INTRODUCTION TO DROs

Dielectric Resonator Oscillator (DROs) are microwave oscillators that use a dielectric resonator (DR) as the frequency and stabilizing element in order to achieve excellent frequency stability, high Q and very low microphonics. The DR, when used as part of the resonating circuit of any active microwave device, produces a steady state oscillation under the right conditions at the resonant frequency of the DR.

OSCILLATOR THEORY AND CIRCUIT DESIGN

MITEQ's DRO circuits utilize both silicon bipolar transistors and GaAs MESFET devices. All microwave oscillators are designed by adding resonating elements (L, C or R) in various configurations to different ports of a transistor. These elements generate a negative resistance at a certain resonant frequency and set the device into oscillation. In the case of a DRO, the resonating element is the DR, which can be modeled electrically as an L, C, R network, as shown in Figure 1.

DIELECTRIC RESONATOR ELECTRICAL MODEL

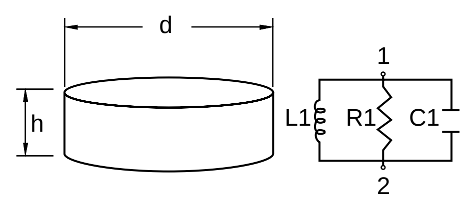


FIGURE 1

The Dielectric Resonator is made of a high dielectric constant (ε = 30 to 80) ceramic material, often barium titanate ($Ba_2Ti_9O_{20}$). This material exhibits a high Q (9000 @ 10 GHz) and low temperature coefficient of frequency (TC to ±6 ppm/°C typical).

The cylindrical shape as shown in Figure 1 is the most popular. It has good separation between the desired TEδ(0,1) mode and other higher order resonant modes, making it easier to couple to microstrip circuits, as well as easy to mount.

The resonator is magnetically coupled to one or more ports of the transistor using a transmission line, as shown in Figure 2.

DIELECTRIC RESONATOR MAGNETICALLY COUPLED TO DIFFERENT PORTS OF TRANSISTOR USING TRANSMISSION LINE

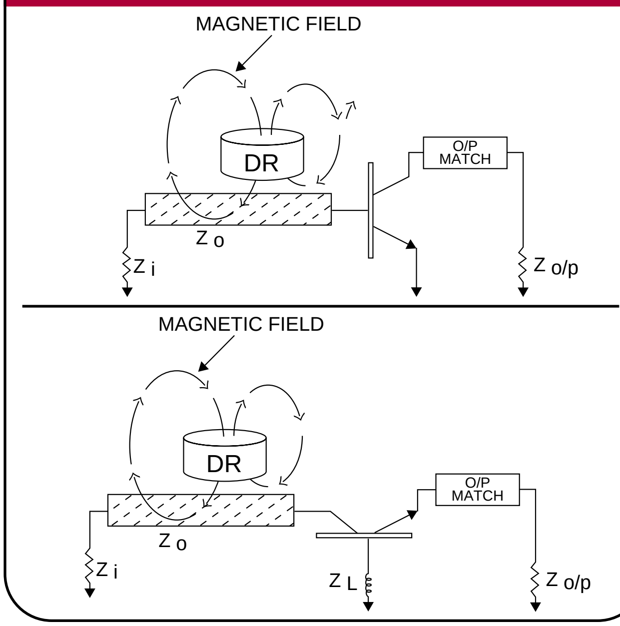


FIGURE 2

OSCILLATOR FABRICATION TECHNIQUES

MITEQ DROs are manufactured using state-of-the-art thin-film hybrid micro-circuit technology. These DROs are suited for applications requiring rugged construction for operation under severe environmental stress.

TYPICAL DRO PERFORMANCE SPECIFICATIONS AND APPLICATIONS

When comparing different types of oscillators versus a DRO, an engineer may wish to consider the following performance specifications:

FREQUENCY ACCURACY AND SETTABILITY

The frequency accuracy of a free-running DRO is typically within 500 kHz and can be set to within 100 kHz.

FREQUENCY STABILITY

DROs are highly stable free-running oscillators exhibiting low temperature coefficient of frequency drift (typically 4 ppm/°C) and having better stability than free-running cavity oscillators, Gunn diode oscillators or VCOs.

