LONG-TERM STABILITY OF RHODE & SCHWARZ QUARTZ CLOCKS

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ABSTRACT. Modern time measurements in Romania started in 1967 with the installation of Rhode & Schwarz Quartz Clocks. The paper shows both the evolution of these measurements and the stability of the system, which became a few times better than in the beginning, 35 years ago. The evolution of the original R1, R2, R3, R4 oscillators was analyzed. After 1994, the receivers were connected to a digital chronometer, in order to perform the acquisition of the measuring data. New comparisons of R1, R2, R3 with M1, M2, M3 quartz clocks and GNST GPS receiver were made.

1. THE 1967 - 1990 PERIOD

In 1967, at Bucharest Astronomical Observatory a system of quartz clocks, model Rohde & Schwarz was installed. The system was made up of 4 frequency standards, XST type, with crystal oscillator and a complete set of accessories, including a comparing oscilloscope and signal receivers. The estimated standard stability (aging after 100 days of operation) was maximum 2×10^{-9}. The four frequency standards denominated RS1, RS2, RS3, RS4 were in operation in the interval 1967 - 1990.

Their main work was to synchronize and guide sidereal clocks and secondary clocks in the institute, as required by the status of Time Service Department. At the same time, the functional parameters were measured by means of time signals comparisons for RS1, RS2, RS3, RS4 using the oscilloscopic method and intercomparisons between clocks and time signals.

The Zeiss Transit Instrument was used for the study of irregularities of Earth Rotation, connected with the rezults of BIH and IPMS. An interesting, new method of time system inter-comparison, by means of television signals, was proposed by Vladimir Ptacek (Prague Astronomical Observatory) and Victor Stavinschi (Bucharest Astronomical Observatory). The accuracy was of the order of milliseconds.

The quartz clocks were also compared using the so called "flying clock" method, initiated by Hewlet Packard Company. The Earth Rotation research group also joined MERIT campaign, performing observation and time comparisons. Visual observations were stopped in 1988 due to the MERIT conclusion.

Between 1982-1985 a set of hydrogen masers, built by the Romanian Institute of Materials Technology was installed in the Astronomical Institute. Victor Stavinschi, the chief of Time Service, started to test the accuracy and the stability of the new frequencies standards. The results were not satisfactory in comparison with the old Rohde&Schwarz clocks. The measurements were performed in order to determine the parameters of frequency standards, determined frequency standards errors, relative error in frequency, daily variation of relative error in frequency, sidereal time error, frequency dependence by ambient temperature and frequency dependence by power supply. The measurements performed in order to determine the parameters of frequency standards related to comparisons of time signals for RS1, RS2, RS3, RS4 by means of the oscilloscopic method and also the relative error in frequency and daily variation of relative error in frequency. To determine the sidereal time errors the coincidence method has been used with a CAO comparing oscilloscope. These measurements has been performed continuously.

2. DEVELOPMENTS FROM 1990 TILL NOW

After 1990, the RS3, RS4 were eliminated due to their frequency - different with 1.1×10^{-6} (RS3) and 1.8×10^{-6} (RS4) from the nominal one. In 1994, RS3 started operate with a new crystal oscillator, mounted by Tiberiu Bocaniciu, the chief of Time Service. Due to their instability, maser clocks were discharged from the system, only their Thompson quartz clocks remaining in operation, named M1, M2, M3, with a standard stability of maximum1.0×10^{-10}.

In 1998, a GPS time receiver type GNSS 300T was mounted in order to receive both GPS and GLONASS signals, with an error of $\pm 0.1 \mu s$ from UTC. It is possible to determine the error of the compared standard $\pm 0.1 \mu s$, instead of $\pm 1.0 ms$ by the time signal comparison. A computer assists all the measurements, performed with an accuracy of $0.1 ns$.

By means of the method of BIPM, the Group standard (RS1, RS2, RS3, M1, M2, M3) made of these 6 frequency standards was established. The polynomial coefficients of the evolution of the clocks were computed and a prognosis of the evolution of their mean error was made. The differences between the prognosis and the results didn't exceed $\pm 0.1 ms$.

3. COMPARISON RESULTS

Statistical studies were continuously performed in order to have a complete image of the process. We have tried underline the Rode & Schwarz clocks, their stability and fiability.

The results are contained in the following figures.

