



### FEATURES

Dual output frequency range

$$f_{OUT} = 11.07 \text{ GHz to } 11.62 \text{ GHz}$$

$$f_{OUT}/2 = 5.535 \text{ GHz to } 5.810 \text{ GHz}$$

Output power ( $P_{OUT}$ ): 8 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<sup>2</sup>

### APPLICATIONS

Point to point and multipoint radios

Test equipment and industrial controls

Very small aperture terminals (VSATs)

### GENERAL DESCRIPTION

The HMC1165 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.

### FUNCTIONAL BLOCK DIAGRAM

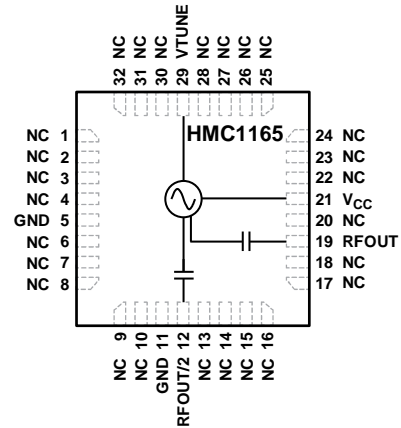


Figure 1.

13393-001

The output power is 8 dBm typical from a 5 V supply voltage. The VCO is housed in a RoHS-compliant LFCSP and requires no external matching components.

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**REVISION HISTORY**

**10/15—Revision 0: Initial Version**

## SPECIFICATIONS

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

Table 1.

| Parameter                                  | Min   | Typ  | Max   | Unit                    | Test Conditions/Comments                                |
|--|-------|------|-------|-------------------------|---|
| <b>FREQUENCY</b>                           |       |      |       |                         |   |
| Range                                      |       |      |       |                         |   |
| Output Frequency ( $f_{OUT}$ )             | 11.07 |      | 11.62 | GHz                     |   |
| Half Output Frequency ( $f_{OUT}/2$ )      | 5.535 |      | 5.810 | GHz                     |   |
| Drift Rate                                 |       | 1.2  |       | MHz/ $^{\circ}\text{C}$ |   |
| Pulling                                    |       | 0.35 |       | MHz p-p                 | Pulling into a 2.0:1 voltage standing wave ratio (VSWR) |
| Pushing                                    |       | 10   |       | MHz/V                   | At VTUNE = 5 V  |
| <b>OUTPUT POWER (<math>P_{OUT}</math>)</b> |       |      |       |                         |   |
| R <sub>FOUT</sub>                          | 4.5   | 8    | 11.5  | dBm                     |   |
| R <sub>FOUT/2</sub>                        | 2     | 5    | 10    | dBm                     |   |
| Supply Current ( $I_{CC}$ )                |       | 185  |       | mA                      | $V_{CC} = 4.75\text{ V}$                                |
|  | 160   | 210  | 280   | mA                      | $V_{CC} = 5.00\text{ V}$                                |
|  |       | 230  |       | mA                      | $V_{CC} = 5.25\text{ V}$                                |
| <b>HARMONICS, SUBHARMONICS</b>             |       |      |       |                         |   |
| 1/2  |       | 35   |       | dBc                     |   |
| 3/2  |       | 16   |       | dBc                     |   |
| Second                                     |       | 14   |       | dBc                     |   |
| Third                                      |       | 25   |       | dBc                     |   |
| <b>TUNING</b>                              |       |      |       |                         |   |
| Voltage (VTUNE)                            | 2     |      | 13    | V                       |   |
| Sensitivity                                | 70    |      | 310   | MHz/V                   |   |
| Tune Port Leakage Current                  |       |      | 10    | $\mu\text{A}$           | VTUNE = 13 V  |
| <b>OUTPUT RETURN LOSS</b>                  |       |      |       |                         |   |
|  |       | 4    |       | dB                      |   |
| <b>SSB PHASE NOISE</b>                     |       |      |       |                         |   |
| 10 kHz Offset                              |       | -88  | -82   | dBc/Hz                  |   |
| 100 kHz Offset                             |       | -113 | -109  | dBc/Hz                  |   |

**ABSOLUTE MAXIMUM RATINGS**

Table 2.