FREQUENCY PULLING FACTOR

Pulling is an oscillators sensitivity to VSWR changes. Since the DRO is a high Q oscillator, its frequency pulling factor is better than other free-running sources. The frequency pulling figure for an unbuffered (at 10 GHz) DRO is typically less than 5 MHz peak-to-peak for a 1.5:1 VSWR varying through all phases.

RF POWER OUTPUT

A DRO exhibits good power efficiency compared to other oscillators, such as a Gunn oscillator or VCO, due to lossless coupling of dielectric resonator element. It also has less power variation over temperature.

EFFECT OF POWER SUPPLY VARIATION AND OTHER NOISE CONSIDERATION

Frequency pushing is small, typically 15 kHz/volt. Also, residual noise is lower and the oscillator exhibits low microphonics (noise caused by mechanical vibrations).

LIMITATIONS OF A DROs PERFORMANCE

FREQUENCY STABILITY

DRO stability is not as good as phase-locked oscillators, but for applications requiring small size, low cost and a slightly lesser stability specification, the DRO is more suitable.

BANDWIDTH

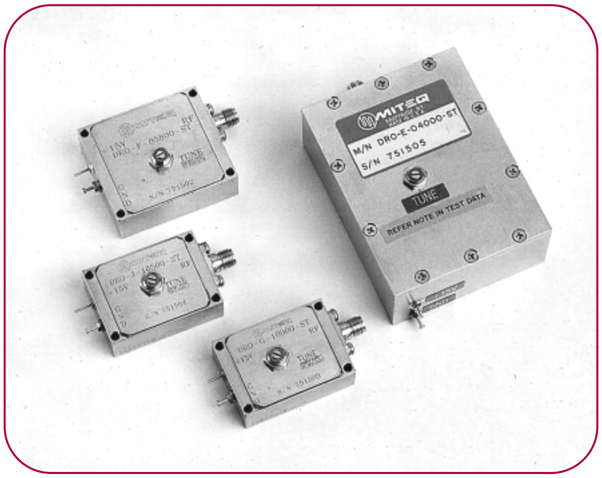
Mechanical tuning bandwidth is another limiting factor. Typically the bandwidth is 0.2% of center frequency, it can only be increased up to 3% of center frequency for special applications.

PHASE NOISE

DROs typically offer excellent phase noise performance. Typical phase noise curves can be seen on page 6.

MECHANICALLY-TUNED DIELECTRIC RESONATOR OSCILLATOR

DRO SERIES



FEATURES

- **Ultra-clean source ideal for low spur application**
- **Miniaturized designs**
- **High-reliability construction**
- **Low phase noise**

OPTIONS

- **High power (-HT-ST)**
- **Voltage tuning (-VT-ST)**
- **Special (-SP) (please contact factory before ordering)**
  Special is defined as a requirement with a specification(s) different than the standard catalog. For example, extended mechanical and electrical tuning, extended or narrowed temperature range, lower output power, different DC power requirement, etc.

GENERAL SPECIFICATIONS

MITEQ's standard dielectric resonator oscillators have been designed to meet the following maximum environmental conditions (for standard specification, see page 5):

Operating temperature .... -55 to +95°C
Storage temperature .... -65 to +115°C
Humidity .... 95% relative humidity, noncondensing
Vibration .... MIL-STD-810B, Method 514, Procedure 5

ORDERING INFORMATION

DRO SERIES

DRO - □ - □□□□□ - □□ - □□

Series (D, E, F, G, H, J, K & Ka)
Frequency (MHz)
Option (for HT or VT only)
ST or SP

ST: standard
HT-ST: high power standard
VT-ST: voltage tunable standard
SP: special

Example 1: 12 GHz DRO standard: DRO-G-12000-ST.
Example 2: 4.5 GHz DRO with +17 dBm power: DRO-E-04500-HT-ST.
Example 3: 15 GHz DRO with voltage tuning: DRO-H-15000-VT-ST.
Example 4: 8 GHz DRO with any specification different than listed in catalog DRO-F-08000-SP, please contact MITEQ.

