LTC5590

Dual 600MHz to 1.7GHz High Dynamic Range Downconverting Mixer

FEATURES

- **Conversion Gain: 8.7dB at 900MHz**
- **IIP3: 26dBm at 900MHz**
- **Noise Figure: 9.7dB at 900MHz**
- **15.6dB NF Under 5dBm Blocking**
- **High Input P1dB; 14.1dBm at 5V**
- **53dB Channel-to-Channel Isolation**
- **1.25W Power Consumption at 3.3V**
- **Low Current Mode for <800mW Consumption**
- **Enable Pins for Each Channel**
- **50Ω Single-Ended RF and LO Inputs**
- **LO Input Matched In All Modes**
- **0dBm LO Drive Level**
- **Small Package and Solution Size**
- **–40°C to 105°C Operation**

APPLICATIONS

- 3G/4G Wireless Infrastructure Diversity Receivers (LTE, CDMA, GSM)
- MIMO Infrastructure Receivers
- High Dynamic Range Downmixer Applications

DESCRIPTION

The LTC®5590 is part of a family of dual-channel high dynamic range, high gain downconverting mixers covering the 600MHz to 4GHz RF frequency range. **The LTC5590 is 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.

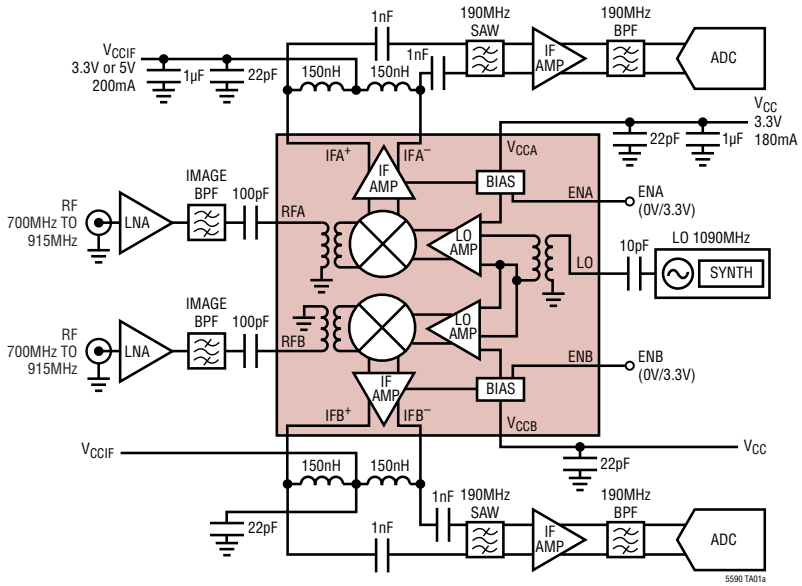
The LTC5590's high conversion gain and high dynamic range enable the use of lossy IF filters in high selectivity receiver designs, while minimizing the total solution cost, board space and system-level variation. A low current mode is provided for additional power savings and each of the mixer channels has independent shutdown control.

High Dynamic Range Dual Downconverting Mixer Family

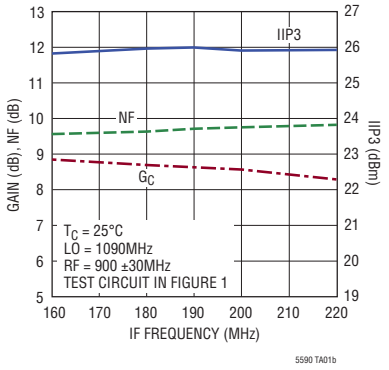
PART NUMBER	RF RANGE	LO RANGE
LTC5590	**600MHz to 1.7GHz**	**700MHz to 1.5GHz**
LTC5591	1.3GHz to 2.3GHz	1.4GHz to 2.1GHz
LTC5592	1.6GHz to 2.7GHz	1.7GHz to 2.5GHz
LTC5593	2.3GHz to 4GHz	2.4GHz to 3.6GHz

TYPICAL APPLICATION

Wideband Receiver



Wideband Conversion Gain NF and IIP3 vs IF Frequency (Mixer Only, Measured on Evaluation Board)

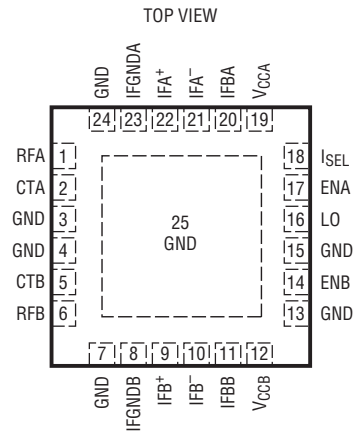


ABSOLUTE MAXIMUM RATINGS

(Note 1)

Mixer Supply Voltage (V_{CC}).....4.0V
IF Supply Voltage (V_{CCIF}).....5.5V
Enable Voltage (ENA, ENB) .....–0.3V to V_{CC} + 0.3V
Power Select Voltage (I_{SEL}) .....–0.3V to V_{CC} + 0.3V
LO Input Power (1GHz to 3GHz).....9dBm
LO Input DC Voltage..... ±0.1V
RFA, RFB Input Power (1GHz to 3GHz) 15dBm
RFA, RFB Input DC Voltage ..... ±0.1V
Operating Temperature Range (T_C).....–40°C to 105°C
Storage Temperature Range .....–65°C to 150°C
Junction Temperature (T_J) ..... 150°C

PIN CONFIGURATION



UH PACKAGE
24-LEAD (5mm × 5mm) PLASTIC QFN
T_{JMAX} = 150°C, θ_{JC} = 7°C/W
EXPOSED PAD (PIN 25) IS GND, MUST BE SOLDERED TO PCB

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC5590IUH#PBF	LTC5590IUH#TRPBF	5590	24-Lead (5mm × 5mm) Plastic QFN	–40°C to 105°C

Consult LTC Marketing for parts specified with wider operating temperature ranges.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, unless otherwise noted. Test circuit shown in Figure 1. (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply Requirements (V_{CCA}, V_{CCB}, V_{CCIFA}, V_{CCIFB})					
V_{CCA}, V_{CCB} Supply Voltage (Pins 12, 19)		3.1	3.3	3.5	V
V_{CCIFA}, V_{CCIFB} Supply Voltage (Pins 9, 10, 21, 22)		3.1	3.3	5.3	V
Mixer Supply Current (Pins 12, 19)			188	TBD	mA
IF Amplifier Supply Current (Pins 9, 10, 21, 22)			191	TBD	mA
Total Supply Current (Pins 9, 10, 12, 19, 21, 22)			379	TBD	mA
Total Supply Current – Shutdown	ENA = ENB = Low			500	µA
Enable Logic Input (ENA, ENB) High = On, Low = Off					
ENA, ENB Input High Voltage (On)		2.5			V
ENA, ENB Input Low Voltage (Off)				0.3	V
ENA, ENB Input Current	–0.3V to V_{CC} + 0.3V	–20		30	µA
Turn On Time			1		µs
Turn Off Time			1.5		µs

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, unless otherwise noted. Test circuit shown in Figure 1. (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Low Current Mode Logic Input (I_{SEL}) High = Low Power, Low = Normal Power Mode					
I_{SEL} Input High Voltage		2.5			V
I_{SEL} Input Low Voltage				0.3	V
I_{SEL} Input Current	–0.3V to V_{CC} + 0.3V	–20		30	µA
Low Current Mode Current Consumption (I_{SEL} = High)					
Mixer Supply Current (Pins 12, 19)			123	TBD	mA
IF Amplifier Supply Current (Pins 9, 10, 21, 22)			116	TBD	mA
Total Supply Current (Pins 9, 10, 12, 19, 21, 22)			239	TBD	mA

AC ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (Δf = 2MHz for two tone IIP3 tests), unless otherwise noted. Test circuit shown in Figure 1. (Notes 2, 3, 4)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
LO Input Frequency Range			700 to 1500		MHz
RF Input Frequency Range	Low Side LO High Side LO		1100 to 1700 600 to 1100		MHz MHz
IF Output Frequency Range	Requires External Matching		5 to 500		MHz
RF Input Return Loss	Z_O = 50Ω, 700MHz to 1600MHz		>12		dB
LO Input Return Loss	Z_O = 50Ω, 700MHz to 1500MHz		>12		dB
IF Output Impedance	Differential at 190MHz		300Ω||2.3pF		R||C
LO Input Power	f_{LO} = 700MHz to 1500MHz	–4	0	6	dBm
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		>57		dB
RF to IF Isolation	f_{RF} = 600MHz to 1700MHz		>17		dB
Channel-to-Channel Isolation	f_{RF} = 600MHz to 1700MHz		53		dB

High Side LO Downmixer Application: I_{SEL} = Low, RF = 700MHz to 1100MHz, IF = 190MHz, $f_{LO} = f_{RF} + f_{IF}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Conversion Gain	RF = 700MHz RF = 900MHz RF = 1100MHz	TBD	8.6 8.7 8.5		dB dB dB
Conversion Gain Flatness	RF = 900 ±30MHz, LO = 1090MHz, IF = 190 ±30MHz		±0.25		dB
Conversion Gain vs Temperature	T_C = –40°C to 105°C, RF = 1950MHz		–0.006		dB/°C
Input 3rd Order Intercept	RF = 700MHz RF = 900MHz RF = 1100MHz	TBD	25.3 26.0 24.8		dBm dBm dBm
SSB Noise Figure	RF = 700MHz RF = 900MHz RF = 1100MHz		9.3 9.7 9.9	TBD	dB dB dB

AC ELECTRICAL CHARACTERISTICS

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (Δf = 2MHz for two tone IIP3 tests), unless otherwise noted. Test circuit shown in Figure 1. (Notes 2, 3)

High Side LO Downmixer Application: I_{SEL} = Low, RF = 700MHz to 1100MHz, IF = 190MHz, $f_{LO} = f_{RF} + f_{IF}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
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, V_{CCIF} = 3.3V f_{RF} = 900MHz, V_{CCIF} = 5V		10.7 14.1		dBm dBm

Low Power Mode, High Side LO Downmixer Application: I_{SEL} = High, RF = 700MHz to 1100MHz, IF = 190MHz, $f_{LO} = f_{RF} + f_{IF}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
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	RF = 900MHz, V_{CCIF} = 3.3V RF = 900MHz, V_{CCIF} = 5V		10.4 10.9		dBm dBm

Low Side LO Downmixer Application: I_{SEL} = Low, RF = 1100MHz to 1600MHz, IF = 190MHz, $f_{LO} = f_{RF} – f_{IF}$

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Conversion Gain	RF = 1200MHz RF = 1400MHz RF = 1600MHz		8.6 8.4 7.7		dB dB dB
Conversion Gain Flatness	RF = 1600 ±30MHz, LO = 1790MHz, IF = 190 ±30MHz		±0.22		dB
Conversion Gain vs Temperature	T_C = –40°C to 105°C, RF = 1600MHz		–0.008		dB/°C
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		 15.0 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	RF = 1400MHz, V_{CCIF} = 3.3V RF = 1400MHz, V_{CCIF} = 5V		11.0 14.4		dBm dBm

Note 1: Stresses beyond those listed under 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.

