

High Stability and Low Power Demand
In a Compact Oscillator

NOTE

APP



For years, manufacturers have sought to provide an oscillator that offers tight stability in a compact package. An Oven Controlled Crystal Oscillator (OCXO) provides excellent stability, but for portable applications, and particularly for demanding military applications, the OCXO package may be too large and it may also require too much power from a battery.

Greenray Industries' new T75 Series TCXOs (temperature compensated crystal oscillator) satisfy the need for tight stability performance, a compact package and low power consumption.

The heart of any oscillator is the crystal. The new T75 Series TCXOs utilize an AT Strip crystal, from sister company Statek Corporation, that offers distinct advantages over a normal circular blank crystal.

The AT Strip crystal is extremely rugged and can handle very high shock and vibration levels. Special versions of this crystal have survived up to 100,000g's of shock, making the crystal ideal for use in severe environments such as Smart Munitions. Typical g-sensitivity of this crystal is $2.5 \times 10^{-9}/g$ in the worst axis, which is the Z axis, and less than $2 \times 10^{-10}/g$ in the X and Y axes.

G-Sensitivity can be further improved to approximately $3 \times 10^{-10}/g$ in the Z axis, thereby minimizing stability and phase noise affects from shock and vibration. This is very important for portable and airborne applications that rely on consistent performance under shock, acceleration, and vibration. The downside to using a lower g-sensitivity crystal is that aging performance is degraded slightly.

One of the limiting factors in making a TCXO perform closer to OCXO stability is crystal perturbations. Perturbations are isolated events which happen at specific temperatures and normally over just a few degrees, causing the frequency of the crystal to jump by up to several parts per million (ppm).

All crystals inherently have perturbations – what is important is how many and how large they are. Perturbations are very repeatable over temperature within a manufacturing run. There are many theories about the origin of crystal perturbations, including blank stress, cleanliness, and particulate matter leaving the crystal.

Greenray has worked with Statek to significantly reduce AT Strip perturbations to typically less than 1×10^{-7} to allow compensation to temperature stabilities as tight as $\pm 2 \times 10^{-7}$. It is important to test tight stability TCXOs every two degrees over temperature to ensure that perturbations do not exceed specifications.

The AT Strip crystals have been designed to also improve aging performance. Long-term aging of the TCXOs is very good, typically much less than 1ppM/year, and projecting to 3ppm or less for 10 years. An example of long-term aging for a 40MHz TCXO is shown in Figure 1.

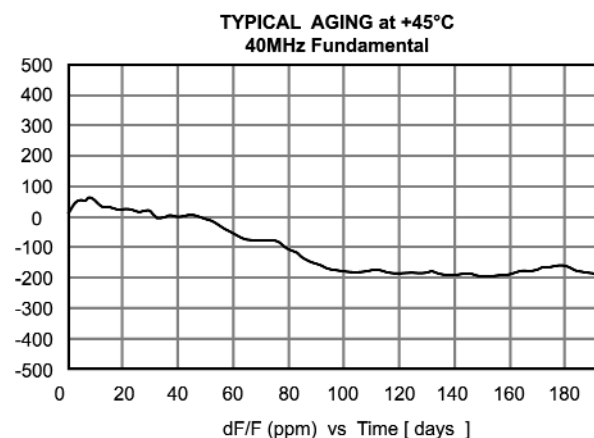


Figure 1

In order to improve TCXO performance, Greenray uses analog temperature compensation. This has less effect on short term stability and phase noise than utilizing digital compensation which, although it can yield very stable units, can also cause frequency jumps that wreak havoc at the system level, causing lock problems and noise issues.

Greenray's proprietary analog compensation features a 5th order polynomial curve-fit. A simple way of explaining this is that the higher the order of compensation, the more points along the temperature curve you can compensate for. This is important because crystals do not follow a perfect curve-fit over temperature. In other words, the 5th order compensation will yield a more stable oscillator than a 3rd order compensation because it can account for more instabilities of the crystal.

