CURRENT ACTIVITIES OF THE NATIONAL STANDARD TIME AND FREQUENCY LABORATORY OF THE TELECOMMUNICATION LABORATORIES, CHT TELECOM CO., LTD., TAIWAN

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Abstract

The National Standard Time and Frequency Laboratory of the Telecommunication Laboratories, CHT Telecom Co., Ltd., as the national laboratory for time and frequency metrology in Taiwan, is responsible for the maintenance and dissemination of the national time and frequency standards, and the development of telecommunication synchronization techniques.

This report covers the four most important activities in the Time and Frequency area undertaken in Taiwan:

- Clocks and time scales
- ***Eight HP 5071A high- performance cesium clocks***
- ***Two active H-masers CH1-75 (tuned)***
- ***A new national time scale generator of UTC (TL) is under development***

- Time transfer
- ***GPS and Glonass code and carrier-phase observations***
- ***Two-way Satellite Time and Frequency Transfer***
- ***Time transfer using optical fiber***

- Dissemination
- ***High-frequency Broadcasting Service***
- ***Speaking Clock Service***
- ***Computer Time Service (TCTS) system in Taiwan***
- ***NTP Service***

- Other research activities
- ***Frequency synchronization using GPS carrier phase***
- ***Network synchronization***
- ***A phase-noise measurement system.***

INTRODUCTION

TL operates the Quality System in accordance with ISO17025 and ISO 9001. The accreditation bodies are CNLA (Chinese National Laboratory Accreditation) and RWTUV (Taiwan), respectively. TL has undergone peer assessment; the technical assessors were from NML, Australia and CRL, Japan. This report covers the four most important activities in the Time and Frequency area undertaken in Taiwan:

- Clocks and Time scales
- Time transfer
- Dissemination

● Other research activities

CLOCKS AND TIME SCALES

We have actually:

- Nine HP 5071A high-performance cesium clocks
- Two active H-masers CH1-75 (tuned)

UTC (TL) was derived from Cs809 until 29 June 2002 and from Cs300 through the present and steered in frequency toward UTC. The other cesium clocks and H-masers have been running through the period too. A paper national time scale generator of UTC (TL) is under development with improved reliability.

TIME TRANSFER

GPS AND GLONASS OBSERVATIONS

Due to clocks having become more precise and accurate, the timing community is continuously seeking more precise and accurate systems to help them with synchronization. The Global Positioning System (GPS) is not only a navigation system, but also a reliable time transfer system.

A GPS receiver can be programmed to display the difference between the local clock and the GPS time. GPS can easily provide the capability to allow synchronization of clocks to better than 100 ns in time.

In the technique of GPS common view, two GPS receivers (known as GPS time transfer units) simultaneously observe the same GPS satellite. Two clocks located at different sites can be compared with each other by means of the GPS time derived by the two GPS receivers. Since the GPS time is in common, the difference between the outputs from the two GPS receivers, programmed as mentioned above, is simply the difference between the two clocks. This technique, known as GPS common view, can be used to synchronize clocks over a large geographical area with an uncertainty as good as 3-5 ns.

For routine international collaboration, TL operates two AOA TTR-6 GPS receivers and obeys the recommended GPS common-view tracking schedules of BIPM. Data in the CCDS format are sent to BIPM monthly. A GPS/GLONASS multi-channel receiver R100-30T from 3S navigation is operating as well. Two Ashtech Z12T GPS receivers are set for the research in the IGS/BIPM pilot project.

TWO-WAY SATELLITE TIME TRANSFER

We set up one set of C-band and three sets of Ku-band earth station equipment for two-way satellite time transfer experiments. As for the modem, we have one ATLENTIS modem and three SATRE modems. We have performing the TWSTT experiments with CRL (Japan) by utilizing the ATLANTIS modem and a Ku-band ground station through the JCSAT satellite since June 2000. We plan to execute the TWSTT experiment with NML (Australia) and NIST (USA) through a SATRE modem and the C-band facility. A 2.4 m Ku-band ground station and a TWSTT experiment with CRL, NML, and USNO (USA) is being planned. A link between VSL and TL by using the PAM satellite is being discussed.

TIME TRANSFER USING OPTICAL FIBER

We began to investigate optical fiber two-way time transfer and built a test system. The test system is based on an Odetics, Inc. SONET/SDH OC-3 interface adapter to access the SONET overhead data. We designed the unused overhead bytes in each SONET frame to transfer a time reference pulse. A short-term stability of 5 ps has been achieved through a loop-back test of the short-distance (about 5 m) single-mode fiber. There is still much work to do to improve the system in the future.

DISSEMINATION

HIGH-FREQUENCY BROADCASTING SERVICE

The HF time and frequency broadcast service using standard frequencies 5 and 15 MHz has been maintained continuously since 1969.

SPEAKING CLOCK SERVICE

We have designed and set up a public voice time service station called the 117 time service (the dialing number is 117). This system can provide an accurate voice time signal to public users, and the time difference between the voice time signal and UTC (TL) is less than 10 ms all around Taiwan Island. We use an industrial-based personal computer (IPC) to develop our time synchronized speaking clock (TSSC) system. The system can be traced to UTC (TL) via IRIG-B (Inter-Range Instrumentation Group, B) code and is broadcast through PSTN automatically 24 hours a day.

