



# DIELECTRIC RESONATOR OSCILLATORS



## DRO Series

- Mechanically Tuned
- Mechanically and Voltage Tuned

## TCDRO Series

- Temperature Compensated

## PLDRO Series

- Ultra-Low Phase Noise

## MFO Series

- Multifunction Subassemblies

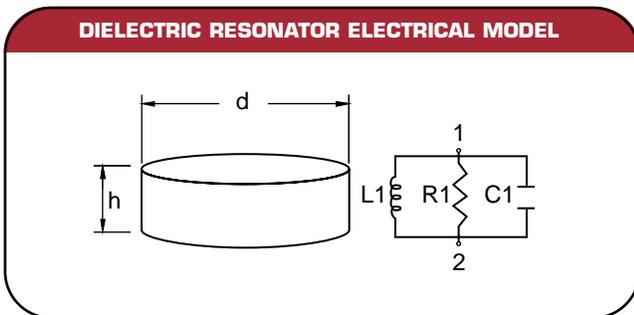
# INTRODUCTION TO DROs

## INTRODUCTION TO DROs

Dielectric Resonator Oscillators (DROs) are microwave oscillators that use a dielectric resonator (DR) as the frequency 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.

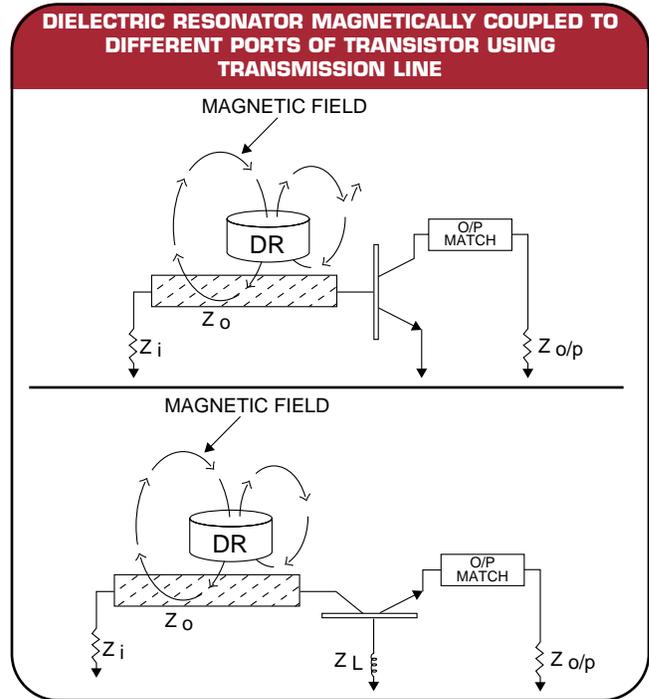


**FIGURE 1**

The Dielectric Resonator is made of a high dielectric constant ( $\epsilon = 30$  to  $80$ ) ceramic material, often barium titanate ( $\text{Ba}_2\text{Ti}_9\text{O}_{20}$ ). This material exhibits a high Q ( $9000 @ 10 \text{ GHz}$ ) and low temperature coefficient of frequency (TC to  $\pm 6 \text{ ppm}/^\circ\text{C}$  typical).

The cylindrical shape as shown in Figure 1 is the most popular. It has good separation between the desired  $\text{TE}_{\delta}(0,1)$  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.



**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  $4 \text{ ppm}/^\circ\text{C}$ ) and have better stability than free-running cavity oscillators, Gunn diode oscillators or VCOs.

## INTRODUCTION TO DROs (CONT.)

### 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 OSCILLATORS

## 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.



DRO-E-04000-ST

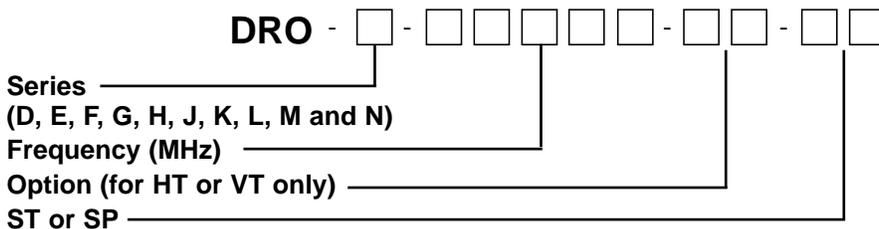
## ENVIRONMENTAL CONDITIONS

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% at 40°C, noncondensing
Shock (survival).....	30 g's, 10 ms pulse
Vibration (survival) .....	20 to 2000 Hz random to 4 g's rms

