

## DESCRIPTION

Demonstration circuit 1017 is an I/Q modulator featuring the LT<sup>®</sup>5558. The LT<sup>®</sup>5558 is a 600MHz to 1.1GHz direct I/Q modulator designed for high performance wireless applications, including wireless infrastructure. It may also be configured as an image reject upconverting mixer, by applying 90° phase-shifted signals to the I and Q inputs.

A high-speed, internally matched LO amplifier drives two double-balanced mixer cores, allowing the use of a low power, single-ended LO source. It enables direct RF modulation using differential baseband I and Q signals. It supports GSM, EDGE, CDMA, CDMA2000, W-CDMA, 64-QAM, OFDM and other modulation formats.

The I/Q baseband inputs consist of voltage-to-current converters that in turn drive double-balanced mixers. The outputs of these mixers are summed and applied to an on-chip RF transformer, which converts the

differential mixer signals to a 50Ω single-ended output. The four balanced I and Q base-band input ports are intended for DC coupling from a source with a common-mode voltage level of about 2.1V. The differential input impedance of the baseband inputs is approximately 3KΩ, making them ideally suited for voltage-drive applications.

The LO path consists of a LO buffer with single-ended input, and precision quadrature generators which produce the LO drive for the mixers.

Demonstration circuit 1017 is designed for an RF output frequency range from 600MHz to 1.1GHz.

**Design files for this circuit board are available. Call the LTC factory.**

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# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 1017

## HIGH LINEARITY DIRECT QUADRATURE MODULATOR

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**Table 1. Typical Performance Summary ( $T_A = 25^\circ\text{C}$ )**

PARAMETER	CONDITION ( $f_{RF} = 2\text{MHz}$ , $f_{LO} = 850\text{MHz}$ )	VALUE
Supply Voltage		4.5V to 5.25V
Supply Current	$V_{CC} = 5\text{V}$ , EN = High	108mA
Maximum Shutdown Current	$V_{CC} = 5\text{V}$ , EN = Low	0.1 $\mu\text{A}$
RF Frequency Range		600 to 1100MHz
Baseband Frequency Range		DC to 400MHz
LO Input Return Loss	$Z_0 = 50\Omega$ , PLO = 0dBm	10.6dB
RF Output Return Loss	$Z_0 = 50\Omega$	-15.8dB
LO Input Power		-10 to +5dBm
LO Frequency Range		600 to 1100MHz
Conversion Gain	PRF = -10dBm, PLO = 0dBm, defined as PRF/PBB	9.7dB
Output 3rd Order Intercept	2-Tone, PRF = -10dBm/Tone, $\Delta f = 100\text{KHz}$ , PLO = 0dBm	+22.4dBm
Output 2nd Order Intercept	2-Tone, PRF = -10dBm/Tone, $\Delta f = 100\text{KHz}$ , PLO = 0dBm	+65dBm
Output 1dB Compression	PLO = 0dBm	+7.8dBm
LO leakage	PLO = 0dBm	-43.7dBm
Image Rejection	PLO = 0dBm	-49dBc

## APPLICATION NOTE

### RF FREQUENCY RANGE

No tuning is required for operation over the RF frequency range of 600MHz to 1.1GHz.

### BASEBAND FREQUENCY RANGE

The baseband frequency range extends from DC to 400MHz (3dB bandwidth).

### LO TO RF LEAKAGE

The LT<sup>®</sup>5558 offers excellent LO to RF leakage performance, typically -43.7dBm.

The LO leakage may be further reduced by the introduction of small differential DC offsets ( $V_{\text{BBIP}} - V_{\text{BBIM}}$ ,  $V_{\text{BBQP}} - V_{\text{BBQM}}$ ) at the baseband inputs, typically less than 10mV. These DC offsets may be introduced, for example, using the DC offset points shown in Figure 1.

### SIDETONE TO RF LEAKAGE

The LT<sup>®</sup>5558 also offers very good image rejection (sidetone suppression) at the RF port. The image rejection may be further enhanced by the introduction of small differential phase and amplitude offsets at the baseband inputs.

