FEATURES

- Dual output frequency range
  - \( f_{\text{out}} = 12.17 \text{ GHz} \) to 13.330 GHz
  - \( f_{\text{out}/2} = 6.085 \text{ GHz} \) to 6.665 GHz
- Output power \( (P_{\text{out}}) \): 10.5 dBm
- Single-sideband (SSB) phase noise: \(-113 \text{ dBc/Hz} \) at 100 kHz
- No external resonator needed
- RoHS-compliant, 5 mm \( \times \) 5 mm, 32-lead LFCSP: 25 mm

APPLICATIONS

- Point to point and multipoint radios
- Test equipment and industrial controls
- Very small aperture terminals (VSATs)

GENERAL DESCRIPTION

The HMC1167 is a monolithic microwave integrated circuit (MMIC) voltage controlled oscillator (VCO) that integrates a resonator, a negative resistance device, and a varactor diode, and features a half frequency output.

Because of the monolithic construction of the oscillator, the output power and phase noise performance are excellent over temperature.

The output power is 10.5 dBm typical from a 5 V supply voltage. The VCO is housed in a RoHS-compliant LFCSP and requires no external matching components.

![Functional Block Diagram](image-url)
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## REVISION HISTORY

1/16—Revision 0: Initial Version
## SPECIFICATIONS

$T_A = -40^\circ C$ to $+85^\circ C$, $V_{cc} = 5 \, V$, unless otherwise noted.

### Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Frequency ($f_{out}$)</td>
<td>12.17</td>
<td>13.33</td>
<td>GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half Output Frequency ($f_{out}/2$)</td>
<td>6.085</td>
<td>6.665</td>
<td>GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift Rate</td>
<td>1.2</td>
<td>MHz/°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulling</td>
<td>2</td>
<td>MHz p-p</td>
<td></td>
<td></td>
<td>Pulling into a 2.0:1 voltage standing wave ratio (VSWR)</td>
</tr>
<tr>
<td>Pushing</td>
<td>2</td>
<td>MHz/V</td>
<td></td>
<td></td>
<td>At $VTUNE = 5 , V$</td>
</tr>
<tr>
<td>OUTPUT POWER ($P_{out}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$RF_{OUT}$</td>
<td>7</td>
<td>10.5</td>
<td>15</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>$RF_{OUT}/2$</td>
<td>−1</td>
<td>+4</td>
<td>+8</td>
<td>dBm</td>
<td></td>
</tr>
<tr>
<td>Supply Current ($I_{cc}$)</td>
<td>175</td>
<td>200</td>
<td>250</td>
<td>mA</td>
<td>$V_{cc} = 4.75 , V$</td>
</tr>
<tr>
<td></td>
<td>220</td>
<td></td>
<td></td>
<td>mA</td>
<td>$V_{cc} = 5.00 , V$</td>
</tr>
<tr>
<td>HARMONICS, SUBHARMONICS</td>
<td></td>
<td></td>
<td></td>
<td>dBc</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>39</td>
<td></td>
<td></td>
<td>dBc</td>
<td></td>
</tr>
<tr>
<td>3/2</td>
<td>31</td>
<td></td>
<td></td>
<td>dBc</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>20</td>
<td></td>
<td></td>
<td>dBc</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>26</td>
<td></td>
<td></td>
<td>dBc</td>
<td></td>
</tr>
<tr>
<td>TUNING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage ($VTUNE$)</td>
<td>2</td>
<td>13</td>
<td></td>
<td>V</td>
<td>$VTUNE = 13 , V$</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>75</td>
<td>350</td>
<td></td>
<td>MHz/V</td>
<td></td>
</tr>
<tr>
<td>Tune Port Leakage Current</td>
<td>10</td>
<td></td>
<td></td>
<td>μA</td>
<td></td>
</tr>
<tr>
<td>OUTPUT RETURN LOSS</td>
<td>2</td>
<td></td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td>SSB PHASE NOISE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 kHz Offset</td>
<td>−86</td>
<td>−82</td>
<td></td>
<td>dBc/Hz</td>
<td></td>
</tr>
<tr>
<td>100 kHz Offset</td>
<td>−113</td>
<td>−110</td>
<td></td>
<td>dBc/Hz</td>
<td></td>
</tr>
</tbody>
</table>
### ABSOLUTE MAXIMUM RATINGS

Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCC</td>
<td>5.5 V dc</td>
</tr>
<tr>
<td>VTUNE</td>
<td>0 V to 15 V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>−40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>−65°C to +150°C</td>
</tr>
<tr>
<td>Nominal Junction Temperature</td>
<td>135°C</td>
</tr>
<tr>
<td>(to Maintain 1 Million Hours Mean Time to Failure (MTTF))</td>
<td></td>
</tr>
<tr>
<td>Nominal Junction Temperature (T_a = 85°C)</td>
<td>116°C</td>
</tr>
<tr>
<td>Maximum Reflow Temperature (MSL3 Rating)</td>
<td>260°C</td>
</tr>
<tr>
<td>Thermal Resistance (Junction to Ground Pad)</td>
<td>29°C/W</td>
</tr>
<tr>
<td>ESD Sensitivity</td>
<td></td>
</tr>
<tr>
<td>Human Body Model (HBM)</td>
<td>300 V (Class 1A)</td>
</tr>
<tr>
<td>Field Induced Charged Device Model (FICDM)</td>
<td>300 V (Class II)</td>
</tr>
</tbody>
</table>

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

**ESD CAUTION**

**ESD (electrostatic discharge) sensitive device.**

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.
Table 3. Pin Function Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 4, 6 to 10, 13 to 18, 20, 22 to 28, 30 to 32</td>
<td>NC</td>
<td>No Connect. However, these pins can be connected to RF/dc ground without affecting the performance of the device.</td>
</tr>
<tr>
<td>5, 11</td>
<td>GND</td>
<td>Ground. These pins must be connected to RF/dc ground.</td>
</tr>
<tr>
<td>12</td>
<td>RFOUT/2</td>
<td>Half Frequency Output. This pin is ac-coupled.</td>
</tr>
<tr>
<td>19</td>
<td>RFOUT</td>
<td>RF Output. This pin is ac-coupled.</td>
</tr>
<tr>
<td>21</td>
<td>VCC</td>
<td>Supply Voltage (5 V).</td>
</tr>
<tr>
<td>29</td>
<td>VTUNE</td>
<td>Control Voltage and Modulation Input. The modulation bandwidth is dependent on the drive source impedance.</td>
</tr>
<tr>
<td></td>
<td>EP</td>
<td>Exposed Pad. The package bottom has an exposed metal pad that must be connected to RF/dc ground.</td>
</tr>
</tbody>
</table>
INTERFACE SCHEMATICS

Figure 3. RFOUT Interface

Figure 4. RFOUT/2 Interface

Figure 5. Vcc Interface

Figure 6. VTUNE Interface

Figure 7. GND Interface
TYPICAL PERFORMANCE CHARACTERISTICS

Figure 8. Output Frequency vs. Tuning Voltage

Figure 9. Output Power vs. Tuning Voltage

Figure 10. Sensitivity vs. Tuning Voltage

Figure 11. Supply Current (ICC) vs. Tuning Voltage

Figure 12. RFOUT/2 Output Frequency vs. Tuning Voltage

Figure 13. RFOUT/2 Output Power vs. Tuning Voltage
Figure 14. SSB Phase Noise vs. Tuning Voltage

Figure 15. SSB Phase Noise vs. Offset Frequency at VTUNE = 5 V
THEORY OF OPERATION

The HMC1167 voltage controlled oscillator is a free running voltage controlled frequency source. The output frequency is controlled by applying a variable tune voltage to the VTUNE port. Because VTUNE is varied from the lowest to the highest allowed voltage, the VCO output frequency increases from the lowest to the highest operating frequency. This VCO output frequency change with the applied VTUNE input results in the VCO frequency sensitivity characteristic (MHz/V). The VCO frequency sensitivity is not constant and varies across the tunable range.

The HMC1167 VCO covers the minimum to maximum frequencies specified in this data sheet over the entire specified temperature range, including the VCO frequency drift (MHz/°C). For low phase noise operation, drive the VTUNE port from a low noise voltage source; excessive noise on the VTUNE port results in poor phase noise performance. The VTUNE port modulation bandwidth is typically greater than 10 MHz.