Note 2: The LTC5590 is guaranteed functional over the case operating temperature range of –40°C to 105°C. (θ_{JC} = 7°C/W)

Note 3: SSB Noise Figure measured with a small-signal noise source, bandpass filter and 6dB matching pad on RF input, bandpass filter and 6dB matching pad on the LO input, and no other RF signals applied.

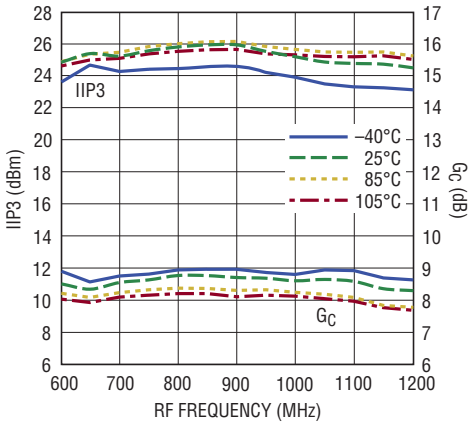
Note 4: Channel A to channel B isolation is measured as the relative IF output power of channel B to channel A, with the RF input signal applied to channel A. The RF input of channel B is 50Ω terminated and both mixers are enabled.

TYPICAL AC PERFORMANCE CHARACTERISTICS

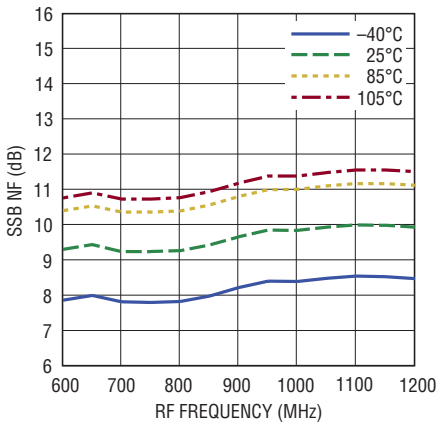
High Side LO

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (–3dBm/tone for two-tone IIP3 tests, Δf = 2MHz), IF = 190MHz, unless otherwise noted. Test circuit shown in Figure 1.

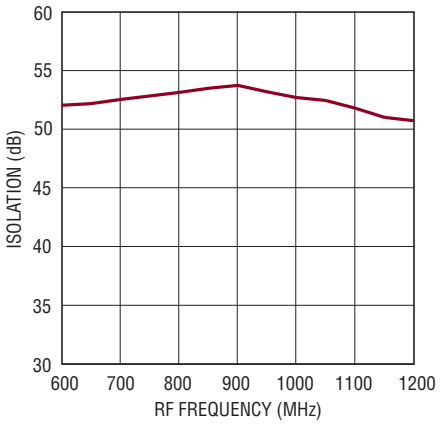
Conversion Gain and IIP3 vs RF Frequency



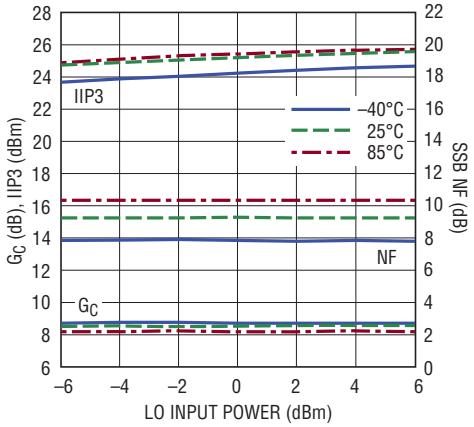
SSB NF vs RF Frequency



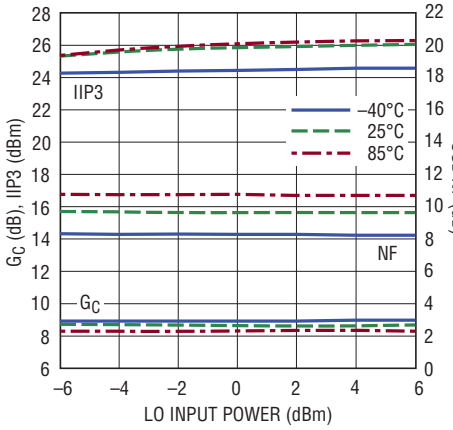
Channel Isolation vs RF Frequency



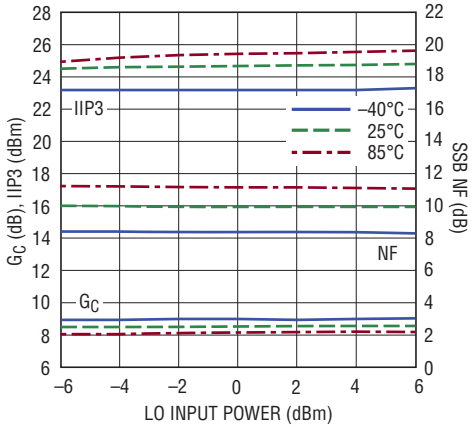
700Mhz Conversion Gain, IIP3 and NF vs LO Input Power



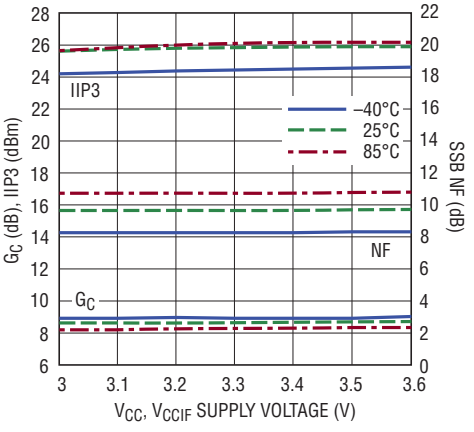
900MHz Conversion Gain, IIP3 and NF vs LO Input Power



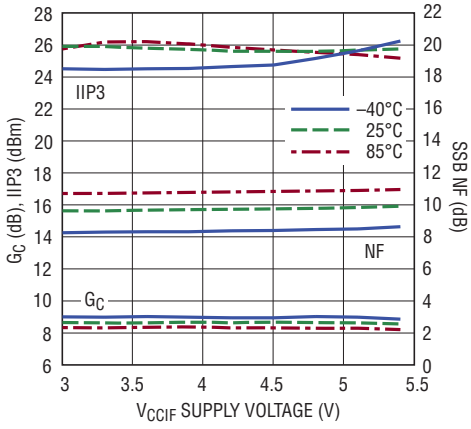
1100MHz Conversion Gain, IIP3 and NF vs LO Input Power



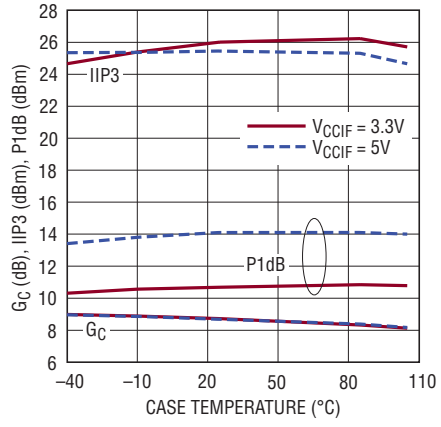
Conversion Gain, IIP3 and NF vs Supply Voltage (Single Supply)



Conversion Gain, IIP3 and NF vs Supply Voltage (Dual Supply)



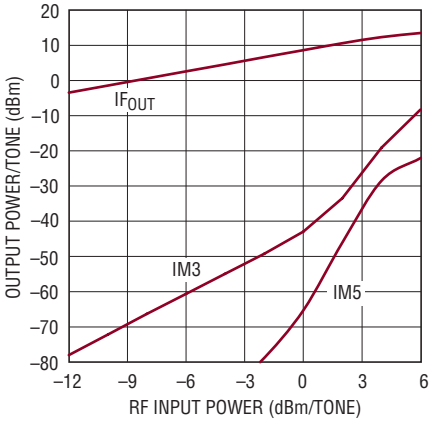
Conversion Gain, IIP3 and RF Input P1dB vs Temperature



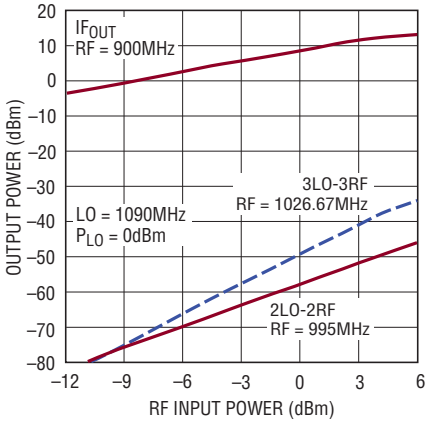
TYPICAL AC PERFORMANCE CHARACTERISTICS High Side LO

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (–3dBm/tone for two-tone IIP3 tests, Δf = 2MHz), IF = 190MHz, unless otherwise noted. Test circuit shown in Figure 1.

