Calibration of optical tachometers using a generator system of light pulses

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***Abstract* — In this paper, we described a generator system of light pulses, which is used to calibrate optical tachometers by direct measurement with a measurement uncertainty of less than or equal to 0,1 µHz/Hz.**

***Index Terms* — generator system of light pulses, calibration of optical tachometers.**

I. INTRODUCTION

For a long time the SNM performed the calibration of optical tachometers by the direct comparison method of a tachometer to be calibrated with a tachometer calibrated, using a measurement system conformed by a mechanic rotation system or by a stroboscopic lamp. This method was implemented with little equipment reporting a high measurement uncertainty due to the used standard and the stability of the measurement system. In order to improve the measurement system the SNM developed a generator system of light pulses, which generates periodic pulses of light onto the photosensor of the tachometer, so that the tachometer register a proportional reading (in rpm) at the generated frequency (in Hz), by means of the following relationship: 1 Hz = 1 rps = 60 rpm [1].

II. GENERATION OF LIGHT PULSES

A frequency generator, which is connected to a emitter circuit of light pulses capable of turning on and off a emitter diode of light pulses at the same frequency of the generated signal, is the responsible for sending a periodic signal of light pulses to the tachometer to be calibrated. The emitter circuit of light pulses is conformed by a conditioning circuit and a light emitter diode. The conditioning circuit consists of a transistor and a current limiting resistor. The transistor acts as a switch for rapid response onto the light emitter diode, converting the electrical pulses into pulses of light. An arrangement of a small lantern is used, which contains an ultra-bright white light emitter diode to cover most of the spectrum. Figure 1 shows the block diagram of the emitter circuit of light pulses.

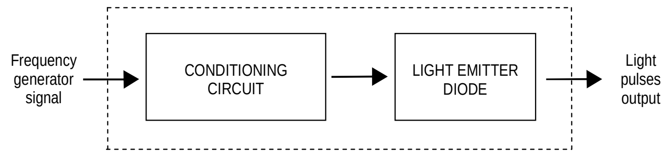

Figure 1. Block diagram of the emitter circuit of light pulses.

III. GENERATOR SYSTEM OF LIGHT PULSES OF THE SNM

In the Laboratory of Time and Frequency of the SNM a signal of 5 MHz, provided by our Symmetricom 5071A Cesium oscillator, is distributed. This standard frequency belongs to the SIM Time Network [3], which is a network of continuous comparisons of various standards oscillators of countries from the Inter-American Metrology System (SIM). Thanks to this tool we obtain valid traceability to the Coordinate Universal Time (UTC) through NIST, CENAM, NRC (institutes that participate in the SIM Time Network and also contributing to the maintenance of UTC). This standard frequency is used to improve the time base of our equipments. The generator system of light pulses is conformed by a frequency generator and an emitter circuit of light pulses. The Tektronix AFG3102 frequency generator is connected by external reference to the standard frequency of laboratory, obtaining valid traceability to UTC. Figure 2 shows a photo of the measurement system.

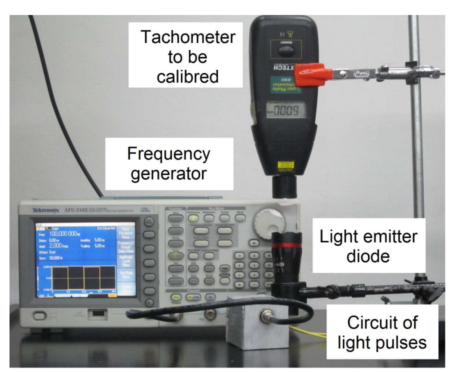

Figure 2. Photo of the generator system of light pulses of the SNM.

IV. NOISE CHARACTERIZATION OF THE GENERATOR SYSTEM OF LIGHT PULSES OF THE SNM

The generator system of light pulses is characterized to evaluate the noise of the measurement system and their continuous performance. For this reason it is necessary to have a verification circuit simulating be the tachometer to be calibrated, such that it detects and regenerates the periodic signal of the generator system of light pulses. The verification circuit is conformed of a system of reception of light pulses, compound by a phototransistor for converting the light pulses into a current signal; and a circuit for conditioning and regeneration of the signal, conformed by a resistor and a comparator for eliminate unwanted signals. In conclusion, the verification circuit regenerates the test signal in a square wave signal. Figure 3 shows the block diagram of the verification circuit.

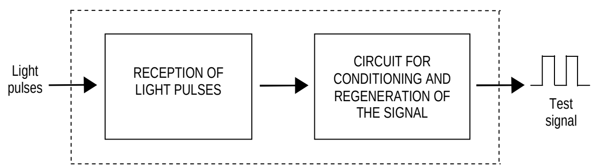

Figure 3. Block diagram of the verification circuit.

With the frequency generator we apply a test signal of 100 Hz in pulse mode with amplitude of 2 V to the emitter circuit of light pulses; the signal is captured and regenerated by the verification circuit. Then the test signal is measured with a frequency counter, verifying by this way its performance and immunity against external influences. The Fluke PM6690 frequency counter is connected by external reference to the standard frequency of laboratory, obtaining valid traceability to UTC.

We have historical information of more than 2 years performing continuously the noise characterization of the generator system of light pulses, for which we have seen that their contribution of uncertainty is less than or equal to 0,1 µHz/Hz, which is a value that does not affect the measurement because it is 1000 times less than the maximum permissible error of an optical tachometer, currently considered in the order of 100 µHz/Hz (0,01%). In effect, Figure 4 shows the stability obtained in the noise characterization of the generator system of light pulses in terms of the square root of the Allan variance ($\sigma(\tau)$) [2] using the AMTyF software [4], obtaining a value around than 0,01 µHz/Hz (1 x 10^{-8} Hz/Hz). Take into account that the square root of the Allan variance includes the uncertainty associated with each individual measurement. This uncertainty is generated by the measurement system due to various parameters, including the most important components of the total uncertainty.

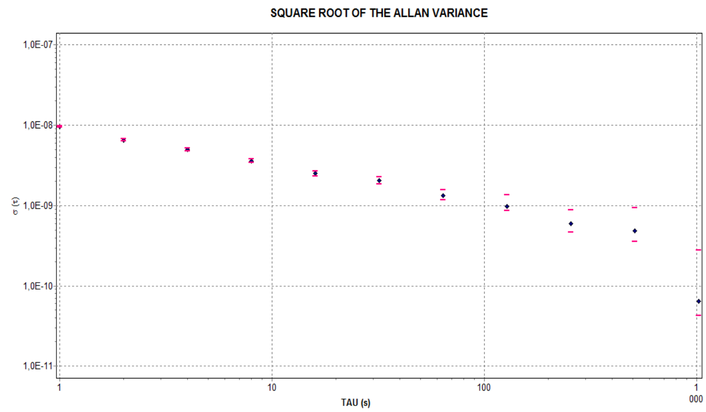

Figure 4. Noise characterization of the generator system of light pulses in terms of the square root of the Allan variance.

V. CONCLUSION

This work shows that it is possible to calibrate optical tachometers using a generator system of light pulses with a measurement uncertainty of less than or equal to 0,1 µHz/Hz.

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