

## Introduction to Frequency Control

### Terms + Products

Frequency control is the process of maintaining the stability of clocking and timing in digital devices. All digital circuits today require clocks to ensure that processes happen at very specific intervals.

In the 1970's, the digital watch was introduced. The design used kHz watch crystals to keep the timing, which is a process we still use today. Real-Time Clocks (RTC) are used to timing in most processors and are used in registers as counters. Oscillators provide RF signals and TCXOs are used in two-way communication devices to provide clear communication.

### Crystals

Crystal packages are getting smaller every day. Currently, ECS Inc. International carries both 1.2 x 1.0 mm and 1.6 x 1.2 mm package sizes. Globally, the most common crystal package size is 3.2 x 2.5 mm. 32.768 kHz watch crystals are getting smaller as well with the most common size being the 3.2 x 1.5 mm or the 1.2 x 1.0 mm. While sales of smaller package sizes are growing each year, demand to reduce BOM cost is often paramount. So, HC-49 SM packages like our CSM-7X (5PX) are still global best-sellers. Crystals are used most often in processors. They require matching caps on the PCB to make the oscillator loop.

### Oscillators

Oscillators are also trending smaller than ever before. We are seeing an uptick in sales on parts like our ECS-1612MV, our smallest MHz oscillator at 1.6 x 1.2 mm. Over the last 5 years, our most popular oscillator packages have been 3.2 x 2.5 mm and the 2.5 x 2.0 mm. Our MultiVolt™ Oscillators are quartz based and are the preferred oscillator configuration. MV oscillators are available at 32.768 kHz, as MHz oscillators and as TCXOs. There are low jitter, tight tolerance, low current, and AEC-Q200 options available. Overall, MV oscillators offer better performance at a lower cost than comparative MEMS devices.

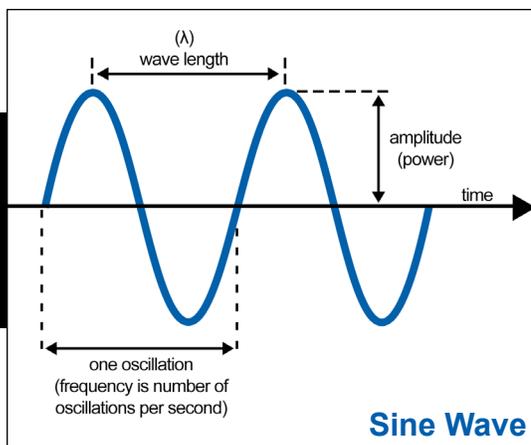
### TCXOs + OCXOs

TCXOs are common in sizes ranging from 2.0 x 1.6 mm to 7.0 x 5.0 mm packages that are necessary for a variety of applications including GPS. We offer both CMOS and Clipped Sine Wave outputs depending on use in either an analog or digital application. MultiVolt™ TCXOs are quickly improving to a point where they can be considered to replace traditional TCXOs.

OCXOs are oscillators that have an internal heater and temperature control circuit to maintain the crystal inside at its "turn-point". OCXOs will offer considerably better stability, jitter, and phase noise. Design and manufacturing of OCXOs are more expensive than other oscillators.

### Timing Acronyms

Hz - Hertz; 1 cycle per second  
 kHz - Kilo Hertz; 1,000 Hz per second  
 MHz - Mega Hertz; 1,000,000 Hz per second  
 GHz - Giga Hertz; 1,000 MHz  
 mS - Millisecond; 1/1,000<sup>th</sup> of a second  
 μS - Microsecond; 1/1,000,000<sup>th</sup> of a second  
 nS - Nanosecond; 1/1,000<sup>th</sup> of a microsecond  
 pS - Picosecond; 1/1,000<sup>th</sup> of a nanosecond  
 fs - Femtosecond; 1/1,000<sup>th</sup> of a picosecond



### Common Frequencies in Electronics

50 Hz - Frequency of A/C power in the UK  
 60 Hz - Frequency of A/C power in the U.S.  
 32.768 kHz - Frequency of Real Time Clocks (RTC)  
 13 MHz / 26 MHz - Frequencies of GSM and LTE cell phone clocks  
 13.56 MHz - RFID and NFC frequencies  
 900 MHz - Common mobile GSM frequency  
 1575.42 MHz - Common GPS frequency  
 2450 MHz / 2.45 GHz to 5000 MHz / 5 GHz - Common Wi-Fi Frequency  
 RF - Radio frequency bandwidth typically 3 kHz to 300 GHz

### Common Terms in Frequency Control

Quartz - A single crystal of Silicon Dioxide (SiO<sub>2</sub>)  
 Nominal Frequency - Specified center frequency  
 Fundamental Mode - Primary frequency of crystal cut  
 Overtone (3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, etc.) - Integral multiples of the fundamental frequency  
 AT-Cut - Most common angle cut of crystals  
 Quartz Blank - Finished crystal which is mounted in holder  
 Crystal Electrodes - Plated areas on both sides of the blank  
 TH Crystal - Thru Hole Crystal  
 SMD Crystal - Surface Mount Crystal  
 ESR - Equivalent Series Resistance  
 CL - Load Capacitance

### Common Oscillator Basics Terms

32.768 kHz - Common watch frequency  
 XO - Crystal Clock Oscillator  
 VCXO - Voltage Controlled Crystal Oscillator  
 TCXO - Temperature Compensated Crystal Oscillator  
 VC-TCXO - Voltage Controlled Temperature Compensated Crystal Oscillator  
 OCXO - Oven Controlled Crystal Oscillator  
 MultiVolt™ - MultiVolt™ Oscillators including 32 kHz, XOs, and TCXOs  
 Programmable - Digitally programmable oscillators  
 AEC-Q200 - Qualification of automotive grade oscillators

### Common Oscillator Output Terms

TTL - *Transistor-Transistor Logic*  
 An ASIS built with bi-polar junctions and resistors that use a 5V supply  
 LVCMOS / CMOS - *Low Voltage Complementary Metal Oxide Semiconductor*  
 A low voltage class of CMOS technology found in integrated circuits; often 3.3V but JEDEC standards allow down to 1.1V  
 LVDS - *Low Voltage Differential Signaling*  
 Can operate at a low power point and can run at very high speeds; often 2.5V supply and can be used in applications requiring <100 MHz  
 LVPECL - *Low Voltage Emitted Couple Logic*  
 Differential signaling systems and are primarily used in high speed and clock distribution circuits  
 HCSL - *High Speed Current Steering Logic*  
 Differential logic output producing 0V and 0.725V supply swings; Used for low jitter and low EMI applications  
 Cipped Sine Wave  
 Sinusoidal wave form where the upper and lower peaks have been clipped off - beyond the capability of the amplifier and not needed. This results in a distorted square wave form

