

Telecommunication Technologies of the Unified National Synchroninformation System

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Abstract—A development of the unified national synchronous information system (UN SIS) of Ukraine aims at solving the problem of a full-scale frequency and time provision of consumers at the state level. The UN SIS should function as a main source of the synchronous information generated and distributed through the objects. A transportation of synchronization signals to consumers from the national standards, which are intended to reproduce and preserve physical quantities like time and frequency, requires high accuracy. There are different mechanisms to distribute synchronous information throughout the country. Transmission of synchronization signal by means of modern telecommunication technologies is a promising direction, providing the necessary accuracy and reliability, information security, and quality of services. Taking into account an active development of asynchronous telecommunication networks (IP networks), it is effective to transmit synchronous information through these networks based on the PTP protocol of precision time, which allows to distribute the time scale with up to hundreds of nanoseconds accuracy. The paper presents the results of scientific research confirming a possibility to distribute signals of accurate time throughout the country using the existing IP networks and domestic equipment. A development of the UN SIS will allow to provide both the objects of uniformed services and consumers in many sectors of the Ukrainian economy with a high-quality synchronous information. It meets the requirements of the increased information security due to the development of a modern autonomous system independent from the foreign sources and services.

Keywords—*telecommunication technologies; synchronous information; IP network; PTP protocol; signal of accurate time*

I. INTRODUCTION

Modern infocommunication technologies are characterized by intensive use of the reference values of time

and frequency scale to ensure synchronous operation of high-tech systems in telecommunications, metrology, defense, cybersecurity, and in many sectors of the economy [1-4]. High-precision measurements of time and frequency is an important part of ensuring a unity of the measurements in the state, on which high-quality operation of the digital telecommunications, military facilities, synchronization of technological processes in science and economy, and people awereness depend.

The existence of its own system of high-quality and efficient synchronization and information support of economic sectors is, to a certain extent, a sign of a high level of the state development. Despite the fact that currently the state service of State Service of Uniform Time and Standard Frequencies [5], while forming and maintaining the national time scale at the level of the best national scales in the world, practically does not perform the function of transmitting synchronization signals through the information channels. As a result, the problems of using modern telecommunication technologies are the burning issues of today that update scientific research to solve this problem.

II. WAYS OF TRANSMITTING SYNCHRONIZATION INFORMATION

The State Service of Uniform Time and Standard Frequencies, including the State Enterprise "Ukrmetrteststandard", only partially transmits the reference time and frequency signals to the consumers and performs the function of time scale.

Technical means of the Service do not form a unified system and cannot meet the requirements of all consumers, that induces them to use synchronization information of the other states (for example, from the satellite navigation systems GNSS), which poses a threat to national security and

increases the risks of losing the unity of time and frequency measurements within the state. It is known that the main disadvantages of such satellite systems are the dependence of signal quality on non-stationary characteristics of the open medium of radio signal propagation, absence of protection against intentional distortion of synchronization information, etc. [4, 5].

Effective transfer of information about uniform precise time, reference frequencies, precise timestamps (synchronization information) to the objects in need is possible through the creation of a unified national synchronous information system (UN SIS) [4, 5]. Implementation of the proposed idea will create the conditions for information security of the critical infrastructure of the country, as well as the applied results of a dual use will be received for the state institutions, such as the Armed Forces of Ukraine, State Enterprise Derzhspetszviatok (The State Service of Special Communications and Information Protection of Ukraine), and State Enterprise "Ukrmetrteststandard".

In general, a set of large systems or their subsystems and separate dedicated objects, primarily high-tech government information systems, can be the consumers of synchronization information. The national facilities requiring synchronization information are telecommunication networks, digital television, integrated electric power systems, metrology, billing, air and railway transport, oil and gas pipelines, agricultural, environmental and other sectors of the economy. Also, it should be noted the importance of obtaining reference signals of the precise time by special services, which solve the problems of the national cybersecurity of the state and the need to introduce a unified (Kyiv) accounting and reporting time.

There are different distribution mechanisms and protocols which are used to transfer synchronization information to the consumers from the state frequency and time standards or precise time service that support the coordinated national scale. The protocols intended for remote transmission of timestamps in digital code are the protocol of IRIG family and the Network Time Protocol (NTP), which is developed for a widespread use in the computer networks with IP protocol. Additionally, the ToD (Time of Day) protocol has found its application in metrology. To implement the ToD protocol, an asynchronous interface of RS-232 type is used that transmits NMEA messages with a time scale information supplemented by an analog pulse signal with a frequency of 1 Hz (or 1 PPS), which accurately records the timing of scale transition through a zero value of seconds. Also, a modern protocol has been developed for transmitting a timestamp over existing IP networks. This protocol is defined in the IEEE-1588 international standard as the Precision Time Protocol (PTP). The analysis results of technical characteristics and application features of these protocols are given in Table 1.