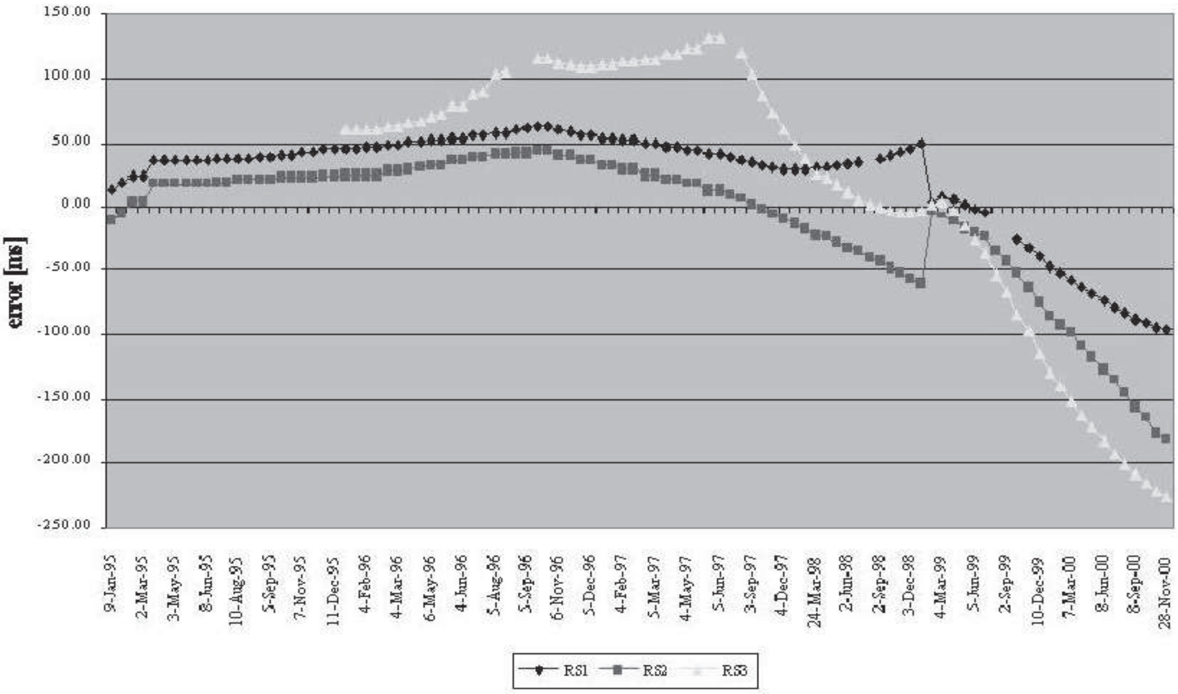

Figure 1. Time differences RSi - UTC.

From the graph one can see the better correlation of the RS1 and RS2 frequency standards with UTC. After the adjustment from 1999, we have noticed that the slope increased due to the frequency variation.

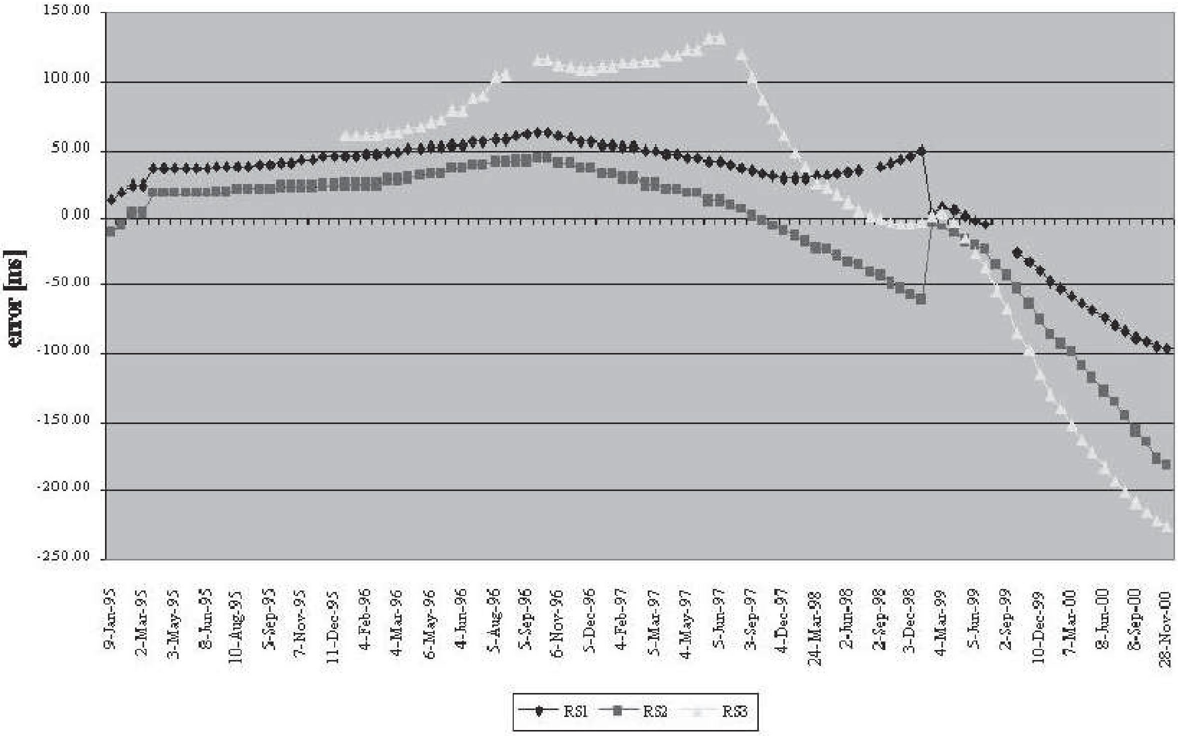

Figure 2. Frequency long term stability.

