RF2494

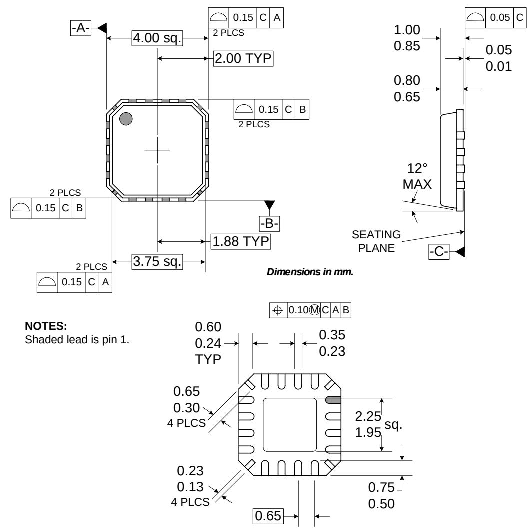
HIGH FREQUENCY LNA/MIXER

Typical Applications

- Part of 2.4GHz IEEE802.11b WLANs
- Digital Communication Systems
- Spread-Spectrum Communication Systems
- WLAN or Wireless Local Loop
- Portable Battery-Powered Equipment
- UHF Digital and Analog Receivers

Product Description

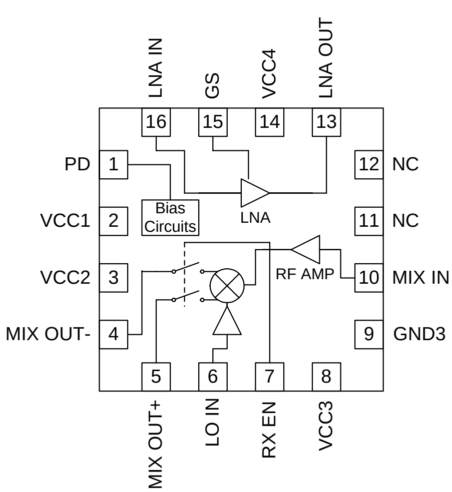
The RF2494 is a monolithic integrated UHF receiver front end suitable for 2.4GHz ISM band applications. The IC contains all of the required components to implement the RF functions of the receiver except for the passive filtering and LO generation. It contains an LNA (low-noise amplifier), a second RF amplifier and a double balanced mixer. The output of the LNA is made available as an output to permit the insertion of a bandpass filter between the LNA and the RF/Mixer section. The mixer outputs can be selectively disabled to allow for the IF filter to be used in the transmit mode.



Package Style: LCC, 16-Pin, 4x4

Optimum Technology Matching® Applied

☐ Si BJT	☐ GaAs HBT	☐ GaAs MESFET
☑ Si Bi-CMOS	☐ SiGe HBT	☐ Si CMOS
☐ InGaP/HBT	☐ GaN HEMT	☐ SiGe Bi-CMOS



Functional Block Diagram

Features

- Single 2.7V to 3.6V Power Supply
- 2400MHz to 2500MHz Operation
- Two Gain Settings: 35dB or 19dB
- 4.0dB Cascaded NF, High Gain Mode
- 20mA DC Current Consumption
- Input IP_3: -23dBm or -8dBm

Ordering Information

RF2494	High Frequency LNA/Mixer
RF2494 PCBA-H	Fully Assembled Evaluation Board (2.5GHz)

RF Micro Devices, Inc.
7628 Thorndike Road
Greensboro, NC 27409, USA
Tel (336) 664 1233
Fax (336) 664 0454
http://www.rfmd.com

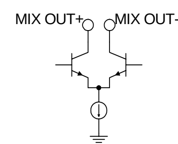
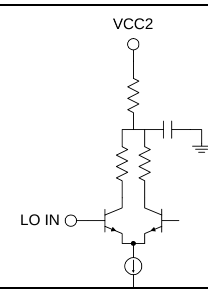
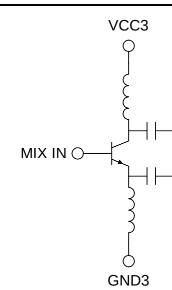
Absolute Maximum Ratings

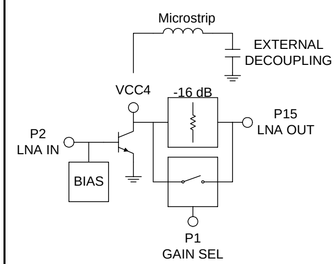
Parameter	Rating	Unit
Supply Voltage	-0.5 to 3.6	V_{DC}
Input LO and RF Levels	+6	dBm
Operating Ambient Temperature	-40 to +85	°C
Storage Temperature	-40 to +150	°C