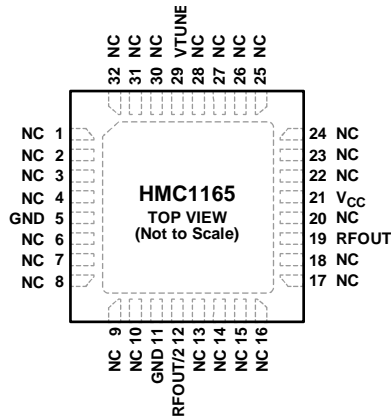
| Parameter  | Rating          |
|--|-----------------|
| V <sub>CC</sub>  | 5.5 V dc        |
| VTUNE  | 0 V to 15 V     |
| Temperature  |                 |
| Operating  | –40°C to +85°C  |
| Storage  | –65°C to +150°C |
| Nominal Junction (to Maintain 1 Million Hours Mean Time to Failure (MTTF)) | 135°C           |
| Nominal Junction (T <sub>A</sub> = 85°C)                                   | 117°C           |
| Maximum Reflow Temperature (MSL3 Rating)                                   | 260°C           |
| Thermal Resistance (Junction to Ground Paddle)                             | 27.6°C/W        |
| ESD Sensitivity (Human Body Model)   | Class 1A        |

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.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



- NOTES**
1. NO CONNECT. HOWEVER, THESE PINS CAN BE CONNECTED TO RF/DC GROUND WITHOUT AFFECTING THE PERFORMANCE OF THE DEVICE.
  2. EXPOSED PAD. THE PACKAGE BOTTOM HAS AN EXPOSED METAL PAD THAT MUST BE CONNECTED TO RF/DC GROUND.

