Technical Specification for Three Phase Pole Mounted Microprocessor-Based Controlled Automatic Circuit Reclosers for Distribution Networks

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1. **Purpose and Scope**

1.1 This specification covers requirements for outdoor 15kV three-phase pole-mounted auto-reclosers with programmable protection features and integrated remote operation capability and which are for use on distribution networks at nominal A.C. voltages of 13.8kV.

1.2 In addition this specification defines the communication protocols required for seamless integration into a central SCADA system.

2. **References**

Unless otherwise specified herein, all equipment shall be designed and manufactured in accordance with the relevant current overseas standards including all amendments at the time of calling quotations, in particular:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/IEEE C37.60-2003</td>
<td>Standard requirements for overhead, pad mounted, dry vault, and submersible automatic circuit reclosers and fault interrupters for AC systems up to 38kV</td>
</tr>
<tr>
<td>IEC 62271-111 2005</td>
<td>High voltage switchgear &amp; controlgear – Part 3: Overhead, pad mounted, dry vault, and submersible automatic circuit reclosers and fault interrupters for AC systems up to 38kV</td>
</tr>
<tr>
<td>IEC 62271-100:2001</td>
<td>High-voltage switchgear and controlgear - Part 100: High-voltage alternating-current circuit-breakers</td>
</tr>
<tr>
<td>DNP 3.0</td>
<td>Distribution Network Protocol</td>
</tr>
</tbody>
</table>

3. **Definitions and Abbreviations**

**Automatic Detection Group Selection (ADGS)**

An automated feature to determine and activate a pre-programmed group of protection settings based on the direction of power flow.

**Auto-recloser (AR)**

A mechanical switching device that, after opening, closes automatically after a predetermined time. Several reclosures could occur before lockout.

**Cold load pick-up (CLP) feature**

A feature that allows modification of the over-current protection characteristics in order to prevent nuisance tripping under conditions of system energisation.

**Dead time**

Also referred to as "Reclosing Interval". This is the time between the instant that the current is interrupted by the AR and the instant the contact of the AR closes as a result of an automatic reclose operation. [IEC 50-448-04-09]

**Definite time lag (DTL) protection element**

A protection element with a settable time delay that is constant above the pick-up current setting.

**Delayed protection operation**

The protection functionality enabling delayed circuit-breaker operation, whether this is due to an IDMTL or DTL protection element.
Distributed Network Protocol (DNP 3.0)
A set of communication protocols designed for data acquisition between substation computers, master stations, remote terminal units (RTUs) and intelligent electronic devices (IEDs) in the electric utility industry.

Effectively earthed system
An earthed system in which the healthy phase power frequency phase-to-earth over voltages associated with earth faults are limited to 80% of the highest phase-to-phase voltage of the system.

Fast curve protection element
A family of curves with operating times approximately constant (slightly inverse) relative to the multiple of pick-up setting.

Instantaneous protection element
An element with no intentional time delay active above a pre-determined pick-up current setting.

Inverse definite minimum time (IDMT) protection element
A protection element of which the minimum operating time is adjustable and is inversely proportional to the fault current.

Lockout
Where the recloser remains open and will not reclose automatically.

Pole-mounted remote terminal unit (PMRTU)
A remote terminal unit that is designed for pole mounting and that operates specific pole-mounted equipment remotely.

Rapid protection operation
The protection functionality enabling rapid circuit-breaker operation, whether this is due to an instantaneous, fast curve, or a definite time delay protection element with relatively short definite time delay.

Reset time
The time duration after a circuit-breaker close operation for which the measured currents are below a fault detecting level. On the expiry of this time the protection sequence resets.

Secure control
A single mechanically non-latching switch that effects one state of a control function only. An example of which is either a non-latching switch or two separate push buttons that effect one state of a control function only in each position. If a control is activated repeatedly it only effects that state and does not change the state of the control.

Sensitive earth fault (SEF) relay
A relay that is sensitive to very low earth fault currents and in which the operating settings are for current magnitude and definite time delay.

Supervisory
Remote control and indications of an AR or a PMRTU by means of a telecommunications link.