Caution! ESD sensitive device.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Overall					T=25°C, V_{CC}=3V, RF=2442MHz, LO=2068MHz, -10dBm
RF Frequency Range		2400 to 2500		MHz	
IF Frequency Range	10	374	500	MHz	
Cascade Gain	33	35	38	dB	IF=374MHz, GAIN SEL=1
	17	19	21	dB	IF=374MHz, GAIN SEL=0
Cascade IP3	-29	-25	-19	dBm	Referenced to the input, GAIN SEL = 1
		-8		dBm	Referenced to the input, GAIN SEL = 0
Cascade Noise Figure		4.1		dB	Single sideband, GAIN SEL = 1 including image filter
		12		dB	Single sideband, GAIN SEL = 0 including image filter
Input P1dB		-35		dBm	GAIN SEL = 1
		-19		dBm	GAIN SEL = 0
LNA					
Noise Figure		2.3		dB	GAIN SEL = 1
		7		dB	GAIN SEL = 0
Input VSWR			2:1		No external matching
Input IP3		-7		dBm	GAIN SEL = 1
		-7		dBm	GAIN SEL = 0
Gain		10		dB	GAIN SEL = 1
		-6		dB	GAIN SEL = 0
Reverse Isolation		22		dB	
Output Impedance		50		Ω	
RF Amp and Mixer					
Noise Figure		6		dB	Single sideband
Input Impedance		50		Ω	
Input IP3		-17		dBm	
Conversion Voltage Gain		25		dB	With Current Combiner (2.2kΩ between open collectors and approximately 200Ω single-ended load)
Differential Output Resistance		22		kΩ	
Differential Output Capacitance		0.44		pF	
Shunt Output Capacitance		0.4		pF	
LO Input					
LO Level	-15	-10	0	dBm	
LO to RF Rejection		42		dB	LO input to LNA input
LO to IF Rejection		15		dB	LO input to IF output
LO Input VSWR			2:1		
Power Down Control					
Logic Controls “ON”	V_{CC}-0.3			V	Voltage at the input of RX EN, PD
Logic Controls “OFF”			300	mV	and GAIN SEL
Turn on Time		400	1000	nS	From PD Going high.
Turn on Time		100	200	nS	From RX EN Going high. PD = “1”

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Power Supply					
Voltage	2.7	3.3	3.6	V	
Current Consumption	15	17	26	mA	GAIN SEL=1, RX EN=1, PD=1
		17	26	mA	GAIN SEL=0, RX EN=1, PD=1
	8	10	16	mA	GAIN SEL=X, RX EN=0, PD=1
		0.2	10	μA	GAIN SEL=X, RX EN=X, PD=0

Pin	Function	Description	Interface Schematic
1	PD	The power enable pin. When PD is >V_{CC}-300mV, the part is biased on. When PD is <300mV, then the part is turned off and typically draws less than 1μA.	
2	VCC1	Supply voltage for bias circuits and logic control. A 10pF external bypass capacitor is required and an additional 0.01μF is required if no other low frequency bypass capacitors are nearby. The trace length between the pin and the bypass capacitors should be minimized. The ground side of the bypass capacitors should connect immediately to ground plane.	
3	VCC2	Supply voltage for LO_Buffer. A 10pF bypass capacitor is required and an additional 0.01μF is required if there is no other low frequency bypass capacitor in the area. The trace length between the pin and the bypass capacitors should be minimized. The ground side of the bypass capacitors should connect immediately to ground plane.	See pin 6.
4	MIXOUT-	The inverting open collector output of the mixer. This pin needs to be externally biased and DC isolated from other parts of the circuit. This output can drive a Balun, with MIXOUT+, to convert to unbalanced to drive a SAW filter. The Balun can be either broadband (transformer) or narrowband (discrete LC matching). Alternatively, MIXOUT+ may be used alone to drive a SAW single-ended, with an RF choke (high Z at IF) from VCC to MIXOUT-.	
5	MIXOUT+	The non-inverting open collector output of the mixer. This pin needs to be externally biased and DC isolated from other parts of the circuit. This output can drive a Balun, with MIXOUT+, to convert to unbalanced to drive a SAW filter. The Balun can be either broadband (transformer) or narrowband (discrete LC matching). Alternatively, MIXOUT+ may be used alone to drive a SAW single-ended, with an RF choke (high Z at IF) from VCC to MIXOUT+.	See pin 4.
6	LO IN	LO input pin. This input needs a DC-blocking cap. External matching is recommended to 50Ω.	
7	RX EN	This control pin allows the mixer output pins to be put into a high impedance state. This allows the transmit signal path to share the same IF filter as the receiver.	
8	VCC3	Supply voltage for mixer preamp.	See pin 10.
9	GND3	Ground pin for mixer preamp. This lead inductance is intended to be similar to VCC3 lead inductance.	See pin 10.
10	MIX IN	Mixer RF Input port. This pin is NOT internally DC-blocked. An external blocking capacitor must be provided if the pin is connected to a device with DC present. A value of >22pF is recommended. To minimize the noise figure it is recommended to have a bandpass filter before this input. This will prevent the noise at the image frequency from being converted to the IF.	
11	NC	Not connected.	
12	NC	Not connected.	