## TEST EQUIPMENT AND SETUP

Refer to Figure 1 for proper measurement equipment setup. Before performing measurements on the DUT, it is very important to evaluate the test system performance to ensure that: 1) distortion-free input signals are applied and 2) the spectrum analyzer internal distortion is minimized. Follow the guidelines below to do this.

Use high performance signal generators with low harmonic output (>75dBc) for 2-tone measurements. The signal generators must provide 2 equal amplitude outputs in quadrature with one another. High quality combiners that provide broadband 50 ohm termination on all ports should be used. The combiners should have good port-to-port isolation (>30 dB) to prevent the signal generators from modulating each other and generating intermodulation products. Attenuators on the outputs of these generators can also be used to increase the effective port-to-port isolation.

Spectrum analyzers can produce significant internal distortion products if they are overdriven. Sufficient spectrum analyzer input attenuation should be used to avoid saturating the instrument. A typical input 3<sup>rd</sup> order intercept point for a spectrum analyzer is +40dBm, with 20dB input attenuation applied. This is more than 10dB above the intercept point of the DUT, and should yield accurate 3<sup>rd</sup> order distortion results.

### QUICK START PROCEDURE

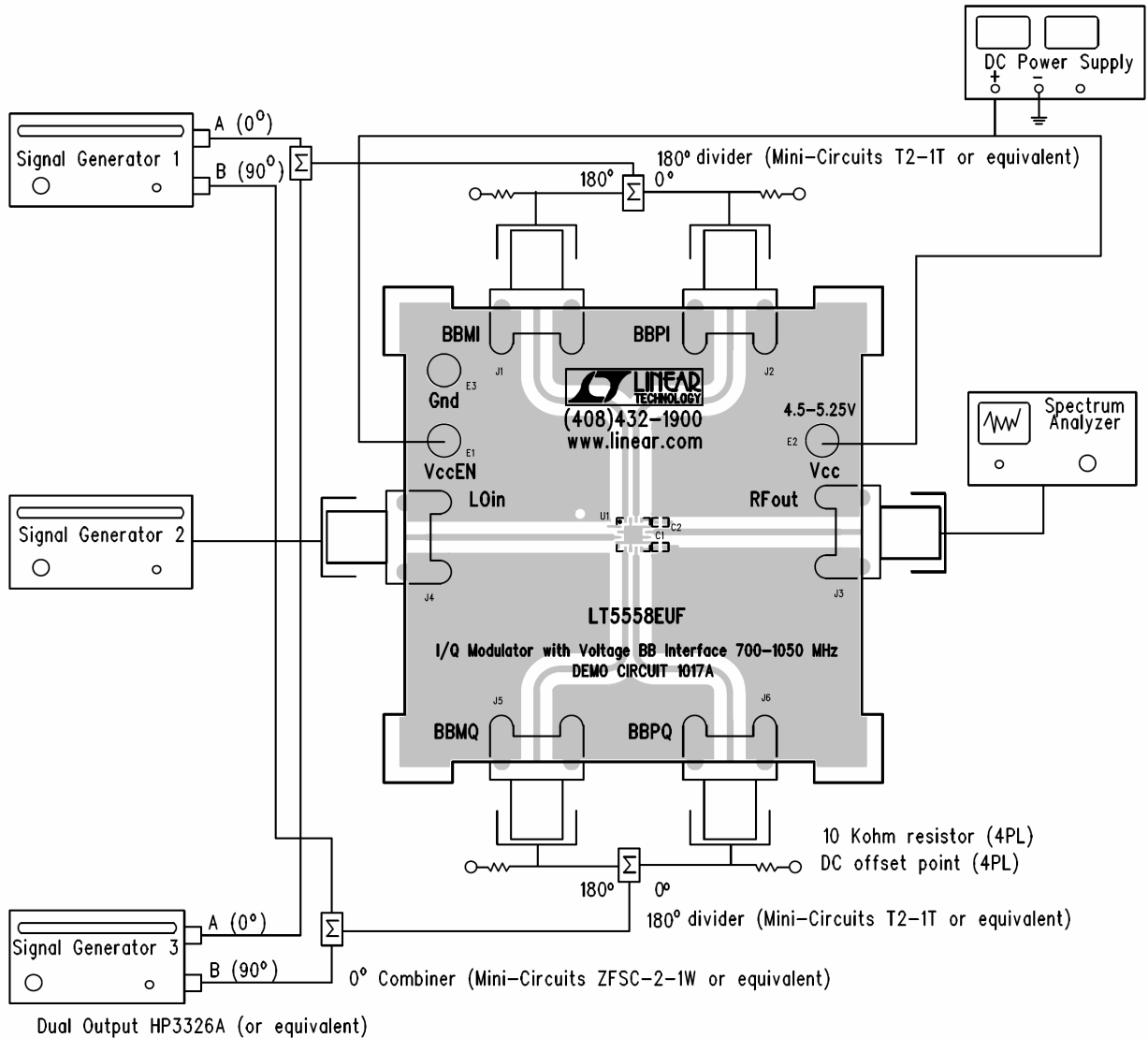
Demonstration circuit 1017 is easy to set up to evaluate the performance of the LT<sup>®</sup>5558. Refer to Figure 1 for proper measurement equipment setup.

