EX-219

Hi-Reliability Evacuated Miniature Crystal Oscillator (EMXO)

Frequency stabilities [10 to 20 MHz]					
Parameter	**Min**	**Typ**	**Max.**	**Units**	**Condition**
vs. operating temperature range (reference to +25°C)	-50 -75 -100		+50 +75 +100	ppb ppb ppb	-10 … +60°C -20 … +70°C -40 … +85°C
Initial tolerance for fixed frequency vs. supply voltage change vs. load change	-1 -10 -10		+1 +10 +10	ppm ppb ppb	at time of shipment Vs ± 5% Load ± 5%
vs. aging /1 day vs. aging /1st year vs. aging /10 year vs. aging /10 year vs. aging /10 year	-2 -200 -1000 -1500 -2000		+2 +200 +1000 +1500 +2000	ppb ppb ppb ppb ppb	after 7 days of operation 10 to <12MHz 12 to <16MHz 16 to 20MHz
Warm-up Time @+25°C			120 180	seconds seconds	to ±1000 ppb of freq at 1hr after turn-on to ±100 ppb of freq at 1hr after turn-on

Frequency stabilities [>20 to 120 MHz]					
Parameter	**Min**	**Typ**	**Max.**	**Units**	**Condition**
vs. operating temperature range (reference to +25°C)	-75 -100 -150		+75 +100 +150	ppb ppb ppb	-10 … +60°C -20 … +70°C -40 … +85°C
Initial tolerance for fixed frequency vs. supply voltage change vs. load change	-1.5 -15 -15		+1.5 +15 +15	ppm ppb ppb	at time of shipment Vs ± 5% Load ± 5%
vs. aging /1 day vs. aging /1st year vs. aging /10 year	-3 -300 -3000		+3 +300 +3000	ppb ppb ppb	after 7 days of operation
Warm-up Time @+25°C			120 180	seconds seconds	to ±1000 ppb of freq at 1hr after turn-on to ±100 ppb of freq at 1hr after turn-on

Single Supply Voltage (Vs) Option					
Parameter	**Min**	**Typ**	**Max.**	**Units**	**Condition**
Supply voltage	3.13	3.3	3.47	VDC	
	4.75	5.0	5.25	VDC	
Power consumption			2.2 0.7 1.2	Watts Watts Watts	during warm-up steady state @ +25°C steady state @ -40°C

Dual Supply Voltage Option					
Parameter	**Min**	**Typ**	**Max.**	**Units**	**Condition**
Oscillator Supply Voltage (Vosc)	3.13	3.3	3.47	VDC	
	4.75	5.0	5.25	VDC	
Oscillator Supply Current (Iosc)			60	mA	
Oven Supply Voltage (Voven)	3.13	3.3	3.47	VDC	
	4.75	5.0	5.25	VDC	

Oven Power Consumption (Ioven)			2.0 0.6 1.1	Watts Watts Watts	during warm-up steady state @ +25°C steady state @ -40°C

RF Output

Parameter	Min	Typ	Max.	Units	Condition
Signal		**HCMOS**			
Load		15		pF	
Signal Level (Vol)			0.1	Vs	
Signal Level (Voh)	0.9			Vs	
Rise/Fall Time			+7	ns	(10-90%)
Duty cycle	40		60	%	(Voh-Vol)/2
Signal		**Sinewave**			
Load		50		Ohm	
Output Power (0dBm)	+0	+2	+4	dBm	50 Ohm load
Output Power (+3dBm)	+3	+5	+7	dBm	50 Ohm load
Output Power (+5dBm)	+5	+7	+9	dBm	50 Ohm load
Harmonics			-30	dBc	
Subharmonics			-40	dBc	Only for Freq from >55 to 120 MHz
Spurious			-80	dBc	Met during qualification (not tested)

Frequency Tuning (EFC)

Parameter	Min	Typ	Max.	Units	Condition
Tuning Range	Sufficient to compensate for 10 years aging				EFC (0V to Vref)
EFC Input DC Resistance	100		200	kOhm	
Vref	+2.4	+2.5	+2.6	VDC	source current 1 mA maximum

