Prospective scope of WAMS use in synchronous zone of Unified Power System of Russia and power systems of contiguous countries

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SUMMARY

Taking in to consideration ability to synchronize current values of mode parameters and to receive synchronized voltage phasor angles, there are following sphere of the WAMS introduction in power systems:

- for normal conditions monitoring and emergency process analysis in power system;
- for models verification;
- for improvement of estimation programs, "advisor" of dispatcher and Centralized Emergence Control Systems;
- for direct control of power plant units.

KEYWORDS

Unified Power System, Measurement, Synchronize, Control, Emergency, Phasor.

Substantial higher level of observability and controllability is expected to be reached with introduction of Wide Area Measurements system (WAMS) technology both for Unified Power System (UPS) of Russia and synchronous zone of contiguous countries of former USSR (UPS/IPS) on the whole. Evidently, when we are speaking about new technology, its efficiency may be either underestimated or overestimated.

At the same time this technology has already been introduced in some Power systems and the first steps have been done in UPS/IPS. It affords in some credibility value to forecast the perspective of wide WAMS technology application.

Usage perspectives of this technology are considered further, bearing in mind, first of all, its two more substantial new abilities.

- Ability to synchronize the current values of operating conditions and their configuring into convenient format for later use in a power system control center.
- Ability to receive time synchronized absolute voltage phasor angle and, respectively, relative values of these angles.

It should be noted that partly these problems had been resolved even before modern WAMS technology was created. So in some cases in order to synchronize operating conditions time signals of radiobroadcasts were used; the fact of current and voltage sinusoid distortion, for example, like during short circuit, was used to fix the moment of emergency process onset. In 50^{th} and 60^{th} phantom circuits and other indirect methods were offered to determine relative angles.

WAMS technology affords to gain these results with high accuracy and on a regular basis, that in its turn allows considering the use of WAMS ability for regular solving of certain problems in sphere of power system observability and controllability.

In the long run WAMS technology is intended for controlling power system, providing quality improvement of adopted design and operating decisions. In this regard WAMS system depending on its specifications may be used on different temporal control levels from the decisions taken on the basis of event analysis long before the moment of taking the decision (hours, days and longer) and up to those ones taken in the course of changing the normal power system operating condition and even in the course of transient (emergency) process.

It is obvious that, operational capabilities of WAMS use on different temporal levels depend first of all upon information delays in the telecommunication system. Generally, measuring and synchronization of measured parameters means provide information with speed necessary for control at any temporal level.

The second important feature is information volume, supplied by WAMS for decision-making, which is determined by a number of WAMS devices in the control area. It is obvious, when using WAMS that measured data volume should not decrease in comparison with the volume in the existing measuring and information gathering system. It goes without saying that on the first stage of development WAMS should add the existing system.

Finally, WAMS technology provides new information, absolute and relative voltage phasor angle in check points. These parameters are in some cases more informative in comparison with normally measured, though hardly they may restitute at least part of the latter.

Depending on listed WAMS characteristics it is possible to count on various degree of its usage and efficiency in the process of power system control.

The extent of scientific study and operational evaluation of WAMS efficiency in fields under consideration is different and therefore proposed valuations are out of equal ranking and are not to be considered as final ones.

WAMS use for emergency process analysis in power system

At present emergency conditions analysis is fulfilled on the base of previous operating conditions and transient process oscilloscope patterns, received by means of recording devices at substations and power stations. These records are gathered and ”manually” synchronized on time. On some reasons these records are not always complete or can not be deciphered completely. As a result to figure out the cause of emergency and its development is seemed to be rather complex problem.

When developed WAMS technology is available it is possible to hope for automated operating conditions synchronization and operational gathering of initial information in control stations. Besides, owing to WAMS additional operating conditions can be recorded in particular relative angles between voltage phasors, which in their turn can be helpful when analyzing the emergency situation, determining the nature of synchronic oscillations in the post emergency condition, power system damping properties and others.

Generally all this together assist to more qualitative analysis of emergency processes and respectively decision making on preventing similar cases in future.

Continuous monitoring of basic parameters in normal conditions, for the purpose of finding out the periodic and non-periodic oscillations in the power system and the level of stability (margin of stability) in weak sections. In conditions of Unified Power System of Russia and synchronous UPS/IPS zone these questions have a great meaning due to availability of numerous relatively weak sections of electric grid. Carrying capacity in such sections can make up only a few percent of a smaller from unified systems and at the same time absolute meaning of carrying capacity can make up a few GW. Underrate of such connections, i.e. operation with unreasonably large margins incurs considerable economic losses and at the same time stability

disturbance and asynchronous condition in sections of such connections represents serious danger to power system.

