TIME AND FREQUENCY ACTIVITIES AT THE LITHUANIAN NATIONAL TIME STANDARD LABORATORY

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Abstract

Since June 2001, the Lithuanian National Time and Frequency Standard Laboratory has been responsible for the maintenance and dissemination of the national time scale UTC (LT), as well as for units of time and frequency. The Laboratory is equipped with two HP5071A atomic clocks (one with a high-performance Cs tube) and two multi-channel TTS-1 and TTS-2 GPS receivers. The TTS-2 system is fitted with a temperature-stabilized GPS antenna. For dissemination of the Lithuanian Time Scale UTC (LT), the Datum 2001 and SyncServer S250 NTP servers are used. Laboratory activities on coordination of the BALTICTIME project "Reinforcing e-Government services in Baltic States through legal and accountable Digital Time Stamps" (a European FP6 program) are presented. Also, the applications in legal metrology of the technology developed for measuring GSM audio call durations by generating digital time marks traceable to UTC (LT) are demonstrated.

INTRODUCTION

On 5 April 2002, the government of the Republic of Lithuania approved the Time and Frequency Standard Laboratory of the Semiconductor Physics Institute as keeper of the National Time and Frequency Standard. Since May 2001, the National Laboratory of Time and Frequency Standard has participated in the process of forming the International Atomic Time Scale (TAI).

LABORATORY DESCRIPTION

The most important part of the UTC (LT) laboratory is its staff, which currently consists of five persons. The duties in time transfer and laboratory equipment control are shared among the laboratory engineers according to the technical procedures of Quality Management System ISO/IEC 17025. The configuration of the laboratory equipment is presented in Figure 1. Laboratory equipment and its functionality are described in more detail in Reference **[1]**. The most important equipment of the laboratory is the HP5071A and AGILENT5071A cesium atomic clocks. The weights of the clocks, which are used by

BIPM for TAI calculations, are presented on Figure 2. Last year, the second NTP server, an S250 made by Symmetricom, was added. That allowed us to extend the possibilities of disseminating UTC (LT) through the Internet using NTP technology. The S250 NTP server is equipped with a GPS receiver, which ensures the secure operation of the server. Laboratory NTP servers handle more than 200,000 queries from more than 1,000 IP addresses per day. The temperature control and stabilization system of atomic clock room was improved; thus, we are able to keep the temperature at 21 ± 0.5°C.

