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Wide Area Monitoring System in North-West Power System on the Base of Modernized Digital Disturbance Recorder

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1 INTRODUCTION

Implementation of wide area measurement system (WAMS) into United Power System (UPS) of Russian Federation requires use of special devices for measurement of system state parameters – Phasor measurement units (PMU). Based upon tests in the Russian Federation it is recommended to use as PMU devices 1133A Power SentinelTM produced by Arbiter Systems Inc. and SMART-WAMS developed by RTSoft.

PARMA Ltd. developed new approach for measurements of parameters for WAMS – equipping of digital disturbance recorders (DDR) with PMU functionality which will provide time synchronization, angle measurements and data transfer according to IEEE C37.118 standard requirements.

To implement of described above conception was developed the new DDR model PARMA RP 4.11, which provides time synchronization of measurements and PMU functionality. New device developed in the same form-factor as the previous DDR model PARMA RP 4.06.

Such approach allows solve the following problems:

- To provide the measurements of power system state parameters for WAMS.
- To reduce significantly expenses of owners of electro energetic objects for installation of measurement equipment which is required to implement the measurements of power system state parameters.
- To provide realization of additional functionalities, such as double-sided overhead line fault localization (OLFL), power quality measurements etc.

PARMA Ltd. together with Transmission System Operator of Russian UPS (SO UPS) implementing the project for construction of WAMS in Northwestern United Power System (NW UPS) system on the base of modernized digital disturbance recorders PARMA RP 4.11 and special software.

Realization of this project allows practically implement the technical and software WAMS solutions offered by PARMA and by results of works draw a conclusion about possibility of implementation of such approach in the Russian UPS.

2 EQUIPMENT AND SOFTWARE OF WAMS IN NW UPS ON THE BASE PARMA RP 4.11

2.1 Digital disturbance recorder PARMA RP 4.11

DDR of 4th generation PARMA RP 4.11 is developed in the same form-factor as the previous DDR model PARMA RP 4.06. with qualitatively new possibilities and on the base of available design,

technological and software achievements, and also with great experience which PARMA Ltd has gathered during development and production of the this kind of the equipment.

Besides advanced functions of registration of emergency processes PARMA RP 4.11 has following functionality:

- The built-in time synchronization of measurements with a time tag GPS/GLONASS with accuracy 1-2 mcs;
- Support of interfaces of time synchronization: IRIG-B and NMEA on interface RS485 (Acutime), on optical lines and interfaces RS232 from GPS receiver - model PARMA RV9.01;
- The built-in module of the vector measurements, allowing use the registrar as PMU in WAMS systems with data output by C37.118 protocol;
- Registration of power quality parameters according to requirements of standard IEC 61000-4-30 with binding to time tags;
- Support of data exchange protocols with SCADA IEC 60870-5-104, OPC, IEC 61850;
- Advanced automatic built-in OLFL with improved accuracy and selective characteristics, new functionality for lines with difficult topology;
- Possibility of two-sided FLM with use of the synchronized measurements.



Fig. 1: Front panel of DDR PARMA RP 4.11 registration block

Design features of the DDR:

- Operates under control of an operating system of exact time MS Windows CE Embedded 6.0;
- Installation of local color touch screen display and film keyboard, built-in the front panel of the block of registration is possible;
- Possibility of choice of sampling rate of measurements;
- Adjustment of level of operation of discrete signals from 24 to 220 V;
- Possibility of direct connection of the external data storage unit to interface USB for information transfer;
- As the built-in data storage device it is applied solid-state disc (SSD);
- The design of the recorder is in the same form-factor as DDR PARMA RP 4.06M;



Fig. 2: Design of block of registration DDR PARMA RP 4.11

2.2 Specialized WAMS software WAProtectorTM

Specialized SW of WAMS WAProtectorTM system - is client-server application which provides acquisition and processing of great volume of the data of synchronized measurements from DDR's in a real time mode.

Due to client-server architecture WAProtectorTM system has following features:

- Data acquisition and data processing in real time is executed on the server of system which works irrespective of visualization means.

