LTC5590
Dual 600MHz to 1.7GHz High Dynamic Range Downconverting Mixer

DESCRIPTION

Demonstration circuit 1710A-A is a dual 600MHz to 1.7GHz high dynamic range downconverting mixer featuring the LTC®5590. The LTC5590 is part of a family of dual-channel high dynamic range, high gain downconverting mixers covering the 600MHz to 4.5GHz frequency range. **The demo circuit 1710A-A and the LTC5590 are optimized for 600MHz to 1.7GHz RF applications. The LO frequency must fall within the 700MHz to 1.5GHz range for optimum performance.** A typical application is a LTE or GSM receiver with a 700MHz to 915MHz RF input and high side LO.

The LTC5590 is designed for 3.3V operation, however the IF amplifiers can be powered by 5V for the highest P1dB. A low current mode is provided for power savings, and each of the mixer channels has independent shutdown control.

The LTC5590's high conversion gain and high dynamic range enable the use of lossy IF filters in high-selective receiver designs, while minimizing the total solution cost, board space and system-level variation.

High Dynamic Range Dual Downconverting Mixer Family

DEMO #	IC PART #	RF RANGE	LO RANGE
DC1710A-A	**LTC5590**	**600MHz to 1.7GHz**	**700MHz to 1.5GHz**
DC1710A-A	LTC5590	1.3GHz to 2.3GHz	1.4GHz to 2.1GHz
DC1710A-C	LTC5592	1.6GHz to 2.7GHz	1.7GHz to 2.5GHz
DC1710A-D	LTC5593	2.3GHz to 4.5GHz	2.1GHz to 4.2GHz

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

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PERFORMANCE SUMMARY

T_C = 25°C, VCC = VCCIF = 3.3V, ENA = ENB = High, ISEL = Low, P_{LO} = 0dBm, P_{RF} = –3dBm (Δf = 2MHz for two-tone IIP3 tests), unless otherwise noted. (Note 1)

PARAMETER	CONDITIONS	VALUE	UNITS
VCC Supply Voltage Range		3.1 to 3.5	V
VCCIF Supply Voltage Range		3.1 to 5.3	V
Total Supply Current (VCC + VCCIF), Normal Power Mode	Both Mixer Channels Enabled	379	mA
Total Supply Current (VCC + VCCIF), Low Power Mode	Both Mixer Channels Enabled, ISEL = High	239	mA
Total Supply Current During Shutdown	ENA = ENB = Low	≤500	µA
ENA, ENB Input High Voltage (Channel Enabled)		>2.5	V
ENA, ENB Input Low Voltage (Channel Disabled)		<0.3	V
ENA, ENB Input Current	–0.3V to VCC + 0.3V	–20 to 30	µA
ISEL Input High Voltage (Low Power Mode)		>2.5	V
ISEL Input Low Voltage (Normal Power Mode)		<0.3	V
ISEL Input Current	–0.3V to VCC + 0.3V	–20 to 30	µA

PERFORMANCE SUMMARY

T_C = 25°C, VCC = VCCIF = 3.3V, ENA = ENB = High, ISEL = Low, P_{LO} = 0dBm, P_{RF} = –3dBm (Δf = 2MHz for two-tone IIP3 tests), unless otherwise noted. (Note 1)

PARAMETER	CONDITIONS	VALUE	UNITS
LO Input Frequency Range		700 to 1500	MHz
LO Input Return Loss	Z_0 = 50Ω, f_{LO} = 700MHz to 1500MHz	>12	dB
LO Input Power Range	f_{LO} = 700MHz to 1500MHz	–4 to 6	dBm
RF Input Frequency Range	Low Side LO High Side LO	1100 to 1700 600 to 1100	MHz MHz
RF Input Return Loss	Z_0 = 50Ω, f_{RF} = 700MHz to 1400MHz	>12	dB
IF Output Frequency	Can be re-matched for other frequencies	190	MHz
IF Output Return Loss	Z_0 = 50Ω	>12	dB
LO to RF Leakage	f_{LO} = 700MHz to 1500MHz	< –36	dBm
LO to IF Leakage	f_{LO} = 700MHz to 1500MHz	< –26	dBm
RF to LO Isolation	f_{RF} = 600MHz to 1700MHz	>56	dB
RF to IF Isolation	f_{RF} = 600MHz to 1700MHz	>17	dB
Channel-to-Channel Isolation	f_{RF} = 600MHz to 1200MHz f_{RF} = 1200MHz to 1700MHz	>50 >45	dB dB
High Side LO Downmixer Application: ISEL = Low, RF = 700MHz to 1100MHz, IF = 190MHz, $f_{LO} = f_{RF} + f_{IF}$			
Conversion Gain	RF = 700MHz RF = 900MHz RF = 1100MHz	8.6 8.7 8.5	dB dB dB
Input 3rd Order Intercept	RF = 700MHz RF = 900MHz RF = 1100MHz	25.3 26 24.8	dBm dBm dBm
SSB Noise Figure	RF = 700MHz RF = 900MHz RF = 1100MHz	9.3 9.7 9.9	dB dB dB
SSB Noise Figure Under Blocking	f_{RF} = 900MHz, f_{LO} = 1090MHz, f_{BLOCK} = 800MHz, P_{BLOCK} = 5dBm P_{BLOCK} = 10dBm	 15.6 21.2	 dB dB
2LO – 2RF Output Spurious Product ($f_{RF} = f_{LO} - f_{IF}/2$)	f_{RF} = 995MHz at –10dBm, f_{LO} = 1090MHz, f_{IF} = 190MHz	–77	dBc
3LO – 3RF Output Spurious Product ($f_{RF} = f_{LO} - f_{IF}/3$)	f_{RF} = 1026.67MHz at –10dBm, f_{LO} = 1090MHz, f_{IF} = 190MHz	–77	dBc
Input 1dB Compression	f_{RF} = 900MHz, VCCIF = 3.3V f_{RF} = 900MHz, VCCIF = 5V	10.7 14.1	dBm dBm
Low Power Mode, High Side LO Downmixer Application: ISEL = High, RF = 700MHz to 1100MHz, IF = 190MHz, $f_{LO} = f_{RF} + f_{IF}$			
Conversion Gain	RF = 900MHz	7.7	dB
Input 3rd Order Intercept	RF = 900MHz	21.5	dBm
SSB Noise Figure	RF = 900MHz	9.9	dB
Input 1dB Compression	f_{RF} = 900MHz, VCCIF = 3.3V f_{RF} = 900MHz, VCCIF = 5V	10.4 10.9	dBm dBm