13383-002

Figure 2. Pin Configuration

Table 3. Pin Function Descriptions

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

INTERFACE SCHEMATICS

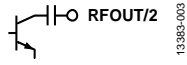


Figure 3. RFOUT/2 Interface

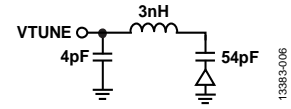


Figure 6. VTUNE Interface

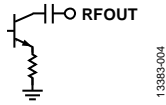


Figure 4. RFOUT Interface



Figure 7. GND Interface

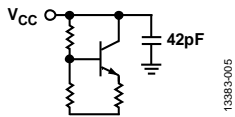


Figure 5. VCC Interface

# TYPICAL PERFORMANCE CHARACTERISTICS

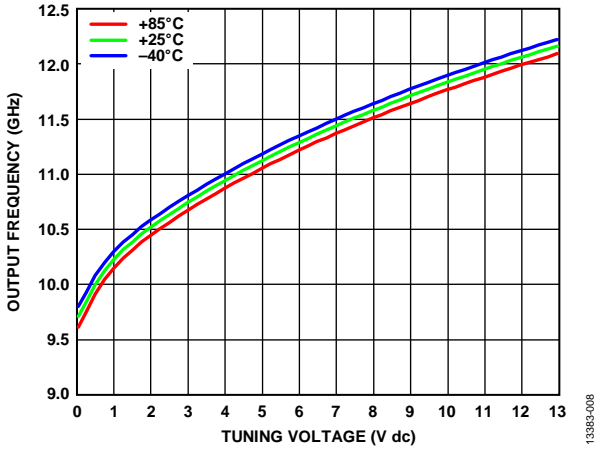


Figure 8. Output Frequency vs. Tuning Voltage

13383-008

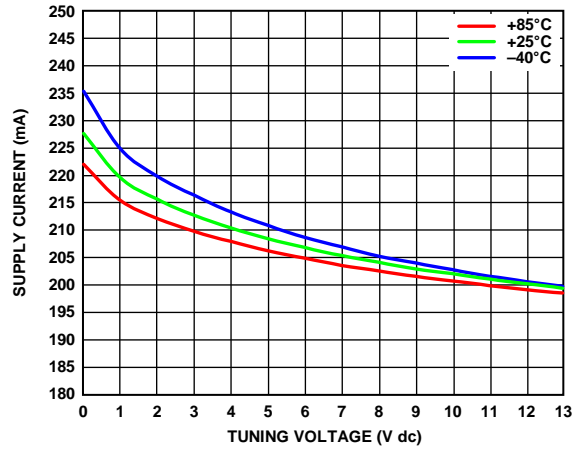


Figure 11. Supply Current vs. Tuning Voltage

13383-011

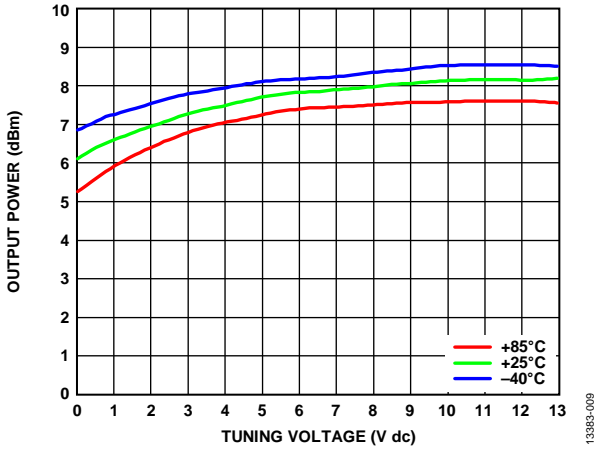