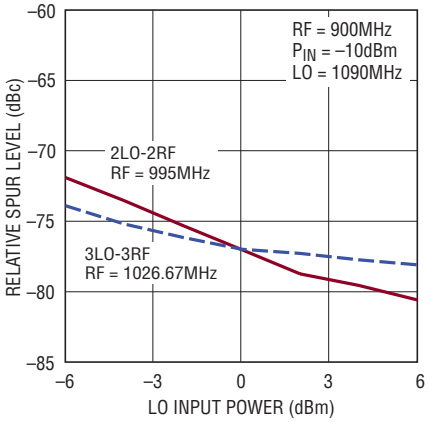
2-Tone IF Output Power, IM3 and IM5 vs RF Input Power



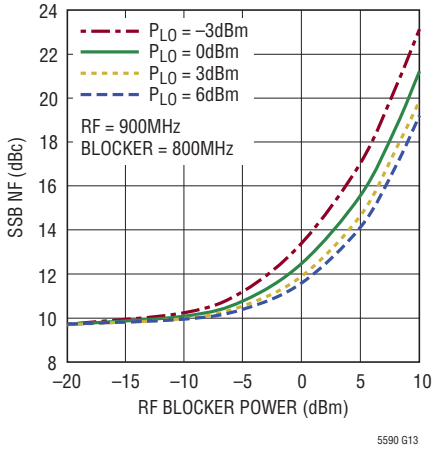
Single-Tone IF Output Power, 2 × 2 and 3 × 3 Spurs vs RF Input Power



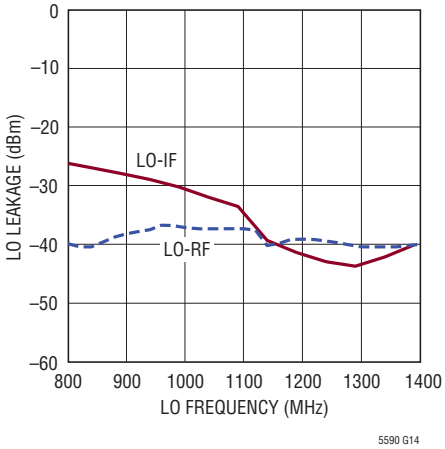
2 × 2 and 3 × 3 Spur Suppression vs LO Input Power



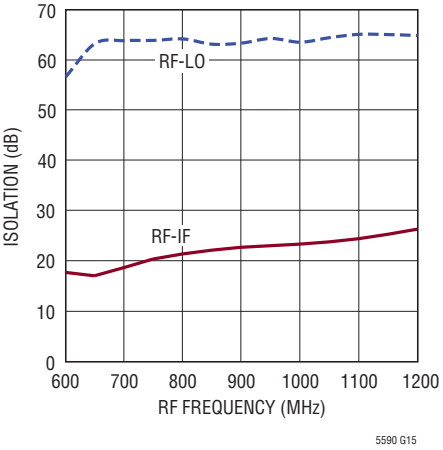
SSB Noise Figure vs RF Blocker Power



LO Leakage vs LO Frequency



RF Isolation vs RF Frequency



TBD

TBD

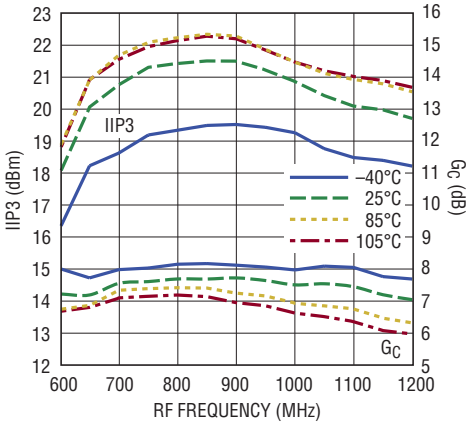
TBD

TYPICAL AC PERFORMANCE CHARACTERISTICS

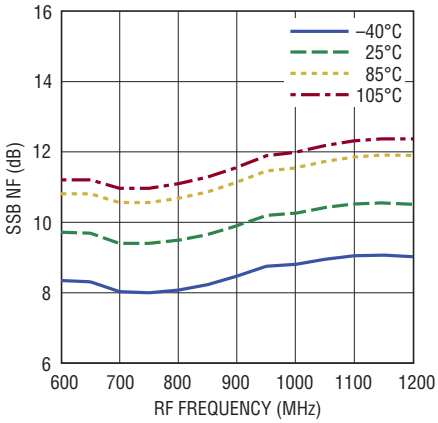
Low Power Mode, High Side LO

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = High, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (–3dBm/tone for two-tone IIP3 tests, Δf = 2MHz), IF = 190MHz, unless otherwise noted. Test circuit shown in Figure 1.

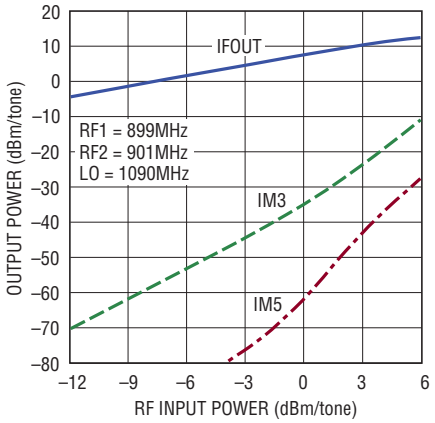
Conversion Gain and IIP3 vs RF Frequency



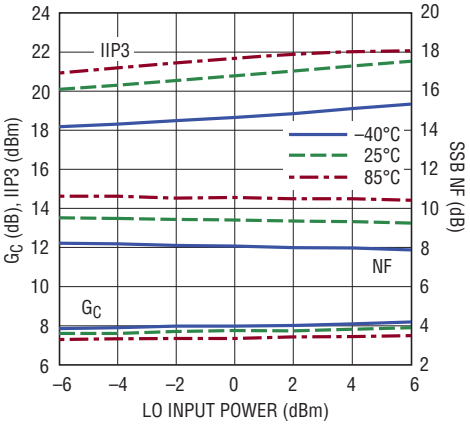
SSB NF vs RF Frequency



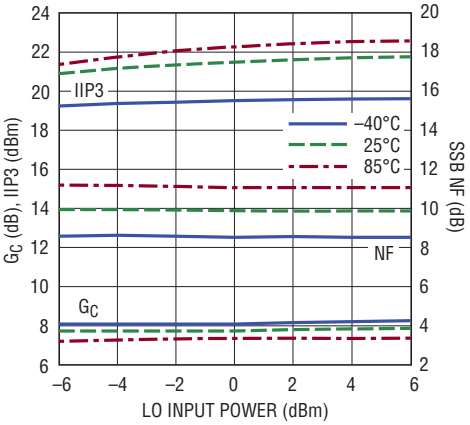
2-Tone IF Output Power, IM3 and IM5 vs RF Input Power



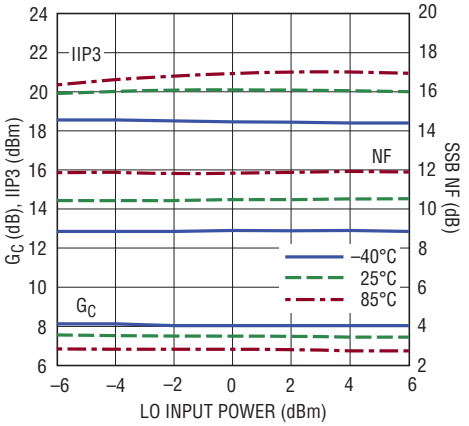
700MHz Conversion Gain, IIP3 and NF vs LO Input Power



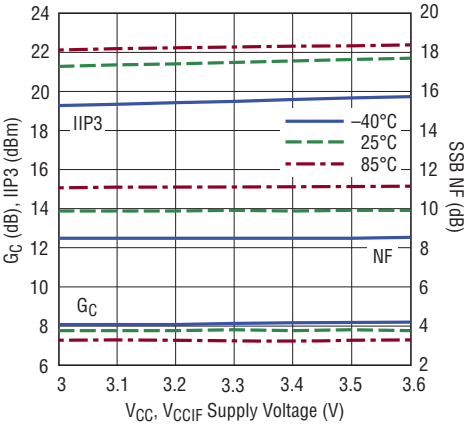
900MHz Conversion Gain, IIP3 and NF vs LO Input Power



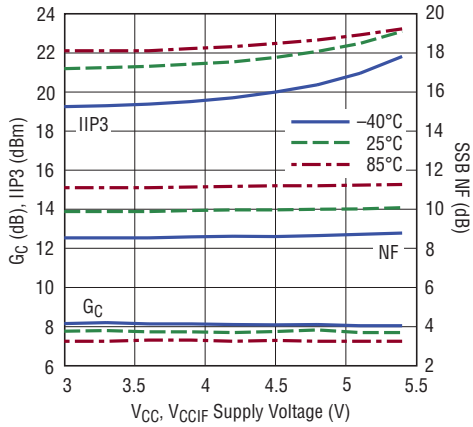
1100MHz Conversion Gain, IIP3 and NF vs LO Input Power



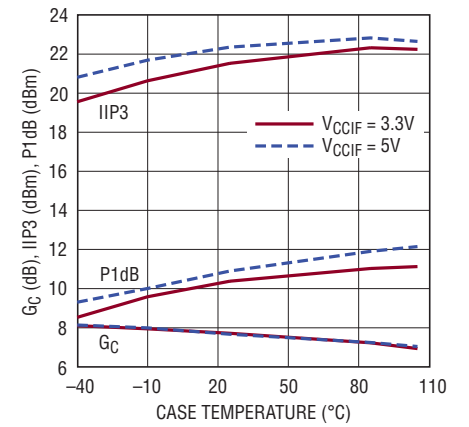
Conversion Gain, IIP3 and NF vs Supply Voltage (Single Supply)



Conversion Gain, IIP3 and NF vs Supply Voltage (Dual Supply)



Conversion Gain, IIP3 and RF Input P1dB vs Temperature

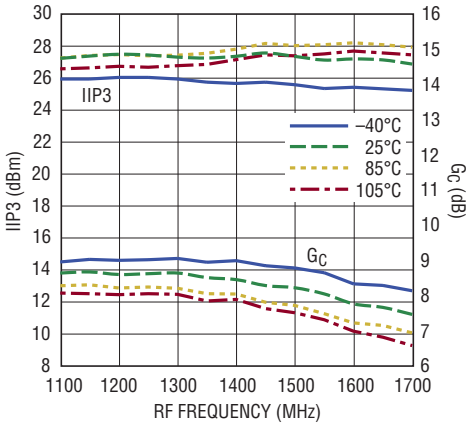


TYPICAL AC PERFORMANCE CHARACTERISTICS

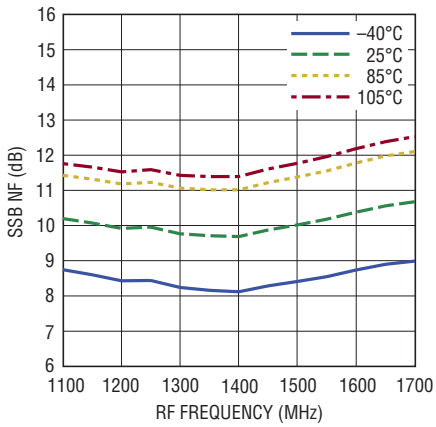
Low Side LO

V_{CC} = 3.3V, V_{CCIF} = 3.3V, ENA = ENB = High, I_{SEL} = Low, T_C = 25°C, P_{LO} = 0dBm, P_{RF} = –3dBm (–3dBm/tone for two-tone IIP3 tests, Δf = 2MHz), IF = 190MHz, unless otherwise noted. Test circuit shown in Figure 1.