Additional Parameters [10 to 20 MHz]

Parameter	Min	Typ	Max.	Units	Condition
Phase Noise (10MHz Output)		-120 -145 -150 -155	-110 -135 -145 -150	dBc/Hz dBc/Hz dBc/Hz dBc/Hz	10 Hz 100 Hz 1 KHz 10 KHz
ADEV			$2X10^{-11}$		
G-Sensitivity (total gamma)			1	ppb/g	Test at 10g sine vibration at 100Hz

Additional Parameters [>20 to 55 MHz]

Parameter	Min	Typ	Max.	Units	Condition
Phase Noise (40MHz Output)		-100 -130 -145 -150	-90 -120 -140 -145	dBc/Hz dBc/Hz dBc/Hz dBc/Hz	10 Hz 100 Hz 1 KHz 10 KHz
ADEV			$5X10^{-11}$		
G-Sensitivity (total gamma)			1	ppb/g	Test at 10g sine vibration at 100Hz

Additional Parameters [>55 to 120 MHz]

Parameter	Min	Typ	Max.	Units	Condition
Phase Noise (100MHz Output)		-90 -125 -140 -145	-85 -115 -135 -140	dBc/Hz dBc/Hz dBc/Hz dBc/Hz	10 Hz 100 Hz 1 KHz 10 KHz
ADEV			$5X10^{-11}$		
G-Sensitivity (total gamma)			1	ppb/g	Test at 10g sine vibration at 100Hz

Environmental Conditions (Qualified to meet)

Radiation Tolerant (operating)	Active devices are selected from product families that are inherently radiation tolerant to meet 100krad (Si) Total Ionizing Dose
Mechanical Shock (non operating)***	MIL-STD-202, Test Method 213, Condition E (1000G, 0.5msec)
Vibration Random (non operating)***	MIL-STD-202, Test Method 214, Condition I-H (30Grms, 3 minutes/axis)
Vibration Sine (non operating)***	MIL-STD-202, Test Method 204, Condition D (20Gpk, 20 minutes/axis)
Storage Temperature***	-55°C minimum and +85°C maximum
Note: *** Met during qualification	

Screening Options

Ordering Code	"S"	"B"	"E"
Test Inspection	S-Level Screening	B-Level Screening	Electrical Verification (EM)
Nondestructive Bond Pull	MIL-STD-883 Meth 2023	N/A	N/A
Internal Visual	IAW MIL-PRF-55310	IAW MIL-PRF-55310	IAW MIL-PRF-55310
Stabilization Bake	MIL-STD-883 Meth 1008, Cond C 150°C for 48hrs	MIL-STD-883 Meth 1008, Cond C 150°C for 48hrs	MIL-STD-883 Meth 1008, Cond C 150°C for 48hrs
Thermal Shock	MIL-STD-883 Meth 1011, Cond A 0°C to 100°C for 15cycles	N/A	N/A
Temperature Cycling (1)	MIL-STD-883 Meth 1010, Cond A -55°C to 85°C (2) for 10cycles	MIL-STD-883 Meth 1010, Cond A -55°C to 85°C (2) for 10cycles	N/A
Constant Acceleration (1)	MIL-STD-883 Meth 2001 1000g's (3) Y1 Only	MIL-STD-883 Meth 2001 1000g's (3) Y1 Only	N/A
Seal (Fine & Gross Leak) (1)	N/A (Vacuum Seal)	N/A (Vacuum Seal)	N/A (Vacuum Seal)
PIND	MIL-STD-883 Meth 2020, Cond B 10g peak at 60Hz minimum	N/A	N/A
Pre-Burn-in Electrical Test	IAW MIL-PRF-55310	IAW MIL-PRF-55310	IAW MIL-PRF-55310
Burn-in (1)	85°C (2) for 240hrs	85°C (2) for 240hrs	N/A
Post-Burn-in Electrical Test	IAW MIL-PRF-55310	IAW MIL-PRF-55310	N/A
Radiographic	MIL-STD-883 Method 2012	N/A	N/A

Notes:
(1) These test inspections deviate from the screening requirements for Class 2 oscillators listed in MIL-PRF-55310.
(2) The maximum operating and storage temperature of the EX-219 is +85°C. The EX-219 shall not be exposed to temperature higher than +85°C for an indefinite period of time. However, the EX-219 can tolerate manufacturing process temperatures up to +100°C maximum for 168 hours total accumulative time.
(3) The design and construction of the EX-219 can withstand up to 1000g's constant acceleration.