## ORDERING INFORMATION

### DRO SERIES



- 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

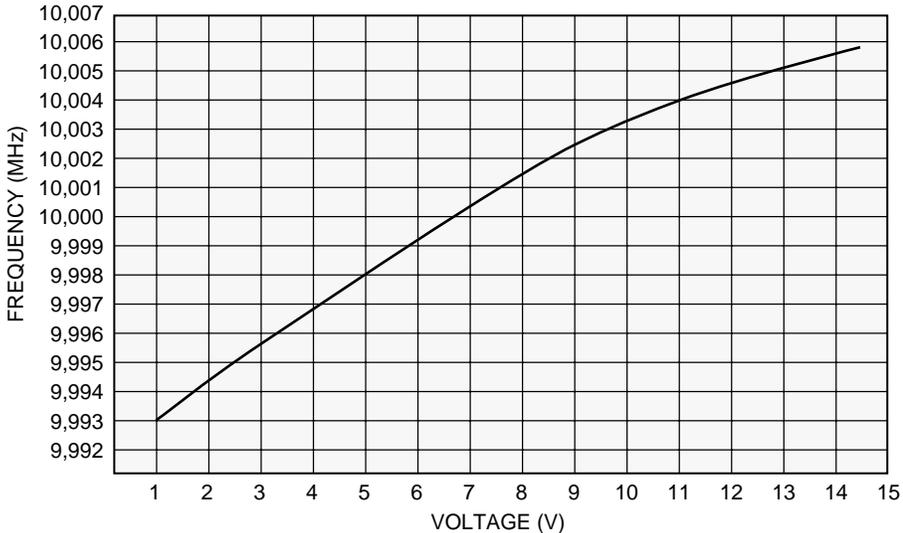
PARAMETERS	UNITS	SERIES - ST (STANDARD)										
		D	E	EF	F	G	H	J	K	L	M	N
Operating frequency range (2)	GHz	2.4–3.7	3.7–4.8	4.8–6.5	6.5–8.8	8.8–12	12–16	16–18	18–20	20–22	22–24	24–26
Output power (1)	dBm, min.	+13	+13	+13	+13	+13	+13	+11	+11	+11	+11	+11
Output power variation over temperature range	dB, max.	±2	±2	±2	±2	±2	±2	±2	±1.5	±1.5	±1.5	±1.5
Harmonics and fundamental	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										
<b>VOLTAGE TUNABLE OPTION (VT-ST)</b>												
Electrical 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 offset	dBc/Hz, typ.	N/A	N/A	N/A	85	80	75	75	75	75	75	75
<b>HIGH POWER OPTION (HT-ST)</b>												
Output power	dBm, min.	+17	+17	+17	+17	+17	+17	+17	+17 <sup>(5)</sup>	+17 <sup>(5)</sup>	+17 <sup>(5)</sup>	+17 <sup>(5)</sup>
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.  
 5. Additional negative bias is required. Output power without negative bias is +14 dBm.

MITEQ also offers DROs with enhanced specifications as special models (-SP).

# DRO SERIES TYPICAL TEST DATA

### TYPICAL TUNING CURVE (F = 10 GHz)



### TYPICAL PHASE NOISE CURVE (F = 10 GHz)



# TEMPERATURE-COMPENSATED DIELECTRIC RESONATOR OSCILLATORS

## TCDRO SERIES

### FEATURES

- Ultra-clean source ideal for low spur application
- High-reliability design
- Very low frequency drift over temperature
- Buffered output



**TCDRO-G-10664-SP**

### OPTIONS

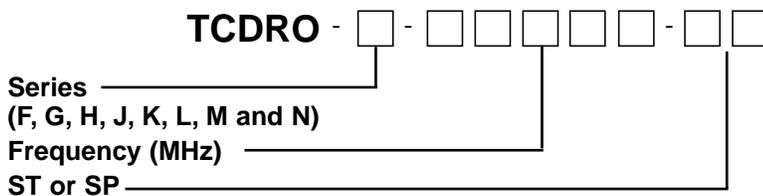
- **Special (-SP) (please contact factory before ordering)**  
Special is defined as a requirement with a specification(s) different than the standard catalog. For example, extended or narrowed temperature range, different output power, different DC power requirement, etc.

## ENVIRONMENTAL CONDITIONS

Operating temperature .....	-55 to +95°C
Storage temperature .....	-65 to +115°C
Humidity .....	95% at 40°C, noncondensing
Shock (survival).....	30 g's, 10 ms pulse
Vibration (survival) .....	20 to 2000 Hz random to 4 g's rms

## ORDERING INFORMATION

### TCDRO SERIES



ST: standard  
SP: special

Example 1: 6.5 GHz TCDRO standard: TCDRO-F-06500-ST.

Example 2: 12 GHz TCDRO with temperature range from -55 to +85°C: TCDRO-G-12000-SP.

## TEMPERATURE COMPENSATED DIELECTRIC RESONATOR OSCILLATORS

### ELECTRICAL SPECIFICATIONS

PARAMETERS	UNITS	SERIES - ST (STANDARD)							
		F	G	H	J	K	L	M	N
Operating frequency range (2)	GHz	6.5–8.8	8.8–12	12–16	16–18	18–20	20–22	22–24	24–26
Output power (1)	dBm, min.	+17	+17	+17	+17	+11	+11	+11	+11
Output power variation over temperature range	dB, max.	±1.5	±1.5	±1.5	±1.5	±1.5	±1.5	±1.5	±1.5
Harmonics and fundamental	dBc, min.	-20	-20	-20	-20	-20	-20	-20	-20
Spurious	dBc, min.	-80	-80	-80	-80	-80	-80	-80	-80
Mechanical tuning	MHz, min.	±10	±10	±10	±10	±10	±10	±10	±10
Frequency pushing	kHz/V, max.	15	15	20	25	30	30	30	30
Frequency pulling (1.5:1 VSWR)	MHz, p-p max.	.5	.5	.5	.5	1	1	1	1
Frequency drift temp. coefficient (3)	ppm/°C, max.	.9	.9	.9	.9	.9	.9	.9	.9
Phase noise @ 10 kHz offset	dBc/Hz, typ.	85	80	75	75	75	75	75	75
DC power requirements	Volts	15	15	15	15	15	15	15	15
Current	mA, max.	220	220	220	230	120	120	120	120
Outline drawing		6	7	7	7	7	7	7	7
Temperature range	°C	-20 to +70							

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

MITEQ also offers TCEROs with enhanced specifications as special models (-SP).