Toggled control
A single mechanically non-latching switch/push-button that enables a single control function on the first operation of the switch/push-button and disables the function on the second operation of the same switch/push button.

Sequence co-ordination
The feature that allows protection devices to maintain sequence co-ordination for combinations of rapid and delayed protection operations.

4. Requirements
4.1 General
4.1.1 The auto-recloser shall be suitable for use on non-effectively earthed and effectively earthed networks and under the system conditions and service conditions as follows:

Table 1: General Requirements of the ARs
Nominal system voltage (r.m.s.) | 13.8 kV  
---|---  
Lightning Impulse Withstand Voltage (BIL) | 110 kV  
System frequency | 60 Hz  
Number of phases | 3  
Rated Continuous Current | 630 A  
Short Circuit Symmetrical Current | 12.5 kV  
Minimum Trip Current (Phase Faults) | 40A  
Minimum Trip Current (Ground Faults) | 40 A  
Minimum Trip Current (Sensitive Ground Fault) | 4 A  
Closing Time | < 60 mSeconds  
Opening Time | < 35mSeconds  
Interrupting Time | < 50 mSeconds  
Arcing time | < 15 mSeconds  
Mechanical Life (operating cycles) | > 20,000  
Current Sensors | 3  
Voltage Sensors | 6  
Operational mode | Bi-directional  
Interrupting medium | Vacuum  
Altitude | Up to 1000m  
Ambient temperature | 24°C (minimum)  
| 32°C (maximum)  
Maximum daily variation | 9°C  
Average Monthly Precipitation | 90 mm to 350 mm  
Lightning Activity | 33% probability of Thunderstorms  
Pollution | Areas of coastal salt spray and/or industrial pollution with equivalent salt deposit densities in the range of 2.0 to 3.0 g/m2  
Wind velocity | 0 - 7 m/s  
Average Relative Humidity | ~ 80%  

4.2 Mounting
4.2.1 The automatic recloser shall be suitable for single pole mounting on timber poles.
4.2.2 All recloser tanks are to be supplied with standard pole mounting brackets fixed to the rear of the tank.
4.2.2.1 Brackets shall be designed to enclosure that the recloser maintains standard clearances from the pole and the earthed metal equipment.
4.2.2.2 It shall be possible to easily pass a technician’s tool belt between the pole and the tank.
4.2.2.3 Bracket(s) shall be suitable to independently carry the total weight of the tank.
4.2.2.4 Adequately rated lifting eyes shall be provided and they shall be designed to allow the completely assembled automatic recloser to be easily lifted using available lifting equipment.
4.2.3 Control cabinets shall be mounted independently of the tank.
4.2.4 A detailed drawing of the complete automatic recloser mounting arrangement should be provided, illustrating the minimum clearances (phase-to-earth and clearance to structure).

4.3 Control Cabinet
4.3.1 Cabinets housing control and protection equipment shall be independently mounted of the automatic recloser.
4.3.2 Cabinet shall be designed for the specified service conditions, adequately ventilated and fitted with substantial door securing devices capable of ensuring entry by only authorised personnel.
4.3.3 It shall be possible to disconnect the cable at the automatic recloser while the automatic recloser is connected to the power system, without causing damage or malfunction: care shall be taken that CTs are not open circuited.
4.3.4 Cabinets shall be adequately sealed and dust protected and shall be internally treated to prevent moisture condensation. The degree of protection shall be suitable for this purpose.

4.3.5 The control equipment shall not suffer any damage if one or more poles of the circuit breaker fail to respond to either a trip or a close command.

4.3.6 Electronic modules shall perform continuous diagnostic monitoring and shall contain hardware and software watchdog checking.

4.4 Grounding

4.4.1 The contractor shall ensure the electrical continuity of all exposed metals.

4.4.2 The control cable shall be adequately earthed to shield the control equipment against electrical interference.

4.5 Control and Indication

4.5.1 General

4.5.1.1 The control system of the auto-recloser shall allow for four levels of control and indication.

- Operator hook stick control and indication
- Local control and indication
- Remote control and indication
- Engineering access and control

4.5.2 Operator Insulated Stick Control and Indication

4.5.2.1 This control level is to be used as a last resort manual control, in the event of failure of all the other control and indication levels.

