FREE-RUNNING DIELECTRIC RESONATOR OSCILLATOR SECTION
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.

The Dielectric Resonator is made of a high dielectric constant ($\varepsilon = 30$ to 80) ceramic material, often barium titanate ($\text{Ba}_2\text{Ti}_3\text{O}_{10}$). 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 $\text{TE}_{01}$ 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.

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 have 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

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 50.
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 (-HP-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.

ELECTRICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>UNITS</th>
<th>SERIES - ST (STANDARD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating frequency range (Note 2)</td>
<td>GHz</td>
<td>D</td>
</tr>
<tr>
<td>Output power (Note 1)</td>
<td>dBm, min.</td>
<td>+13</td>
</tr>
<tr>
<td>Output power variation over temperature range</td>
<td>dB, max.</td>
<td>±2</td>
</tr>
<tr>
<td>Fundamental</td>
<td>dBc, max.</td>
<td>N/A</td>
</tr>
<tr>
<td>Harmonics</td>
<td>dBc, max.</td>
<td>-20</td>
</tr>
<tr>
<td>Spurious</td>
<td>dBc, max.</td>
<td>-80</td>
</tr>
<tr>
<td>Mechanical tuning</td>
<td>MHz, min.</td>
<td>±3</td>
</tr>
<tr>
<td>Frequency pushing</td>
<td>kHz/V, max.</td>
<td>10</td>
</tr>
<tr>
<td>Frequency pulling (1.5:1 VSWR)</td>
<td>MHz, P-P max.</td>
<td>2</td>
</tr>
<tr>
<td>Frequency drift temp. coefficient (Note 3)</td>
<td>ppm/°C, max.</td>
<td>5</td>
</tr>
<tr>
<td>Phase noise @ 10 kHz offset</td>
<td>dBC/Hz, typ.</td>
<td>105</td>
</tr>
<tr>
<td>DC power</td>
<td>Volts (Note 4)</td>
<td>15</td>
</tr>
<tr>
<td>Current</td>
<td>mA, max.</td>
<td>150</td>
</tr>
<tr>
<td>Outline drawing</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Temperature range</td>
<td>°C</td>
<td>-20 to +70</td>
</tr>
</tbody>
</table>
MECHANICALLY-TUNED DIELECTRIC RESONATOR OSCILLATOR

ELECTRICAL SPECIFICATIONS (CONT.)

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>UNITS</th>
<th>SERIES - ST (STANDARD)</th>
<th>VOLTAGE TUNABLE OPTION (VT-ST)</th>
<th>HIGH POWER OPTION (HP-ST)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>E</td>
<td>EF</td>
</tr>
<tr>
<td>Electrical tuning @ Vvar = 1–15 V</td>
<td>MHz, min.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Phase noise @ 10 kHz offset</td>
<td>dBC/Hz, typ.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Output power</td>
<td>dBM, min.</td>
<td>+17</td>
<td>+17</td>
<td>+17</td>
</tr>
<tr>
<td>Current</td>
<td>mA, max.</td>
<td>220</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>Frequency pulling (1.5:1 VSWR)</td>
<td>MHz, P-P max.</td>
<td>2</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Outline drawing</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

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

TYPICAL TUNING CURVE (F = 10 GHz)

TYPICAL PHASE NOISE CURVE (F = 10 GHz)
MECHANICALLY-TUNED DIELECTRIC RESONATOR OSCILLATORS

ORDERING INFORMATION

DRO - ______ - ______ - ______ - ______

Series
D, E, EF, F, G, H
J, K, L, M or N

Frequency MHz

Type
Standard (ST)
Voltage Tunable Standard (VT-ST)
High Power Standard (HP-ST)
Special Requirement (SP)

Note: When specifying type, include applicable detailed information.

Example 1: 12 GHz DRO standard: DRO-G-12000-ST.
Example 2: 4.5 GHz DRO with +17 dBm power: DRO-E-04500-HP-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.