# ULTRA-LOW PHASE-LOCKED DIELECTRIC RESONATOR OSCILLATORS

## PLDRO SERIES

### FEATURES

- Ultra-low phase noise
- Reference from 5 to 200 MHz
- Internal reference available
- Small package
- Low power consumption



**PLDRO-13.050**

### ELECTRICAL SPECIFICATIONS

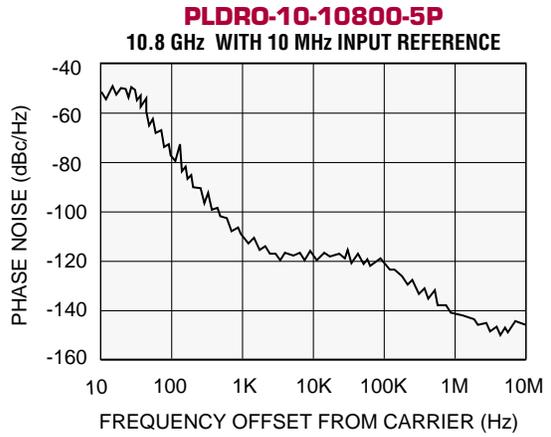
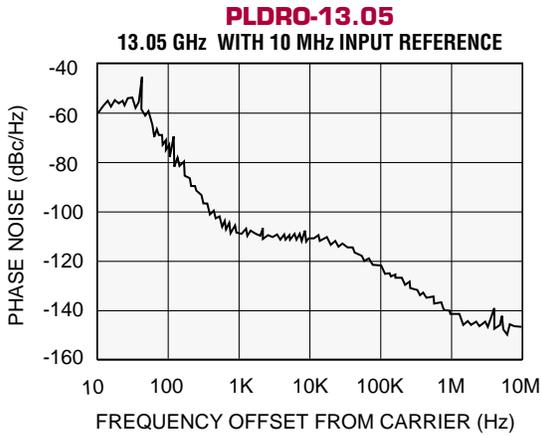
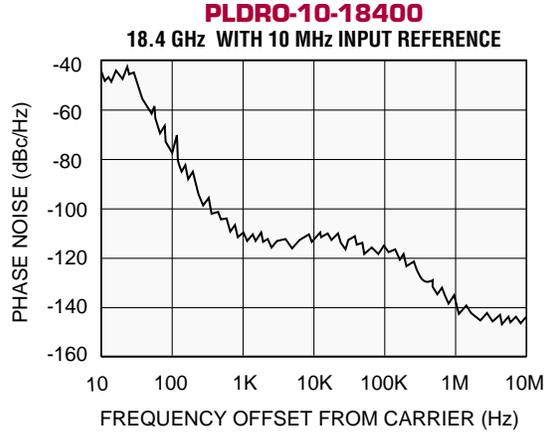
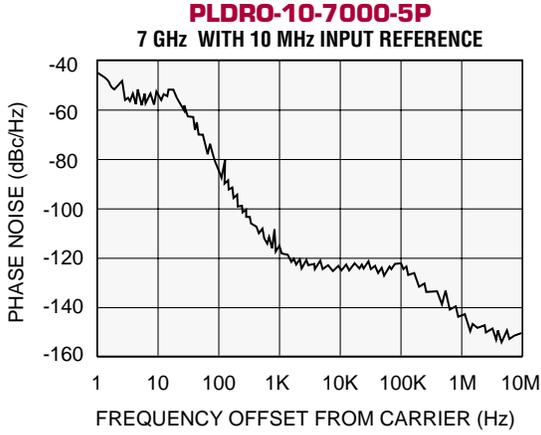
Output frequency range	
Subharmonic	1.75 – 7 GHz
Fundamental	7 – 13 GHz
Doubled	13 – 26 GHz
DC voltage	+5 VDC @ 300 mA
With doubler	450 mA
Output power	+13 dBm minimum
Output spurious	< -80 dBc typical
Output harmonics	≤ -20 dBc typical
Reference frequency	5 – 200 MHz (customer specified)*
Reference input power	0 ±3 dBm
Load VSWR	2:1
Connectors	
REF IN	SMA female
RF OUT	SMA female
DC power	Solder pin feedthru
Phase alarm	TTL “high” in-lock, “low” out-of-lock
Phase noise	See graphs
* Internal reference available.	