TABLE 1. TECHNICAL CHARACTERISTICS AND APPLICATION FEATURES OF PROTOCOLS

<i>Protocol</i>	<i>Accuracy provided</i>	<i>The need for a separate network</i>	<i>Application features</i>
IRIG-B	10 μ s - 1 ms	yes	-
ToD	0.1 - 10 μ s	yes	At a distance of up to 10 m
NTP	1 - 100 ms	no (UDP/IP network)	Depends on a network
PTP (IEEE-1588-2008)	0.1 - 10 μ s	no (UDP/ IP network or Ethernet)	Does not depend on a network *

* for a network that supports PTP in accordance with the requirements of the standard

Based on the data given above, we can conclude that the PTP protocol is the only one that can provide a microsecond accuracy and does not require a development of a dedicated network. Experimental studies and the global practice of implementing PTP protocol on existing networks in different industries led to the intensification of its standardization in various sectors of the economy [4, 5]. Implementation of PTP protocol is largely due to the active transition of telecommunication operators to the use of packet switching technologies in the networks. It is worth noting that in such networks, the PTP protocol can be applied with some deterioration in performance, even without its support by other network equipment.

III. ANALYSIS OF THE USE CASES OF TECHNICAL MEANS OF THE UN SIS TELECOMMUNICATIONS OF UKRAINE

An important problem of creating the UN SIS of Ukraine is the justification of the technical means chosen to organize the transmission of synchronization information, that is, the means of telecommunication [4]. There are three ways to solve this problem: 1) to create your own separate digital transport synchronization network; 2) to rent UN SIS as a separate one imposed on information networks, primarily on primary and secondary ones; 3) to transmit the synchronization information along with other useful information in their transport environment, and then select it in the synchronization nodes in one way or another. It can be argued that currently the most developed networks are the synchronization networks of information infrastructures, including telecommunications, where an extensive theoretical and practical experience of their development and operation has been accumulated [3, 4].

In order to reduce the costs of developing the UN SIS of Ukraine, as one of the stages, it can be proposed to develop separate but interconnected synchronization networks of telecommunication operators of different departments and sectors of the economy of Ukraine, or individual large synchronization facilities. A large number of industry-specific synchronization networks with different types of primary sources and synchronization devices from the technical side can significantly reduce the quality of synchronization information and they are not economically feasible, so the number of such networks should be limited. In essence, a development of other, separate but interconnected synchronization networks, such as regional, departmental, or private ones, is an alternative to the project concept of the

UNSIIS of Ukraine. Such establishment may have the following disadvantages. Firstly, the UNSIIS of Ukraine will have a status of the national one, and not just telecommunication and other operators. In addition, today a number of synchronization facilities, not only in the field of telecommunications and informatization, require synchronization information as a comprehensive product [5]. The UNSIIS should become a queuing system for domestic consumers of synchronization information with further involvement of partners from other countries and continents. Secondly, a fragmentation and refinement of synchronization networks, even specific local telecommunication networks, to the "personal business" of the operators/owners, which is currently observed in the industry, will complicate a number of interaction procedures. In the future, this situation can not only cause deterioration in performance of synchronization infrastructures, their failure or partial loss of synchronization, but it can also lead to a complete failure of synchronization of all or some telecommunication networks in the country and, as a result, to emergency situations.

Separate, but interconnected synchronization networks of telecommunication operators can be considered as separate components of the UNSIIS of Ukraine. The choice of synchronization method of the national digital communication network is a responsibility of the national administrations. Right now, the UNSIIS of Ukraine, which would overtake all synchronization facilities of Ukraine (railway transport, oil and gas pipelines, electric power industry, space and defense facilities, etc.), can be developed only under the state programs of Ukraine. Here we can distinguish three strategies for implementing the UNSIIS project of Ukraine [4]:

- to offer the UNSIIS of Ukraine for all consumers of synchronization information. Such centralized management (let's say, at the level of the Cabinet of Ministers) can reduce technical and economic costs, but it requires significant capital investment at the initial stage (permissible construction steps);
- to offer separate synchronization networks for different consumers of synchronization information of Ukraine;
- to offer a digital transport network (primary) and partially a network of synchronization information services (secondary) of the Derzhspetszviazok (The State Service of Special Communications and Information Protection of Ukraine) as a set of innovative means. The indicated synchronization networks need to be reconstructed and expanded, and there need to be developed a dedicated network of the UNSIIS of Ukraine in order to provide consumers of all sectors of the economy of Ukraine with the necessary synchronization signals. First of all, it is necessary to ensure the transmission of information about the precise time, and then move on to the transmission of synchronization signals of the unified Kyiv accounting and reporting time to consumers throughout Ukraine and update the existing synchronization equipment, including the one of the domestic manufacturers, which is much cheaper than the imported.

