

RADITEK short form Catalog

Phase Locked Sources, Synthesizers and Oscillators

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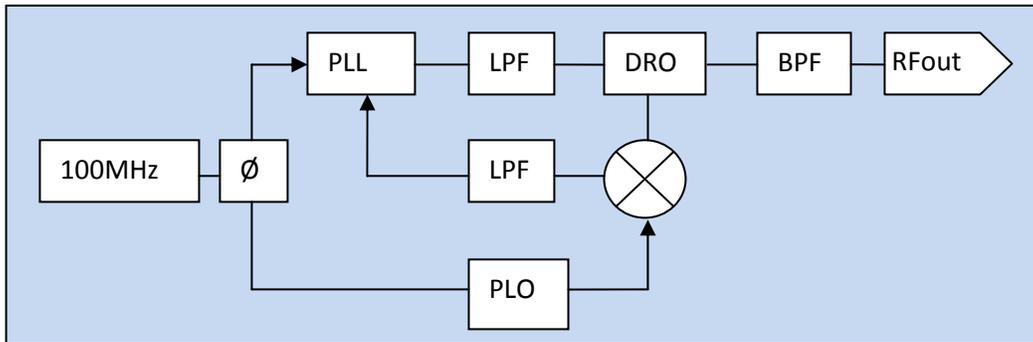
Phase Locked Sources, Synthesizers and Oscillators

Raditek is known around the world for its excellence in isolator technology. Raditek is also becoming very well known as the supplier of choice for other products as well. Such products several types of **oscillators including: DROs (Dielectric Resonator Oscillators), Phase Locked DROs and synthesizers. Raditek also has supporting lines of Crystal oscillators: VCXO, TCXO, VCTCXO and OCXO** include: Broadband Couplers, Cavity filters and (Ovenized Crystal Oscillator).

The Raditek RSYN family of high performance variable frequency synthesizers and RSPLO synthesized single frequency oscillators offers PLDRO like performance with a non sub-harmonically related reference. (Standard PLDRO requires a sub-harmonically related reference) , and the units are surprisingly low cost, with very respectable phase noise!

RADITEK synthesizers have a serial digital programming input.

The following is one of many solutions:



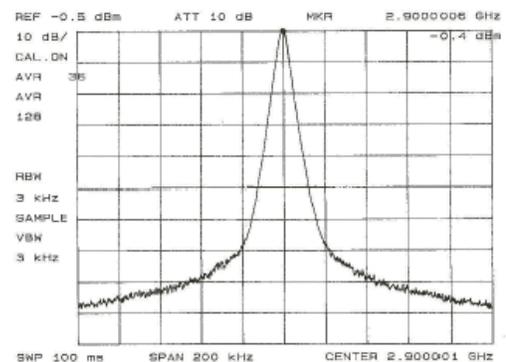
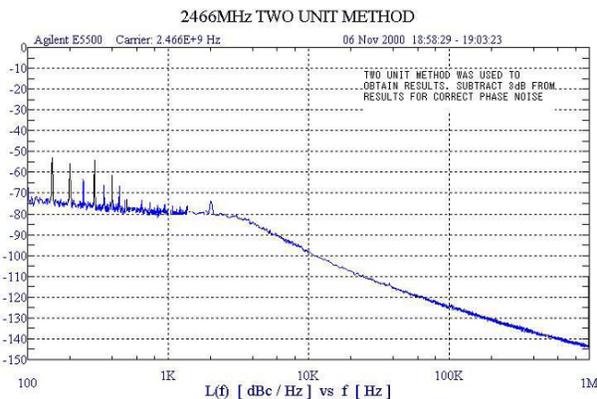
For example, the **RADITEK RSYNTH-L70 Series synthesizers** are excellent Microwave Signal Sources offering 100MHz Tuning in 100KHz step sizes between 100MHz to 4 GHz Frequency range, and suitable for use in many applications Including: ISM, U-NII etc. The PLO's internal 10MHz TCXO reference, make this

A self contained complete oscillator solution.

