NEXT GENERATION OF NEAR ATOMIC STANDARD PERFORMANCE QUARTZ OSCILLATORS FOR TELECOMMUNICATIONS

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ABSTRACT

The next generation of near atomic standard performance quartz oscillators has been developed to address the needs of telecommunications equipment manufacturers. The most prevalent technology trends affecting the quartz oscillator industry are the reduction of size and supply voltages, while maintaining the performance of larger parts from the past. MTI's 270 Series OCXO is packaged in a CO-8, 27x36x19.4mm case, providing an 82% volume reduction, and achieves thermal stability of 2e-10 per –30 to +70C with a 5V supply. Performance characterization includes warm-up time and power, thermal stability and power, voltage stability, aging rate, phase noise, output spectrum and electrical tuning response.

1. INTRODUCTION

The 270 Series oscillator utilizes SC cut quartz resonators and incorporates dual oven technology, achieving a typical thermal stability of better than 2e-10 per 100°C at a low cost. Housed in a standard CO-8 hermetic package, the product measures 27mm x 36mm x 19.4mm with a volume of 19cc (1.1 cubic inches). The oscillator consumes 5.5W (typical) during warm-up and approximately 1.7W @ 25°C, steady state. Key parameters, such as thermal stability, phase noise, short term stability, supply voltage sensitivity, and aging are comparable to results obtained from typical 52mm x 52mm x 38mm (103 cc or 6.27 in^3) sized traditional units currently available.

The 270 Series follows the legacy of MTI's 220 series [1] and also utilizes a unique oscillator topology, which reduces the component count and improves reliability by a factor of approximately 2 times over traditional circuit designs. Test data characterizing the various key parameters will be shown.

2. PRODUCT DESIGN

The key design goals in developing the 270 Series oscillator have been:

- Incorporate Double Oven Technology for best temperature coefficient
- Small Package: 19 cc (1.1 cu. in.) Standard CO-8 Footprint
- High Performance Drop-in Replacement for single oven designs
- Hermetically Sealed
- Low Power Consumption: 1.7W @ 25°C (still air)
- Lower Component, Reduced Component Stress, High Reliability, MTBF
- Superior Thermal Performance < 2e-10 per 100°C
- Fast Warm-up
- Standard Package, Reduced Size, Surface Mounting, High Integrity Hermetic Seal, Rugged for High Shock and Vibration Environments
- Suitable for High Volume Production, Low Cost

A circuit topology was chosen which reduces the component counts and is similar in nature to our 220 series product [1]. Figure 1 shows the oscillator block diagram. The oscillator assembly, including buffer amplifiers, is ovenized for best performance. An additional buffer is added externally for isolation from user load changes.

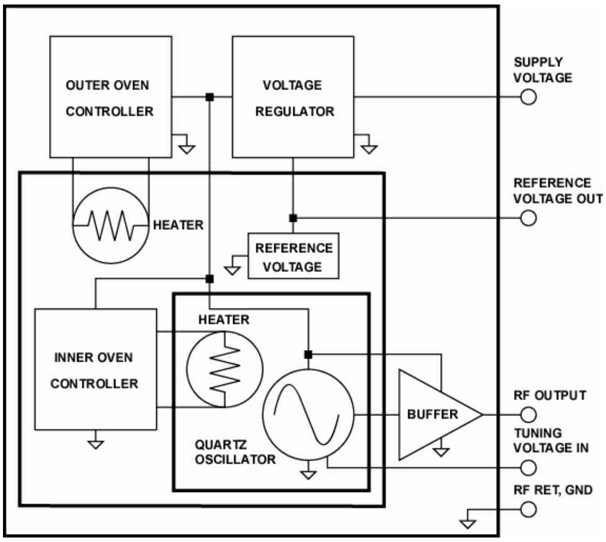

Figure 1

The 270 Series uses a common 5 pin mechanical package, which offers good hermetic seal characteristics and the ability to provide rugged mounting for aerospace applications. Figure 2 shows a photo of both the 270 series and the older generation 260 series (52mm x 52mm x 38mm) product compared to a US 25 cent coin [2] [3].

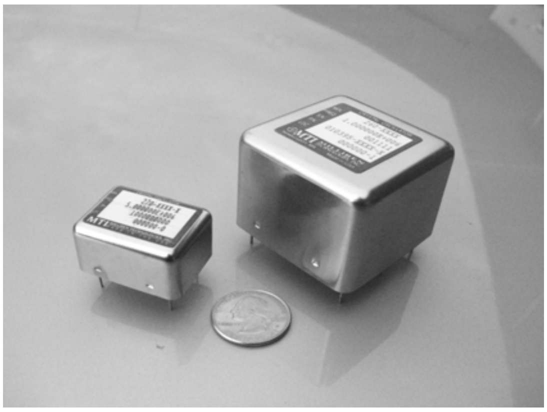

Figure 2

3. PERFORMANCE DATA

Data is shown for a number of important oscillator parameters. Results were chosen to be representative of 5MHz products using SC cut quartz with 12V supply inputs and +9dBm sine outputs. Results for 10MHz are shown where there are significant differences in performance compared to 5MHz.

