

# Development of the Time and Frequency Laboratory of INACAL

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**Abstract** — This paper describes how the Time and Frequency Laboratory of INACAL has been developed and what capability it has to obtain, provide and disseminate the Official Time of the Republic of Peru with the required accuracy and the adequate traceability to the Coordinated Universal Time (UTC). This paper also indicates how the laboratory has been developed in order to provide several calibration services in Time and Frequency with traceability to the UTC.

**Keywords** — Time and Frequency Laboratory; Official Time.

## I. INTRODUCTION

Nowadays to perform various activities in a country it is necessary to have a unique national time reference in order to ensure that national levels of synchronization are appropriate and that these are adequate in the international links. For this reason, in Peru, the Peruvian Navy has been offering for several years the Official Time of the Republic of Peru due to the fact that at the time it was designated this function, it had the equipment necessary to perform this function.

In recent years, the Peruvian Navy no longer had all the necessary equipment to carry out this function, so that the SNM (Servicio Nacional de Metrología, National Metrology Service) of INDECOPI, now Metrology Direction of INACAL, in 2009 saw the need to acquire various equipment to develop the Time and Frequency Laboratory, mainly to maintain and disseminate a time reference in the country (a National Time), as well as to take advantage of this equipment in order to be able to offer various calibration services in Time and Frequency with traceability to the UTC.

With all the appropriate equipment in 2010, an agreement was signed with the Peruvian Navy so that our laboratory provides them the time reference, in such a way that this institution can continue to disseminate the Official Time in the country. This agreement was in force until 2015, when transfer from the SNM of INDECOPI to the Metrology Direction of INACAL was done. The Metrology Direction of INACAL began its labors in June 2015.

Through Law N° 30224 [1], in 2014, INACAL was created and through of Supreme Decree N° 004-2015-PRODUCE [2], in 2015, the functions of INACAL were indicated for subsequently to start its functions as a new institution in this

same year. Supreme Decree N° 004-2015-PRODUCE indicates that one of the functions of the Metrology Direction of INACAL is "maintain, coordinate and disseminate the Official Time of the Republic of Peru", so that INACAL since 2015 is the institution responsible for providing the Official Time in the country, a function that it has been carrying out to the present.

## II. OFFICIAL TIME OF THE REPUBLIC OF PERU

The Official Time of the Republic of Peru is provided by INACAL through the National Time Standard [3] of the Metrology Direction of INACAL. The National Time Standard reproduces the second (s) through the output signal of one pps (pulse per second) of our Symmetricom 5071A Cesium Oscillator. This signal is used as a synchronization signal to be sent to our Meinberg M300 Network Time Protocol (NTP) Server, disabling the GPS that it uses to obtain a Local Time, to start generating from a Local Time, at an arbitrary time, the National Time controlled by the output of one pps from our Cesium Oscillator. The time signal that is obtained from our NTP Server is sent to the web server of INACAL so that finally INACAL can disseminate (via our web site and via NTP) the Official Time of the Republic of Peru. Figure 1 shows a photo of the National Time Standard of the Metrology Direction of INACAL.

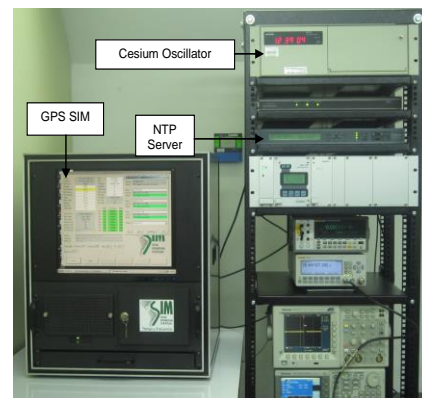


Figure 1. National Time Standard of the Metrology Direction of INACAL.

Through the INACAL website you can find the link "*Hora Oficial del Peru*" (Official Time of Peru), in where you can observe the Official Time of the Republic of Peru. By entering this link you can locate the steps to follow so that any user or company in the country can synchronize their watches or servers with the Official Time provided by INACAL for free of charge providing currently this time signal to various companies in the country (such as Telecommunications companies, broadcasting, banks, municipal savings banks, among others). INACAL in 2016 signed an agreement with the Peruvian Navy to provide them this time reference.

### III. TRACEABILITY OF THE TIME AND FREQUENCY LABORATORY OF INACAL

In the Time and Frequency Laboratory of the Metrology Direction of INACAL is distributed a 1 pps signal and a 5 MHz signal provided by our Symmetricom 5071A Cesium Oscillator. This standard oscillator contributes to the maintenance and creation of the "*SIM Time Network*" [4], which is a network of continuous comparisons of various standard oscillators of Inter-American Metrology System (SIM) countries.

Thanks to this tool we obtain valid traceability to the UTC through NIST, CENAM or NRC, which are National Metrology Institutes (NMIs) that participate in the SIM Time Network and also contribute to the maintenance of UTC.

