APPLICATION NOTE #812 R1

New Frequency Control Technologies

A Comparative Analysis of New Technologies and Traditional Quartz Based Technology

ABSTRACT

Over the years there has been a steady progression in the development of frequency control technologies. While many changes have been the result of the natural evolution of technology, the main drivers have been enhanced manufacturing capabilities, demands to reduce costs, and various technical requirements for smaller sizes, greater stability, reduced power consumption, and faster start-up.

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1 Introduction

Quartz-based devices, primarily Bulk Acoustic Wave (BAW) devices, have long been the standard by which all commercially available clocking sources have been compared. The history of quartz crystals as very stable, high quality resonators for frequency control is well documented and universally recognized. Frequency versus temperature response, aging, jitter and phase noise characteristics of quartz-based frequency control devices are all well chronicled in the industry. However, a concise technical comparison of such characteristics with frequency control devices utilizing new technologies has been lacking. To establish a benchmark between MEMS and other devices against established quartz based devices, the authors of this analysis began a study in 2007, and published *A Comparative Analysis of Frequency Control Devices* in 2008. This comparison study is an update and expansion of the earlier benchmark analysis.

2 Devices Studied and Methodology

This study applied standard measurement techniques under the same test conditions for the following devices in order to provide a direct comparison of performance and capability:

I MEMS I oscillators (manufacturer A)
II MEMS II Oscillators (manufacturer B)
III Programmable M/N Multiplier Oscillators with quartz crystals as resonators (manufacturer C)
IV Quartz Free Oscillators – Temperature-compensated L/C oscillators without any external resonators (manufactured by Pletronics, Inc., Series QF55)
V Traditional Quartz (Bulk Acoustic Wave) Clock Oscillators (Series SM55 manufactured by Pletronics, Inc.)

All of the devices studied were purchased from a national distributor of electronic components and are readily available commercially. Parts manufactured by Pletronics, Inc. were taken from factory inventory.

The results presented here are based upon established frequency control measurement techniques that employed the current testing technology commercially available at the time the devices were studied in 2012. All of the tests were performed under identical conditions unless otherwise noted.

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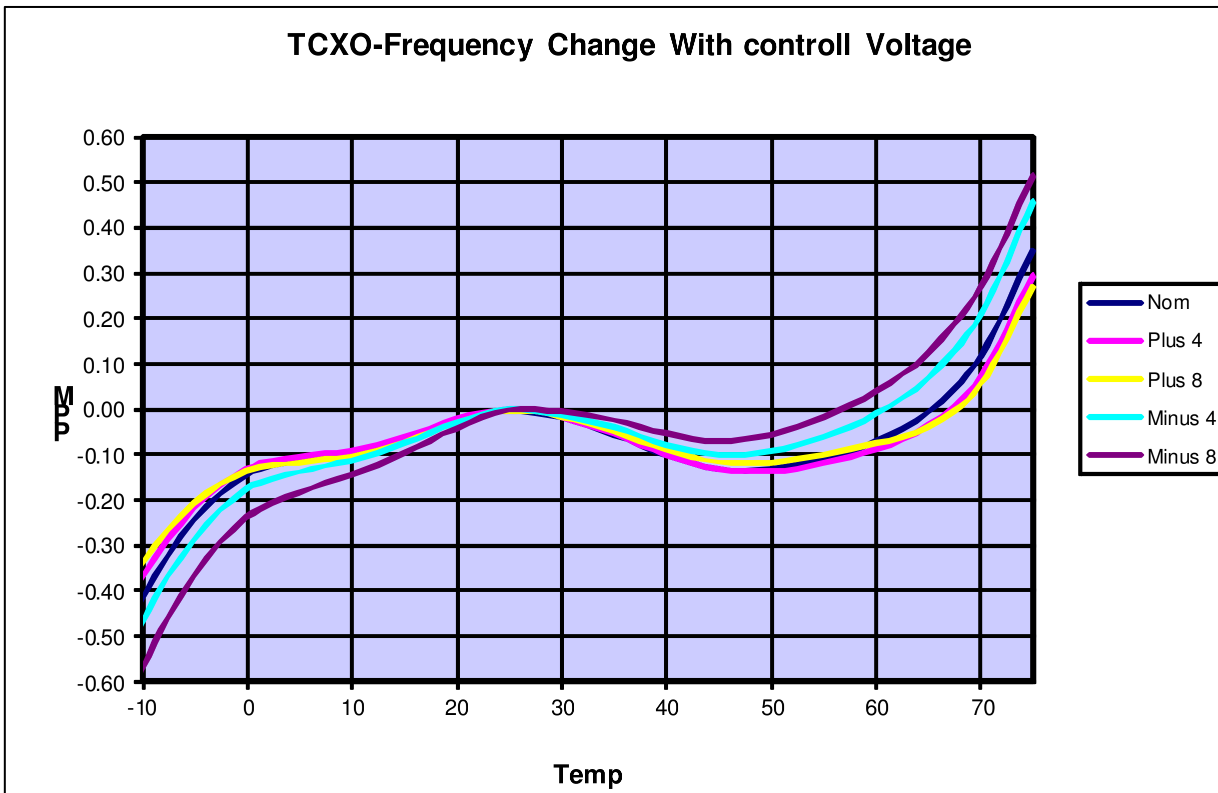
1.1 Figure 1