Group A Inspection (included 100% w/ screening options S and B)

Group A Inspection is performed in accordance with Table V of MIL-PRF-55310
- Subgroup 1: Electrical test
- Subgroup 2: Visual and Mechanical inspection
- Subgroup 3: Solderability

Group B Inspection (included 100% w/ screening options S and B)

Group B Inspection consists of frequency aging testing in accordance with MIL-PRF-55310 with the exception of using a 3rd order log fit for the 1st year aging projection (see app note #11 for detailed information)

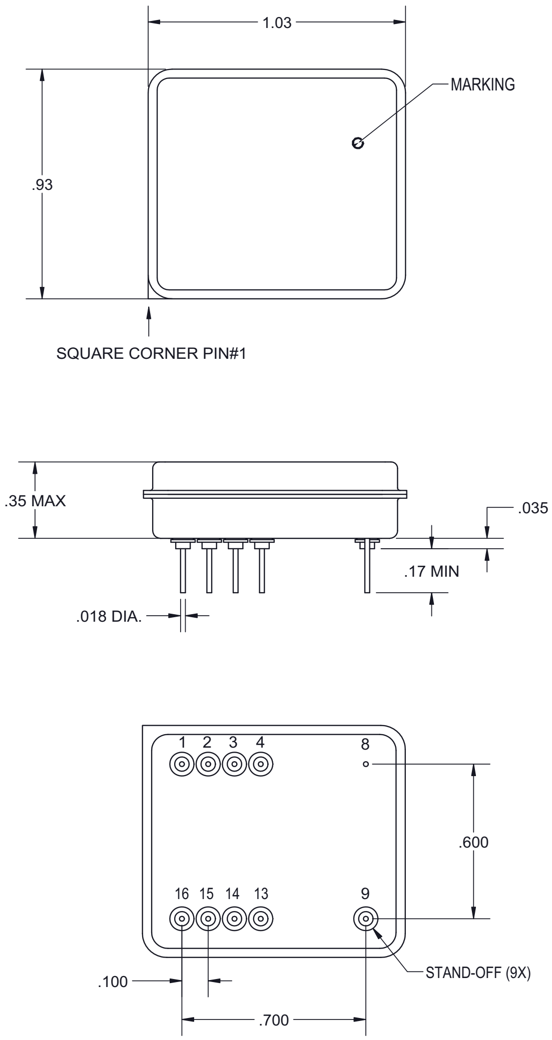
Group C Inspection (optional, destruct specimens required)

Group C Inspection is optional and shall be requested on the customer's purchase order. Group C Inspection can be performed in accordance with either MIL-PRF-55310 or MIL-PRF-38534

Other Notes

1. Contact factory for improved stabilities or additional product options. Not all options and codes are available at all frequencies.
2. Unless stated otherwise, all values are valid after warm-up time and refer to typical conditions for supply voltage, frequency control voltage, load and temperature (25°C).
3. Phase noise degrades with increasing output frequency.
4. Subject to technical modification.
5. Contact factory for availability.

Outline Drawing / Enclosure



DIMENSIONS ARE IN INCHES

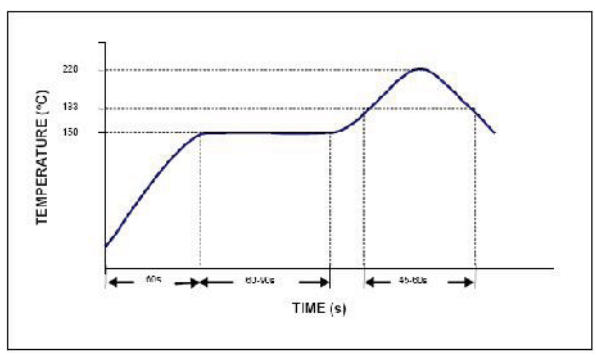
PIN NUMBERS ARE SHOWN FOR REFERENCE AND NOT MARKED ON THE UNIT

