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AUTOMATYCZNY SYSTEM MONITOROWANIA SYNCHRONIZACJI PRECYZYJNYCH SYGNAŁÓW CZASOWYCH W ELEKTROWNIACH INTELIGENTNYCH

Streszczenie: W artykule rozważono kwestie zwiększenia produktywności i niezawodności zintegrowanego komputerowo systemu do kontroli dokładnych sygnałów czasowych w obiektach elektroenergetycznych SMART-Grid poprzez stworzenie specjalistycznego oprogramowania automatycznego. W artykule opisano zoptymalizowane i wdrożone oryginalne rozwiązania techniczne elementów systemu - bloków przekształtników pierwotnych.

Słowa kluczowe: zautomatyzowany system, oprogramowanie, monitoring wielokanałowy, sygnał zegarowy, energetyka, SMART-Grid

AUTOMATED SYSTEM FOR MONITORING SYNCHRONIZING PRECISE TIME SIGNALS AT SMART-GRID POWER PLANTS

Summary: The issues of increasing the productivity, reliability and reliability of a computer integrated system for controlling accurate time signals at electric power facilities SMART-Grid by creating specialized automated software have been considered. Optimized and implemented original technical solutions to system components - blocks of primary converters.

Keywords: automated system, software, multi-channel monitoring, clock signal, electric power industry, SMART-Grid.

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1. Introduction

At modern digital substations of smart electric power systems of SMART technologies, in digital telecommunications, mobile communication systems, devices are used that generate clock signals to resolve temporary uncertainties [1], [2], [3], [4], [5]. Such devices have a number of technical requirements for accuracy, stability, speed and other quality indicators. The task of the clock signals monitoring characteristics is one of the most important and relevant both at the stage of manufacturing synchronization devices (SD), and in the process of their technical operation.

Analysis of the last researches and publications. An analysis of the publications suggests that in order to ensure continuous monitoring of the parameters of the power system equipment built in accordance with the concept of the SMART-Grid, it is necessary to use the SD, the task of which is to create time stamps with an accuracy of ± 1 μs [4], [5], [6]. Very important are the requirements for the reliability of such synchronization devices and the quality of the generated clock signals. Ensuring high reliability can be realized through appropriate control of the parameters of the clock signals. That is why in the problem solving process it is relevant to conduct scientific research and practical implementation of a competitive automated system for monitoring the exact time signals of the SMART-Grid power supply systems.

Research problem. The work aim is to increase the productivity, reliability and reliability of accurate time clock signals quality indicators automated monitoring at SMART-Grid electric power facilities by creating specialized software for an information-measuring system, as well as developing and optimizing its hardware components - primary converters (CPC) units.

Statement of the main research material.

Clock signals quality indicators monitoring in the conditions of multi-flexible integrated production of DC, as well as in the process of their technical operation at modern digital substations of the SMART-Grid power supply system, requires large-scale automation using computer technology [2], [3], [4], [5]. As a automation result, it is planned to obtain the monitoring system improved indicators.

It is supposed to provide an increase in the SD clock signals monitoring process performance by increasing the measuring channels number (multichannel), using modern IP technologies, and optimizing hardware and software [7].

To increase the reliabilityof the DC clock signals monitoring, optimization of an automated monitoring system blocks and nodes is envisaged [5], [7].

Theoretical research results confirmation are developed software and hardware systems for accurate time clock signals automated monitoring.

2. Clock signals multi-channel monitoring method and its electrical implementation

The clock signals multi-channel monitoring method [5], [7], [8] provides for the creation of an automated computer-integrated system with sensors geographically distributed over the monitoring objects, which are proposed to use TIMETER PCU primary converter units, the structure of which is shown in Fig. 1.

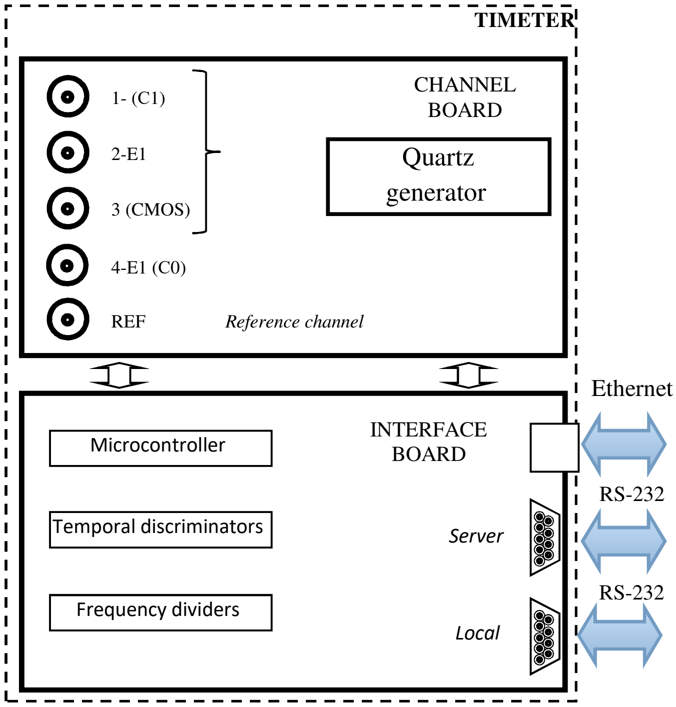

Figure 1. TIMETER PCU structure

PCU TIMETER provides simultaneous time interval deviation (TID) measurements to four clock signals. Controlled signals are fed to the measuring inputs through connectors 1- (C1), 2-E1, 3 (CMOS) and connector 4-E1 (C0). It is possible to carry out measurements relative to the reference signal connected to the input of the reference signal channel (via the REF connector). The reference signal, if it is necessary to further process it (filtering, using the "holdover" mode, etc.), can be programmatically connected to a crystal oscillator, which is included in the phase-locked loop.

