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TIME AND FREQUENCY ACTIVITIES AT INTI

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RESUMEN

Este artículo resume las actividades desarrolladas en el área de Tiempo y Frecuencia en el laboratorio de Patrones Cuánticos, perteneciente al centro INTI-Física y Metrología del Instituto Nacional de Tecnología Industrial (INTI).

ABSTRACT

This article presents briefly the activities in the Time and Frequency area in the Laboratory of Quantum Standards of the Centre INTI-Physics and Metrology at the National Institute of Industrial Technology (INTI).

Key Words: standards — time

1. INTRODUCTION

INTI is legally the National Metrology Institute (NMI) in Argentina. It has been designated by the law No. 19 511 and the decree No. 788/03 as the institute responsible for the realization and maintenance of the units in the Argentinian Legal Metric System (SIMELA). This activity consists specifically in realizing, reproducing and maintaining the national standards of measurement, and disseminating their accuracy.

Concerning the Time and Frequency area, INTI has a laboratory adequately equipped (see Figure 1) for realizing and maintaining the units of time (second) and of frequency (Hertz).

2. CONTRIBUTION TO THE REALIZATION OF INTERNATIONAL ATOMIC TIME (TAI)

There are three governmental institutions in Argentina contributing data to the realization of TAI: INTI, the Instituto Geográfico Nacional (IGN) and the Observatorio Naval Buenos Aires (ONBA). INTI participates in the realization of Coordinated Universal Time (UTC) sending regularly clock data to the International Bureau of Weights and Measures (BIPM), located in Sèvres, France. Consequently, it maintains a local realization of UTC that is denominated UTC(INTI).

In parallel, INTI is part of the network of laboratories in the Time and Frequency Metrology Working Group (TFMWG) to which belong the NMIs members of the Inter-American Metrology System (SIM). As today, 19 countries participate in this group providing atomic clock data automatically and almost in real time. These data are sent to a main server located at the National Institute of Standards and Technology (NIST) and to complementary servers at the Centro Nacional de Metrología (CENAM, Mexico) and at the National Research Council (NRC, Canada). These servers simultaneously receive clock data from the NMIs in the TFMWG at ten-minutes intervals over 24 hours. Data are accessible at `http://www.tf.nist.gov/sim/` in the form of a grid that provides the values of GPS time - SIMT[2] for each participating laboratory.

Fig. 1. From left to right: GPS satellite, GPS constellation, SIM antenna and time transfer system, caesium clock.

This system provides also the information on the satellites tracked, the differences between the GPS time and the local time (in nanoseconds), their maximum and minimum values, the length of the track, the azimuth and the elevation of the satellites.

A specially designed software transforms the data [GPS time - UTC(INTI)] into the standard format of time transfer data for the BIPM, CGGTTS (CCTF GPS GLONASS Time Transfer Standard), and automatically posts this information in a server of the BIPM for contributing to the realization of UTC. The results, expressed as values [UTC-UTC(INTI)] at five-day intervals are published each month to-

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[2]For those laboratories in the TFMWG of SIM contributing to UTC at the BIPM, SIMT corresponds to UTC.

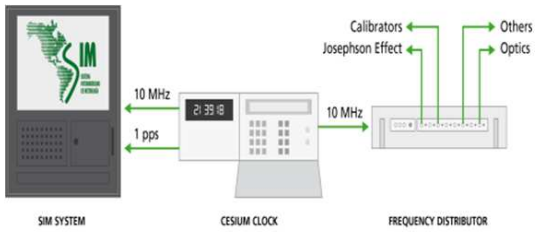

Fig. 2. Scheme of the distribution of the reference frequency at INTI.

