TCXO Application vs. OCXO Application

Dave Kenny

Advances in IC technology have led to enhancements in both OCXO's and TCXO's that have blurred their historical differences. As technology has improved, the functionality of both types of oscillators has made it difficult for many designers to determine which technology is appropriate for a particular application. This application note seeks to provide the designer with a comparison of OCXO's and TCXO's to assist in making smarter selections and achieve the optimal performance for a given application.

The current dividing line between OCXO and TCXO technology is about the level of 0.28 PPM over the desired temperature range. The development of TCXO's for Stratum 3 applications has led to advances in stability over temperature range – approaching the stabilities traditionally achieved by OCXO's. With both technologies available for the application, it can be confusing to decide which is the most appropriate for a given application.

TCXO Technology:

A TCXO is a voltage controlled crystal oscillator with a correction voltage applied to the voltage control pin. This voltage changes with temperature to bring the frequency back to nominal. This application exercises the crystal over the entire frequency range of the specification. Any crystal related issues such as coupled modes cannot be corrected for and are superimposed on the resulting frequency-temperature curve. This makes the design and manufacturing of the crystal a difficult and critical part of the TCXO.

The majority of TCXO's require a voltage control function. This allows for exact setting of frequency, adjustments for long-term aging and the ability to phase lock the device to other sources. This function VCTCXO, (voltage controlled temperature compensated crystal oscillator) works by adjusting the load capacitance presented to the crystal. The changes made by these adjustments should be taken into account for tight tolerance TCXO's. The capacitors used to adjust frequency have a temperature coefficient, and this temperature coefficient changes the nominal value of the capacitors over temperature. This change has an effect on the compensation of the crystal. In lower precision TCXO's this is usually ignored, but as TCXO precision meets and exceeds 0.5 ppm levels, these effects can no longer be ignored. In a typical application the units will need to be adjusted from 0.5-2 ppm for exact calibration. The device will then need adjustment for long term stability, (aging).

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Figure # 1 shows a frequency-temperature data of a device calibrated to exact frequency. The frequency was then adjusted +/- 4 and +/-8 ppm. The plots were then offset for comparison. This effect from the capacitors has a rotation effect on the crystal curve, and the level of compensation is changed. The plots show the wider the temperature range: the more precise the application, the greater the effect from the voltage control function.

Adjusting a TCXO for 1.0 ppm of calibration and 3 ppm of long term aging can change the compensation by 50-125 ppb. This starts to approach 50% of the compensation limits when the specification is near or below 0.25 ppm. This can be a significant issue when using TCXO's in high precision applications.