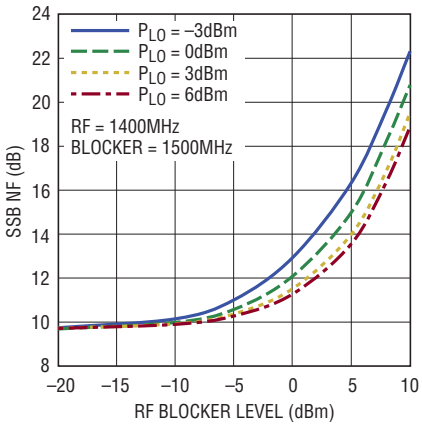
Conversion Gain and IIP3 vs RF Frequency



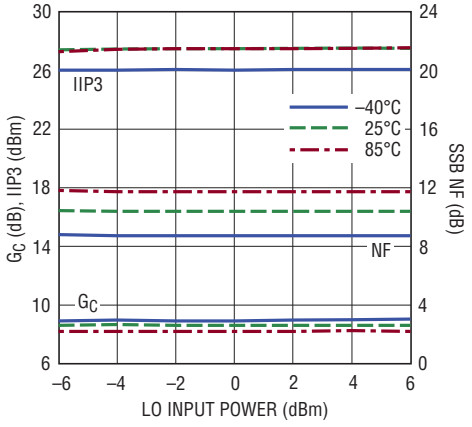
SSB NF vs RF Frequency



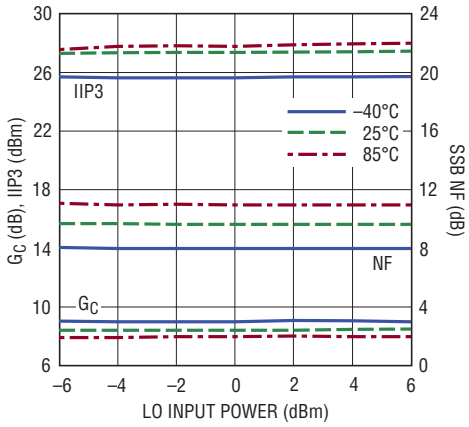
SSB Noise Figure vs RF Blocker Level



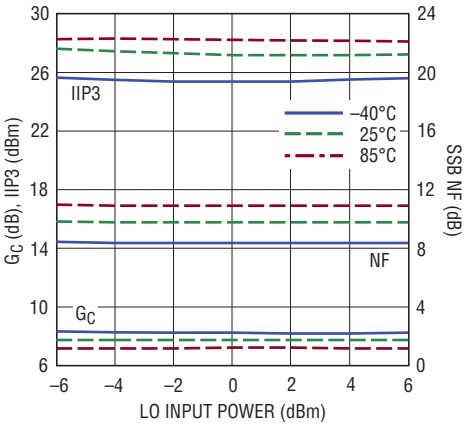
1200MHz Conversion Gain, IIP3 and NF vs LO Input Power



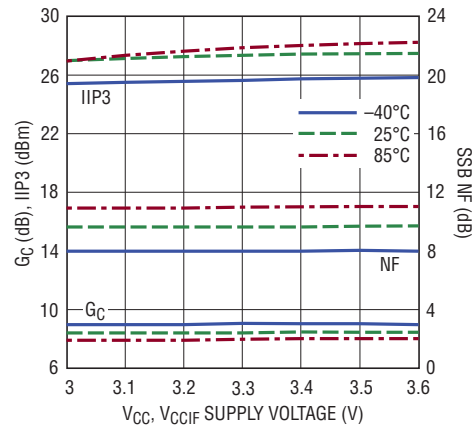
1400MHz Conversion Gain, IIP3 and NF vs LO Input Power



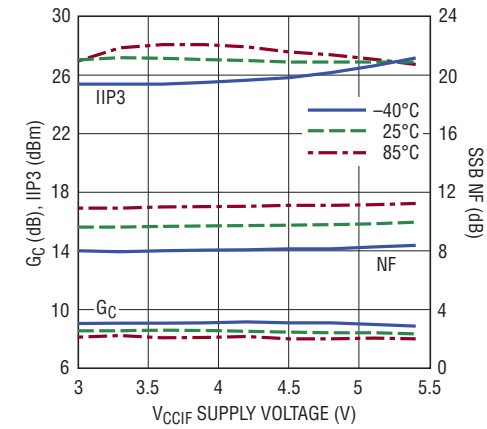
1600MHz Conversion Gain, IIP3 and NF vs LO Input Power



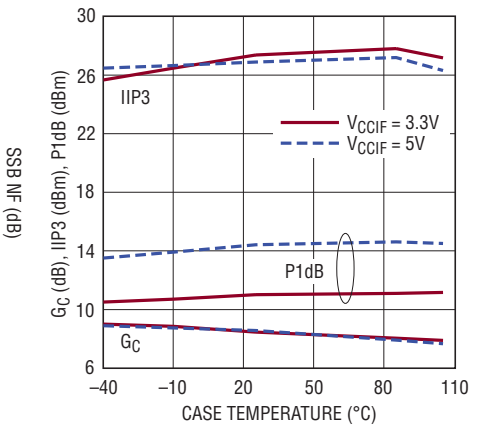
Conversion Gain, IIP3 and NF vs Supply Voltage (Single Supply)



Conversion Gain, IIP3 and NF vs Supply Voltage (Dual Supply)



Conversion Gain, IIP3 and RF Input P1dB vs Temperature

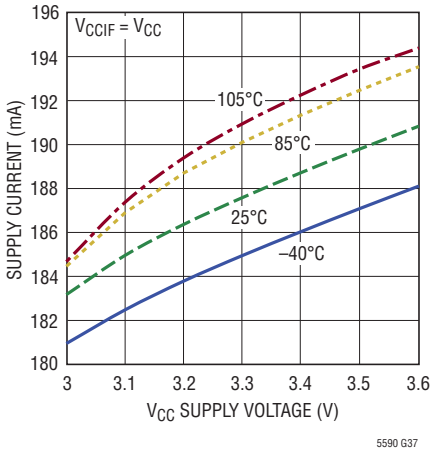


TYPICAL DC PERFORMANCE CHARACTERISTICS

ENA = ENB = High, test circuit shown in Figure 1.

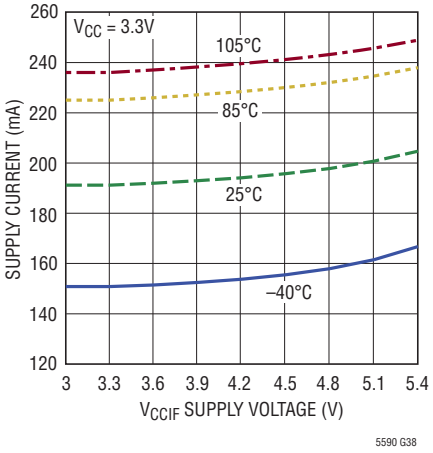
I_{SEL} = Low

V_{CC} Supply Current vs Supply Voltage (Mixer and LO Amplifier)



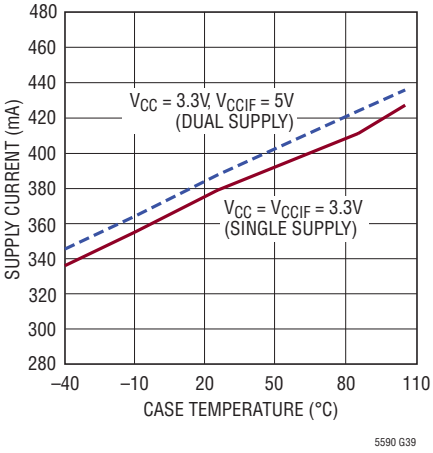
5590 G37

V_{CCIF} Supply Current vs Supply Voltage (IF Amplifier)



5590 G38

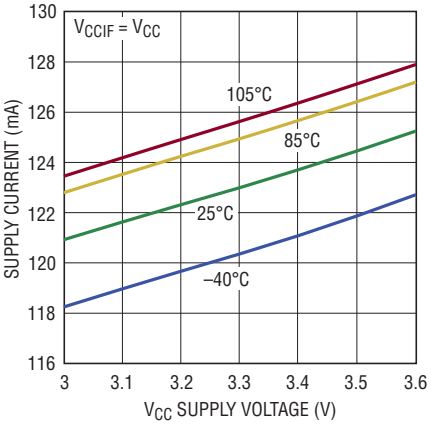
Total Supply Current vs Temperature (V_{CC} + V_{CCIF})



5590 G39

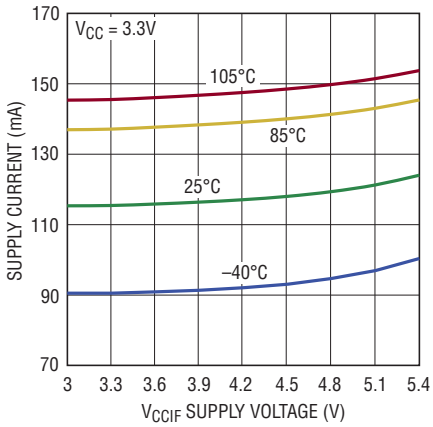
I_{SEL} = High

V_{CC} Supply Current vs Supply Voltage (Mixer and LO Amplifier)



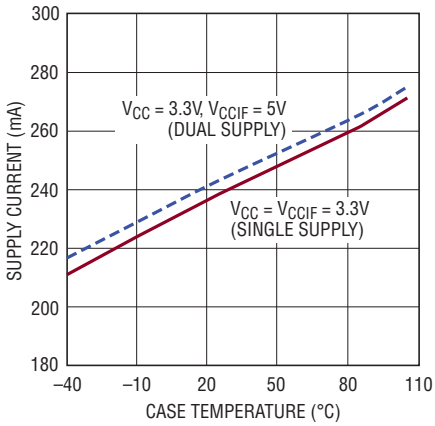
5590 G40

V_{CCIF} Supply Current vs Supply Voltage (IF Amplifier)



5590 G41

Total Supply Current vs Temperature (V_{CC} + V_{CCIF})



5590 G42

PIN FUNCTIONS

RFA, RFB (Pins 1, 6): Single-Ended RF Inputs for Channels A and B. These pins are internally connected to the primary sides of the RF input transformers, which have low DC resistance to ground. **Series DC-blocking capacitors should be used to avoid damage to the integrated transformer when DC voltage is present at the RF inputs.** The RF inputs are impedance matched when the LO input is driven with a 0±6dBm source between 700MHz and 1.5GHz and the channels are enabled.

