



Development of Wide Area Measurement System (WAMS) in the Ural IPS for Mode Stress Estimation. Approaches and Decisions

Andrei V. ZHUKOV¹, Alexander M. GELFAND², S.V. BROVKO²,
Valeria V. KURMAK², Vladimir G. NAROVLIANSKY²
SO UPS¹, ENERGOSETPROJECT Institute²
Russia
narovliansky_v@oaoesp.ru

KEYWORDS

WAMS, PMU, monitored cutset.

1 INTRODUCTION

One of the priority power mode control problems is a better use of power grid transmission capability, characterized by the maximum allowed power flow (MAPF).

Deployment of wide area measurement system allows using a phasor data in real time for these purposes.

The synchrophasor measurement technology is developing due to the appearance of PMU¹ – phasor measurement units of voltage and current at the nodes and branches of power grid. Phasor's data are attached to the exact time stamp by using GPS²/GLONASS³ technology.

Dispatching control room receives from the phasor following data: time stamp, voltage magnitudes at the buses, difference between phase angle and base voltage sine wave, active and reactive power, frequency. Base voltage sine wave is formed on data, received from GPS or GLONASS.

WAMS gives a possibility to receive detailed information about the parameters of steady and transient modes of UPS/IPS. Studying this information gives new knowledge about the dynamic system properties, allows improving computational models. As well it allows solving other problems of quality improvement and control reliability.

On this technical base Margin Stability Monitoring System was developed, realized and put into operation in the northern areas of the Tyumen region in the period 2008 – 2009.

The aim of the WAMS development in Ural IPS was to form the main technical solutions to enhance the transmission capability of backbone network in this region through the development and implementation of facilities to determine the current values of stability margin in Russian UPS.

A new method to identify "weak" lines in the electricity system for appropriate PMU setting is proposed. Report provides information about using this method in the criteria for the nodes choice for PMU setting. Variant of PMU setting in Ural IPS is proposed.

¹ PMU – Phasor Measurement Unit

² GPS - Global Positioning System

³ GLONASS - GLObal NAVigation Satellite System

2 REVEALING OF MINIMUM VOLTAGE POINTS FOR AN ASSESSEMENT OF PMU SETTING NODES

The considered method allows to detect the presence and location of "weak" lines in an electro power system, namely, those lines, the current operating mode is potentially dangerous in terms of possible disturbance of power system stability.

Let some line is limited by nodes with voltage $\dot{U}_1, \dot{U}_2$. Change of voltage along a line depends on their magnitudes and an angle of relative turn of vectors $\dot{U}_1, \dot{U}_2$ and looks like:

$$\dot{U}_x = (1-x) \cdot \dot{U}_1 + x \cdot \dot{U}_2.$$

So distribution of the voltage square module along a line is a parabola. Solving equation $\partial(|\dot{U}(x)|^2)/\partial x = 0$, we will receive position of top of a parabola, i.e. a point of minimum $x_{\min}$ of a voltage square module along a line.

If $x_{\min} \in [0;1]$, this point is situated at a transmission line. Such point we will name further a minimum voltage point (MVP).

If the additional condition is thus satisfied, namely, reactive capacity from both ends flows down in a line, we will name such point «a significant minimum voltage point» (SMVP).

SMVP at a transmission line is a precursor of problems which can arise at increase of power flow along this line.

The voltage magnitude in such point decreases in process of increase in a relative angle between vectors $\dot{U}_1, \dot{U}_2$. At achievement of some critical value of an angle (near 180°) MVP coincides with the electric centre.

To supervise a situation, it is necessary to monitor relative angle change and minimum voltage on lines with SMVP in-line.

It is shown, that MVP revealing is possible long before the mode approaches to stability loss. It gives the effective mechanism for the control of a condition of all power supply system.

Revealing SMVP is easy for automating, using the information on vectors of voltage and currents in nodes of an electropower system, that can be received from PMU in real time or at numerical calculation of a mode on a design stage.

Using the method make possible to raise efficiency and completeness of "weak" power lines revealing and, by that, to increase control reliability of power system mode and protective automatics work.

The fragment of backbone network (500 kV the Ural IPS) is presented on fig. 1 for an illustration. The control cutset of network and the revealed lines with SMVP are marked. From drawing it is visible, that set of the revealed lines corresponds to set of the cutset lines.

Practical coincidence of these two groups make possible to conclude that the proposed method allows revealing authentic set of "weak" network lines for which it is expedient to consider a question on installation of PMU for MAPF monitor.