3.1 Phase Noise Results

Phase noise data is shown in Figures 3 and 4 for 5MHz and 10MHz versions respectively. Results were obtained using a HP 3048 system for pairs of like units. Typical specification limits are shown as solid straight lines.

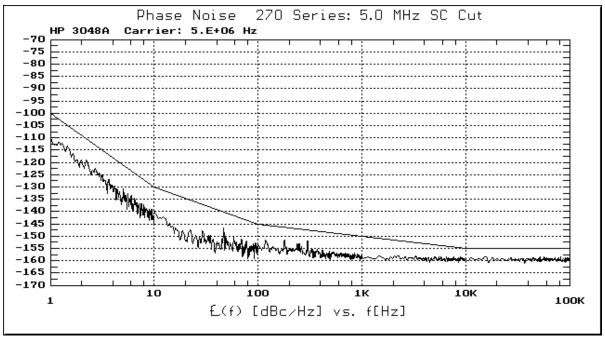

Figure 3

3.2 Output spectrum Results

Output spectrum shown in Figure 5 is a typical example of performance at both 5MHz and 10MHz. The output circuit incorporates a multi-pole filter, which allows for low harmonic content as seen in the graph.

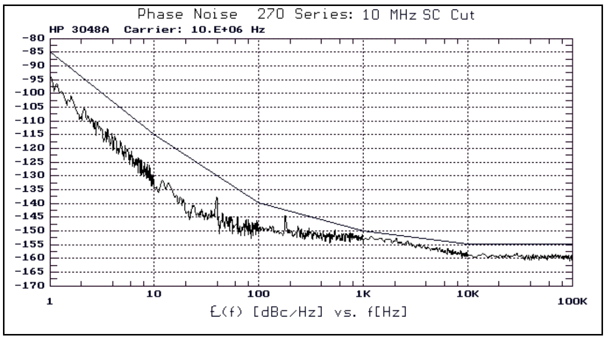

Figure 4

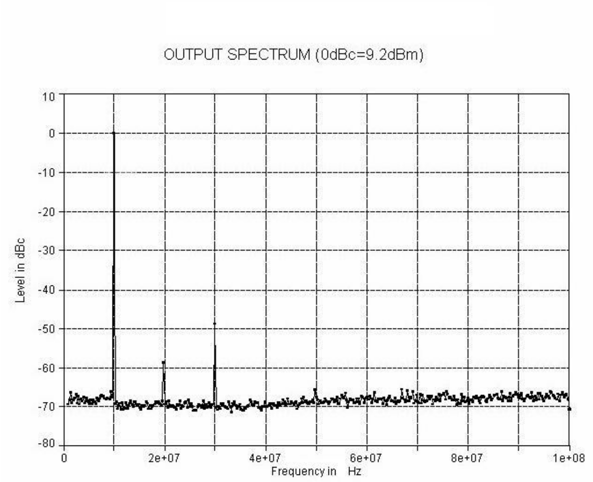

Figure 5

Thermal stability Results

Thermal stability for small steps of 10°C approximating a ramp is shown in Figure 7. The right-hand axis shows the associated Temperature vs. Time graph. The unit was subjected to an up-down ramp from -30°C to 70°C with returns to 25°C. The results show a temperature stability performance of 1.6e-10. Figure 8 shows the Power vs. Time graph associated with the ramped temperature test. The power measured was measured in stirred air and is approximately 20% higher than still air.

The thermal stability for both large temperature excursions as well as quasi ramps was investigated. Temperature performance for a delta of 100°C step at 68°C/min rate from –30°C to 70°C and +70°C to -30°C at -38°C /min, is shown for 5MHz units in Figure 6. The stability graph is referenced to the "Temperature vs. Time" graph referred to the right-hand axis. The results show positive going frequency transients of +1.9e-9 and -1.5e-9 for negative thermal transitions. This is not usually a specified parameter, but is useful in characterizing the servo response of the oven(s).

