KS ELECTRONICS LLC

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KS Electronics

KS Electronics was established in February of 1989, to meet the specialized needs of companies engaged in two way RF Communications, by providing them with over 60 years of experience at all levels in designing and manufacturing of crystal filters, L/C filters, TCXO, VCXO's, VC-TCXO's, VCO's and DCXO's. Organized for CUSTOM WORK, we offer attention to minute details and customers specifications at all levels of their requirements.
KS Electronics has the latest available test equipment from the leading manufacturers (calibrated to MIL-C-45662) to do customized testing of all the required specifications. Our personnel are trained to use all the test equipment to meet stringent customer needs and more. We also have the capability of environmental testing for the full military range.

Engineering

We have a stringent set of design standards to meet or exceed your requirements. Using state of the art software, our engineers design the proper products for your valued application. At KS Electronics your dreams becomes reality. Our design time is reduced by the use of high speed computers and our in house capability of making prototypes. Our technical staff has over 15 years of college level education.

Oscillator Products

KS Electronics has the capabilities, experience and production technique to meet your exact oscillator requirements. Some of the oscillators are available in SMD packages.

TCXO

- Up to 350 MHz in frequency.
- +15 dBm output into 50 ohms.
- Frequency stability:
  ±1 ppm from -40ºC to + 85ºC.
- Low power consumption 250 mW typical.
- Low phase noise. Typical SSB phase noise is -140 dBc / Hz at 1 kHz offset. Excellent noise floor -165 dBc / Hz min.
- In house facility for the measurement of phase noise.
- Typical volume 2.5 cubic inch max.
- Typical aging of 0.5 ppm per year max.
- External adjustment of frequency available for 10 years aging.

VCXO

- Up to 350 MHz in frequency.
- Crystal controlled stability over the full military range.
- Wide band tuning range ±5000 ppm pulling range with excellent temperature stability of ±5 ppm from -30ºC to +85ºC.
- Linearity of ±2% over the tuning range of 0.0V ±10V.
- Positive (+ve) or negative (-ve) tuning slope available.
- Excellent short term stability and phase noise.
- Low input power.
- Small volume (2.5 cubic inch max.).
- External mechanical or electrical adjustment of frequency available.

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DCXO

- Up to 350 MHz in frequency.
- ±0.1 ppm stability over -40ºC to + 85ºC.
- Low power consumption (600 mW max.).
- Excellent phase noise.
- Aging is 0.5 ppm per year max.
- External mechanical adjustment for frequency for 10 years of aging.

VC-TCXO

- Up to 350 MHz in frequency.
- This combines both TCXO and VCXO into one unit.
- Wide pull with excellent temperature stability.
- Excellent short term stability and SSB phase noise.

LC Filters

- Up to 250 MHz in frequency.
- Group delay equalized with excellent selectivity.
- Low pass , high pass , band rejects and band pass versions available.
- We also have resources to make helical resonator filters. Helical resonators filters are used where the crystal filters are not practical to make, and the requirement is too narrow for L/C filters.

VCO

- Up to 500 MHz in frequency.
- +16 dBm output into 50 Ω.
- Excellent tuning linearity ±5% max.
- Temperature stability of 25 ppm / ºC.
- Low power consumption (400 mW typical).
- Harmonics / spurious: -10 dBc / -60 dBc.
- Typical SSB phase noise of -100 dBc / Hz at 10 kHz offset from carrier.
- Full military temperature range of -55ºC to + 105ºC available.
- Supply voltage sensitivity of less than 2000 ppm per volt.

Crystal Filters

- Wide variety of crystal filters from 1 MHz up to 500 MHz in assorted and customized bandwidths , selectivity's and packages.
- Phase and amplitude matched sets.
- Flat group delay with excellent selectivity.
- Third order intermodulation intercept point of + 30 dBm with two in band input signals at 0.0 dBm.
- 70 MHz crystal filters 1.1 MHz Bandwidth. Low insertion loss.
- Standard 10.7 MHz, 21.4 MHz , 45 MHz or 70 MHz two pole monolithic crystal filters.
- ***m***-derived crystal filters for steep selectivity.
- Single sideband crystal filters.
- Notch, wide BW-steep / deep notch filters.

OCXO

- We have standard OCXO's at 10 MHz with second optional output at 5 MHz.
- Excellent temperature stability.
  0.02 ppm -10ºC to +55ºC
  0.05 ppm -55ºC to +60ºC
- Input power 0.65 W at -55ºC less than 0.55 W at 25ºC.
- Warm up time: less than 10 minutes for 0.002 ppm temperature stability, at room temperature (25ºC).
- Excellent phase noise -100 dBc / Hz at 100 Hz offset.
- 0.0 dBm ±3 dB into 50 Ω.
- Electrical tuning available for external adjustment of frequency.

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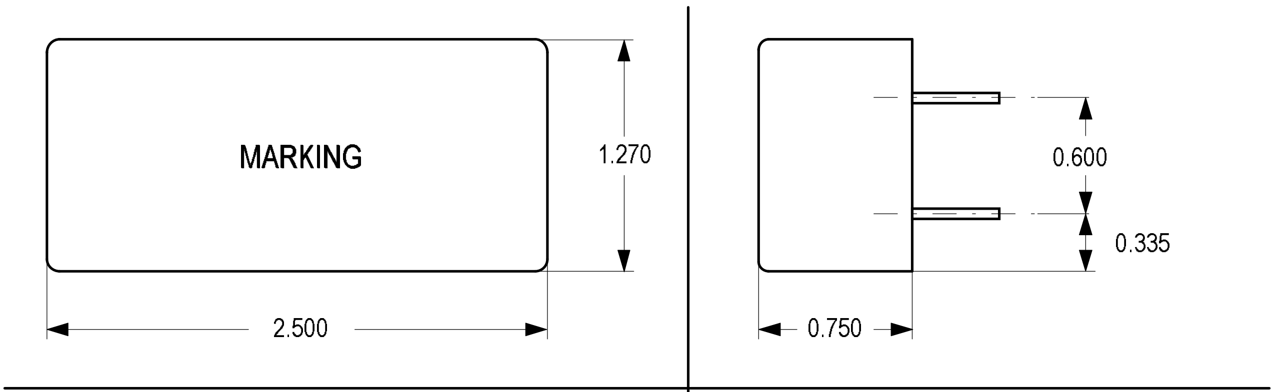

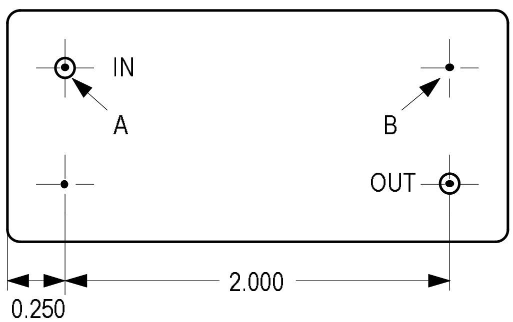

A = 0.040 terminal / 2 places / 0.250 min.
B = 0.040 GND pin / 2 places / 0.250 min.

KS ELECTRONICS LLC	
CRYSTAL FILTERS	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	unless noted otherwise

Crystal Filter - Electrical Specifications :

Center frequency	:	5 MHz to 500 MHz
3 dB BW	:	±5.0 kHz min.
55 dB BW	:	±28.0 kHz max.
Insertion loss	:	6.0 dB typical
VSWR	:	< 1.5 : 1 at center frequency
Input / Output impedance	:	50 Ω
Ultimate attenuation	:	-60 dBc min.
Spurious response	:	-20 dBc min.
Operating temperature	:	0ºC to +70ºC
Storage temperature	:	-40ºC to +85ºC
Inter modulation intercept point	:	+30 dBm (third order) *
Humidity	:	Designed to meet the requirements of MIL-STD-810C, method 507.1, procedure II, group ID
Shock	:	Designed to meet the intent of MIL-STD-810C, method 516.2, procedure V, bench handling test.
Vibration	:	Designed to meet the intent of MIL-STD-810C, method 514.2, table 514.2-VII, procedure X, curve AW.
**** Test condition***	:	2 in band 0 dBm signals input to the filter. The intermode signals shall also be in band. The distortion products shall be more than 60 dB down from the desired signals. See section "Crystal Filters"

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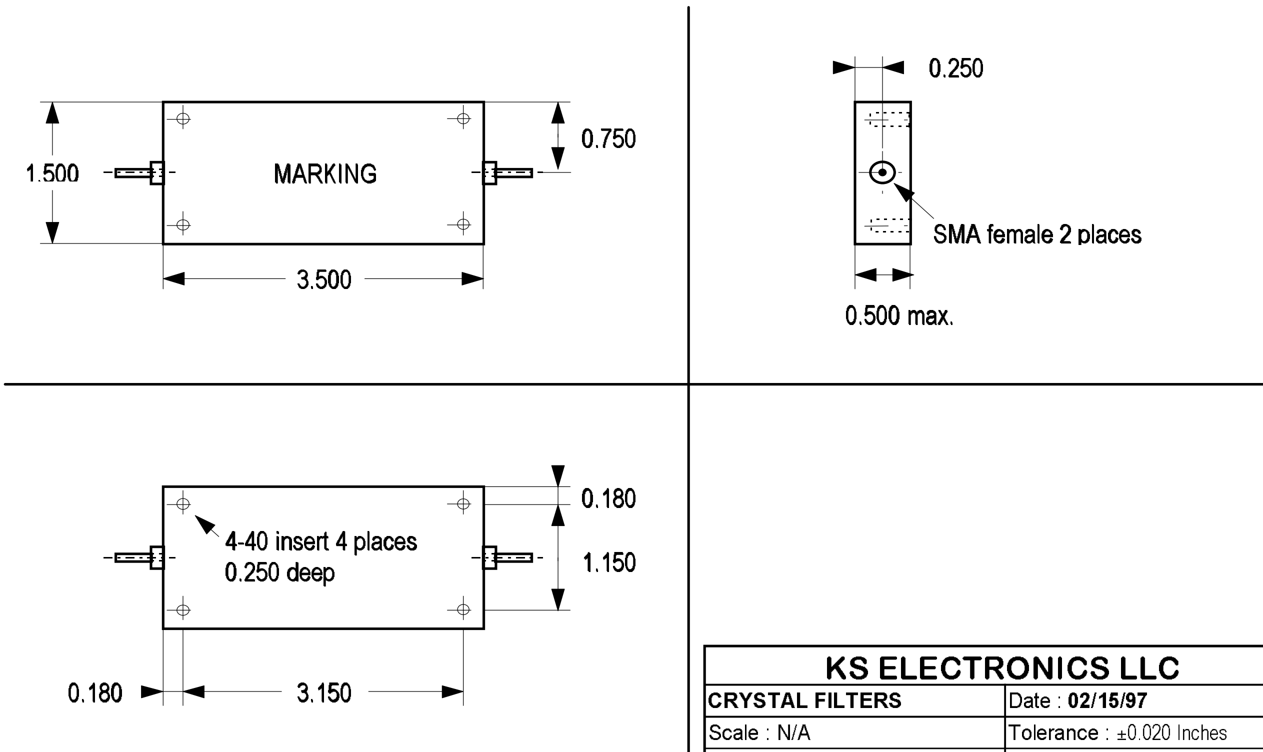

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CRYSTAL FILTERS	Date : 02/15/97
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	unless noted otherwise

Crystal Filters - Electrical Specifications :

Center frequency	:	70 MHz ±20 kHz
1 dB BW	:	±500 kHz min.
60 dB BW	:	±900 kHz max.
Insertion loss	:	14.0 dB typical
Ripple	:	1.0 dB max.
Input / Output impedance	:	50 Ω
Spurious response	:	≥ -60 dBc typical
Group delay variation	:	10 µS max. over 1 dB BW
Operating temperature	:	0°C to +70°C

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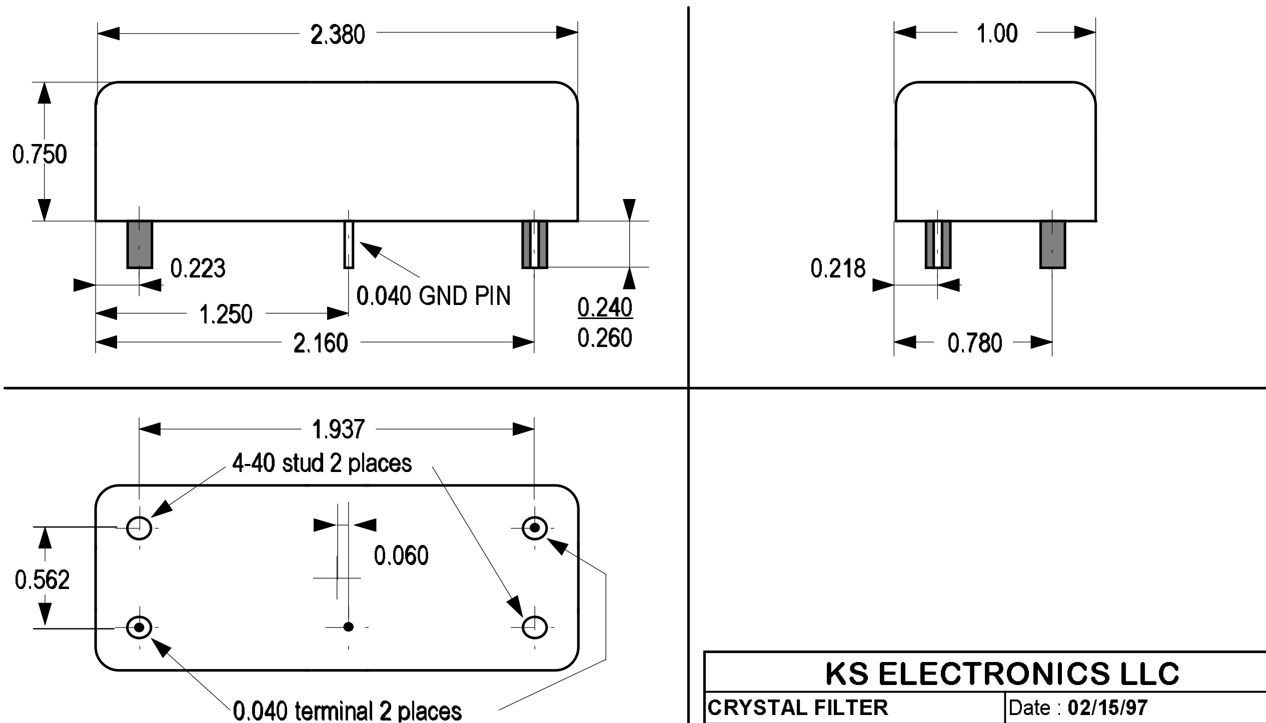

Package can be customized as required !

KS ELECTRONICS LLC	
CRYSTAL FILTER	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	Approved:

Crystal Filter - Electrical Specifications :

Frequency	:	10.7 MHz / 21.4 MHz
3 dB BW	:	±7.5 kHz min.
60 dB BW	:	±15.0 kHz max.
Ripple	:	1.0 dB max.
Insertion loss	:	4.0 dB max.
Input / Output impedance	:	50 Ω
Ultimate attenuation	:	> 100 dB min.
Spurious response	:	> 80 dBc typical
Operating temperature	:	-30ºC to +80ºC

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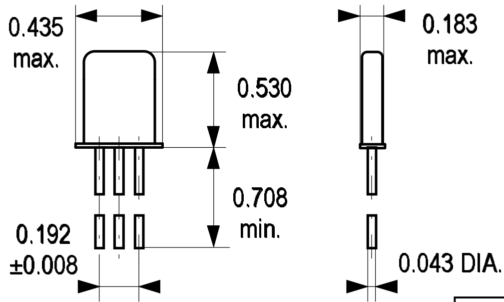
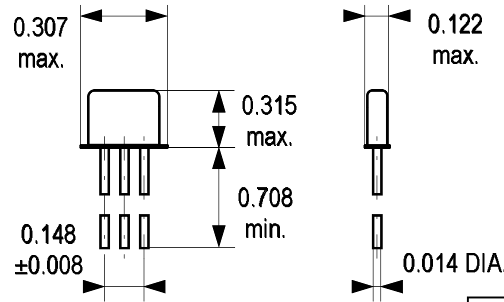
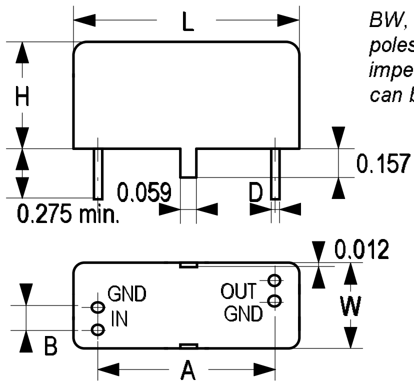


HC-49/U



UM-1



BW, number of poles, input / output impedance, package size, can be customized.

