LTC5510 1MHz to 6GHz Wideband High Linearity Active Mixer

DESCRIPTION

Demonstration circuit 1983A showcases the LTC®5510 wideband high linearity active mixer for both upconverting and downconverting applications. **Its input port is optimized for 30MHz to 3GHz, and its output port is optimized for 1.2GHz to 2.1GHz.** The LO input can be either high side or low side.

Another demonstration circuit, the DC1984A, is designed for evaluating the LTC5510 at the lower output frequency range of 10MHz to 1.3GHz.

DEMO BOARD	INPUT RANGE	LO RANGE	OUTPUT RANGE
DC1983A	**30MHz to 3GHz**	**5MHz to 6GHz**	**1.2GHz to 2.1GHz**
DC1984A	30MHz to 2.6GHz	5MHz to 6GHz	10MHz to 1.3GHz

The LTC5510 is a high linearity active mixer optimized for applications requiring very wide input bandwidth, low distortion, and low LO leakage. The IC includes a double-balanced active mixer with input buffer and a high speed LO amplifier. The mixer can be used for both up- and down-conversion and requires only 0dBm of LO power to achieve excellent distortion and noise performance. The LTC5510 is optimized for 5V but can also be used with a 3.3V supply with reduced performance. The shutdown function allows the part to be disabled for further power saving.

Design files for this circuit board are available at http://www.linear.com/demo/DC1983A

PERFORMANCE SUMMARY

Specifications are at T_C = 25°C, V_{CC} = 5V, EN = High, P_{LO} = 0dBm, P_{IN} = –10dBm (–10dBm/tone for two-tone tests), unless otherwise noted. (Note 1)

PARAMETER	CONDITIONS	VALUE	UNITS
Input Frequency Range		30 to 3000	MHz
Output Frequency Range		1200 to 2100	MHz
LO Input Frequency Range		5 to 6000	MHz
LO Input Power Range		–6 to 6	dBm
Supply Voltage Range	5V Supply, R1 = 4.75kΩ (Default Configuration) 3.3V Supply, R1 = 1.8kΩ	4.5 to 5.3 3.1 to 3.5	V V
Supply Current	5V Supply, R1 = 4.75kΩ (Default Configuration) 3.3V Supply, R1 = 1.8kΩ	99.6 94	mA mA
Total Supply Current During Shutdown	EN = Low	1.3	mA
EN Input High Voltage (On)		>1.8	V
EN Input Low Voltage (Off)		<0.5	V
EN Input Current	–0.3V to V_{CC} + 0.3V	–20 to 200	µA
Turn-On Time	EN: Low to High	0.6	µs
Turn-Off Time	EN: High to Low	0.6	µs
Temperature Monitor Pin (TEMP) DC Voltage at T_J = 25°C	I_{IN} = 10µA I_{IN} = 80µA	697 755	mV mV
Temperature Monitor Pin (TEMP) Voltage Temperature Coefficient	I_{IN} = 10µA I_{IN} = 80µA	–1.80 –1.61	mV/°C mV/°C

PERFORMANCE SUMMARY

Specifications are at T_C = 25°C, V_{CC} = 5V, EN = High, P_{LO} = 0dBm, P_{IN} = –10dBm (–10dBm/tone for two-tone tests), unless otherwise noted. (Note 1)

PARAMETER	CONDITIONS	VALUE	UNITS
5V Wideband Up/Downmixer Application: f_{IN} = 30MHz to 3000MHz, f_{OUT} = 1575MHz, 5V Supply, R1 = 4.75kΩ (Default Configuration)			
Conversion Gain	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	1.5 1.4 1.1 1.2	dB dB dB dB
Two-Tone Output 3rd-Order Intercept (Δf = 2MHz)	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	27.8 25.0 26.0 24.5	dBm dBm dBm dBm
SSB Noise Figure	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	11.6 12.1 11.6 11.8	dB dB dB dB
SSB Noise Figure Under Blocking	f_{IN} = 900MHz, f_{LO} = 2475MHz, f_{BLOCK} = 800MHz, P_{BLOCK} = +5dBm	20.3	dB
LO-IN Leakage	f_{LO} = 20MHz to 3300MHz	< –50	dBm
LO-OUT Leakage	f_{LO} = 20MHz to 1000MHz f_{LO} = 1000MHz to 3300MHz	< –40 < –33	dBm dBm
IN-OUT Isolation	f_{IN} = 20MHz to 1150MHz f_{IN} = 1150MHz to 3000MHz	>40 >22	dB dB
IN-LO Isolation	f_{IN} = 30MHz to 3300MHz	>55	dB
Input 1dB Compression	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	11.0 12.2 11.5 11.6	dBm dBm dBm dBm
3.3V Wideband Up/Downmixer Application: f_{IN} = 30MHz to 3000MHz, f_{OUT} = 1575MHz, 3.3V Supply, R1 = 1.8kΩ			
Conversion Gain	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	1.5 1.4 1.1 1.2	dB dB dB dB
Two-Tone Output 3rd-Order Intercept (Δf = 2MHz)	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	24.2 23.3 23.9 22.3	dBm dBm dBm dBm
SSB Noise Figure	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	11.2 12.2 11.4 11.4	dB dB dB dB
SSB Noise Figure Under Blocking	f_{IN} = 900MHz, f_{LO} = 2475MHz, f_{BLOCK} = 800MHz, P_{BLOCK} = +5dBm	20.8	dB
LO-IN Leakage	f_{LO} = 20MHz to 3300MHz	< –50	dBm
LO-OUT Leakage	f_{LO} = 20MHz to 1000MHz f_{LO} = 1000MHz to 3300MHz	< –40 < –33	dBm dBm
IN-OUT Isolation	f_{IN} = 20MHz to 1150MHz f_{IN} = 1150MHz to 3000MHz	>40 >22	dB dB
IN-LO Isolation	f_{IN} = 30MHz to 3300MHz	>55	dB
Input 1dB Compression	f_{IN} = 190MHz, f_{LO} = 1765MHz, Upmixer f_{IN} = 900MHz, f_{LO} = 2475MHz, Upmixer f_{IN} = 2150MHz, f_{LO} = 575MHz, Downmixer f_{IN} = 2600MHz, f_{LO} = 1025MHz, Downmixer	8.9 10.7 10.1 9.6	dBm dBm dBm dBm