PERFORMANCE SUMMARY

T_C = 25°C, VCC = VCCIF = 3.3V, ENA = ENB = High, ISEL = Low, P_{LO} = 0dBm, P_{RF} = –3dBm (Δf = 2MHz for two-tone IIP3 tests), unless otherwise noted. (Note 1)

PARAMETER	CONDITIONS	VALUE	UNITS
Low Side LO Downmixer Application: ISEL = Low, RF = 1100MHz to 1600MHz, IF = 190MHz, $f_{LO} = f_{RF} – f_{IF}$			
Conversion Gain	RF = 1200MHz RF = 1400MHz RF = 1600MHz	8.6 8.4 7.7	dB dB dB
Input 3rd Order Intercept	RF = 1200MHz RF = 1400MHz RF = 1600MHz	27.5 27.3 27.2	dBm dBm dBm
SSB Noise Figure	RF = 1200MHz RF = 1400MHz RF = 1600MHz	9.9 9.7 10.4	dB dB dB
SSB Noise Figure Under Blocking	f_{RF} = 1400MHz, f_{LO} = 1210MHz, f_{BLOCK} = 1500MHz, P_{BLOCK} = 5dBm P_{BLOCK} = 10dBm	 15 20.8	 dB dB
2RF – 2LO Output Spurious Product ($f_{RF} = f_{LO} + f_{IF}/2$)	f_{RF} = 1305MHz at –10dBm, f_{LO} = 1210MHz, f_{IF} = 190MHz	–72	dBc
3RF – 3LO Output Spurious Product ($f_{RF} = f_{LO} + f_{IF}/3$)	f_{RF} = 1273.33MHz at –10dBm, f_{LO} = 1210MHz, f_{IF} = 190MHz	–72	dBc
Input 1dB Compression	f_{RF} = 1400MHz, VCCIF = 3.3V f_{RF} = 1400MHz, VCCIF = 5V	11 14.4	dBm dBm

Note 1: Subject to change without notice. Refer to the latest LTC5590 data sheet for 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 (VCC).....4.0V
IF Supply Voltage (VCCIF).....5.5V
Enable Voltage (ENA, ENB) .....–0.3V to VCC + 0.3V
Bias Adjust Voltage (IFBA, IFBB).....–0.3V to VCC + 0.3V
Power Select Voltage (ISEL) .....–0.3V to VCC + 0.3V
LO Input Power (300MHz to 3GHz).....9dBm
RFA, RFB Input Power (300MHz to 3GHz) 15dBm
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 VCC and VCCIF turrets. Instead, make all necessary connections with power supplies turned off, then increase to operating voltage.

ENABLE FUNCTION

The LTC5590's two mixer channels can be independently enabled or disabled. When the Enable voltage (ENA or ENB) is logic high (>2.5V), the corresponding mixer channel is enabled. When the Enable voltage is logic low (<0.3V), the mixer channel is disabled. The voltages at the enable pins should never fall below –0.3V or exceed the power supply voltage by more than 0.3V. The Enable pins must be pulled high or low. If left floating, the on/off state of the IC will be indeterminate. A logic table for the Enable control (ENA, ENB) is shown in Table 1.

Table 1. Enable Control Logic Table

ENA, ENB	MIXER CHANNEL STATE
Low	Disabled
High	Enabled

DETAILED DESCRIPTION

LOW POWER MODE

The LTC5590 features a low power mode, which allows the flexibility to choose a 37% total power saving when lower RF performance is acceptable. When the ISEL voltage is logic low (<0.3V), both mixer channels operate at nominal power and best performance. When the ISEL voltage is logic high (>2.5V), both mixer channels are in low power mode and operate with reduced performance. The ISEL voltage should never fall below –0.3V or exceed the power supply voltage by more than 0.3V. The ISEL pin must be pulled low or high. If left floating, the operating state of the IC will be indeterminate. A logic table for ISEL is shown in Table 2.