Follow the procedure below:

1. Connect all test equipment as shown in Figure 1.
2. Set the DC power supply's current limit to 150mA, and adjust output voltage to 5V.
3. Connect Vcc to the 5V DC supply, and then connect VCCEN to 5V; the modulator is enabled (on).
4. Set Signal Generator #1 to provide an 850MHz, 0dBm, CW signal to the demo board LO input port.
5. Set the Signal Generators #2 and #3 to provide two -10dBm CW signals to the combiner ports - one at 2MHz, and the other at 2.1MHz. For both generators, output B should lead output A by 90 degrees. These 2 signals must be in quadrature to drive the demo board properly. This is most conveniently accomplished by using signal generators with dual outputs with adjustable phase. An example is the HP3326A shown in Figure 1.
6. To measure 3<sup>rd</sup> order distortion and conversion gain, set the Spectrum Analyzer start and stop frequencies to 851.8MHz and 852.3MHz, respectively. Sufficient spectrum analyzer input attenuation should be used to avoid distortion in the instrument.
7. The 3<sup>rd</sup> order intercept point is equal to  $(P_1 - P_3) / 2 + P_1$ , where  $P_1$  is the average power level of the two fundamental output tones at 852MHz and 852.1MHz;  $P_3$  is the average power level of the two 3<sup>rd</sup> order products at 851.9MHz and 852.2MHz. All units are in dBm.
8. To measure 2<sup>nd</sup> order distortion, set the Spectrum Analyzer start and stop frequencies to 854MHz and 856MHz, respectively. Sufficient spectrum analyzer input attenuation should be used to avoid distortion in the instrument.
9. The 2<sup>nd</sup> order intercept point is equal to  $2 * P_1 - P_2$ , where  $P_1$  is the power level of the fundamental output tone at 852MHz,  $P_2$  is the 2<sup>nd</sup> order product at 854.1MHz. All units are in dBm.