4.5.2.2 Refer to clauses 4.8.2 and 4.8.3.

4.5.3 Local Control and Indication

4.5.3.1 The auto-recloser shall provide local control and indications to the operator. In this mode the local operator shall be able to trip and close the auto-recloser.

4.5.3.2 The operator shall be able to switch the auto-recloser between local and remote control modes.

4.5.3.3 The recloser shall provide the following features while in local control mode:

- Trip (with no reclosing for diagnostic activities)
- Close (single shot)
- Auto-reclose (On/Off)
- Definite time protection (On/Off)
- Sensitive earth fault protection (On/Off)
- Viewing trip sequences and status information

4.5.3.4 The recloser shall allow the following information to be viewed while in local control mode:

- Switch status (open or closed)
- Remote control disable status
- Automatic sequence enable status
- Equipment integrity alarms

4.5.3.5 Information shall be able to be viewed in full sunlight on the local controller.

4.5.4 Remote Control and Indication

4.5.4.1 The recloser shall be able to offer in the future, remote control and indication through integration with the installed GPL SCADA system. Refer to 4.9.

4.5.4.2 The recloser shall be able to operate using the DNP 3.0 communication protocol over radio systems, wireless cellular and fibre optic communication media.

4.5.4.3 The recloser shall allow the secure control of the following features to be available while in remote control mode:

- Tripping and closing
- Enable and disable automatic sequences (reclosing)
- Enable and disable Definite time protection
- Change Protection Setting groups
- Reset fault flags and currents

4.5.4.4 The recloser shall allow the following information to be viewed while in remote control mode:
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Circuit Reclosers for Distribution Networks

- Switch status (open or closed)
- Remote control disable status
- Automatic sequence enable status
- Definite time protection disable status
- Equipment integrity alarms
- Over current trip
- Over/under voltage and frequency trip
- Definite time trip
- Lockout
- Auxiliary supply health
- Active protection setting groups

4.5.4 The recloser shall allow the following measurement information to be viewed while in remote
control mode:

- Phase current
- Phase voltage
- Operations counter
- Battery voltage
- Fault current
- MW and MVar

4.5.5 Engineering Access and Control
4.5.5.1 The auto-recloser shall be capable of being controlled and operated locally using a compatible
PC, serial cable or phone modem and the suppliers software.
4.5.5.2 The controller shall contain a clock (with leap year support) that can be both locally and remotely
set.
4.5.5.3 A facility for selecting all the protection, operating and communication characteristics shall be
locally available in the controller.
4.5.5.4 Password protection against unauthorised changes shall be available.
4.5.5.5 Non-volatile memory storage shall be sized to store date and time-stamped real time and
persistent data, for at least a period of 30 days with a 15 second sampling interval.
4.5.5.6 The auto-recloser controller shall be equipped with a pointer to indicate up to where the last data
was read in order to provide for regular uploading of data without re-loading previously read data.
4.5.5.7 The controller shall allow the following features to be controlled/monitored using this mode:

- Tripping and closing
- Enable and disable automatic sequences (reclusing)
- Read and display metering data
- Read the event recorder in time sequence complete with feeder currents.
- Examination of auto-recloser/controller malfunction alarms
- Read all existing auto-recloser settings
- Read and write auto-recloser settings
- Download auto-recloser settings

4.6 Protection Function
4.6.1 General
4.6.1.1 The reclosers shall be supplied complete with an integrated microprocessor based control and
protection system incorporating all the features stated in the following sub section of this clause.
4.6.1.2 The sensitive earth fault protection function shall be equipped with harmonic filtering to prevent
operation when harmonics are present in the primary residual earth currents (3rd harmonic
rejection).
4.6.1.3 All protection functions, i.e., over-current (O/C), earth fault (E/F) and sensitive earth fault (SEF)
shall have elements with characteristics that comply with IEC 60255.
4.6.1.4 The recloser shall be capable of standalone operation.
4.6.1.5 All user settings and parameters will be retained in non-volatile memory.
4.6.2 **Over Current Fault Protection Function**
4.6.2.1 The over current trip settings shall be completely programmable.
4.6.2.2 The over current protection shall provide phase, ground and negative sequence over current protection.