Table 2. ISEL Logic Table

ISEL	OPERATING MODE
Low	Normal power, best performance
High	Low power, reduced performance

RF INPUTS

Demonstration circuit 1710A-A's RF inputs of channel A and channel B are identical. For the RF inputs to be matched, the appropriate LO signal must be applied. The RF inputs' impedance is dependent on LO frequency, but the demonstration circuit 1710A-A's RF inputs are well matched to 50Ω from 700MHz to 1.4GHz, with better than 12dB return loss, when a 700MHz to 1.5GHz LO signal is applied. Outside this frequency range, the desired impedance match can be obtained through the adjustment of external matching component values.

LO INPUT

The LTC5590's LO amplifier is optimized for the 700MHz to 1.5GHz LO frequency range. LO frequencies above and below this frequency range may be used with degraded performance. The LO input is always 50Ω-matched when VCC is applied to the chip, even when one or both of the channels is disabled. The nominal LO input level is 0dBm. The LO input power range is between –4dBm and 6dBm.

IF OUTPUTS

Demonstration circuit 1710A-A features single-ended, 50Ω-matched IF outputs for 190MHz. The channel A and the channel B IF outputs are identical, and the impedance matching is realized with a bandpass topology using IF transformers as shown in Figure 1. Only channel A is shown for clarity and simplicity.

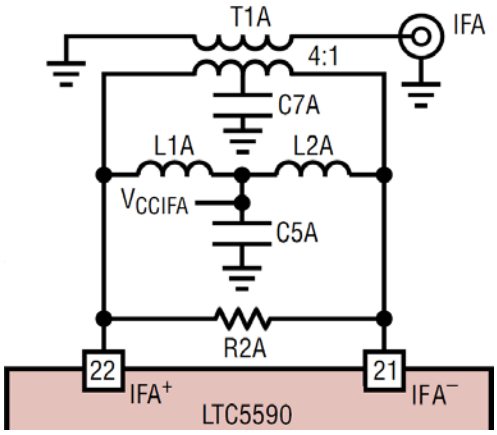


Figure 1. IF Output with Bandpass Matching

Demonstration circuit 1710A-A can be easily reconfigured for other IF frequencies by simply replacing inductors L1A, L2A, L1B and L2B. Inductor values for several common IF frequencies are presented in Table 3, and return losses are plotted in Figure 2. An external load resistor, R2A, can be used to improve impedance matching if desired.

Table 3. Inductor Values vs. IF Frequencies

IF FREQUENCY (MHz)	L1A, L2A, L1B, L2B (nH)
140	270
190	150
240	100
300	56
380	33
450	22

For IF frequencies below 90MHz, the values of the inductors become unreasonably high, and the lowpass topology shown in Figure 3 is preferred. See the LTC5590 data sheet for details.

DETAILED DESCRIPTION

Demonstration circuit 1710A-A's IF outputs can be easily converted to lowpass matching. Follow the procedures below, and refer to Figure 3 and Figure 4 to modify the channel A IF output. Modifications for Channel B are similar.

a. Remove existing L1A, L2A, and C7A.

b. Cut the traces leading to the IF transformer close to the pads of L1A and L2A.

c. Insert series inductors onto the cut traces.

d. Install a 0Ω jumper between the pads of C5A and C7A.

e. Install resistor at location R2A.

f. Install C9A next to, or on top of, R2A.