IV. EXPERIMENTAL STUDIES RESULTS OF THE PRECISE TIMESTAMPS TRANSMISSION OVER THE IP NETWORKS

Let us analyze the research results of PTP protocol on the possibility of its implementation in the intelligent power systems [4]. Since the base standard of PTP protocol contains a wide range of permissible installations and settings, the specialists optimize a configuration of the protocol depending on the characteristics of the industry networks where this protocol will be implemented, which increases the characteristics or simplifies implementation of the protocol.

Experimental studies of the information system for transmitting the precise timestamps over the existing IP networks were carried out using a set of US-1588 equipment of domestic production ("Information Service Technologies Ltd", Kyiv) and a laboratory sample of a quality control device for generating synchronization signals, which includes a blocks of primary transducers (BPT) "TIMETER" [4]. The US-1588 is intended for transmitting the precise timestamps over the data transmission networks using the packet switching based on TCP/IP or UDP/IP protocols at a speed of 10/100 Mbit/s that are compliant with the requirements of IEEE-1588 standard [4]. The most common example of these packet networks where the US-1588 equipment can be used, is the local 10/100 Mbit/s Ethernet network or the IPv4-based network.

The experimental studies of the information system for transmitting the precise timestamps, which consists of the digital information transmission system based on the US-1588M and US-1588S equipment that provides digital transmission of synchronization information over the corporate IP network of the NUBiP of Ukraine. The measured parameters are characteristics of the TIE synchronization signals determined in accordance with the International Recommendations ITU-TG.810 and G.8262 [4]. The experimental studies of the set of US-1588 equipment of domestic production showed a compliance of its main characteristics with the requirements of the "energy" profile of PTP protocol when transmitting the precise timestamps over the existing corporate IP-network of the NUBiP of Ukraine [4]. It is worth noting that the contribution of the synchronizing device US-1588M ("master") to the deviation of time interval is no more than 50 ns at a rate not exceeding 200 ns. The parameters of the set of US-1588 equipment allow to ensure instability of the transmitted timestamps at the level of 300 ns (range).

Fig. 1 shows the measurement results of the TIE of output signal of information system of the precise timestamps transmission over the corporate IP-network of the NUBiP of Ukraine. Taking into account the measurement results, it can be stated that the maximum deviation does not exceed one microsecond.

V. CONCLUSION

Implementation of the proposed idea as a set of innovative means that will work as part of the unified national synchronous information system of Ukraine from the national standard source, is a great alternative to foreign satellite navigation systems. The system will allow to ensure

information survivability and increase reliability by diversifying digital transmission of synchronization signals.

The solution of this problem at the state level will create the conditions, firstly, to increase information security of the users, and, secondly, to increase competitiveness in the market through the cost-effective integrated service delivery to both government agencies and corporate consumers.

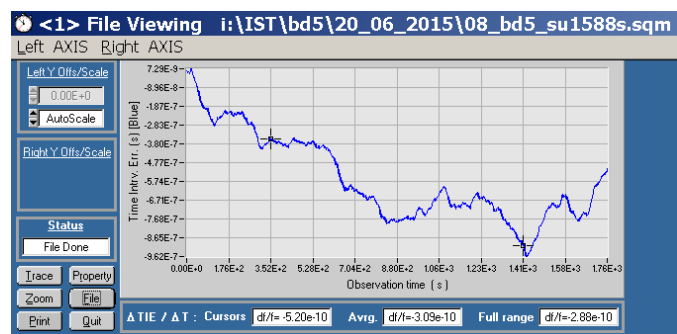


Fig. 1. The measurement results of the TIE of output signal of the information system of the precise timestamps transmission over the corporate IP-network of the NUBiP

It is important that the implementation of the proposed idea will create conditions for information security of critical infrastructure of the country. Also, we will receive the applied results of a dual use for the state institutions, such as the Armed Forces of Ukraine, State Enterprise Derzhspetsviazok (The State Service of Special Communications and Information Protection of Ukraine), State Enterprise “Ukrmetrteststandard”, etc. The proposed set of innovative means will not only provide high-quality reference signals of the uniform time, but also create the conditions for effective synchronous information support of other infrastructure facilities of the country with the lowest costs, and will have the applied dual-use results for the Armed Forces of Ukraine, due to the development of a unified national synchronous information system of Ukraine, that is a modern autonomous ground-based system, independent of foreign time and frequency services.

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