- For graphic data presentation in WAProtectorTM it is only required client access to the server through Internet or Ethernet connection. The program for graphic representation executed on the client personal computer and doesn't influence on data processing in real time for server WAProtectorTM.

Such architecture provides high reliability of system reached by separation of graphic data presentation from data processing in real time.

Thus, it is possible to realize multi-user access to the data with user settable view and possibility of display of all available data – measurements, calculations, messages, oscillographies etc.

WAProtectorTM provides data acquisition from PMU in IEEE C37.118 or IEEE 1344 format not dependent on model and manufacturer of these devices.

Data exchange with other WAMS systems is implemented by means of program modules of format IEEE C37.118 and IEEE 1344, data for an exchange and its volume are completely adjusted and set by the Transmission System Operator (TSO).

Data exchange with SCADA systems is made via standard formats, such as IEC 60870-5-101/104, DNP3, etc.

The analysis of data in real time mode allows rapidly detects the beginning of transient modes in power supply systems with flexibly adjusted installations and algorithms.

System WAProtectorTM – it is some kind of protective relay, with ample opportunities on the system adjustment, tracing various types of disturbances in a power system, for example: detection of phase angles difference, detection of power oscillations, detection of instability of voltage, overheats detection, voltage low/high detection, detection of low/high of frequency, detection of harmonious distortions.

System WAProtectorTM configuration is implemented by means of UniFusion Engineering Studio it is environment of adjustment of multipurpose system by user-manager. All options in UniFusion Engineering Studio are implemented on drag and drop technology by means of addition of program-logic blocks (function - logic, arithmetic, comparisons etc.) and specify connections between them that allow to adjust algorithms of processing of the information without any skills in programming.

Functionality of WAProtectorTM allows use it as a centre of powerful, modern WAMS system working in a real time mode, flexibly adjusted for needs of users.

WAProtectorTM is used in systems WAMS of System Operators ELES (Slovenia), RWE (Germany), Elering (Estonia).

3 PILOT PROJECT ON IMPLEMENTATION OF WAMS IN NORTHWEST POWER SYSTEM ON THE BASIS OF MODERNIZED DDR

PARMA Ltd. together with System Operator of Russian UPS implement the pilot project on construction WAMS in NW UPS on the base of modernized digital disturbance recorders PARMA RP 4.11 and special software WAProtectorTM.

Under the pilot project is provided modernization of 3 existing DDR model PARMA RP 4.06M to DDR PARMA RP 4.11 on objects of the generation and grid companies in an operational zone of Interregional Dispatching Office (IDO) of NW UPS. Data of angle measurements from modernized DDR's transferred on installed in the dispatching center of Northwestern Power system specialized SW WAProtectorTM.

Considering constructive and functional features of new DDR PARMA RP 4.11, easy modernization of existing on objects of electro energetic DDR PARMA RP 4.06 or RP 4.06M to RP 4.11 is possible, by simple replacement of existing equipment on the new one. Thus all cable of measurement circuits, power supply, signalization system and data communication which were earlier laid on object, will be connected to the new equipment without necessity of change of schemes and a lining of new cables.