Pin Connections for Single Supply Option		
Pin	**With EFC**	**Fixed Frequency**
1	EFC Input	No Connection
2-4	No Connection	No Connection
8	Ground (Case)	Ground (Case)
9	RF Output	RF Output
13-14	No Connection	No Connection
15	Vref	No Connection
16	Supply Voltage Input (Vs)	Supply Voltage Input (Vs)
Pin numbers are for reference only and not marked on parts.		

Pin Connections for Dual Supply Option		
Pin	**With EFC**	**Fixed Frequency**
1	EFC Input	No Connection
2-4	No Connection	No Connection
8	Ground (Case)	Ground (Case)
9	RF Output	RF Output
13	Oven Supply Voltage Input (Voven)	Oven Supply Voltage Input (Voven)
14	No Connection	No Connection
15	Vref	No Connection
16	Oscillator Supply Voltage Input (Vosc)	Oscillator Supply Voltage Input (Vosc)
Pin numbers are for reference only and not marked on parts.		

Recommended Solder Reflow

Maximum temperature is 230°C for 10 seconds



Ordering Information

EX - 219 - C A F - 107 A S S - 10M0000000

Product Family
EX: EMXO

Package
219: 24x26x9mm

Supply Voltage
Single Supply:
C: 5.0 V
D: 3.3 V
Dual Supply:
S: Voven = 3.3V, Vosc = 3.3 V
T: Voven = 5.0V, Vosc = 3.3 V

RF Output
A: CMOS
G: Sinewave (0 dBm)
H: Sinewave (+3 dBm)
J: Sinewave (+5 dBm)

Temperature Range
K: -10°C to +60°C
D: -20°C to +70°C
F: -40°C to + 85°C

Stability Code
508: ±50 ppb
758: ±75 ppb
107: ±100 ppb
157: ±150 ppb

Frequency Control
A: Electrical Tuning
F: Fixed Frequency

Screening Option
S: "S" Level Screening
B: "B" Level Screening
E: "EM" Engineering Model

Crystal Option
S: Swept Quartz
N: Non-Swept Quartz

Frequency
XXXXXXXXXX

Temperature Range and Stability Options Table

Stability/Temperature	F: -40°C to +85°C	D: -20°C to +70°C	K: -10°C to +60°C
508 (+/-50 ppb)			10-20 MHz
758 (+/-75 ppb)		10-20 MHz	>20-120 MHz
107 (+/-100 ppb)	10-20 MHz	>20-120 MHz	
157 (+/-150 ppb)	>20-120 MHz		

Application Notes

All data and notes are for reference only

1. EMXO Technology

The EMXO is an Oven Controlled Crystal Oscillator (OCXO) hermetically sealed in an evacuated package. It is comprised of a heated substrate (oven) and an output substrate. The oven is mounted on a thermally insulated structure that maintains a nearly constant temperature at about +95°C over the operating temperature range whereas the output substrate is mounted directly on the case. Unlike a conventional OCXO, the EMXO is sealed in an evacuated package using high internal vacuum as the insulation medium to achieve lower power consumption and faster warm-up time.

2. Crystal Resonator

A doubly rotated crystal (IT-Cut), which is stress compensated, is used to obtain good phase noise, better aging rate and lower g-sensitivity. The crystal has a 4-point mounting structure for robustness and low g-sensitivity. Synthetic swept quartz is used for the flight model (FM) to achieve higher radiation tolerance. The Temperature Characteristic (TC) of an IT cut crystal in a 3rd order polynomial function has an inflection temperature at +75°C and an upper turn temperature (UTP) of +95°C. To obtain the advantage of minimal frequency sensitivity, the oven temperature is set at or around the UTP of the crystal. Figure 1 shows typical Temperature Characteristic (TC) of an IT cut Crystal.