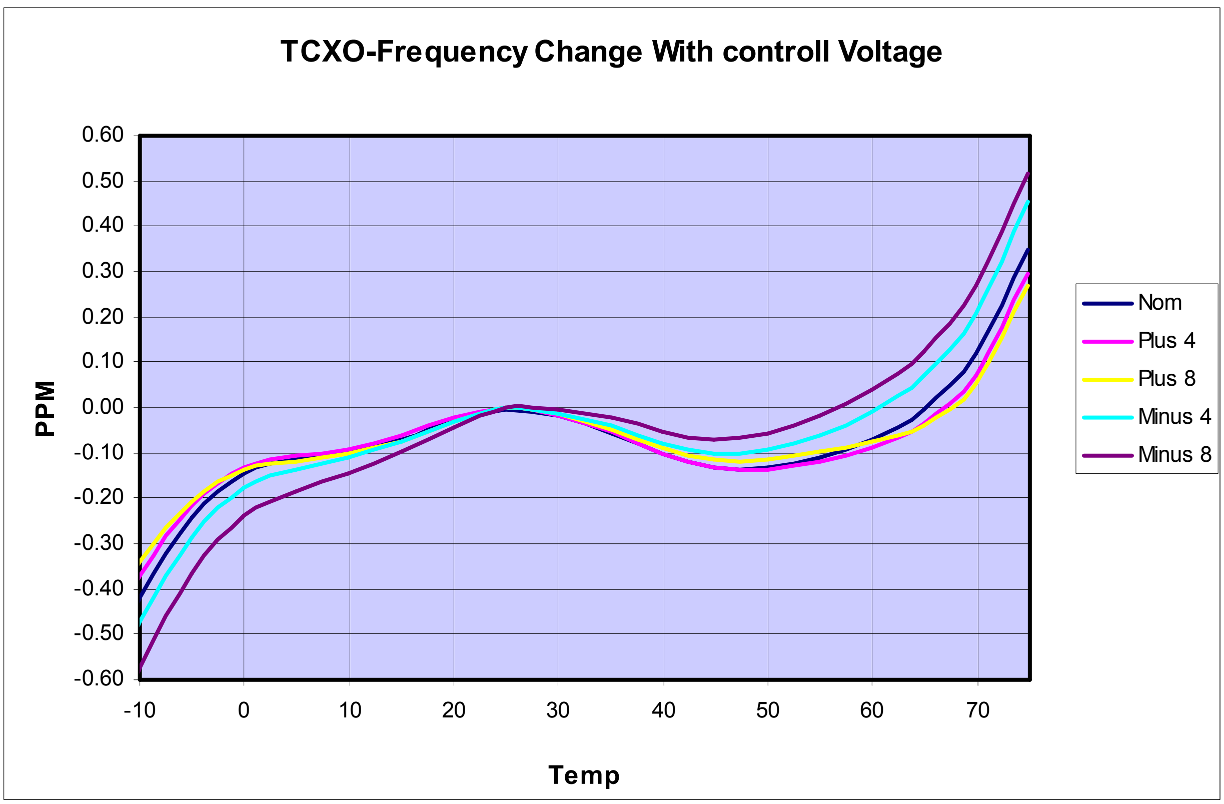

FIG #1

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OCXO Technology:

Ovenized Crystal Oscillators 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.

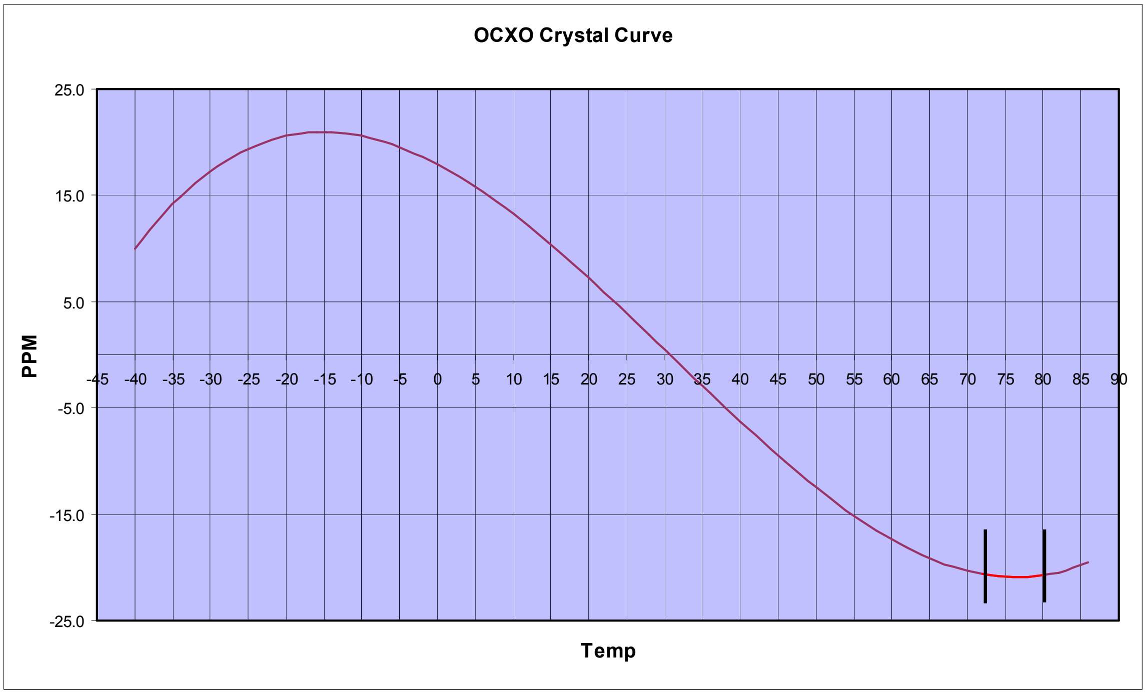

FIG #2

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.