Through the web page of the "*SIM Time and Frequency Metrology Working Group*" you can locate and select the link "*SIM Time Network (USA)*" in where this network of comparisons is given and locating in our case the link "*Peru SIMT (INCP)*" you can see the time difference in nanoseconds (ns) of our standard oscillator with respect to the standards of other NMIs in this network of comparisons. By selecting this link you can observe the behavior of our standard oscillator. We can use this information to make adjustments when necessary in time or frequency to our standard oscillator.

Figure 2 shows the behavior for 30 days of the standard oscillator of the Time and Frequency Laboratory of INACAL in where you can observe how our time varies from a value around 25 ns to a value around 70 ns, presenting an average error of about 50 ns. For this case our standard oscillator has a fractional deviation of average frequency less than  $4 \times 10^{-15}$ .

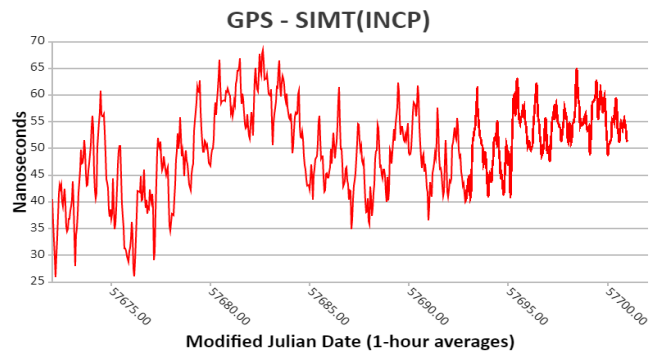


Figure 2. Behavior of the standard oscillator of the Time and Frequency Laboratory of INACAL for the period from October 8<sup>th</sup> to November 8<sup>th</sup>, 2016.

Through this web page you can also locate the link "*SIM NTP Comparisons*" [5], where it gives a network of NTP Server comparisons and placing in our case the link "*Peru*" you can see the time difference in milliseconds (ms) of our NTP Server related to the server of some other NMI that participates in this network of comparisons. In the case that this difference exceeds the value of 50 ms, this difference will be shown in red color as an alert signal for the NMIs to take the actions of the case. Selecting this last link you can observe the behavior in time of our NTP Server. Finally this information helps us to know the difference in time of the time signal sent by our NTP Server to any external user.

Figure 3 shows the behavior in 30 days of the NTP Server of the Time and Frequency Laboratory of INACAL in where you can observe the error in the time of our NTP Server, for example varying normally from around 0 ms up to around 30 ms, presenting an average error of about 10 ms.

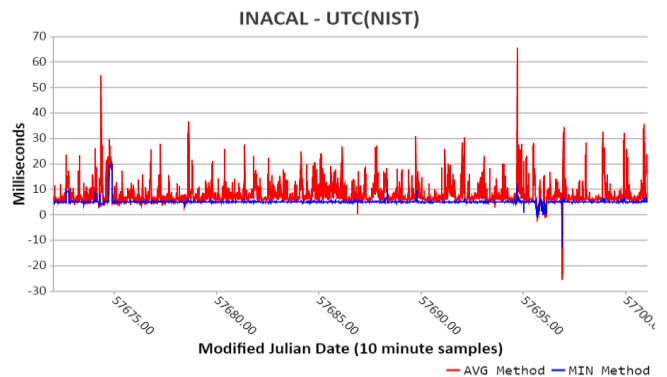


Figure 3. Behavior of the NTP Server of the Time and Frequency Laboratory of INACAL for the period from October 8<sup>th</sup> to November 8<sup>th</sup>, 2016.

Finally with traceability to the UTC, the 1 pps signal from our standard oscillator is used to obtain and maintain the National Time in the country while the 5 MHz signal is used to improve the time base of the laboratory equipment such that they obtain valid traceability to the UTC. Figure 4 shows the traceability chain of the Time and Frequency Laboratory of INACAL.

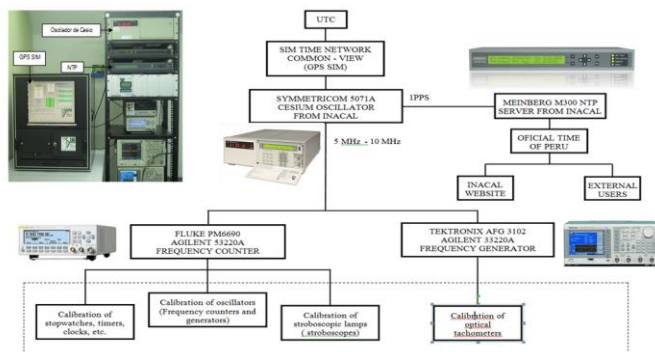


Figure 4. Traceability chain of the Time and Frequency Laboratory of INACAL.

#### IV. HISTORY OF DEVELOPMENT OF THE TIME AND FREQUENCY LABORATORY

The Time and Frequency Laboratory was developed principally to maintain and disseminate a time reference in the country, which has been done since 2010, and since 2015, INACAL provides this time reference as Official Time in the country, date in which INACAL began its functions as a new institution. On the other hand since its creation the laboratory has been participating in various activities and performing various works to meet the demand for calibration in the country in the magnitude of time and frequency, which are indicate below:

Between 2009 and 2010 a measurement system was developed in the laboratory to be able to calibrate stopwatches with the minimum possible uncertainty, without the need to turn on the instrument and only in this case measuring the frequency refresh of LCD of the instrument. This paper was presented in 2013 in the X SEMETRO with the title “*Calibración de cronómetros digitales por el método de inducción con una incertidumbre de medición  $\leq 1 \mu\text{s/s}$* ” [7].