TCTS SERVICE

The Taiwan Computer Time Service (TCTS) system was developed by utilizing an industrial personal computer (IPC) that can be protected against corrosion, moisture, and dust, and can be maintained easily. An embedded PC bus level time code generator, which is synchronized via an IRIG-B code, is used to provide both a source of time data and a time marker for measuring the path delay. The "European Telephone Code" is modified into TCTS time format to match our needs, such as the lunar calendar especially. Two modes, *one-way* and *loop-back*, are operated. The propagation delay is measured precisely and compensated for one-way mode; thus, the measured time correlation between TL and Tai-Chung (about 200 km away from TL) is better than 2 ms after compensation. For the loop-back mode, the accuracy is within 1 ms. We have launched two TCTS systems with eight lines and five speeds via telephone line for the public.

NTP SERVICE

One of the most important time synchronization services we provide for the populace is the Network Time Synchronization Service. The Network Time Synchronization Service uses Network Time Protocol (NTP) to synchronize clocks of computers in the Internet with national standard time. NTP has built a time tracking system with a hierarchical structure. An NTP timeserver with a lower hierarchy is synchronized to that with a higher one. NTP can estimate the network propagation delay and compensate the effect of delay for adjusting the local computer clock. In the Internet, the accuracy of NTP is about a few tens of milliseconds. Thus, it can provide an accurate time source for most information applications, including the Time Stamp Authority (TSA) application.

We have been providing the Network Time Synchronization Service since June 1998. We installed multiple NTP timeservers in our lab and developed a friendly client program implementing Simple Network Time Protocol (SNTP) for Windows OS environments. In addition, we also designed a system to monitor our NTP services, and the monitoring program is used to count the number of NTP accesses of our NTP timeservers. Up to October 2002, the number of NTP requests was more than five million (5,000,000) connections a day. NTP provides an authentication option to implement the security function. However, the present version client program does not implement any authentication function. The design of a powerful authentication mechanism for our NTP system is under development.

OTHER RESEARCH ACTIVITIES

FREQUENCY SYNCHRONIZATION USING GPS CARRIER PHASE

Using carrier-phase double-differencing with respect to receivers and time, a remote OCXO clock can be steered to obtain an excellent performance through weighted least-squares estimation and appropriate controllers. The accuracy of the remote clock can be improved from about 5×10^{-9} to about a few parts in 10^{13} for averaging times of 1 day over a 30-meter baseline. Moreover, the zero-baseline common clock tests with a high-performance cesium clock show that our system has a frequency stability of a few parts in 10^{16} for averaging times of 1 day. Experimental results show that our system is sound and cost-effective in many applications, such as the PRS (Primary Reference Source) of a telecommunication network, a frequency traceable to the National Standard for Frequency Calibration Laboratory, instrument calibrations, etc. Combining the rubidium atomic oscillator, low-cost GPS engines (with a carrier-phase option) and other data links for long-baseline applications is currently under investigation.

NETWORK SYNCHRONIZATION

The telecommunications infrastructure currently installed consists basically of digital switches and transmission links of the Plesiochronous Digital Hierarchy (PDH), Synchronous Optical Networks (SONET), or Synchronous Digital Hierarchy (SDH). The efficient implementation of a switching fabric requires a synchronous multiplexed frame format. Before the signal is fed into the multiplexer, the signal frames are phase-aligned in an elastic store of the synchronizer, in order to implement the synchronous multiplexing. The frequency (or bit rate) offset due to synchronization failure is accommodated in the elastic store and results in slips. Regarding control of the slip rate performance, ITU-T Recommendations G.822 and G823 give the basis for jitter and wander specifications.

The network synchronization quality has an impact on the jitter and wander performance, which may increase the bit error rate or frame slips. Thus, jitter and wander reduction mechanisms are under study. The development of frequency synchronization technology in the telecommunication networks is also in progress.

PHASE-NOISE SYSTEM

We have established a phase-noise measurement system including a phase-noise standard (1,5,10,100 MHz), a single-channel noise detector, a delay line unit, and a single-channel signal analyzer. The noise reference is from a hydrogen maser and the noise level is about –165 dBc/Hz (5 MHz PM at a Fourier frequency of 100 KHz). For a passive device, the phase-noise standard can measure up to –177 dBc/Hz. For measuring carrier frequencies different from 1, 5, 10, and 100 MHz, we use an HP 8662A frequency synthesizer as the noise reference. We also plan to measure the very short-term stability ($\tau < 0.5$

second) by using this phase-noise measurement system, since the traditional time-interval counter is applicable only when τ is about 1 second. The cable delay at variable carrier frequencies can also be measured when the signal is propagating through. Those capabilities provide a new method for evaluating the performance of an active device like an oscillator and a power supply, or of a passive device like a long cable and a distribution amplifier.

We are planning to build a cross-correlation system, which can measure the noise 20 dBc/Hz below the phase-noise reference. All the primary national phase-noise standards will be finished and put into service this year.