UMB / UMC

UMB / UMC

	L	W	H	A	B	D0
H-1	0.433	0.335	0.452	0.291	0.078	0.012
H-2	0.527	0.335	0.433	0.386	0.078	0.012
H-3	0.590	0.472	0.590	0.354	0.098	0.017
H-4	0.728	0.472	0.590	0.527	0.098	0.017
H-5	0.960	0.472	0.590	0.701	0.098	0.017
H-6	1.102	0.472	0.590	0.874	0.098	0.017

KS ELECTRONICS LLC	
STD. 2 POLE FILTER	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	Approved:

10.7/21.4 MHz standard two pole filter - Electrical Specifications :

Frequency	:	10.7 MHz	21.4 MHz
3 dB BW	:	±7.5 kHz min.	±7.5 kHz min.
18 dB BW	:	±25.0 kHz max.	±25.0 kHz max.
Ripple	:	1.0 dB max.	1.0 dB max.
Insertion loss	:	1.5 dB max.	1.5 dB max.
Input / Output impedance *	:	3.0 kΩ / / 2.0 pF ±3.0 pF	1.5 kΩ / / 2.5 pF ±3.0 pF
Ultimate attenuation	:	35 dB min.	35 dB min.
Operating temperature	:	-40°C to +80°C	-40°C to +80°C
Package	:	HC-49/U or UMB/UMC	HC-49/U, UM-1 or UMB/UMC

* 50 Ω option available in UMB/UMC package.

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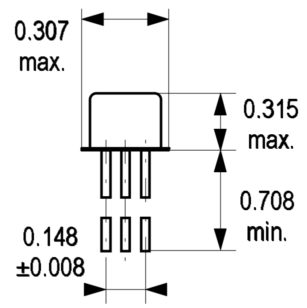
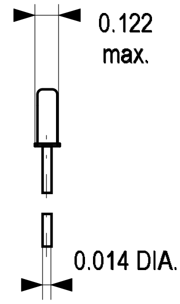
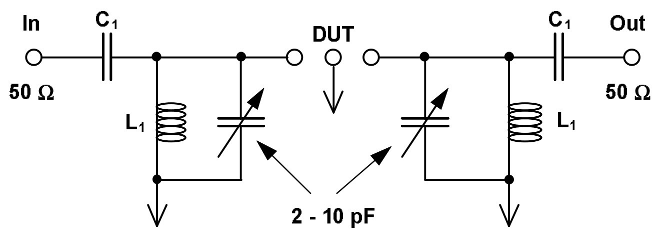


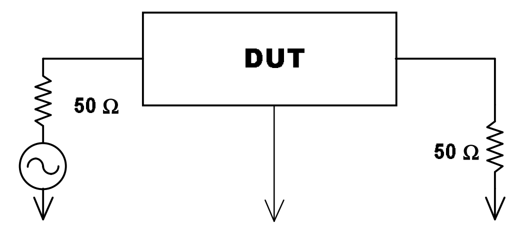


BW, number of poles, input / output impedance, package size, can be customized.

UM-1



	C_1	L_1	Q
45.0 MHz	9.8pF	0.74µH	Q=130
70 MHz 15kHz	7.1pF	0.36µH	Q=110
70 MHz 20kHz	6.4pF	0.36µH	Q=110



KS ELECTRONICS LLC	
45 MHz / 70 MHz 2 Pole Filter	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	Approved:

45 MHz / 70 MHz two pole filter - Electrical Specifications :

Center frequency	: 45.0 MHz	70.0 MHz	70.0 MHz
3 dB BW	: ±7.5 kHz min.	±7.5 kHz min.	±10.0 kHz min.
13 dB BW	: ±25.0 kHz max.	±25.0 kHz max.	±28.0 kHz max.
24 dB BW	: ±50.0 kHz max.	±55.0 kHz max.	±70.0 kHz max.
60 dB BW	: ±910.0 kHz max.	N/A	N/A
Ultimate attenuation	: 60 dB min.	30 dB min.	30 dB min.
Spurious response	: 13 dB min.	13 dB min.	13 dB min.
Ripple	: 0.5 dB max.	1.0 dB max.	1.0 dB max.
Insertion loss	: 1.5 dB max.	2.0 dB max.	2.0 dB max.
Input / Output impedance	: 2600 Ω // 0.0 pF ±2.0 pF	2000 Ω // -1 pF	2500 Ω // -1 pF
Operating Temperature	: -40ºC to +80ºC	-40ºC to +80ºC	-40ºC to +80ºC

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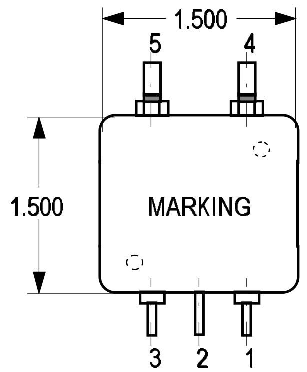

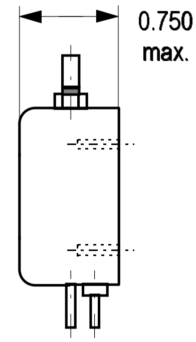

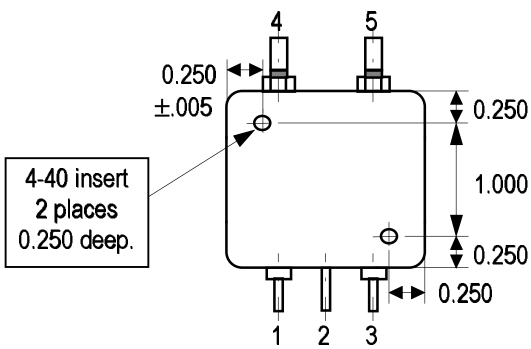

<u>Pin connections:</u>
1 = B+
2 = GND
3 = Select (option)
4 = Output (SMB male connector)
5 = Tune (SMB male connector)
(0.040 dia. Pins 0.250 min.)

KS ELECTRONICS LLC	
70 MHz VCXO P/N 2001	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	Approved:

70 MHz VCXO - Electrical Specifications :

Frequency	:	70 MHz
Harmonic / spurious suppression	:	-25.0 dBc / -60.0 dBc min.
Tuning voltage	:	0V ±9V DC
Tuning slope	:	-ve slope. *
Tuning range	:	±1000 ppm min.
Power output	:	+10 dBm min. into 50 Ω.
Supply voltage (VCC)	:	+15V DC
Supply current (ICC)	:	100 mA max.
Return loss	:	≥ 14 dB
Operating Temperature	:	0ºC to +70ºC

* Increasing tuning voltage decreases frequency.

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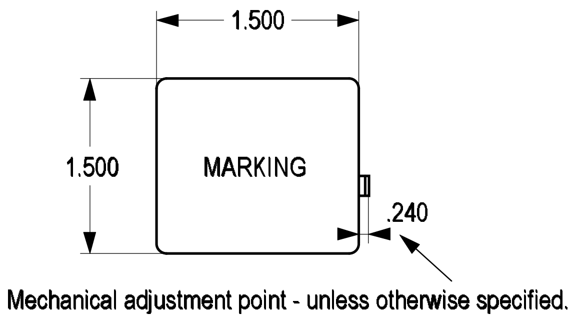

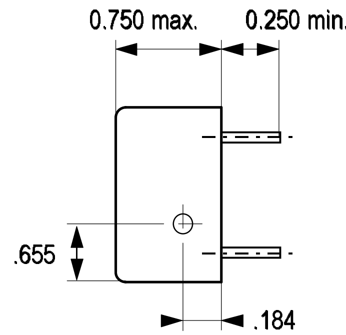

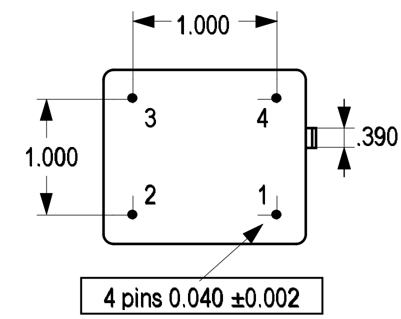

Pin connections:
1 = Supply voltage
2 = Ground
3 = Ground
4 = Output

Height can be customized, pin outs can be changed.

KS ELECTRONICS LLC	
TCXO	Date : 02/15/97
Scale : N/A	Tolerance : ±0.020 Inches
Dimensions : inches	Approved:

TCXO - Electrical Specifications :

Frequency	:	1 kHz to 250 MHz ±1 ppm max. at 25ºC.
Stability over temperature	:	±1 ppm from room temperature setting.
Operating Temperature	:	-30ºC to +85ºC
Output	:	TTL / HCMOS / ECL / sinewave (0.0 dBm)
Spurious / harmonics	:	-20.0 dBc min. where applicable.
Input power (±10%)	:	+5.0V for TTL / HCMOS +12V for sinewave -.5.2V for ECL
Input current	:	100 mA max. depending upon frequency.
Aging	:	±1 ppm / year
Adjustment	:	External mechanical adjustment can be provided. ±5 ppm min. range.

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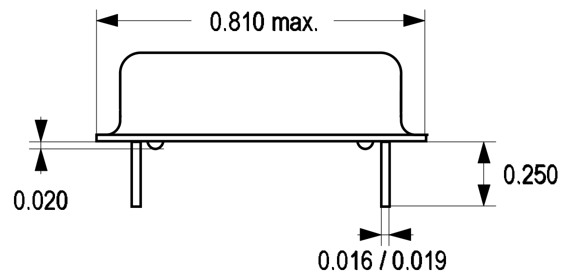

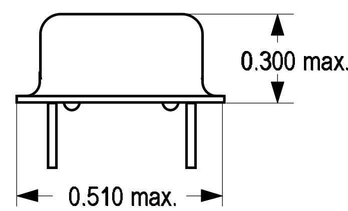

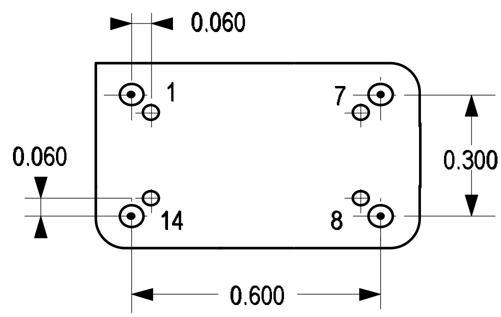

PIN connections:
- 1 : Frequency control voltage
- 7 : Ground / Case
- 8 : Output
- 14 : + 5V DC

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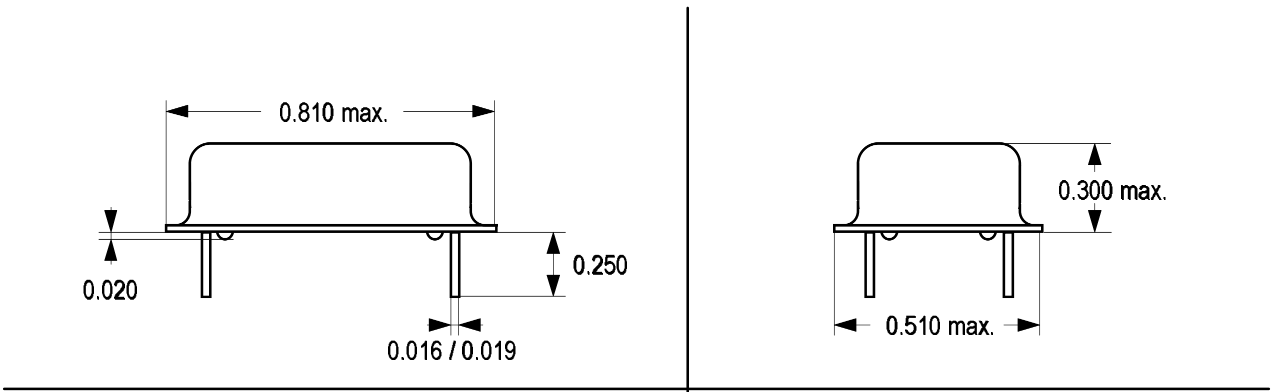
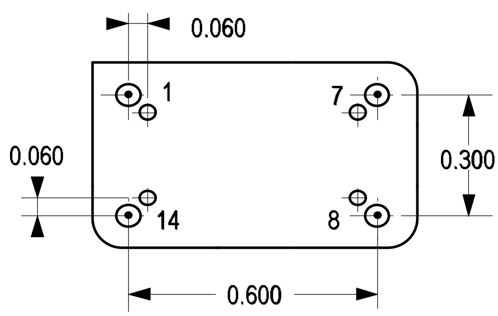
VCXO	Date : 02/15/97
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

VCXO - Electrical Specifications :

Frequency Range	:	1 MHz to 250 MHz
Frequency Deviation	:	±200 ppm min. +ve positive slope *
Frequency Tolerance	:	±0.01% control at 2.5V
Operating temperature range	:	-40ºC to +85ºC
Operating voltage	:	5V DC ±10%
Supply current	:	75 mA max. depending upon frequency.
Control voltage	:	0.0V to 5.0V
Control voltage input impedance	:	100 kΩ
Rise and fall time	:	15 nS max.
Symmetry	:	50 / 50 ±20%

* Increasing tuning voltage increases frequency.





PIN connections:
1 : Frequency control voltage
7 : Ground / Case
8 : Output
14 : Supply voltage

KS ELECTRONICS LLC	
CRYSTAL FILTERS	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

VCO - Electrical Specifications :

Frequency range	:	25 MHz to 400 MHz
Tuning range	:	Octave tuning
Control voltage	:	1V to 18V
Tuning slope	:	1.9 MHz / V to 12 MHz / V depending upon frequency. +ve positive slope on tuning voltage vs. frequency.
Output	:	+10 dBm min.
Input power	:	+15V @ 25 mA max.
Harmonics	:	-10 dBc min.
Frequency pushing	:	1.5 MHz/ V max. depending upon frequency.
Frequency drift	:	-0.02 MHz / °C max.
Operating temperature	:	-40°C to +85°C
Power flatness	:	±1.0 dB
Phase noise	:	100 kHz offset -125 dBc / Hz 1 MHz offset -140 dBc / Hz

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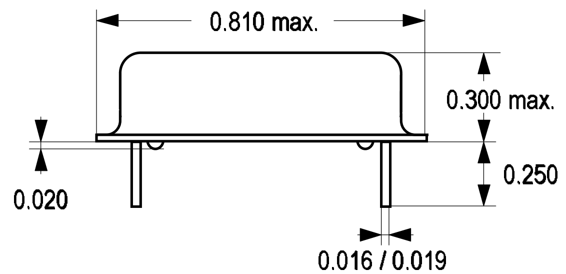
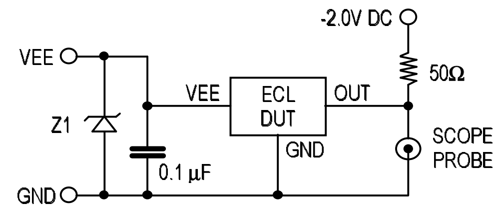
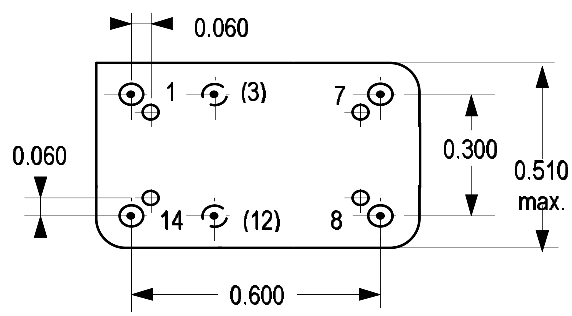


Equivalent test load diagram



Z1 is a transient surge suppressor diode should clamp within 20% of the max. rated operating voltage in less than 10 picoseconds.



