CENTRALIZED SYSTEM FOR POWER SYSTEM DYNAMIC MONITORING

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SUMMARY

Power System Emergency Assessment demands combination of information from different data acquisition facilities. This sort of information can be used in dispatchers control centers only in combination with special software. The most difficult for decoding are emergency data, incoming to the general dispatcher's center in case of Cascading Outages (Cascading Events). In this case the complexity of decoding is increased by the large volumes of information.

Taking into account some specific demands, presented in the registrating and transferring systems, the complete determination of stated problems is possible only if the separate centralized system of direct measurements and monitoring power system's dynamic behavior is created. JSC «NIIPT» developed and have in exploitation such monitoring system, that delivers emergency information to the dispatcher's centers of JSC « North-West MES » and JSC «FSK EES».

This program may work with devises, that accomplish direct measurement of phase angles and phasors in real-time mode of operation. That give ways to introduce WAMS technologies for improvements of Power System operational control.

POWER SYSTEM DYNAMIC MONITORING

Intensive evolution of power engineering put new tasks for large power systems' control. While designing modern power system control it should be taken into account not only the factor, connected with large size of information, that must be accepted, worked up and transmitted during control process. But it should be considered also the problem, connected with distinguishing market features, such as minimization of all resources, toughening and realization of new modes of operation and so on. Quite a considerable requirement to the control system in dynamic modes is the requirement of fast speed of operation, that is especially important for the real time protection and control systems. The most complete accordance to these requirements have the control systems with WAMS technologies in basis.

WAMS technologies are based on fast measurements of current and voltage phasors, and values of frequency and power as well. Measurements of these operational factors at the substations are carried out by special facilities PMU – Phasor Measuring Unit. Information from PMUs data acquisition are transmitted to the concentrator at the substation, then - to the central measuring device, that must work up all the information from the region. An important thing is – all the current information of the region must be attached to scale of united time (UTC) with the accuracy not less than 0,5 msec. For these aims systems of common use Glonass (Russia) and GPS (USA) are used. The transmission of the information

to the central facility must be realized by modern fast-acting channels (basically, fiber-optical). Fast acting of the channels becomes breaking value while using the information from PMU for real time protection control. Special digital network of data's transmission with the aim of using the WAMS system' information in the centralized system of protection control is the most preferable.

One of the most important functions of WAMS system is - registration of the emergency state operation events sequence. This function differs fundamentally from the functions of usual digital recorders. Lets mark this differences briefly.

1) presence of synchronization of all emergency information by united time scale;
2) preliminary treatment of the information at the concentrators of lower level (directly at the substations);
3) presence of the unified base of emergency data for all the power system;
4) specifical system of coding and grading of emergency information, valid all over the power system;
5) registration not only analogous, but discrete signals also (switching devicies operation, protection and automation devices operation and so on);
6) special attention should be paid at the system of display and representation of information. Considering large size of information, short time of the dispatcher for effective analysis, the need of emergency information images optimal formation, may create independent troubles in the whole problem;
7) considerable simplification of this task may be made, if emergency state operation are off-line controlled. In that case the demands to the fast action of transmission and measurement channels can be reduced. Such systems are intended for off-line cascading events analisis. Quite the same task had been put in **JSC «NIIPT»** while developing the centralized system of emergency information monitoring;
8) there are two fundamentally distinguished emergency information users in power system maintenance - protection and automation services (they are interested in fast-acting electromagnetic transitional processes); and dispatchers and regime services (they are interested, first of all, in slow electromechanical processes). Starting information in both systems is almost the same. Moreover, additional system of discrete information about the sequence of the events must be the same also. That's why the optimal decision is to create one integrated system of concurrently registration of electromagnetic and electromechanical emergency processes. The separation of information flows can be realized on the level of MES and CO with rational distribution of priorities in transmission of the information between upper levels. This way had been chosen by JSC "NIIPT" for creating centralized system of emergency process registration.

For decoding of emergency process at large distributed net objects it is necessary to combine data from different recorders. Data combination is basically complicated enough, even when all the recorders have time synchronization of data from the same source of time. The task becomes much more complicated if we use data from different devices as information sources. Typical example is using emergency data from autonomous digital recorders and from separate microprocessor-based protection relay, recorders of damaged place on the lines, recorders of energy quality, multyfunctional electric energy and power meters and so on. Joining of all these emergency information in a united body demands creating special software. Without that software the largest part of information about the most complicated cascading events remains not decoded, or demands considerable emount of time, which rule out the possibility to use this information by dispatcher's personnel.

