Very New Small OCXO With Low Short And Medium Term Noise And Low Thermal Sensitivity

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***Abstract*—RAKON has developed a new 10MHz integrated OCXO in a very small package (51.3*41.3*14.2 mm^3) for the use of cleaning the atomic clock noise in short term medium term. We present the product and its performances.**

The main characteristics, obtained with our new platforms: "ROX5242T1N" (OCXO operating at 10MHz and fitted with SC cut 3rd overtone quartz crystal resonator), are:

- **thermal stability over – 40°C to +85°C better than 5E-11 (T1 Class),**
- **residual ageing less than 1E-10 per day,**
- **short term stability (Allan deviation) at a few parts in 1E-13 for t = 1s to 1000s,**
- **package: 51.3 x 41.3 x 14.2 mm^3,**
- **compatibility with 12V and 5V supply voltage,**
- **digital or analog frequency control,**
- **phase noise L(f):**

At	**1Hz**	< -110dBc/Hz
	10Hz	< -140dBc/Hz
	100Hz	< -155dBc/Hz
	1000Hz	< -160dBc/Hz
	10000Hz and over	< -163dBc/Hz

I. INTRODUCTION

OCXO's are always required to clean the atomic clock noise in short term and medium term [1] or are also used in the instrumentation as a frequency and phase reference. Decades after decades, the dimension of the clock device has been reducing continuously, but in the same time, the clock demands better performances to the OCXO in short-term and phase noise. That's why RAKON has developed a new 10MHz integrated OCXO in a very small package (51.3*41.3*14.2 mm^3). We will present the product, its performances and the method to measure them.

II. METHODS/RESULTS

Knowing the performance of our high end resonators in term of short-term ([2] and [3]), thanks to the reduction of the dimension of the OCXO and of the resonator for Telecom application and thanks to the new digital components and processes, we could develop an OCXO with these three combined items and a system to measure the short-term of 12 parts in parallel with the adapted precision.

III. OCXO DESIGN

Fig. 1. ROX5242T1N package (51.3 x 41.3 x 14.2 mm3)

In figure 1, we can see the dimensions of the product. They reduce compared to the previous design [2] given equivalent performances. To achieve a good medium term stability, we had to reduce at the maximum the sensitivity of the OCXO to

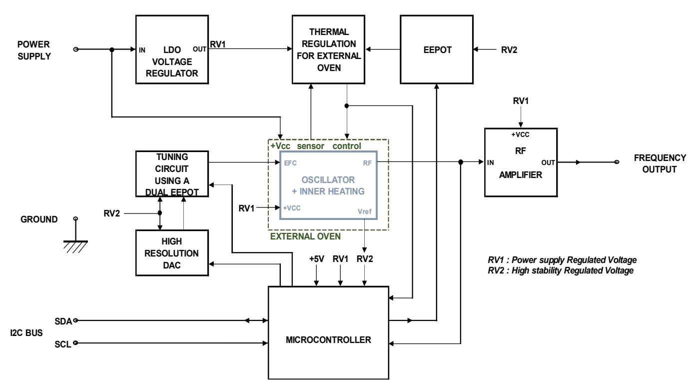

Fig. 2. Block diagram of the ROX5242T1N

the temperature and the ageing of the X'tal. As you can see in the block diagram (figure 2), we have used a double oven structure. The total temperature reduction factor is about 10000 at the level of X'tal (HC43 10MHz third overtone). In figure 3, we can see the frequency deviation in the temperature range of

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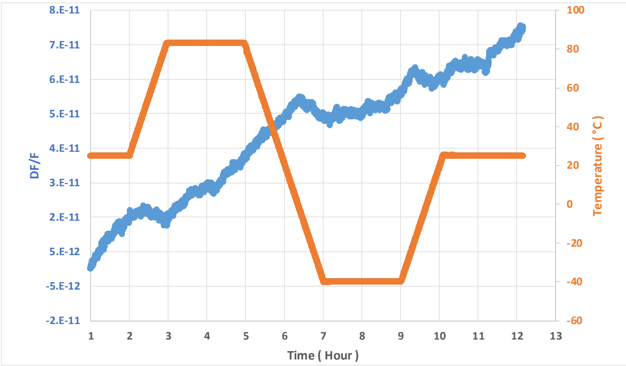


Fig. 3. ROX5242T1N frequency variation versus temperature with a thermal gradient of 1°C/min. There is no overshoot with the slope change.