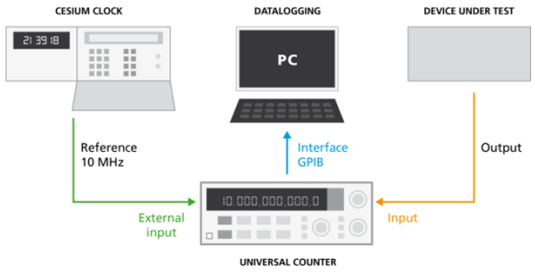

Fig. 3. Scheme of measurement at INTI of the internal time system of an oscillator using the caesium clock as the reference.

gether with those of other institutes, in a publication of the BIPM named Circular T.

3. CONTRIBUTION TO THE PILOT EXPERIMENT RAPID UTC (UTCR)

The institute has recently put into operation a new system for time transfer developed by the NIST and the CENAM. This system collects time transfer data at one-hour intervals along the day, and sends them to a server located at the BIPM. These data contribute to the experimental phase of the implementation of a rapid UTC at the BIPM.

4. INTERNAL SERVICES AT INTI

The units of time and frequency are those of the International System of Units (SI) realized with the highest accuracy; they provide a reference to the realization of other units, such as the volt and the metre.

Our laboratory provides traceability to time and frequency to the national standards of measurement maintained at INTI. Figure 2 shows the structure of the equipment used to obtain the 10 MHz signal from the caesium clock using a frequency distribution amplifier. This signal is provided internally to the laboratory at INTI realizing the unit of electromotive force (Josephson effect), the unit of length (frequency comb), the calibration of the frequency of optical stabilized lasers, and other applications.

INTI also provides traceability to independent private calibration laboratories and to those that integrate the SAC network (Argentinian Service of Calibration and Measurement). This network is integrated by calibration laboratories under the supervision of INTI which provide services of calibration, measurement and testing, and extend calibration certificates traceable to INTI to more than one thousand small and medium-size enterprises.

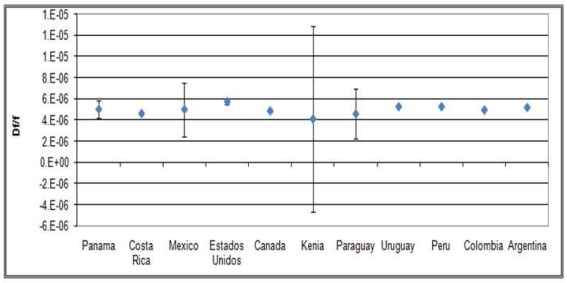

Fig. 4. Plot with the results of the SIM-TFMWG comparison.

5. CALIBRATION SERVICES TO CLIENTS

INTI provides several services in the area of time and frequency such as calibration of frequency-metres, time interval counters, oscillators, GPS receivers, digital stop-watches, etc.

Figure 3 shows the scheme for a frequency calibration using the caesium clock in the laboratory, traceable to UTC, as the reference. A time interval counter (TIC) connected to a computer via an interface GPIB allows the automatic uploading of data for their treatment with home-made software. This software provides options on different configurations depending on the type of measurement. Concluding this process, a certificate of calibration is emitted informing on the instability, the fractional deviation of the frequency (δf/f) and the average frequency of the calibrated time device.

6. INTERNATIONAL COMPARISONS

An effective method for determining the calibration uncertainties is realizing comparisons with other NMIs. In particular, international comparisons within the Americas Region are organized within the SIM-TFMWG. The eleven laboratory members of

this group, including INTI, participated in a comparison with a travelling stop-watch that was calibrated following the method adopted by each laboratory. The National Metrology Institute in Panama (CENAMEP) acted as the pilot laboratory, and was charged with the measurement collection and processing. The results of the comparison are presented in Figure 4; the relative deviation for each participant is plotted with the respective uncertainty.

7. FUTURE DEVELOPMENTS

GPS receivers from clients need to be installed at INTI during several days for their calibration. INTI is developing a strategy of remote calibration that will simplify the operations. The technique is similar to that in use for some clock comparisons in TAI, consisting of simultaneous observations of satellites (denominated "satellite common-view") with the reference receiver and the receiver under calibration.