### ENVIRONMENTAL CONDITIONS

Operating temperature .....	-30 to +80°C
Storage temperature .....	-50 to +100°C
Humidity .....	95% at 40°C, noncondensing
Shock (survival).....	30 g's, 10 ms pulse
Vibration (survival) .....	20 to 2000 Hz random to 4 g's rms
Weight .....	125 grams

# ULTRA-LOW PHASE-LOCKED DIELECTRIC RESONATOR OSCILLATORS

## TYPICAL TEST DATA



## ORDERING INFORMATION

External Reference Option:

**PLDRO** -    -      -

External Reference Frequency (MHz)      Output Frequency (MHz)      D.C. Supply (+volts)

Internal Reference Option:

**PLDRO-I** -      -

Output Frequency (MHz)      D.C. Supply (+volts)

# MULTIFUNCTION DRO SUBASSEMBLIES

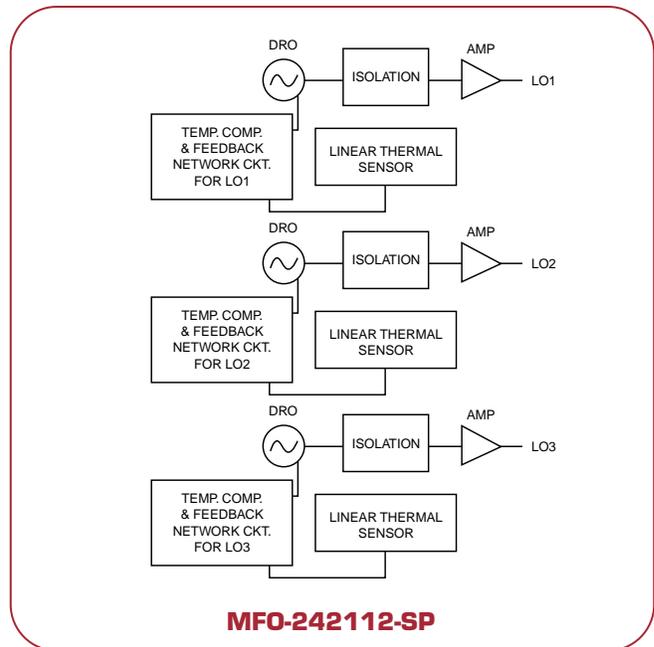
## THREE OUTPUT TEMPERATURE-COMPENSATED OSCILLATOR

### 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



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:

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

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

where

$F(t)_{LO1}$  = frequency of LO1 at temperature t

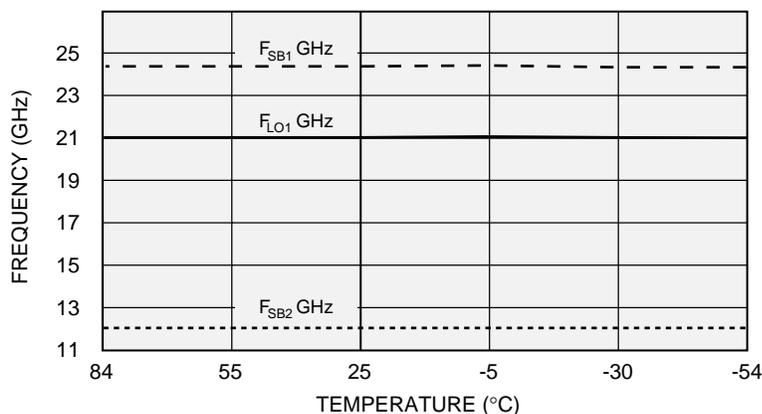
$F(t)_{LO2}$  = frequency of LO2 at temperature t

$F(t)_{LO3}$  = frequency of LO3 at temperature t

$\lambda^1, \lambda^2$  = constants.

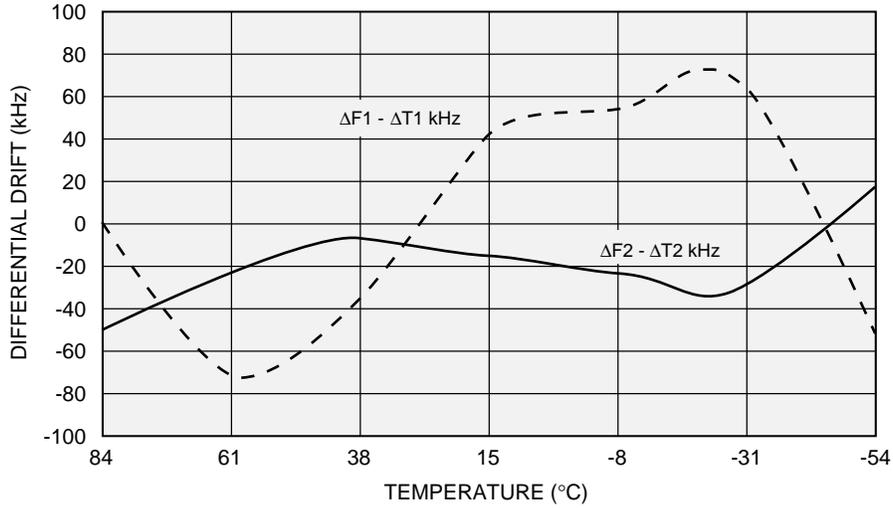
A triple DRO unit was built with the three oscillators consisting of DROs operating at 12, 21 and 24 GHz. Their frequencies tracked per equation (1) and (2) below with the values of  $\lambda_1, \lambda_2$  being 500 MHz and 3 GHz, respectively. The following are the performance test data and graph on this unit.