Figure 9. Output Power vs. Tuning Voltage

13383-009

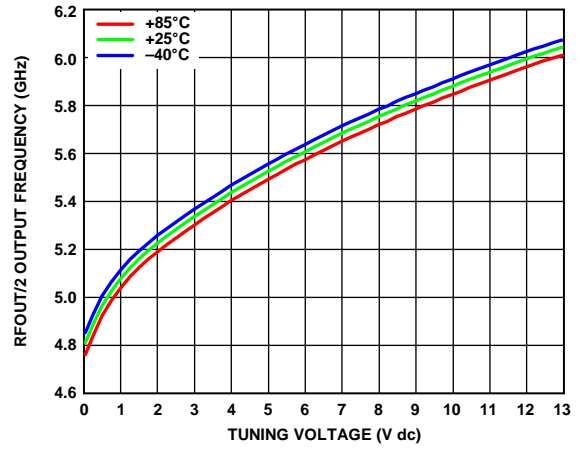


Figure 12. RFOUT/2 Output Frequency vs. Tuning Voltage

13383-012

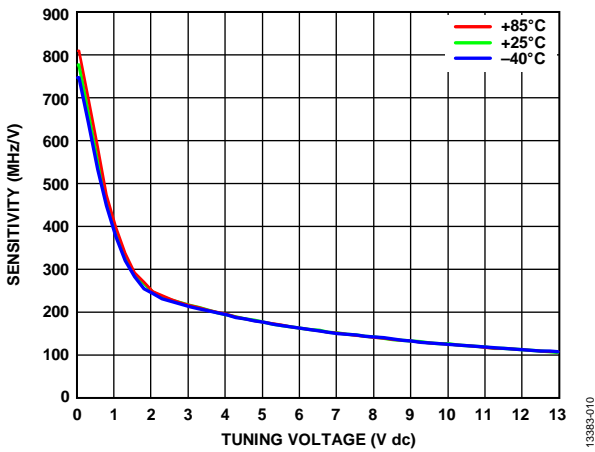


Figure 10. Sensitivity vs. Tuning Voltage

13383-010

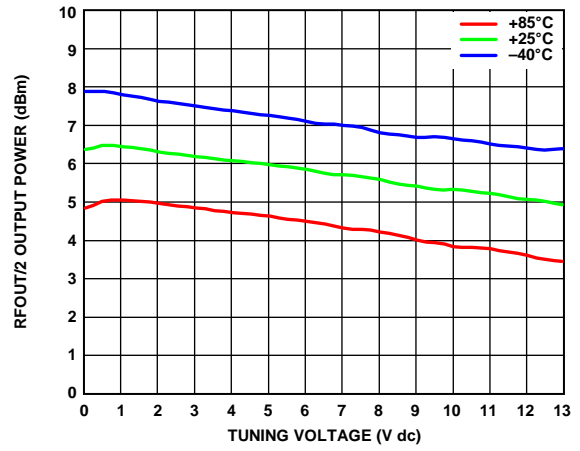


Figure 13. RFOUT/2 Output Power vs. Tuning Voltage

13383-013

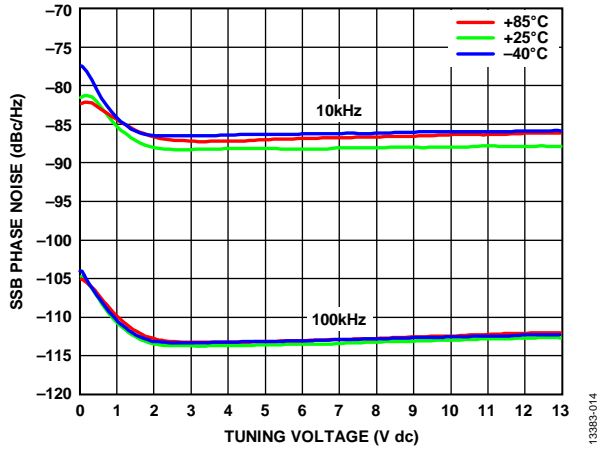


Figure 14. SSB Phase Noise vs. Tuning Voltage

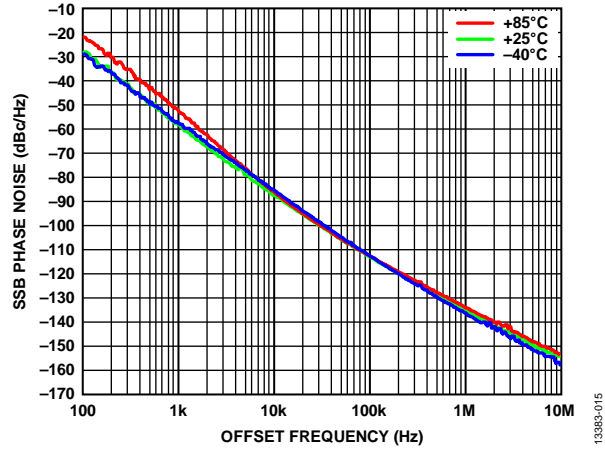


Figure 15. SSB Phase Noise vs. Offset Frequency at VTUNE = 5 V



## APPLICATIONS INFORMATION

The HMC1165 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.

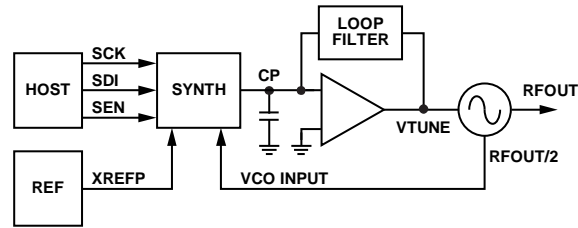


Figure 16. Typical Application Diagram

EVALUATION PRINTED CIRCUIT BOARD (PCB)