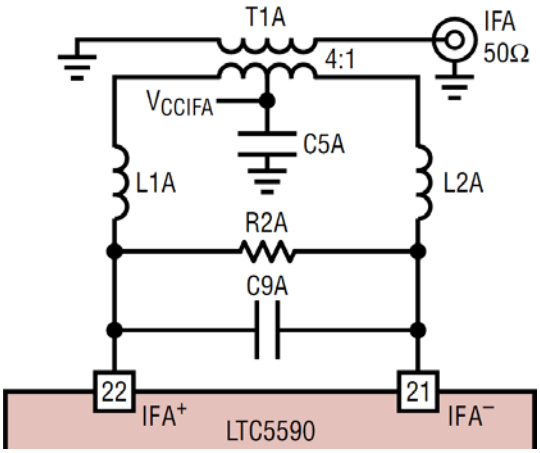


Figure 3. IF Output with Lowpass Matching

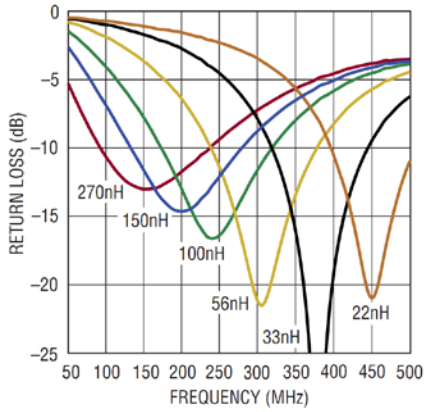


Figure 2. IF Output Return Loss with Bandpass Matching

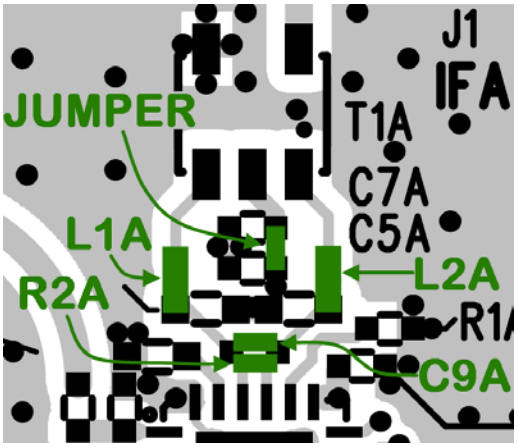


Figure 4. IF Output with Lowpass Matching

MEASUREMENT EQUIPMENT AND SETUP

The LTC5590 is a dual high dynamic range downconverting mixer IC with very high input 3rd order intercept. Accuracy of its performance measurement is highly dependent on equipment setup and measurement technique. The recommended measurement setups are presented in Figure 5, Figure 6, and Figure 7. 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 that provide broadband 50Ω-termination on all ports and have good port-to-port isolation should be used, such as the MCLI PS2-17.
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

MEASUREMENT EQUIPMENT AND SETUP

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.

A SPECIAL NOTE ABOUT RF TERMINATION

The LTC5590 consists of high linearity passive double-balanced mixer cores and IF buffer amplifiers. Due to the bidirectional nature of all passive mixers the LO±IF mixing products, also referred to as pseudo-image spurs, are always present at the RF input, typically at a level 12dB below the RF input signal. Mismatched impedances at the pseudo-image spur frequencies, such as when filters are used for SSB NF measurements, can significantly impact the linearity and noise figure measurements. To avoid interference from the pseudo-image spurs, terminate the RF input port with an isolator, diplexer, or attenuator. In the recommended measurement setups presented in Figure 6 and Figure 7, the 6dB attenuator pad at the demonstration circuit's RF input serves this purpose.

QUICK START PROCEDURE

Demonstration circuit 1710A-A is easy to set up to evaluate the performance of the LTC5590. Refer to Figure 5, Figure 6, and Figure 7 for proper equipment connections. The following procedures describe performing measurements on Mixer Channel A. The measurement procedures for Mixer Channel B are identical.

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 –3dBm.
2. Calibrate the Network Analyzer.
3. Connect all test equipment as shown in Figure 5 with the signal generator and the DC power supply turned off.
4. Increase the DC power supply voltage to 3.3V, and verify that the total current consumption is close to the figure listed in the Typical Demonstration Circuit Performance Summary. The supply voltage should be confirmed at the demo board VCC, VCCIF and GND terminals to account for lead ohmic losses.

QUICK START PROCEDURE

5. With the LO signal applied, and all unused demo board ports terminated in 50Ω, measure return losses of the RFA input and IFA output ports.
6. Set the test signal to 0dBm, and re-calibrate the Network Analyzer.
7. Terminate all unused demo board ports in 50Ω. Measure return losses of the LO input port.

RF PERFORMANCE MEASUREMENTS

1. Connect all test equipment as shown in Figure 6 with the signal generators and the DC power supply turned off.
2. Increase the DC power supply voltage to 3.3V, and verify that the total current consumption is close to the figure listed in the Typical Demonstration Circuit Performance Summary. The supply voltage should be confirmed at the demo board VCC, VCCIF and GND terminals to account for 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 –3dBm CW signals, 2MHz apart, at the appropriate RF frequencies to the demo board RFA input port.
5. Measure the resulting IFA output on the Spectrum Analyzer:
   a. The wanted two-tone IF output signals are at:

      $f_{IF1} = f_{RF1} – f_{LO}$, and
      $f_{IF2} = f_{RF2} – f_{LO}$ for low side LO,
      and
      $f_{IF1} = f_{LO} – f_{RF1}$, and
      $f_{IF2} = f_{LO} – f_{RF2}$ for high side LO

   b. The 3rd order intermodulation products which are closest to the wanted IF signals are used to calculate the Input 3rd Order Intercept:

      $f_{IM3,1} = f_{RF1} – f_{LO} - \Delta_{IF}$, and
      $f_{IM3,2} = f_{RF2} – f_{LO} + \Delta_{IF}$ for low side LO,
      and
      $f_{IM3,1} = f_{LO} – f_{RF1} + \Delta_{IF}$, and
      $f_{IM3,2} = f_{LO} – f_{RF2} - \Delta_{IF}$ for high side LO
      Where $\Delta_{IF} = f_{RF2} – f_{RF1}$.

6. Calculate Input 3rd Order Intercept:

   $$IIP3 = (\Delta_{IM3})/2 + P_{RF}$$

   Where $\Delta_{IM3} = P_{IF} - P_{IM3}$. P_{IF} is the lowest IF output signal power at either f_{IF1} or f_{IF2}. P_{IM3} is the highest 3rd order intermodulation product power at either $f_{IM3,1}$ or $f_{IM3,2}$. P_{RF} is the per tone RF input power.
7. Turn off one of the RF signal generators, and measure Conversion Gain, RF to IF isolation, LO to IF 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 7 with the signal generator and the DC power supply turned off.
3. Increase the DC power supply voltage to 3.3V, and verify that the total current consumption is close to the figure listed in the Typical Demonstration Circuit Performance Summary. The supply voltage should be confirmed at the demo board VCC, VCCIF and GND terminals to account for lead ohmic losses.
4. Measure the single-sideband noise figure.