3 REQUIREMENTS TO PMU ARRANGEMENT

The design decision on WAMS development in Ural IPS considers results of the analysis of power system operating modes in normal and repair schemes, requirements of standards [1], [2], the list of reference cutsets of Ural IPS [3], requirements to receiving information from the nodes, making the most essential impact on power system mode of Urals IPS, other analytical materials [4].

The requirements to PMUs arrangement have been generated as a result of the project.

A) PMUs should provide monitoring:

- 1) the power stations that influence on power system mode essentially,
- 2) the substations which phase angles specify power system mode conditions,
- 3) intersystem and interstate lines of Urals IPS.

B) PMU should be established:

Actual Trends in Development of Power System Protection and Automation
30 May – 3 June 2011, Saint Petersburg

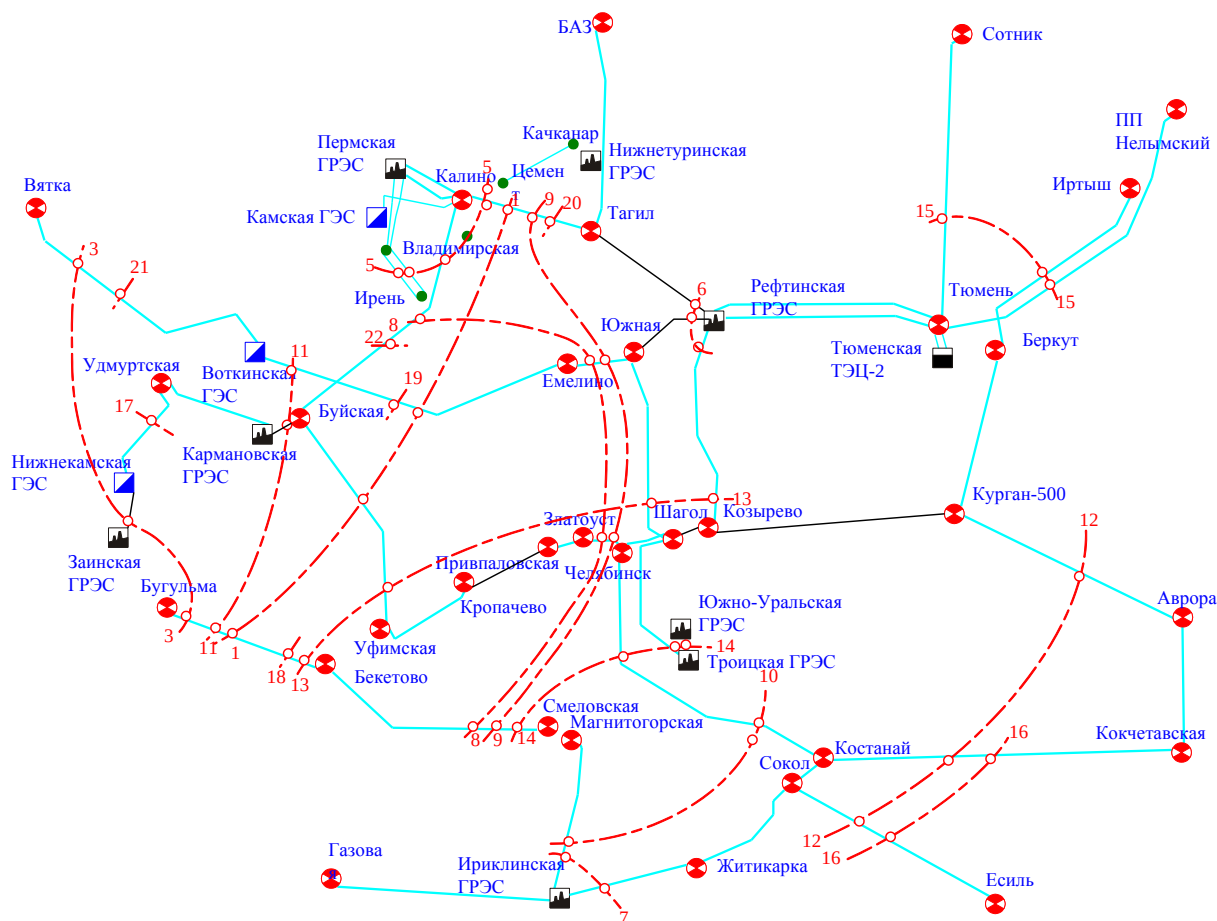


Fig. 1: The fragment of backbone network (blue continuous lines - the revealed lines with MVPs, red dashed lines - reference controllable cutsets).