-40°C to 85°C. The residual variation can be compensated by adding a voltage on the frequency control voltage. The thermal compensation is managed by a microcontroller. The residual frequency variation in temperature is less than 5E-11. The double oven structure also gives a good warm up time to have a relative frequency deviation from the frequency at one hour better than 1E-8. You see typical curves of warm up on figure 4.

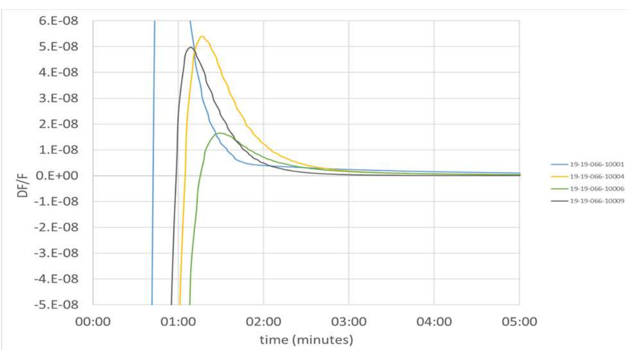


Fig. 4. ROX5242T1N typical relative frequency variations during warm up.

For the ageing, due to all the improvements in the X'tal process [4], we can have a daily ageing compatible with the requirement of some parts in 1E-13 between 1s and 1000s.

To limit the impact of the external fluctuation and noise of the supply voltage, we have introduced a double voltage regulation inside the product. That permits to have a version 12V and 5V. The figure 5 shows the extremely low residual sensitivity to the supply voltage variation. It is less than 5E-12 for 5% of supply voltage variation. To reduce the impact of the current consumption on the stability of the internal ground, reference for the frequency control voltage, we have also added a DAC to control the frequency. This adding has no impact on the phase-noise (figure 6). The frequency versus temperature curve comes independent of the frequency control voltage (figure 7). The schematic was reviewed to have a better phase-noise floor and guarantee the short-term of the OCXO and avoid the intermodulation problem on the atomic clock [1].

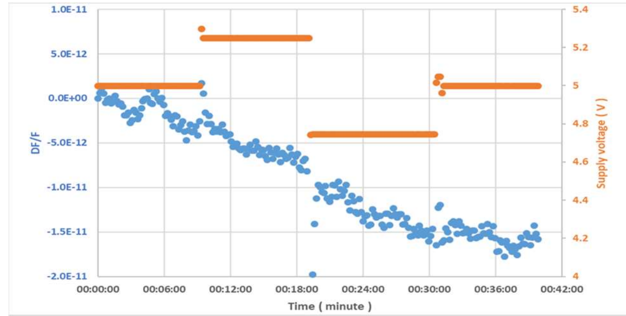


Fig. 5. ROX5242T1N relative frequency variation versus supply voltage variation of 5% arround 5V.

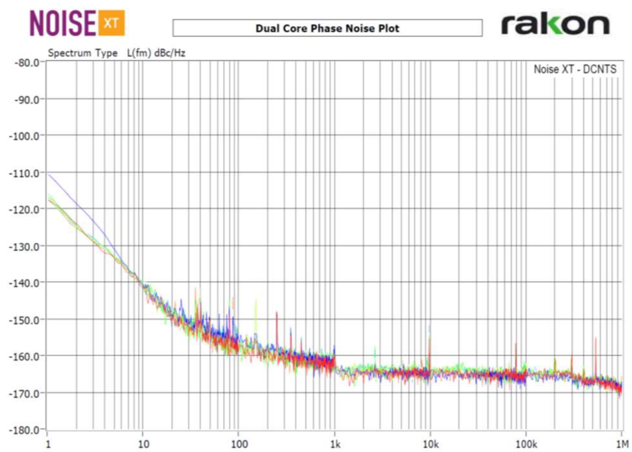


Fig. 6. ROX5242T1N phase-noise of 12 parts.

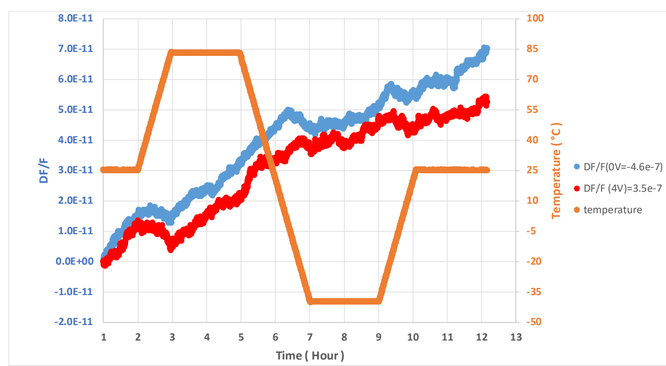


Fig. 7. ROX5242T1N thermal sensitivity versus frequency control DAC values equivalent to 0, 2 and 4V.