Emergency data, coming in mutual dispatcher's centre of electric net in case of complicated system damage, including several substations and electric power stations, is especially

complex. The complexity of decoding such emergency data is connected not only with problems of time synchronization, but with the necessity of processing large volumes of information.

Taking into consideration some specific requirements to the systems of registration and transmission of emergency information (large volumes, short periods for processing and so on) the complete solution of mentioned tasks is possible only if the centralized system of monitoring of emergency and transitional processes in power supply system are created. JSC "NIIPT" has been working in this direction for several years. At present time in exploitation is the system of monitoring, providing registration of emergency information at Vyborg's HVDC back-to-back tie from 20 digital recorders and more than 70 microprocessor-based protective devices. All emergency information is worked up and transmitted to dispatchers centres JSC «North-West MEC » and JSC «FSC EES».

The hardware and the software of the engineered complex have two-level structure. The lower level is presented by the server for centralized treatment of information, taken from the distributed sources. It's saved in the archives and distributed between the tasks, started up at the workstations. The server can be located directly at the substation, in the system autonomous mode of operation, or at the remote centre of dispatcher's control, in regime of registration of emergency in the whole power system.

The oscillograph processing is possible in double-server regime, when information is transmitted and displayed directly in the workstation of the substation and at the same time in central dispatch center of power supply system. The substation server takes and works up information only about emergency processes on this substation, and central server takes and works up information from all recorders in the system. The upper level can be settled directly at the substation, or can be brought out to the remote dispatcher's center and work in emergency regime. The upper level is represented by local net equipment and workstation with the resources, which are enough for complete representation of information about the regime and for substation control. Working stations of the complex, besides usual, has several additional functions:

- Review frame, that allows to realize express analysis of all emergency process and move fast along time axis;
- Change the scale of graphical representation of signals at time axis and amplitude, "Magnifier" and "Zoom" instruments also;
- Possibility of work with groups of signals;
- Express review of damaged area (which connections, equipment, signals are involved in accident);
- An display of numerical meaning to the information graphical representation and its transmission to the every place of display area;
- Wide assortment of instruments for preparing the document's printing;
- Definition of minimax amplitudes and effective values;
- Special users tools for program configuration.

Concentration of information on the upper level allows using the programs of logical examination for all decentralized information. For logical examination of information from different spots of power supply system, a special program "Logical signals processing" is used.

This program provides permanent control of main scheme status, all the changes, connected with switching equipment. The program generates text messages about the changes in main scheme to the dispatcher and provides the transmission of discovered results of changes to "List of events" and so on. This program provides the ability to create algorithms of definition of logical signals values, calculation of these values in real-time mode of operation. Saying "logical signals" we mean the signals, which values are defined as the result of mathematic

actions with analogous and discrete signals at a certain algorithm. The application of this program allows concentrating operative and emergency information for the personnel, solving the tasks of various blocking, controlling personnel's actions, checking up the authenticity of signals, controlling the accuracy of emergency devices', automation, switching devices' resources.

This system provides the possibility of measuring not only modules, but angles also. With the discretization pitch 500 mcs the error of defining the point of transfer through zero doesn't exceed 1 mcs. The accuracy of defining the interval of time between two points of transfer through zero (phase angle between two variables) for the first harmonic is not worse than 0,5 degree. However, this procedure is badly formalized and must be done by hand. It reduces the value of this monitoring way. Moreover, such systems of measuring by definition can't work in real-time mode of operation, that expels the possibility of using it for the aims of control.

Fundamentally new possibilities discover the devices, that provide accuracy of direct angles' measuring in real-time mode of operation 1degree. That gives us an opportunity to improve the accuracy of state estimation program's work, to verify more exactly operational factors of the equipment, to define instability of voltage and angles, discover the overheating of the wires and solve other problems. Practical steps in this direction are being done nowadays. At the JSC «NIIPT» are successfully made the proving of new device for phasors measurement, developed by the native companies. These testings confirmed the real possibility to improve the accuracy of the Power System regime measurements with WAMS technologies. The application of these devices with the software complex of JSC "NIIPT" enhances the possibility to improve the quality of the Power System operational control.