TCXO's for Small Cell Applications

Dave Kenny

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Advances in IC technology have led to enhancements in both OCXO's and TCVCXO'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. TCVCXO technology has been developed to a point where it is a viable option in applications where only OCXO's were an option. This application note seeks to provide the designer with information pertaining to the enhanced performance characteristics of current TCVCXO technology and briefly compare that performance to OCXO technology

TCXO Technology Background:

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 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 TCVCXO.

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 TCVCXO, (temperature compensated voltage controlled crystal oscillator) works by adjusting the load capacitance presented to the crystal. Most small cell requirements include a Voltage Control option.

Small Cell TCXO Technical Requirements:

Exact TCVCXO specifications vary with the manufacturer. In general, Small Cells require +/- 0.1 ppm stability over a specified temperature range. One of the more common specifications is 0-80° C with +/- 5 ppm of pullability for the voltage control function. It is only in the last several years that crystal technology has improved to the point where they could be reliably compensated to this level. There are a number of technical issues to consider in the manufacture of these crystals. The crystals for the TCVCXO must be produced free of perturbations with very low aging characteristics as well as extremely low hysteresis characteristics.

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Figure # 1 shows a frequency-temperature and hysteresis characteristic for the small cell grade TCVCXO. This performance level would have typically been delegated to the OCXO realm not long ago. Improved semiconductors and optimized crystal design and manufacturing processes make it possible for TCXO's to compete in the +/- 0.1 ppm stability realm. These devices are typically TCVCXO's. A correction voltage is required to adjust frequency for drift and long term aging characteristics. The frequency adjustment is usually generated by NTP, PTP (IEEE-1588) implementation. These TCXO's have very low aging rates and very linear characteristics with regards to the control voltage function. The precise compensation, low hysteresis, low aging rates and low power consumption make this device an ideal solution for small cell applications. These devices use approximately 2 mA of current. An OCXO for this application would require approximately 100 mA of current for the application. The size, power requirements and warm-up time place traditional OCXO's at a significant disadvantage when compared to TCVCXO's designed for this application.

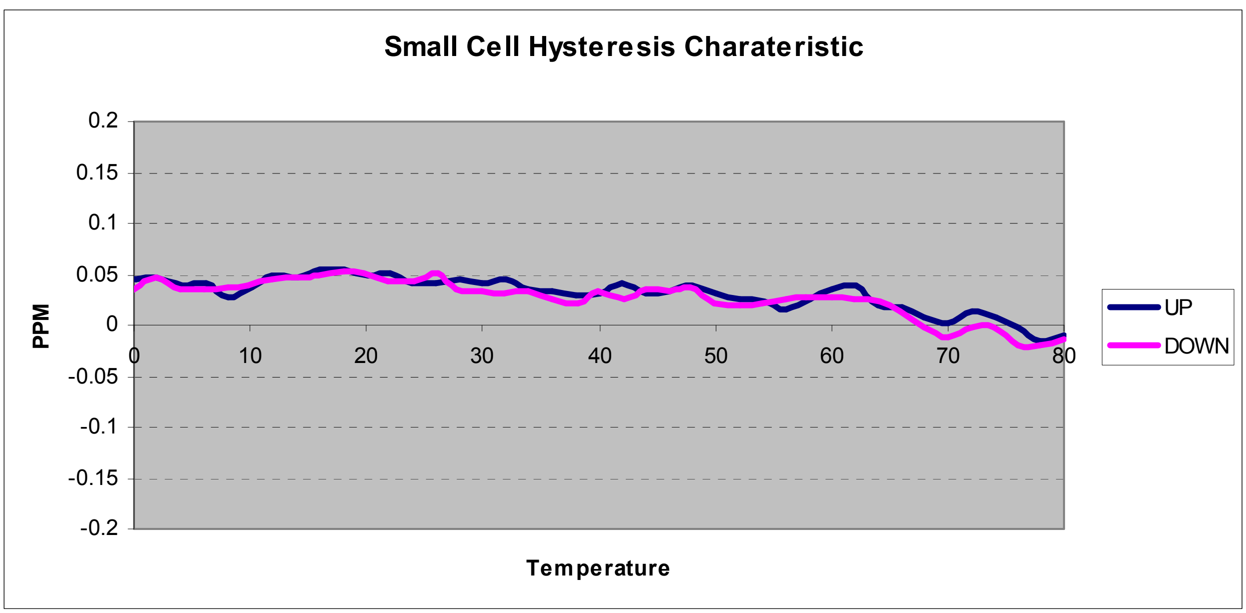

FIG #1

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OCXO Technology:

Ovenized Crystal Oscillators are typically used for high precision frequency control 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.