1) on power stations with capacity above 500 MW if it is available MVP and/or reference cutset on an attached line and it is not available electrically allied power station with capacity above 900 MW,

2) on nuclear power plant,

3) on power stations with capacity above 500 MW if it is available MVP and/or reference cutset on an attached line and if there is no PMU on the opposite end of this line,

4) on substations 500 kV (excepting switching nodes) if it is available MVP and/or reference cutset on an attached line and if there is no PMU on the opposite end of this line,

5) on substations 500 kV with loading above 500 MW if nearby there is no electrical facility with established PMU.

C) PMU on power stations should supervise following joinings:

1) the lines entering into reference cutset,

2) lines of a high voltage 500 kV (in case of absence of lines of this class - lines of power delivery of other voltage class).

D) PMU on substations should supervise following joinings:

1) backbone network lines,

2) loading on substations.

The diagram of decision-making on necessity of PMU installation on electropower objects is presented (fig. 2).

Actual Trends in Development of Power System Protection and Automation
30 May – 3 June 2011, Saint Petersburg

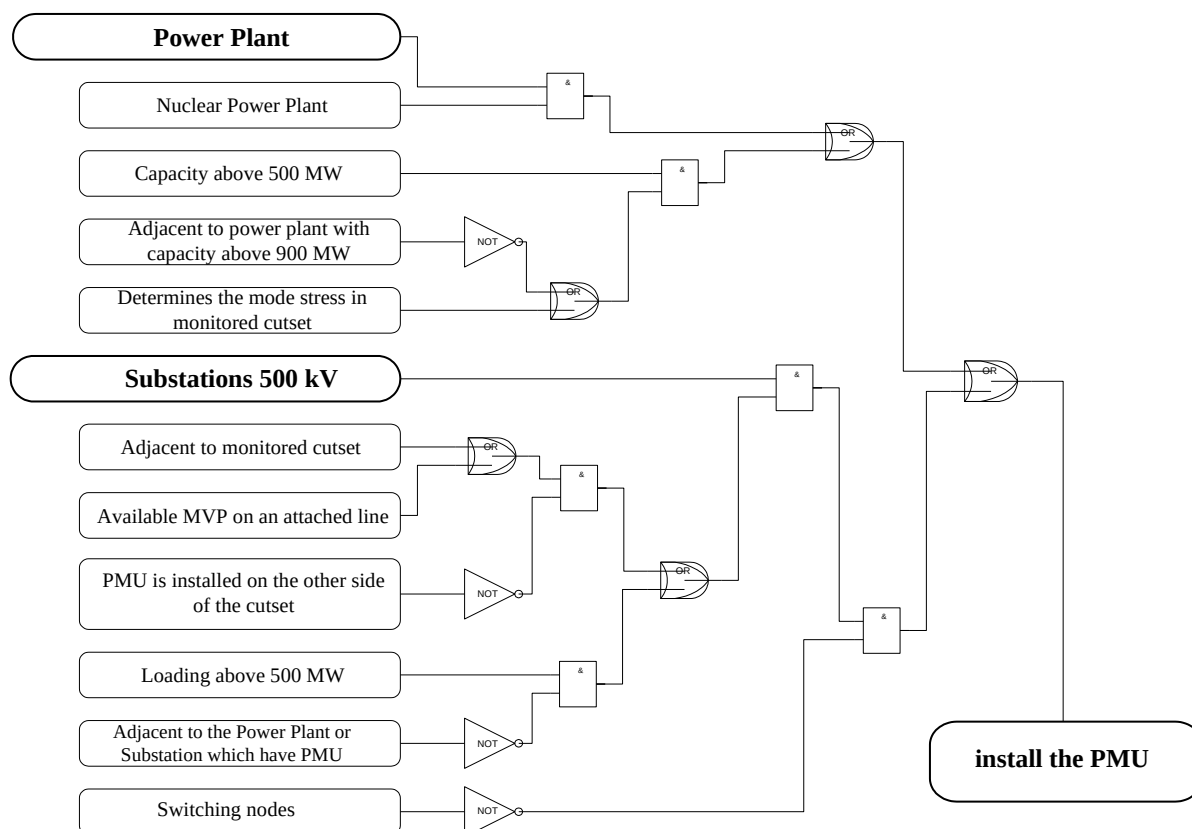


Fig. 2: The diagram of decision-making on necessity of PMU installation on electropower objects.

Fig. 3 illustrates the results of solving the problem of PMU arrangement in Ural IPS.