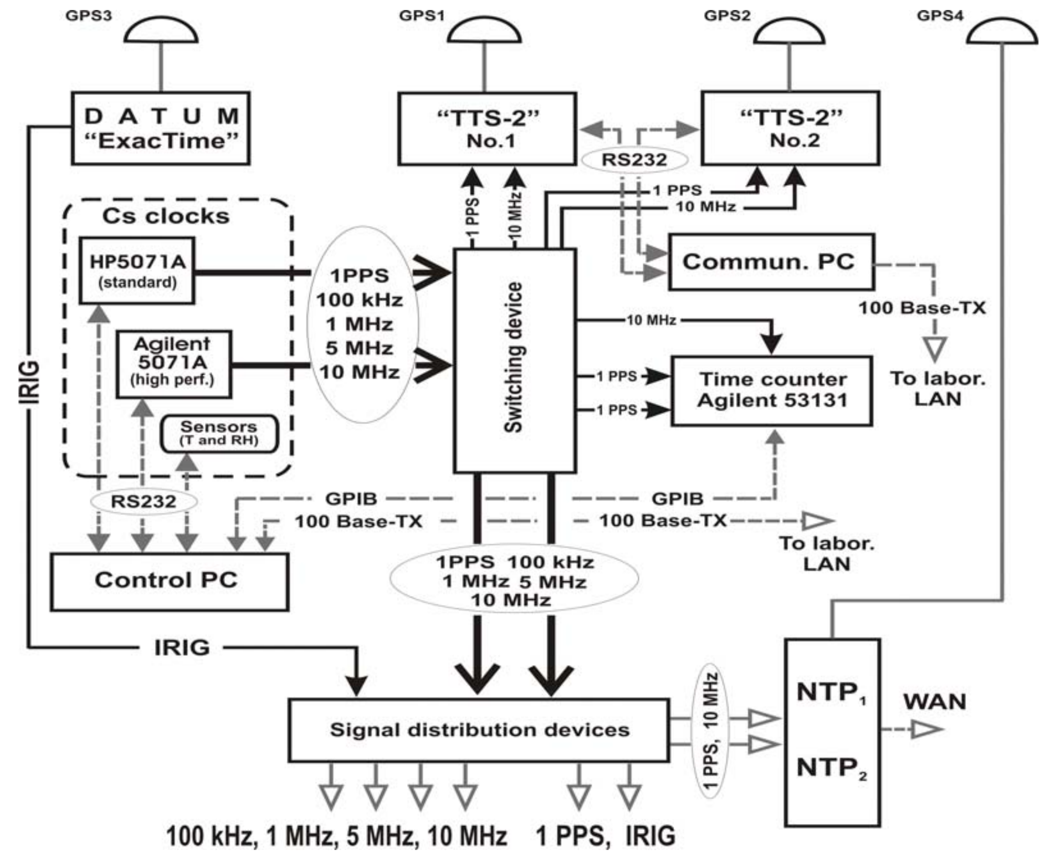

Figure 1. Schematic representation of the laboratory equipment.

DISSEMINATION OF UTC (LT)

Traditional calibrations of working standards and measuring instruments are used for transferring time and frequency units (second and Hz) generated by laboratory atomic clocks. NTP technology is the main measure for dissemination of the UTC (LT) time. Low-cost equipment named NTP Time Access Point (NTP TAP) was developed by laboratory engineers. Use of NTP Access Points is planned for transferring UTC (LT) time to the Lithuanian regional Metrology Centers (MC) and calibration laboratories. The basis of NTP Time Access Point is a PC running a LINUX operating system and developed application software that generates second pulses (PPS) and time code signals in RS232 output. JAVA technology was used for the development of application software. The PC system clock is the timing source for PPS and time code signal generation. An NTP client program running on a PC and a synchronized PC system clock are configured for communication with an NTP server of the UTC (LT) laboratory.

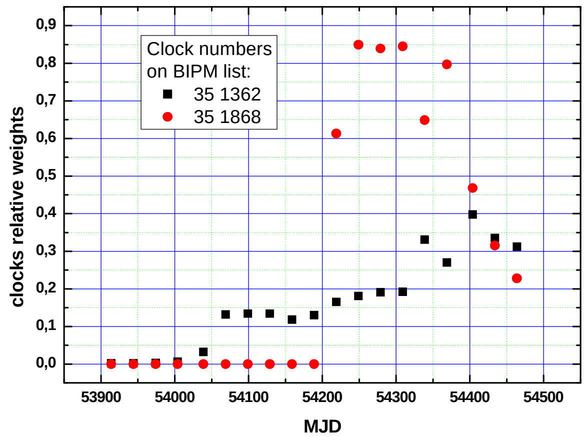

Figure 2. Weights of LT clocks used for TAI calculations.

In this way, the traceability of generated PPS and time codes was implemented. Traceability characteristics are obtained using an NTP DUMP and data analysis (EVALUATION PC) system installed on the UTC (LT) laboratory site (see Figure 3). Time stamps of NTP messages were analyzed as described in Reference **[2]**. Experimental NTP TAP implemented on the PC with P5 100 MHz CPU and 32 MB RAM demonstrated 10-ms traceability for generated PPS at the output of the Signal Distribution Device of the UTC (LT) laboratory. Experimental NTP TAP was connected directly to the laboratory LAN. Our plans are to organize a UTC (LT)-traceable NTP time dissemination network involving five Lithuanian Metrology Centers (see Figure 4).