Pin outs can be changed as required.

Disable or complementary output option:
- 1 : NC / disable / complementary output
- 7 : -5.2V DC
- 8 : Output
- 14 : Case and circuit ground

Disable or complementary output option:
- 1 : Tuning voltage (option)
- 3 : Tristate control (output will be an ECL low when high)
- 7 : -5.2V DC
- 8 : Output
- 12 : NC / complementary output (option)
- 14 : Case and circuit ground

KS ELECTRONICS LLC	
ECL CLOCK OSCILLATOR	Date : 02/15/97
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

ECL CLOCK OSCILLATOR - Electrical Specifications :

ECL logic type	:	10K / 10 KH
Frequency range	:	4 MHz to 115 MHz / 4 MHz to 200 MHz
Temperature range	:	0ºC to +70ºC standard.
Frequency stability	:	±100 ppm under all conditions.
Input voltage	:	- 5.2V DC ±5%
Output	:	10K ECL / 10 KH ECL
Load	:	50 Ω into -2V DC
Input current	:	100 mA max.
Symmetry	:	50 / 50 ±20% max.
Rise and fall time	:	2 nS / 1 nS typical

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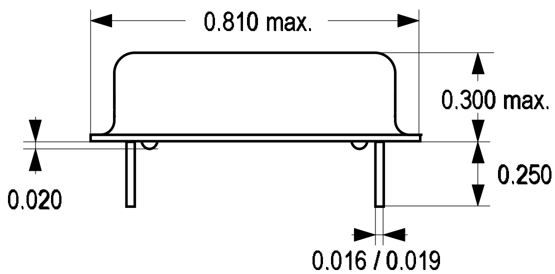
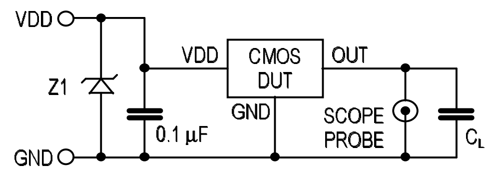
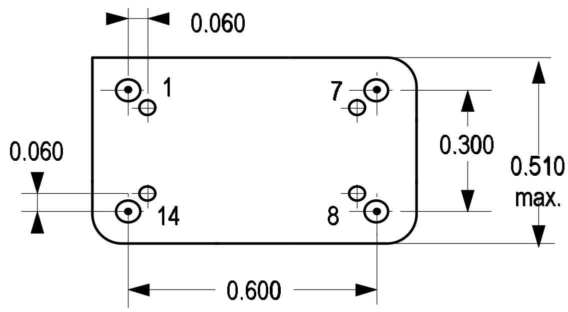


Equivalent test load diagram



C_L = 50 pF (including probe and fixture)
Z1 is a transient surge suppressor diode should clamp within 20% of the max. rated operating voltage in less than 10 picoseconds.



Pin connections:
- 1 : NC / enable (option) or output
- 7 : Ground / case
- 8 : Output
- 14 : +5V DC

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CMOS CLOCK OSCILLATOR	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

CMOS CLOCK OSCILLATOR - Electrical Specifications :

Frequency	:	200 Hz to 50 MHz
Operating temperature	:	Type A = (-40ºC to +85ºC)
		Type B = (-55ºC to +125ºC)
Temperature range	:	0ºC to +70ºC standard
Operating voltage	:	4.50V DC min. to 5.50V DC max.
Maximum supply voltage	:	7.00V DC
Input current vs. frequency	:	1.2 mA / MHz
Output	:	High speed CMOS logic output.
Package	:	14 pin DIP compatible.

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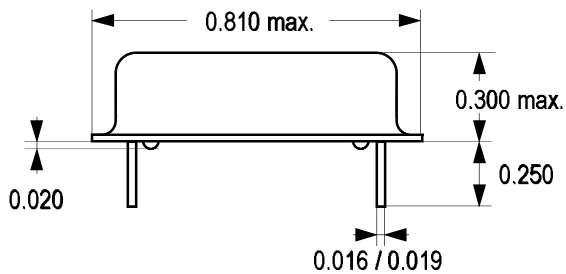
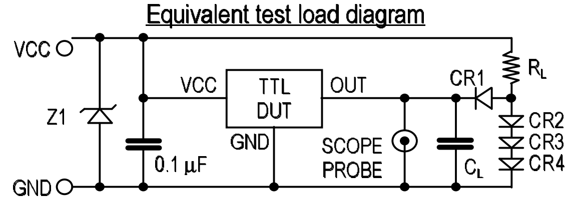
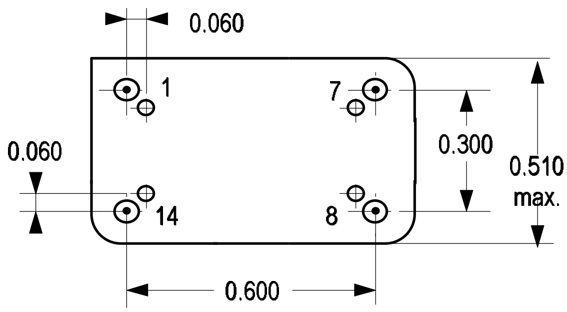


Equivalent test load diagram



C_L = 15 pF (including probe and fixture)
CR1 - CR4 = 1N3064 or equivalent
R_L = 390Ω
Z1 is a transient surge suppressor diode should clamp within 20% of the max. rated operating voltage in less than 10 picoseconds.



Pin connections:

1 : NC / enable (option) or output
7 : Ground / case
8 : Output
14 : +5V DC

KS ELECTRONICS LLC	
TTL CLOCK OSCILLATOR	Date : **02/15/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

TTL CLOCK OSCILLATOR - Electrical Specifications :

Frequency	:	10 kHz to 100 MHz
Supply voltage	:	5.0V ±10%
Operating temperature	:	0°C to +70°C
FAN OUT	:	10 TTL loads
Storage temperature	:	-55°C to +125°C
Frequency stability	:	± 0.01% max. under all conditions. Other stability available upon request.
Output logic type	:	TTL, tristate output available.
Symmetry	:	50 / 50 ±20% max.
Package	:	14 pin DIP compatible, fully hermetically sealed.

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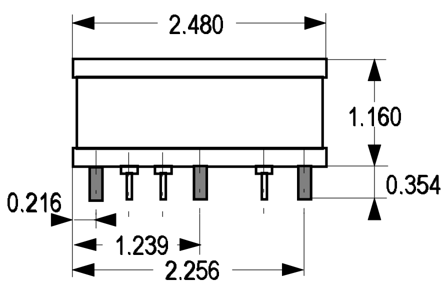
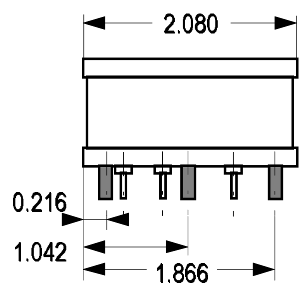
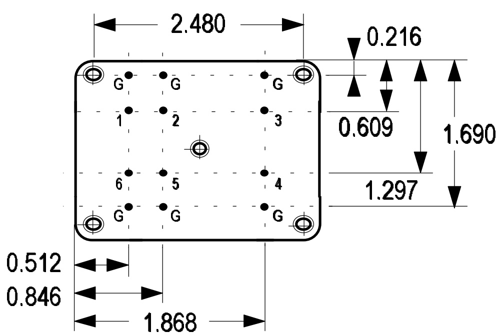


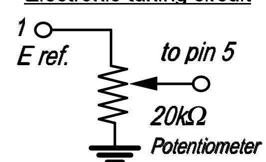


All pins 0.040 inch ±0.005 mounting studs M3-7H.



PIN connection:
1 - E ref. Output
2 - DC input
3 - Frequency output
4 - Double freq. out
5 - Freq. adj. Input
6 - Not connected
G - GND 6 places

Electronic tuning circuit



KS ELECTRONICS LLC	
OCXO-5 MHz & 10 MHz	Date : 02/15/97
Scale : N/A	Tolerance : ±0.010 Inches
Dimensions : inches	Approved:

OCXO - 5 MHz & 10 MHz - Electrical Specifications :

Standard frequencies	:	5 MHz and 10 MHz	
Frequency stability	:	$\pm 5x10^{-8}$ -55ºC to +60ºC /	$\pm 2x10^{-8}$ -10ºC to +55ºC
		$\pm 5x10^{-9}$ for 10% of 12V /	$\pm 5x10^{-8}$ for 50Ω - 200Ω
Short term stability	:	$< 2x10^{-11}$ for 1 s. 5 MHz out. /	$< 3x10^{-11}$ for 1 s. 10 MHz out.
Aging rate after	:	$< \pm 5x10^{-9}$ per day	
24 hours of constant operation	:	$< \pm 1.5x10^{-7}$ per year	
Output into 50 Ω	:	0 dBm ±3.0 dB at 5 MHz /	0 dBm ±3.0 dB at 10 MHz
Harmonics	:	Better than -30 dBc.	
Input power	:	+12V ±10% /	< 0.55 W steady state at +25ºC
			< 0.65 W steady state at -55ºC
Warm up time	:	$<\pm 1x10^{-7}$ -55ºC < 7.0 S min. /	$<\pm 1x10^{-7}$ +25ºC < 5.0 S min.
		$<\pm 5x10^{-8}$ -55ºC < 8.0 S min. /	$<\pm 5x10^{-8}$ +25ºC < 5.5 S min.
		$<\pm 2x10^{-8}$ -55ºC < 12.0 S min. /	$<\pm 2x10^{-8}$ +25ºC < 10.0 S min.
Phase Noise	:	-100 dBc / Hz at 10 Hz offset	
		-120 dBc / Hz at 100 Hz offset	
		-140 dBc / Hz at 1 kHz offset	
Frequency adjustment	:	Electronic by means of +ve control. Voltage range from + 1V to + 8V DC settable to $1x10^{-8}$ range for 10 years aging.	
Package	:	As shown, hermetically sealed.	

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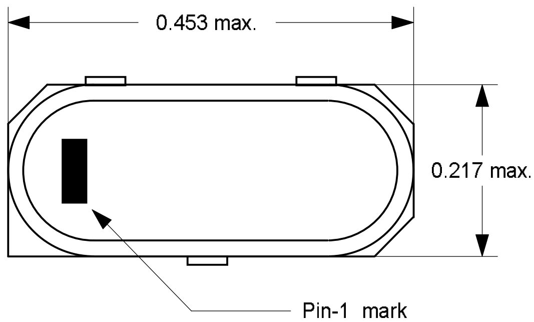

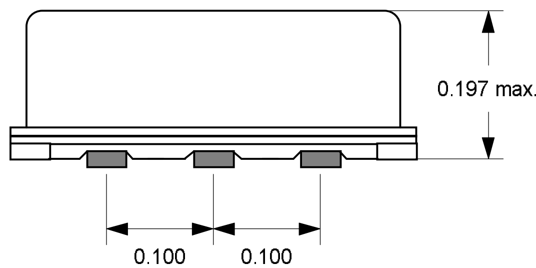

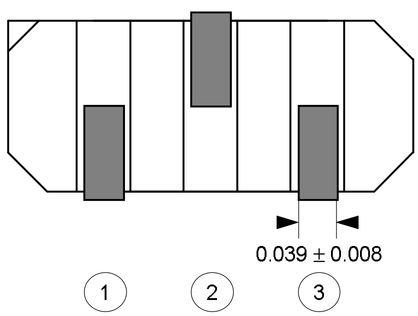

Pin	Connection
1	VDD
2	GND
3	OUT

KS ELECTRONICS LLC	
SMD mini Clock Oscillator	Date : **4/8/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

SMD Miniature Crystal Clock Oscillator - Electrical Specifications :

Frequency	:	300 kHz to 80 MHz	
Supply voltage	:	5.0V ±10%	50 mA max.
		3.0V ±10%	70 mA max.
Operating temperature	:	0°C to +70°C	
Storage temperature	:	-40°C to +90°C	
Frequency stability	:	± 0.015% max. under all conditions.	
Output logic type	:	TTL or CMOS compatible.	
Symmetry	:	50 / 50 ±10% max.	
Package	:	As shown.	

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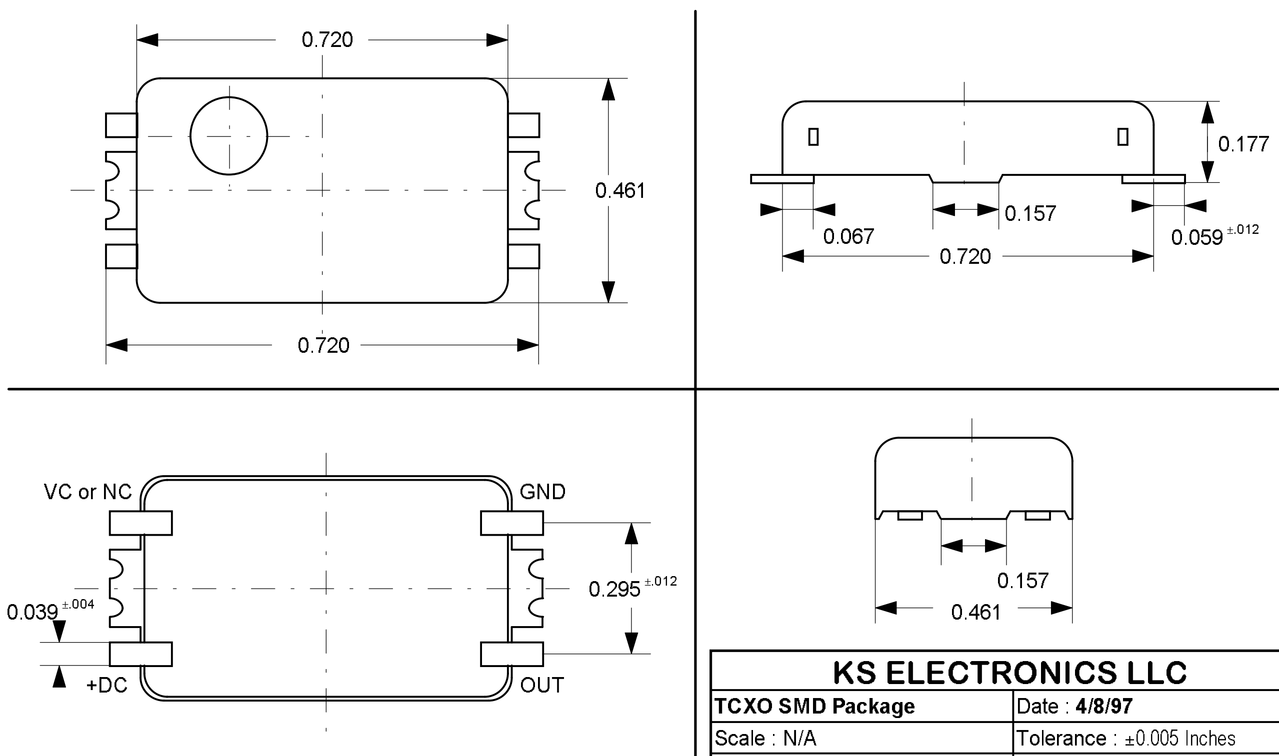
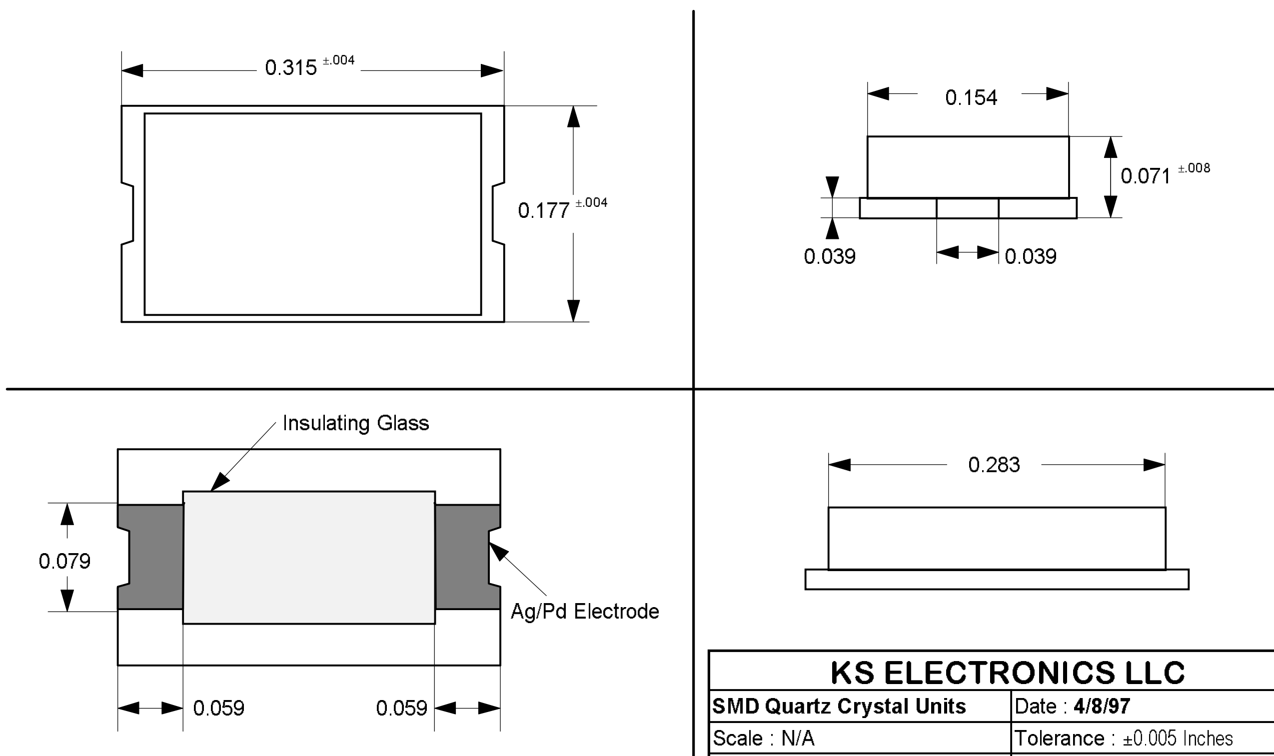