4.6.3 **Over/ Under Frequency Protection Function**
4.6.3.1 The over frequency protection function shall detect frequencies above the normal system frequency. An over frequency trip setting up to 5Hz, in steps of 0.1Hz, above the system frequency shall be detectable.
4.6.3.2 Under frequency protection settings shall be separate to the over frequency setting. The setting range down to 5Hz, in steps of 0.1Hz, below the system frequency shall be provided.
4.6.3.3 The number of continuous cycles at and below the Under Frequency threshold or at and above the Over Frequency threshold, before a trip will occur must be selectable from 2 to 1000 cycles.
4.6.3.4 It shall be possible to separately enable / disable the Over and Under Frequency protection functions.
4.6.3.5 An auto-close function shall be provided to enable the automatic recloser to close once the frequency returns to normal.

4.6.4 **Over /Under Voltage Protection Function**
4.6.4.1 The over voltage protection function shall detect voltages above the normal system voltage. An over voltage trip setting of 100% up to 150%, in steps of 1%, above the nominal system voltage shall be detectable.
4.6.4.2 Under voltage protection settings shall be separate to the over voltage setting.
4.6.4.3 The setting range of 50% to 100%, in steps of 1%, below the nominal system voltage shall be provided.
4.6.4.5 It shall be possible to separately enable / disable the Over and Under Voltage protection functions.
4.6.4.6 An Auto close function shall be provided to enable the auto-recloser to close once the voltage returns to normal.

4.6.5 **Directional Blocking Function**
4.6.5.1 The auto recloser shall provide Directional Blocking to ensure the protection functionality of as specified below:
- Auto recloser and the Control Element shall be capable to detect the direction of the fault current.
- Configuration for Directional Blocking shall include the separate settings for Characteristic Angle for over current and earth fault elements.
- The Directional Blocking shall have the facilities to configure the auto recloser to trip or block for upstream and downstream faults. This setting shall be configured separately for over current, earth faults and sensitive earth faults.
- Information about Directional Blocking operation in case of the protection trip shall be recorded accordingly in the device log.

4.6.6 **Earth Fault Protection Function**
4.6.6.1 The rapid protection operation of the recloser shall be possible by selecting a fast curve or instantaneous protection element.
4.6.6.2 Co-ordination of the fast curves or instantaneous protection elements between two devices in series shall be possible either by selecting suitable curves from a family or by addition of a selectable time increment, or any other acceptable solution.

4.6.7 **Sensitive Earth Fault (SEF) Protection Function**
4.6.7.1 A primary earth fault current of 4A to 30A in steps not exceeding 1A shall be detectable.
4.6.7.2 Delayed protection operation shall be possible by selecting a definite time protection element with time delay from 3s to 25s, in 1s steps.

4.6.8 **Cold Load Pickup (CLP)**
4.6.8.1 A cold load pickup feature shall be provided that allows selectable modification of protection characteristics under system power restoration conditions.
4.6.8.2 Loss of supply shall be automatically detected and the recloser shall apply the CLP feature to the first shot curves, regardless of whether the recloser is open or closed.

4.7 **Auxiliary Supply**
4.7.1 An auxiliary supply shall be supplied with the following minimum requirements.
4.7.2 A ‘battery low’ indication shall be locally and remotely available and shall allow for a further ten auto-recloser operations.
4.7.3 The battery shall be capable of initiating correct operation of the auto-recloser for not less than 36 hours after the loss of ac supply.

4.8 **Operating Mechanism**
4.8.1 The auto-reclosers shall be supplied to be able to use a low voltage system supplied from either a battery or a voltage transformer to operate the closing mechanism.
4.8.2 The auto-recloser shall incorporate provision for an operator to manually open the recloser using a standard operating stick in the event of a failure of the electrical control system.
4.8.3 A clear and unambiguous indication of the status of the auto-recloser main contacts shall be provided to an operator standing on the ground. The indication shall remain visible for the product’s working life.