**TYPICAL  
FREQUENCY VS. TEMPERATURE**



# MULTIFUNCTION DRO SUBASSEMBLIES

## TYPICAL DIFFERENTIAL DRIFT MFO-242112-SP

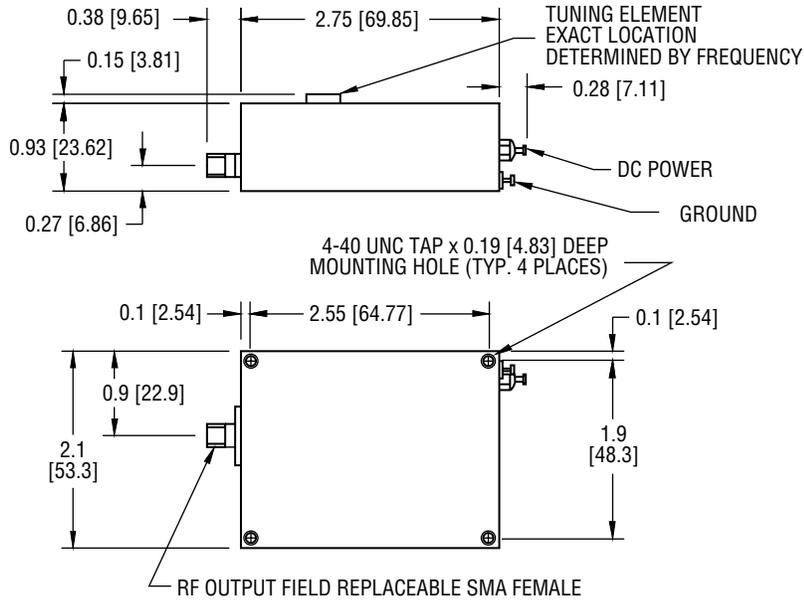


## TRIPLE OSCILLATOR AND DIFFERENTIAL FREQUENCY VS. TEMPERATURE

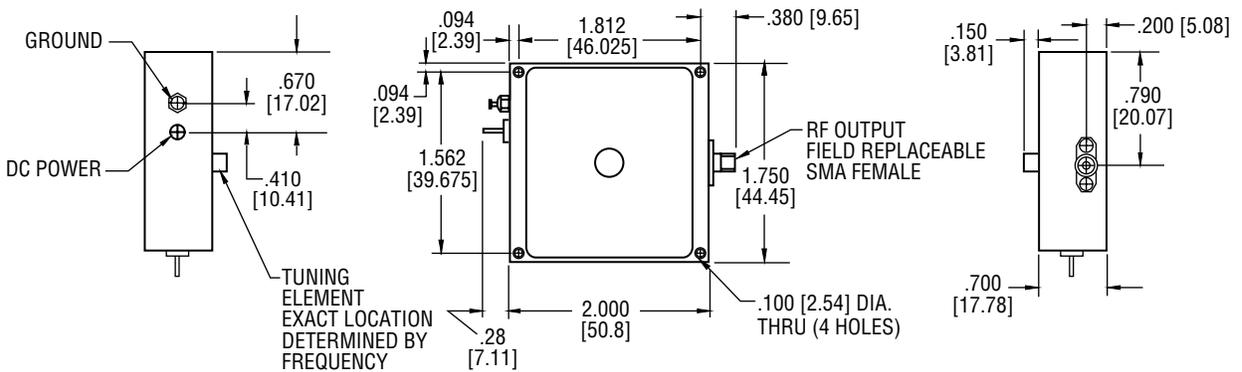
TEMPERATURE (°C)	$F_{L01}$ (GHz)	$F_{SB1}$ (GHz)	$F_{SB2}$ (GHz)	$\Delta T1 = [F_{SB1} - 2(F_{L01})]$ (GHz)	$\Delta T2 = [2(F_{L01}) - F_{SB2}]$ (GHz)	$\Delta F1 - \Delta T1$ (kHz)	$\Delta F2 - \Delta T2$ (kHz)
84	12.0075	24.4993	21.0018	0.4844	3.0132	-50	-5
55	12.0073	24.4993	21.0022	0.4847	3.0124	-20	-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



