KOMORSAN – Remote Digital Monitoring System for Overhead and Underground Cable Networks

An aggregate data processing from the intelligent monitoring system sensors, which is based on heuristic algorithms, brings an opportunity to manage problems before accident occurs. The integrated systems of overhead lines and underground power cables outage monitoring and management provide a simple solution in terms of the power system reliability enhancement and removing the problem of false operating and functional losses of separate diagnostic devices. Implementing modern hardware-software systems that are using complex data processing algorithms, deriving data from various diagnostic devices, is a vital component of an effective decision-making.

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Today the electric power industry is passing through fundamental transformation from centralized to decentralized model. There is an "energy transition" based on the concept of an active consumer – a new energy subject, which, in addition to the traditional function of energy consumption from external sources, also performs the function of energy accumulation and generation. Power supply becomes an ecosystem of power generators and consumers, which are freely integrating in general infrastructure and energy exchange.

New technologies of flexible network construction and its intelligent management form new principles for monitoring systems organization in order to provide the required reliability and quality characteristics and to implement economically optimal use of own capacities in combination with the consumption of electricity from the existing power system. Creation of an effective monitoring system for power transmission lines and power facilities based only on hardware devices without using software-analytical complexes, which employ deterministic and probabilistic approaches, is impossible.

MAIN FUNCTIONS OF A MONITORING SYSTEM IN THE MODEL "INTERNET OF ENERGY"

While building a network of "Internet of Energy" model one of the most important moments becomes a control of new subjects inclusion in energy system and obtaining the information about needs and power capacity supply. It is necessary to control the process real-time of electrical capacity income to the system, where three main points can be highlighted:

1) network sections reliability evaluation;
2) lines transmission capacity dynamic determination;
3) accurate measurement of amplitudes and voltage phases in the line for the energizing lines phase synchronization.

Renewable energy sources, which have stochastic nature of generation, while connecting to the system, can disrupt the optimality of active and reactive power flows. This causes overloading of particular network sections and power losses increase. Small generation sources are low inertia sources, that why they have small margin of transient stability during abrupt mode change, for example, in case of short circuit on a line. In case of connection a large volume of generation to a network using renewable energy sources, voltage fluctuation and higher-order harmonics generation in the system are amplified. The cases of load shedding necessity at the moment of emerging disturbances appearance using particular switched on generating equipment, as well as capacity balancing while energy system operation, become frequent because of the difficulties in RES power output prediction.

In order to solve above mentioned problems of distributed generation and to identify potentially dangerous energy system section it is necessary to evaluate in real-time conditions the system reliability and timely implement front-rank technologies. Network The KOMORSAN monitoring system provides predictive capabilities and the functionality of the optimal energy transmission path determination. Implementation of modern hardware-software systems that are using complex data processing algorithms, deriving data from various diagnostic devices, allows you to meet all power system monitoring tasks. At the same time, such a complex should be able to process data using probabilistic methods for false data detection, provide predictive diagnostics and apply mechanisms of machine intelligence.

DIAGNOSTIC DEVICES AS A PART OF A MONITORING SYSTEM

Undoubtedly, high-precision monitoring devices are one of the main parts of a modern hardware-software monitoring complex that efficiently operates in the power grid "cellular" structure. Synchronized vector phase measurements of currents and voltages in the network are required for power exchange analysis. Data synchronization in a single time scale allow you to operate with phasors in

KOMORSAN – digital monitoring system

order to analyze line state and technological electricity losses, as well as to apply traveling wave method for accurate localization of fault location. The dynamic capacity factor control performed by intelligent sensors allows to signal the malfunction in reactive power compensation devices operation and is used for intelligent compensation devices adjustment, which is extremely important for line operating modes optimizing and its transmission capacitance increasing. Continuous monitoring of load currents symmetry also allows to identify undesirable modes of line operation and the trends of their development. Fault indicators produced by ANTRAKS provide all above-mentioned functionality.

Conductor slack sensors, sensors of frequency and amplitude of wire swinging, vibration parameters sensors allow to provide predictive diagnostics of overhead lines mechanical damage for further repair. Wire icing sensors make it possible to timely remove the ice from a wire. Continuous monitoring performed by conductor temperature sensors together with current measurement provide evaluation of line load and its possible increasing in particular line section, that is necessary for network configuration optimization, retrofitting planning, making a right choice of configuration in an emergency case.

For real-time data synchronization from various devices, reliable communication channels in the monitoring complex are required. At the moment, several channels are traditional for power equipment:

1) cellular networks GSM/3G/4G with low measure of reliability in case of overload or in difficult weather conditions;
2) WiFi/WiMax coverage, as a rule, significantly territorially limited;
3) communication using PLS and LoRa, which has a speed limit.

A number of power equipment transfers data according self-organizing network (Mesh) technology, with data transfer from one device to another. The permanent availability of three or more Mesh network nodes for each diagnostic device installed on the power line provides channel reservation. This allows to effectively solve the task of load balancing. Data transmission via Mesh-RF, Mesh-PLC communication channels which provide ease reconfiguration, high speed and reliability is the best solution in terms of data transfer in monitoring system of the distribution network with "cellular" structure.

PROGRAM-ANALYTICAL FUNCTIONS OF KOMORSAN MONITORING SYSTEM

Successful operation of the monitoring system in a grid with a "cellular" structure implies a simple integration of data from various devices. For such data integration ANTRAKS company apply different types of communication modules. The network state analysis is based on the algorithm of real measurements results and archive events processing. The monitoring system should be able to provide real time processing a network structure, which is a weighted graph, and take into account possible negative values (in case of low level of reliability) for the edges of this graph.

In order to provide stable and trouble-free monitoring system operation, the algorithms of data processing must solve the problem of false tripping or individual diagnostic devices failure. Construction of graphical probabilistic model based on Bayesian network makes it possible to minimize false decision-making while fault location detection.

The use of modern technologies of machine learning and neural networks allows to make it by processing the received information. And also is is possible to rank the network sections for reliability and maximum efficiency for a consumer comparing it with the existing experience of the network operating.

The monitoring system KOMORSAN, using standard communication protocols, is able to interact with an expert system that calculates the loads balance and configures the network, depending on the active user needs. Due to special algorithms of current surges and transient processes analyzing, the monitoring system can form prognostic precautions, detecting the power equipment damage beginning and emergency situation probability increasing.

The monitoring system KOMORSAN is user-friendly and includes a geographical information system that provides a graphical visualization of power facilities on a map and the devices data output, along with their exact coordinates. Geographical data storage is implemented in the form of separate thematic layers with possibility of combining them: geographical map, network mimic diagram and power map. The storage of qualitative and quantitative characteristics of facilities is realized as a database with on-line data transmission. Addition of new devices to the system, as well as full information from diagnostic devices is available in a user-friendly form, according the "plug and config" ideology.

The monitoring system KOMORSAN is easily configured with possibility to assign users permissions and rights. The monitoring system usage protects the power system and provides its maximum efficiency for the active user.

CONCLUSION

Such systems provide an opportunity of technological and economical energy supply reliability and quality enhancement, create new possibilities for consumers of choice of necessary power supply conditions and are effective for network integration and micro-grid management. P