

SC D2 Information systems and telecommunication  
PS 3 Maintaining reliable and secure operation  
in an evolving environment

**Development of information-analytical system for automatic fault analysis and relay protection performance evaluation**

**D. A. Zhukov**  
**PJSC "RusHydro", Russia**  
**O. A. Fedorov**  
**JSC "RTSoft" Russia**  
[Dmitr.Zhukov@gmail.com](mailto:Dmitr.Zhukov@gmail.com)

The importance of analyzing information about the stationary and transient processes during pre-fault and fault conditions in high voltage electrical networks can hardly be overestimated. Analysis can be performed after recording of emergency event data at a power plants and substations, thereafter depending on the analysis conditions and time constraints, the analysis purposes may differ. Operational personnel use the results of the analysis during post-fault actions and restoring their consequences, the result of the analysis is to estimate the state of the disconnected and outaged equipment and the possibilities of bringing it back in service in order: to prevent further development of outage, to avoid damage to personnel and equipment health, to quick restoration of power system configuration creating more reliable post-fault grid conditions. Protection department professionals are using results of analysis to evaluate the performance of relay devices, the analysis in this case results in detecting conditions for correct operation / failures of relay devices (or relay functions), reporting of relay performance indexes investigating the causes of misoperation. Analysis process involves the need to collect a variety of technological data: dynamic data, generated during transient processes, and static data, representing the equipment characteristics and settings of protection and control devices. Despite of widespread deployment of digital relay protection, digital fault recorders (DFR), phasor measurement units (PMU), which have data integration with SCADA systems of power plants and substations, the process of performing an analysis of emergency events still contains a significant proportion of manual operations, and examples of the automatic analysis are still unique to utilities throughout the world.

The complexity of automatic analysis implementation in practice is linked to the need of normalization and structuring of information data streams generated by DFR and relays of various manufacturers during emergency events, as well as providing all required information for the process analysis in a machine-understandable format. The solution of this problem was made possible by the development of common standards for information exchange, enabling integration of devices and applications, regardless of the specific software platform implementation. The most important standards for information exchange services and for enabling automatic analysis algorithms are groups of IEC 61850, IEC 61970/61968 (CIM), and IEC 60255-24 (COMTRADE) and IEEE C37.232 (COMNAME) standards. Group of IEC 61850 standards allow the collection of dynamic data required for analysis: emergency event waveforms, recorded by protection devices, independent DFR, automatic voltage and excitation controls; PMUs; SCADA measurements; event logs from relay devices. Group of IEC 61970/61968 standards allow presentation of statistical data required for the analysis, in a machine-understandable format: electrical topology information, characteristics of the equipment, protection devices connection schemes with protected equipment and current/voltage transformers, their settings and function logic. Group of IEC 61970/61968 standards, together with IEC 60255-24 and IEEE C37.232 allow definition of semantics for all signals and measurements, represented in the dynamic data.

The report describes the experience of the design and development of information-analytical system for automatic fault analysis and relay protection performance evaluation (the System),

assembled in software and hardware for hydro power plants in PJSC "RusHydro" company. The System automatically triggers and collects required information for the emergency event, starts data processing to identify operation conditions of relay protection devices (of each relay protection function), as well as makes a preliminary conclusion about the correct / failure operation of relay protection devices. Information model and algorithmic services of the System were developed according to IEC 61850, IEC 61970/61968 specifications and recommendations, however the information metamodel was extended with new semantics. Performance evaluation and detection of possible relay failures is based on automatic comparison of information received from relay, DFR, PMU, RTU field-devices with the expected etalon operation of relay protection obtained through digital modelling. This process requires a detailed simulation of the identified fault events and modelling of relay operation. The result of these simulations will be used as reference when compared with the actual information from relay devices to detect inconsistencies and alarming on possible hidden failures in relay settings or operation. During development process of the System there were successfully solved a number of information and technological challenges that are relevant not only for the systems of automatic fault analysis, but also for power facility automation systems in general: collection of process data from devices from different manufacturers; creation of unified semantic metamodel for both static and dynamic data; integration of different applications built on various software platforms. The obtained results can be interesting both for professionals involved in the development of information exchange standards or development of other automation systems, as well as representatives of the electricity companies, aimed at maximizing the effect of the use of information technology in asset management and condition-based maintenance of power facilities.