Also typical Phase Noise is below -100dBc/Hz at 10KHz offset using high-Q CRO. It runs from a supply of 5V at 60mA.

With a stability of 1ppm from -20 to 60°C

Fig 1 Phase noise plots of RSYNTH-L70



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Basic Oscillator Theory

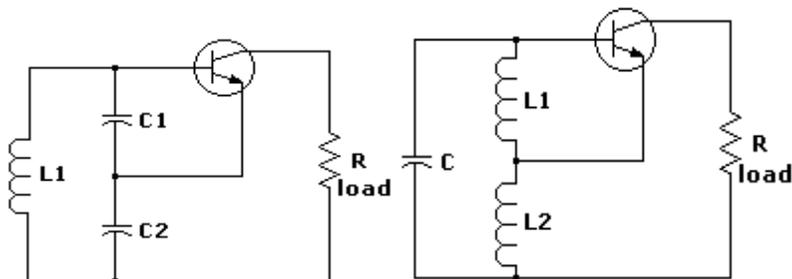


Figure 2 and 3 - Schematics of a Hartley and a Colpitts Oscillator.

The basic Colpitts oscillator circuit look like Fig 3 (right) above, and you will see the transposition of the L (Inductor) and C (Capacitance), compared to the (on the left) Hartley type. These basic structures still form the basic core of many VCOs (Voltage controlled oscillators), by having the “tank” or tuned circuit being made tunable by adding a (variable capacitance) Varactor diode.

Positive feedback is applied to compensate for the losses in the tuned circuit, the amplifier and feedback circuit create a negative resistor. It can be shown that the input impedance is a negative resistor in series with C1 and C2. And the frequency is determined by:

$$f_o = \frac{1}{2\pi [LC_1C_2 / (C_1 + C_2)]^{1/2}}$$

Figure 4 - formula - Colpitts oscillator

Frequency or Phase Stability of an Oscillator

Frequency or phase stability of an oscillator is usually considered in the long term stability case, where frequency changes are measured over minutes, hours, days and years. Of interest here are the effects of the components changes, with ambient conditions, on the frequency of oscillation. These might be caused by changes in the input voltage, variations in temperature, humidity and ageing of our components. Short term stability is also of great interest and it can be mathematically proven that the higher the circuit Q, the higher the stability factor becomes. The higher the circuit Q, the better the ability the tuned circuit can filter out undesired harmonics AND noise.

Dielectric Resonator Oscillators (DRO)

These are used widely in today's electronic warfare, missile, radar and communication systems. They find use both in military and commercial applications. The DROs are characterized by low phase noise, compact size, frequency stability with temperature, ease of integration with other hybrid MIC circuitries, simple construction and the ability to withstand harsh environments.

These characteristics make DROs a natural choice both for fundamental oscillators and as the sources for oscillators that are phase-locked to reference frequencies, such as crystal oscillators. They are high Q and very small tuning range, and are suitable for fixed frequency oscillators, whether free running, phase locked or synthesized from a non harmonically related reference

Raditek Options include: DRO, PLO (PLDRO), either Internal Reference “IR” or external reference “ER”

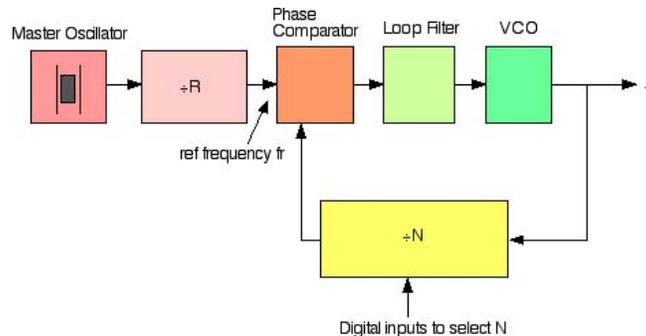
Phase Locked Sources, Synthesizers and Oscillators

RADITEK Synthesizers Introduction:

A frequency Synthesizer is an electronic system for generating any of a range of frequencies from a single fixed timebase or oscillator. A phase locked loop does for frequency what the “Automatic Gain Control” does for voltage. It compares the frequencies of two signals and produces an “error signal” which is proportional to the difference between the input frequencies. The error signal is used to drive a “voltage-controlled oscillator” (VCO) which creates the output frequency. The output frequency is fed through a “frequency divider” back to the input of the system, producing a negative feedback loop.