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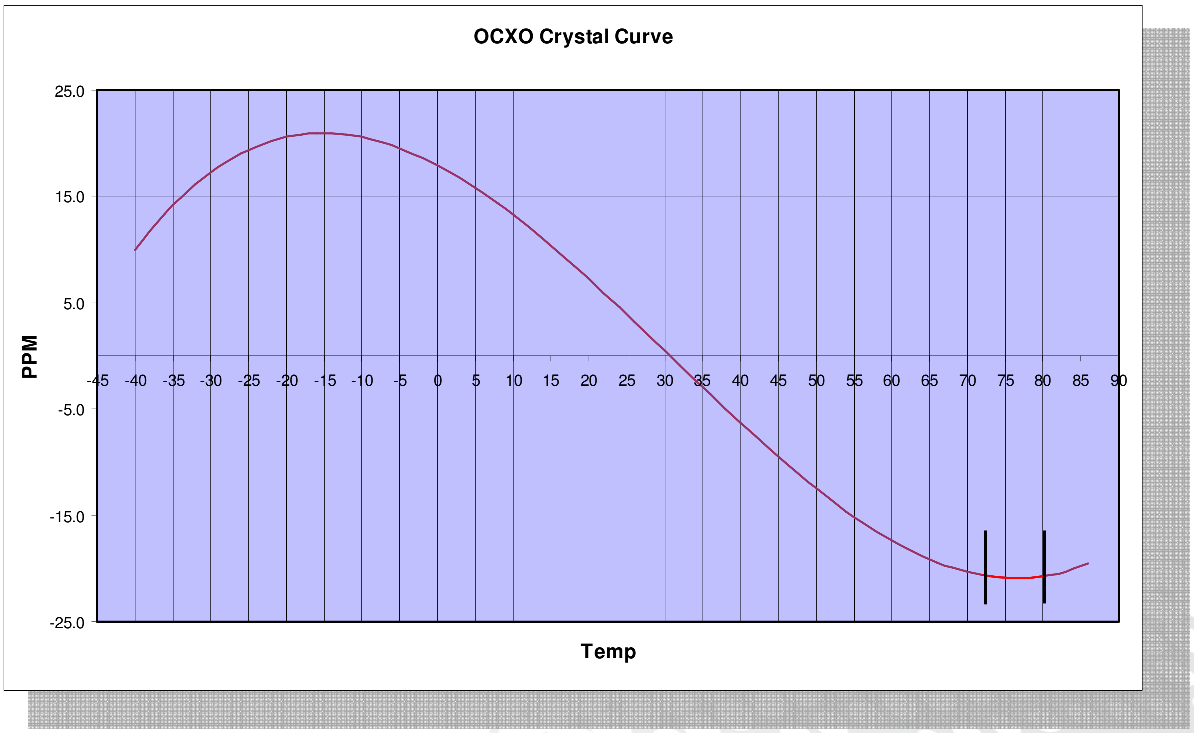
2 OCXO Technology

Ovenized Crystal Oscillators (OCXO) are typically used for high precision frequency applications. This approach heats the crystal and associated oscillator circuitry to the upper turning point of the crystal. Figure 2 shows the part of the upper turning point used in the OCXO application.

