The quantity time relation in the ionizing radiations

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Abstract: The area of metrology has taken a step forward with regard to the calculation of uncertainty. This mathematical tool used in laboratories is essential to ensure that the values resulting from a measurement are reliable. For this to be possible, all equipment used in a measurement process must be reliable and, above all, traceable to the international metrology system. We propose to present in this work: (i) the development and calibration of a microcontrolled time device with a resolution of 1x10-4 s, in order to characterize the time greatness and make it reproducible; (ii) the calibration of the quartz clock present in a computer present in the dosimetry laboratories; (iii) a more in-depth study of the influence of time quantity on calibrations of instruments used in the area of radiological protection, diagnostic radiology and radiotherapy, with measurements performed on the Kerma magnitude in air or its rate;

Keywords: Calibration, Time, Uncertainty, Ionization Chamber.

1. INTRODUCTION

The continuous quality of life improvement, the research for knowledge of the input quantity related to ionizing radiations used in radiodiagnosis, radiotherapy and radioprotection, determining the quantity specific and/or their ratios, as well as the reduction of unnecessary doses exposure of workers and public, safety respecting for ionizing sources handling which are: time of exposure, distance and shielding. In this way, exposures in the areas surrounding the dosimeter should be guaranteed as low as reasonably possible, taking into account social and economic factors known as the ALARA principle (REF: Standard 3.01)

The ionizing radiation reference dosimetry is based on the instruments calibration used in laboratories, hospitals, clinics, inspections, industries among many other applications.

Therefore, ionizing radiation quantities measurement used as reliable and reproducible way [1], maintaining, tracing and disseminating according to international standards and the international system units (Ref. TRS457, TRS398, ICRP, IEC , SI).

In order to realize these quantities measurements, with and without radiation and their ratios, it will be necessary to correlate the instrument or suitable material measurement, charge accumulated in a time interval, in seconds.

In order to uncertainty contribution evaluate of a time measurement device, defined as the elapsed time between two events, a microcontroller device, a universal counter, and a computer timer are compared to a traced cesium standard.[2]

The time quantity measurement as ionizing radiation measurement system input quantity occurs when the device begins its measurement and after a time interval has elapsed, it ends.

2. THOERY FUNDAMENTATION

The quantity integral or its ratio is correlated with the elapsed measurements at a time interval given, that way the quantity time and frequency must be taken into account, both in the correction coefficient and its associated uncertainties.[3]

Because the measurement, in the initial and final recording case on the device or counter, will follow a equipment itself probability distribution.

The uncertainties analyses increasing the need to arising from traceability automated systems takes place in the quantity time in the computer or operating system, at first without analyses integrated system and memories the use of the computer used.[4] Thus, the uncertainty comparison function between the quantity time instruments will follow equation (1).

$$U_c^2(d) = u^2(\Delta t) + u^2(disp1) + u^2(cont) + u^2(l_s) \quad (1)$$

Where U(d) is the comparison expanded uncertainty, u(Δt) is the elapsed time uncertainty, u(disp1) is the device 1 uncertainty, u(cont) is the counter uncertainty and $u(l_s)$ is the calibration standard uncertainty.

At this method, the evaluated uncertainty were considered all input quantities independent, between the quantity time and the measurement systems, but all probability distributions will be taken into account.

The computer time absolute accuracy was determined by elapsed time comparison between the computer's stopwatch and the reference counter.

Although, the absolute accuracy of measurement were useful, but at this results comparison were taken the standard time measurement as reference for relative time computer.[2]

3. MATHERIALS AND METHODS

The partnership development between the Primary Time and Frequency Laboratory (LPTF) of the Division of Time Service (DISHO / ON) and the National Laboratory of Ionizing Radiation Metrology (LNMRI) of the Institute of Radioprotection and Dosimetry (IRD / CNEN) could be possible the method development comparison using the equipment and components below:

- Standard Cesium – CSAC, made by Symmetricom, model AS.45s (Chip Scale Atomic Clock).

- Universal Counter, made by Fluke, model PM6681 (High Resolution Programmable Time/Counter Analyzer).

- Microcontroller, made by Microship, model ATMEGA328P.

- Personal Computer, made by HP, processor AMD Phenom(tm) IIx4 B95 3.00GHz, memory RAM de 4.00GB, operational system Windows 7 professional - 64 Bits.

3.1. Comparison

The 10 MHz frequency from Cesium standard output thought BNC - J3, plus BNC – type T, is connected to the Universal Counter input, using the BNC - IN Reference connector whith also in channel A input has another BNC - type T connector.

This parallel connection series was to obtain the same frequency of 10 MHz at cesium standard reference, Microcontrollers devices (PPS) and Counter systems, figure 1.

The range measurements Microcontroller system were 600, 1200, 1800, 2400, 3000, and 3600 PPS, where an initial start pulse was sent to each PPS value for the Universal Counter BNT - EXT ARM connector on the back side to Microcontroller and to computer timer.

