Study Committee C2

POWER SYSTEM OPERATION AND CONTROL

Paper 10559_2022

«SO UPS», JSC

Development of dispatching monitoring and control technology in Russia based on PMU data

M.N. Govorun, A.V.Zhukov, V.A. Diyachkov, E.I.Satsuk, D.M.Dubinin

JSC «SO UPS», Russia

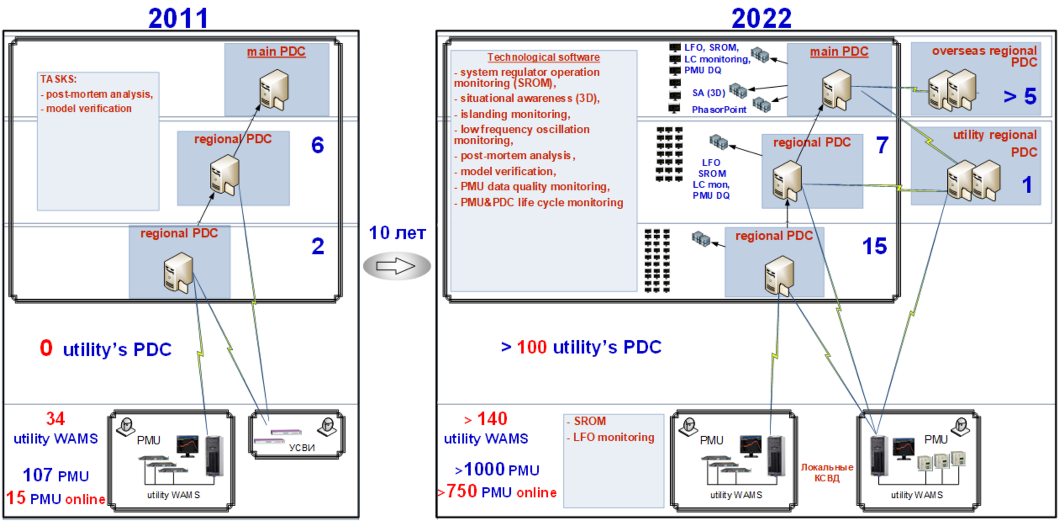
Motivation

- Basic goal of synchrophasor technology development is improvement of operational and automatic control technologies of power system:
  - ❑ new quality information about the behaviour of power system;
  - ❑ the creation of WAMS in Russian power system (on-, off line);
  - ❑ the development technological tasks/systems based on PMU data (WAMPAC);
  - ❑ the deployment of WAMPAC into the dispatch loop.

	Challenge	Decision
1	Development of national standards	❑ PMU & PDC requirements ❑ development a set of tests of PMU & PDC ❑ WAMS requirements (development, deployment, operation)
2	Requirements to equipment of PMU on power stations (P ≥ 500 MW), substations (U ≥ 500 кV) in: ❑ transmission lines (U ≥ 330 kV); ❑ generators (more than 200 MW), hydrogenators (more than 100 MW); ❑ lines & transformers in control sections U ≥ 220 kV	
3	Implementation of national solutions	Five producers of PMU & PDC and software
4	PMU & PDC certification	The creation of PMU & PDC certification system

Development of technological software

- Situational awareness software;
- Low frequency oscillations monitoring software;
- Power system stabilizer operation monitoring software;
- Software for monitoring the quality and reliability of PMU data;
- Software for monitoring the life cycle of PMU, PDC and WAMS complexes



Development of WAMS in Russia from 2011 to 2022

Study Committee C2

POWER SYSTEM OPERATION AND CONTROL

«SO UPS», JSC

Paper 10559_2022

Development of dispatching monitoring and control technology in Russia based on PMU data

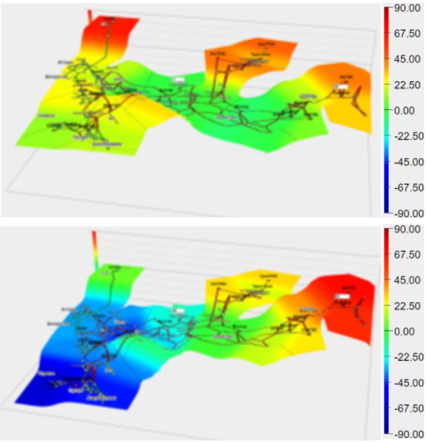
Situational awareness

The purpose of situational awareness software is to visualize the dynamics of changes in regime parameters (frequency, voltage and phase angle) and information support for the dispatcher for situational analysis of the electric power regime of the power system and technological disturbances in power system of Russia:

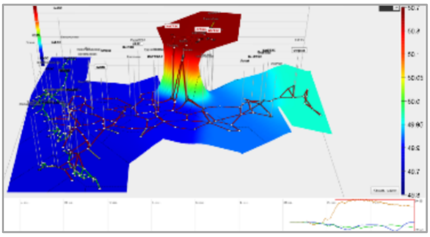
- identification of forced and inter-area low frequency oscillations;
- islanding monitoring;
- localization of technological disturbances;
- control of frequency and voltage regulation;
- increasing the observability of the power system mode;
- post-mortem analysis with event playback in real time.

The following new features in this software are currently being developed and tested:

- real time event identification;
- real-time visualization on the map of the source of low-frequency oscillations based on dissipating energy flow (DEF) method.