Note 1: Subject to change without notice. Refer to the latest LTC5510 data sheet for the most-up-to-date specifications.

DETAILED DESCRIPTION

Absolute Maximum Ratings

NOTE. Stresses beyond absolute maximum ratings may cause permanent damage to the device. Exposure to any absolute maximum rating condition for extended periods may affect device reliability and lifetime.

Supply Voltage (V_{CC}) 6.0V
Enable Voltage (EN) ....–0.3V to V_{CC} + 0.3V
LO Input Power (1MHz to 6GHz) .... +10dBm
IN Input Power (1MHz to 6GHz) .... +18dBm
Temp Monitor Input Current (TEMP)....................10mA
Operating Temperature Range (T_C) .... –40°C to 105°C

Supply Voltage Ramping

Fast ramping of the supply voltage can cause a current glitch in the internal ESD protection circuits. Depending on the supply inductance, this could result in a supply voltage transient that exceeds the maximum rating. A supply voltage ramp time of greater than 1ms is recommended.

Do not clip powered test leads directly onto the demonstration circuit's V_{CC} and EN turrets. Instead, make all necessary connections with power supplies turned off, then increase to operating voltage.

Supply Voltage

The LTC5510 automatically detects the supply voltage and configures internal components for 5V or 3.3V operation. The auto-detect circuit switches at approximately 4.1V. To avoid undesired operation, the mixer should only be operated in the 4.5V to 5.3V or 3.1V to 3.6V supply range.

For best overall temperature performance, the external bias adjustment resistor, R1, should be set to 4.75kΩ for 5V supply and 1.8kΩ for 3.3V supply. By default, demonstration circuit 1983A is configured for 5V supply with R1 = 4.75kΩ pre-installed.

Enable Function

The LTC5510 features Enable/Shutdown control. When the applied Enable (EN) voltage is logic high (>1.8V), the mixer is enabled. When the Enable (EN) voltage is logic low (<0.5V), the mixer is shutdown reducing current consumption to approximately 1.3mA. The Enable voltage should never fall below –0.3V or exceed the power supply voltage by more than 0.3V.

Temperature Monitor (Temp)

The LTC5510's junction temperature can be estimated by forcing a current into the on-chip diode and measuring the resulting voltage:

10µA forced current:

$$T_J = \frac{V_D - 742.4}{-1.796}$$

80µA forced current:

$$T_J = \frac{V_D - 795.6}{-1.609}$$

Where T_J is the junction temperature in °C, and V_D is the TEMP pin voltage in mV.

IN Port

Demonstration Circuit 1983A's IN port is broadband matched to 50Ω from 30MHz to 3GHz.

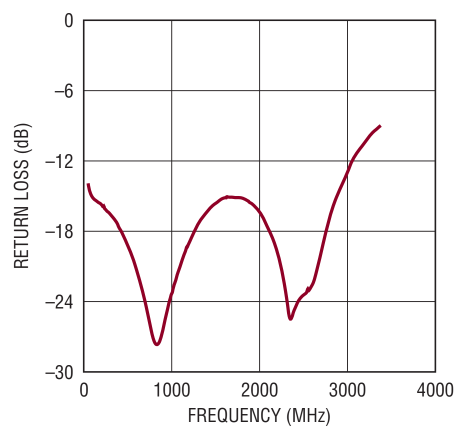


Figure 1. IN Port Return Loss

DETAILED DESCRIPTION

LO Input

Demonstration Circuit 1983A's LO input port is broadband matched to 50Ω from 5MHz to 6GHz, with better than 10dB return loss. The impedance match is maintained whether the part is enabled or disabled.