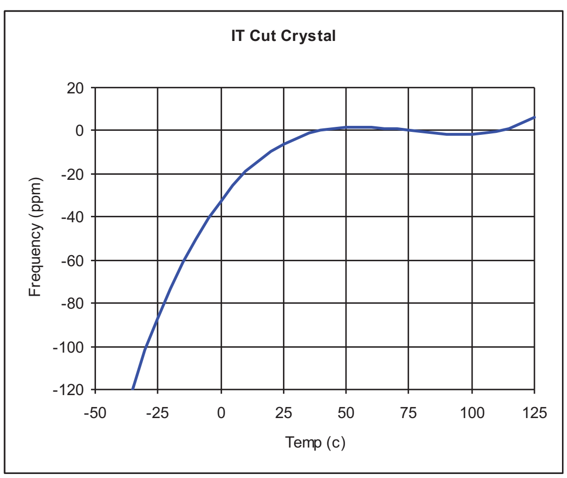


Figure 1

3. Warm-up Characteristic

At cold turn-on, the oven is fully powered and the oven temperature rises to the preset temperature which is about 95°C. When the set temperature has been reached, the oven power consumption is cut back to the steady state condition. At steady state, the oven is proportionally controlled and maintains a nearly constant oven temperature. The turn-on power consumption must be higher than the steady state power to prevent power starving, especially at the cold end of the operating temperature. The warm-up time is inversely proportional to the case temperature. Since the EMXO is evacuated and has much less thermal mass than a conventional OCXO, its warm-up time is much faster. Figure 2 shows the typical Warm-up Power characteristic at -40°C and +25°C.

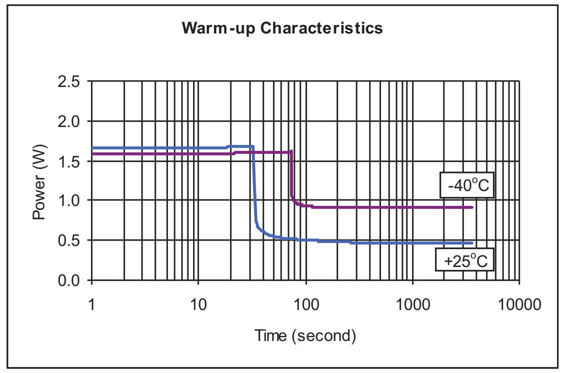


Figure 2

During warm-up, the output frequency follows the TC of the crystal frequency until the oven power has cut back to the steady state condition. After oven cut back, the frequency still slowly changes until the oven temperature reaches equilibrium state. Figure 3 shows the Warm-up Frequency characteristic at -40°C and +25°C.

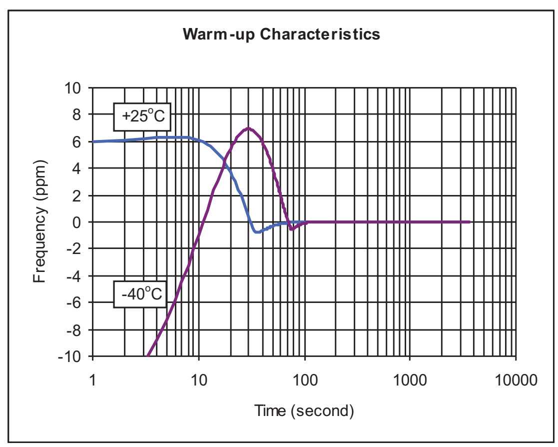


Figure 3

4. Operating Temperature Characteristic

The operating temperature specified herein is the device case temperature. Since the oven is proportionally controlled, its power consumption is inversely proportional to the case temperature. Figure 4 shows the steady state power versus case temperature. If the case temperature rises above the maximum operating temperature, the oven will shut off. Thus, the output frequency is no longer stable and follows the TC for the crystal. Figure 5 shows frequency versus case temperature. Although the maximum operating temperature is +85°C, the case temperature can increase up to +95°C without causing any permanent damage. However, the maximum temperature shall not exceed +95°C for an indefinite period of time and, during the manufacturing process, shall not exceed +100°C for more than 168hrs total accumulative time. If a part has been exposed to a temperature above +95°C for a longer duration, it might possibly accelerate internal outgassing. In turn, it will degrade the internal vacuum pressure causing an increase in power consumption.