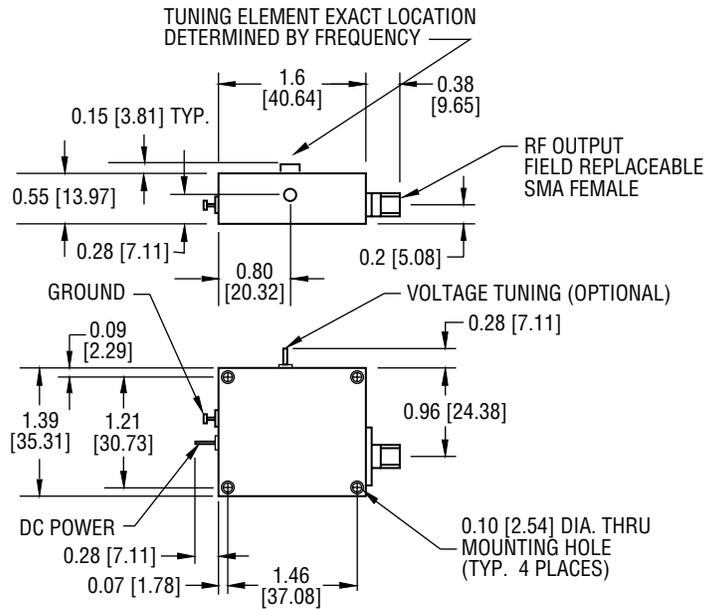
## OUTLINE 2



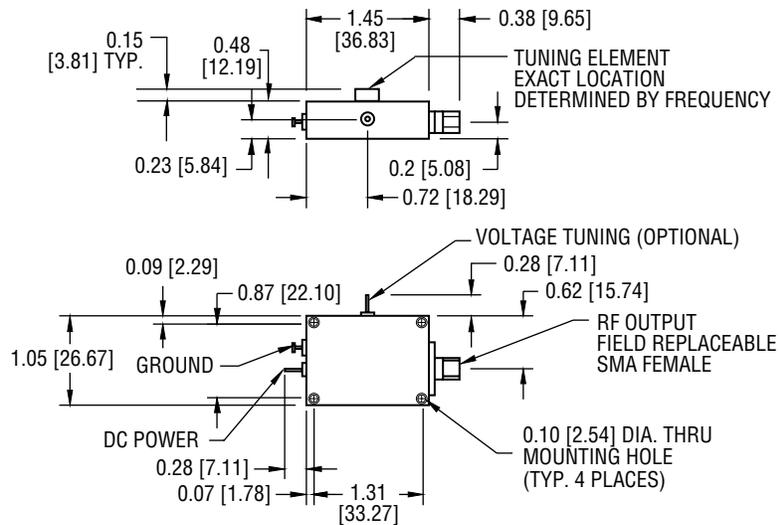
NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.

# OUTLINE DRAWINGS (CONT.)

## OUTLINE 3



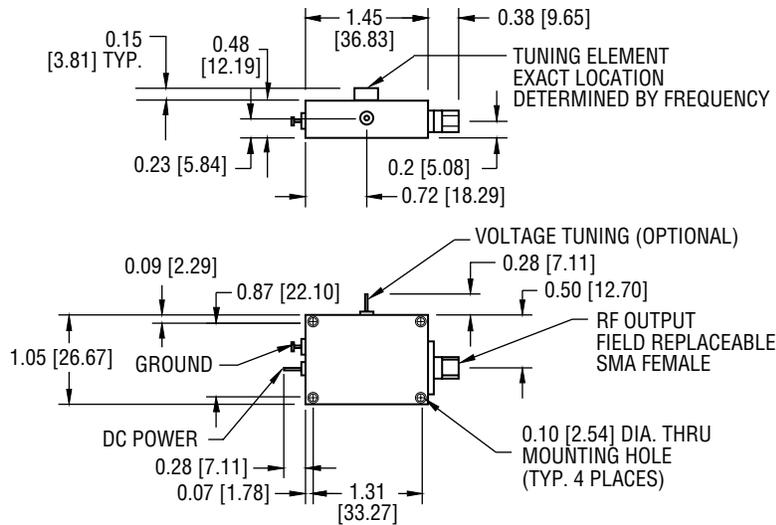
## OUTLINE 4



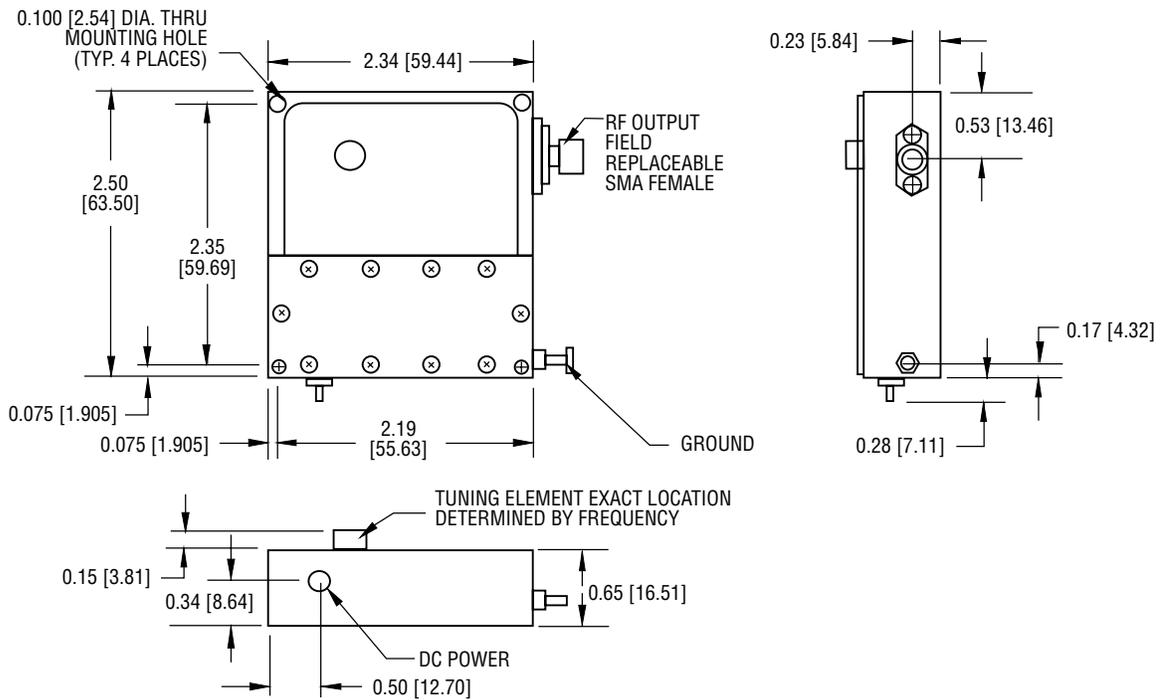
NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.