KS ELECTRONICS LLC	
TCXO SMD Package	Date : **4/8/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

TCXO SMD Package - Electrical Specifications :

*Frequency **	:	Up to 20 MHz	
Supply voltage	:	5.0V ±10%	3mA max.
Operating temperature	:	-30°C to +80°C	
Storage temperature	:	-40°C to +90°C	
Frequency stability	:	± 3 ppm max. Other stability available upon request.	
Package	:	SMD as shown.	
Mechanical Frequency Adj.	:	Internal Trimmer ±3 ppm min.	
Output	:	1V Peak to Peak min. into 10kΩ // 10pF.	

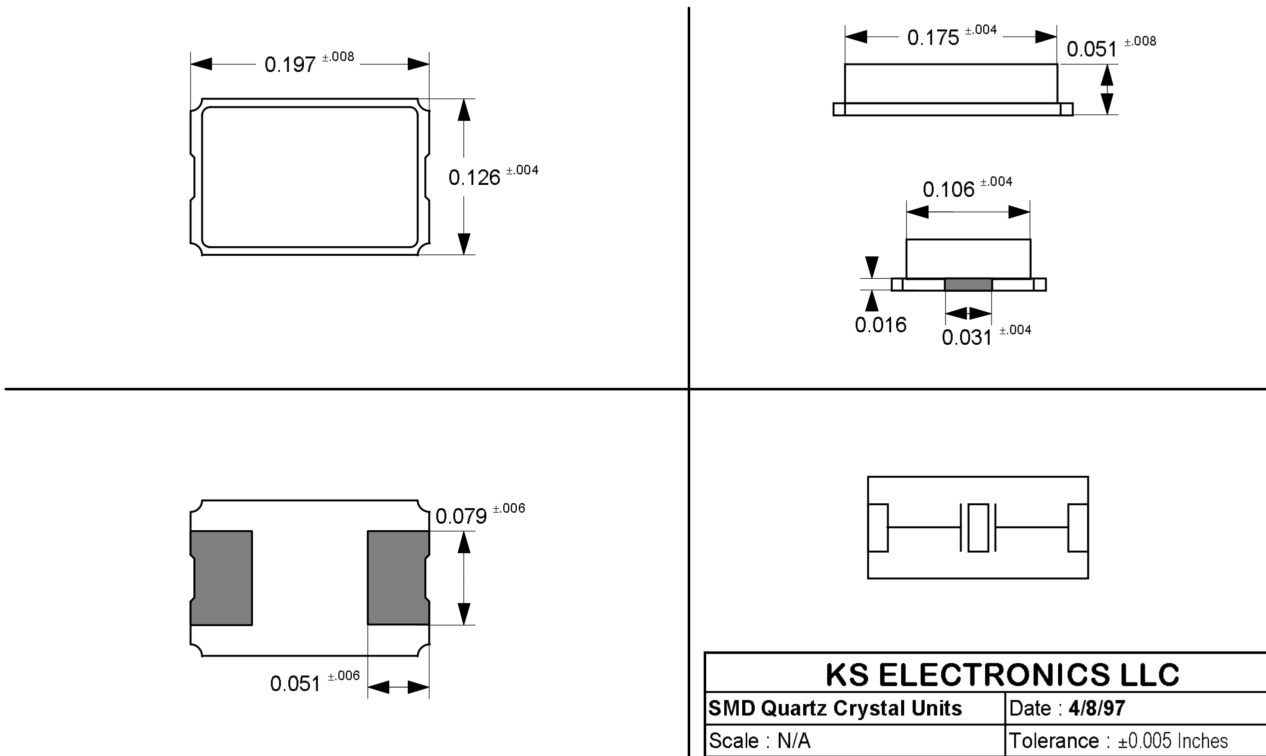
** Standard Frequencies*	:	*9.6 MHz*	*10 MHz*	*10.24 MHz*
		12.0 MHz	*12.8 MHz*	*15.36 MHz*



KS ELECTRONICS LLC	
SMD Quartz Crystal Units	Date : **4/8/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

SMD Quartz Crystal Units - Electrical Specifications :

Frequency	:	Fundamental up to 40 MHz. 3rd overtone up to 90 MHz.
Room temp. cal. tol.	:	±100 ppm max.
Operating temperature	:	-10ºC to +60ºC
Resistance	:	Up to 12 MHz 100Ω 12 - 14 MHz 80Ω 14 - 40 MHz 60Ω
Frequency stability *(Over operating temperature)*	:	± 0.01% max. under all conditions from ***room*** setting. Other stability available upon request.
Shunt capacity	:	7 pF max.
Package	:	As shown above.



KS ELECTRONICS LLC	
SMD Quartz Crystal Units	Date : **4/8/97**
Scale : N/A	Tolerance : ±0.005 Inches
Dimensions : inches	unless noted otherwise

SMD Quartz Crystal Units - Electrical Specifications :

Frequency	:	Up to 45 MHz in fundamental mode.
Frequency Tolerance	:	±100 ppm max.
Operating temperature	:	-10ºC to +60ºC
Frequency stability (over operating temperature)	:	± 100 ppm max. from ***room*** setting.
Resistance	:	Up to 25 MHz 150Ω 25 - 80 MHz 80Ω
Shunt capacity	:	7 pF max.
Package	:	As shown above.

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Announces a new product release .....

NEW

WIDE BAND VCXO

Further technical information will be available soon !

Wide Band VCXO - Electrical Specifications :

Frequencies up to	:	400 MHz
Tuning voltage	:	0 ±5.0 Volts
Stability over operating temperature	:	±5 ppm from -20ºC to +70ºC
Output	:	0.0 dBm min. into 50 Ω
Supply voltage	:	+15V @ 50 mA max.
Minimum pull range	:	± 1000 ppm min. linearity ±10% max.

-ve slope standard

+ve slope available. Please consult our technical staff.

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Announces a new product release .....

NEW

Digital µP Controlled TCXO

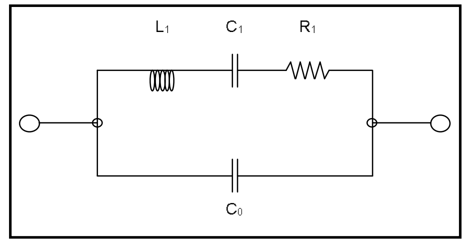
Further technical information will be available soon !

Digital µP Controlled DC-TCXO - Electrical Specifications :

Frequency	:	1 kHz to 250 MHz ±0.5 ppm max. at 25ºC
Stability over temperature	:	±0.1 ppm from room temperature setting.
Operating temperature	:	-30ºC to +85ºC
Output	:	TTL / HCMOS / sinewave (0.0 dBm)
Spurious / harmonics	:	-20.0 dBc min. where applicable.
Input power (±10%)	:	+5.0V for TTL / HCMOS +12V for sinewave
Input current	:	100 mA max. depending upon frequency.
Aging	:	±1 ppm / year
Adjustment	:	External mechanical adjustment can be provided. ±10 ppm min. range.

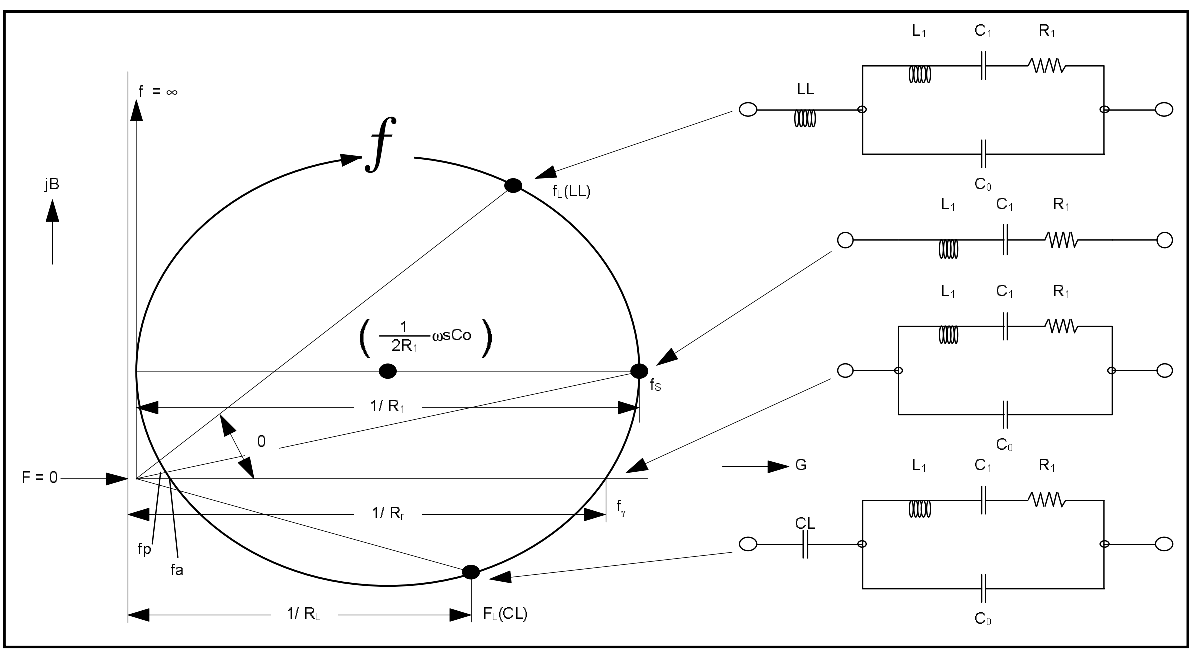
AT-cut Crystals

Equivalent Circuit Parameters



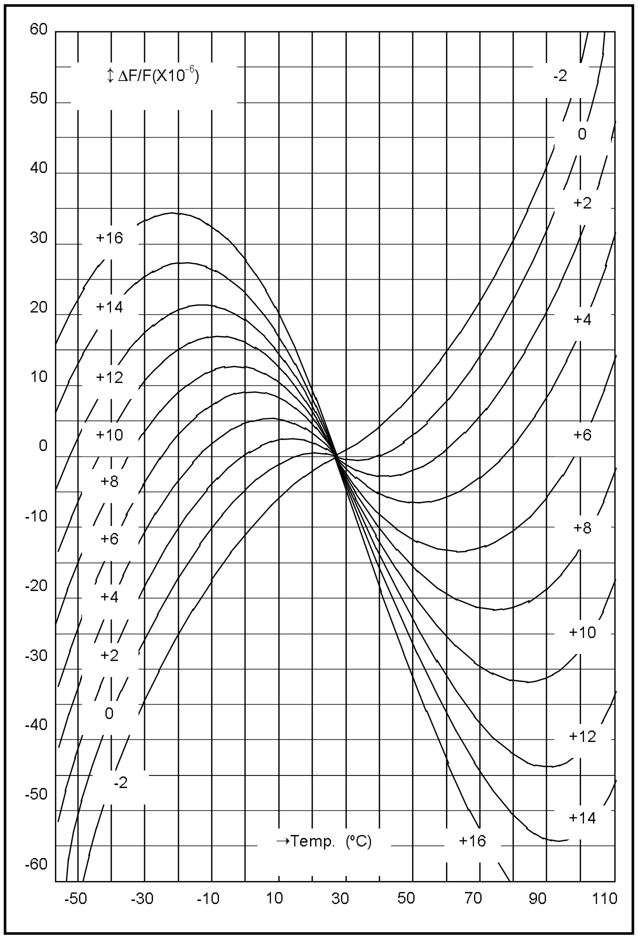
fs	=	$1/\{2\pi\sqrt{L_1 \bullet C_1}\}$
fp	=	$1/\{2\pi\sqrt{L_1 \bullet C_1 \bullet C_0 / (C_1+C_0)}\}$
	=	$1/\{1+1/(2\gamma)\}$
γ	=	C_0 / C_1
Q	=	$2\pi \bullet fs \bullet L_1 / R_1$
	=	$1/(2\pi \bullet fs \bullet C_1 \bullet R_1)$
M	=	$Q/\gamma = 1/(2\pi \bullet fs \bullet C_0 \bullet R_1)$

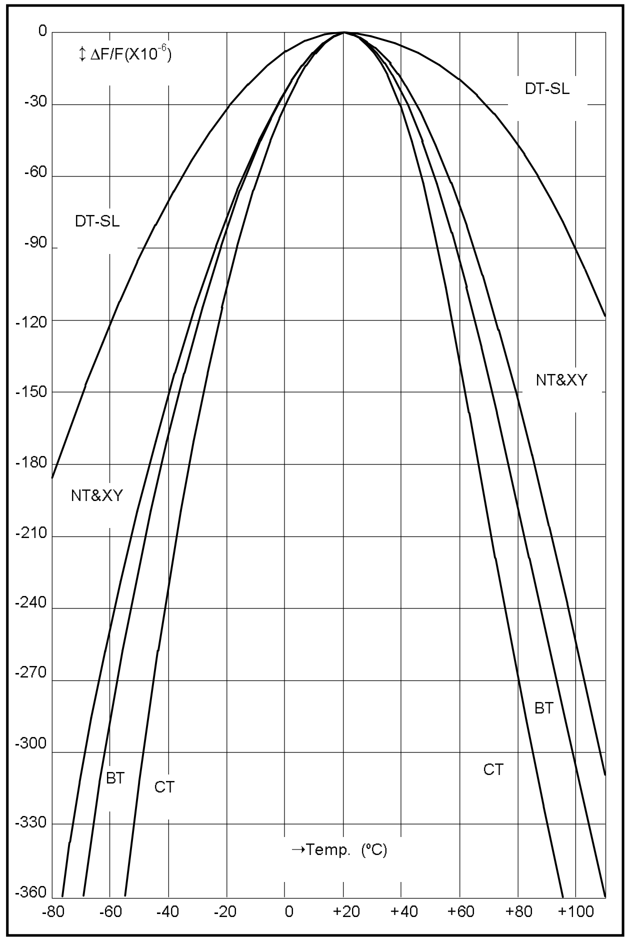
As shown, near the resonance frequency, the equivalent electrical circuit of a crystal unit is represented by motional inductance (***L_1***), which represents the mechanical vibration of the unit, motional capacitance (***C_1***), series resistance (***R_1***), in series circuit and a shunt capacitance (***C_0***) which adds the stray capacitance of the holder to the static capacitance between the electrodes in parallel with this. In the picture down is shown the admittance locus of a crystal unit. In actual measurement, the low frequency (resonance frequency ***fr***), resonance resistance ***Rr***, and high frequency (anti resonance frequency ***fa***) at which the susceptance (in admittance locus) or reactance (in impedance locus) of the crystal unit becomes zero can be easily measured. Since the ***Q*** of a crystal unit is higher than 10^4, it can be used even if fs ≠ fr, R_1 ≠ Rr; fp ≠ fa are assumed. Moreover, when fr = fa or M ≤ 2, the unit becomes capacitive (B ≥ O) and a parallel resonance oscillator will not oscillate.