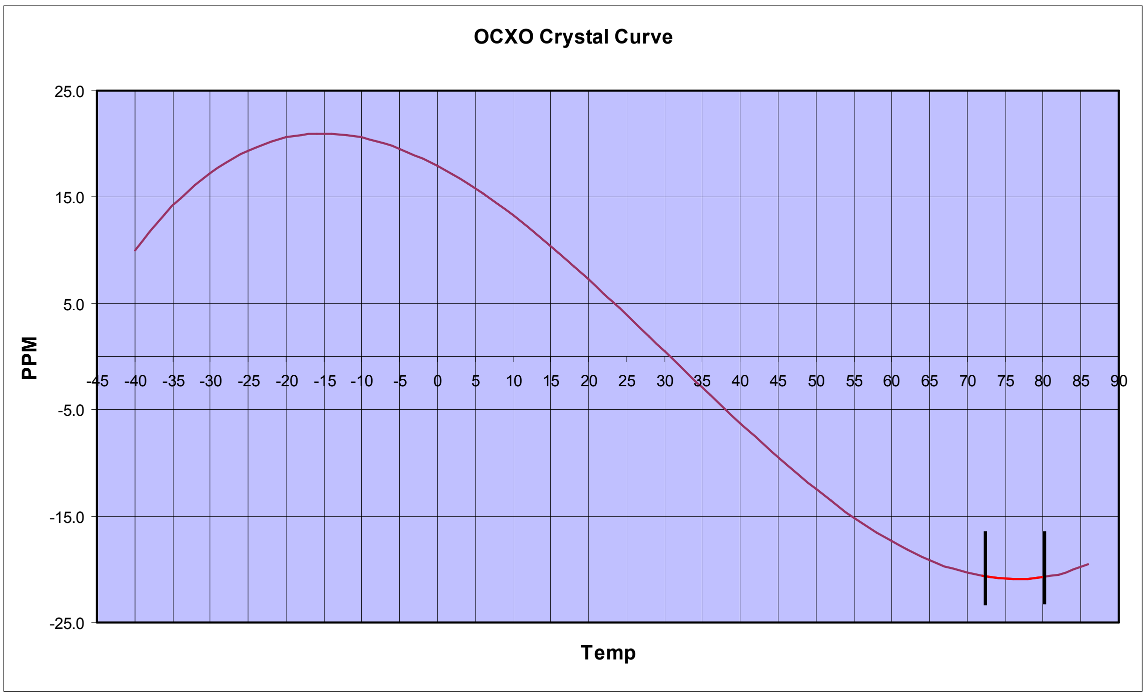

FIG #2

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.

The OCXO has an advantage in only 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. By contrast, a TCVCXO electrically compensates for the crystal characteristic. This places a strong emphasis on the quality of the crystals being used in these applications.

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APPLICATION NOTE #813

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Summary:

The data presented in this application note was taken from commercially available, off-the-shelf OCXO's and small cell grade TCVCXO's. The exact numbers will differ between manufacturers, but the general trends and approximate magnitudes should be similar.

The following table outlines differences to be considered between OCXO and TCVCXO products. In general, TCVCXO's are preferred when size and power are critical to the application. OCXO's historically had an advantage with a lower sensitivity to small stability changes when changing the voltage control functions to the max or min value. The semiconductors used for small cell grade applications has compensation circuitry for that function. This improved performance makes TCVCXO's extremely competitive with OCXO technologies.

	TCXO	OCXO
Current draw	1-3 mA typical typ.	250-400 mA at startup, 70 to 165 mA @ 25°
Size	Typ. 5X7 mm or smaller	Typ. 9X14 mm 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	Low	Low
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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