MECHANICAL SPECIFICATIONS

Size per outline number
1 ........................................ 2.1\" x 2.75\" x 1.08\"
2 ........................................ 1.75\" x 2\" x 0.85\"
3 ........................................ 1.39\" x 1.6\" x 0.7\"
4 ........................................ 1.05\" x 1.45\" x 0.63\"
5 ........................................ 1.05\" x 1.45\" x 0.63\"

Weight ......................... Frequency dependent, please consult MITEQ where critical

RF connectors............... SMA female
DC connectors .............. Feedthru filter

ENVIRONMENTAL SPECIFICATIONS

MITEQ's standard dielectric resonator oscillators have been designed to meet the below maximum environmental conditions (for standard specification, see pages 49 and 50).

Temperature
Operating ....................... -55 to +95°C
Storage ......................... -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

OUTLINE DRAWINGS

OUTLINE 1

TUNING ELEMENT
EXACT LOCATION
DETERMINED BY FREQUENCY

0.28 [7.11]

4-40 UNC TAP x 0.19 [4.83] DEEP
MOUNTING HOLE (TYP. 4 PLACES)

0.38 [9.65]

0.15 [3.81]

0.93 [23.62]

0.27 [6.86]

0.1 [2.54]

2.1 [53.3]

0.9 [22.9]

2.55 [64.77]

1.9 [48.3]

0.1 [2.54]

DC POWER
GROUND

RF OUTPUT FIELD REPLACEABLE SMA FEMALE

NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.
OUTLINE 2

OUTLINE 3

NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.
NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.
This page is intentionally blank
TCDRO SERIES

FEATURES

- Ultra-clean source ideal for low spur application
- High-reliability design
- Very low frequency drift over temperature
- Buffered output
- 100% burn-in

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.

ELECTRICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>UNITS</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating frequency range (Note 2)</td>
<td>GHz</td>
<td>6.5–8.8</td>
<td>8.8–12</td>
<td>12–16</td>
<td>16–18</td>
<td>18–20</td>
<td>20–22</td>
<td>22–24</td>
<td>24–26</td>
</tr>
<tr>
<td>Output power (Note 1)</td>
<td>dBm, min.</td>
<td>+17</td>
<td>+17</td>
<td>+17</td>
<td>+17</td>
<td>+11</td>
<td>+11</td>
<td>+11</td>
<td>+11</td>
</tr>
<tr>
<td>Output power variation over temperature range</td>
<td>dB, max.</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
<td>±1.5</td>
</tr>
<tr>
<td>Harmonics and fundamental</td>
<td>dBC, min.</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
<td>-20</td>
</tr>
<tr>
<td>Spurious</td>
<td>dBC, min.</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
<td>-80</td>
</tr>
<tr>
<td>Mechanical tuning</td>
<td>MHz, min.</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
<td>±10</td>
</tr>
<tr>
<td>Frequency pushing</td>
<td>kHz/V, max.</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Frequency pulling (1.5:1 VSWR)</td>
<td>MHz, P-P max.</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Frequency drift temp. coefficient (Note 3)</td>
<td>ppm/°C, max.</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Phase noise @ 10 kHz offset</td>
<td>dBC/Hz, typ.</td>
<td>85</td>
<td>80</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>DC power requirements</td>
<td>Volts</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Current</td>
<td>mA, max.</td>
<td>220</td>
<td>220</td>
<td>220</td>
<td>230</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Outline drawing</td>
<td></td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Temperature range</td>
<td>°C</td>
<td>-20 to +70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 TCDROs with enhanced specifications as special models (-SP).
TEMPERATURE COMPENSATED DIELECTRIC RESONATOR OSCILLATOR

ORDERING INFORMATION

TCDRO -

Series
F, G, H, J, K, L, M or N

Frequency MHz

Type
Standard (ST)
Special Requirements (SP)

Note: When specifying options, include applicable detailed information.

Example 1: 6.5 GHz TCDRO standard: TCDRO-F-06500-ST.
Example 2: 12 GHz TCDRO with any specification different than listed in catalog: TCDRO-G-12000-SP, please contact MITEQ.