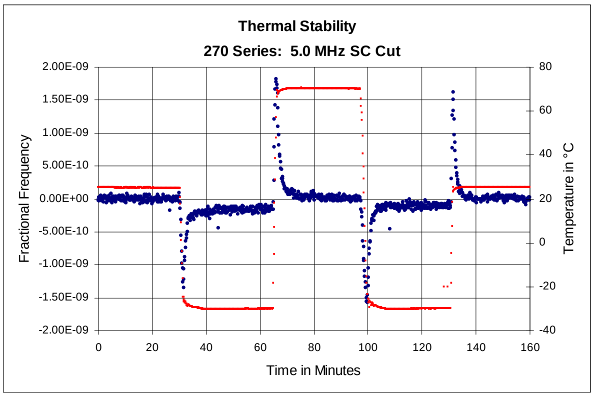

Figure 6

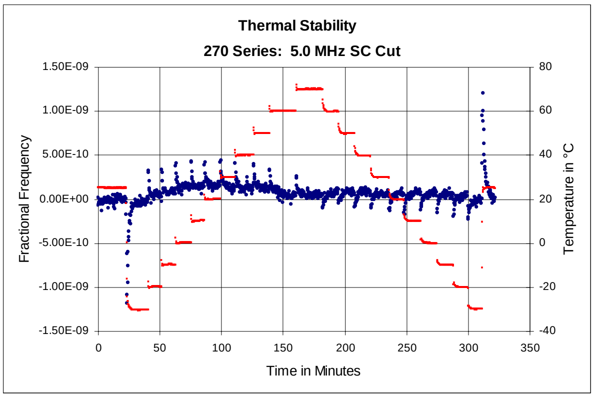

Figure 7

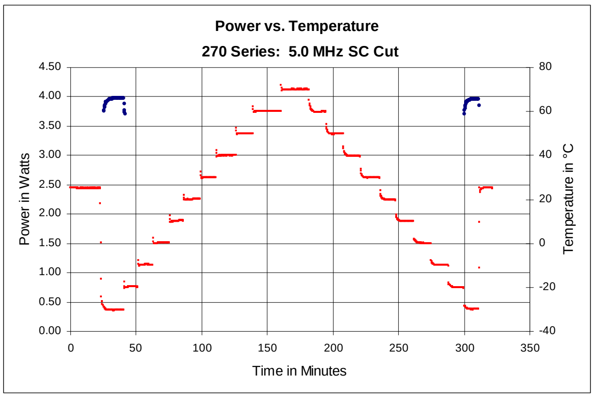

Figure 8

3.3 Warm-up Results

Warm-up data is shown in Figure 9 for a 5MHz SC 270 series oscillator. The measurements were made after an off period of greater than 2 hours at 25°C. A graph of Power vs. Time is shown in Figure 10. The warm-up and power consumption was measured in still air. The frequency is within a 2e-8 window in approximately 5 minutes at 25°C. The 6e-8 positive section of the graph represents a transient caused by a less than perfect SC crystal cut.

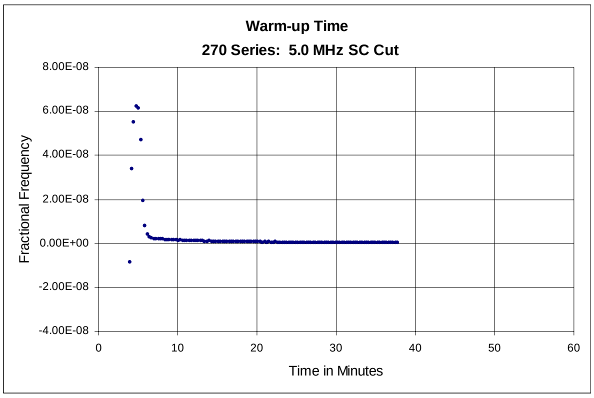

Figure 9

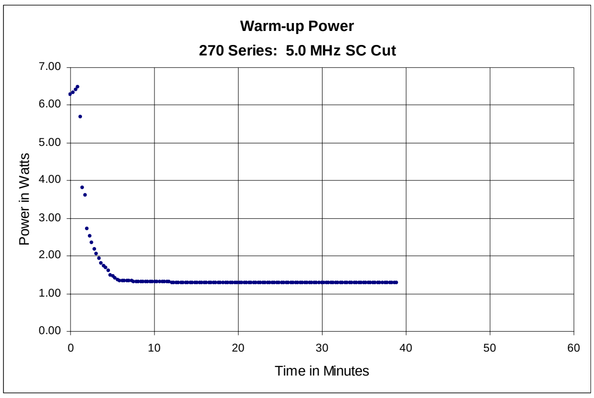

Figure 10

3.4 Tuning Function Results

Tuning curve is shown in Figure 11 below is typical for 5MHz SC oscillators. Note that the tuning rate of the 10MHz oscillator is approximately 4 times greater than the 5MHz product. The tuning range scales proportionally to the dX/dF of the quartz crystal and the available reactance swing of the tuning varactor diode. Note that the non-linearity scaled to the right-hand axis on the graph. Many specifications omit the 0 to 0.5V range to avoid this area. The linearity represented here is approximately 5.5%.