MECHANICALLY-TUNED DIELECTRIC RESONATOR OSCILLATORS

ELECTRICAL SPECIFICATIONS

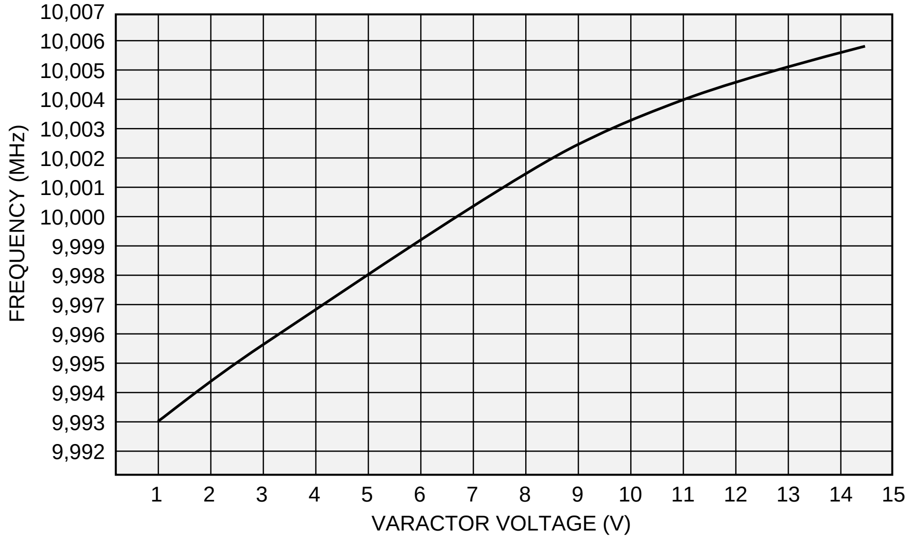
PARAMETERS	UNITS	SERIES - ST (STANDARD)										
		D	E	EF	F	G	H	J	K	L	M	N
Operating frequency range (2)	GHz	2.4 – 3.7	3.7 – 4.8	4.8 – 6.5	6.5 – 8.8	8.8 – 12	12 – 16	16 – 18	18 – 20	20 – 22	22 – 24	24 – 26
Output power (1)	dBm, min.	+13	+13	+13	+13	+13	+13	+11	+11	+11	+11	+11
Output power variation over temperature range	dB, max.	±2	±2	±2	±2	±2	±2	±2	±1.5	±1.5	±1.5	±1.5
Harmonics & fudamental	dBc, min.	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20
Spurious	dBc, min.	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80	-80
Mechanical tuning	MHz, min.	±3	±5	±10	±10	±10	±10	±10	±10	±10	±10	±10
Frequency pushing	kHz/V, max.	10	10	15	15	15	20	25	30	30	30	30
Frequency pulling (1.5:1 VSWR)	MHz, p-p max.	2	2	3	5	5	5	5	1	1	1	1
Frequency drift temp. coefficient (3)	ppm/°C, max.	5	5	5	5	5	5	5	5	5	5	5
Phase noise @ 10 kHz offset	dBc/Hz, typ.	105	105	95	90	85	80	80	80	80	80	80
DC power requirements	volts (4)	15	15	15	15	15	15	15	15	15	15	15
Current	mA, max.	150	150	120	120	120	120	120	120	120	120	120
Outline drawing		1	1	2	3	4	4	4	5	5	5	5
Temperature range	°C	-20 to +70										
		VOLTAGE TUNABLE OPTION (VT-ST)										
Elect. tuning @ Vvar = 1–15 V	MHz, min.	N/A	N/A	N/A	10	12	20	20	25	25	25	25
Phase noise @ 10 kHz off (VT)	dBc/Hz, typ.	N/A	N/A	N/A	85	80	75	75	75	75	75	75
		HIGH POWER OPTION (HT-ST)										
Output power	dBm, min.	+17	+17	+17	+17	+17	+17	+17	+17	+17	+17	+17
Current	mA, max.	220	220	220	220	220	230	230	320	320	320	320
Frequency pulling (1.5:1 VSWR)	MHz, p-p max.	2	2	0.5	0.5	0.5	0.5	0.5	1	1	1	1
Outline drawing		1	1	2	3	5	5	5	5	5	5	5

Notes: 1. Output power is guaranteed into 50 ohm load.
2. Operating frequency must be specified.
3. Averaged over the full temperature range.
4. Alternate DC voltage available