This enables the T75 to provide stabilities as tight as $\pm 0.2\text{ppM}$ over -20 to $+70^\circ\text{C}$, $\pm 0.3\text{ppM}$ over -40 to $+85^\circ\text{C}$, and $\pm 1\text{ppM}$ over -55 to $+90^\circ\text{C}$. These stabilities are much tighter than typical TCXO performance obtained by using thermistor compensation or 3rd order compensation. Yields are not as high on the tightest stability options, so there are cost advantages to picking more typical stabilities like $\pm 0.5\text{ppM}$ or $\pm 1.0\text{ppM}$. Figure 2 is an example of frequency vs. temperature of a compensated oscillator.

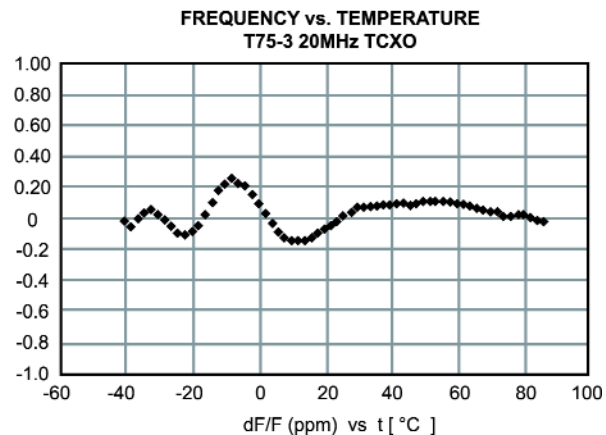


Figure 2

Analog compensation provides excellent short term stability as well. Typical performance from the TCXO is $<3 \times 10^{-10}$ with a sampling period of 0.1 and 1.0 second. This performance remains consistent over temperature, with a few isolated occurrences of up to 2×10^{-9} for the same sampling rates. The temperature can be slewed up to $2^\circ\text{C}/\text{minute}$ without significant performance degradation.

T75 Series TCXOs offer either a Tristate option or a Voltage Reference option. The Tristate function turns the output on and off, but allows the oscillator to continue to run, minimizing the stabilization time of the TCXO. This function is useful for test functions, giving the ability to easily test one part at a time when multiple units are being operated simultaneously, as is typically the case in Telecom and Communications systems. The Tristate is enabled with a "HI" or floating input, and disabled with a "LOW" 0V input.

The Voltage Reference is an internally regulated voltage output that can be used to bias the Electrical Frequency Control (EFC) port of the TCXO and set the unit on the nominal frequency. The voltage output for a +3.3V unit would be +2.4VDC (typical), and for a +5.0V unit would be +4.3VDC (typical).

The TCXO can be adjusted via the specified EFC voltage, or by biasing the EFC with the Voltage Reference (VREF) (ref. Figure 3), or the center frequency can be set internally by Greenray and not be adjustable by the customer. The EFC input is advantageous to customers who like the option of recalibrating the TCXO over time. Some bias the input by using electrical adjustment via software and a D/A Converter, while others just use a simple potentiometer voltage divider to adjust the external voltage to the unit.

If the Supply Voltage to the unit is very stable, the voltage divider (ref. Figure 4) may be used. Caution is advised using this method however, because any instability in the supply voltage could be directly input to the EFC port causing stability changes over temperature. The units typically adjust $\pm 5\text{ppM}$ with the EFC function, so a relatively small voltage change would move the frequency considerably.