AT-cut Crystals

Typical Freq. Vs. Temp. Curves Various cut of Crystal





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SC-cut Crystals

SC-CUT

In the family of doubly rotated AT cuts which includes the IT and FC most widely known is the SC (Stress Compensated) cut.

The main advantages of these resonators, in particular the SC type, over the commonly used singly rotated AT cut are:

1. A reduced amplitude-frequency response which allows an improved signal to noise ratio.
2. A superior thermal transient characteristic resulting in improved short term stability and faster warm up times during oven operation.
3. Improved frequency-temperature stability during oven operation at or near the inflection temperature.
4. A higher C_0 / C_1 ratio resulting in reduced sensitivity to circuit component changes.

It should particularly be noted that where the AT has an inflection point in the area of 25°C to 30°C depending on design and frequency (see theoretical family of Curves on previous page) the FC will be in the area of 45°C to 55°C with the IT 70°C to 80°C and the SC 85°C to 95°C.

SWEPT QUARTZ

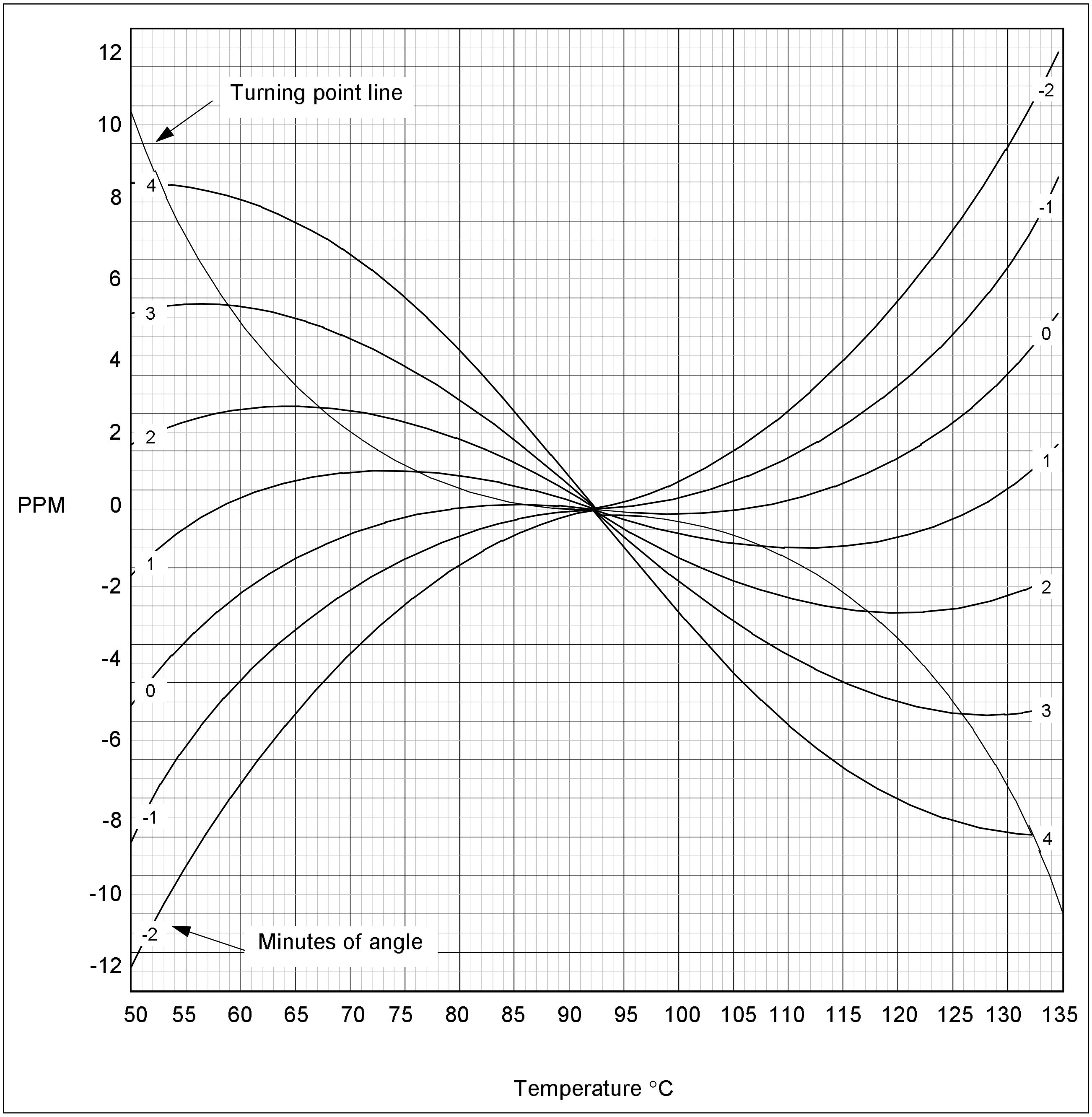
It has been determinated that quartz crystals can be adversely affected when exposed to radiation as encountered in nuclear or deep space environments. It is theorized, that impurities, inherent in the raw material, causes changes in the lattice structure of the quartz when subjected to ionizing radiation sufficient to effect a frequency shift. In order to "harden" it against this effect, the quartz is subjected to a sweeping process that is basically an electrolytic reaction in which positively charged impurity ions such as sodium lithium are driven or "swept" from the bar under conditions of an intense electrical field and high temperature. As swept quartz is much more expensive to buy and process than regular quartz, it should only be specified when absolutely necessary.

PHASE NOISE: SC-CUT CRYSTALS

We have been designing crystals to minimize PHASE NOISE, for many years. We have an on going program to further improve our product in this area, including work with SC-cut crystals. SC-cut crystals are also known as D.R.A.T. (Doubly Rotated AT) crystals .

SC-cut Crystals

SC-CUT Frequency-Temperature Curves Theoretical



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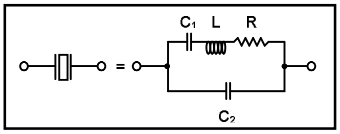
Crystal Formulas

- Crystal equations.



- Series resonance (Fo).

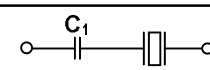
$$F_0 = \frac{1}{2\Pi\sqrt{LC_1}}$$

- Parallel resonance (Fp) reactance (X).

$$F_P = \frac{1}{2\Pi\sqrt{LC_e}} \qquad C_e = \frac{C_1\,C_0}{C_1 + C_0}$$

$$X = \frac{(\omega^2 - \omega^2_b)}{j\omega C_{eq}\,(\omega^2 - \omega^2_p)}$$

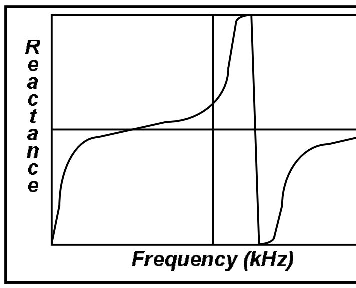
- Series resonant frequency of the entire branch when capacitor (CL) is placed in series with the crystal.



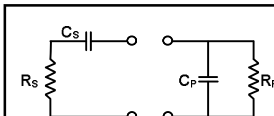
$$F_p = F_o\sqrt{1 + \frac{C_1}{C_o + C_L}}$$

- Reactance of the branch when a capacitor is placed in series with the crystal.

$$X = \frac{(\omega^2 - \omega^2_o)}{j\omega C_o\,(\omega^2 - \omega^2_p)} \qquad C_{eq} = \frac{C_1\,C_0}{C_1 + C_0}$$



- Series RC to parallel RC transformation (strictly valid only in the vicinity of ω_o).

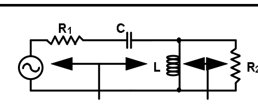


$$Q = \frac{1}{\omega_o R_S C_S} = \omega_o R_p C_p$$

$$R_S = \frac{R_P}{Q^2 + 1} \qquad R_P = R_S(Q^2 + 1)$$

$$C_S = C_P\left(1 + \frac{1}{Q^2}\right) \qquad C_P = \frac{C_S}{\left(1 + \frac{1}{Q^2}\right)}$$

- Impedance transformation, high pass type. A low pass type of transformation may be realized by interchanging the inductor and capacitor.

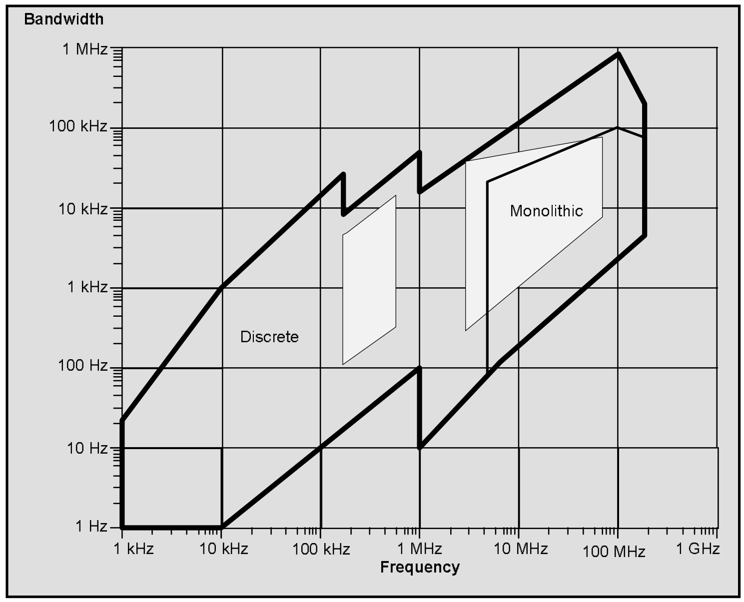


$$C = \frac{1}{\omega_o\sqrt{R_1 R_2}} \qquad L = \frac{\sqrt{R_1 R_2}}{\omega_o}$$

Crystal Filters

Best Operating Regions

This chart gives the regions where crystal filters can be built. The "Discrete Filter" region shows where filters can be build using individual crystals, capacitors, coils, transformers, and resistors. The "Monolithic" region defines where filters, that employ two or more resonators per individual crystal unit (plus some other discrete components), can be manufactured.



The difficulty increases as the edge of the chart is approached and some filter types cannot be realized at or near the edge of the chart. Filters which fall in the two highlighted regions will be the most producible and all approximation types can be realized within these regions

Attenuation (A)

The attenuation of a filter is the relative output level at any frequency. The zero reference value is taken either as the point of minimum attenuation, or the value at a defined frequency point (F_{ref}). Attenuation is generally expressed in dB.

Bandwidth (BW)

The bandwidth of a filter at x dB is the difference between the upper frequency and the lower frequency at the x dB level.

$$BWx = FxH - FxL$$

Bandwidth Ratio (BWr)

The bandwidth ratio of the passband bandwidth to the center frequency.

$$BWr = \frac{BW_x}{Fo}$$

Crystal Filters

Center Frequency (Fo)

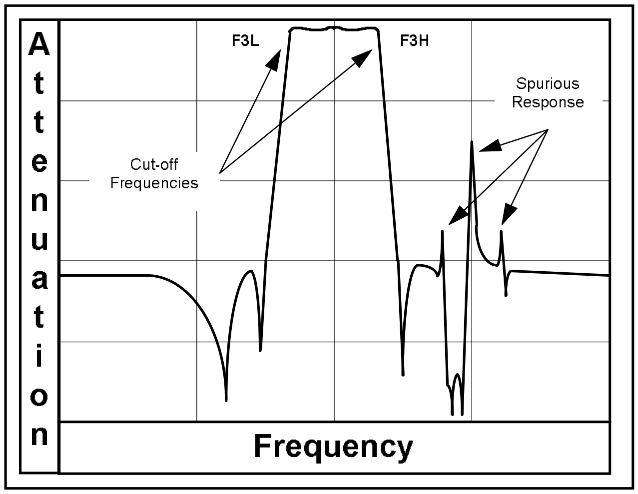
Center frequency is defined as the arithmetic mean of the 3 dB points. For wide bandwidth filters the geometric mean of the 3 dB points may be substituted.

$$Fo = \frac{F3H + F3L}{2.0}$$

$$Fo = \sqrt{F3H \bullet F3L}$$

Cut-Off Frequency

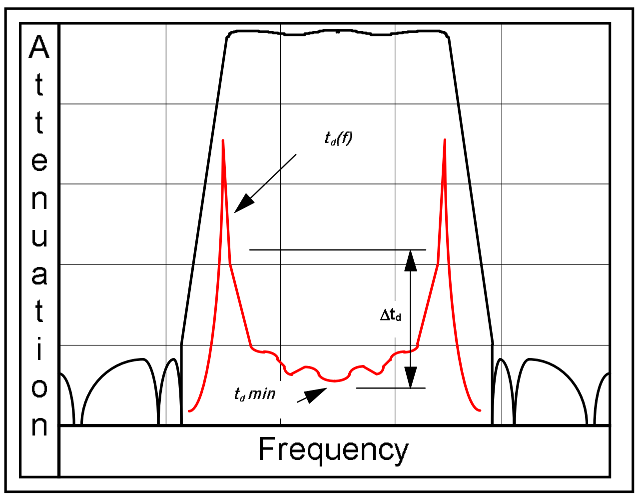
Either of the two frequencies defining the edges of the passband. For example F3L and F3H, read as "Frequency of the 3 dB point" on the High (Low) side of the center frequency.



Differential Group Delay (Δt_d)

The differential group delay is the difference between the group delay at any frequency to the minimum group delay value in the passband.

$$\Delta t_d = t_d(f) - t_d\ min.$$



Discriminators

Discriminators are similar to filters because they are also frequency selective networks. However, they produce an output DC signal that is proportional to the input frequency.

Crystal Filters

Group Delay (t_d)

The group delay (also called time delay or envelope delay) is the derivative of the phase of the transfer function with respect to the frequency. The negative sign is used to force the time to be a positive number. If the inverse of the transfer function is used the negative sign should be eliminated.

$$t_d = -\frac{d\Phi}{d\omega}$$

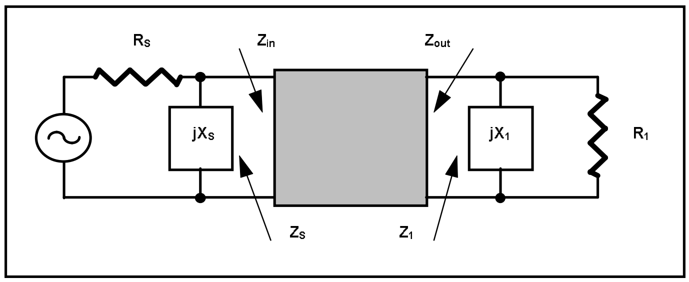
It is approximated by:

$$t_d = -\frac{\Delta\Phi\ (Deg.)}{360\ \Delta F\ (Hz)}$$

(Seconds)

Input Impedance (Z_{in})

Input impedance is the impedance looking into the input of the filter.



Insertion loss (IL)

Insertion loss is the ratio of the power delivered to the load, with the filter removed from the test circuit, to the power delivered to the load, with the filter installed. It is measuring at the frequency where maximum transmission occurs, and is expressed in dB.

Intermodulation Distortion (IM)

Intermodulation distortion is a measure of a additional frequency components generated within the filter, caused by the nonlinear interaction of two or more input signals. Third order products are the most common problem in crystal filters.