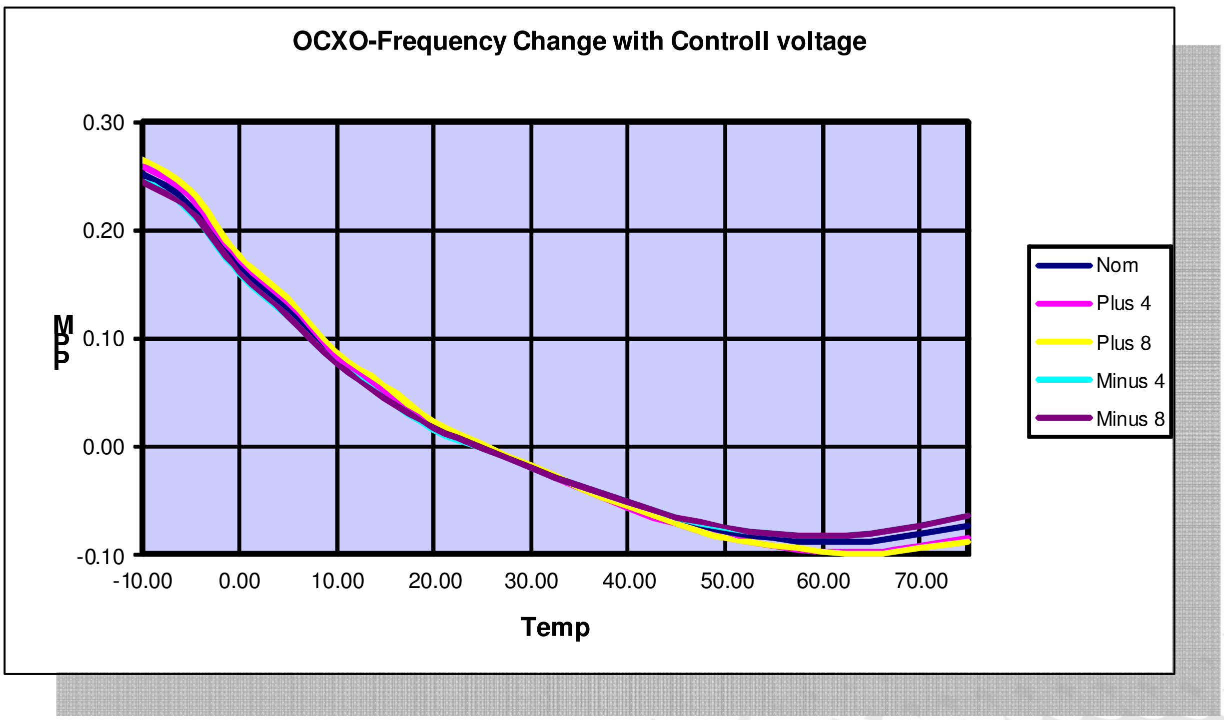
2.1 Figure 2



The crystals for these oscillators are manufactured so the upper turning point is above the highest specified temperature range. The crystal and associated circuitry is heated to and maintains a narrow temperature window around that point on the crystal, and the device is tuned to frequency at that temperature.

2.2 Figure 3

The temperature stabilized environment has some inherent advantages. This approach greatly reduces the temperature coefficient effects talked about previously. Figure # 3 shows the frequency-temperature characteristic for the OCXO when the EFC is changed +/-4 ppm and +/- 8 ppm similar to the TCXO. The data shows the OCXO’s stability related to control voltage changes is in the range of 5-10 ppb, as compared to the TCXO which is 50-100 ppb.



The OCXO has the added advantage of exercising the crystal over a very narrow temperature window, typically a couple degrees or less. This greatly reduces the chances of exciting unwanted modes in the crystal. The greatest drawbacks to this approach are the size of the devices and the power requirements. As technology moves forward, both the size and power requirements of these devices continues to decrease.

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3 Summary

The data presented in this application note was taken from commercially available, off-the-shelf products. The exact numbers will differ between vendors, but the general trends and approximate magnitudes should be similar. The key issues to review before choosing the appropriate device is the change in frequency stability with the adjustments necessary for calibration and long term stability, (aging). The OCXO has only a quarter of the sensitivity to these effects as the TCXO. This should be taken into account when considering the lifetime of the product.

The following table outlines differences to be considered between OCXO and TCXO products. In general, TCXO's are preferred when size and power are critical to the application. These tend to be hand held or battery operated devices. OCXO's are a more robust product in terms of frequency stability. This type product tends to be better suited for communication/network applications. Table A should help guide the designer to choosing the most appropriate technology for there application.

3.1 Table A

	TCXO	OCXO
Current Draw	1 - 3 mA typical	250 - 400 mA at startup,
Size	5x7mm or smaller typical	9x14mm or larger
Cost	Lower	Higher
Stabilization	0.1 - 2.0 seconds	30 seconds to 4 minutes
V_{CC}	3.3 V or 5.0 V available	3.3 V or 5.0 V available
Sensitivity to other crystal modes	Higher, crystal excited over entire temperature range	Lower, crystal excited over narrow temperature range
Sensitivity to changes by EFC/	Higher, see Figure 1	Lower, see Figure 3
Long Term Stability (Aging)	Similar	Similar
Mechanical Complexity	Simple, IC and Crystal	Complex, IC, Crystal, Heater
Phase Noise	Similar for fundamental, overtone not typically used	Similar for fundamental, better for overtone
EFC/ Voltage Control	±4 to ±8 ppm	±4 to ±8 ppm