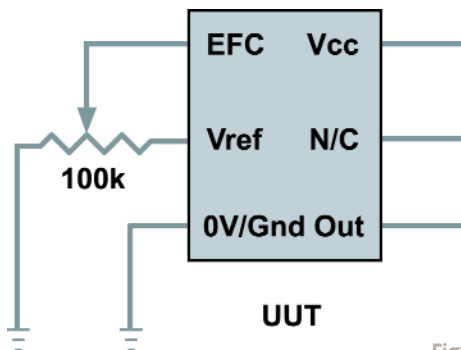


Figure 3

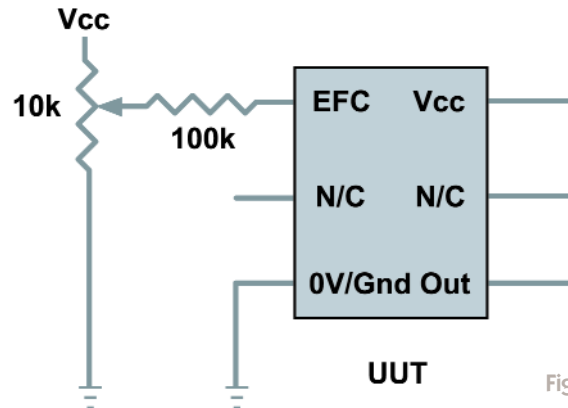


Figure 4

Greenray high performance TCXOs incorporate a low noise ASIC oscillator which can output either a +3.3V or +5.0V CMOS square wave, or a 0.8Vp-p Clipped Sine wave into a 10kohm/10pF load. The Clipped Sine wave version of this oscillator draws very low input power of less than 2mA at 25MHz. The CMOS version is also very low with less than 4mA at 25MHz. Both parts address the need for very low input power to lengthen battery life.

The TCXO is designed for the 10MHz to 50MHz frequency range, and a typical phase noise plot is displayed in Figure 5. The oscillator also has a unique feature of variable crystal drive to optimize temperature compensation and phase noise.

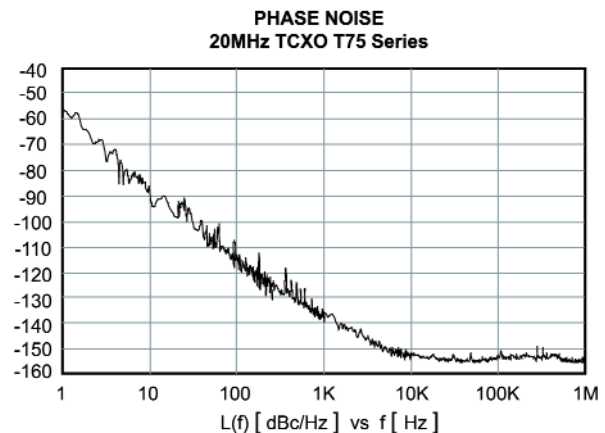


Figure 5

The 7x5mm T75 Series implements a custom surface mount ceramic package (see Figure 6) which hermetically protects the active integrated circuitry of the unit and allows the part to be used in very harsh environments, including high humidity or moisture and extreme temperature variations. By using hermetic sealed crystals, it is possible to ensure repeatable low aging performance.

The ceramic package and IC are made as an assembly to optimize production, and the individually packaged and sealed crystals are mounted externally as the final step in the manufacture of the part. This process

Key attributes of the T75 Series TCXOs include:

- Frequencies from 10 to 50MHz
- Supply Voltages of +3.3 & 5.0VDC
- Low power consumption – as low as 2mA
- Temp Stability as low as $\pm 0.2\text{ppM}$
- Low Aging - $< 3\text{ppM}$ over 10 years
- Acceleration sensitivity down to $3 \times 10^{-10}/g$
- Withstands high shock and vibration

The T75 Series TCXOs are ideally suited for:

- Smart Munitions
- Mobile Receivers
- Airborne Communications
- Mobile Instrumentation
- Microwave Receivers
- Telecom Stratum 3
- Wireless Communications

optimizes customization and allows any frequency to be chosen between 10.0MHz and 50.0MHz.

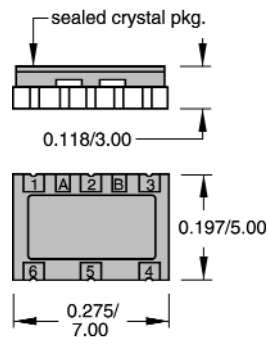


Figure 6



For additional information about the T75 Series TCXOs and Greenray's entire line of high performance frequency control products, visit Greenray on the web or call us today.

Author: Phil Myers, Greenray Industries, Inc.



Precision quartz-based oscillators for the wireless, wired telephony, aerospace, military, satellite, and other communications markets.



Greenray Industries, Inc.
840 West Church Road, Mechanicsburg, PA 17055
Telephone: 717-766-0223 Fax: 717-790-9509
www.greenrayindustries.com e-mail: sales@greenrayindustries.com