# OUTLINE DRAWINGS (CONT.)

## OUTLINE 5



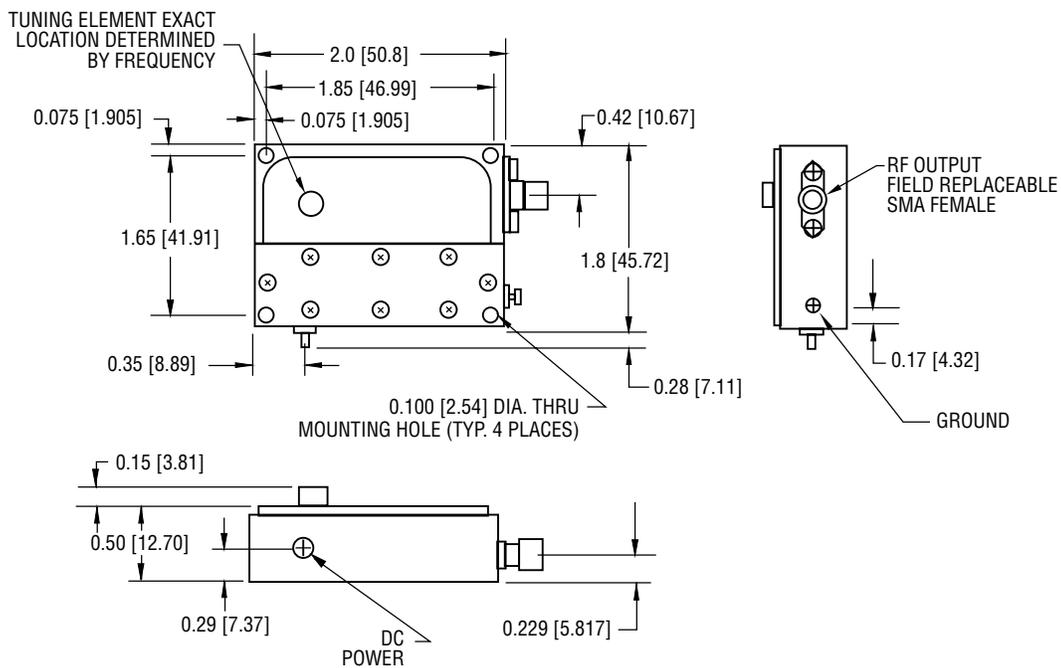
## OUTLINE 6



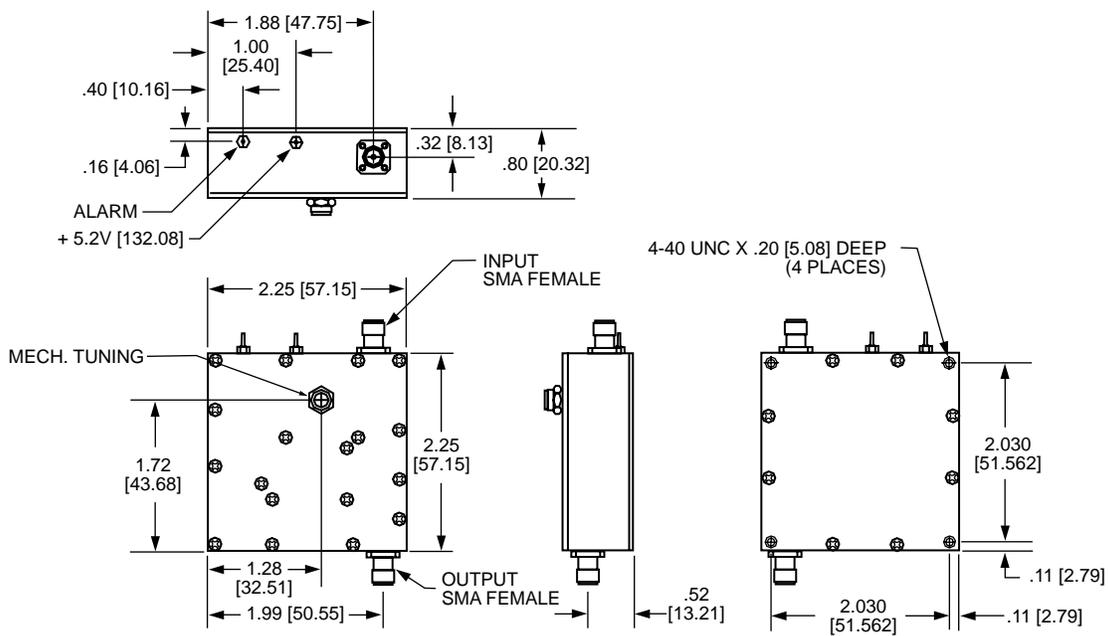
NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.

# OUTLINE DRAWINGS (CONT.)

## OUTLINE 7



## OUTLINE 8



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



**DIELECTRIC RESONATOR  
OSCILLATORS**

TEL.: (631) 439-9172  
 FAX: (631) 436-7431  
 E-MAIL: aannarumma@miteq.com

DATE \_\_\_\_\_

**COMPANY** \_\_\_\_\_

**ADDRESS** \_\_\_\_\_

**CONTACT** \_\_\_\_\_

**TEL.** \_\_\_\_\_

**FAX** \_\_\_\_\_

**E-MAIL:** \_\_\_\_\_

For additional information, please complete and fax this form to (631) 436-7431.