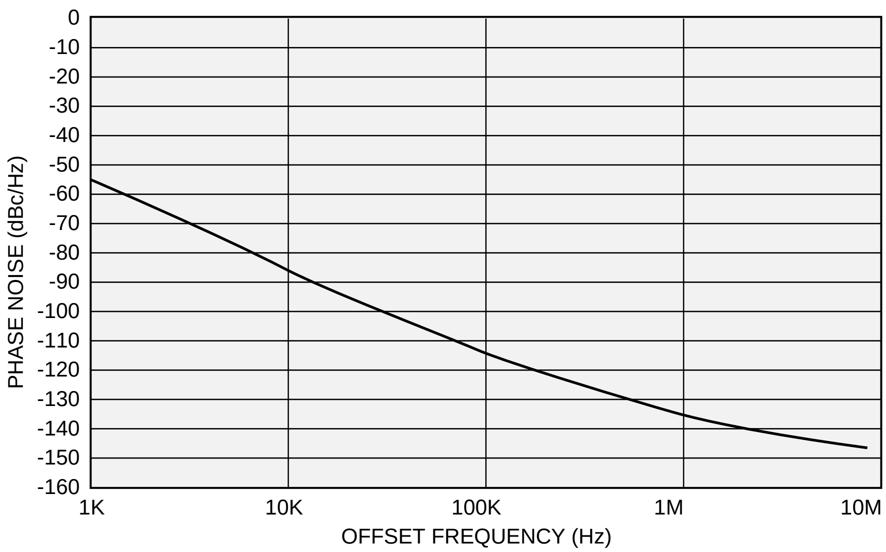
MITEQ also offers DRO's with enhanced specifications as special models (-SP).
For additional information please contact Ted Chiarenza at (631) 439-9511 or e-mail tchiarenza@miteq.com

DRO SERIES TYPICAL TEST DATA

TYPICAL VARACTOR TUNING CURVE
(F = 10 GHz)



TYPICAL PHASE NOISE CURVE
(F = 10 GHz)



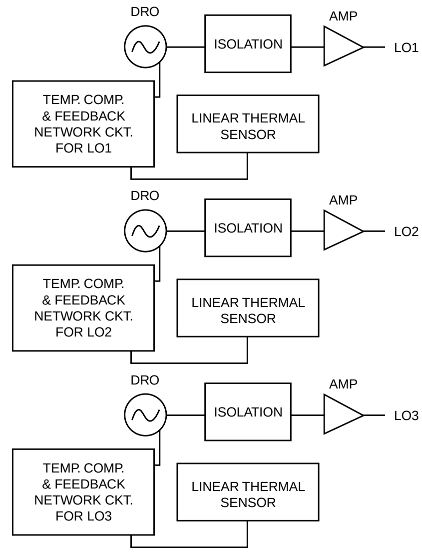
THREE OUTPUT TEMPERATURE COMPENSATED OSCILLATOR

FEATURES

- **Three oscillators in one package**
- **Ruggedized MIC construction (RF section)**
- **Military temperature operation**
- **Low profile package**
- **Field-replaceable SMA connectors**

APPLICATIONS

- **EW systems**
- **Radar systems**



MFO-242112-SP

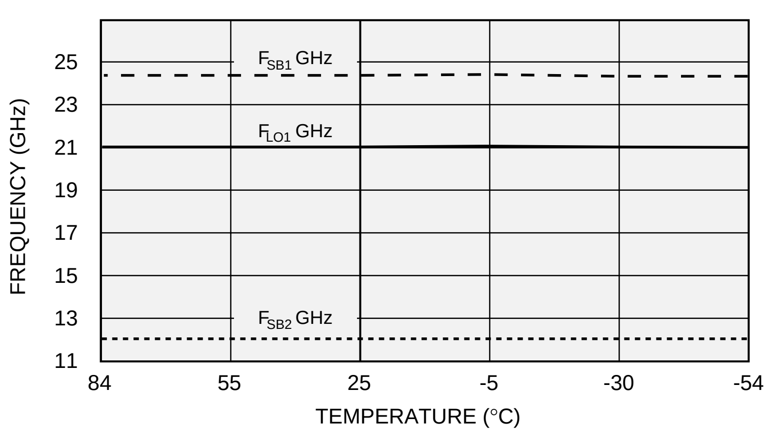
The latest multifunction oscillators, the MFO series subsystem, are three temperature-compensated DROs with frequency tracking to a mathematical algorithm. As shown in the block diagram, the triple oscillator subsystem consists of three DROs at three different frequencies in X- thru K-band that are temperature compensated and track frequency to the following equation:

$$F(t)_{LO3} - 2F(t)_{LO1} = \lambda^1 \pm 500\text{ kHz} \quad (1)$$
$$F(t)_{LO2} - 2F(t)_{LO1} = \lambda^2 \pm 500\text{ kHz} \quad (2)$$