It is possible to hope that continuous monitoring of conditions using WAMS will afford to evaluate margin of stability with more precise, taking into account real mode. Essential meaning has control of relative angles which provides the most information capacity for the stability level evaluation.

Analytical models verification is an important link in order to provide research and design works in the sphere of power system development and assuring their stability and reliability as well as in forming operating conditions for the nearest and further perspective. Particularly such problem is assigned when developing digital models of UPS/IPS synchronous zone and then models of superunification UCTE–UPS/IPS.

Precision time synchronization of measurements and use of relative angles values as additional parameters when taking check measurements using WAMS improves accuracy of condition reproduction which is used as a base for the results comparison and verification of models for calculation of power system normal conditions. Synchronized records of operational conditions, including relative angles during transient processes afford to evaluate accuracy of imaging in the power system damping features model and some other parameters which are difficult to formalize, that is necessary in verification of analytical models for transient processes calculation.

Earlier considered WAMS technology possibilities are offered to use mainly when forming perspective conditions and during carrying out research and design works as well.

Further, possible scope of WAMS technology use is considered when power system is controlled in automatic and operating on-line condition.

Efficiency improvement of state estimation programs.

State estimation program of current condition and controlled object diagrams is widely used in automatic and on-line control UPS of Russia. Efficiency improvement of state estimation on the base of current values measurement, when using WAMS technology, may be obtained as by precision synchronization in time of all aggregated measurements as by direct measurement of relative angles. The latter increases a number of interconnected operating parameters, that evidently improves accuracy of condition reproduction including cases when certain measurements fell out.

“Advisor” of dispatcher and Centralized Automatic Emergence Control System (CAECS)

Both these systems have common part where calculation is executed on a real time basis, conditions of stability and a scope of control actions in each calculated emergency disturbance with providing the current condition and diagram of control district (regional, integrated power system or UPS on whole).

Calculation is made cyclically. Then obtained results are saved in memory for the following automatic use if emergence disturbance occurred and/or in order to send them to dispatcher as a "piece of advice” if condition is necessary to be changed or different constraints appeared and etc. A cycle of calculations in the existing CAECS takes a few tens of seconds. Quality of decisions taken through the calculation depends upon volume of information used as well as upon method of its representation to the state estimation program, which is used in the input. Evidently, that quality of taken decision may be improved due to all measurement synchronization, used for control actions calculation and usage of relative angles values as additional data that can be provided by WAMS technology.

Upon that the result is obtained only under the condition of providing all WAMS procedures within previous calculation cycle i.e. when state estimation program provides data to

the beginning of the next calculation cycle. Increasing of cycle duration is not desirable since it results in data contamination due to neglected changing of the current condition.

Emergency Plant Power Control

Finally one more trend in WAMS technology usage for improving stability level and reliability of power system is organization of power control at big power plants according to so called absolute angle.

The idea of such a control was expressed in the USSR in 60-th by professor Yurevich. For the last time a new wave of interest was shown to this idea owing to new opportunities in angles measurements in power system by means of WAMS. During last few years this idea is developed by specialists of JSC "NIIPT" under the direction of doctor Andreyuk and doctor Asanbayev.

They offered method of turbine control based upon absolute angles measured according to WAMS technology. The main idea of this controlling method is to compensate in some extent emergency deviations of absolute angle of each generator from target valuation. So that absolute angle values are supposed to be determined without considerable delay unlike the relative values.

The law of power control for the generator ($P_г$) represented commonly as follows:

$$\Delta P_{\Gamma} = K_{\delta o}\int \Delta\delta dt + K_o\Delta\delta + K'S + K^{"}pS$$

Where $\Delta\delta$ is a deviation of absolute voltage phasor angle on power station bus bars from target setting.

S, pS – the first and the second derived functions of this angle

$K_{\delta o}$, K_{δ}, $K^{'}$, $K^{"}$ – control factors.

The result of carried out analysis showed that stability level in power systems with weak connections can be substantially improved. At the same time it is possible to provide an optimal generator effect method:

- Minimum essential total volume of actions is provided.
- Actions are in the most extent implemented in vicinity of emergency disturbance area.

Thus far, all research is of theoretical nature. Practical application of this idea is expedient only with WAMS being developed. Besides, wide variety of power equipment with particular objective parameters and control systems at power stations represent a problem to be overcome for practical implementation.

Along with this, in case of successful implementation the control system could be rather helpful in respect of improving stability and reliability of the UPS of Russia.

Thus, in case of WAMS devices implementation, additional means of power system observability and controllability can be obtained. Scope of use and WAMS technology efficiency in great extent depends upon amount of these devices integrated into the power system and dynamic properties of the system in whole.