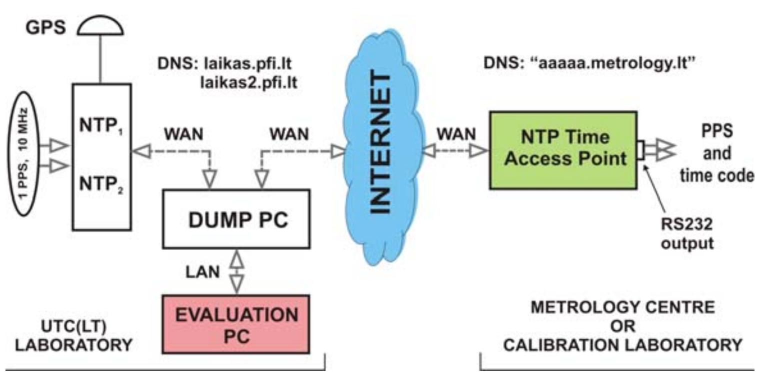

Figure 3. The UTC (LT)-traceable NTP time dissemination scheme.

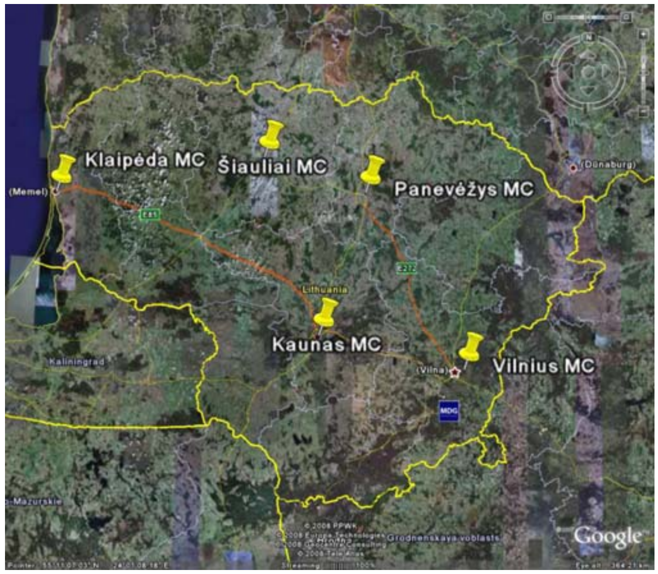

Figure 4. The network of Lithuanian Metrology Centers.

TIMING OF GSM AUDIO CONNECTIONS

Technology for measurement of durations of GSM audio calls has been developed. Call duration is measured by using an end-to-end method, making calls between two GSM terminals (Siemens MC35i). The structure of the GSM testing system is presented in Figure 5. One GSM terminal was mobile and equipped with a test signal generator. Pseudo-noise DTMF-like signals were used as test signals transmitted through the GSM channel. A receiving GSM terminal was connected to a PIC16F84A-type microcontroller, which was used as a generator of digital time stamps at the opening and closing of the GSM audio channel. Traceability of generated time stamps to UTC (LT) was assured by supplying the PIC microcontroller with once per second pulses (PPS) and a 10 MHz clock signal from an HP5071A Cs clock keeping the UTC (LT) time scale. The uncertainty of generated digital time stamps was 100 μs. The combined uncertainty of the call duration measurement obtained was about 100 ms. Calibration of the GSM call testing system was done using a Creative “Sound Blaster Live! 24 bit”-based two-channel signal analyzer with a timing resolution higher than 30 μs. The uncertainty in generation of time stamps with respect to the time scale UTC (LT) obtained was 100 μs. The time stamps (T_{UTC}) generated by the system developed and the time stamps (T_{GSM}) obtained from the GSM network operator were compared (see Figure 6). A few hundred test calls of duration 5-22 s were made. Some results of comparison are presented in Figure 7. Positive $\Delta\tau$ values correspond to the delay of GSM time stamps with respect to UTC time stamps. Those GSM time stamps ware generated by call STOPs initiated by the laboratory GSM terminal. Standard deviations of $\Delta\tau(0)$ and $\Delta\tau(1)$ are in the range of 2-22 ms. The differences of mean values of generated time stamps are caused partially by the specifics of the synchronization of the GSM network timing system with the UTC (LT) time scale. The results show good accuracy of the method and instrumentation. The system developed could be used as a GSM call-timing assessment instrument. The technology developed was used for testing and verification of the timing systems of GSM operators which are to meet the requirements of legal metrology. The GSM timing control system is described in more detail in Reference **[3]**.