In 2010 the laboratory participated in a comparison of stopwatches in the SIM region obtaining a consistent result, which shows that the measurement system for the calibration of stopwatches of the laboratory is adequate. This comparison was published in 2011 in the NCSLI Measure journal with the title “*An interlaboratory Stopwatch Comparison in the SIM Region*” [6].

Between 2010 and 2011 we developed in the laboratory a generator system of light pulses to perform the calibration of optical tachometers by direct measurement. This paper was presented in 2014 at CPEM 2014 with the title “*Calibration of optical tachometers using a generator system of light pulses*” [8].

In 2011 with the equipment that was in the laboratory we developed the calibration service of frequency counters and generators by directly measuring the time base of these instruments.

In 2012 we received by donation of the NIST a Symmetricom 5071A Cesium Oscillator, which replaced our Symmetricom 8040C Rubidium Oscillator as the reference standard of the laboratory. This equipment allowed improving our level of accuracy and at the same time to have a primary standard of time due that the definition of the second is derived from Cesium.

In 2012 was carried out the peer review of the laboratory and in 2013 was presented the quality system of the institution so that in 2014 were finally approved the Calibration and Measurement Capabilities (CMCs) of the laboratory, which are currently published on the International Bureau of Weights and Measures (BIPM) website.

Between 2012 and 2013 was developed in the laboratory a frequency measurement system to perform the calibration of stroboscopic lamps or stroboscopes by direct measurement. This paper was presented in 2016 at the Simposio de Metrología 2016 (2016 Metrology Symposium) of CENAM with the title “*Calibración de estroboscopios utilizando un sistema de medición de frecuencias*” [10].

In 2013 the Symmetricom 5071A Cesium Oscillator of the Metrology Direction of INACAL (before SNM of INDECOPI) was declared as National Time Standard due the institution already had a system of time generation that guarantees traceability to industry, science and technology within the national scope. The National Time Standard was declared together with other standards of the institution according to Resolution of SNM N° 001-2013/SNM-INDECOPI with the title “*Patrones Nacionales de Medición para las Magnitudes de Volumen, Conductividad Electrolítica y Tiempo*” [3].

Between 2013 and 2014 a measurement system to be able to calibrate stopwatches by directly measuring the frequency of the time base of the instrument was developed in the laboratory. This paper was presented in 2015 in the XI SEMETRO with the title “*Medición de la base de tiempo del cronómetro digital por el método de inducción*” [9].

In 2015 a TAI-1 Time Transfer Receiver was received by donation of the NIST in order to contribute directly to the UTC. In 2016 the equipment was put in operation to send data to the BIPM and to participate in the key comparisons of time and frequency. At the moment INACAL is in a test state to be able to perform this function and it is expected that by 2017 Peru will be able to contribute to the maintenance of the UTC, which will allow us to be a reference in the SIM region.

It should be noted that by December 31, 2016, an additional second should be inserted at 0 hours UTC, which is a practice that is performed periodically for the UTC to coincide with the International Atomic Time (TAI). This is done by enabling the GPS priority of the NTP Server (which is used to obtain the Local Time) in such a way that it is updated automatically. After this upgrade, enabling priority of one pps from our Cesium Oscillator in the NTP Server is done in order to get the National Time again.

On the other hand in the web page of the SIM Time and Frequency Metrology Working Group, by selecting the link "Publications", you can locate the papers development in the laboratory that has been presented in different international metrology events.

#### V. SERVICES OF THE TIME AND FREQUENCY LABORATORY OF INACAL

Currently the Time and Frequency Laboratory of INACAL has all the necessary equipment to obtain, maintain and disseminate the Official Time of the Republic of Peru, as well as it has all the necessary equipment to be able to provide the following calibration services at the request of interested people or companies:

- Calibration service of stopwatches.
- Calibration service of optical tachometers.
- Calibration service of frequency counters.
- Calibration service of frequency generators.
- Calibration service of stroboscopes.

The laboratory has CMCs published in the BIPM website to perform these calibration services, except for the calibration service of stroboscopes, so the results issued by the Time and Frequency Laboratory of INACAL are recognized in any associated member country to Metro Convention Treaty, which created BIPM.

#### VI. CONCLUSION

This paper shows that the Time and Frequency Laboratory of INACAL was properly developed and that it has all the necessary equipment to obtain, provide and disseminate the Official Time of the Republic of Peru with the required

accuracy and traceability to UTC. In addition, INACAL now has international recognition in Time and Frequency and can offer calibration services with traceability to the UTC.

#### VII. ACKNOWLEDGEMENT

We thank the SIM Time and Frequency Metrology Working Group for their various contributions and constant support in the development of the Time and Frequency Laboratory of INACAL in the course of these years, especially to the NMIs from USA and Mexico.

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