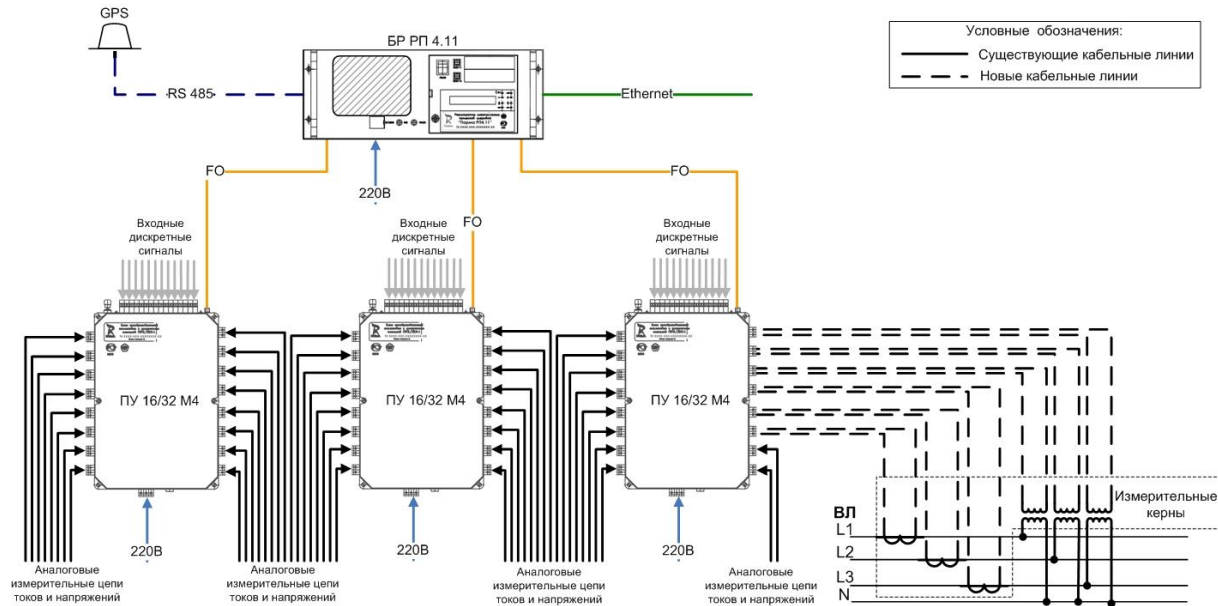


Fig. 3: Modernization of existed DDR on object of electro energetics

For realization of vector measurements it is required to install and connect GPS/GLONASS antenna and to connect measurement circuits of new DDR to measuring circuits of instrument transformers of lines, which monitoring of transient modes it is necessary to provide.

Such approach allows during offered modernization of DDR considerably to reduce volumes of designing, works on installation and on lining of cables and connections, that in turn reduces cost of realization of measurements in interests of both existing, and new constructed WAMS.