4.9 **Communication**
4.9.1 As a minimum, one independent RS-232 communication port that allows for simultaneous operation shall be provided. This is to be used as follows:
4.9.1.1 To upload the non-volatile data to and from a personal computer.
4.9.1.2 To interface to remote communications equipment (e.g. modems, radio-modems).
4.9.2 The RS-232 port shall be able to operate at a minimum of 9600 bps.
4.9.3 The protocol to be supported by the automatic recloser controller for remote communications shall be DNP 3.0.
4.9.4 The recloser shall be able to interface with the Local and Central SCADA systems (CSC-2000 Substation Automation System and CSGC-3000 CSA/EMS respectively) over a WAN.
4.9.4.1 Single mode fibre optic communication of wavelengths 1310 nm and 1550 nm.
4.9.4.2 The recloser shall be able to provide communication redundancy by means of a wireless communication link such as radio and/or wireless cellular.
4.9.4.3 All communication modes shall account for the use of adapters to provide seamless integration and translation of DNP3.0 xml messages to formats compatible with IEC 61850 and IEC 61970.
4.9.4.4 Communication system of the recloser shall be able to interface with the SCADA Control Unit, to offer real-time control of the reclosers. Technical specifications for the SCADA Control Unit are outlined as follows:
Table 2: Technical Specifications of the SCADA Control Unit

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/D conversion resolution</td>
<td>≥ 14 bit</td>
</tr>
<tr>
<td>Time setting accuracy of entire system</td>
<td>≤ 1 ms</td>
</tr>
<tr>
<td>SOE recording resolution</td>
<td>≤ 2 ms</td>
</tr>
<tr>
<td>Duplicate system availability</td>
<td>≥ 99.9%</td>
</tr>
<tr>
<td>Refreshing period of real time graphic data (analog signal)</td>
<td>≤ 2s</td>
</tr>
<tr>
<td>Refreshing period of real time graphic data (switching signal)</td>
<td>≤ 1s</td>
</tr>
<tr>
<td>Response time for telemetry information (from I/O input terminal to tele-control workstation outlet)</td>
<td>≤ 3s</td>
</tr>
<tr>
<td>Response time for telecommunication change (from I/O input terminal to tele-control workstation outlet)</td>
<td>≤ 2s</td>
</tr>
<tr>
<td>Protocol used to connect to GPL network</td>
<td>TCP/IP</td>
</tr>
</tbody>
</table>

4.9.5 The communication scheme shall provide a collision avoidance and retry scheme to provide maximum probability of successful transmission on a busy network.

4.10 Software
4.10.1 The reclosers shall be accompanied by control and monitoring software that will enable both remote and local access.

5. Commissioning
5.1 Subsequent to delivery, the equipment shall be tested to prove that it conforms to the specified requirements.
5.2 Calibration certificates shall be included in the purchase.

6. Installation
6.1 The contractor shall install the auto-recloser, surge arrestors, control cabinet and communication apparatus.
6.2 The auto-recloser shall be programmed with the settings specified at a later date, using engineering access and control (see 4.5).
6.3 The auto-recloser shall be grounded according to requirements and network standards.
6.4 The installation of the auto-recloser shall serve as a demonstration to chosen personnel.

7. Training
7.1 Training material shall be provided in the form of drawings, instructions and/or audio visuals for the reclosers.
7.2 Training shall cover the following identified topics. This list is however not exhaustive.
   - Basic recloser features
   - Recloser Operations
   - Application of protection and control settings
   - Fault finding
   - Installation
   - Maintenance
   - Handling
   - Storage
8. **Drawings and Manuals**

8.1 Detailed drawings shall be provided in both electronic and printed formats, without submitting diagrams that are considered the sole responsibility of the manufacturer.

8.2 Drawings submitted shall include:

- Layout drawings
- Schematic and wiring diagrams
- Detailed dimension drawings
- Mounting details for pole-mounted units

8.3 Detailed operation and maintenance manuals shall be provided that incorporates a detailed comprehensive trouble-shooting guide and schematic diagrams and component layouts of all printed circuit boards.
Bibliography