If the VCO output frequency drifts, the instantaneous error signal will increase, driving the frequency in the opposite direction so as to compensate for the drift. Thus the output is *locked* to the frequency at the reference input, which in turn is derived from a very stable crystal oscillator.

The block diagram below shows the basic elements and arrangement of a PLL based frequency synthesizer.



In practice this type of frequency synthesizer cannot operate over a very wide range of frequencies, because the comparator intrinsically has a limited bandwidth and may suffer from aliasing problems. This would lead to false locking situations, or an inability to lock at all. In addition, it is hard to make a high frequency VCO that operates over a very wide range. This is due to several factors, but the primary restriction is the limited capacitance range of the variable capacitance, Varactor diodes. However, in most systems where a synthesizer is used, we are not after a huge tuning bandwidth, but rather over some defined range, such as a number of radio channels in a specific band.

Many radio applications require frequencies that are higher than can be directly input to a digital counter. To overcome this, the entire counter could be constructed using high-speed logic such as ECL, or more commonly, using a fast, initial division stage called a *prescaler* which divides the frequency to a manageable level. Since the prescaler is part of the overall division ratio, a fixed prescaler can cause problems designing a system with narrow channel spacings - typically encountered in radio applications. This can be overcome using a dual-modulus prescaler.

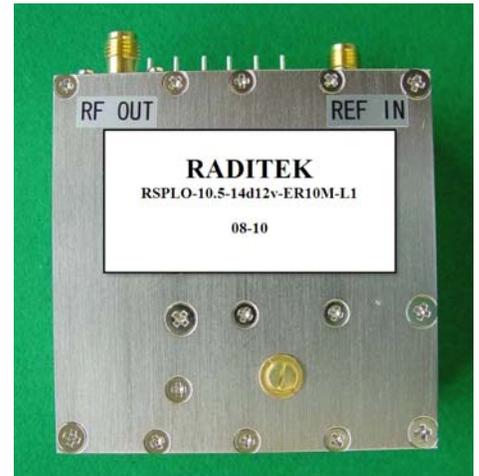
Further practical aspects concern the amount of time the system can switch from channel to channel, time to lock when first switched on, and how much noise there is in the output. All of these are a function of the *loop filter* of the system, which is a low-pass filter placed between the output of the frequency comparator and the tuning input of the VCO. Usually the output of a frequency comparator is in the form of short error pulses, but the input of the VCO must be a smooth noise-free DC voltage. (Any noise on this signal naturally causes frequency modulation of the VCO.). Heavy filtering will make the VCO slow to respond to changes, causing drift and slow response time, but light filtering will produce noise and other problems with harmonics.

Harmonics occur due to the non linear frequency components in the synthesizer active devices, such as buffer amplifiers etc. They do not usually cause any problems as they are so far away from the output and usually 20-30 dB down relative to the required output level. Additional harmonic filtering can reduce the harmonics (for a relatively narrow band synthesizer) to 50-60 dBc, if necessary. Other undesirables include sub harmonics and spurious. For very high frequencies, sometimes a frequency **Doubler** is used; which is a non linear device, diode or amplifier, which generates a number of harmonics, it is usually in a balanced configuration so as to suppress the odd harmonics, thereby giving a high level second harmonic. This second harmonic is now the desired output frequency and the original first harmonic, now well suppressed becomes the sub-harmonic. Another example exists on the **PLOs** (Phase locked Sources), we make, using a **Sampling Phase detector**, which generates many sub -harmonics-which are harmonics of the reference.