For the standards R1 and R2, their frequency variations were positive and the linear time dependent; R3 having a new crystal, his stability is not of the same order. The monthly variation of relative frequency for RS1 and RS2 standards were 1.4×10^{-10} and 0.4×10^{-10}, respectively. Annual variation is less than 17×10^{-10} and 6×10^{-10}, respectively. The values of the frequency stability, computed with Allan's formula are, for RS1, RS2 and RS3, $0.11, 0.09, 0.22(\times 10^{-10})$, respectively.

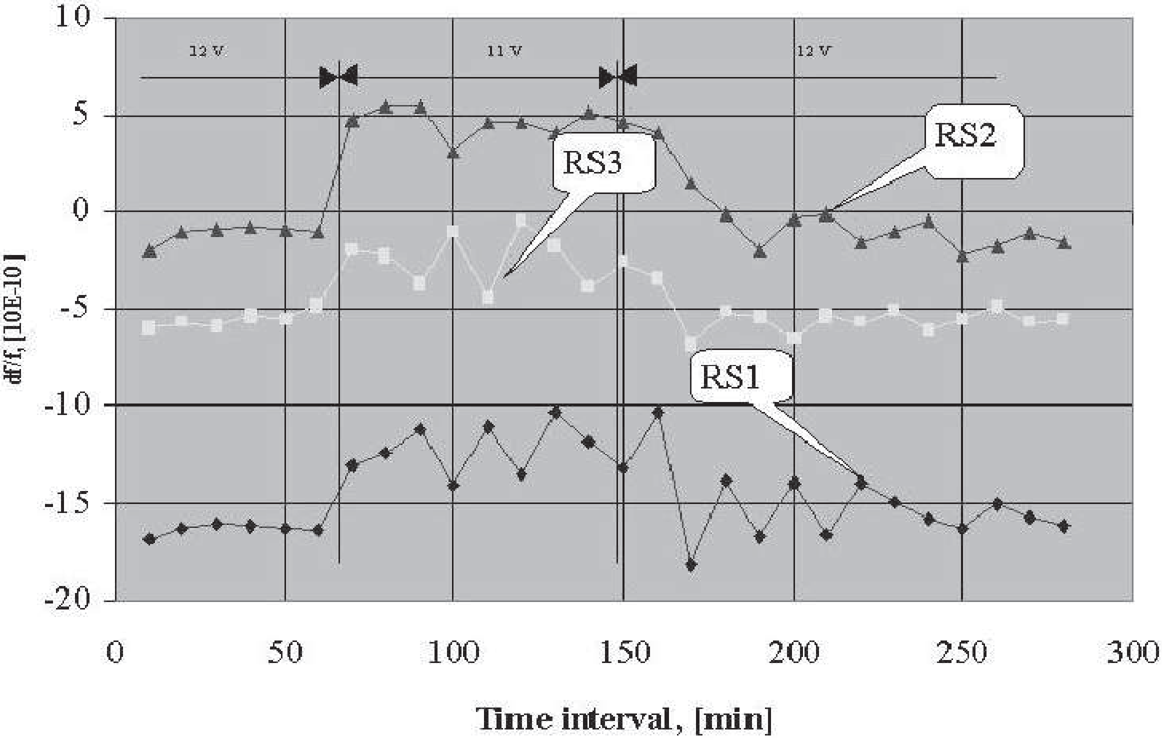

Figure 3. Effect of operating voltage.

A variation of 10% of the power voltage determined a 5×10^{-10} variation of the relative frequency of the standards.

In a similar way a temperature variation of 10^0C implies a variation of the relative frequency less than 1.0×10^{-10}.

4. CONCLUDING REMARKS

The evolution of Rohde&Schwarz frequency standards which was analyzed shows that the stability of the system has become a few times better than in the beginning, 35 years ago. In spite of the fact that the system is old, it represents a good time reference for astronomical observations connected with the GNSS 300T GPS receiver.

5. REFERENCES

Stavinschi, M. : 1984, *St. Cerc Fiz.*, **36**, 448. Bocaniciu, T., Paraschiv, P., Stavinschi, M., Popescu, P., Popescu, R.: 2001, *Proceedings of International Conference of Metrology*, Bucharest, 18-20 Sept. 2001, vol. 3, 641.