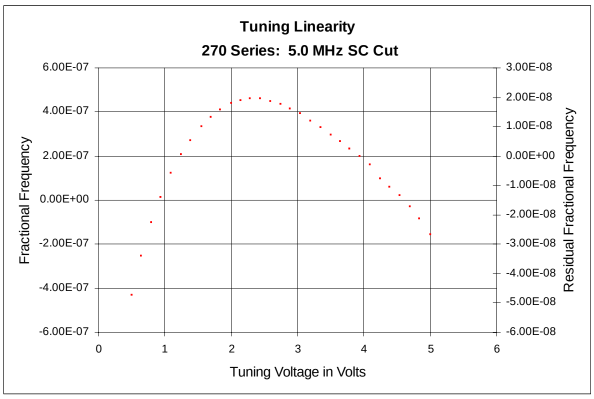

Figure 11

3.5 Supply Sensitivity Results

The supply sensitivity is characterized in a similar fashion to the thermal stability. The supply voltage is varied over 5% increments while the frequency is being recorded. Like the thermal stability measurements, the frequency and voltage are measured with respect to time, and then correlation is made between the time and voltage axis. As is seen in Figure 12, the effects of 5% change in the supply voltage are minimal. The right-hand axis shows the Voltage vs. Time function. Note that the random measurement noise is on the order of any voltage induced frequency effects.

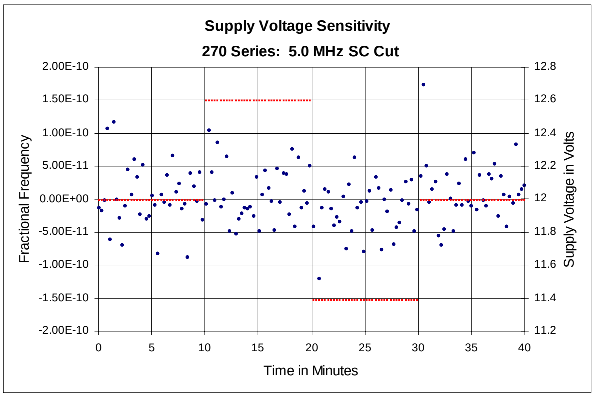

Figure 12

3.6 Aging Test Results

Aging test results for 5MHz 270 series oscillators is shown in Figure 13. The average initial aging rates for 5MHz 270 series units are less than 2e-10/day over the first 30 days. The example shown exhibits a rate of better than 3e-11/day in the first 30 days and substantially better over the first 150 days. 10MHz types have typical results of about 1e-10 to 2e-10/day for the same period.

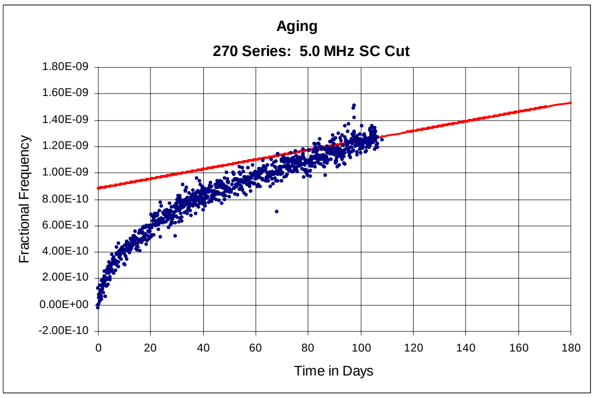

Figure 13

4. CONCLUSION

The data presented gives an overview of the 270 series product performance. The required physical volume has been reduced by better than 80% allowing system designers to achieve new size-performance goals. Results collected over the past several years show that oscillators with a small physical size can equal performance obtained with much larger products of the past [2] [3] [4]. The reduced complexity and lower component stress help greatly in the goal of improving reliability as well as reducing overall production costs.

5. REFERENCES

[1] B. Milliren, "A Miniature Precision Oven Quartz Oscillator Sets New Size VS. Performance Standard", Proceedings of the EFTF, March, 2000.

[2] M. Vaish, "A High Precision Quartz Oscillator With Performance Comparable To Rubidium Oscillators In Many Respects", Proceedings of the 1996, Frequency Control Symposium.

[3] E. Cantor and M. Vaish, Statistical Results From High Volume Production Of Ultra Stable Precision Quartz Oscillators, Proceedings of the 1999, Frequency Control Symposium.

[4] R. Karlquist "Manufacturing Issues for a High Performance Crystal Oscillator", Proceedings of the 2000, Frequency Control Symposium, p 238.