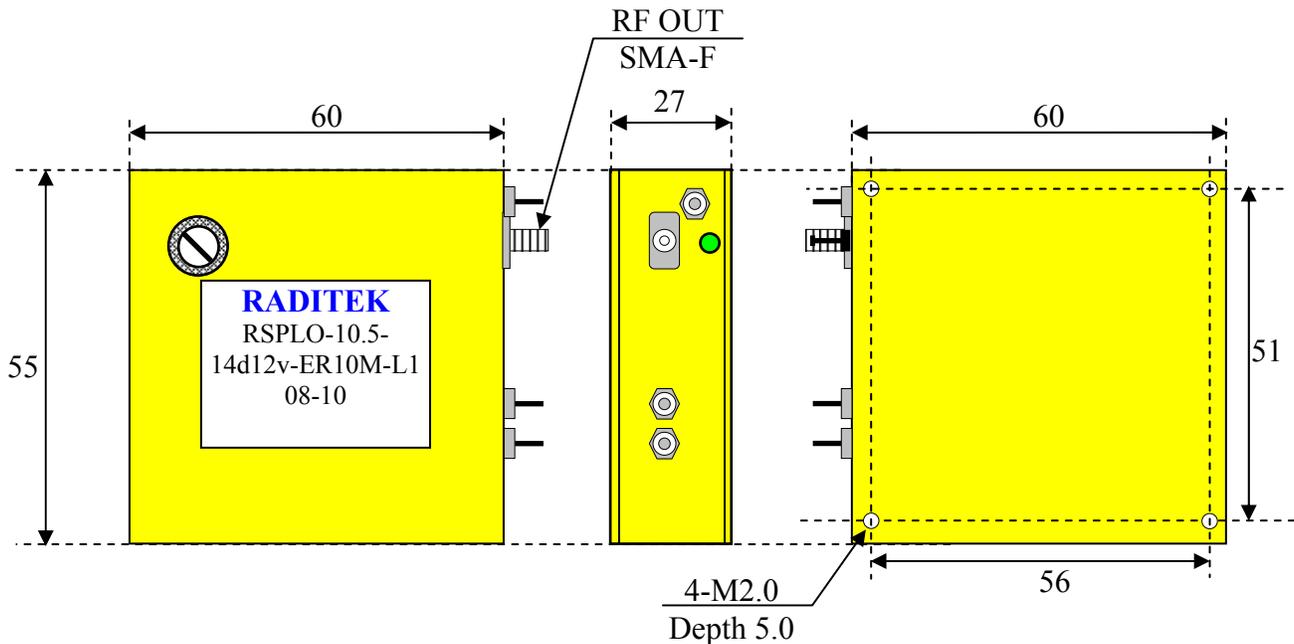
Phase Locked Sources, Synthesizers and Oscillators

RSPLO Fixed frequency Synthesizer - PLDRO Replacement

Output frequency	Typical specifications:-	
5.3 - 13	GHz	
13 To 26.0	GHz	(with doubler)
Channel step	500KHz	
SSB Phase noise		
	-80dBc/Hz	100Hz offset
	-90dBc/Hz	1KHz offset
	-90dBc/Hz	10KHz offset
	-105dBc/Hz	100KHz offset
	-130dBc/Hz	1MHz offset
Frequency stability	±1.0 ppm	-10 to 50°C
RF output power	14 dBm	
DC bias	+12V @ 500mA	
Package size	60(L) x 65 (W) x 20(H)	mm

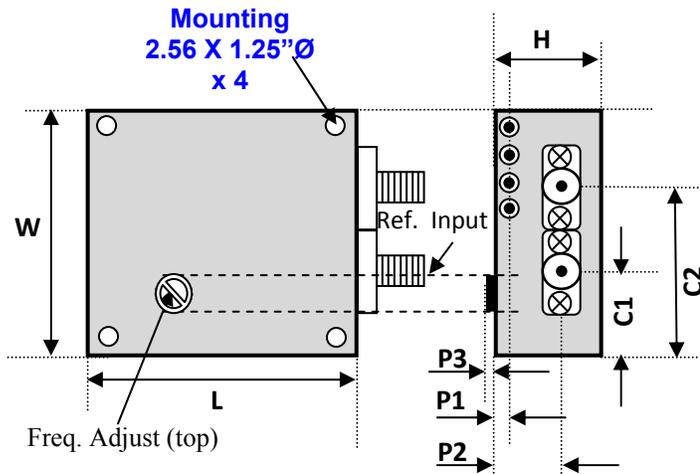


Order as RSPLO-Frequency out (MHz or GHz)-RF power out/voltage-reference MHz-step size (MHz)-option