CTA, CTB (Pins 2, 5): RF Transformer Secondary Center-Tap on Channels A and B. These pins may require bypass capacitors to ground to optimize IIP3 performance. Each pin has an internally generated bias voltage of 1.2V and must be DC-isolated from ground and V_{CC}.

GND (Pins 3, 4, 7, 13, 15, 24, Exposed Pad Pin 25): Ground. These pins must be soldered to the RF ground plane on the circuit board. The exposed pad metal of the package provides both electrical contact to ground and good thermal contact to the printed circuit board.

IFGNDB, IFGNDA (Pins 8, 23): DC Ground Returns for the IF Amplifiers. These pins must be connected to ground to complete the DC current paths for the IF amplifiers. Chip inductors may be used to tune LO-IF and RF-IF leakage. Typical DC current is 95mA for each pin.

IFB^+, IFB^-, IFA^-, IFA^+ (Pins 9, 10, 21, 22): Open-Collector Differential Outputs for the IF Amplifiers of Channels B and A. These pins must be connected to a DC supply through impedance matching inductors, or transformer center-taps. Typical DC current consumption is 48mA into each pin.

IFBB, IFBA (Pins 11, 20): Bias Adjust Pins for the IF Amplifiers. These pins allow independent adjustment of the internal IF buffer currents for channels B and A, respectively. The typical DC voltage on these pins is 2.2V. If not used, these pins must be DC isolated from ground and V_{CC}.

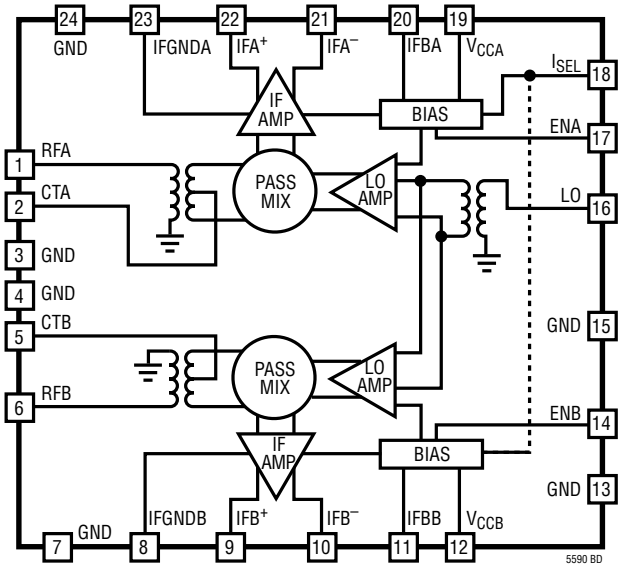
V_{CCB} and V_{CCA} (Pins 12, 19): Power Supply Pins for the LO Buffers and Bias Circuits. These pins must be connected to a regulated 3.3V supply with bypass capacitors located close to the pins. Typical current consumption is 94mA per pin.

ENB, ENA (Pins 14, 17): Enable Pins. These pins allow Channels B and A, respectively, to be independently enabled. An applied voltage of greater than 2.5V activates the associated channel while a voltage of less than 0.3V disables the channel. Typical input current is less than 10µA. These pins must not be allowed to float.

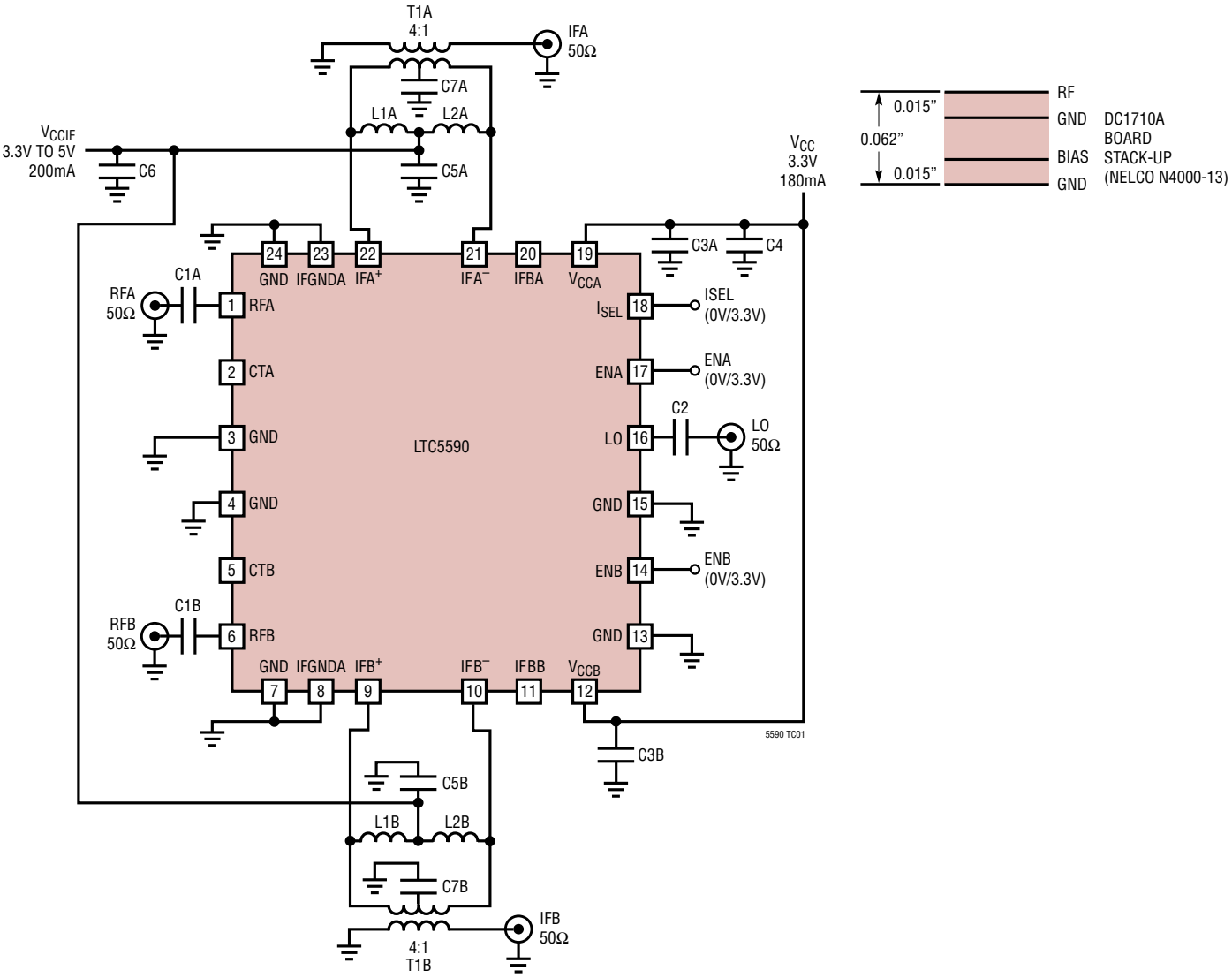
LO (Pin 16): Single-Ended Local Oscillator Input. This pin is internally connected to the primary side of the LO input transformer and has a low DC resistance to ground. **Series DC-blocking capacitors should be used to avoid damage to the integrated transformer when DC voltage present at LO input.** The LO input is internally matched to 50Ω for all states of ENA and ENB.

I_{SEL} (Pin 18): Low Current Select Pin. When this pin is pulled low (<0.3V), both mixer channels are biased at the normal current level for best RF performance. When greater than 2.5V is applied, both channels operate at reduced current, which provides reasonable performance at lower power consumption.

BLOCK DIAGRAM



TEST CIRCUIT



L1, L2 vs IF FREQUENCIES	
IF (MHz)	**L1, L2 (nH)**
140	270
190	150
240	100
300	56
380	33
450	22

REF DES	VALUE	SIZE	COMMENTS
C1A, C1B	100pF	0402	AVX
C2	10pF	0402	AVX
C3A, C3B C5A, C5B	22pF	0402	AVX
C4, C6	1µF	0603	AVX
C7A, C7B	1000pF	0402	AVX
L1, L2	150nH	0603	Coilcraft
T1A, T2B	TC1-1W-7ALN+		Mini-Circuits

Figure 1. Standard Downmixer Test Circuit Schematic (190MHz)

APPLICATIONS INFORMATION

Introduction

The LTC5590 consists of two identical mixer channels driven by a common LO input signal. Each high linearity mixer consists of a passive double-balanced mixer core, IF buffer amplifier, LO buffer amplifier and bias/enable circuits. See the Pin Functions and Block Diagram sections for a description of each pin. Each of the mixers can be shutdown independently to reduce power consumption and low current mode can be selected that allows a trade-off between performance and power consumption. The RF and LO inputs are single-ended and are internally matched to 50Ω. Low side or high side LO injection can be used. The IF outputs are differential. The evaluation circuit, shown in Figure 1, utilizes bandpass IF output matching and an IF transformer to realize a 50Ω single-ended IF output. The evaluation board layout is shown in Figure 2.

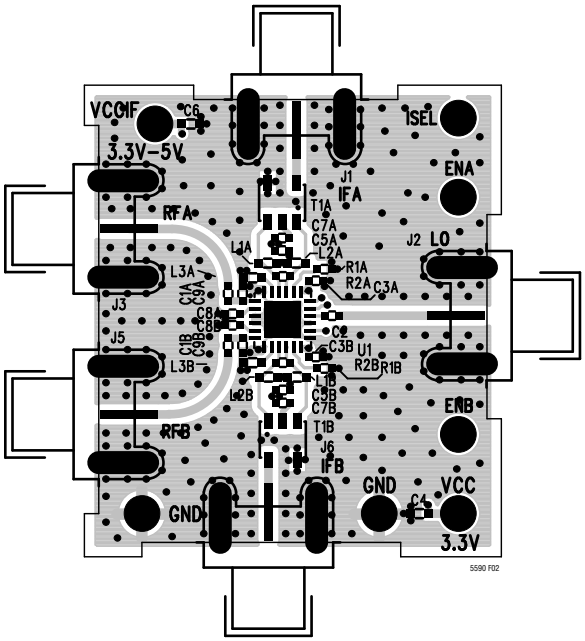


Figure 2. Evaluation Board Layout

RF Inputs

The RF inputs of channels A and B are identical. The RF input of channel A, shown in Figure 3, is connected to the primary winding of an integrated transformer. A 50Ω match is realized when a series external capacitor, C1A, is connected to the RF input. C1A is also needed for DC blocking if the source has DC voltage present, since the primary side of the RF transformer is internally DC-grounded. The DC resistance of the primary is approximately 4.5Ω.

