## DESCRIPTION

Demonstration circuit 1233A-x is a high linearity up-converting mixer featuring the LT5579.

The LT®5579 is a high performance upconverting mixer IC optimized for output frequencies in the 1.5GHz to 3.8GHz range. It features single-ended LO input and RF output ports to simplify board layout and to reduce system cost.

The LT5579 offers a superior alternative to passive mixers. Unlike passive mixers which have conversion loss and require high LO drive levels, the LT5579 delivers conversion gain at significantly lower LO input levels and is less sensitive to LO power level variations. Only -1dBm of LO power is needed, and the balanced design results in low LO signal leakage to the RF output. The lower LO drive level requirements, combined with the excellent LO leakage performance, translate into lower LO signal contamination of the output signal.

The DC1233A-x series of demonstration circuits are designed for evaluating the LT5579 IC at several common frequency ranges:

| VERSION | APPLICATION | IF INPUT | LO INPUT | RF OUTPUT |
|---|---|---|---|---|
| -A | WiMAX | 456MHz | Low-side | 3.6GHz |
| -B | WiMAX | 456MHz | High-side | 2.6GHz |
| -C | UMTS | 240MHz | High-side | 2.14GHz |
| -D | PCS | 240MHz | Low-side | 1.95GHz |

Demonstration circuit 1233A-x can be easily optimized for operations at other frequencies. Refer to the "Application Note" section and the LT5579 data sheet for details.

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



**Table 1. Typical Demo Circuit Performance Summary ($T_A$ = 25°C, $V_{CC}$ = 3.3V, $P_{IF}$ = -5dBm (-5dBm/tone for 2-tone tests, Δf = 1MHz), $P_{LO}$ = -1dBm, unless otherwise noted. Low side LO for 1950MHz and 3600MHz. High side LO for 2140MHz and 2600MHz.)**

| PARAMETER | CONDITIONS | TYPICAL PERFORMANCE | | | |
|---|---|---|---|---|---|
| Supply Voltage | | 3.3V | | | |
| Supply Current | | 226mA | | | |
| LO Input Frequency Range | | 1.1GHz to 4GHz | | | |
| LO Input Power | | -5 to +2dBm | | | |
| | | **1233A-A** | **1233A-B** | **1233A-C** | **1233A-D** |
| | | **WiMAX 3.6GHz** | **WiMAX 2.6GHz** | **UMTS** | **PCS** |
| IF Input Frequency Range | 12dB Return Loss, LO applied | 330 to 505MHz | 330 to 505MHz | 174 to 263MHz | 174 to 263MHz |
| RF Output Frequency Range | 10dB Return Loss, LO applied | 3170 to 4100MHz | 2260 to 2780MHz | 2035 to 2285MHz | 1840 to 2020MHz |
| Conversion Gain | | -0.5dB | 1.3dB | 2.6dB | 1.9dB |
| Conversion Gain vs. Temperature | $T_A$ = -40°C to 85°C | -0.027dB/°C | -0.027dB/°C | -0.020dB/°C | -0.020dB/°C |
| Output 3rd Order Intercept | | 23.2dBm | 26.2dBm | 27.3dBm | 28dBm |
| Output 2nd Order Intercept | | 54dBm | 45dBm | 42dBm | 40dBm |
| Single Sideband Noise Figure | | 12dB | 12dB | 9.9dB | 9.9dB |
| Output Noise Floor | $P_{OUT}$ = -5dBm | -155.5dBm/Hz | -157.5dBm/Hz | -158.1dBm/Hz | -158.1dBm/Hz |
| Output 1dB Compression | | 10.7dBm | 13.7dBm | 13.9dBm | 13.6dBm |
| IF to LO Isolation | | 73dB | 74dB | 81dB | 80dB |
| LO to IF Leakage | | -22dBm | -26dBm | -28dBm | -25dBm |
| LO to RF Leakage | | -35dBm | -36dBm | -35dBm | -34dBm |