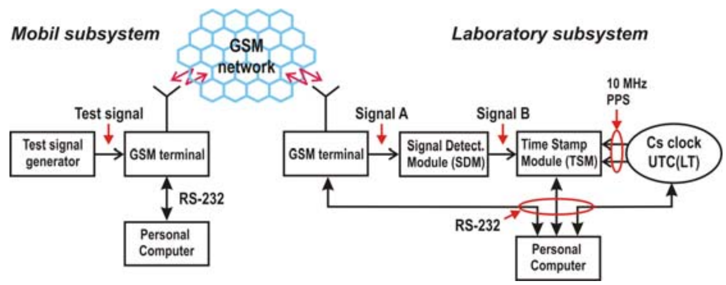

Figure 5. Structure of the GSM testing system.

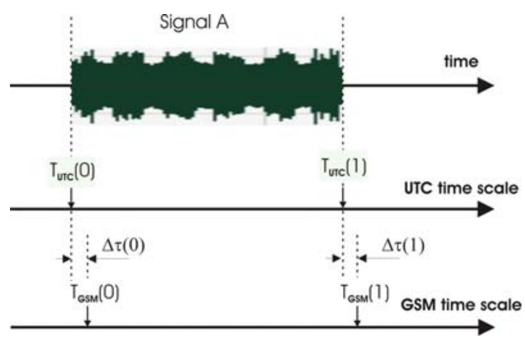

Figure 6. Time stamps generated in the UTC (LT) and GSM system time scales.

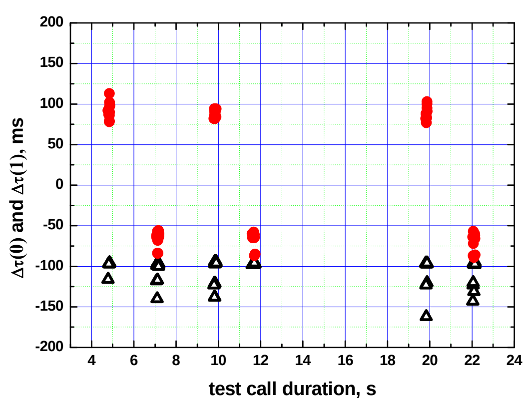

Figure 7. Differences of time stamps generated in the UTC (LT) and GSM time scales.
Δ, ● – time stamps generated at the START and STOP of the GSM calls respectively.

BALTICTIME PROJECT "LEGAL AND ACCOUNTABLE DIGITAL TIME STAMPS"

The Laboratory coordinates the European FP6 program project *"Reinforcing eGovernment services in Baltic States through a legal and accountable Digital Time Stamp."* The BALTICTIME project is designed to enhance confidence in the time-stamping service through adopting capacities of the Time Standard Laboratories (National Metrology Institutes) of the EU metrology system as the most authoritative and legal backbone for the Time Stamping Authority (TSA). The overall objective of the BALTICTIME project is to develop the legal and accountable Digital Time Stamping (DTS) system, which will be the technical base of the TSA providing the layer of Trust in eGovernmental transaction environment and to demonstrate DTS system performance for time-critical functions or validation data for digital signature.