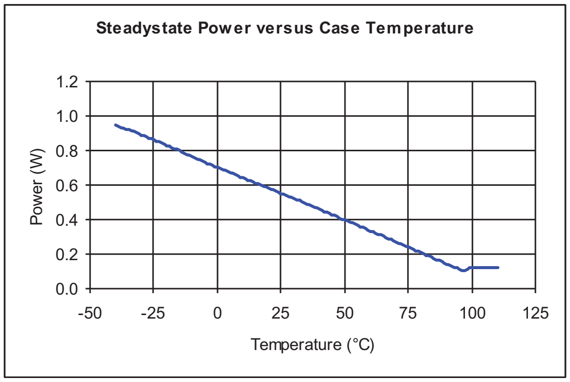


Figure 4

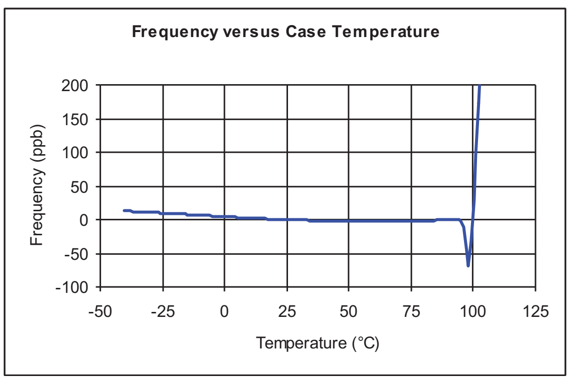


Figure 5

5. Initial Frequency Accuracy

There are two options for defining initial frequency accuracy.

a. Fixed Frequency: This option does not have an output frequency adjustment. The output frequency will be set to the specified limit at time of shipment.

b. Electronic Frequency Control (EFC): This option offers frequency adjustment with input voltage at pin #1. The EFC is positive and monotonic as shown in Figure 6. This option will allow the end user to adjust the output frequency closer to the nominal frequency or to correct for long term aging. A low noise internal voltage reference (Vref) is offered with this option for biasing a voltage divider resistor network or DAC to control the EFC input. Using a noisy voltage reference to control the EFC input can degrade phase noise or ADEV performance.

Initial frequency accuracy is not specified for the EFC option. The EFC pull range is sufficient to correct the effects of frequency aging over a 10 to 15 year product life.

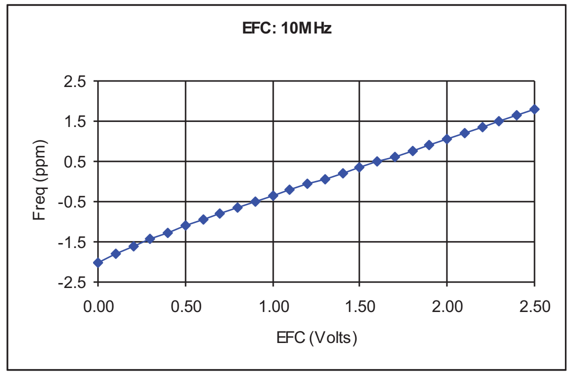


Figure 6

6. Supply Ripple of Single Supply Option

Most applications require a single supply input voltage for both the oscillator and oven circuitries. Although a voltage reference is used to regulate the supply voltage to the oscillator stage, the output buffer still uses the external supply voltage directly. Thus, the supply ripple can have a direct influence on the output signal. Figure 7 shows the typical ripple response.

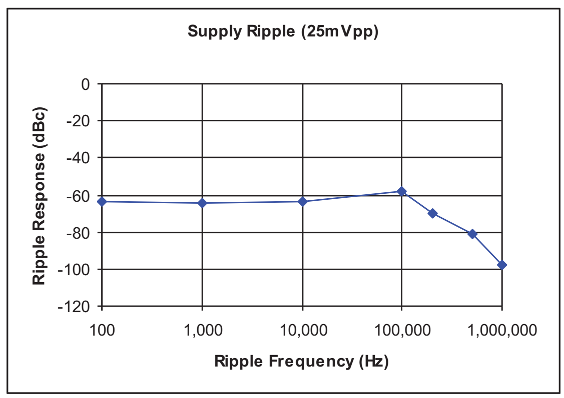


Figure 7

An external LC filter can be used in the supply line to suppress the ripple amplitude. The current rating of the inductor used in the filter shall be capable of handling high input current especially during warm-up.