QUICK START PROCEDURE

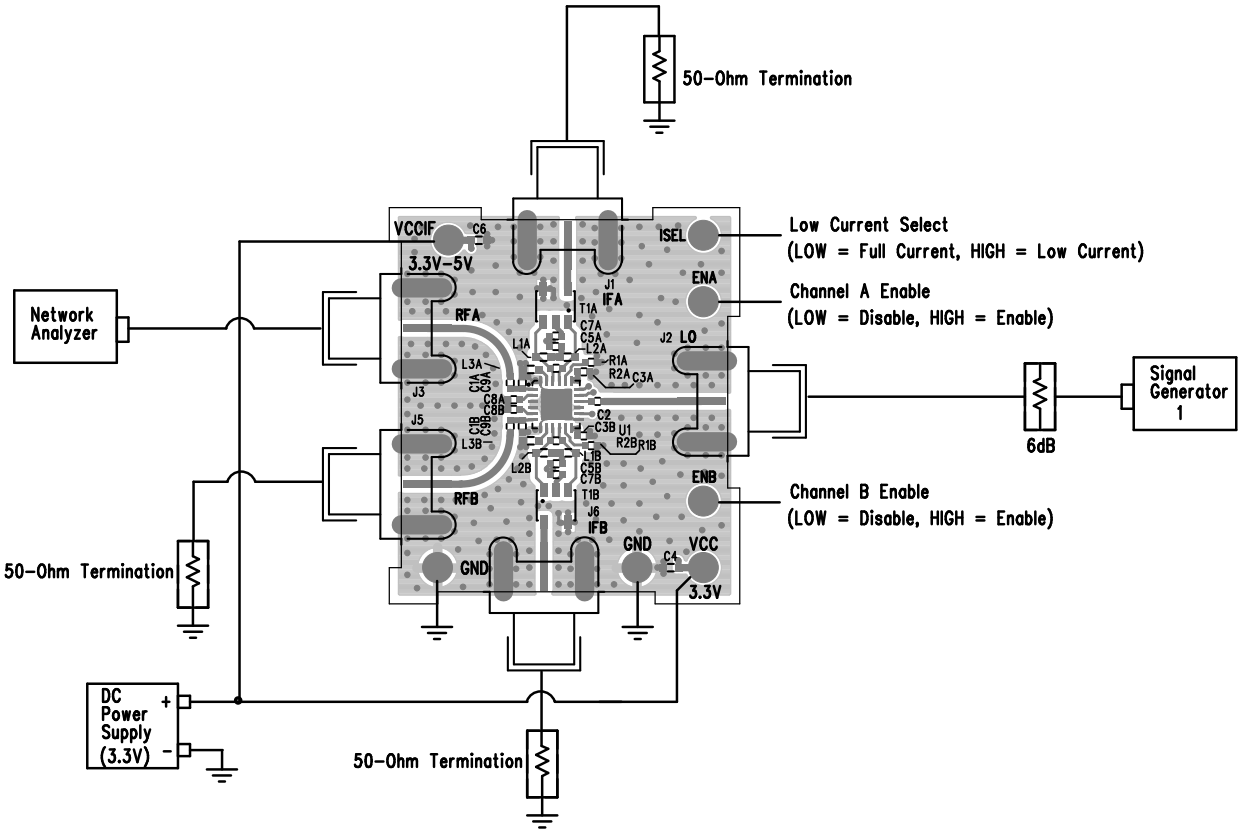


Figure 5. Proper Equipment Setup for Return Loss Measurements

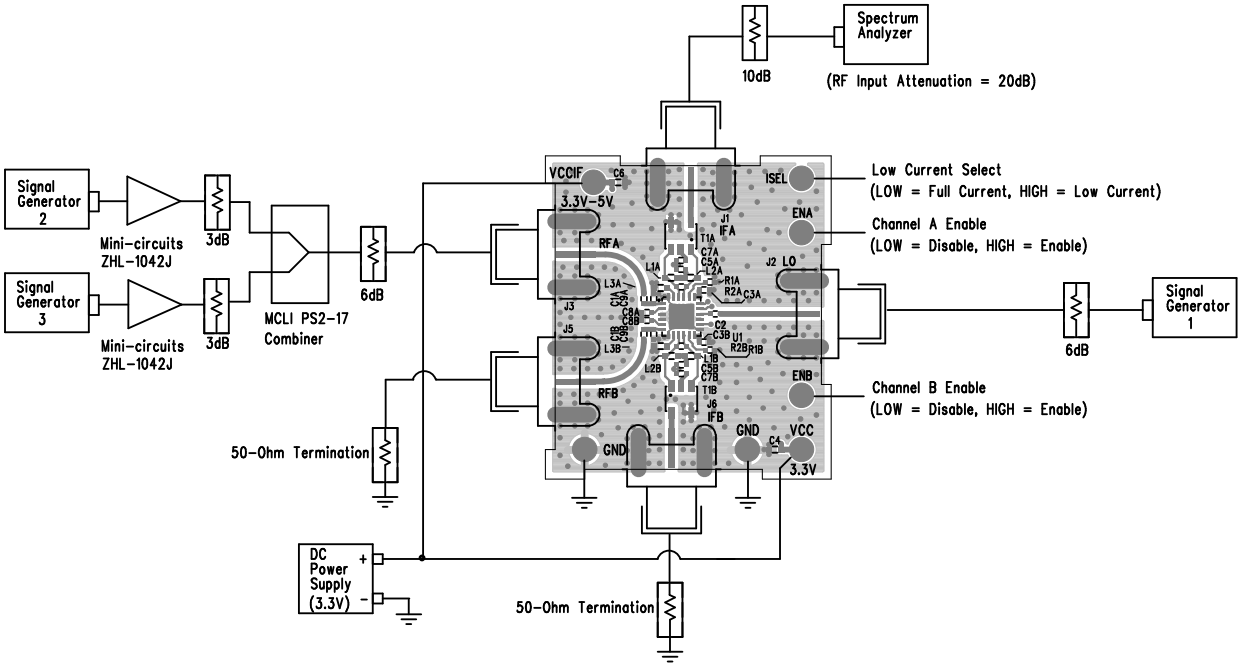