# APPLICATION NOTE

### ABSOLUTE MAXIMUM RATINGS

Supply Voltage......................................................3.6V
LO Input Power............................................ +10dBm
LO Input DC Voltage.................... -0.3V to $V_{CC}$ + 0.3V
RF Output DC Current....................................... 60mA
IF Input Power (Differential).......................... +13dBm
$IF^+$, $IF^-$ DC Currents ........................................... 60mA
$T_{JMAX}$ .................................................................150°C
Operating Temperature Range.............. -40°C to 85°C
Storage Temperature Range............... -65°C to 150°C

### IF INPUT INTERFACE

The standard demonstration circuit 1233A-x can be reconfigured for other IF input frequencies. The details of the matching circuit are omitted in this guide, since the LT5579 datasheet presents in depth explanations and the IC's IF input differential impedance. Matching component values for several common IF input frequencies are listed in Table 2. Refer to the demonstration circuit schematic in Figure 3.

**Table 2. IF Input Component Values**

| IF Freq. (MHz) | C1,C2 (pF) | C9 (1) (pF) | C3 (pF) | TL1,TL2 (3) | L1,L2 (nH) | R1,R2 (Ω) |
|---|---|---|---|---|---|---|
| 70 | 1000 | 120 | (2) | 4.7nH | 100 | 9.1 |
| 140 | 1000 | 120 | (2) | $Z_0$=70Ω | 100 | 9.1 |
| 240 | 82 | 33 | (2) | $Z_0$=70Ω | 40 | 11 |
| 450 | 33 | 33 | (2) | $Z_0$=70Ω | 40 | 11 |

**NOTE:**

1. Center of C9 is 3mm from the edge of the IC package for all cases.
2. C3 is a small-valued capacitor used to improve the LO-RF leakage in some applications, and it has little effect on impedance matching. C3's value and location depend on LO and RF frequencies and are determined experimentally. In certain instances, two common-mode capacitors to ground instead of one single differential capacitor may provide better leakage suppression.
3. The 70Ω microstrip transmission line TL1 and TL2 provide inductances required for matching. At lower frequencies, external inductors are necessary.
4. R1 and R2 set the DC current in the mixer core to the optimum level of 50mA per side. Their values should be well matched for best LO leakage performance. 0.1% tolerance is recommended.
5. L1 and L2 reduce the loading effect of R1 and R2. Their self-resonant frequency should be at least several times the IF frequency. High quality wire-wound type inductors are recommended. The DC resistances of L1 and L2 need to be accounted for in the selection of R1 and R2.

### LO INPUT INTERFACE

The LT5579's LO input port is internally matched from 1.1GHz to 4GHz, with a minimum return loss across this range of about 9dB at 2.3GHz. External matching should be used for lower LO frequencies for best performance. Refer to the LT5579 datasheet for more information and impedance data.

### RF OUTPUT INTERFACE

The LT5579 utilizes an internal RF transformer to step down the mixer core output impedance to simply RF output matching. Matching component values for several common RF output frequencies are listed in Table 3. High quality precision microwave capacitors, such as the AVX Accu-p series, should be used for C8 to minimize parasitics.

**Table 3. RF Output Component Values**

| RF Frequency (MHz) | C8 (pF) | L3 (nH) |
|---|---|---|
| 1650 | 1.5 | 6.8 |
| 1750 | 1.2 | 6.8 |
| 1950 | 1 | 4.7 |
| 2140 | 0.45 | 3.9 |
| 2600 | - | 1.0 |
| 3600 | 0.7 | 0Ω |

## TEST EQUIPMENT AND SETUP

The LT5579 is a high linearity upconverting mixer IC. Accuracy of its performance measurement is highly dependent on equipment setup and measurement technique. The following precautions are recommended:

1. Use high performance signal generators with low harmonic output. Otherwise, utilize low-pass filters at the signal generator outputs to suppress higher-order harmonics.
2. Turn off the signal generators' output automatic-level-control (ALC). This prevents conflict in power-level control between the two sources, which can introduce intermodulation products.
3. High quality combiners that provide broadband 50Ω termination on all ports and have good port-to-port isolation should be used. Attenuators on the outputs of the signal generators are recommended to further improve source isolation to prevent the sources from modulating each other and generating intermodulation products.
4. Beware of the signal generators', and if used, source amplifiers' 1dB compression point. When driven close to their 1dB compression point, the sources and amplifiers may introduce additional distortions.
5. The level of intermodulation products from the input sources needs to be much lower than the products expected to be generated by the DUT. In general, IM products measured at the input connector to the DUT should be 25dB or more below the expected level at the DUT output.
6. If possible, use small attenuator pads with good VSWR on the demonstration circuit's input and output ports to improve source and load match to reduce reflections, which may degrade measurement accuracy.
7. Use narrow resolution bandwidth (RBW) and engage video averaging on the spectrum analyzer to lower the displayed average noise level (DANL) in order to improve sensitivity and to increase dynamic range. The trade off is increased sweep time.
8. Spectrum analyzers can produce significant internal distortion products if they are overdriven. Generally, spectrum analyzers are designed to operate at their best with about –30dBm to -40dBm at their input filter or preselector. Sufficient spectrum analyzer input attenuation should be used to avoid saturating the instrument, but too much attenuation reduces sensitivity and dynamic range.
9. Before performing measurements on the demo circuit, the system performance should be evaluated to ensure that: 1) clean input signal can be produced, 2) the spectrum analyzer's internal distortion is minimized, 3) the spectrum analyzer has enough dynamic range and sensitivity, and 4) the system is accurately calibrated for power and frequency.

## QUICK START PROCEDURE

Demonstration circuit 1233A-x is easy to set up to evaluate the performance of the LT5579. Refer to Figure 1 and Figure 2 for proper measurement equipment connections and follow the procedure below:

**NOTE:** Care should be taken to never exceed absolute maximum input ratings.

### RETURN LOSS MEASUREMENTS

1. Configure the Network Analyzer for return loss measurement, set appropriate frequency range, and set the test signal to –5dBm.
2. Calibrate the Network Analyzer.
3. Connect all test equipment as shown in Figure 1.
4. Apply 3.3V DC supply power, and verify that the current consumption is approximately 226mA in the presence of LO signal. The supply voltage should be confirmed at the demo board $V_{CC}$ and GND terminals to account for ohmic losses due to the high current.
5. With the LO signal applied, and the unused demo board port terminated in 50Ω, measure return loss of the IF input and RF output ports.
6. Set the test signal to –1dBm, and re-calibrate the Network Analyzer.
7. Terminate the IF input and RF output ports in 50Ω. Measure return loss of the LO input port.

### RF PERFORMANCE MEASUREMENTS

1. Connect all test equipment as shown in Figure 2.
2. Set the LO source (Signal Generator 1) to provide a -1dBm, CW signal to the demo board LO input port at appropriate LO frequency.
3. Set the IF sources (Signal Generators 2 and 3) to provide two -5dBm CW signals, 1MHz apart, to the demo board IF input port at the appropriate IF frequency.
4. Measure the resulting RF output on the Spectrum Analyzer:

   a. The wanted two-tone RF output signals are at:

      $f_{OUT(1,2)} = f_{LO} + f_{IF(1,2)}$ for low-side LO, and

      $f_{OUT(1,2)} = f_{LO} – f_{IF(1,2)}$ for high-side LO

   b. The 2nd order intermodulation product which is closest to the wanted RF signals is used to calculate the Output 2nd Order Intercept:

      $f_{IM2} = f_{LO} + (f_{IF1} + f_{IF2})$ for low-side LO, and

      $f_{IM2} = f_{LO} - (f_{IF1} + f_{IF2})$ for high-side LO

   c. Similarly, use the 3rd order intermodulation products which are closest to the wanted RF signals to calculate the Output 3rd Order Intercept:

      $f_{IM3,1} = f_{LO} + f_{IF1} - \Delta_{IF}$, and

      $f_{IM3,2} = f_{LO} + f_{IF2} + \Delta_{IF}$ for low-side LO, and

      $f_{IM3,1} = f_{LO} - f_{IF1} + \Delta_{IF}$, and

      $f_{IM3,2} = f_{LO} - f_{IF2} - \Delta_{IF}$ for high-side LO

   Where $\Delta_{IF} = f_{IF2} – f_{IF1}$.