Phase angle monitoring form (6:00 MSK, 19:00 MSK)



Islanding

Low frequency oscillations monitoring

- low frequency oscillation monitoring in control sections of power system:
  - ❑ amplitude of active power oscillations;
  - ❑ duration of oscillations;
  - ❑ oscillation source identification;
- generating an alarm when the preset thresholds are exceeded.
- Low frequency oscillations of active power monitoring software was put into operation in 9 control rooms
- Using Dissipation Energy Flow method

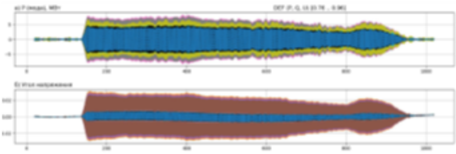
$$W_{ij}^{D} \approx \int 2\pi \Delta P_{ij} \Delta f_i dt + \Delta Q_{ij} \frac{d(\Delta V_i)}{\tilde{V}_i + \Delta V_i}$$

The symbol Δ denotes the operation of extracting (filtering) the mode from the measurement signal. P_{ij} –active power on the $i-j$ line, Q_{ij} – reactive power, f_i – frequency, V_i – voltage, $\tilde{V}_i$ – average voltage value at point i.

The main advantage of this method is the ability to determine the direction of dissipative energy propagation. The direction of the energy dissipation flow is determined by the slope of linear regression:

$$W_{ij}^{D}(t) = DE_{ij} * t + b_{ij}$$

Positive DE_{ij} values indicate the flow of oscillation energy from the object to the system, while negative values indicate the opposite direction of the flow.



Study Committee C2

POWER SYSTEM OPERATION AND CONTROL

«SO UPS», JSC

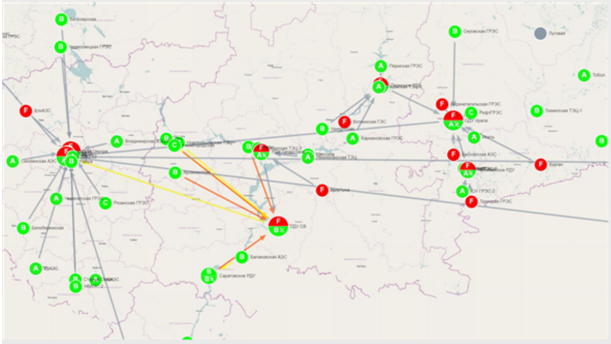
Paper 10559_2022

Development of dispatching monitoring and control technology in Russia based on PMU data

PMU data quality monitoring

Basic functions of PMU data quality monitoring software are:

- real-time evaluation of the correctness of the operation of PMU, PDC and WAMS complexes, as well as the communication system;
- determination of PMU data quality classes by integral indicators - data streams are assigned quality classes A, B, C, D, E, F;
- detection of cyclic failures in the work of communication system, PMUs, local and regional PDCs;
- continuous automatic diagnostics of the serviceability of PMU and PDC, as well as data transmission channels;
- automatic creation of reports based on monitoring results in order to analyze the work of the communication infrastructure and identify incorrect settings of the elements of the communication system that provides transmission and retransmission of PMU data.

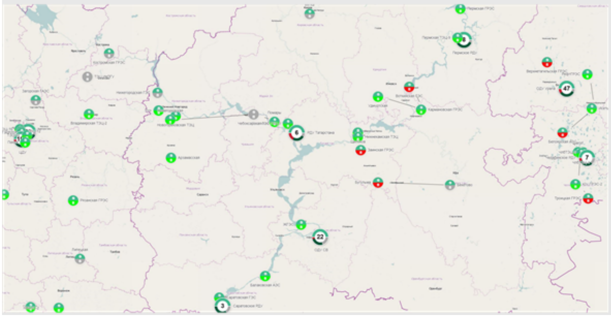


Class	Latency (ms)	Losses (%)
class A	100	0,2
class B	100..500	0,2
class C	500..1000	0,2 .. 2
class D	1000..2000	2,0 .. 10
class E	> 2000	> 10
class F	the data is not correct	

Life cycle PMU&PDC monitoring

The development of software is intended to automate the following processes:

- automation of technical accounting and analysis of the functioning of PMU, local and regional PDC;
- maintaining PMU and PDC configuration protocols and preparation of reporting information;
- monitoring of the functioning of PMU, local and regional PDC and their operational condition;
- systematization of configuration settings and reliability of PMU and PDC functioning;
- transfer of current settings about PMU and PDC to automated systems.



Conclusion

- The level of development of synchrophasor technology in Russia is sufficient to improve the technology of monitoring and control of power system operation based on PMU data
- The quality of PMU data is regulated by Russian national standards, as well as the created information and communication infrastructure of the System Operator allows the effective use of PMU data to improve the efficiency of operational dispatch operation.
- The main goal of further development of WAMS is to further develop the technological software in the direction of expanding functionality, creating expert systems and decision support tools for predicting potential emergencies and early warning of the dispatcherits and technical adaptation of WAMS SO to the changed conditions:
  - increased requirements for functionality, technical characteristics and reliability due to the use of PMU data in real-time applications integrated into the control loop of the dispatcher;
  - to ensure scaling with a significant increase of PMU and regional PDC of other companies.