Figure 6. Proper Equipment Setup for RF Performance Measurements

QUICK START PROCEDURE

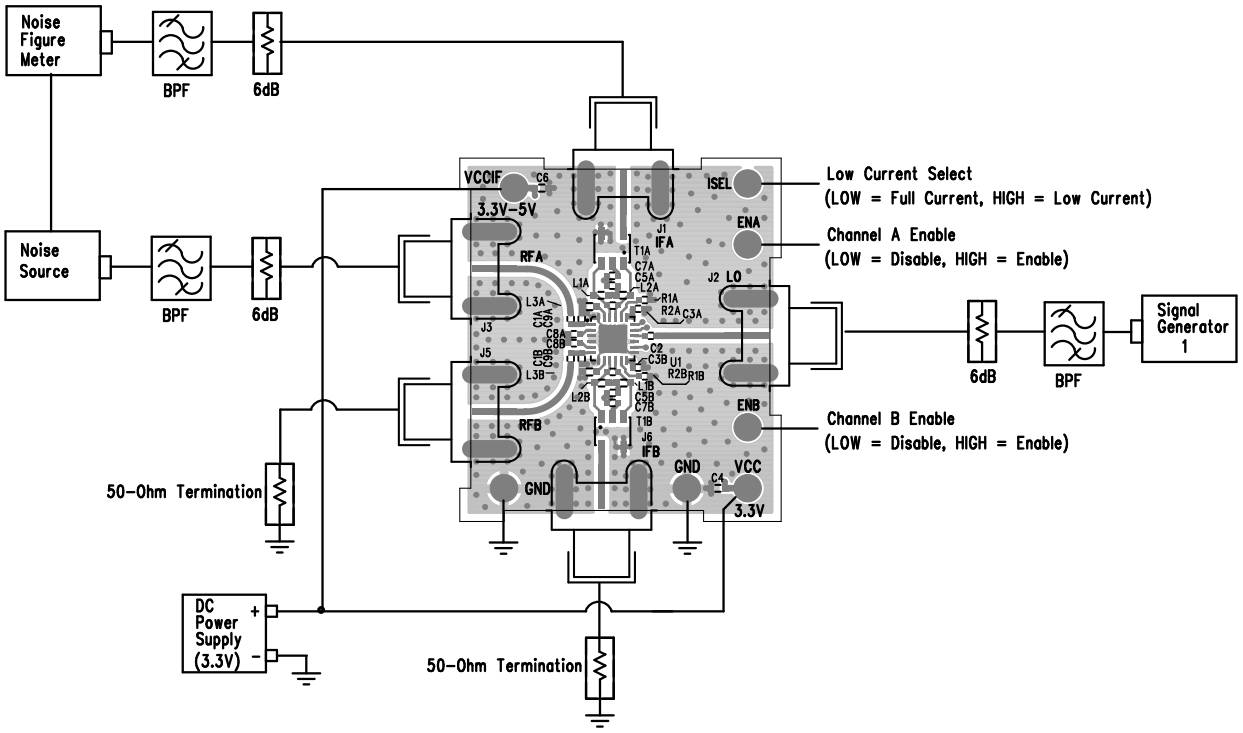
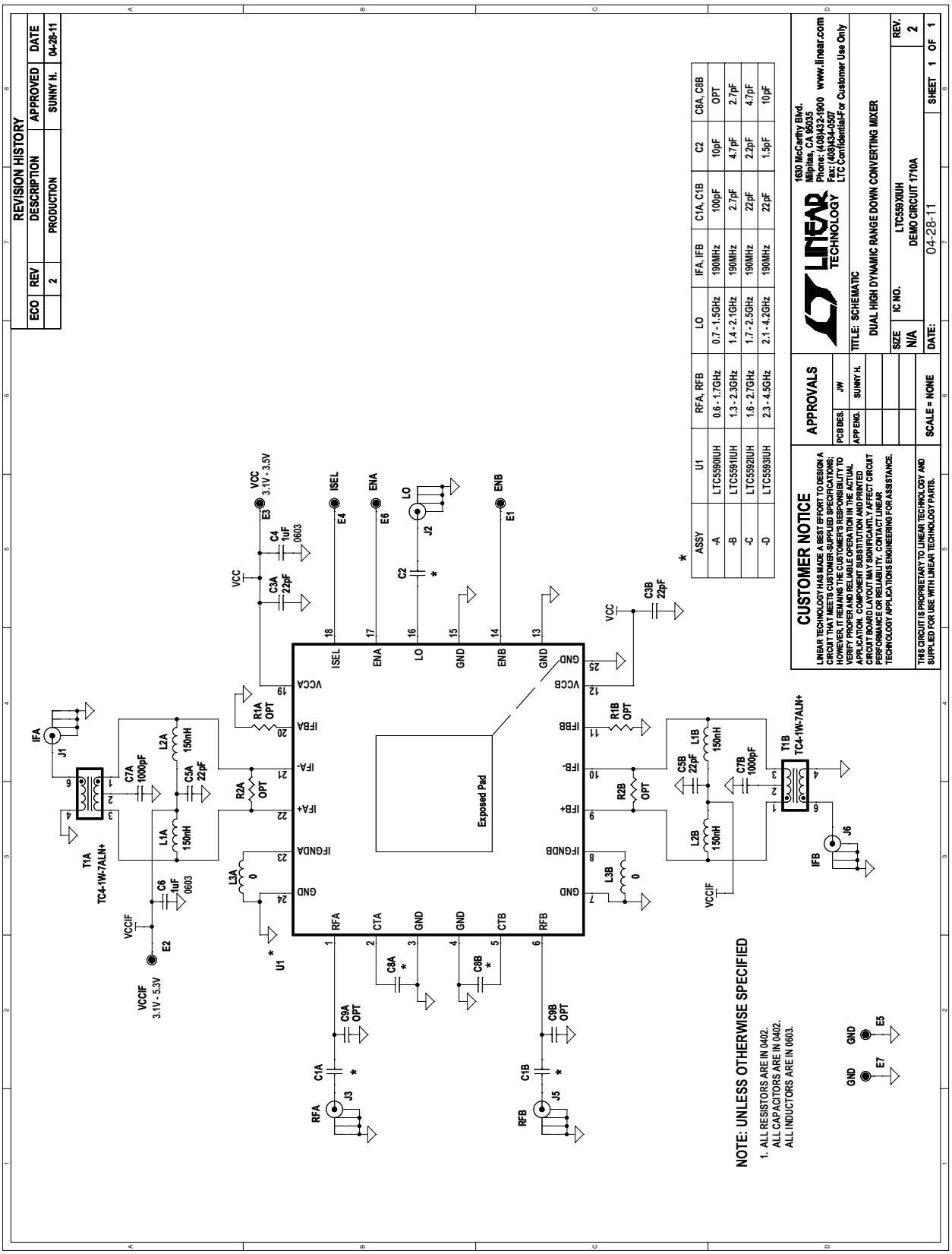