The list of participants is:

1. Semiconductor Physics Institute (PFI) from Lithuania (project coordinator)
2. Cybernetica AS (CYBER) from Estonia
3. Nergal S.r.l. (NERGAL) from Italy
4. Latvian National Metrology Center (LVMC) from Latvia
5. Borowiec Astrogeodynamic Observatory (CBK) from Poland
6. State Tax Inspectorate (VMI) from Lithuania
7. Applied Research Institute for Perspective Technologies (PROTECH) from Lithuania.

The project is divided into two phases:

A. Development of a DTS system based on the National Time Standard Laboratory ensuring an auditable, accountable, and transparent time-stamping service;
B. Demonstration and evaluation of the BALTICTIME DTS system performance for time-critical functions in eGovernment services with possibilities for a cross-border time-stamping service.

The main technological tasks of the BALTICTIME project are:

1. To develop the interface between the National Time Standard Laboratories, keepers of National Coordinated Time Scales UTC (k), and the Digital Time Stamping systems of the TSA
2. To develop the time stamps archive as the network of Archive Units (AU) with an internal time scale generator traceable to the Universal Coordinated Time Scale (UTC)
3. To develop a security system based on an interoperable certificate database
4. To demonstrate the BALTICTIME system performance for eGovernment services with cross-border time-stamping possibilities
5. To analyze potential demand for time-stamping services and possible nontechnical obstacles for their acceptance.

The BALTICTIME system will be mainly based on the hardware common to the National Time Metrology laboratories. Technical specifications will be assessed according to the requirements of the standards **[**References **4-6]**.

The BALTICTIME DTS system designed consists of two parts: DTS of the main site and DTS of the remote site (see Figure 8). The DTS of the main site is intended to provide a digital time-stamp service for small (detached) users, while the DTS of the remote site will serve the big group of users. The DTS of the remote site will be installed in the facilities of such organizations as the State Tax Inspectorate, financial organizations, and the like, where a large number of electronic documents like tax declarations or financial transactions must be time stamped in a short time.

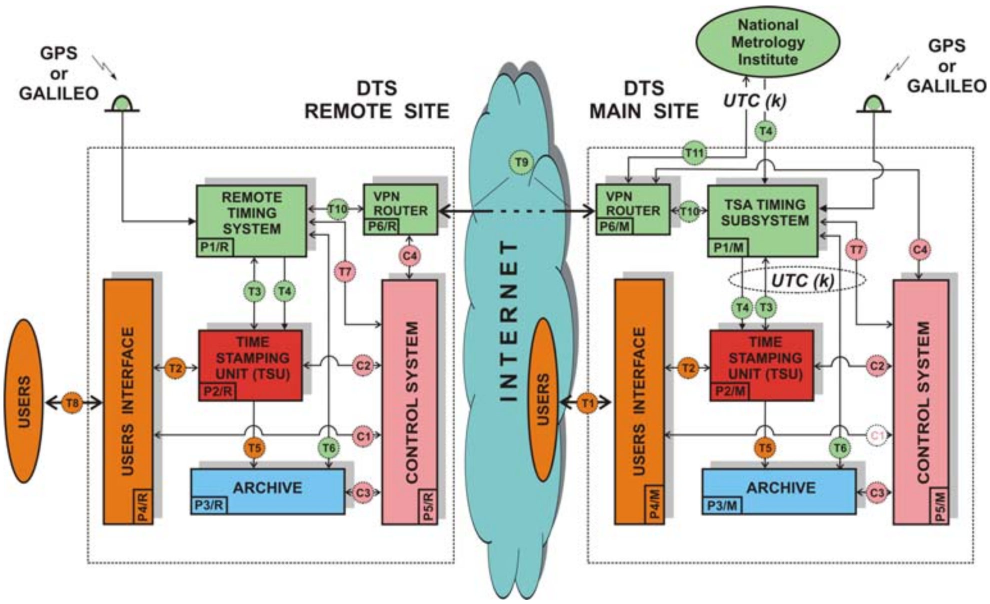

Figure 8. The structure of the BALTICTIME Digital Time Stamping System.