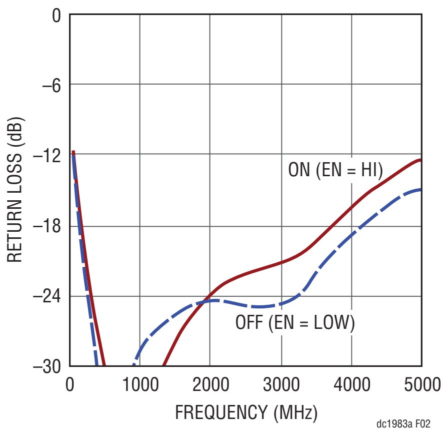


Figure 2. LO Port Return Loss

OUT Port

Demonstration Circuit 1983A utilizes a compact multilayer chip hybrid balun at the output port. The output port is well matched to 50Ω from 1.2GHz to 2.1GHz. The OUT port can be re-matched for other frequencies. See the LTC5510 data sheet for more details and impedance data.

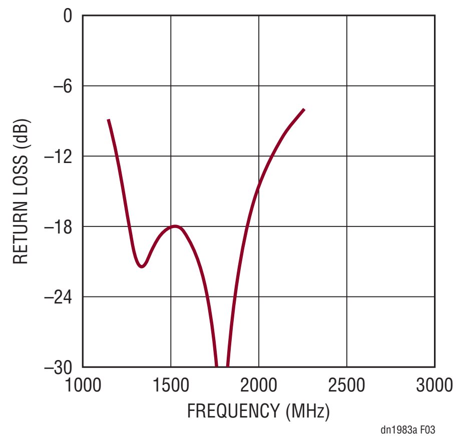


Figure 3. OUT Port Return Loss

QUICK START PROCEDURE

Demonstration circuit 1983A is easy to set up to evaluate the performance of the LTC5510. Refer to Figure 4, Figure 5, and Figure 6 for proper equipment connections.

NOTE. Care should be taken to never exceed absolute maximum input ratings. Make all connections with RF and DC power off.

Return Loss Measurements

1. Configure the Network Analyzer for return loss measurement, set appropriate frequency range, and set the test signal to 0dBm.
2. Calibrate the network analyzer.
3. Connect all test equipment as shown in Figure 4 with the DC power supply turned off.
4. Increase the DC power supply voltage to 5V, and verify that the total current consumption is close to the figure listed in the Performance Summary. The supply voltage should be confirmed at the demo board VCC and GND terminals to account for test lead ohmic losses.
5. Terminate unused demo board ports in 50Ω. Measure return losses of the IN, LO and OUT ports.

RF Performance Measurements

1. Connect all test equipment as shown in Figure 5 with the signal generators and the DC power supply turned off.

QUICK START PROCEDURE

2. Increase the DC power supply voltage to 5V, and verify that the total current consumption is close to the figure listed in the Performance Summary. The supply voltage should be confirmed at the demo board VCC and GND terminals to account for test lead ohmic losses.
3. Set the LO source (Signal Generator 1) to provide a 0dBm CW signal at appropriate LO frequency to the demo board LO input port.
4. Set the RF sources (Signal Generators 2 and 3) to provide two –10dBm CW signals, 2MHz apart, at the appropriate frequencies to the demo board IN port.
5. Measure the resulting output on the Spectrum Analyzer:
6. Calculate Output 3rd-Order Intercept:

$$OIP3 = \frac{\Delta IM3}{2} + P_{OUT}$$

Where $\Delta_{IM3} = P_{OUT} - P_{IM3}$. P_{OUT} is the lowest fundamental output signal power. P_{IM3} is the highest 3rd-order intermodulation product power.

7. Turn off one of the RF signal generators, and measure Conversion Gain, IN-OUT isolation, LO-OUT leakage, and Input 1dB compression point.

Noise Figure Measurement

1. Configure and calibrate the noise figure meter for mixer measurements.
2. Connect all test equipment as shown in Figure 6 with the signal generator and the DC power supply turned off.
3. Increase the DC power supply voltage to 5V, and verify that the total current consumption is close to the figure listed in the Performance Summary. The supply voltage should be confirmed at the demo board VCC and GND terminals to account for test lead ohmic losses.
4. Measure the single-sideband noise figure.