Figure 7. Proper Equipment Setup for Noise Figure Measurement

PARTS LIST

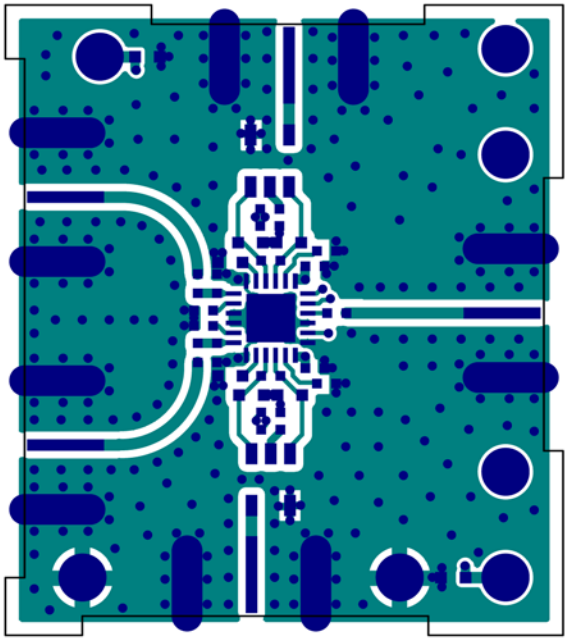
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	2	C1A, C1B	CAP., C0G, 100pF, ±1%, 50V, 0402	AVX, 04025A101FAT
2	1	C2	CAP., C0G, 10pF, ±1%, 50V, 0402	AVX, 04025A100FAT
3	4	C3A, C3B, C5A, C5B	CAP., C0G, 22pF, ±1%, 50V, 0402	AVX, 04025A220FAT
4	2	C4, C6	CAP., X5R, 1µF, ±10%, 10V, 0603	AVX, 0603ZD105KAT
5	2	C7A, C7B	CAP., X7R, 1000pF, ±5%, 50V, 0402	AVX, 04025C102JAT
6	0	C8A, C8B, C9A, C9B (OPT)	CAP., 0402, OPTION	
7	7	E1, E2, E3, E4, E5, E6, E7	TESTPOINT, TURRET, 0.061"	MILL-MAX, 2308-2-00-80-00-00-07-0
8	5	J1, J2, J3, J5, J6	CONN., SMA, 50Ω, EDGE-LAUNCH	AMPHENOL CONNEX, 132357
9	4	L1A, L1B, L2A, L2B	IND., WIRE-WOUND, 150nH, ±2%, 0603	COILCRAFT, 0603CS-R15XGLW
10	2	L3A, L3B	RES., CHIP, 0Ω, 0603	VISHAY, CRCW06030000Z0EA
11	0	R1A, R1B, R2A, R2B (OPT)	RES., 0402, OPTION	
12	2	T1A, T1B	TRANSFORMER, SMT, RF WIDEBAND, 4:1	MINI-CIRCUITS, TC4-1W-7ALN+
13	1	U1	IC., LTC5590IUH, QFN 5X5	LINEAR TECHNOLOGY, LTC5590IUH#PBF