The first task of the project is to develop the timing interface which transfers the time scales kept by the National Time Standard Laboratories to the Digital Time Stamping systems of TSA. The timing interface components are colored in green on the Figure 8. Partners responsible for the development of the timing interface are the Time and Frequency Standard Laboratory of Semiconductor Physics Institute (PFI) and the Borowiec Astrogeodynamic Observatory (CBK) of the Poland Academy of Science. The timing interface will synchronize one-site-located DTS components (Archive Units, Time Stamping Units, User Interfaces, and Control Systems) on a level better than 100 μs and will transfer the UTC (k) time scale from the National Time Standard Laboratories to the DTS sites with an uncertainty of 10 ms. For that purpose, the complex technology based on the transmission of second pulses and NTP communications and technology, which apply two independent NTP servers, are under development. Virtual Private Network (VPN) and GSNS (GPS and GALILEO) technologies will be applied for security and reliability intensions.

The second task is the development of archive system which will be used for issued time storage and verification. Partners responsible for that task are Nergal S.r.l. (NERGAL) and Cybernetica AS (CYBER). The archive system is designed as a network of Archive Units running on independent PCs whose clocks are synchronized by the Timing Interface. The software of the Archive Units is prepared for a LINUX operating system using MySQL open technologies.

The Time Stamping Unit (TSU) developed by the Open TSA project is integrated into the BALTICTIME Digital Time Stamp system. Cybernetica AS (CYBER) is the partner responsible for adaptation and integration of TSU with Archive System and User Interfaces.

User Interfaces and Control Systems are the key parts of the security system. Semiconductor Physics Institute (PFI) and Cybernetica AS (CYBER) are partners responsible for the development of the security system for the BALTICTIME project. The user interface for small users will be developed as a Web application.

The list of projects whose results are used in developing BALTICTIME system is:

- Open TSA
- Open SSL
- Open Evidence
- Open LDAP
- MySQL.

All software components of the BALTICTIME system are developed for a LINUX operating system.

OTHER PROJECTS

The Lithuanian National Time and Frequency Standard Laboratory participates in the following projects:

1. Formation of the independent atomic time scale TA (PL) using atomic clocks operating in the Polish and Lithuanian Timing Laboratories
2. "Galileo Time and Synchronization Applications" (HARRISSON) coordinated by Consorzio Torino Time
3. EURAMET project No.860 "Time comparison using transportable Cs-clock"
4. EURAMET supplementary comparison TF.TI-K1 project No.828 "Comparison of time interval (cable delay) measurement."

REFERENCES

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[2] D.L. Mills, 2006, *"Analysis of Errors,"* **Computer Network Time Synchronization: The Network Time Protocol** (CRC Press, Boca Raton, Florida), pp. 175-185.

[3] R. Miškinis, A. Burokas, J. Karuža, V. Simanavičius, D. Smirnov, E. Urba, and A. Mašonis, 2007, *"Timing of GSM audio connections by generating UTC(LT) traceable digital time stamps,"* in Proceedings of the Joint Meeting of the 21st European Frequency and Time Forum (EFTF) and the 2007 IEEE International Frequency Control Symposium (FCS), 29 May-1 June 2007, Geneva, Switzerland (IEEE Publication), pp. 836-839.

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[5] *"Internet X.509 Public Key Infrastructure Time-Stamp Protocol (TSP),"* RFC3161 (Internet Engineering Task Force), 2001.

[6] *"Electronic Signatures and Infrastructure (ESI); Policy requirements for time-stamping authorities,"* ETSI TS 102 023 v1.2.1 (European Telecommunications Standard Institute, Sophia Antipolis Cedex, France), 2003.