Phase Locked Sources, Synthesizers and Oscillators

RPLO-B-ER or IR-0.5 ppm Phase lock DRO



Dimensions		1	2	3
W	Width	1.5"	1.883"	1.5"
L	Length	2.0"	2.0"	2.0"
H	Height	0.50"	0.652"	1.00"
C1	RF Out	0.335"	0.718"	0.278"
C2	RF In	0.895"	1.278"	1.140"
P1		0.116"	0.116"	0.775"
P2		0.314"	0.467"	In-0.5775" Out-0.277"
P3		0.040"	0.040"	0.040"
Model		1	2	3

Specifications	Spec	Units
*Reference Power	-3 to +13	dBm
Supply Voltage	12 to 16	V
▶ Supply Current	325-200	mA
Operating Temp.	-40 to +70	°C
Storage Temp.	-55 to +85	°C
▶ Power	2	dB
Lock Alarm	TTL low	V

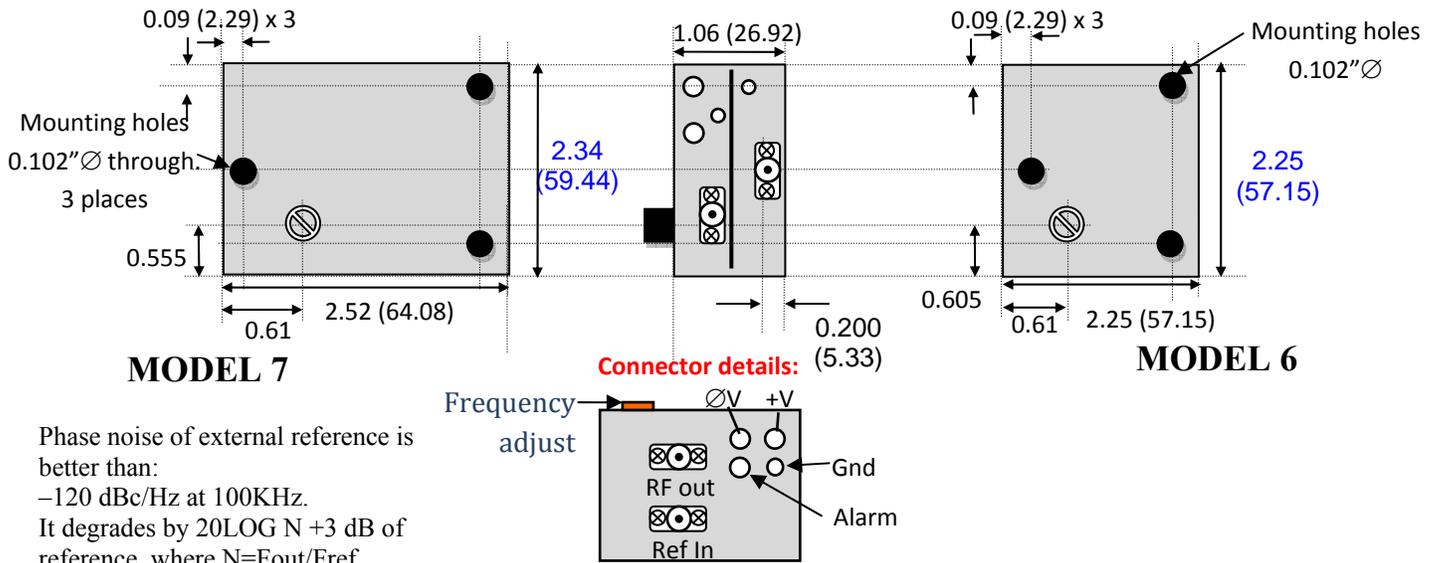
* Model 3 - Ref Power >7

Frequency (GHz)	Units	0.9-1.4	1.4-2.0	1.9-2.8	2.8-4.0	3.9-5.6	5.6-8.0
RF Power LP	dBm (min)	12-15	12-15	12-15	12-15	12-15	12-15
Reference Frequency	MHz (max)	50~500	50~500	50~500	50~500	50~500	50~500
Mechanical Tuning >+/-	MHz	0.819~1.106	1.162~1.568	1.637~2.210	2.323~3.136	3.274~4.420	4.646~6.272
Harmonics	dBc	-25					
Spurious	dBc	-70					
▶ Phase Noise (1 Hz BW)							
<100 kHz	REF+dB	20*log(N)+3					
@ 100 kHz	dBc/Hz	-137 to -134	-134 to -131	-131 to -128	-128 to -125	-125 to -122	-122 to -119
@ 1 MHz	dBc/Hz	-141	-141	-141	-141	-141	-141
Model id		1	1	1	1	1	1

Frequency (GHz)	Units	7.9-11.3	11.3-16.0	16.0-19.6	19.6-23.9	23.9-32.2	32.2-43.4
RF Power LP	dBm (min)	13-16	13-16	13-16	13-16	7-10	6-9
Reference Frequency	MHz (max)	50~500	50~500	50~500	50~500	50~500	50~500
Mechanical Tuning >+/-	MHz	6.6~9.2	9.6~12.6	13.2~15.2	16.0~18.8	19.6~25.1	26.4~34.0