SCHEMATIC DIAGRAM

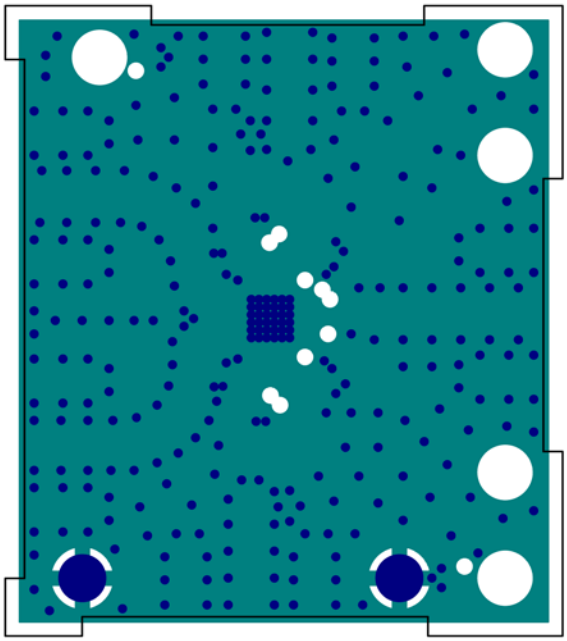


PCB LAYOUT

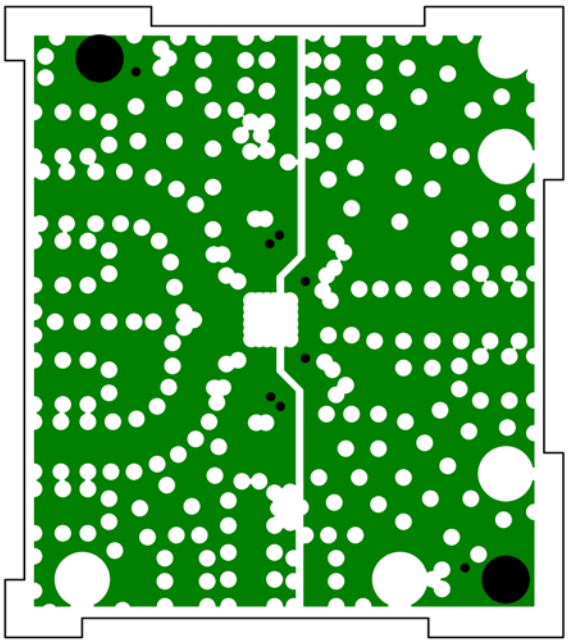
Layer 1. Top Layer



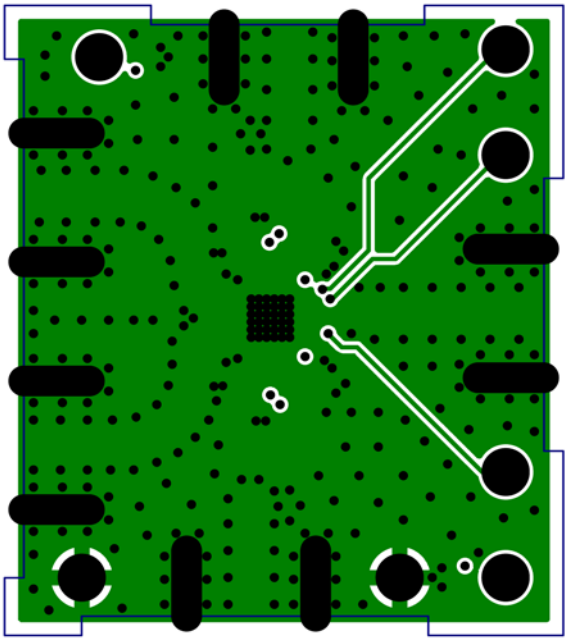
Layer 2. Ground Plane



Layer 3. Power Plane



Layer 4. Bottom Layer



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

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