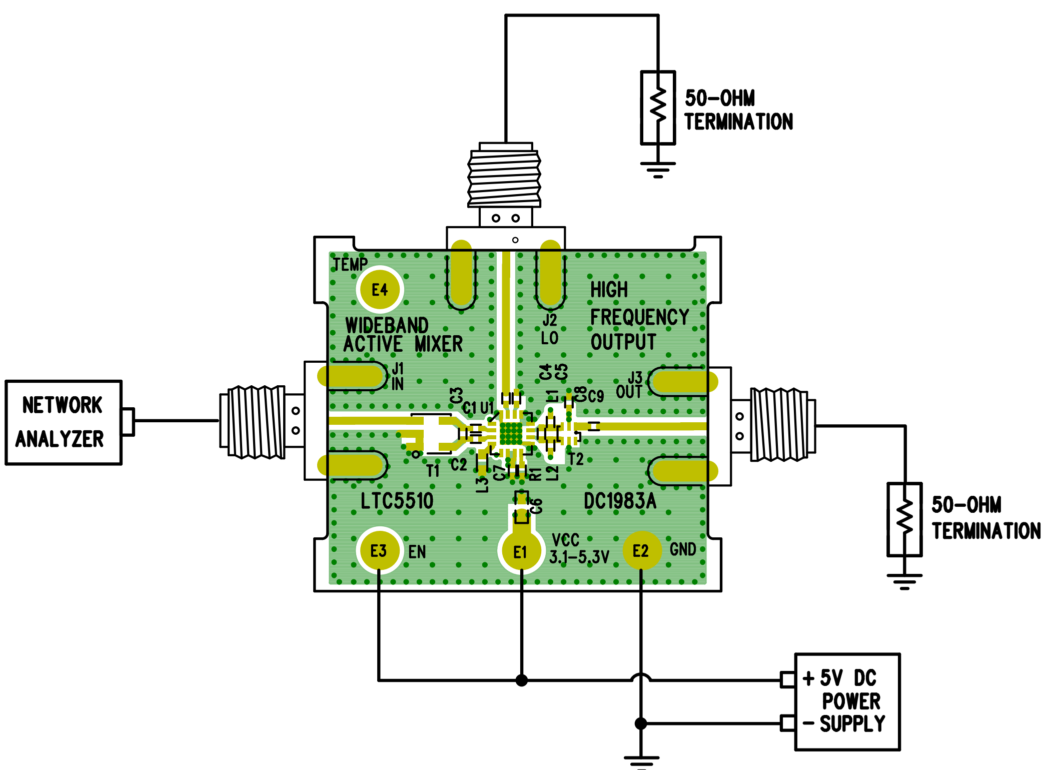


Figure 4. Proper Equipment Setup for Return Loss Measurements

QUICK START PROCEDURE

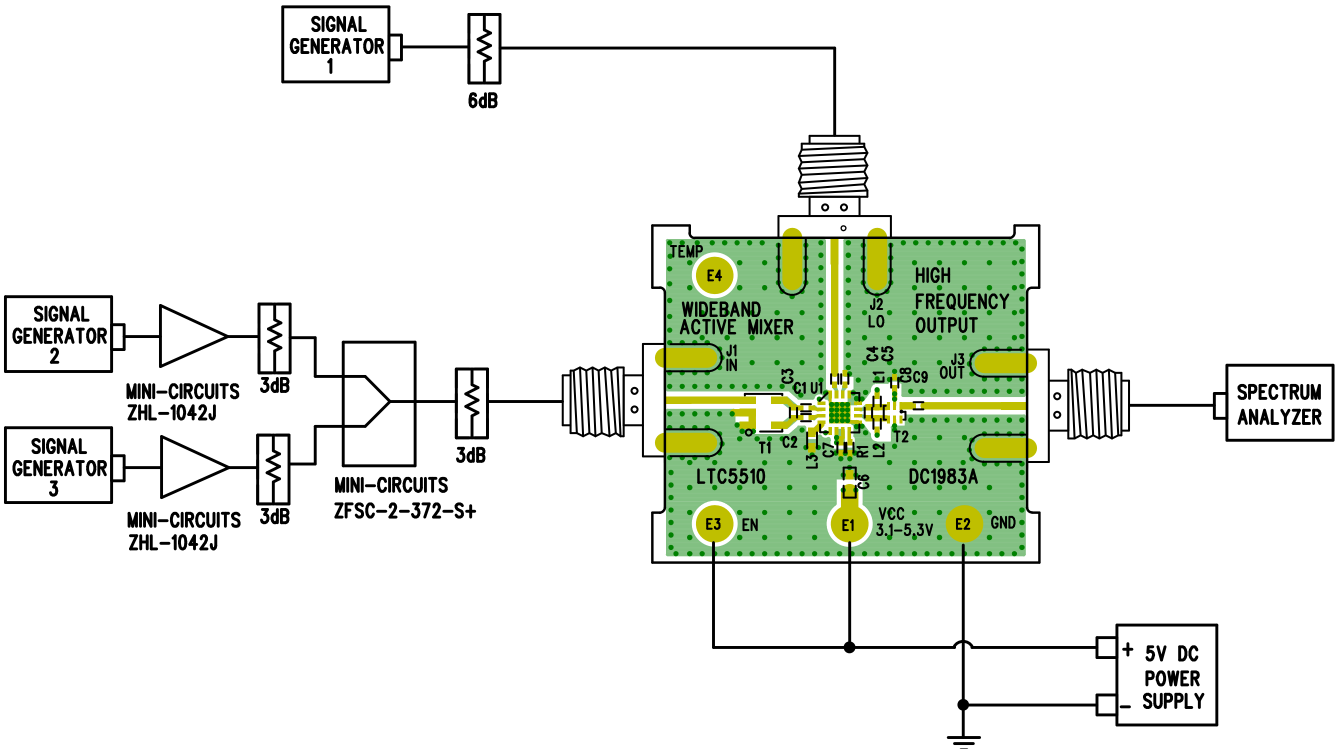


Figure 5. Proper Equipment Setup for RF Performance Measurements

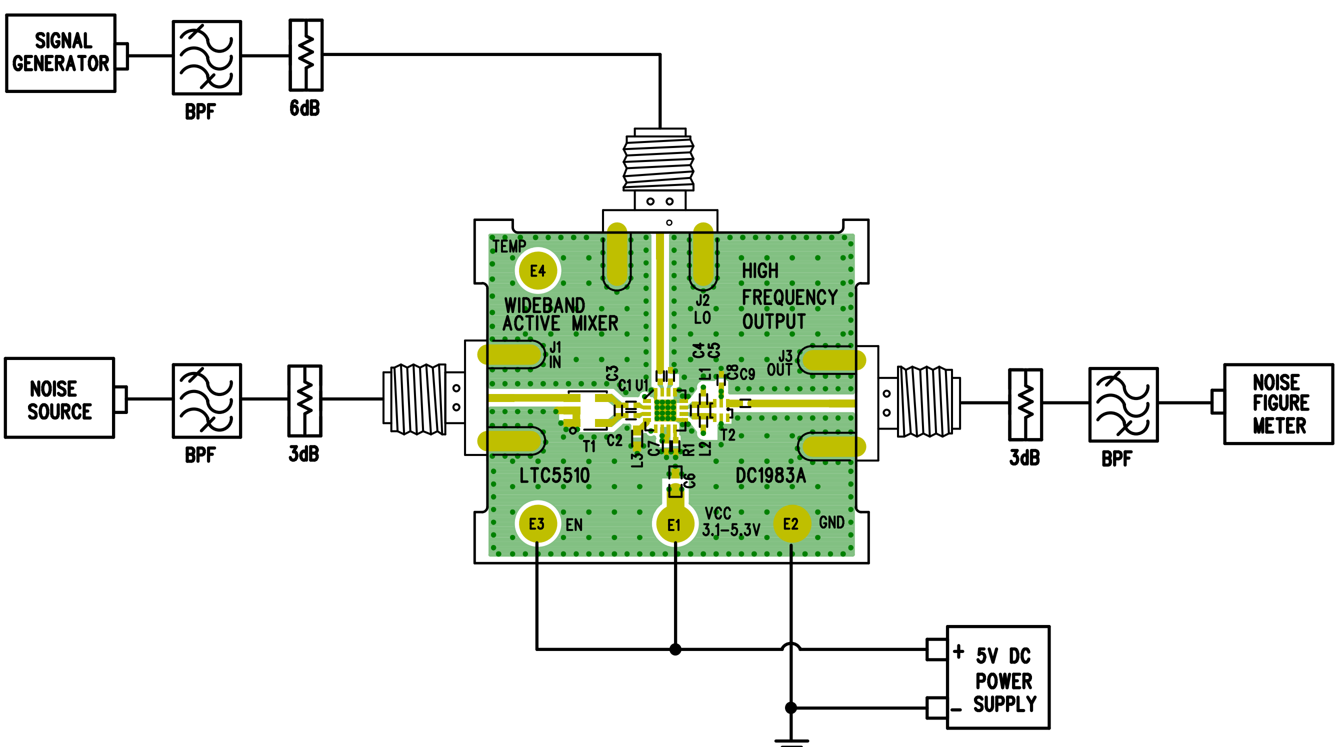


Figure 6. Proper Equipment Setup for Noise Figure Measurement

MEASUREMENT EQUIPMENT AND SETUP

The LTC5510 is a wideband active mixer IC with very high linearity. Accuracy of its performance measurement is highly dependent on equipment setup and measurement technique. The recommended measurement setups are presented in Figure 4, Figure 5, and Figure 6. The following precautions should be observed:

1. Use high performance signal generators with low harmonic output and low phase noise, such as the Rohde & Schwarz SME06. Filters at the signal generators' outputs may also be used to suppress higher-order harmonics.
2. A high quality RF power combiner which provides broadband 50Ω termination on all ports and have good port-to-port isolation should be used, such as the Mini-Circuits ZFSC-2-372-S+.
3. Use high performance amplifiers with high IP3 and high reverse isolation, such as the Mini-Circuits ZHL-1042J, on the outputs of the RF signal generators to improve source isolation to prevent the sources from modulating each other and generating intermodulation products.
4. Use 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.
5. A high dynamic range spectrum analyzer, such as the Rohde & Schwarz FSEM30, should be used for linearity measurement.
6. 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. However, the trade off is increased sweep time.
7. 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 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.
8. Before taking measurements, the system performance should be evaluated to ensure that:

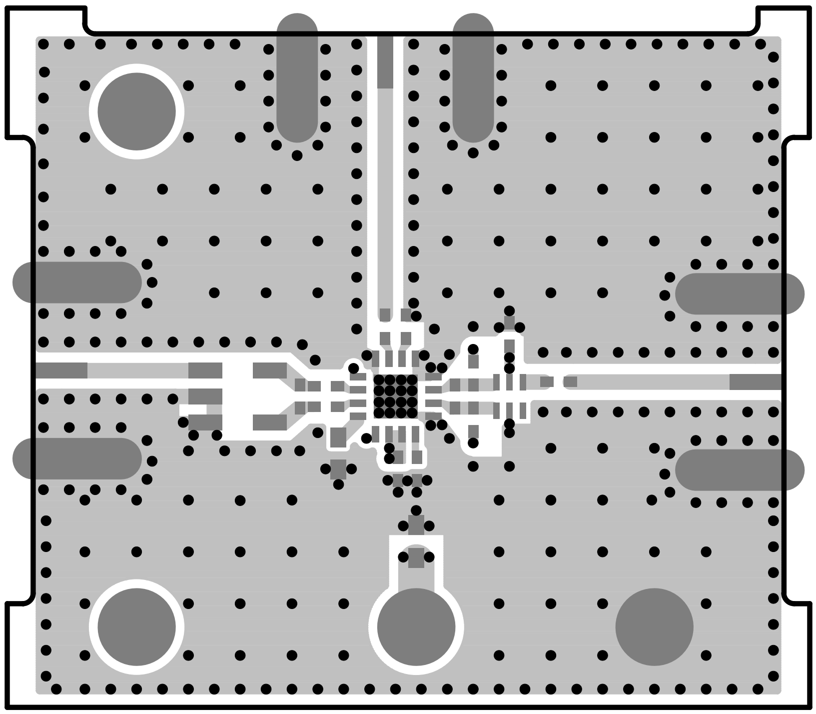
a. Clean input signals can be produced. The two-tone signals' OIP3 should be at least 15dB better than the DUT's IIP3.

b. The spectrum analyzer's internal distortion is minimized.

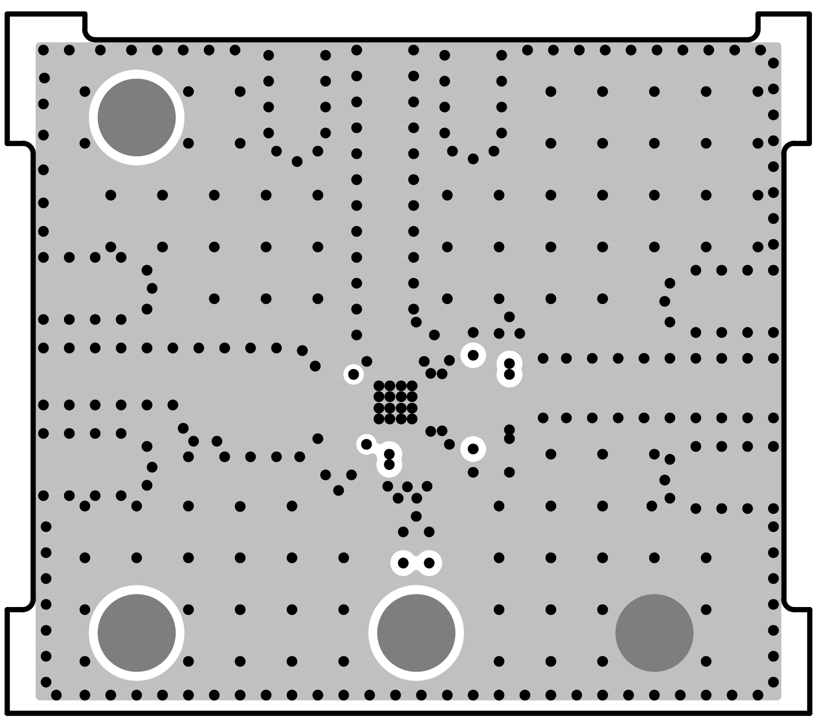
c. The spectrum analyzer has enough dynamic range and sensitivity. The measurement system's IIP3 should be at least 15dB better than the DUT's OIP3.

d. The system is accurately calibrated for power and frequency.

