SC D2 Information systems and telecommunication
PS 1 The impact of emerging information and communication technologies on electric power utilities

Experience of development and implementation of automated system for monitoring and analysis of functioning of relay protection devices (IED's) and assessment of correct protection operation

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Every year the number of new modern and reconstructed power facilities (power plant and substation) increases. At the same time, scope of numerical relay protection devices (IED's) of different types and manufacturers in the total scope of all type protection devices operated increases. As a result, the difficulty of maintenance of IED's, as well as difficulty of troubleshooting IED's malfunction and analysis of incorrect protection operation increase.

Today in most situations, the IED's malfunctions are detected after occurrence of fault event (incorrect trip) or after preventive maintenance.

The article describes the experience of developing and implementation of automated system for monitoring and analysis of functioning of numerical relay protection devices and assessment of correct protection operation for power facilities of 6-750 kV.

Benefits of implementation of automated system for monitoring numerical relay protection devices include:

- reduce cases of incorrect protection operation and increase of the reliability of functioning relay protection devices by establishing a regular monitoring IED's condition, supervising change settings and timely detecting device malfunctions;
- device maintenance by their actual condition and reducing operating costs for excess work performed by the preventive maintenance.

The main solution in system development is the usage of two-level architecture: lower level - power facilities (power plant and substation) and upper level - control centre. At the system` lower level collection, processing, storage data for monitoring IED's and local analysis protection operation are performed. Upper level of system include data collection from lower levels, processing and storage results of monitoring IED's, global analysis of fault events and assessment of protection operation. As a system` data collection source at power facilities SCADA with retransmission data according to IEC 60870-5-104 protocol and/or IED's with direct data collection according to IEC 61850 are used. Data exchange between lower and upper levels of system is implemented on the basis of application layer Protocol HTTPS, which is used on top of SOAP.

Information model and algorithmic services of the System were developed according to IEC 61970/61968 specifications and recommendations, however the information metamodel was extended with new semantics for monitoring and assessment of operation numerical relay protection devices.

Description of functions for monitoring and corresponding algorithm for detecting malfunction is given in Table 1.

Table 1

IED monitoring functions	Detected malfunctions and problems
Software self-diagnostic signals monitoring	The internal software platform failure of numerical device. Failure of the internal real-time operating system of microprocessor-based device
Hardware self-diagnostic signals monitoring	Malfunction of the electronic modules of the numerical device
Reboots monitoring	Automatically reboots of the IED Unexpected IED reboots
Current measurements monitoring	Failure is detected when CT supervision internal function operates. Failure is detected using phase-by-phase comparison of the analog measurements between different windings of the same CT or multiple CTs of the same bay.
Voltage measurements monitoring	Failure is detected when VT supervision internal function operates. Failure is detected using phase-by-phase comparison of the analog measurements between different windings of the same VT or multiple VTs on the same voltage level.
Power supply monitoring	IED power supply failure. Input circuits (external trip & other) power supply failure. Output circuits (CB trip & other) power supply failure.
SCADA communication monitoring	Errors or failure in digital data exchange with SCADA; Errors or failure of GOOSE messaging; Failure of a communication link to SCADA.
Monitoring of the pilot-wiring channel and communication equipment for protection	Failure of a pilot-wiring channel for protection. Malfunction of communication equipment for protection.
Monitoring the changing device configuration and settings	Invalid values for the IED settings. Changing IED active settings group. Changing the firmware of IED. Malfunction of the configuration is detected by comparing it to an approved reference configuration.
Monitoring the changing positions of control switch	Changing positions of the IEDs' control switch. Position abnormalities of the IED's control switch is detected by comparing it to an approved reference position.

The process of monitoring and analysis for each malfunction registered includes:

- Description of malfunction.
- IED monitoring function for localization malfunction type.
- Critical or non-critical malfunction.
- Date and time.
- Typical reason of malfunction on the recommendations of the manufacture.
- Typical action for troubleshooting of malfunction on the recommendations of the manufacturer.
- Scheduled date of troubleshooting.
- Actual data of troubleshooting.