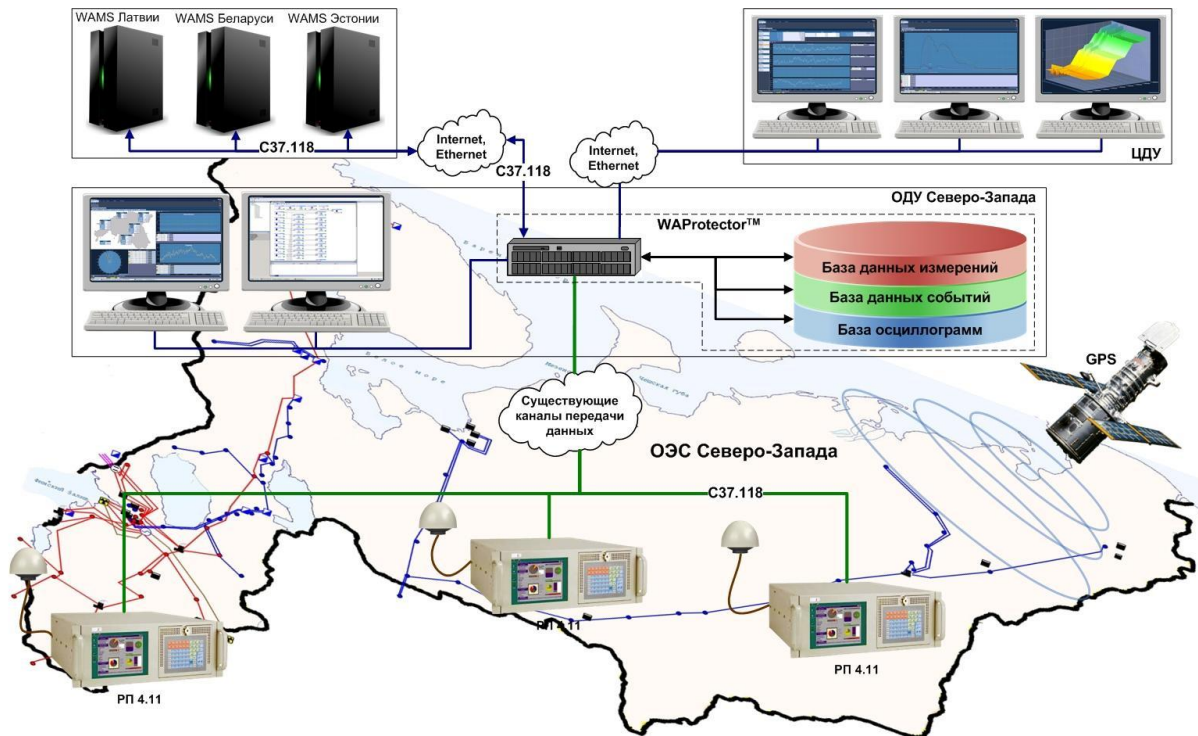


Fig. 4: Structure of WAMS in NW UPS on the base of modernized DDR

Thus owner of objects receive new equipment of registration of disturbances, realizing a number of additional functions, and System Operator of Russian UPS realizes the synchronized measurements of system state parameters in demanded sections in interests of WAMS systems.

Installation of powerful modern SW of acquisition and processing of data allows to create full-function WAMS system of NW UPS, working in a real time mode.

All data of measurements and calculated values are stored in a cyclic database within 14 days.

All events detected by system and generated messages are stored in a database of events on 10 000 records.

In case, when system detects transient mode, it is possible to record the transient process in a separate database of oscillographies, with set thresholds and algorithms of record start, record time before the beginning and after the end of transient mode.

All data of measurements and the calculations, detected events, system messages and also information from databases are accessible to users in the IDO of NW UPS and can be displayed and analyzed in user-settable form.

4 CONCLUSION

Implementation of project described in present paper for WAMS system construction on the base of modernized DDR and specialized provides:

- in practice implement the new approach and new developed equipment with advanced functionalities of disturbance registration and PMU;
- estimate quality and completeness of realization in new DDR PARMA RP4.11 of IEEE C37.118 requirements and accuracy of measurements;
- collect information about required activities and expenses for modernization of existing equipment DDR on objects: project development, installation and commissioning;
- work through and practically decide organization, technical and other points which will appear during implementation of project;
- install specialized SW for WAMS data acquisition and processing in real time, with remote access to the system of TSO specialist, to demonstrate complete WAMS solution of PARMA. Comfortable easy adjustable user interface, big opportunities of for obvious data visualization, comprehensive analysis of information of measurements and stored data, flexible and simple settable for user algorithms of data processing allows WAProtector to significantly enlarge and supplement the features of WAMS software suit used by SO UPS.

All above mentioned allows to SO UPS to evaluate the opportunities of equipment and SW of WAMS for measurement of parameters, data acquisition, processing and analysis. In practice use new approach for WAMS construction, expose issues and problems relating to realization of such way and develop methods and means of it solving, measure costs which requires for implementation of offered conception for entire power system.

Owners of electro energetic objects where DDR's will be modernized can acquaint with advanced and new functions of new equipment and measure possible costs for synchronized angle measurements for WAMS purposes.

In consideration of abundance of DDR's on the electro energetic objects of Russia, and volume of existing DDR's manufactured by PARMA, taking into attention tendency of SO UPS to develop existing WAMS the offered approach presents a lot of perspectives in the future.

Simple modernization of existing DDR's produced by PARMA and, possibly, by other manufacturers, by replacing of DDR's equipment and keeping the existing infrastructure of connections without of necessity of large-scale projecting and lesser scope of works on objects requires significantly lower expenses for realization and provides benefits for each organizations of electro energetic sector involved and as result simply and fast realizable in practice. This allows in the future install the angle measurements equipment on large quantity of objects with relative low expenses.