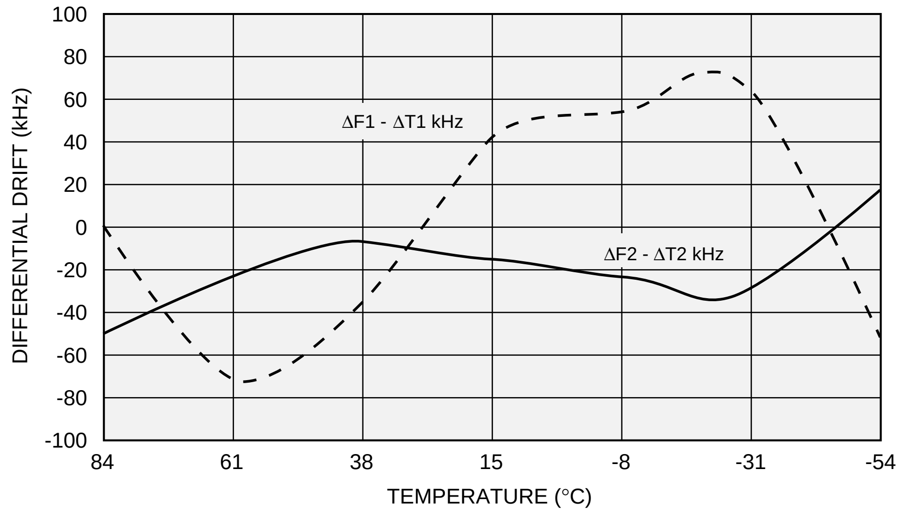
where
$F(t)_{LO1}$ = frequency of LO1 at temperature t
$F(t)_{LO2}$ = frequency of LO2 at temperature t
$F(t)_{LO3}$ = frequency of LO3 at temperature t
λ^1, λ^2 = constants.

A triple DRO unit was built with the three oscillators consisting of DROs operating at 12, 21 and 24 GHz. Their frequencies tracked per equation (1) and (2) below with the values of λ_1, λ_2 being 500 MHz and 3 GHz, respectively. The following are the performance test data and graph on this unit.