ENVIRONMENTAL SPECIFICATIONS

MITEQ’s standard dielectric resonator oscillators have been designed to meet the below maximum environmental conditions (for standard specification, see pages 49 and 50).

Temperature
Operating ....................... -55 to +95°C
Storage .......................... -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

MECHANICAL SPECIFICATIONS

Outline drawings
Size:
Outline 6..................... 2.5” x 2.34” x 0.8”
Outline 7..................... 1.8” x 2” x 0.65”

Weight................................... Frequency dependent, please consult MITEQ where critical

RF connectors ...................... SMA female
DC connectors ...................... Feedthru filter

OUTLINE DRAWINGS

OUTLINE 6

OUTLINE 7

NOTE: DIMENSIONS SHOWN IN BRACKETS [ ] ARE IN MILLIMETERS.
ETCO SERIES:
0.10–4 GHz (FUNDAMENTAL)
4–24 GHz (MULTIPLIED)

FEATURES
• Flexible design for customer requirements
• Electronically tuned for low noise source
• Up to octave band tuning (to 4 GHz)
• High Q resonator (narrow band units)
• Internal regulation for improved phase noise
• Small package
• 100% temperature testing
• Three-year warranty

ELECTRICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output frequency range coverage (in bands)</td>
<td>0.10 – 24 GHz</td>
</tr>
<tr>
<td>Output power</td>
<td>+13 dBm minimum</td>
</tr>
<tr>
<td>Output harmonic</td>
<td>-20 dBc maximum</td>
</tr>
<tr>
<td>Output spurious and subharmonics</td>
<td>-50 dBc maximum (-25 dBc subs &gt; 12 GHz)</td>
</tr>
<tr>
<td>Phase noise</td>
<td>See graph</td>
</tr>
<tr>
<td>Input tuning voltage (tuning bandwidth related)</td>
<td>0–15 V maximum</td>
</tr>
<tr>
<td>Input tuning (modulation) bandwidth</td>
<td>up to 10 MHz maximum</td>
</tr>
<tr>
<td>Load VSWR</td>
<td>1.5:1</td>
</tr>
<tr>
<td>DC power (typical)</td>
<td></td>
</tr>
<tr>
<td>Fundamental (to 4 GHz)</td>
<td>+12 to +15 V @ 200 mA</td>
</tr>
<tr>
<td>Multiplied (4–12 GHz)</td>
<td>+12 to +15 V @ 300 mA</td>
</tr>
<tr>
<td>Multiplied (12–24 GHz)</td>
<td>+12 to +15 V @ 400 mA</td>
</tr>
</tbody>
</table>

Note: Nonstandard tuning requirements available, please contact MITEQ.

TYPICAL PHASE NOISE

-60  -70  -80  -90  -100  -110  -120  -130  -140  -150

-160 -150 -140 -130 -120 -110 -100 -90 -80 -70

FREQUENCY OFFSET (Hz)

1K 10K 100K 1M 10M

1000 MHz (OCTAVE BAND)
200 MHz (NARROW BAND)
2000 MHz (OCTAVE BAND)
ELECTRICALLY TUNED COAXIAL OSCILLATOR

ORDERING INFORMATION

ETCO - [Series] - [Start Frequency MHz] - [Stop Frequency MHz] - [Positive D.C. Supply Voltage (12 – 15)]

Example: Part Number ETCO-1000-10500-12P Electrical Tuned Coaxial Oscillator tunes from 10 GHz to 10.5 GHz with +12 volt supply.

MECHANICAL SPECIFICATIONS
Outline drawing ..................... 166335
Size ................................. 2.25" X 2.25" X 0.6"
Weight ........................... 100 grams
RF connectors .............. SMA female
Voltage input .................. Filtercon
Tuning input.................. Filtered or non
(Customer specify)

ENVIRONMENTAL SPECIFICATIONS
Temperature
Operating ..................... -10 to +60°C
Storage ...................... -40 to +85°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

Note: Extended temperature ranges available, please contact MITEQ.

166335
ETCO SERIES

OUTLINE DRAWING

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