IV. Measurement

To measure the short-term and the medium term stability, we have used our new test bench MOBSAC with some small modifications [4]. It was optimized to measure 12 parts in parallel with a resolution lower than 1E-13. The frequency reference for the measurement is an HSO14 (RAKON OCXO) locked on a rubidium HP5065A, which the Allan deviation (ADEV) versus time is presented in figure 8 and is sufficient

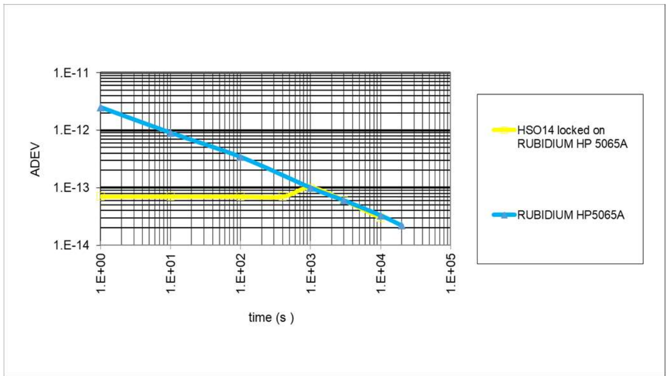
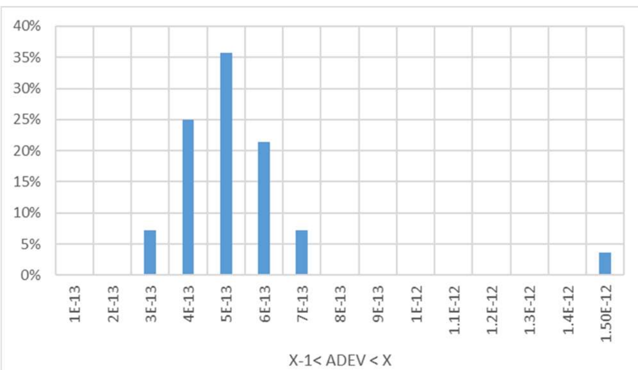


Fig. 8. Frequency Reference ADEV versus time.



for the OCXO's ADEV measurement upper than 1E-13 for an integration time from 1s to 10000s. The ADEV(10s) statistics (figure 9) gives a good yield for ADEV(10s) below 1E-12. Versus the time of integration, the OCXO has a good ADEV from 1s to 1000s even if there is rapid thermal variation up to 1°C/min (see figures 10 and 11).

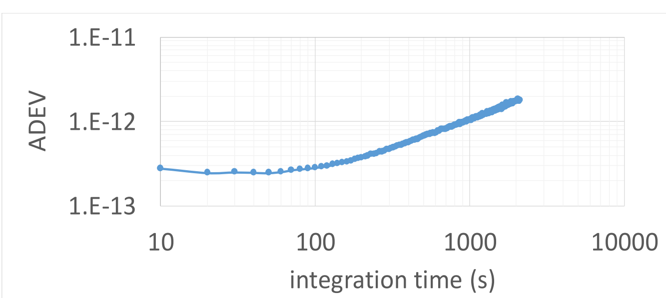


Fig. 10. ROX5242T1N ADEV versus time without temperature variation.

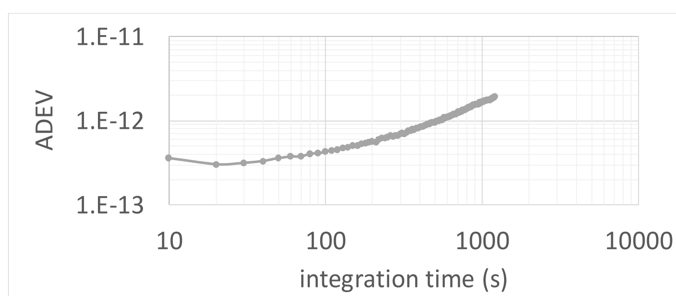


Fig. 11. ROX5242T1N ADEV versus time with temperature variation slope of 1°C/min, shown in figure 3.

V. CONCLUSION

In conclusion, we have developed an OCXO, the ROX5242T1N, which gives a very good short-term and medium term from 1s to 1000s (some parts in E-13), even if there is temperature gradient upper than 1°C/min. Its phase noise floor and its dimensions are also smaller compared to the previous design.

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