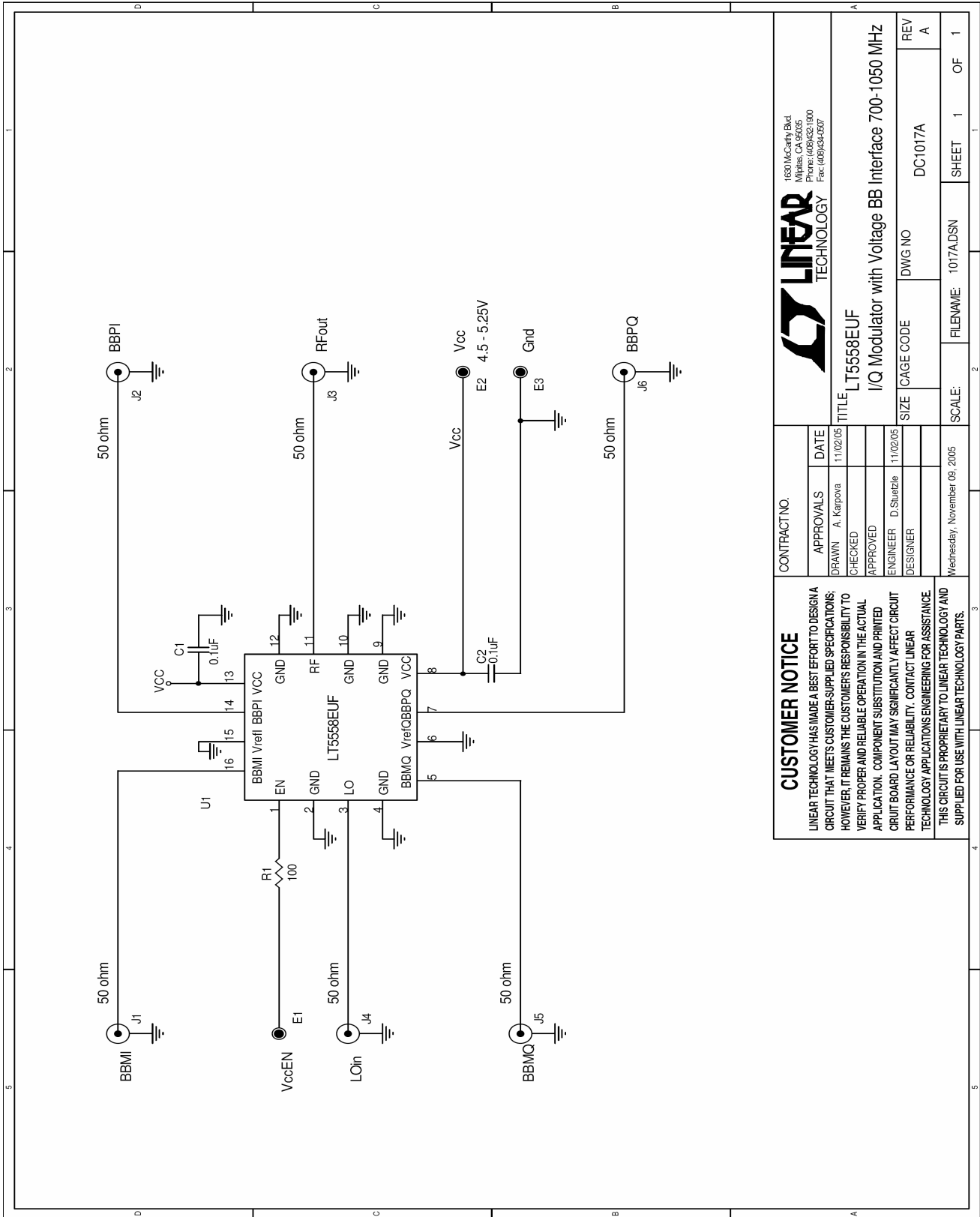
# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 1017 HIGH LINEARITY DIRECT QUADRATURE MODULATOR

Figure 1. Proper Measurement Equipment Setup



# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 1017

## HIGH LINEARITY DIRECT QUADRATURE MODULATOR



<b>CONTRACT NO.</b>		<b>DATE</b>	
APPROVALS		11/02/05	
DRAWN A. Karpova		CHECKED	
APPROVED		ENGINEER D. Shvetzlb	
DESIGNER		11/02/05	
Wednesday, November 09, 2005		SCALE:	
FILENAME: 1017A.DSN		SHEET 1 OF 1	
<p><b>CUSTOMER NOTICE</b></p> <p>LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.</p> <p>THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.</p>		<p><b>LINEAR TECHNOLOGY</b></p> <p>1600 McCarthy Blvd Milpitas, CA 95035 Phone: (408)432-1900 Fax: (408)434-6300</p>	
TITLE		REV	
LT15558EUF		A	
I/Q Modulator with Voltage BB Interface 700-1050 MHz		DC:1017A	
SIZE		DWG NO	
CAGE CODE		REV	