TYPICAL FREQUENCY VS. TEMPERATURE



TYPICAL DIFFERENTIAL DRIFT
MFO-242112-SP

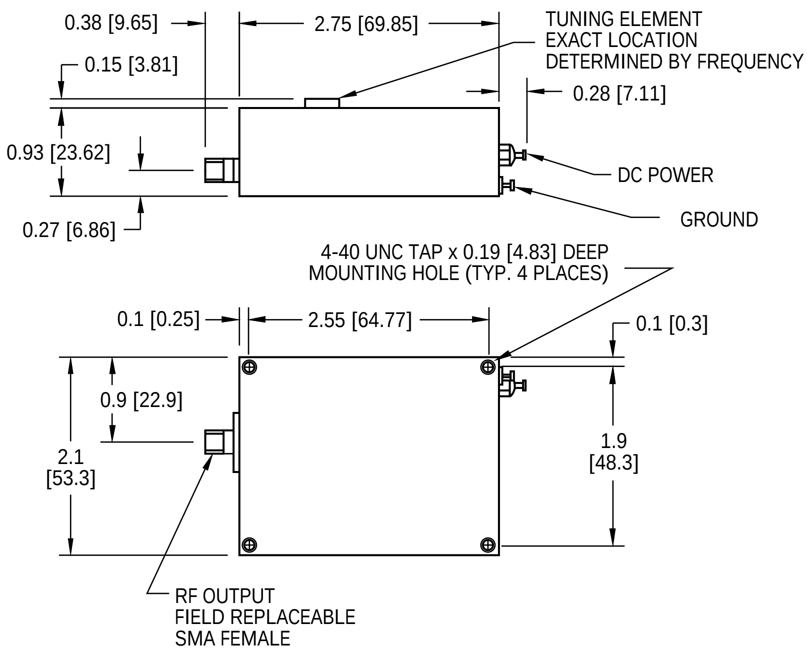


TRIPLE OSCILLATOR AND DIFFERENTIAL FREQUENCY VS. TEMPERATURE

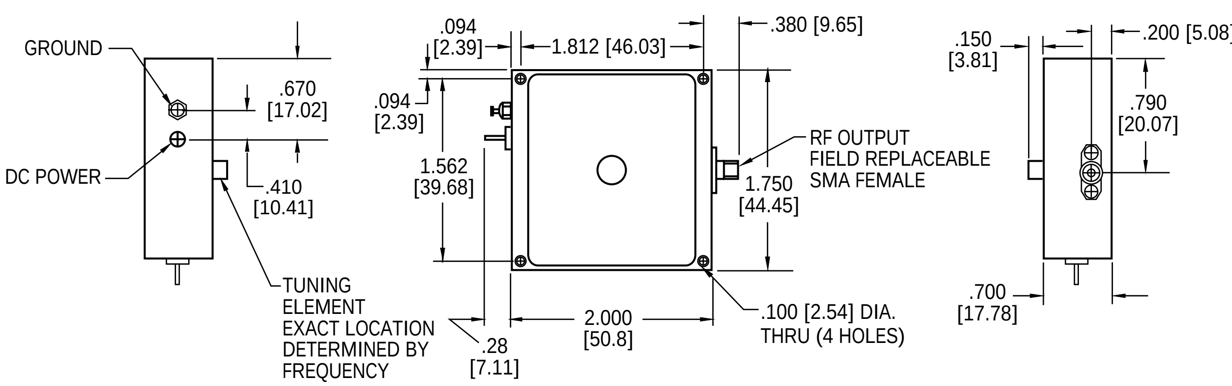
TEMPERATURE (°C)	F_{L01} (GHz)	F_{SB1} (GHz)	F_{SB2} (GHz)	$\Delta T1=[F_{SB1}-2(F_{L01})]$ (GHz)	$\Delta T2=[2(F_{L01})-F_{SB2}]$ (GHz)	Δ_{F1}-Δ_{T1} (kHz)	Δ_{F2}-Δ_{T2} (kHz)
84	12.0075	24.4993	21.0018	0.4844	3.0132	-50	-5
55	12.0073	24.4993	21.0022	0.4847	3.0124	-20	-80
25	12.0065	24.4979	20.9998	0.4849	3.0132	0	0
-5	12.0057	24.4960	20.9973	0.4846	3.0141	-30	90
-30	12.0047	24.4940	20.9955	0.4846	3.0139	-30	70
-54	12.0036	24.4921	20.9944	0.4850	3.0127	10	-50