Intercept points

In order to facilitate comparison and to normalize which the fundamental carrier frequencies and the IM product would have equal amplitudes. The equation

$$I_n = \frac{S}{N-1} + P$$

which defines it is where I_n is the Nth order intercept point in dBm, S is the relative suppression from the carriers in dB, N is the order of the intermodulation product, and P is the power level of the carrier tones in dBm.

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Load Impedance (Z_1)

Load impedance is the impedance, both real and reactive, of the network that is connected into the output of the filter.

Output Impedance (Z_{out})

The output impedance is the impedance looking into the output terminals of the filter.

Overshoot

When a driving signal is suddenly applied to a filter, the output will gradually build up and sometimes exceed its steady state value. This is the overshoot response of the filter.

Passband (BW_x)

The passband of a filter is the bandwidth of the filter measured at low attenuation levels (where x represents the level) and is usually 6 dB or less.

Percent Bandwidth (Δ)

The percent bandwidth is the bandwidth ratio expressed as a percentage.

$$\Delta = 100BW_r = 100\,\frac{BW_x}{F_O}$$

Phase Linearity ($\Delta\Phi$)

The phase linearity is the deviation of the insertion phase of the filter (Φ) from the "best straight line" fit over a specified frequency range, usually within the passband.

$$\Delta\Phi = \Phi - \Phi_{s1}$$
$$\Phi_{s1} = \mu F + b$$

The coefficients, m and b, can be determined using any practical means, from a mathematical "least squares fit", to an empirical fit using available test equipment.

Poles and Zeros

The poles and zeros of the transfer function define locations of singularities within the s-plane and are used as a measure of the complexity of the network. Except for some wide band filters, one crystal is required for each pole in the network. Thus, a six pole network requires six crystals.

Frequency reference (F_{ref})

The reference frequency is any defined frequency. It is used only where its important to system performance.

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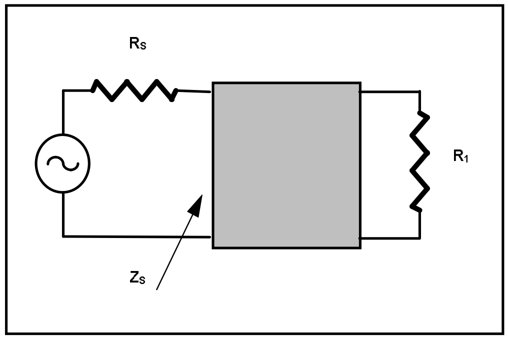
Reflection Coefficient (ρ)

The Reflection coefficient is the coefficient to determine the power is reflected by a filter. When operating in a stopband region *Z* is not equal to *R*, so some or all of the power will be reflected back, and dissipated in the source resistor. Since *Z* is a positive real function, the magnitude of *ρ* is always less or equal to unity and can reach zero only when Z and R are identical. When *Z* equals either zero infinity *ρ* = 1 and the worst possible match is archived where all of the power is reflected back and dissipated in the source resistor.



$$\rho = \frac{Z - R}{Z + R}$$

Return Loss (A_e)

The return loss, is the reflected power (A_e) also called echo attenuation and is always expressed in dB. The power transferred to the load (A_t) is the difference between the maximum available and the reflected power. Within the passband, *ρ* will be very small or zero and its maximum value will establish the maximum passband ripple.

$$A_t = -10 \log(1- |\rho^2|)$$
$$A_p = -10 \log(1- |\rho_{max}^2|)$$

Ringing

Ringing is the response of the decay of the output signal from a filter when the driving signal is suddenly removed.

Roll-Off

Roll-off is a relative comparison of the rate at which the attenuation at the edges of the passband.

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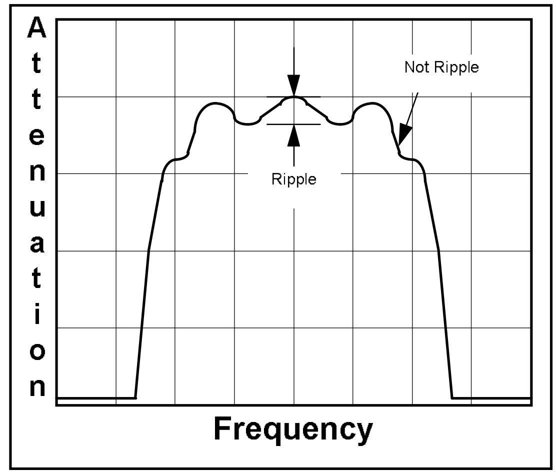
Crystal Filters

Ripple (Ap)

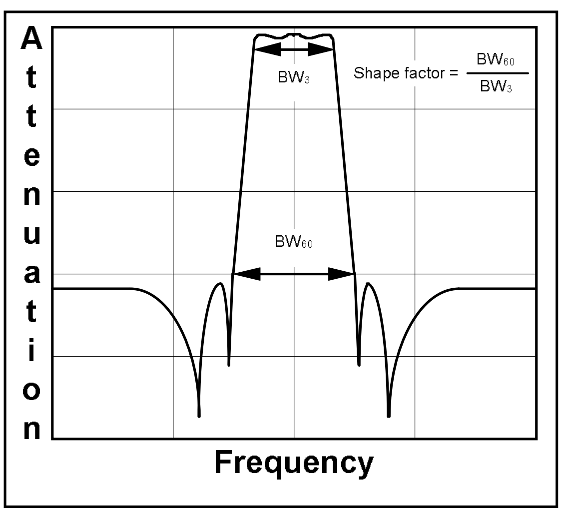
Ripple is defined as the difference in attenuation between the highest peak and the lowest valley within the passband. It is measured in dB. This can be a confusing specification and it should be used with caution. Ripple is actually a design parameter and should be not used to specify passband flatness.



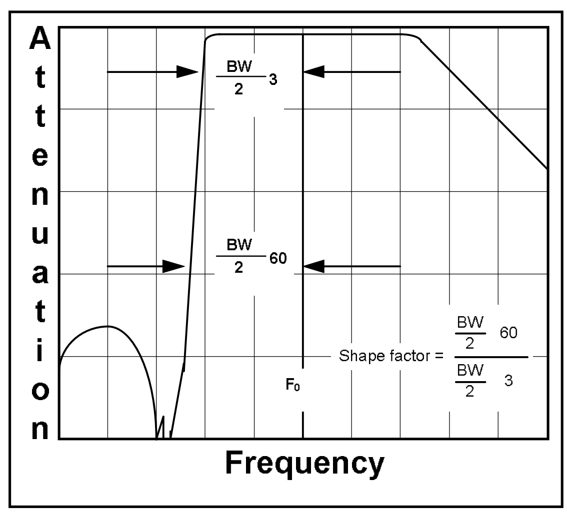
Shape Factor ($SF_{y/x}$)

Shape factor is the ratio of the stopband bandwidth (y) to the passband bandwidth (x), x and y can be any number but usually they are 60 dB and 3 dB, respectively.

Symmetrical filter



Asymmetrical filter



Source Impedance (Z_S)

Source impedance is the impedance, both real and reactive, of the network that is connected to the input terminals of the filter.

Crystal Filters

Spurious Responses

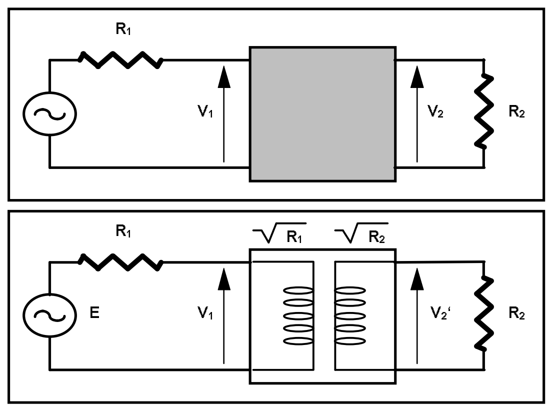
Spurious responses are produced by unwanted vibrational modes in the crystals. Every filter parameter including phase, amplitude and delay can be moderately to severely distorted by them. They are generally located on the high frequency side of the passband and, in the wideband filters, they can occur even within the passband.

Stopband(s)

The stopband(s) of a filter define the range of frequencies and the attenuation level(s) over which the attenuation value must be maintained.

Transfer Functions (H(s))

The transfer function is the mathematical relation between the maximum voltage available (V_2') to the actual voltage transferred to the load at any frequency. The maximum voltage available will be the transformed value V_2'. $|H(jw)|^2$ is the ratio of the maximum power available from the generator to the actual power in the load. The synthesis of the filter is based upon this function.



$$H(s) = \frac{V_2'}{V_2} = \frac{E}{2V_2}\sqrt{\frac{R_2}{R_1}}$$

Transition Region

The transition regions are the frequency bands where the attenuation changes from the passband to the stopband.

Ultimate Attenuation

Ultimate attenuation is the vague specification that must not be used. It is ambiguous because it does not specify the range over which the attenuation must be met. A clear way to specify it is to require the needed attenuation from a low frequency, say DC, to the lower stopband edge, and from the upper stopband edge to 100 MHz (or whatever the required upper frequency limit may be).

VSWR Is the **V**oltage of the **S**tanding **W**ave **R**atio.

Crystal Filters Formulas

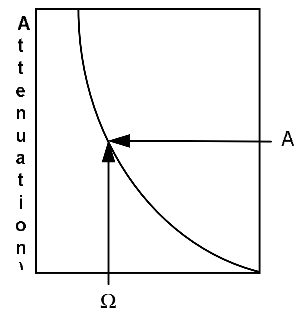
- Total phase shift across the passband. $\Delta\varnothing = N \cdot 90^{o}$
- Average time delay in the passband (BW). $td = \frac{\Delta\varnothing}{360\ BW}$
- Estimate of the natural impedance of the filter (R_O). $R_0 = \frac{20BW\ (\text{in Hz})}{F^2_0\ (\text{in MHz})}$

- Normalized frequency (Ω) for an "N" pole, Butterworth filter at any attenuation level "A".
- Normalized frequency (Ω) for an "N" pole, "A_p" ripple Chebyshew filter at any attenuation level "A". This is only valid for attenuation levels equal or greater than the ripple value.

$$1.0\Omega = [10^{A/10} -]^{1/2N}$$

$$\Omega = \left\{ \frac{ACOSH(\varepsilon)}{N} \right\}$$

$$\varepsilon = \sqrt{\frac{(10^{A/10} - 1)}{(10^{Ap/10} - 1)}}$$

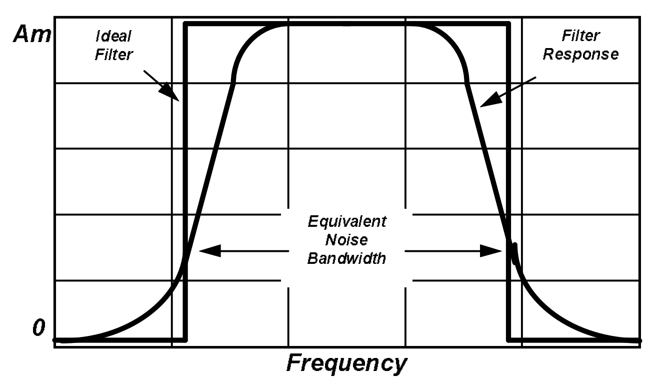


- Best possible return loss for a filter with coil losses Rp and natural impedance Ro. $Ae = -20.LOG(Ro / Rp)$

- Equivalent noise bandwidth (B_N): The equivalent bandwidth is the bandwidth of an ideal filter which would pass the same amount of white noise as the filter being tested. ΔF is the frequency step size between ω_i and ω_{i+1}. The equivalent noise bandwidth is primarily controlled by the passband. Values attenuated by 40 dB or more have only a small influence on it.

$$BN = \int_0^{\infty} \frac{|H(jw)|^2}{A^2m} dF$$

$$\cong \frac{1}{A^2{}_m} \sum_{F_{60L}}^{F_{60H}} \frac{|H(jw_i)|^2 + |H(jw_{i+1})|^2}{2} \Delta F$$



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TCXO

What is a TCXO?

A TCXO (Temperature Compensated Crystal Oscillator) typically consists of a precision quartz crystal, a temperature compensation network, an oscillator circuit and a variety of buffer and / or output stages determined by the output requirement. The temperature compensation network is used to sense the ambient temperature and pull the crystal frequency in a manner that reduces the 'frequency vs. temperature' effect on the quartz crystal. Because each crystal has a temperature characteristic that is unique as a fingerprint, KS-ELECTRONICS uses a computer generated network that is tailor made for each individual crystal. The form and configuration of the temperature compensation network will vary greatly depending on requirements such as input voltage, temperature range and temperature stability.

When to use a TCXO?

A TCXO is generally needed when overall stability requirements fall between those of a clock oscillator on the low end and an ovenized oscillator on the high end. Also, the long term aging effects of a TCXO are better than those of most clock oscillators.

Advantages of a TCXO

Tighter frequency vs. temperature stability than a clock oscillator.
Typically ±0.2 ppm to ±5 ppm.

Improving aging with respect to a clock oscillator.
Typically ±1 ppm per year, ±5 ppm for 10 years.

Lower power consumption than a OCXO.
Typically 10 mW to 50 mW on a +5V DC TCXO and up to 150 mW depending on input voltages and output requirements.

Smaller package volume than an OCXO.
Typically from 0.125 cubic inches to 2 cubic inches.

Disadvantages of a TCXO

Limited maximum frequency vs. temperature stability.
Quartz crystal hysteresis and pertubations limit how well a particular crystal can be compensated. In most cases the best practical limit is about ±0.2 ppm over a 0ºC to +50ºC temperature range, but better stability can be achieved under special conditions.

Higher cost than a clock oscillator.

Larger package size than a clock oscillator.

TCXO

Specifying a TCXO

TCXO's found in the catalog offer the lowest price and shortest lead times. For some special customer requirements, from simple modifications of a standard catalog model specification, to custom designs, customer source control drawings are required. At KS ELECTRONICS we have a broad range of experience in manufacturing custom TCXO's for applications ranging from low cost models for the telecommunication industry, to precision, high reliability models for military and space.

• Acceleration sensitivity

Acceleration sensitivity (also known as G- sensitivity) is defined as the frequency shift caused by subjecting a quartz crystal to a constant acceleration. This acceleration is most commonly in the form of sinusoidal or random vibration. As the oscillator is vibrated, the quartz crystal vibrates and generates FM sidebands of the RF output that are the same frequency as the vibration frequency. The amplitude of the sidebands are a direct result of the crystal's acceleration sensitivity. The higher the sensitivity, the higher the sidebands amplitude. Since the vibrating frequency range is generally ≤ 2000 Hz, these sidebands can be much higher in amplitude than the oscillator phase noise. Therefore, in certain situations it may be necessary to specify a "phase noise during vibration" specification. KS ELECTRONICS has developed TCXO's with low acceleration sensitivity crystals to minimize these effects and will help you develop a specification to meet your requirements. Because there are numerous cost / performance tradeoffs with respect to package size, temperature stability, aging, input voltage, etc. KS ELECTRONICS recommends that you contact one of our engineers to discuss your requirements - if possible at the initial design stage of your project. By knowing your application and requirements KS ELECTRONICS can help you develop the right combinations of specifications to provide the best overall price / performance tradeoffs.

• Aging

In clock oscillators with moderate temperature stability, aging is usually of little consequence. However, in highly temperature stable TCXO's, crystal aging becomes a significant factor in the oscillators overall frequency error. Therefore, TCXO's employ specially processed crystals in evacuated glass or coldweld holders. Many TCXO specifications both moderate and long term aging requirements such as $1 \cdot 10^{-8}$ per day and $1 \cdot 10^{-6}$ per year. The latter actually has more meaning for a TCXO because the temperature sensitivity of the device makes it almost impossible to measure $1 \cdot 10^{-8}$ per day aging except under constant environmental conditions; the small day to day changes in even laboratory ambient temperatures will cause greater frequency shifts than those resulting from crystal aging over short time periods.

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TCXO

• Characteristics of frequency vs. load capacitance

For many applications there are requirements to pull the crystal frequency by using a load reactive element. This may be necessary in order to trim out the manufacturing tolerance or in phase locked loop and frequency modulation applications. In most applications the load reactive element is capacitive and therefore only this case is now considered.