5. Calculate Output 2nd and 3rd Order Intercepts:

   $OIP2 = 2•P_{OUT} – P_{IM2}$

   $OIP3 = (3•P_{OUT} – P_{IM3}) / 2$

   Where $P_{OUT}$ is the lowest power level of the two wanted output signals at either $f_{OUT1}$ or $f_{OUT2}$, $P_{IM2}$ is the 2nd order intermodulation product at $f_{IM2}$, and $P_{IM3}$ is the largest 3rd order intermodulation product at either $f_{IM3,1}$ or $f_{IM3,2}$. All units are in dBm.

   Alternatively, the output intercept can be calculated using the power difference between the desired output signal and the intermodulation products:

   $OIP2 = \Delta_{IM2} + P_{OUT}$

   $OIP3 = (\Delta_{IM3})/2 + P_{OUT}$

   Where $\Delta_{IM(2,3)} = P_{OUT} – P_{IM(2,3)}$.

6. Turn off one of the IF signal generators, and measure Conversion Gain, IF to LO isolation, LO to IF and LO to RF leakages, and Input 1dB compression point.

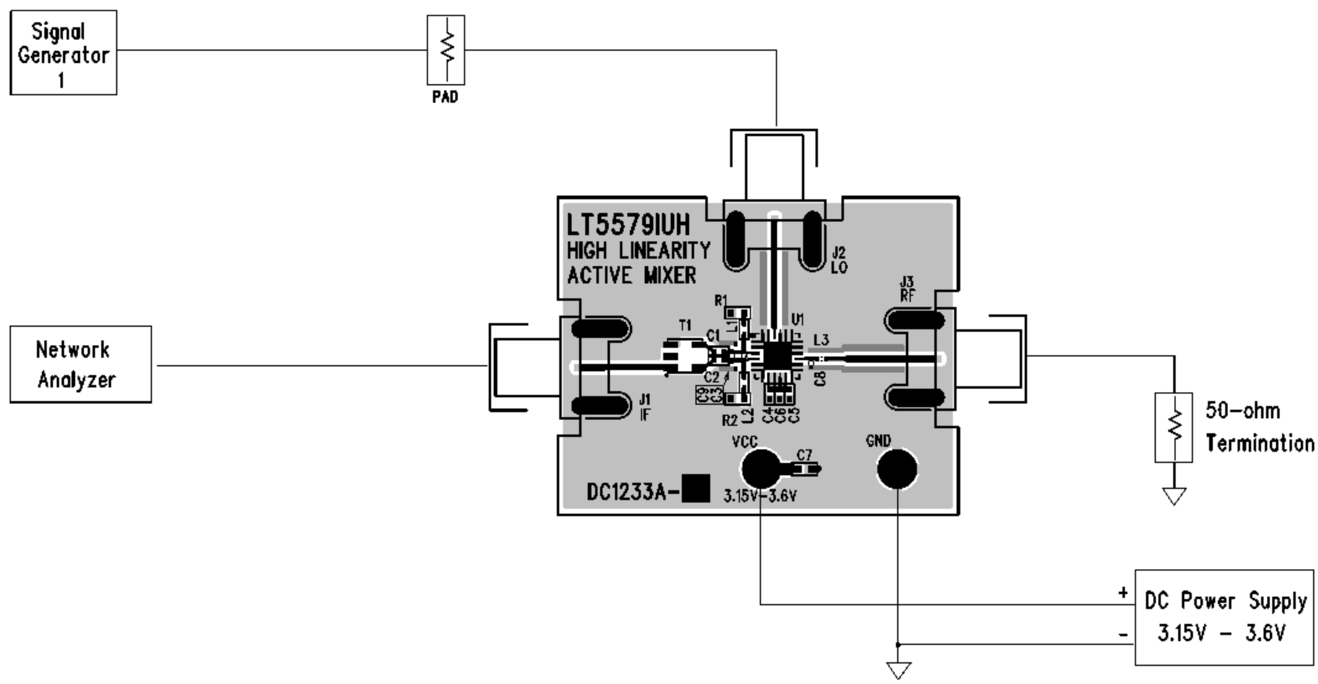



**Figure 1. Proper Equipment Setup for Return Loss Measurements**

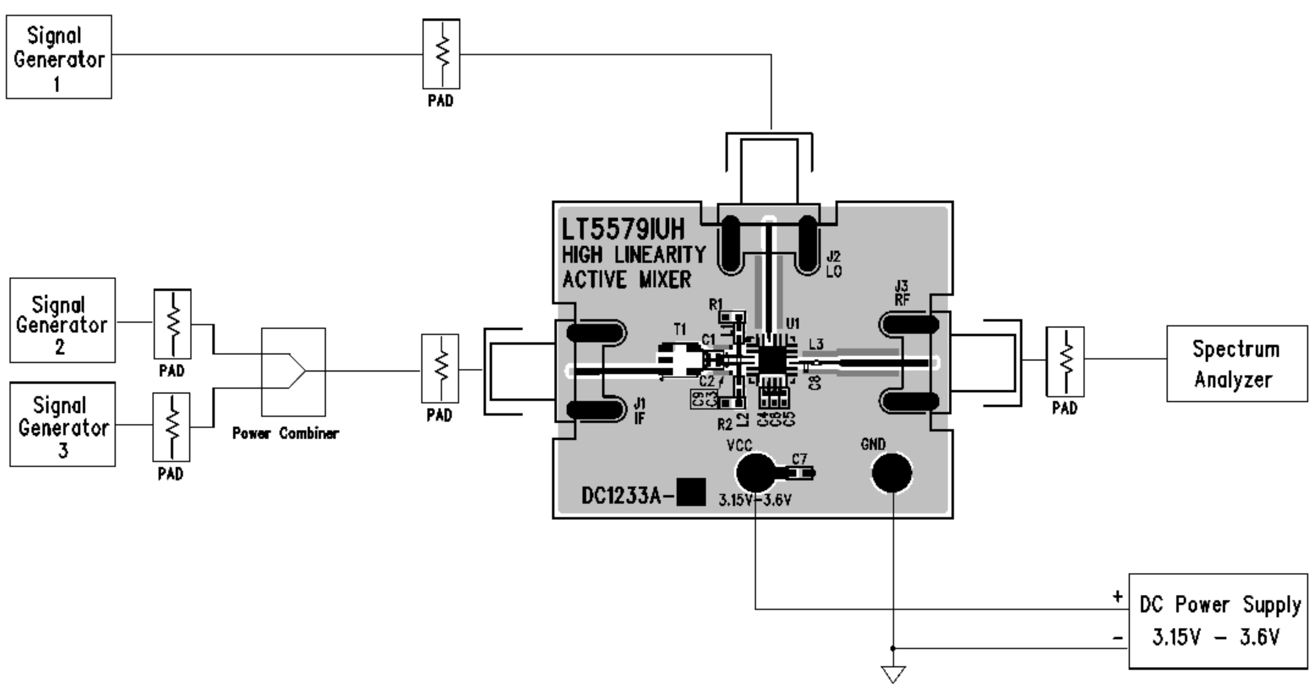