7. Dual Supply Option

The EX-219 offers a dual supply option for independent operation of oscillator (Vosc) and oven (Voven) supply lines. The advantages of using the dual supply option are described below.

a. Supply Ripple: With this option, an external LC filter with a low current rating can be used in the Vosc line to suppress supply ripple.

b. 3.3V LVCMOS Output: If 3.3V LVCMOS output waveform is required and the 3.3Vdc supply does not have sufficient power to operate the 3.3Vdc single supply option, then a dual supply option with 5.0Vdc (Voven) and 3.3Vdc (Vosc) can be used.

8. Thermal Considerations

The thermal resistance from the case of the EX-219 to the mounting plate should be considered when the part is mounted. Heat rise on the case is proportional to the steady state power consumption shown in Figure 4. Since the oven is a servo controlled system, the heat rise on the case will eventually reach an equilibrium point depending on the thermal resistance from the case to the mounting plate.

If the thermal resistance from the case to the mounting plate is too high, the heat rise on the case will cause the oven to shut off sooner.

In the event of oven shut off due to the case temperature exceeding the oven set temperature, there is still remaining self-heating power dissipated by the other components in the oscillator circuitry. This self-heating power is 150 mW typical.

The EX-219 is a 16 pin doublewide dual in-line package (DDIP). It consists of nine glass to metal seal feed-thru pins and one case/GND pin. In space applications, sinking heat through mounting pins is not recommended because the nine feed-thru pins have poor thermally conductive properties. Sinking heat directly from the case of the part to the mounting plate is recommended.

9. Part Installation

Stress relief mounting is highly recommended for the EX-219. Thermally conductive adhesive can be used to mechanically bond the bottom surface of the case to the mounting plate with all ten pins protruding through the clearance holes to the opposite side of the PCB. Then, wires can be used to make connections from the pins to the I/O pads on the PCB as shown in Figure 8.

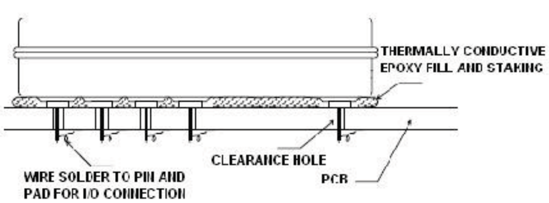


Figure 8

10. No Connection Pins

All "No Connection" pins are NOT electrically connected internally and are recommended to be connected to GND.

11. Aging Projection

MIL-PRF-55310 specifies measurement of frequency aging for 30 days or longer. The measurements obtained shall be fit using the method of least squares to the function (1)

$$f(t) = A(\ln(Bt + 1)) + fo \qquad (1)$$

If the aging trend is not monotonic, the measurement period shall be extended to 40 days or longer after the extremum in the aging trend, and the measurements from 12 days after the extremum is reached to the end of the aging measurement period shall be fit to the above function. Thus, Group B Aging can extend beyond 60 days.

To maintain Group B Aging to 30 days, the EX-219 uses a 3rd order log function (2) for non-monotonic aging trends.

$$f(t) = A+B\ln(t) +C\ln(t)^2 +D\ln(t)^3 + fo \qquad (2)$$

Figure 9 shows that 40 days of aging data fit well to the 3rd order log function with R^2 greater than 99%. The fit function was then used to project for one-year aging.