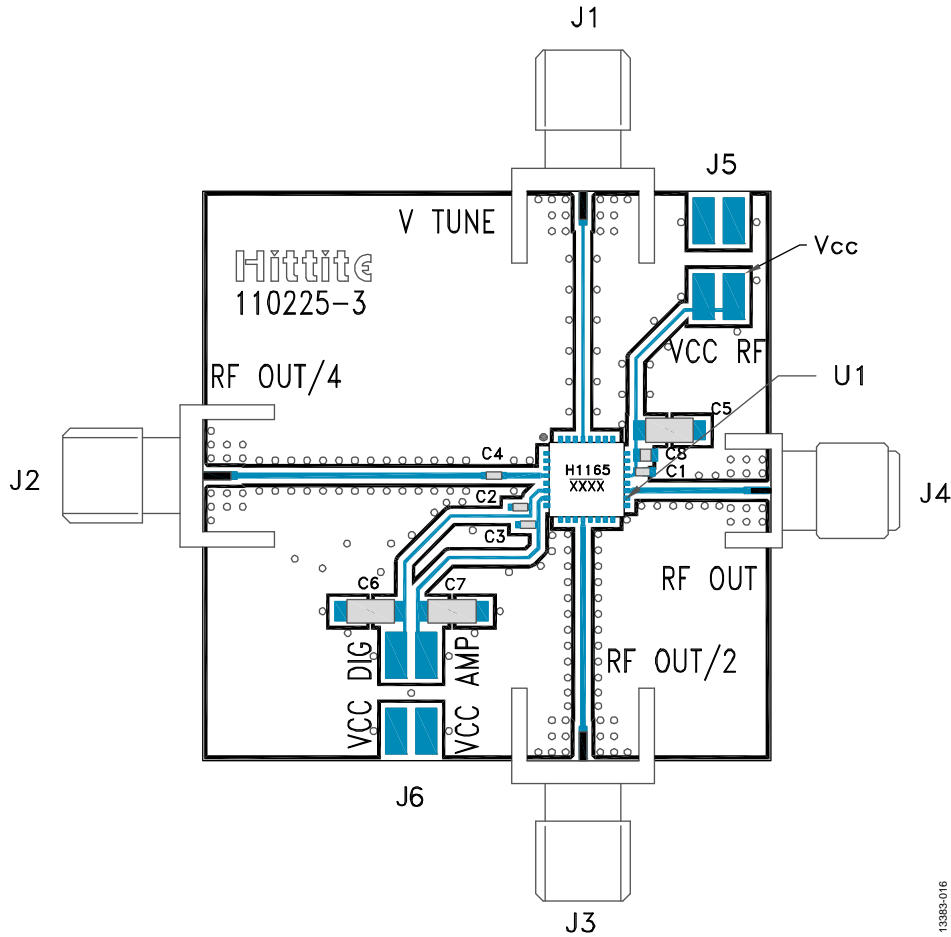


Figure 17. Evaluation Board

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 4. Bill of Materials, EV1HMC1165LP5

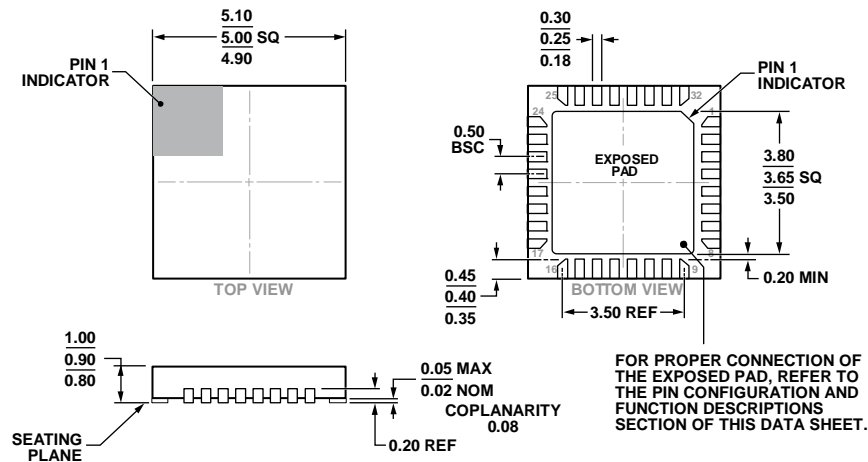
| Item             | Description                          |
|------------------|--------------------------------------|
| J1 to J4         | PCB mount SMA RF connectors          |
| J5, J6           | 2 mm dc headers                      |
| C1 to C3         | 100 pF capacitors, 0402 package      |
| C4               | 1000 pF capacitor, 0402 package      |
| C5 to C7         | 2.2 μF tantalum capacitors           |
| C8               | 0.01 μF capacitor, 0603 package      |
| U1               | HMC1165 VCO                          |
| PCB <sup>1</sup> | 110225 evaluation board <sup>2</sup> |

<sup>1</sup> Circuit board material is Rogers 4350.

<sup>2</sup> Reference this number when ordering the complete evaluation PCB.

# PACKAGING AND ORDERING INFORMATION

## OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-220-VHHD-4.

Figure 18. 32-Lead Lead Frame Chip Scale Package [LFCSP\_VQ]  
5 mm × 5 mm Body, Very Thin Quad  
(HCP-32-1)  
Dimensions shown in millimeters

## ORDERING GUIDE

| Model <sup>1</sup> | Temperature Range | MSL Rating <sup>2</sup> | Package Description                | Package Option | Qty. | Brand <sup>3</sup> |
|--------------------|-------------------|-------------------------|------------------------------------|----------------|------|--------------------|
| HMC1165LP5E        | -40°C to +85°C    | MSL3                    | 32-Lead LFCSP_VQ                   | HCP-32-1       |      | H1165<br>XXXX      |
| HMC1165LP5ETR      | -40°C to +85°C    | MSL3                    | 32-Lead LFCSP_VQ, 7" Tape and Reel | HCP-32-1       | 500  | H1165<br>XXXX      |
| EV1HMC1165LP5      |                   |                         | Evaluation Board                   |                |      |                    |

<sup>1</sup> The HMC1165LP5E and HMC1165LP5ETR are RoHS compliant parts.

<sup>2</sup> See the Absolute Maximum Ratings section, Table 2.

<sup>3</sup> XXXX is a placeholder for the 4-digit lot number.



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