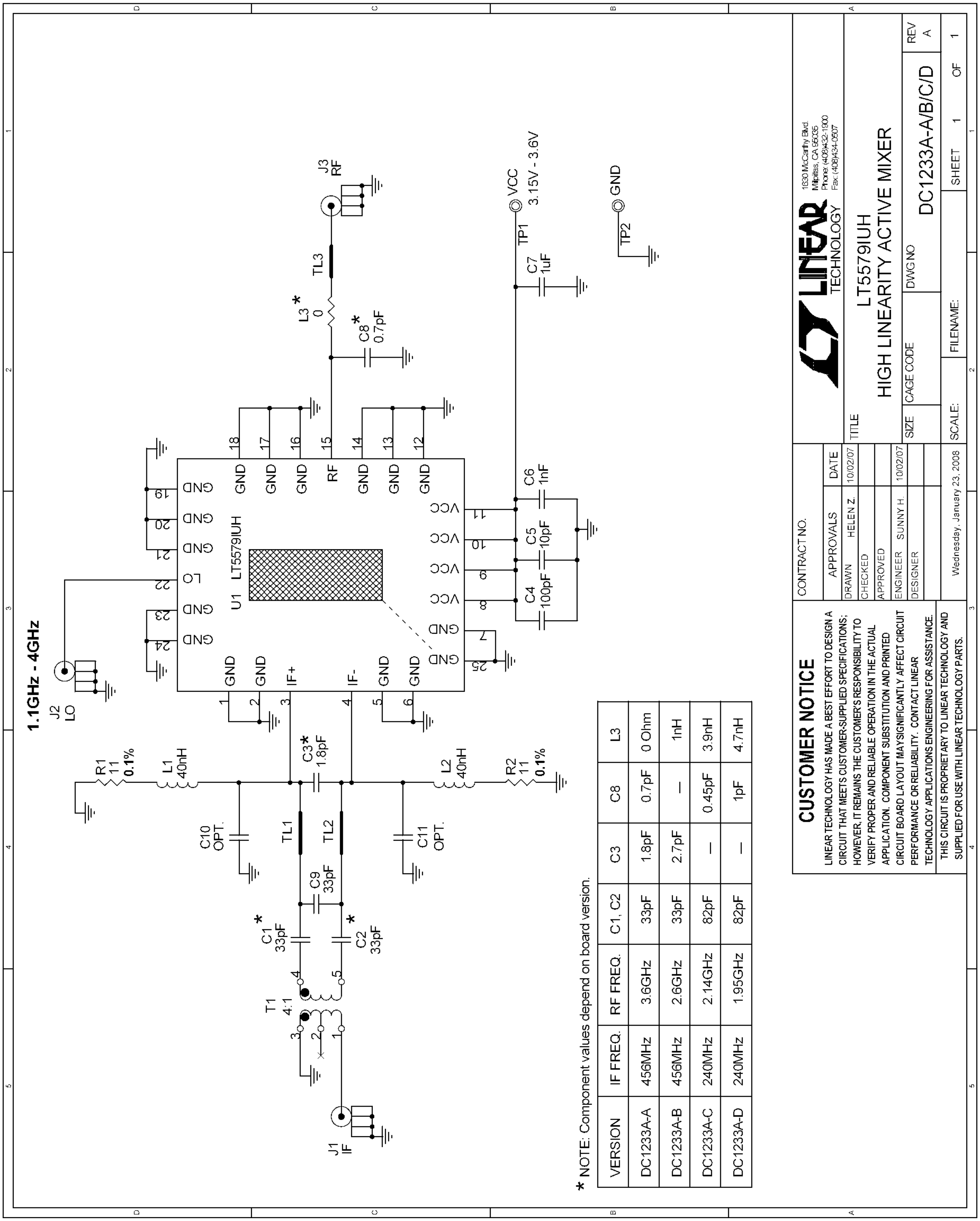



**Figure 2. Proper Equipment Setup for RF Performance Measurements**




* NOTE: Component values depend on board version.

| VERSION | IF FREQ. | RF FREQ. | C1, C2 | C3 | C8 | L3 |
|---|---|---|---|---|---|---|
| DC1233A-A | 456MHz | 3.6GHz | 33pF | 1.8pF | 0.7pF | 0 Ohm |
| DC1233A-B | 456MHz | 2.6GHz | 33pF | 2.7pF | — | 1nH |
| DC1233A-C | 240MHz | 2.14GHz | 82pF | — | 0.45pF | 3.9nH |
| DC1233A-D | 240MHz | 1.95GHz | 82pF | — | 1pF | 4.7nH |

**Figure 3. Demonstration Circuit Schematic**