The secondary winding of the RF transformer is internally connected to the channel A passive mixer core. The center-tap of the transformer secondary is connected to Pin 2 (CTA) to allow the connection of bypass capacitor, C8A. The value of C8A is LO frequency-dependent and is not required for most applications, though it can improve IIP3 in some cases. When used, it should be located within 2mm of Pin 2 for proper high frequency decoupling. The nominal DC voltage on the CTA pin is 1.2V.

For the RF inputs to be properly matched, the appropriate LO signal must be applied to the LO input. A broadband input match is realized with C1A = 100pF. The measured input return loss is shown in Figure 4 for LO frequencies of 0.7GHz, 1.09GHz and 1.5GHz. These LO frequencies correspond to lower, middle and upper values in the LO range. As shown in Figure 4, the RF input impedance is dependent on LO frequency, although a single value of C1A is adequate to cover the 700MHz to 1.5GHz RF band.

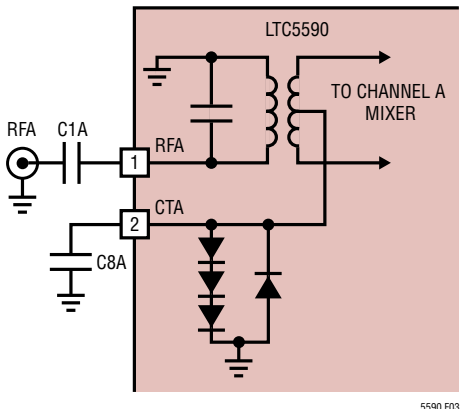


Figure 3. Channel A RF Input Schematic

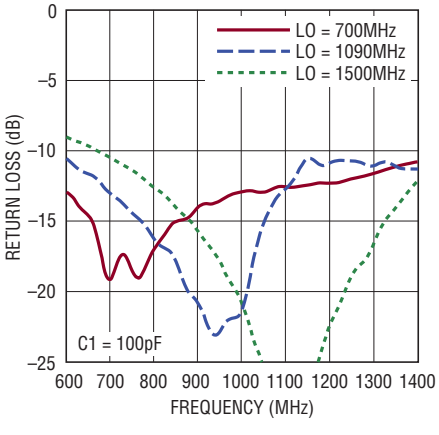


Figure 4. RF Port Return Loss

APPLICATIONS INFORMATION

The RF input impedance and input reflection coefficient, versus RF frequency, are listed in Table 1. The reference plane for this data is Pin 1 of the IC, with no external matching, and the LO is driven at 1.09GHz.

Table 1. RF Input Impedance and S11 (at Pin 1, No External Matching, f_{LO} = 1.09GHz)

FREQUENCY (GHz)	RF INPUT IMPEDANCE	S11	
		MAG	ANGLE
0.6	34.2 + j24.5	0.33	107
0.7	41.3 + j22.4	0.26	97
0.8	48.5 + j18.1	0.18	84
0.9	54.3 + j10.1	0.10	61
1.0	54.2 – j4.6	0.06	–45
1.1	38.4 – j16	0.22	–116
1.2	29.3 – j9.4	0.29	–149
1.3	27.7 – j4.5	0.29	–165
1.4	27.4 – j1.6	0.29	–175
1.5	27.8 – j0.1	0.28	–180
1.6	29.4 + j0.2	0.26	179
1.7	31.2 –j0.5	0.23	–178

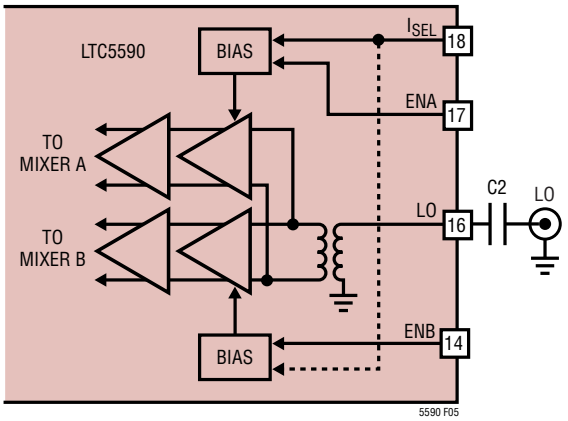


Figure 5. LO Input Schematic

LO Input

The LO input, shown in Figure 5, is connected to the primary winding of an integrated transformer. A 50Ω impedance match is realized at the LO port by adding an external series capacitor, C2. This capacitor is also needed for DC blocking if the LO source has DC voltage present, since the primary side of the LO transformer is DC-grounded internally. The DC resistance of the primary is approximately 4.5Ω.

The secondary of the transformer drives a pair of high speed limiting differential amplifiers for channels A and B. The LTC5590's LO amplifiers are optimized for the 700MHz to 1.5GHz LO frequency range; however, LO frequencies outside this frequency range may be used with degraded performance.

The LO port is always 50Ω matched when V_{CC} is applied, even when one or both of the channels is disabled. This helps to reduce frequency pulling of the LO source when the mixer is switched between different operating states. Figure 6 illustrates the LO port return loss for the different operating modes.

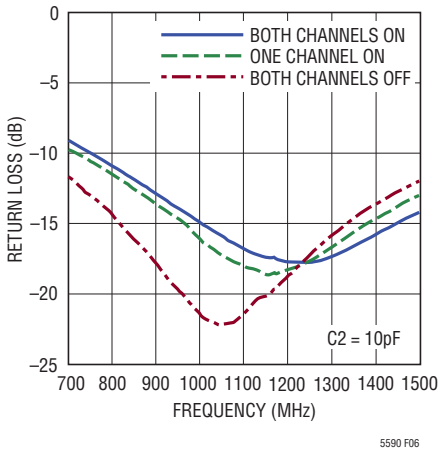


Figure 6. LO Input Return Loss

The nominal LO input level is 0dBm, though the limiting amplifiers will deliver excellent performance over a ±6dBm input power range. Table 2 lists the LO input impedance and input reflection coefficient versus frequency.

Table 2. LO Input Impedance vs Frequency (at Pin 16, No External Matching, ENA = ENB = High)

FREQUENCY (GHz)	INPUT IMPEDANCE	S11	
		MAG	ANGLE
0.7	29.7 + j34.7	0.46	97
0.8	39.9 + j34.1	0.37	86
0.9	48.7 + j26.6	0.26	78
1.0	50.8 + j15.1	0.15	78
1.1	46.5 + j6.2	0.07	116
1.2	39.9 + j2.5	0.12	165
1.3	34.0 + j1.4	0.19	174
1.4	29.2 + j2.1	0.26	173
1.5	25.6 + j3.8	0.33	168

APPLICATIONS INFORMATION

IF Outputs

The IF amplifiers in channels A and B are identical. The IF amplifier for channel A, shown in Figure 7, has differential open collector outputs (IFA+ and IFA–), a DC ground return pin (IFGNDA), and a pin for adjusting the internal bias (IFBA). The IF outputs must be biased at the supply voltage (V_{CCIFA}), which is applied through matching inductors L1A and L2A. Alternatively, the IF outputs can be biased through the center tap of a transformer (T1A). The common node of L1A and L2A can be connected to the center tap of the transformer. Each IF output pin draws approximately 48mA of DC supply current (96mA total). An external load resistor, R2A, can be used to improve impedance matching if desired.

IFGNDA (Pin 23) must be grounded or the amplifier will not draw DC current. Inductor L3A may improve LO-IF and RF-IF leakage performance in some applications, but is otherwise not necessary. Inductors should have small resistance for DC. High DC resistance in L3A will reduce the IF amplifier supply current, which will degrade RF performance.

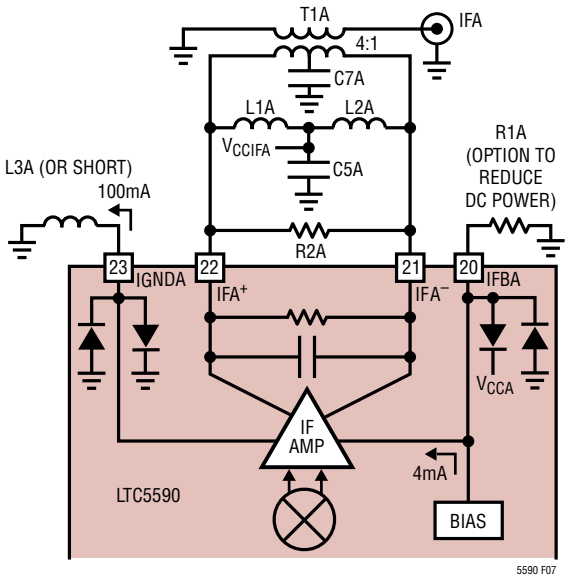


Figure 7. IF Amplifier Schematic with Bandpass Match

For optimum single-ended performance, the differential IF output must be combined through an external IF transformer or a discrete IF balun circuit. The evaluation board (see Figures 1 and 2) uses a 4:1 IF transformer for impedance transformation and differential to single-ended conversion. It is also possible to eliminate the IF transformer and drive differential filters or amplifiers directly.

At IF frequencies, the IF output impedance can be modeled as 300Ω in parallel with 2.3pF. The equivalent small-signal model, including bondwire inductance, is shown in Figure 8. Frequency-dependent differential IF output impedance is listed in Table 3. This data is referenced to the package pins (with no external components) and includes the effects of IC and package parasitics.

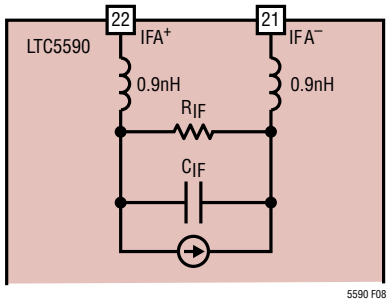


Figure 8. IF Output Small-Signal Model

Bandpass IF Matching

The bandpass IF matching configuration, shown in Figures 1 and 7, is best suited for IF frequencies in the 90MHz to 500MHz range. Resistor R2A may be used to reduce the IF output resistance for greater bandwidth and inductors L1A and L2A resonate with the internal IF output capacitance at the desired IF frequency. The value of L1A, L2A can be estimated as follows:

$$L1A = L2A = \frac{1}{\left[\left(2\pi f_{IF}\right)^2 \bullet 2 \bullet C_{IF}\right]}$$

where C_{IF} is the internal IF capacitance (listed in Table 3).

APPLICATIONS INFORMATION

Values of L1A and L2A are tabulated in Figure 1 for various IF frequencies. The measured IF output return loss for bandpass IF matching is plotted in Figure 9.