Harmonics	dBc	-25					
Spurious	dBc	-80					
▶ Phase Noise (1 Hz BW)							
<100 kHz	REF+dB	20*log(N)+3					
@100 kHz	dBc/Hz	-119 to -116	-116 to -113	-113 to -111	-111 to -110	-109 to -107	-107 to -105
@ 1MHz	dBc/Hz	-144 to -141	-141 to -138	-138 to -136	-136 to -135	-134 to -132	-132 to -130
Model id		1	1	3-sj	3-sj	1	2

Phase Locked Sources, Synthesizers and Oscillators

RPLO-A-3-10.7 GHz-ER Phase Locked Sources



Phase noise of external reference is better than:
 -120 dBc/Hz at 100KHz.
 It degrades by 20LOG N +3 dB of reference, where N=Fout/Ref.

External reference PLO

PART#: RPLO-A-Model-FREQ-POWER-VCC-Reference-Alarm-Package

Isolator at output is standard

Example: RPLO-A-M6-9.3-14d-15v-ER10M

Not to scale. UNITS: inch (mm). Temperature range: -40 to +70°C.

Options include:

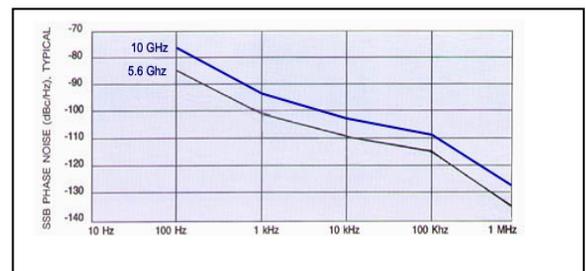
- 12V, 15V, Vcc (± 0.5V)
- Phase lock alarm: Open Collector**
 1. (A1, standard) Locked High (customer supplied 5-16V, Unlocked Low 0.2V Typical ,
 2. (A2 special) Locked Low 0.2V Typical , Unlocked High (customer supplied 5-16V
- 20dBm OP on Model 7

Installation details:

1. Mechanical DRO adjustment is not advised. Monitor the Phase voltage during adjustment (to be mid way), wait 5 minutes (warm up) before any adjustment.
2. Crystal adjustment. Screw adjustment under cover, (on internal reference models). Monitor frequency Adjust after 5 minutes warm up. Monitor the Ref. Monitor port for mid Vcc voltage.