The TIMETER device automatically measures clock signals time interval deviation at time intervals τ = 200 ms, with the allowed quantum values of 0.2 ns, digitally processes them at the observation interval T = 1c and generates data in digital form for further processing.

The processed information is converted into a digital code and transmitted to a computer using Ethernet technology or via the RS-232 (Server) serial interface. It is possible to connect a computer for servicing the TIMETER device via the RS-232 (Local) serial interface.

In the TIMETER PCU, the time interval deviation primary conversion (SD metric) to a digital signal is provided by the adaptive digital phase discriminator (ADPD), which has the patent of Ukraine for the invention [9]. ADPD also provides for the implementation of a code combination adaptively controlled formation and an increase in the reliability of the presentation of measurement results in digital form. The structures of the periodicity control unit and the periodicity clock frequency pulse sequence control system (the presence of the required number of clock pulses or their

absence) have also been developed, which ensures increased reliability and speed of control [10].
The TIMETER PCU reference signal generator automatic frequency control system optimization is performed. Taking into account the presence of nonlinearities in the oscillator frequency self-tuning system mathematical model, due to the control action frequency as a function of the phase coordinate of the system and the restrictions of the “saturation” type, the optimal speed system structure was synthesized [11].

3. Software P4000winXP

P4000winXP software has been developed in the EMBARKADERO environment, which provides the ability to increase up to four measurement channels that can be processed simultaneously. The operator can analyze the received results of SD clock signals monitoring and presented in digital and graphic form. This increases productivity, and also makes it possible to comparatively evaluate the measurement results of all four channels, unlike, for example, the single-channel synchronization parameter meter PJS2000 manufactured by PLLB (Italy).
The automated system for monitoring the SD clock signals in the case of using the P4000winXP software makes it possible to simplify the visualization and analysis of the data that are used to make appropriate management decisions. The system provides direct, independent and reliable monitoring results of synchronization signals with centralized management and data storage.
As an example, in fig. 2 shows an example of graphs of changes in the deviation of the time interval of two controlled clock signals.

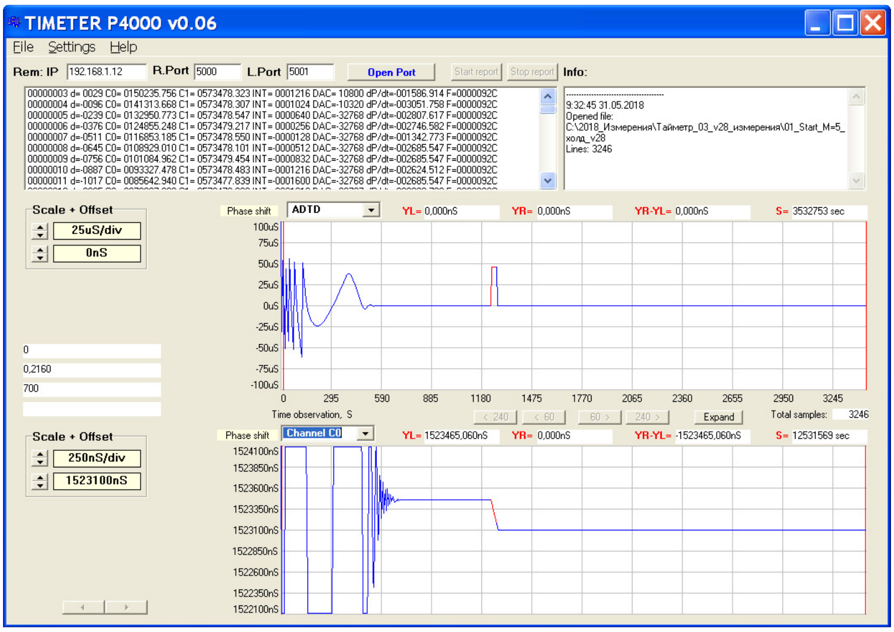

Figure 2. Results of two-channel clock monitoring using P4000winXP software

4. Conclusion

The developed automated computer-integrated complex of software and hardware provides increased productivity, reliability and reliability of accurate time clock signals quality indicators monitoring.
An automated monitoring system, using the developed software P4000winXP and modern IP-technology, provides increased reliability of controlled clock signals measurement results. The obtained measurement results make it possible to promptly make decisions on guaranteed provision of high-quality clock signals to SMART-Grid electric power facilities.
It is possible to use an automated monitoring system to control changes in time delays in the clock signals transmission, which can be caused by a sharp increase in the load of IP networks as a cyberattacks result, as well as for similar monitoring tasks at other objects, for example, metrological and telecommunication ones.

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