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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.

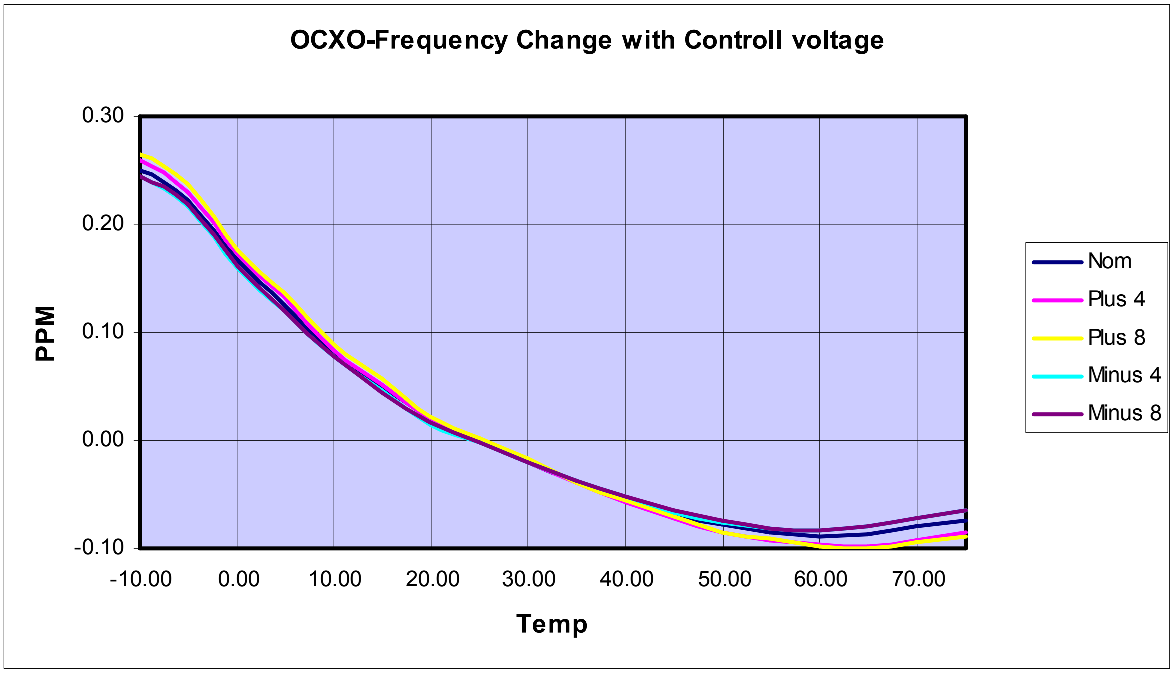

Fig # 3

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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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 #1 should help guide the designer to choosing the most appropriate technology for there application.

	TCXO	OCXO
Current draw	1-3 ma typical typ.	250-400 ma at startup, 70 to 165 ma @ 25°
Size	Typ. 5X7 or smaller	Typ. 9X14 or larger
Cost	Lower	Higher
Stabilization Time	0.1-2 sec.	30 sec. to 4 min
VCC	3 &5 volt available	3 &5 volt available
Sensitivity to other crystal modes	Higher, crystal excited over entire temp range	Lower, crystal excited over narrow temp range
Sensitivity to changes by EFC/Voltage control	Higher, see fig#1	Lower, see fig #3
Long Term Stability (Aging)	similar	similar
Mechanical Complexity	Simple, IC & Crystal	Complex, IC, Crystal, Heater & Controller
Phase Noise	Similar for fund, overtone not typically used	Similar for fund, better for overtone
EFC/Voltage control	+/-4 to +/- 8ppm	+/-4 to +/- 8ppm

Table #1

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