PCB LAYOUT

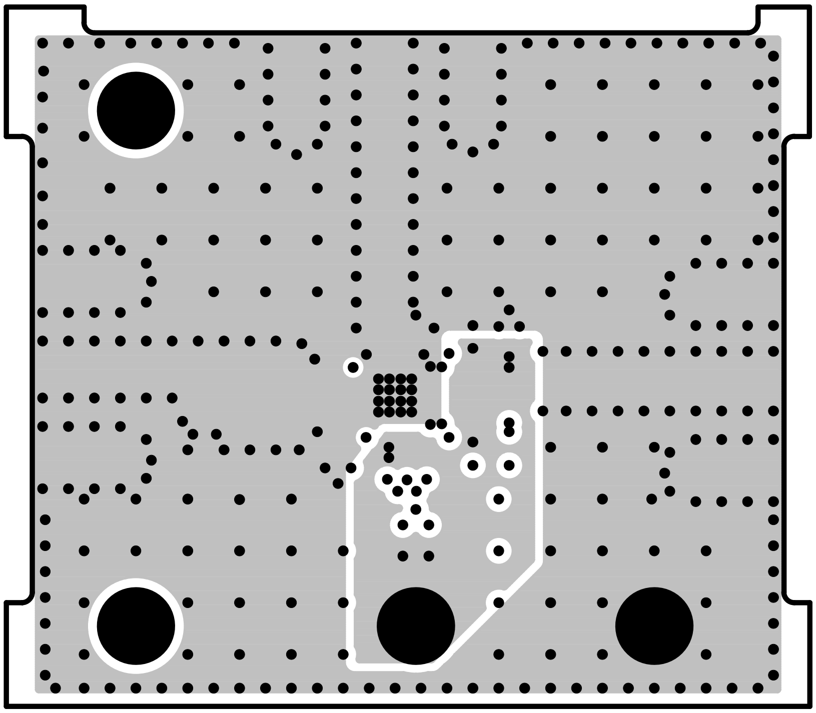


Layer 1, Top Layer

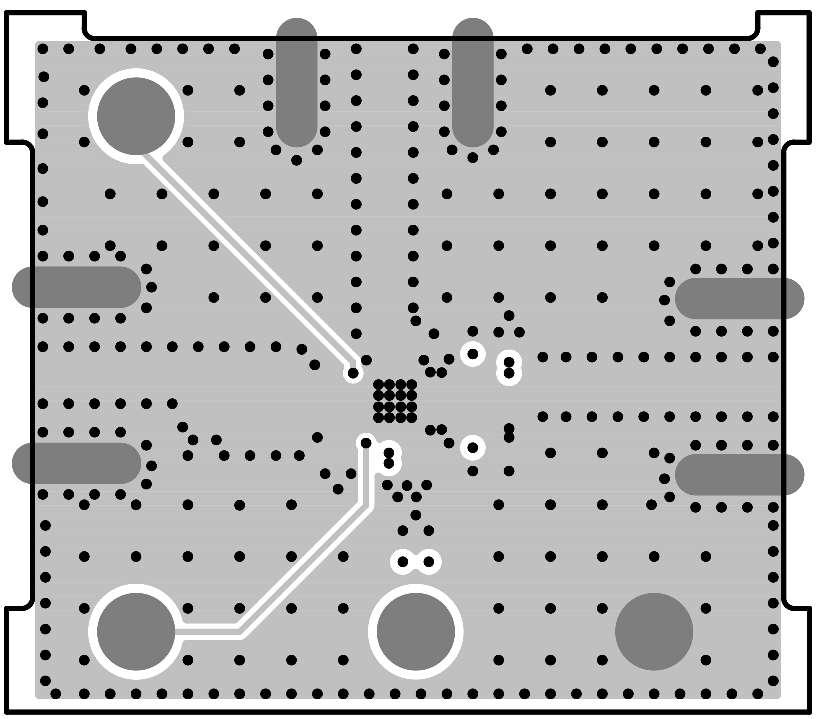


Layer 2, Ground Plane

PCB LAYOUT



Layer 3, Power Plane



Layer 4, Bottom Layer

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	4	C1, C2, C4, C5	CAP, 0402, X7R, 16V, 0.1µF, 10%	MURATA, GRM155R71C104KA88D
2	1	C3	CAP, 0402, C0G, 50V, 0.7pF, ±0.1pF	MURATA, GJM1555C1HR70BB01D
3	1	C6	CAP, 0603, X7R, 16V, 1µF, 10%	MURATA, GRM188R71C105KA12D
4	2	C7, C8	CAP, 0402, X7R, 16V, 10nF, 10%	MURATA, GRM155R71C103KA01D
5	1	C9	CAP, 0402, C0G, 50V, 6.8pF, ±0.1pF	MURATA, GJM1555C1H6R8BB01D
6	4	E1, E2, E3, E4	TESTPOINT, TURRET, 0.094"	MILL-MAX, 2501-2-00-80-00-00-07-0
7	3	J1, J2, J3	CONN, SMA, 50Ω, EDGE-LAUNCH	E. F. JOHNSON, 142-0701-851
8	2	L1, L2	IND, 0402, WIRE-WOUND, 6.8nH, 2%	COILCRAFT, 0402HP-6N8XGLU
9	1	L3	RES, 0603, 0Ω JUMPER	VISHAY, CRCW06030000Z0ED
10	1	R1	RES, 0402, 1/16W, 4.75k, 1%	VISHAY, CRCW04024K75FKED
11	1	T1	XFMR, 1:1, 4.5-3000MHz	MINI-CIRCUITS, TC1-1-13M+
12	1	T2	XFMR, 4:1, 1200-2200MHz	ANAREN, BD1222J50200AHF
13	1	U1	IC, LTC5510IUF#PBF, QFN 4mm × 4mm	LINEAR TECHNOLOGY, LTC5510IUF#PBF
15	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 1983A