OUTLINE DRAWINGS

OUTLINE 1

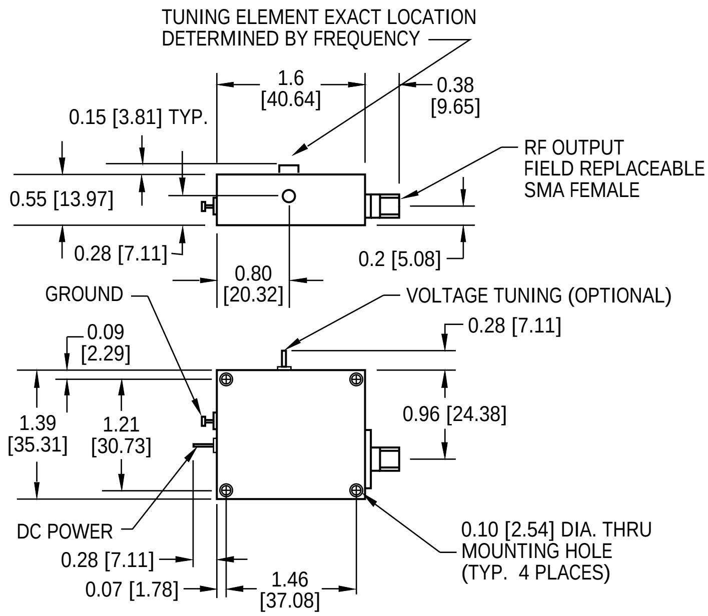


OUTLINE 2

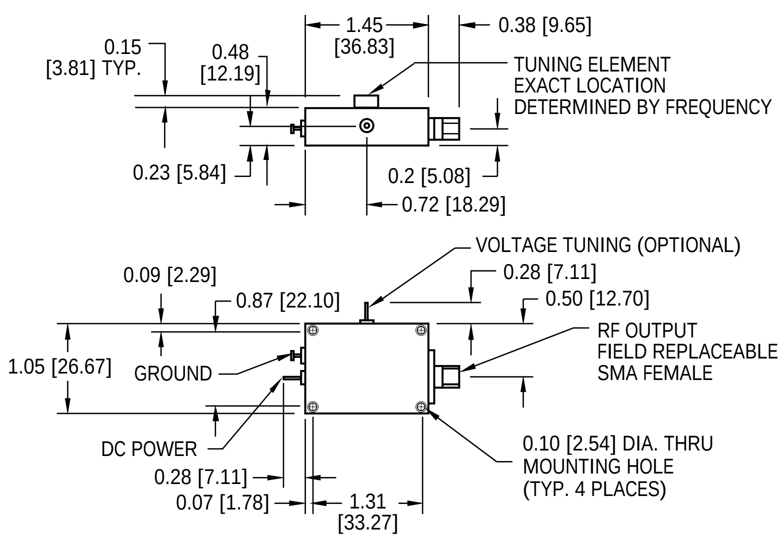


NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.

OUTLINE 3

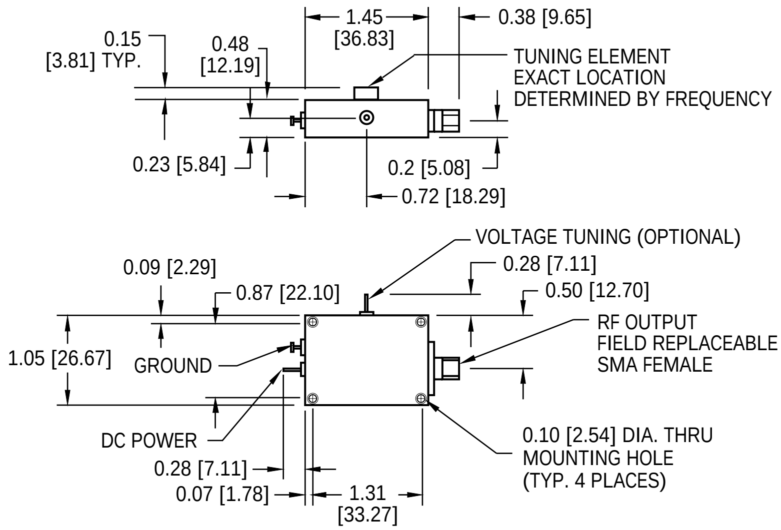


OUTLINE 4



OUTLINE DRAWINGS

OUTLINE 5



NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.

DIELECTRIC RESONATOR OSCILLATORS

TEL.: (631) 439-9511
FAX: (631) 439-9529
E-MAIL: tchiarenza@miteq.com

DATE________________

COMPANY ______________________ ADDRESS ______________________

CONTACT ______________________ ______________________

TEL. ______________________ ______________________

FAX ______________________ ______________________

E-MAIL: ______________________

For additional technical, price and delivery information, please copy, complete and mail or fax this form to (631) 436-7430, or call Dave Krautheimer at (631) 439-9413.

SPECIFICATION PARAMETER	REQUIREMENT 1	REQUIREMENT 2	REQUIREMENT 3
Series oscillator			
Operating frequency			
Output power			
Output power variation			
Harmonic			
Spurious			
Phase noise (offset from carrier)			
Frequency pulling (VSWR)			
Mechanical tuning			
Electrical tuning (tuning voltage)			
DC power			
Current			
Frequency drift temperature coefficient			
Operating temperature			
Quantity			

Special requirements please list below:

____

____

____

PLEASE SEND ADDITIONAL INFORMATION ON THE FOLLOWING PRODUCTS:

- ❑ Mixers
- ❑ Switches
- ❑ Amplifiers
- ❑ IF Signal Processing Components
- ❑ Integrated Assemblies
- ❑ Passive Power Components
- ❑ Fiber Optic Products
- ❑ SATCOM Products