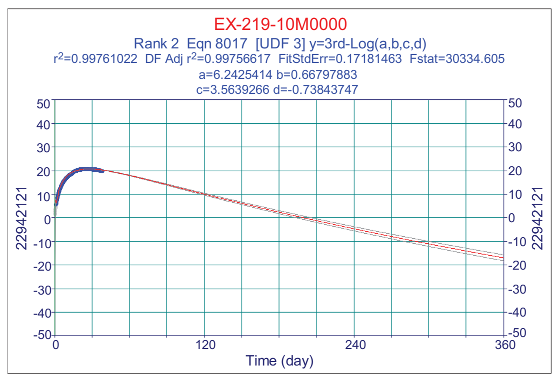


Figure 9

12. Leak Test

Most hermetically sealed packages are back filled with a gas or gasses mixed with some low percentage of detective gas such as He at around 1atm pressure and then are sealed using resistance weld or seam weld methods. Packages sealed in this manner have a typical leak rate of $1x10^{-10}$ to $1x10^{-9}$ atm cc/sec. Therefore, a leak detector having $1x10^{-8}$ atm cc/sec resolution and accuracy will be sufficient to perform the leak test.

On the other hand, the EMXO package is hermetically sealed using a cold-weld process and evacuated under hard vacuum during welding. The cold-weld package is typically used for crystals and achieves a leak rate better than $1x10^{-12}$ atm cc/sec He. The internal vacuum level at seal is better than $1x10^{-5}$ torr. To maintain performance over a mission life of 15 years, the EX-219 package leak rate should achieve $1x10^{-11}$

atm cc/sec He or better. To perform a leak test at this level presents a challenging task. A Krypton-85 leak detector can test leak rates down to this level but the bomb duration is very long and may not be practical for manufacturing.

Contrary to most electronic devices, the EMXO has a proportionally controlled oven whereby power consumption is inversely proportional to thermal resistance from the oven to the case. In this case, the EMXOs vacuum is utilized for thermal insulation. If the vacuum degrades as a result of a leak, the power consumption will be much higher. Hence, electrical parameters such as power consumption and frequency aging can determine package hermeticity. Please request Vectron's EMXO white paper for additional detailed information on package hermiticity.

13. Other Typical Parameters

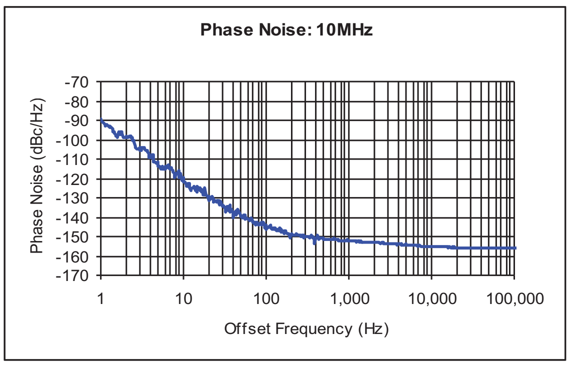


Figure 10

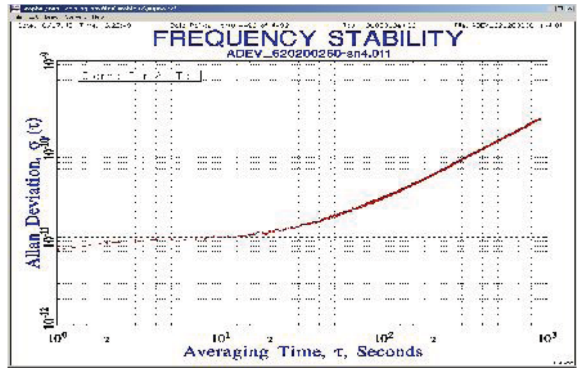


Figure 11 (10MHz)

Rev: 6-24-15 SEM

For Additional Information, Please Contact

USA:
Vectron International
267 Lowell Road, Unit 102
Hudson, NH 03051
Tel: 1.888.328.7661
Fax: 1.888.329.8328

Europe:
Vectron International
Landstrasse, D-74924
Neckarbischofsheim, Germany
Tel: +49 (0) 3328.4784.17
Fax: +49 (0) 3328.4784.30

Asia:
Vectron International
68 Yin Cheng Road(C), 22nd Floor
One LuJiaZui
Pudog, Shanghai 200120, China
Tel: 86.21.6194.6886
Fax: 86.21.6194.6699