The fractional difference in frequency between the load resonance frequency (f_L) and the resonance frequency (f_r) is known as the load resonance frequency offset ***(L.O.)***

$$\underset{(ppm)}{L.O.} = \frac{\Delta f C_L}{f_r} = \frac{f_L - f_r}{f_r} \cong \frac{C_1 \times 10^6}{2(C_0 + C_L)}$$

(C_L, C_0, C_1 are in pF)

In many applications a variable capacitor (trimmer) is used as the load reactive element to adjust the frequency.

The fractional frequency range available between specified values of these load reactive element is called the pulling range ***(P.R.)***

$$\underset{(ppm)}{P.R.} = \frac{F_{L1} - F_{L2}}{f_r} \cong \frac{C_1 (C_{L2} - C_{L1}) \times 10^6}{2(C_0 + C_{L1})(C_0 - C_{L2})}$$

(C_0, C_1, C_{L1}, C_{L2} are in pF)

A useful parameter to the design engineer is the pulling sensitivity ***(S)*** at a specified value of load capacitance.

It is defined as the incremental fractional frequency change for an incremental change in the load capacity.

It is normally expressed in 10^{-6} / pF.

$$\underset{(ppm/pF)}{S} = \frac{-\delta (L.O.)}{\delta C_L} \cong - \frac{C_1 \times 10^6}{2(C_0 + C_L)^2}$$

(C_L, C_0, C_1 are in pF)

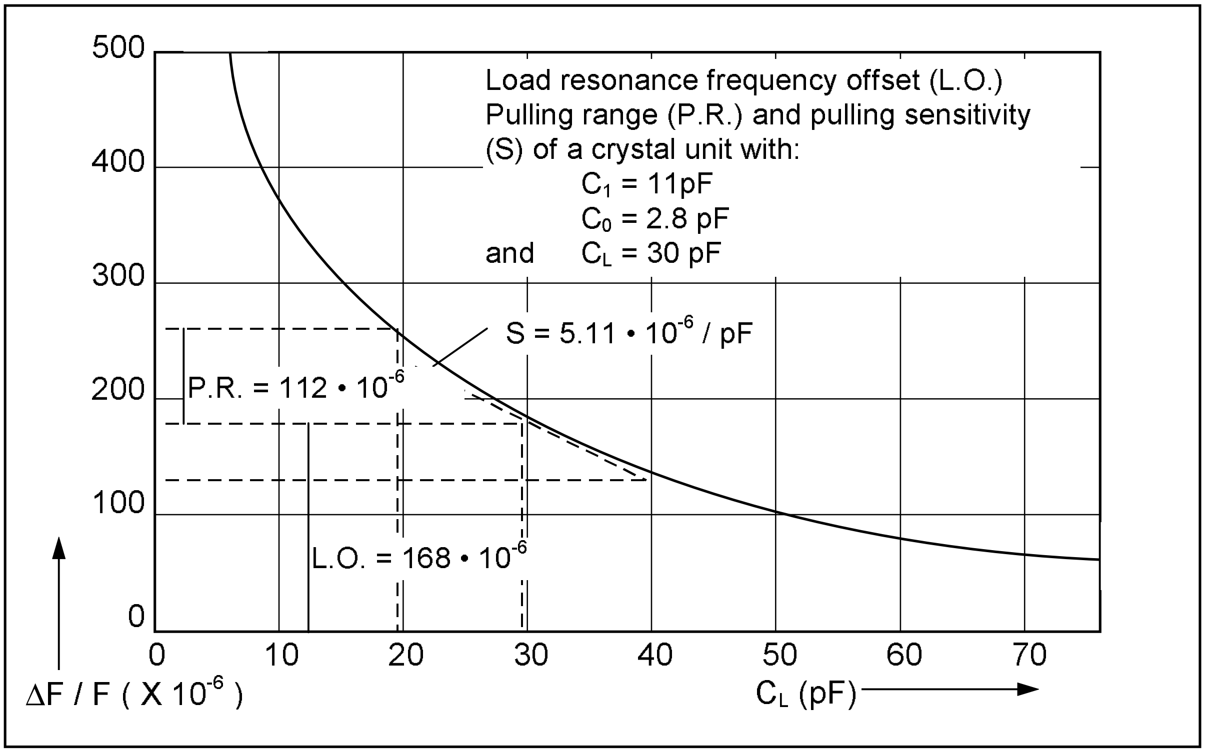
The equivalent circuit of the crystal has one other important parameter this is R_1, the motional resistance. This parameter controls the Q of the crystal unit and will define the level of oscillation in any maintaining circuit. The load resonance resistance for a given crystal unit depends upon the load capacitance with which that unit is intended to operate. The crystal manufacturers have equipment to measure this quantities. The frequency of oscillation is the same in either a series or a parallel connection of the load capacitance. If the external capacitance is designed, the load resonance resistance ***(R_L)*** may be calculated as shown.

$$R_L = R_1 \left(1 + \frac{C_0}{C_L}\right)^2 \Omega$$

(C_L, C_0 are in pF)

TCXO

Characteristics of frequency vs. load capacitance



Frequency adjustment

The primary purpose for a frequency adjustment is to re-adjust the oscillator to its center frequency to compensate for aging. This adjustment can be provided in the following ways:

1. A mechanical adjustment within the oscillator accessible via a hole in the enclosure or a removable seal screw.
2. An electrical adjustment via a lead in the enclosure for either a remotely located potentiometer or a voltage.
3. A combination of both mechanical and electrical.

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TCXO

Input voltage

Most TCXO's are designed to operate at +12V DC, +5V DC or a combination of both. Custom TCXO's can be designed to operate at other positive or negative input voltages as the situation requires. In cases where an ECL output is required, a -5.2V DC supply is usually needed.

RF output

A TCXO can be manufactured with various types of outputs: sine wave, clipped sine wave, TTL, HCMOS, ECL and others. Be sure to specify the desired output type, signal requirements and the load that the oscillator will be driving.

Typical RF output specifications

1. TTL: logic low; 0.4V max., logic high; 2.4V min., pulse width; 40% to 60% @ 1.5V level, rise & fall time; 20 nS 10% to 90% level, load; 10 TTL loads
2. HCMOS: logic low; 0.5V max., logic high; 4.0V min., pulse width; 40% to 60% @ 50% level, rise & fall time; 5 nS 10% to 90% level, load; 10 HCMOS loads
3. ECL: logic low; -1.8V max., logic high; -0.8V min., pulse width; 40% to 60% @ 50% level, rise & fall time; 5 nS 10% to 90% level, load; 1 10K ECL gate
4. Sinewave: +5 dBm minimum into 50Ω, harmonics ≤ -20 dBc

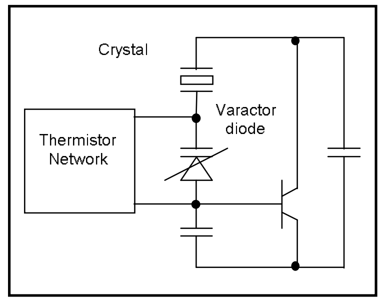
Phase noise

TCXO's can be designed to minimize their phase noise characteristics. Depending on the actual requirement, this will directly affect the cost. Close-in phase noise (typically < 300Hz offset from the center frequency) is directly affected by the crystal resonator. Generally, lower frequency crystals or overtone crystals are best for close-in noise. Also, crystals can be subjected to special processing which will minimize their phase noise characteristics. Phase noise > 300Hz is controlled primarily by the associated oscillator and output circuitry. In some cases the customer may not be as concerned with the phase noise in a 1Hz bandwidth at specific offset frequencies, but it is more concerned with the total overall integrated noise. Noise referenced in this manner can be specified as radians, degree RMS, picoseconds, or residual FM. KS ELECTRONICS has the capability of performing phase noise testing, but does not recommend that this be performed on a 100% basis in manufacturing due to the lengthy test time involved and the associated cost. However, testing can be performed as needed.

TCXO

Temperature stability

The temperature stability of a basic crystal oscillator can be improved by incorporating in the oscillator circuit, components with temperature characteristics approximately equal to and opposite from that of the crystal as shown. The actual technique in all except the most simple TCXO's is based upon use of a varactor diode in series with the crystal as shown. A change in voltage 'V' causes a change in the capacitance of the varactor diode resulting in a change in frequency of oscillation. The thermistor network is tailored to the crystal to cause voltage 'V' to vary with temperature which will compensate for the crystal's frequency versus temperature characteristic. As each individual TCXO requires that its compensation network be matched to its individual crystal, the cost of a TCXO is closely related to the difficulty of the frequency versus temperature specification. The stability requirements of most TCXO's, dictate compensation by means of a multiple thermistor network, with several interdependent variable components, thus making the solution of simultaneous equations by computer the only practical approach to temperature compensation. When a manufacturer specifies a stability of $\pm 1 \bullet 10^{-6}$ over -20ºC to +70ºC, this means a total peak to peak error of $2 \bullet 10^{-6}$ over the temperature range, not referenced to the frequency at any specific temperature. If a reference, such as room temperature is desired, with a maximum allowable error of 10^{-6} from that reference, the specification should clearly state "$\pm 1 \bullet 10^{-6}$ over -20ºC to +70ºC referenced to the frequency at +25ºC". Further, it should be noted that the frequency versus temperature characteristic of a TCXO is not linear; thus a $2 \bullet 10^{-7}$ total error over 0ºC to +50ºC will not produce a gradient of $2 \bullet 10^{-7} / 50 = 4 \bullet 10^{-9}$ per ºC. Pertubations in the crystal characteristics (activity dips) make it virtually impossible to guarantee exceptional stability on a per degree basis in TCXO's.



Vibration and Shock

While most TCXO's will withstand a certain amount of shock and vibration, typically 100 G shock and 5 G to 10 G sine vibration up to 500 Hz, there are cases where the oscillator will be used in environments of considerable higher sinusoidal or random vibration and shock levels. TCXO's can be designed for these higher levels by employing special internal assembly techniques and using special crystal holders. These requirements need to be identified as early in the program as possible, to avoid costly design changes later.

Clock Oscillators

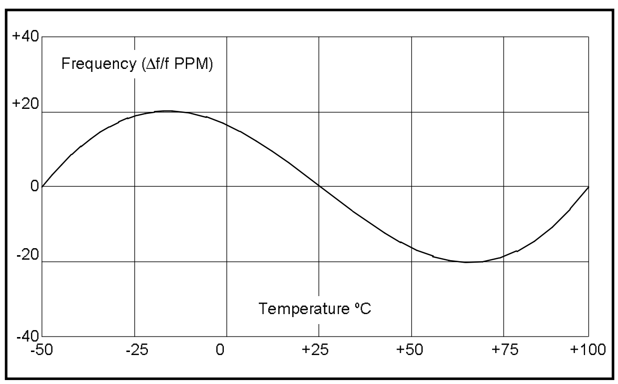
For the moderate stability crystal controlled oscillator where neither temperature compensation nor oven operation are required, there are three primary parameters: output shape, frequency and accuracy / stability.

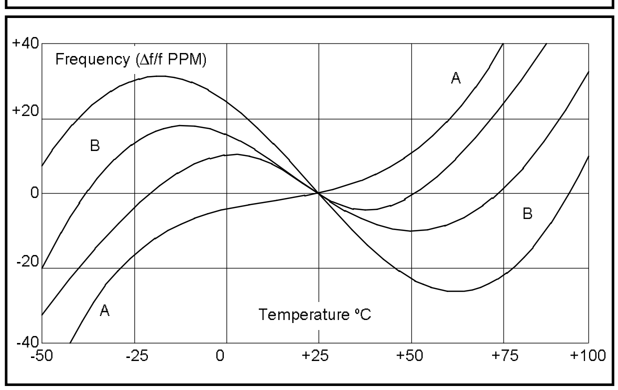
Accuracy / Stability

The most basic element in an oscillator specification is the output frequency. At any given time however, the oscillators output frequency, will differ from the desired specified frequency, resulting in a frequency error. This error is comprised of three primary components:

1. *Initial Stability*. This is generally defined as the difference between the oscillator output frequency and the specified frequency at 25ºC (***room***) at the time of shipment by the oscillator manufacturer. When specifying accuracy it is assumed that the user has no provisions to adjust the oscillators output frequency. When a frequency tuning control is included accuracy no longer needs to be specified; instead the range and settability of the tuning adjustment become more consequential.

2. *Temperature Stability*. The upper picture shows a typical characteristic of a crystal frequency vs. temperature. It is one of family of curves illustrated in the lower picture. It shows that one extreme, curve A, has a relatively flat slope (good temperature stability) near room temperature, but is very frequency sensitive at high and low temperatures. The other extreme, curve B, shows greater sensitivity near room ambient but provides the overall best temperature stability over wide temperature ranges. The angle at which the quartz crystal is cut determines the temperature characteristic of a specific crystal.





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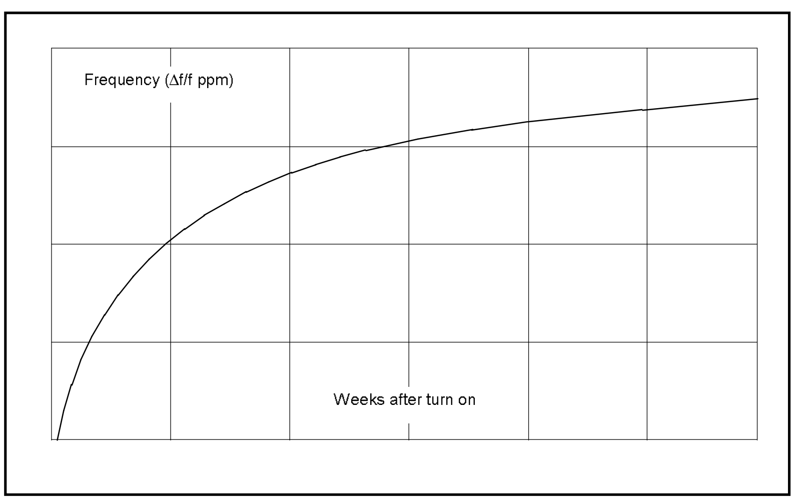
Clock Oscillators

The proper characteristic from this family of curves is selected for each individual crystal oscillator requirement. In a well designed oscillator the stability vs. temperature is determined primarily by the temperature characteristic of the crystal, and the oscillator manufacturer must select the crystal characteristics which conform with the oscillator circuit to insure that the intrinsic stability of the crystal is not degraded. A temperature stability of, for example ±10 ppm over 0ºC to +50ºC means a peak to peak frequency change of 20 ppm over the specified temperature range, not referenced to the frequency at any specific temperature. This is generally accepted definition of temperature stability which, in MIL-O-55310, is called "**frequency-temperature stability**". If a reference temperature is desired with a maximum allowable frequency change from that reference, it should be specified, for example as "±10 ppm over 0ºC to +50ºC referenced to the frequency at +25ºC". While KS ELECTRONICS segregates initial accuracy and temperature stability, the two may be combined in specifying an overall allowable error for oscillator with no frequency tuning adjustment. The appropriate term is "**frequency-temperature accuracy**" and its maximum allowable deviation from the specified nominal frequency over a given temperature range.

3. *Aging (long-term stability)*. Aging refers to the continuous change in crystal operating frequency with time, all other parameters (temperature, supply voltage, etc.) held constant. The better the processing of the crystal, the lower the aging rate (that is, the higher the long-term stability). The picture shows a typical aging curve. It illustrates that when a crystal oscillator is initially turned on by the manufacturer, the crystal ages rapidly, but its stability improves with time. While the aging rate is typically continue to improve with the time, most crystals achieve close to their lowest aging rate within several months after turn on. As long as crystal current is moderate, solder sealed, or resistance welded AT-cut crystals used, most clock oscillators will provide typical aging of 5 ppm during the first year and 3 ppm per year thereafter (5 ppm = 0.0005% = 5 •10^{-6}).



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Clock Oscillators

If the error introduced by this degree of crystal aging exceeds that allowed in the user's system, this can be overcome by specifying the inclusion of a frequency tuning adjustment in the oscillator to permit periodic recalibration and / or, using a higher quality crystal. Improved aging to $1 \bullet 10^{-6}$ per year can be achieved by employing a specially processed crystal housed in an evacuated glass or cold-weld sealed holder. Because aging generally introduces a small part of the overall error in moderate stability clock oscillators, it is often ignored in specifying this devices.