SCHEMATIC DIAGRAM

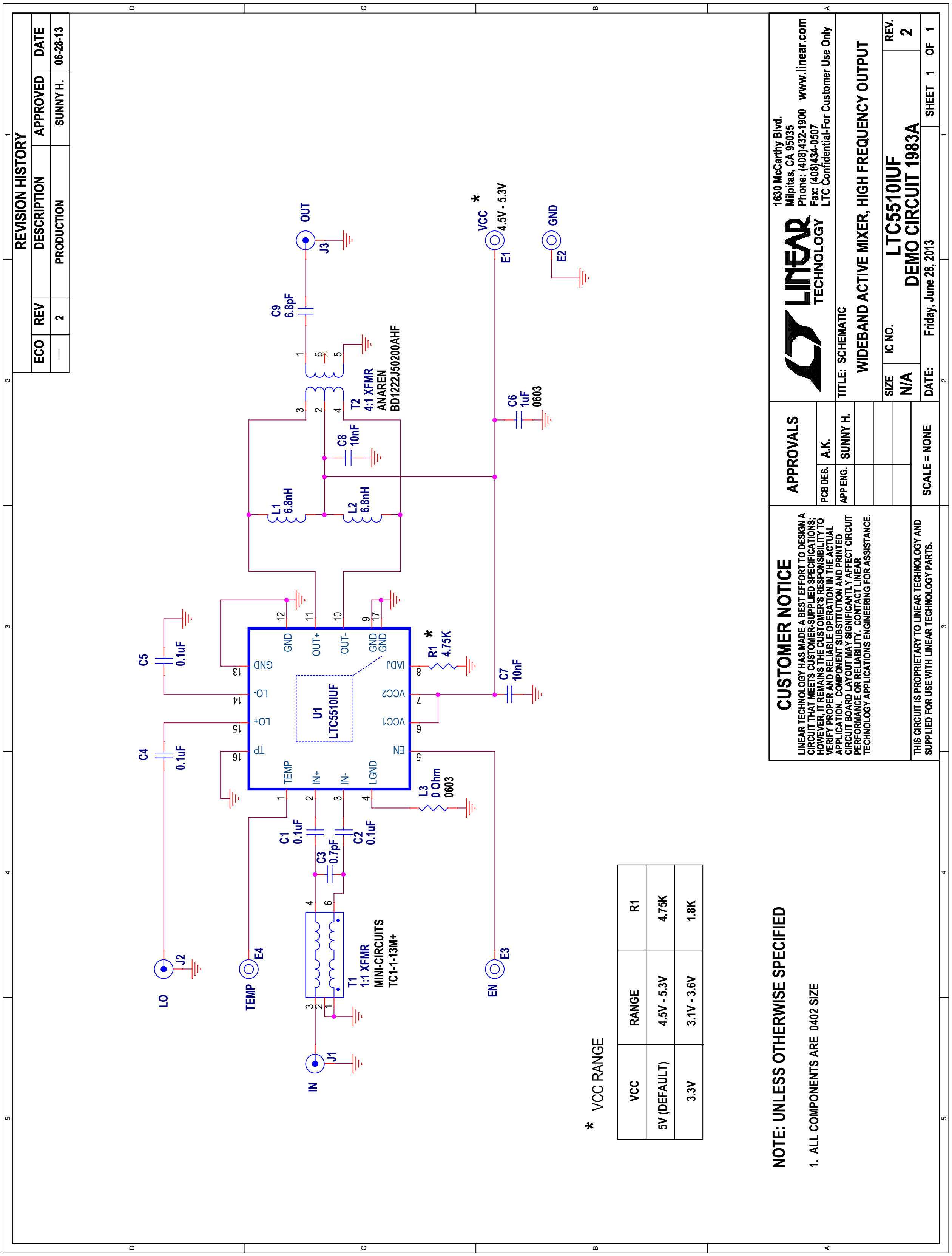


Figure 7. Demonstration Circuit Schematic

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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Please read the DEMO BOARD manual prior to handling the product. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged**.

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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