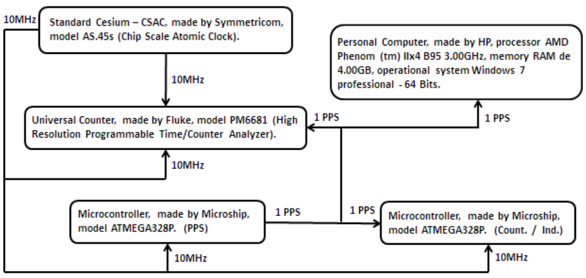

Figure 1. Connection diagram from Standard Cesiun at Microcontroller device and to computer timer.

Simultaneously start the time counting on the three time indicators. After select elapsed time desired, the final pulse - Stop, were sent to the systems, again simultaneously interrupting the time count, thus start the new measurement, by sending another pulse.

The quantity time mean and standard deviation from five data measurement was given by the range from 600, 1200, 1800, 2400, 3000 and 3600 s.

3.2. System device.

3.2.1. Microcontroller

The device uses as base of time an cesium atomic standard, reference standard for measurement of the time quantities, with $1x10^{-4}$ of resolution.

Made by Microchip Technology / Atmel from ATMEGA family 328P, model MCU AVR 32K FLSH 1K EE2K SRAM - 20MHz, with 8 - bit microcontrollers.

It had two operation stages; the first one is to provide the pulse per second, nomed PPS, in order to start counting simultaneously between the microcontroller, the universal counter and the personal computer. After the programmed elapsed time interval has another count end pulse.

2.2.2. Personal computer.

The measurement of the time quantity relative to the personal computer was carried out through the LABVIEW platform, specifically developed for this comparison.

The third PPS pulse was clear the display, them at the LOG A field the program data was record.

3.3. Calibration: Microcontroller and personal computer.

The temperature and humidity ambient conditions range measurement was performed under with of (24 ± 2) ºC and (40 to 70)%, respectively.

The cesium atomic standard, as reference for the calibration between the microcontroller device and the personal computer was obtained by comparing the final and initial measurements.

4. RESULTS

Tables 1 and 2 present the results of the calibrations of the microcontroller device and the personal computer in relation to the cesium standard, respectively.

Table 1. Microcontroller device calibrations results.

Nominal Value (s)	Correction (s)	Expanded Uncertainty (± s)	Coverage Factor (K)	Effective Degrees of Freedom (Veff)
600	0.00012	0.00013	2.0	72
1200	-0.00003	0.00012	2.0	>1000
1800	-0.00002	0.00014	2.0	61
2400	0.00012	0.00013	2.0	73
3000	-0.00003	0.00014	2.0	63
3600	-0.00004	0.00012	2.0	355

Tabela 2. Personal computer calibrations results

Nominal Value (s)	Correction (s)	Expanded Uncertainty (± s)	Coverage Factor (K)	Effective Degrees of Freedom (Veff)
600	0.01	0.00	2.9	4
1200	0.05	0.04	2.9	4
1800	0.04	0.01	2.9	4
2400	0.01	0.01	2.9	4
3000	0.04	0.01	2.9	4
3600	0.07	0.00	2.9	4

Table 3 shows the average relative accuracy of the personal computer obtained from the collection of three samples. One, two and three hours, respectively.

Table 3. Results table for relative computer accuracy (pc) in 3 hours.

Average ($s . s^{-1}$)	Expanded Uncertainty ($\pm s . s^{-1}$)	Coverage Factor (k)	Effective Degrees of Freedom (Veff)
18.5E-6	0.60E-6	2.9	4

Figure 2 shows the plot of the correction - time difference between the standard meter and the microcontrolled device - with their respective uncertainties considering a coverage factor k = 2.9.

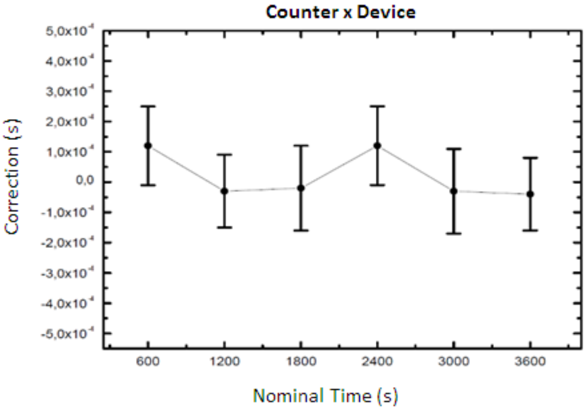

Figure 2. Correction chart x time referring to the time difference between the counter and the device.

5. CONCLUSION

It can be observed that, in both Table 1 and Figure 2, the microcontroller device presented a correction in the order of quantity of 10^{-4} and, therefore, showed good reproducibility and could therefore be used in laboratories as a standard device.

Regarding the computer calibration, we can observe that U = 40 ms, having as a discrepant point, the uncertainty referring to the interval of 1200 s.

Observing table 3, it is verified that the measurement of the time quantity relative to the personal computer, obtained an average relative precision of 18.5 µs and with a measurement uncertainty of 0,60 µs considering a coverage factor k = 2.9. To know how much the personal computer clock delays per day, multiplies the relative accuracy of the computer by 86400 which is the amount of seconds that a day has, arriving at a delay of 1.60 s / day on that personal computer.

5. REFERENCES

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