Table 3. IF Output Impedance vs Frequency

FREQUENCY (MHz)	DIFFERENTIAL OUTPUT IMPEDANCE (R_{IF} || X_{IF} (C_{IF}))
90	403 || – j610 (2.9pF)
140	384 || – j474 (2.4pF)
190	379 || – j381 (2.2pF)
240	380 || – j316 (2.1pF)
300	377 || – j253 (2.1pF)
380	376 || – j210 (2.0pF)
450	360 || – j177 (2.0pF)

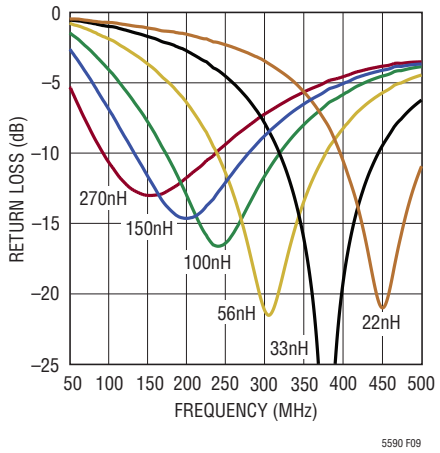


Figure 9. IF Output Return Loss with Bandpass Matching

Lowpass IF Matching

For IF frequencies below 90MHz, the inductance values become unreasonably high and the lowpass topology shown in Figure 9 is preferred. This topology also can provide improved RF to IF and LO to IF isolation. V_{CCIFA} is supplied through the center tap of the 4:1 transformer. A lowpass impedance transformation is realized by shunt elements R2A and C9A (in parallel with the internal RIF and CIF), and series inductors L1A and L2A. Resistor R2A is used to reduce the IF output resistance for greater bandwidth, or it can be omitted for the highest conversion gain. The final impedance transformation to 50Ω is realized by transformer T1A. The measured return loss is shown in Figure 11 for different values of inductance (C9A = OpF). The case with 82nH inductors and R2A = 1k is also shown. The LTC5590 demo board (see Figure 2) has been laid out to accommodate this matching topology with only minor modifications.

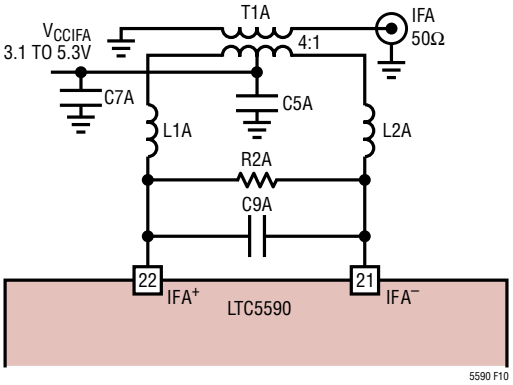


Figure 10. IF Output with Lowpass Matching

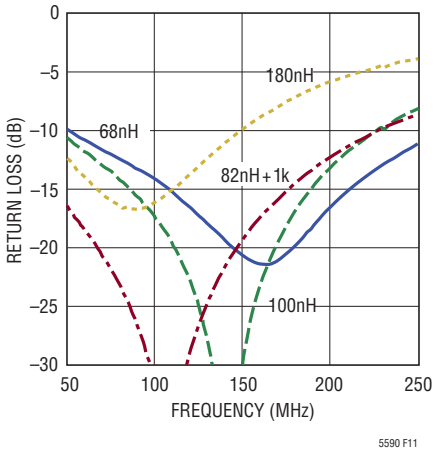


Figure 11. IF Output Return Loss with Lowpass Matching

IF Amplifier Bias

The IF amplifier delivers excellent performance with V_{CCIF} = 3.3V, which allows a single supply to be used for V_{CC} and V_{CCIF}. At V_{CCIF} = 3.3V, the RF input P1dB of the mixer is limited by the output voltage swing. For higher P1dB, in this case, resistor R2A (Figure 7) can be used to reduce the output impedance and thus the voltage swing, thus improving P1dB. The trade-off for improved P1dB will be lower conversion gain.

With V_{CCIF} increased to 5V the P1dB increases by over 3dB, at the expense of higher power consumption. Mixer P1dB performance at 900MHz is tabulated in Table 4 for V_{CCIF} values of 3.3V and 5V. For the highest conversion gain, high-Q wire-wound chip inductors are recommended for L1A and L2A. Low cost multilayer chip inductors may be substituted, with a slight reduction in conversion gain.

APPLICATIONS INFORMATION

Table 4. Performance Comparison with V_{CCIF} = 3.3V and 5V (RF = 900MHz, High Side LO, IF = 190MHz)

V_{CCIF} (V)	R2A (Ω)	I_{CCIF} (mA)	G_C (dB)	P1dB (dBm)	IIP3 (dBm)	NF (dB)
3.3	Open	191	8.7	10.7	26.0	9.7
	1k	191	7.5	11.4	26.0	9.75
5	Open	200	8.7	14.1	25.5	9.8

The IFBA pin (Pin 20) is available for reducing the DC current consumption of the IF amplifier, at the expense of IIP3. The nominal DC voltage at Pin 20 is 2.1V, and this pin should be left open-circuited for optimum performance. The internal bias circuit produces a 4mA reference for the IF amplifier, which causes the amplifier to draw approximately 100mA. If resistor R1A is connected to Pin 20 as shown in Figure 7, a portion of the reference current can be shunted to ground, resulting in reduced IF amplifier current. For example, R1A = 1k will shunt away 1.5mA from Pin 20 and the IF amplifier current will be reduced by 38% to approximately 62mA. Table 5 summarizes RF performance versus IF amplifier current.

Table 5. Mixer Performance with Reduced IF Amplifier Current

RF = 900MHz, High Side LO, IF = 190MHz, V_{CC} = V_{CCIF} = 3.3V

R1	I_{CCIF} (mA)	G_C (dB)	IIP3 (dBm)	P1dB (dB)	NF (dB)
Open	95.5	8.7	26.0	10.7	9.7
4.7kΩ	86.5	8.7	25.6	10.6	9.7
2.2kΩ	78.3	8.6	25.0	10.6	9.6
1kΩ	68.6	8.5	24.1	10.5	9.6

RF = 1400MHz, Low Side LO, IF = 190MHz, V_{CC} = V_{CCIF} = 3.3V

R1	I_{CCIF} (mA)	G_C (dB)	IIP3 (dBm)	P1dB (dBm)	NF (dB)
Open	95.5	8.4	27.3	11	9.7
4.7kΩ	86.4	8.5	26.8	10.9	9.6
2.2kΩ	78.2	8.5	26.2	10.9	9.6
1kΩ	68.5	8.4	25.1	10.8	9.6

Low Current Mode

Both mixer channels can be set to low current mode using the I_{SEL} pin. This allows flexibility to select a reduced current mode of operation when lower RF performance is acceptable, reducing power consumption by 36%. Figure 12 shows a simplified schematic of the I_{SEL} pin interface.

When I_{SEL} is set low (<0.3V), both channels operate at nominal DC current. When I_{SEL} is set high (>2.5V), the DC current in both channels is reduced, thus reducing power consumption. The performance in low power mode and normal power mode are compared in Table 6.

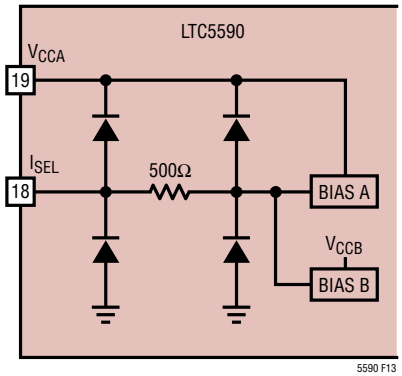


Figure 12. I_{SEL} Interface Schematic

Table 6. Performance Comparison Between Different Power Modes

RF = 900MHz, High Side LO, IF = 190MHz, V_{CC} = V_{CCIF} = 3.3V

I_{SEL}	I_{CCIF} (mA)	G_C (dB)	IIP3 (dBm)	P1dB (dBm)	NF (dB)
Low	376	8.7	26.0	10.7	9.7
High	239	7.7	21.5	10.4	9.9

Enable Interface

Figure 13 shows a simplified schematic of the ENA pin interface (ENB is identical). To enable channel A, the ENA voltage must be greater than 2.5V. If the enable function is not required, the enable pin can be connected directly to V_{CC}. The voltage at the enable pin should never exceed the power supply voltage (V_{CC}) by more than 0.3V. If this

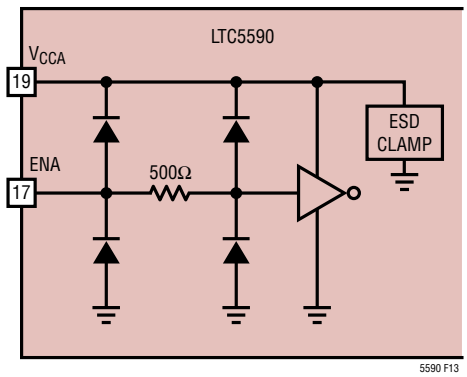


Figure 13. I_{SEL} Interface Schematic

APPLICATIONS INFORMATION

should occur, the supply current could be sourced through the ESD diode, potentially damaging the IC.

The Enable pins must be pulled high or low. If left floating, the on/off state of the IC will be indeterminate. If a three-state condition can exist at the enable pins, then a pull-up or pull-down resistor must be used.

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.