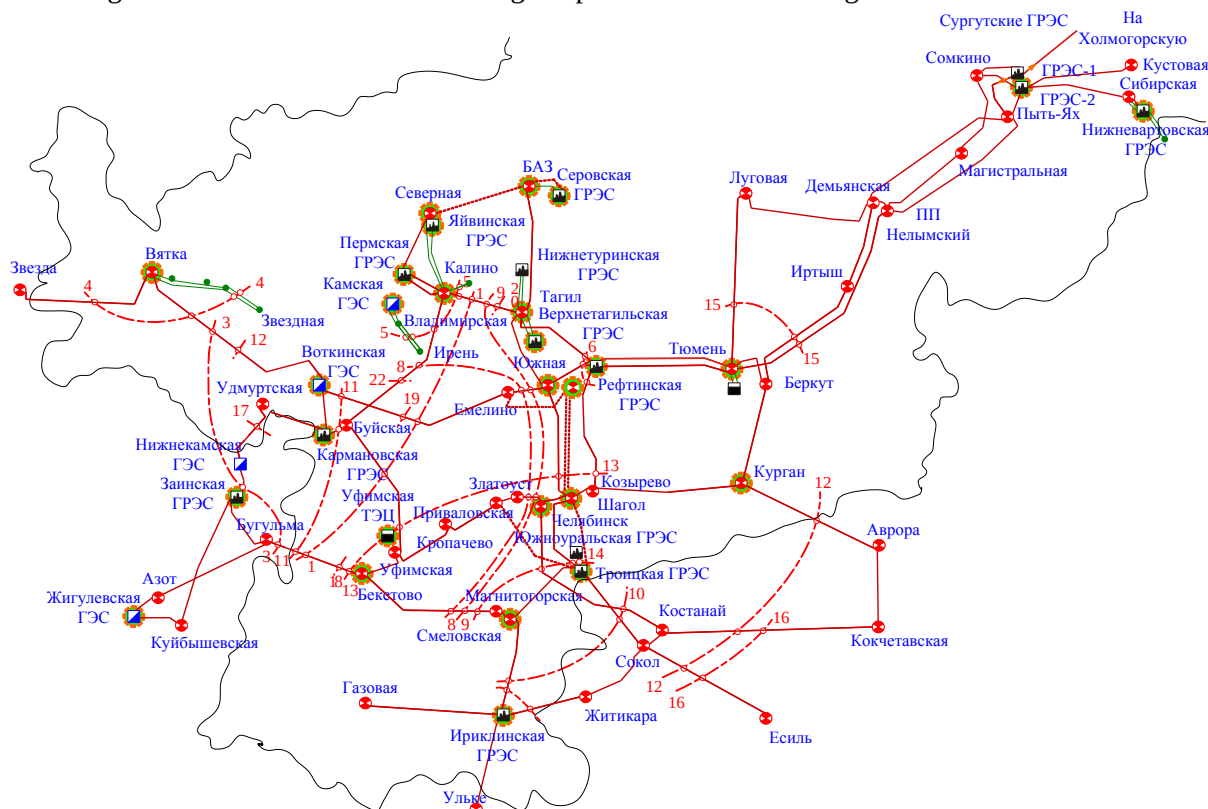


Fig. 3: The design decision on PMU arrangement.

4 CONCLUSION

WAMS uptake make possible:

- 1) to use Ural IPS capacity best with mode control that take into account the current moment restrictions and maintain of reference stability margins; to provide the dispatcher with definition means in a mode of real time of admissible overflows of active capacity in an electric network;
- 2) to provide the dispatcher with on-line instruments to monitor admissible active power overflows;
- 3) to improve accuracy of the power system mode estimation by using measurements of voltage phase angles;
- 4) to provide effective dispatching control of power system mode with demanded reliability level of IPS functioning.

REFERENCES

- [1] Standard of the organization. «SO UPS» JSC. CTO 59012820.29.240.008-2008. Automatic emergency control of power systems modes. Emergency control system for power electrical systems. Process structure conditions. Object creation conditions. Norms and requirements.
- [2] Standard of the organization. «SO UPS» JSC. CO 153-34.20.576-2003 (ПД 34.20.576) Methodical instructions on power systems stability.
- [3] Instruction on operating modes of electric network 500 kV in Ural IPS, the Urals IDO. Ekaterinburg 2009.
- [4] Proceedings of Scientific - Technical Council. The Unified Energy System of Russia, Moscow. On March, 15th, 2010.