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:**

- |  |   |
|--|---|
| <input type="checkbox"/> Mixers                          | <input type="checkbox"/> Integrated Assemblies    |
| <input type="checkbox"/> Switches                        | <input type="checkbox"/> Passive Power Components |
| <input type="checkbox"/> Amplifiers                      | <input type="checkbox"/> Fiber Optic Products     |
| <input type="checkbox"/> IF Signal Processing Components | <input type="checkbox"/> SATCOM Products          |



100 Davids Drive, Hauppauge, NY 11788  
 TEL.: (631) 436-7400 • FAX: (631) 436-7431  
 www.miteq.com

## ISO 9001:2000 CERTIFIED

MITEQ attained its original ISO 9001 registration in June 1993, when fewer than 1500 companies were registered. ISO 9001 has since become a recognized standard for quality in over 90 countries. Nationally, it is accepted by an ever-increasing number of government agencies in place of longstanding military specifications covering quality and inspection criteria. Among those are MIL-Q-9858 and MIL-I-45208.



MITEQ's quality system is certified to ISO 9001 by **National Quality Assurance USA (NQA)**, an accredited registrar of the **American National Standards Institute - Registration Accreditation Board (ANSI-RAB)**. NQA performs a quality audit at MITEQ every six months to assure continued compliance to the standard. Additionally, MITEQ's internal auditing system, coupled with regular management reviews, assures that the quality system is effective, updated and constantly improved.

## ORDERING INFORMATION

### PRICING AND TERMS

A quotation on any item in the catalog is available by contacting the factory. All quotations, unless otherwise noted, are valid for 60 days from the date of issue, F.O.B. (FCA) Hauppauge, NY 11788. Pricing does not include customer or government source inspection unless otherwise noted. On international orders, an irrevocable letter of credit may be required. MITEQ accepts these credit cards:



### QUANTITY DISCOUNTS

A quantity discount is generally available on most catalog items. Due to the wide variety of devices in the catalog, it is not possible to provide a standard discount schedule. When quantities are involved, please contact the factory and the appropriate information will be provided.

### SHIPPING INFORMATION

Unless instructed otherwise by the customer, we will ship UPS in the U.S. F.O.B. (FCA) Hauppauge. Air freight will be used as the primary international means of shipment. Please indicate at time of purchase what method of shipment you require.

### DRAWINGS AND SPECIFICATIONS

Material presented in this catalog is current at the time of printing. Mechanical and electrical requirements are subject to change. If either of these parameters is critical, please contact the factory to verify that the information is current.

### APPLICATION ENGINEERING

We maintain a large support staff of engineers who are experts in specific areas of microwave technology. Each has an engineering background that combines both a formal engineering education with training and experience in product design. As further technical support, we make available the services of our engineering and scientific staff, who may be consulted on more advanced circuit designs or application problems.

### RETURNED MATERIAL

For all items requiring service, regardless of warranty status, MITEQ's Customer Service department should be contacted for a Return Material Authorization (RMA) number. This can be done by either visiting our website ([www.miteq.com](http://www.miteq.com)) and requesting an RMA number online or by calling (631) 439-9300. When requesting an RMA number either over the internet or by phone, you will need to provide the model number, serial number and as much information as possible about the nature of your difficulty. All returns must arrive freight, postage, duties and handling prepaid.

### SOURCE INSPECTION

Government / customer source inspection is available on any item upon receipt of the complete written confirmation of purchase order items, including the prime government contract number. Source inspection with respect to some products increases the unit price and extends delivery because of duplicate standard final inspection and testing. It is recommended wherever possible that a Certificate of Compliance be substituted for source inspection to minimize price and delivery delays.

### REPAIR COSTS

Warranty repairs will be made at no cost to the customer. Units out of warranty, or those which have been mishandled, will require approval by the customer for the charges involved before the repairs can be accomplished. We will provide an estimate for the cost of the repair, which can be applied to the repair, if approval is granted. For those items that are deemed beyond repair, or where the customer may decide not to repair the unit, a handling charge will be applicable.

# DIELECTRIC RESONATOR OSCILLATORS

## ADDITIONAL FREQUENCY GENERATION PRODUCTS

### FREE-RUNNING AND PHASE-LOCKED VOLTAGE-CONTROLLED OSCILLATORS

- Cavity and Coaxial Resonator Designs
  - Fundamental to 3.2 GHz
  - Multiplied to 40 GHz
- Crystal Oscillators to 195 MHz, Single or Multiple Crystal, Moderate to High Stability
- Cavity-Tuned to 6 GHz
- Coaxial Resonator to 3.2 GHz
- Octave Band L-C VCOs

### FREQUENCY SYNTHESIZERS

- Phase-Locked Loop, Communication Band Synthesizers
- Single-Loop Fast Acquisition Synthesizers

### FREQUENCY MULTIPLIERS

- Broadband Active and Passive Multipliers
- Doublers, Triplers and Higher-Order Custom Designs to 50 GHz



100 Davids Drive, Hauppauge, NY 11788  
TEL.: (631) 436-7400 • FAX: (631) 436-7431  
[www.miteq.com](http://www.miteq.com)