Spurious Output Levels

Mixer spurious output levels versus harmonics of the RF and LO are tabulated in Tables 7 and 8 for frequencies up to 10GHz. The spur levels were measured on a standard evalution board using the test circuit shown in Figure 1. The spur frequencies can be calculated using the following equation:

$$f_{SPUR} = (M \bullet f_{RF}) - (N \bullet f_{LO})$$

Table 7. IF Output Spur Levels (dBc), High Side LO

(RF = 900MHz, P_{RF} = –3dBm, P_{LO} = 0dBm, V_{CC} = V_{CCIF} = 3.3V, T_C = 25°C)

		N										
		0	1	2	3	4	5	6	7	8	9	10
M	0	-	–40.0	–42	–54.8	–55.7	–66.5	–81.37	–73.07	–74.33	–72.53	
	1	–31.8	0	–49.0	–47.4	–72.2	–64.0	–88.5	–70.3	–81.6*	–81.2*	*
	2	–68.6	–63.0	–78.6	–73.9	–87.7	–87.8	82.3	*	*	*	*
	3	*	*	*	–81.5	*	*	*	*	*	*	*
	4	*	*	*	–78.0	*	*	*	*	*	*	*
	5	*	*	*	*	*	*	*	*	*	*	*
	6	*	*	*	*	*	*	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*	*	*
	8	*	*	*	*	*	*	*	*	*	*	*
	9	*	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*	*

*Less than –100dBc

Table 8. IF Output Spur Levels (dBc), Low Side LO

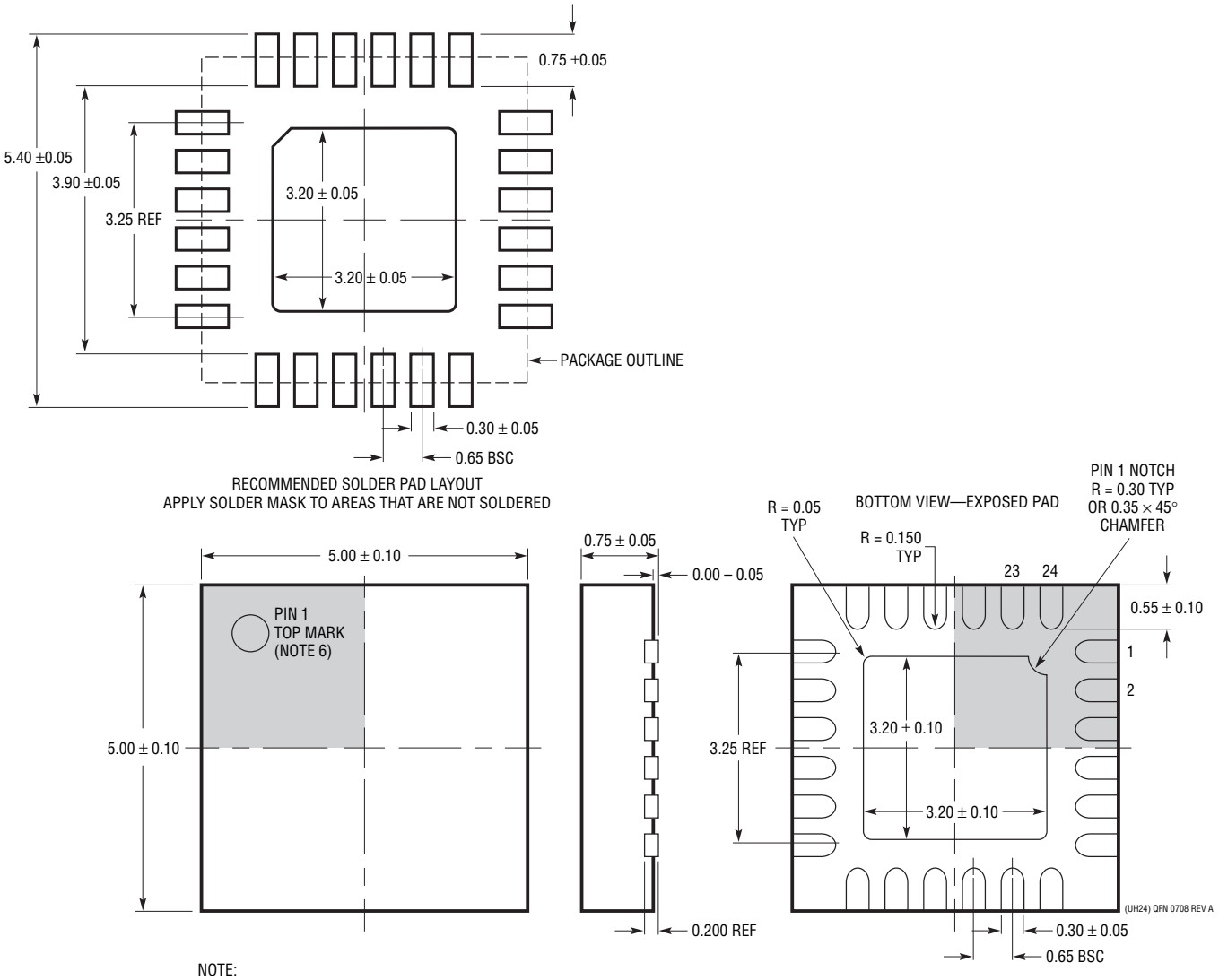
(RF = 1400MHz, P_{RF} = –3dBm, P_{LO} = 0dBm, V_{CC} = V_{CCIF} = 3.3V, T_C = 25°C)

		N										
		0	1	2	3	4	5	6	7	8	9	10
M	0	-	–46.2	–42.2	–55.9	–56.9	–71.3	–67.39	–85.33	–69.93		
	1	–40.8	0	–44.5	–52.2	–75.0	–67.5	–78.3	–73.42	*	*	
	2	–77.5	–74.4	–69.3	–71.7	*	–86.4	–83.2	*	–93.16	*	*
	3	*	–88.74	*	–76.8	–89.21	*	*	*	*	*	*
	4	*	*	*	*	*	*	*	*	*	*	*
	5	*	*	*	*	*	*	*	*	*	*	*
	6	*	*	*	*	*	*	*	*	*	*	*
	7	*	*	*	*	*	*	*	*	*	*	*
	8		*	*	–93.69	*	*	*	*	*	*	*
	9				*	*	–95.59	*	*	*	*	*
	10					*	–94.52	*	*	*	*	*

*Less than –100dBc

PACKAGE DESCRIPTION

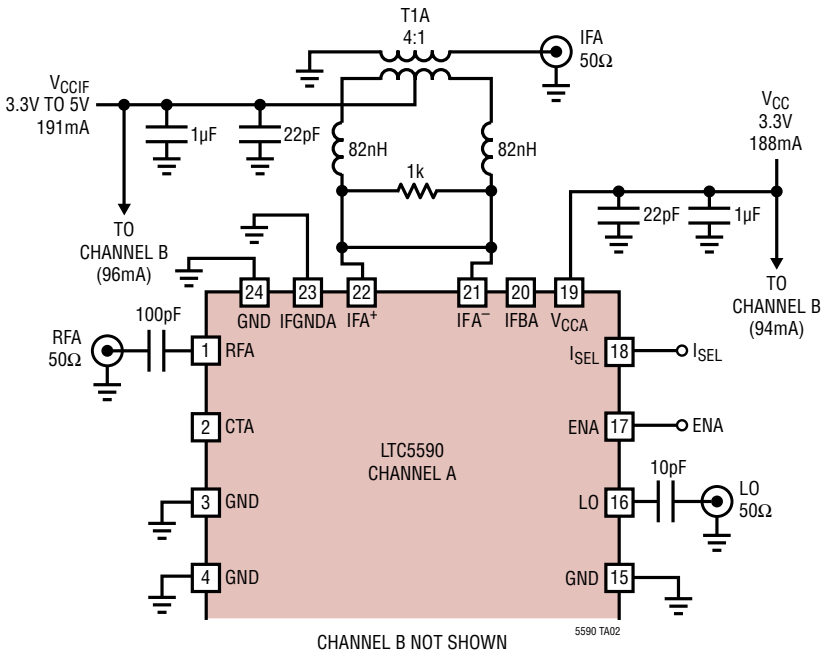
UH Package
24-Lead Plastic QFN (5mm × 5mm)
(Reference LTC DWG # 05-08-1747 Rev A)



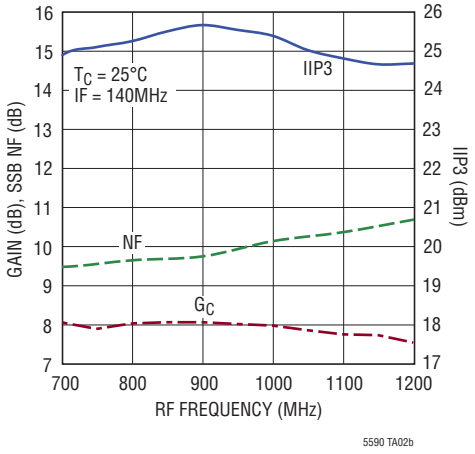
NOTE:
1. DRAWING IS NOT A JEDEC PACKAGE OUTLINE
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.20mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

TYPICAL APPLICATION

Downconverting Mixer with Lowpass IF Matching



Conversion Gain, NF and IIP3 vs RF Frequency



RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
Infrastructure		
LT5527	400MHz to 3.7GHz, 5V Downconverting Mixer	2.3dB Gain, 23.5dBm IIP3 and 12.5dB NF at 1900MHz, 5V/78mA Supply
LT5557	400MHz to 3.8GHz, 3.3V Downconverting Mixer	2.9dB Gain, 24.7dBm IIP3 and 11.7dB NF at 1950MHz, 3.3V/82mA Supply
LTC6416	2GHz 16-Bit ADC Buffer	40.25dBm OIP3 to 300MHz, Programmable Fast Recovery Output Clamping
LTC6412	31dB Linear Analog VGA	35dBm OIP3 at 240MHz, Continuous Gain Range –14dB to 17dB
LTC554X	600MHz to 4GHz Downconverting Mixer Family	8dB Gain, >25dBm IIP3, 10dB NF, 3.3V/200mA Supply
LT5554	Ultralow Distort IF Digital VGA	48dBm OIP3 at 200MHz, 2dB to 18dB Gain Range, 0.125dB Gain Steps
LT5578	400MHz to 2.7GHz Upconverting Mixer	27dBm OIP3 at 900MHz, 24.2dBm at 1.95GHz, Integrated RF Transformer
LT5579	1.5GHz to 3.8GHz Upconverting Mixer	27.3dBm OIP3 at 2.14GHz, NF = 9.9dB, 3.3V Supply, Single-Ended LO and RF Ports
RF Power Detectors		
LTC5581	6GHz Low Power RMS Detector	40dB Dynamic Range, ±1dB Accuracy Overtemperature, 1.5mA Supply Current
LTC5582	10GHz RMS Power Detector	40MHz to 10GHz, Up to 57dB Dynamic Range, ±0.5dB Accuracy Overtemperature
LTC5583	Dual 6GHz RMS Power Detector Measures VSWR	40MHz to 6GHz, Up to 60dB Dynamic Range, >40dB Channel-to-Channel Isolation, Difference Output for vs WR Measurement
ADCs		
LTC2285	14-Bit, 125Msps Dual ADC	72.4dB SNR, >88dB SFDR, 790mW Power Consumption
LTC2185	16-Bit, 125Msps Dual ADC Ultralow Power	74.8dB SNR, 185mW/Channel Power Consumption
LTC2242-12	12-Bit, 250Msps ADC	65.4dB SNR, 78dB SFDR, 740mW Power Consumption

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