be integrated in one single IED.
- The hardware shall comply with IEC 60255-1.
- The manufacturer shall ensure that, if the IED fails while under warranty, a replacement product shall be shipped from the factory within 48 hours of receiving an order, without the need to first return the failed IED.

**General requirements**

- Manufacturer shall offer 5 years of warranty.
- Manufacturer shall ensure that, in the case of failure of the IED while under warranty, a replacement product shall be shipped from the factory within 48 hours of receiving an order, and without the need to first return the failed IED.
- The IED shall be parametrized and configurable using a single software tool, which shall be used for IEC 61850 configuration, monitoring, disturbance recordings withdrawing, troubleshooting and migration of the project file and/or IED configuration to a newer version; the software tool shall be available free-of-charge.
- The product shall support seamless, periodic and easy product firmware updates.