Fan-Out

Output drive capability of the oscillators that drive TTL integrated circuit. Fan-out 1 means that the oscillator can drive 1 standard TTL gate.

Frequency stability vs. Load

Frequency deviation when the load conditions have varied from the standard value.

Frequency stability vs. Mechanical environment

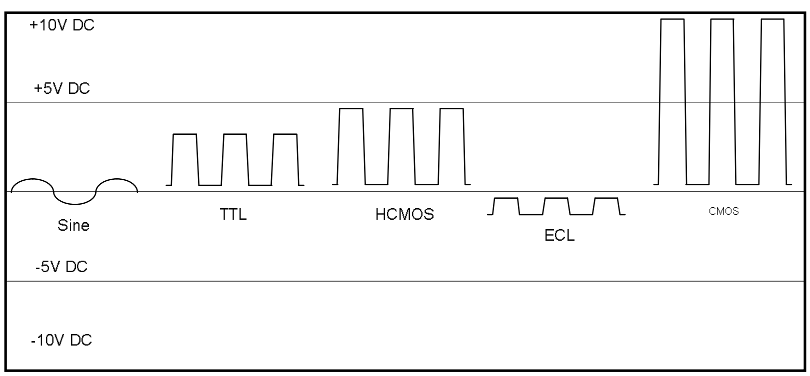
Specified by the deviation before and after shock, dropping, sine wave vibrations, constant acceleration, etc. applied.

Frequency stability vs. Supply voltage

Frequency deviation when the power supply input voltage is varied. The input voltage variation width may be expressed by voltage or percentage.

Output Circuit

The vast majority of systems require a crystal oscillator output which is TTL compatible, CMOS compatible, HCMOS compatible, ECL compatible or sinusoidal. Any of these outputs can be simply generated by circuits which follow the crystal oscillator stage. These are shown in the diagram.



Passing time from low to high (or from high to low) - threshold level

Unless otherwise specified, measurements are made on the leading and trailing edges at the 10% and 90% points as referenced to the flat portion of the maximum amplitude level.

Symmetry (Square wave output waveform only)

Ratio of the high level to the duration of the output pulse. Unless otherwise specified, measurements are made at the 50% level as referenced to the maximum amplitude level.

VCXO & VCO

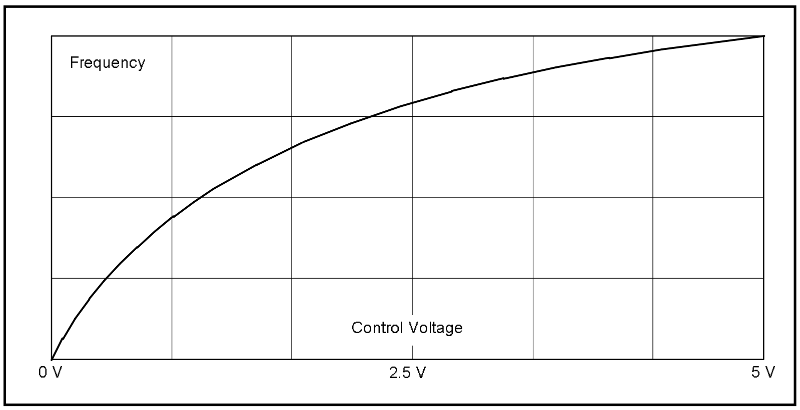
A VCXO (Voltage Controlled Crystal Oscillator) is a crystal oscillator which includes a varactor diode and associated circuitry allowing the frequency to be changed by application of a voltage across that diode. This can be accomplished in a simple clock or sinewave crystal oscillator, a TCXO (resulting in a TC-VCXO Temperature Compensated Voltage Controlled Crystal Oscillator), or an oven controlled type (resulting in a OC-VCXO Oven Controlled Voltage Controlled Crystal Oscillator). There are several characteristics peculiar to VCXO's. In generating a VCXO specification this applies in addition to the characteristics which define fixed frequency crystal oscillators. Primary among the specifications which are peculiar to VCXO's are the following:

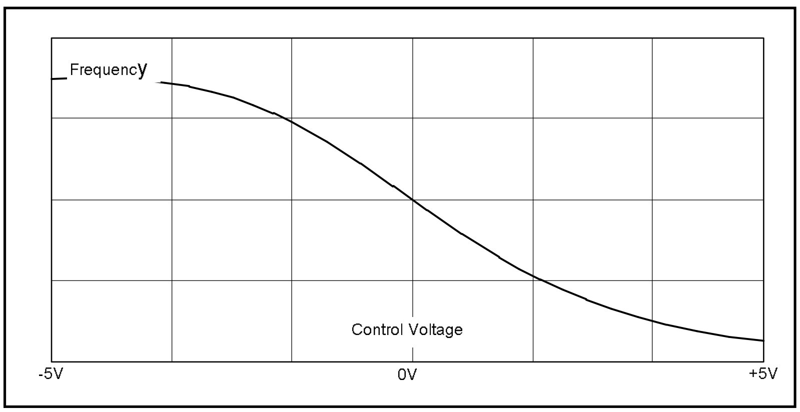
Control Voltage

This is the varying voltage which is applied to the VCXO input terminal causing a change in frequency. It is sometimes referred to as modulation voltage, especially if the input is a AC signal.

Slope (slope polarity)

This denotes the direction of frequency change vs. control voltage. A positive transfer function denotes an increase in frequency for an increasing positive control voltage, as shown in the upper diagram. Conversely, if the frequency decreases with a more positive (or less negative) control voltage, as shown in the lower diagram, the transfer function is negative.





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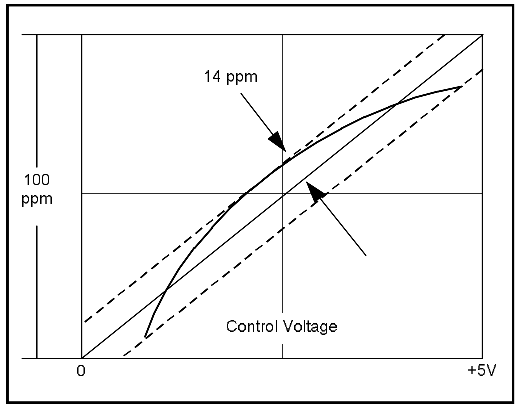
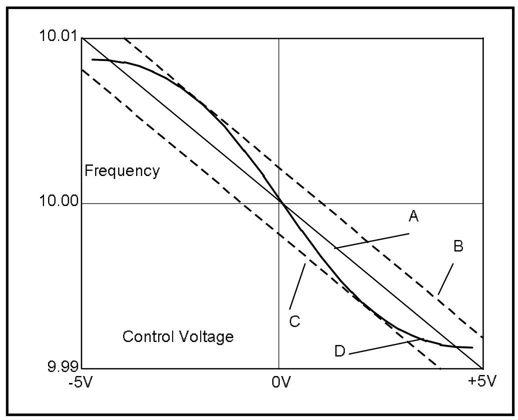
VCXO & VCO

Linearity

The generally accepted definition of linearity is that specified in MIL-O-55310. It is the ratio between frequency error and total deviation, expressed in percent, where frequency error is the maximum frequency excursion from the best straight line, drawn through a plot of output frequency vs. control voltage. If the specification for an oscillator requires a linearity of ±5% and the actual deviation is 20 kHz, as shown in the picture, the curve of output frequency vs. control voltage input vary ±1 kHz (20 kHz • ±5%) from the best straight line "A". These limits are shown by lines "B" and "C". "D" represents the typical curve of a VCXO exhibiting a linearity within ±5%. The VCXO which produces the characteristic indicated in the upper diagram uses a hyper-abrupt junction varactor diode, biased to accommodate a bipolar (±) control voltage. The VCXO which produces the characteristic in the lower diagram uses an abrupt junction varactor diode with an applied unipolar control voltage (positive in this case). Good VCXO design dictates that the voltage to frequency curve be smooth (no discontinuities) and monotonic. All KS ELECTRONICS VCXO's exhibit these characteristics.





Pull

This is the amount of frequency change with results from changes in the control voltage. For example, a ±5V control voltage might result in a pull of ±100 ppm, or a 0V to +5V control voltage might result in a total deviation of 150 ppm or higher.

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Modulation rate (sometimes referred to as deviation rate or frequency response)

This is the rate at which the control voltage can change resulting in a corresponding frequency change. It is measured by applying a sinewave signal with a peak value equal to the specified control voltage, demodulating the VCXO's output signal, and comparing the output level of the demodulated signal at different modulation rates. The modulation rate is defined by KS ELECTRONICS as the maximum modulation frequency which produces a demodulated signal within 3 dB of that which is present with a 100 Hz modulating signal. While non-crystal controlled VCO's can be modulated at very high rates (greater then 1 MHz for output frequencies greater than 10 MHz), the modulation rate of the VCXO's is restricted by the physical characteristics of the crystal. While the VCXO's modulation input network can be broadened to produce a 3 dB response above 100 kHz, the demodulated signal may exhibit amplitude variations of 5 dB to 15 dB at modulation frequencies greater than 20 kHz due to crystal.

Slope / Slope linearity / Incremental sensitivity

This can be a confusing area these terms are often misapplied. Slope should be really called average slope if it is intended to define the total deviation divided by the total control voltage swing. For the VCXO depicted in the upper diagram for linearity, the average slope is -20 kHz / 10V = -2 kHz / V. Incremental sensitivity, often misnomerred slope linearity, means the incremental change of the frequency vs. control voltage characteristic, throughout the range of control voltage. Thus, while the average slope in this example is -2 kHz per volt, the slope for any segment of the curve may be considerable different from -2 kHz / V. For VCXO's with best straight line linearity of ±1% to ±5%, the incremental sensitivity is approximately (very approximately) 10 times as great as the best straight line linearity. Thus a VCXO with a approximately ±5% best straight line linearity can exhibit a slope change of ±50% on a per volt basis. Therefore a specification which reads "Slope: 2 kHz / V ±10%" requires clarification as it could mean either average slope or incremental sensitivity. If it where intended to define average slope, it simply specifies a total deviation of 18 kHz to 22 kHz and would more properly have stated, "Total deviation: 20 kHz ±10%". However if it where intended that the frequency change for each incremental volt must fall between 1.8 kHz and 2.2 kHz, a highly linear VCXO is being specified as a ±10% incremental sensitivity relates approximately to a ±1% best straight line linearity. That element of the specification should read, "Incremental sensitivity: 2 kHz ±10% per volt".

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VCXO & VCO

Other design considerations

Stability

A quartz crystal is a high Q device which is the crystal oscillator's stability determining element. It inherently resist being "pulled" (deviated) from its designed frequency. In order to produce a VCXO with significant deviation, the oscillator circuit must be "de-Q'd". This results in degrading the inherent stability of the crystal in terms of its frequency vs. temperature characteristic, and its short term stability (and associated phase noise) characteristic. Therefore, it is in the user's best interest not to specify a wider range than that absolutely required.

Phase locking

When a VCXO is used in a phase lock loop application, the deviation should always be at least as great as the combined instability of the VCXO itself and the reference or signal onto which it is be locked. KS ELECTRONICS produces a line of VCXO's especially intended for use in phase lock loop applications. However, if the open loop stability requirements of a system are more stringent than available in this production line, a TC-VCXO may be required. For the highest stability open loop requirements, the appropriate may be those described in the TCXO or OCXO sections of this brochure, incorporating a narrow deviation VCXO option, rather than those described in the VCXO section.

Basic oscillator frequencies

Fundamental mode crystals (generally 5 - 35 MHz) permit the widest deviation, while 3^{rd} overtone crystals (generally 35 - 70 MHz) allow deviation approximately $1/9^{th}$ of that which applies to fundamentals. Therefore, all wide deviation VCXO's (greater than ±100 ppm to ±200 ppm deviation) use fundamental crystals; narrower deviation VCXO's can use fundamental mode or 3^{rd} overtone crystals, the selection which often depends upon such specifications as linearity and stability. It is rare that higher overtone and therefore higher frequency crystals find application in VCXO's. Thus, VCXO's with output frequencies higher or lower than available from the appropriate crystal frequencies include frequency multipliers or dividers.

Due to recent advancement in manufacturing higher frequency crystals (in fundamental mode up to 400 MHz), wide band VCXO's (up to ±5000 ppm pull) are possible. KS ELECTRONICS has a new line of these wide band VCXO's available. Please consult KS ELECTRONICS for more information.

OSCILLATOR SPECIFICATIONS

Output Frequency ____________ MHz

Supply Voltage ________ V DC ± ____ % || *Supply Current* ___________ mA max.

Stability at 25ºC ± ______________ ppm || *Aging* ± ___________ ppm / year max.

Output Type ☐ TTL ☐ CMOS ☐ HCMOS ☐ ECL *fan-out* ______ loads

☐ Sinewave _____ V(p-p) / V(rms) / dBm into ____ Ω impedance

Operating Temperature from __________________ ºC *to* __________________ ºC

Phase Noise (L_f @) 1Hz ________ -dBc / Hz 10Hz _______ -dBc / Hz

100Hz ____ -dBc / Hz 1kHz _______ -dBc / Hz 10kHz ______ -dBc / Hz

Max. Dimensions Height _________" Length _________" Wide _________"

Case ☐ Metal ☐ SMD ☐ Other ________________________________

Vibration _________________________ || *Shock* ________________________ G

OCXO

Oven supply Voltage ___________ V || *Max. Warm Up Time* _________ minutes

max. turn on consumption _______ W || *max. consumption on* _____ ºC ______ W

VCXO

Absolute Pull range ± ___________________ min. ± __________________ max.

Deviation Sensitivity (Slope) ± __________ ppm/V || *Bandwidth* ___________ kHz

Control Voltage Range ______ V to ______ V || *Nominal Voltage* ________ V

Linearity (min.) ______________________ % || *Input Resistance* ________ Ω

Audio Frequency Response ± ______ % max. from ________ Hz to ________ kHz

Audio Reference Frequency _________ Hz || *Audio Input Impedance* _______ Ω

TCXO

Temperature Stability ± _________ ppm *over* ___________ ºC to ___________ ºC

Aging Adjustment ☐ Mechanical ☐ Electrical ☐ Both

Adjustment Range ± ______ ppm min.

OTHER REQUIREMENTS

____

____

____

ABOUT YOUR PROJECT

Application ____

Estimated Annual Usage ____________________ *Starting* ____________________

Samples Required By ______________________ *Expected Quantity* ___________

FILTER SPECIFICATIONS

Filter Type ☐ Crystal ☐ MCF ☐ L / C ☐ ____________________

Center Frequency ______________________ MHz ± ________________ Hz

Pass Band __________ dB BW _________________ kHz min.

__________ dB BW _________________ kHz min.

__________ dB BW _________________ kHz max.

__________ dB BW _________________ kHz max.

Stop Band __________ dB BW _________________ kHz min. / max.

__________ dB BW _________________ kHz min. / max.

__________ dB BW _________________ kHz max.

__________ dB BW _________________ kHz max.

__________ dB BW _________________ kHz max.

Ripple ______ dB max. ☐ *peak to peak* ☐ ± *from center frequency.*

I. Loss ______ dB max. ☐ *at center frequency* ☐ *at peak in pass band.*

Spurious Attenuation _______ dB min. _______ dB min. _______ dB min.

Ultimate Attenuation _______ dB min. _______ dB min. _______ dB min.

Group Delay Variation in Pass Band ________________ ☐ µS ☐nS

Phase Variation in Pass Band _____________________ in degrees

Input Impedance ________________ Ω // ± __________________ reactance

Output Impedance _______________ Ω // ± __________________ reactance

Operating Temperature from _________________ ºC *to* ________________ ºC

Max. Dimensions Height ________" Length ________" Wide ________"

Case ☐ From Brochure pg. _____ ☐ Other ________________________

Vibration _______________________ *Shock* _______________________ G

OTHER REQUIREMENTS

____

____

____

____

ABOUT YOUR PROJECT

Application ____

Estimated Annual Usage __________________ *Starting* __________________

Samples Required By _____________________ *Expected Quantity* __________

Name: ______________________

Company: ______________________

Street: ______________________

City / ZIP: ______________________

Phone: ______________________

FAX: ______________________

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