To achieve optimum VCO phase noise performance when using the HMC1167, it is important to use a low noise power supply for Vcc biasing. Because the VCO output frequency changes with small changes in the Vcc bias voltage (pushing), noise on the Vcc bias pin results in increased phase noise. Take care to use low noise regulators, otherwise, bias line noise may corrupt the low phase noise output of the HMC1167.

Internally, the RF output frequency is generated from a doubler circuit. This generation results in an unwanted low level output signal present at half the RFOUT frequency (RFOUT/2). If necessary, this undesired spurious signal can be further filtered on the customer application board using a filter. The RFOUT/2 output signal is available directly at the RFOUT/2 port. The RFOUT/2 port is commonly used to drive a phase-locked loop (PLL)/synthesizer for phase locking the HMC1167 output, if so desired.

Lastly, the HMC1167 RFOUT port incorporates an internal buffer amplifier to provide good output matching. The internal buffer amplifier also isolates the VCO core from the output load and minimizes the VCO frequency change with the changes to the output load impedance (pulling).
APPLICATIONS INFORMATION

The HMC1167 serves as the local oscillator (LO) in microwave synthesizer applications. The primary applications are point to point microwave radios, military, radars, test and measurement, as well as industrial and medical equipment. The low phase noise allows higher orders of modulation and offers improved bit error rates in communication systems, whereas the linear, monotonic tuning sensitivity allows a stable loop filter design. The higher output power minimizes the gain required to drive subsequent stages. The half frequency output reduces the input frequency to the prescaler without the addition of residual phase noise to the input of the phase-locked loop synthesizer.

Figure 16. Typical Application Diagram
The circuit board used in an application uses RF circuit design techniques. Ensure that the signal lines have 50 Ω impedance and that the package ground leads and backside ground paddle are connected directly to the ground plane.

Use a sufficient number of via holes to connect the top and bottom ground planes. The evaluation circuit board shown in Figure 17 is available from Analog Devices, Inc., upon request.

**BILL OF MATERIALS**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1 to J4</td>
<td>PCB mount SMA RF connectors</td>
</tr>
<tr>
<td>J5, J6</td>
<td>2 mm dc headers</td>
</tr>
<tr>
<td>C1 to C3</td>
<td>100 pF capacitors, 0402 package</td>
</tr>
<tr>
<td>C4</td>
<td>1000 pF capacitor, 0402 package</td>
</tr>
<tr>
<td>C5 to C7</td>
<td>2.2 μF tantalum capacitors</td>
</tr>
<tr>
<td>C8</td>
<td>0.01 μF capacitor, 0603 package</td>
</tr>
<tr>
<td>U1</td>
<td>HMC1167 VCO</td>
</tr>
<tr>
<td>PCB¹</td>
<td>110225 evaluation board²</td>
</tr>
</tbody>
</table>

¹ Circuit board material is Rogers 4350.
² Reference this number when ordering the complete evaluation PCB.
## PACKAGING AND ORDERING INFORMATION

### OUTLINE DIMENSIONS

![Diagram of 32-Lead Lead Frame Chip Scale Package (LFCSP)](image)

**Figure 18. 32-Lead Lead Frame Chip Scale Package [LFCSP]**

5 mm × 5 mm Body and 0.90 mm Package Height (HCP-32-3)

Dimensions shown in millimeters

### ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Temperature Range</th>
<th>MSL Rating</th>
<th>Package Description</th>
<th>Package Option</th>
<th>Quantity</th>
<th>Branding</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMC1167LP5E</td>
<td>−40°C to +85°C</td>
<td>MSL3</td>
<td>32-Lead LFCSP</td>
<td>HCP-32-3</td>
<td>500</td>
<td>H1167</td>
</tr>
<tr>
<td>HMC1167LP5ETR</td>
<td>−40°C to +85°C</td>
<td>MSL3</td>
<td>32-Lead LFCSP, 7” Tape and Reel</td>
<td>HCP-32-3</td>
<td>500</td>
<td>H1167</td>
</tr>
<tr>
<td>EV1HMC1167LP5</td>
<td></td>
<td></td>
<td>Evaluation Board</td>
<td></td>
<td></td>
<td>XXXX</td>
</tr>
</tbody>
</table>

1 The HMC1167LP5E and HMC1167LP5ETR are RoHS-compliant parts.
2 See the Absolute Maximum Ratings section, Table 2.
3 XXXX is a placeholder for the 4-digit lot number.