MODEL:	Model 6	Model 7	Units
Frequency	8.0-10.8	3.35-7.9GHz	GHz
Reference	Ext. 5-10	Ext. 10	MHz
Reference	0±3	0±3 dBm	dBm
Stability ppm	As ext. ref.	As ext. ref.	°C
POWER out	+14	+14, 20opt.	dBm
Load VSWR	3.0:1	3.0:1	
Spurious	-75	-75	dBc typ
Harmonics	-20	-20	dBc typ
DC power(Vcc)	+15	+15	V@
±1Volt	190	190	mA typ
Humidity:	95	95	%
Alarm	Optional	Optional	Optional

Typical Phase noise, in dBc/Hz, per offset: +/-4dB			
AT:→	3G	5G	12G
100Hz	20log(N)+3	20log(N)+3	20log(N)+3
1KHz	20log(N)+3	20log(N)+3	20log(N)+3
10KHz	20log(N)+3	20log(N)+3	20log(N)+3
100KHz	20log(N)+3	20log(N)+3	20log(N)+3
1MHz	-140	-140	-135



Phase Locked Sources, Synthesizers and Oscillators

Crystal Oscillators: XO, VCXO, TCXO, VCTCXO, OCXO, Rubidium standards

RADITEK has a whole family of OCXOs (Ovenized Crystal Oscillators), VCXO (voltage Controlled Crystal Oscillator) and TCXO/VCTCXO (Voltage controlled, temperature compensated crystal oscillator), plus Rubidium standards for the ultimate frequency reference! Please contact us for more information, as the range of Crystal oscillator products is far to vast for a short form catalog!

Raditek has a range of standard Frequency SAW Resonators also, we regret we cannot make non standard frequencies unless a minimum volume purchase is anticipated.

A major reason for the wide use of crystal oscillators is their **high Q factor**. A typical Q for a quartz oscillator ranges from 10^4 to 10^6 , compared to perhaps 10^2 for an LC oscillator. The maximum Q for a high stability quartz oscillator can be estimated as $Q = 1.6 \times 10^7/f$, where f is the resonance frequency in megahertz.

Stability Over Temperature and Time

	Clock Oscillator	TCXO	OCXO
0°C to 70°C	±10 ppm	±0.5 ppm	±0.003 ppm
-20°C to 70°C	±25 ppm	±0.5 ppm	±0.003 ppm
-40°C to 85°C	±30 ppm	±1 ppm	±0.02 ppm
-55°C to 125°C	±50 ppm	N/A	N/A

Aging: Typical first year aging

Clock Oscillator	TCXO	OCXO
±3 ppm	±1 ppm	±0.1 ppm (AT-cut); ±0.075 ppm (SC-cut)

Double Rotated (SC-cut) Crystals

While most high stability crystal oscillators use AT-cut crystals, SC-cut crystals are often used in the highest stability OCXO models. An SC-cut crystal is one of a family of double rotated crystals (quartz crystals cut on an angle relative to two of the three crystallographic axes). Others in the family include the IT-cut and FC-cut. The SC-cut represents the optimum double rotated design as its particular angle provides maximum stress compensation.

Atomic Standards: Rubidium

Due to aging and environmental factors such as temperature and vibration, it is hard to keep even the best crystal oscillators within one part in 10^{-10} of their nominal frequency without constant adjustment. For this reason, atomic oscillators are used for applications that require better long-term stability and accuracy.

A Rubidium frequency standard owes its outstanding accuracy and superb stability to a unique frequency control mechanism. The resonant transition frequency of the Rb87 atom (6,834,682,614 Hz) is used as a reference against which an OCXO output is compared. The OCXO output is multiplied to the resonance frequency and is used to drive the microwave cavity where the atomic transition is detected by electro-optical means. The detector is used to lock the OCXO output ensuring its medium and long-term stability. Raditek has several models available.