Pin	Function	Description	Interface Schematic
13	**LNA OUT**	RF signal output for external 50Ω filtering.The use of a filter here is optional but does provide for lower noise floor and better out-of-band rejection.	See pin 14.
14	**VCC4**	Supply voltage for the LNA. This pin should be bypassed with a 10 pF capacitor to ground as close to the pin as possible. The shunt inductance from this pin to ground via the supply decoupling must be tuned to match the LNA output to 50Ω at the desired operating frequency.	
15	**GS**	LNA gain control. When GAIN SEL is >V_{CC}-300mV, LNA gain is at 10 dB. When GAIN SEL is <300mV, the LNA gain is -6dB.	See pin 14.
16	**LNA IN**	This pin is NOT internally DC blocked. An external blocking capacitor must be provided if the pin is connected to a device with DC present. If a blocking capacitor is required, a value of 2pF is recommended.	See pin 14.

Theory of Operation

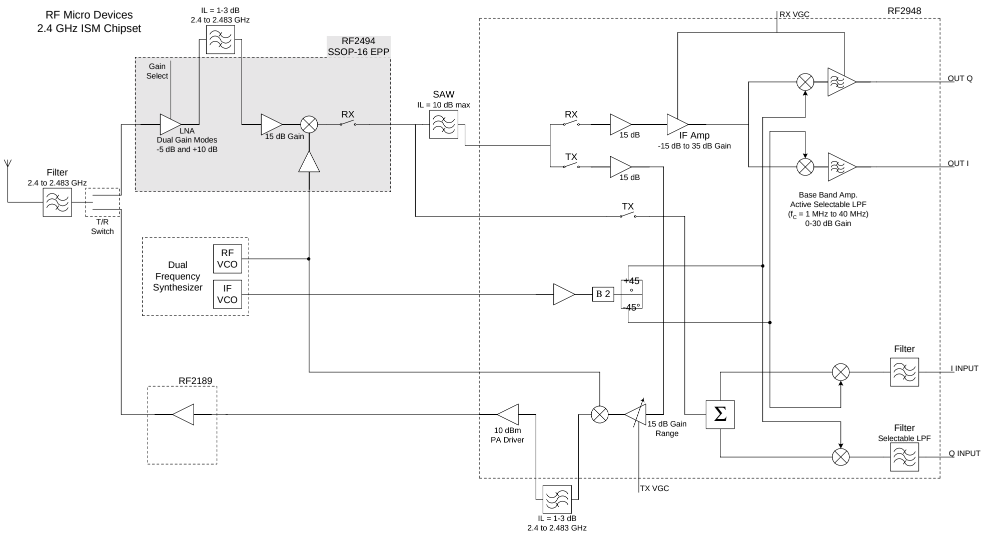


Figure 1. Entire Chipset Functional Block Diagram

The RF2494 contains the LNA/Mixer for this chipset. The LNA is made from two stages including a common emitter amplifier stage with a power gain of 13dB and an attenuator which has an insertion loss of 3dB in high gain mode, and 17dB in low gain mode. The attenuator was put after the LNA so that system noise figure degradation would be minimized. A single gain stage was used prior to the image filter to maximize IP3 which minimizes the risk of large out-of-band signals jamming the desired signal.

The mixer on the RF2494 is also two stages. The first stage is a common emitter amp used to boost the total power gain prior to the lossy SAW filter, to convert to a differential signal to the input of the mixer, and to improve the noise figure of the mixer. The second stage is a double balanced mixer whose output is differential open collector. It is recommended that a “current combiner” is used (as shown in figure 2) at the mixer output to maximize conversion gain, but other loads can also be used. The current combiner is used to do a differential to single ended conversion for the SAW filter. C50 and L15 are used to tune the circuit for a specific IF frequency. L14 is a choke to supply DC current to the mixer that is also used as a tuning element, along with C44, to match to the SAW filter’s input impedance. RL is the SAW filter’s input impedance.

The mixer voltage conversion gain is +25dB when R39 is set to 2.2kΩ. The conversion gain can be adjusted up or down by changing the value of R39. Once R39 is chosen, L15 and C50 can be used to tune the output for the SAW filter.

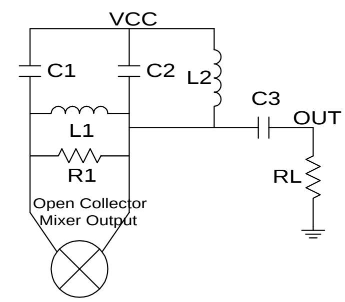


Figure 2. Current Combiner for Mixer Load

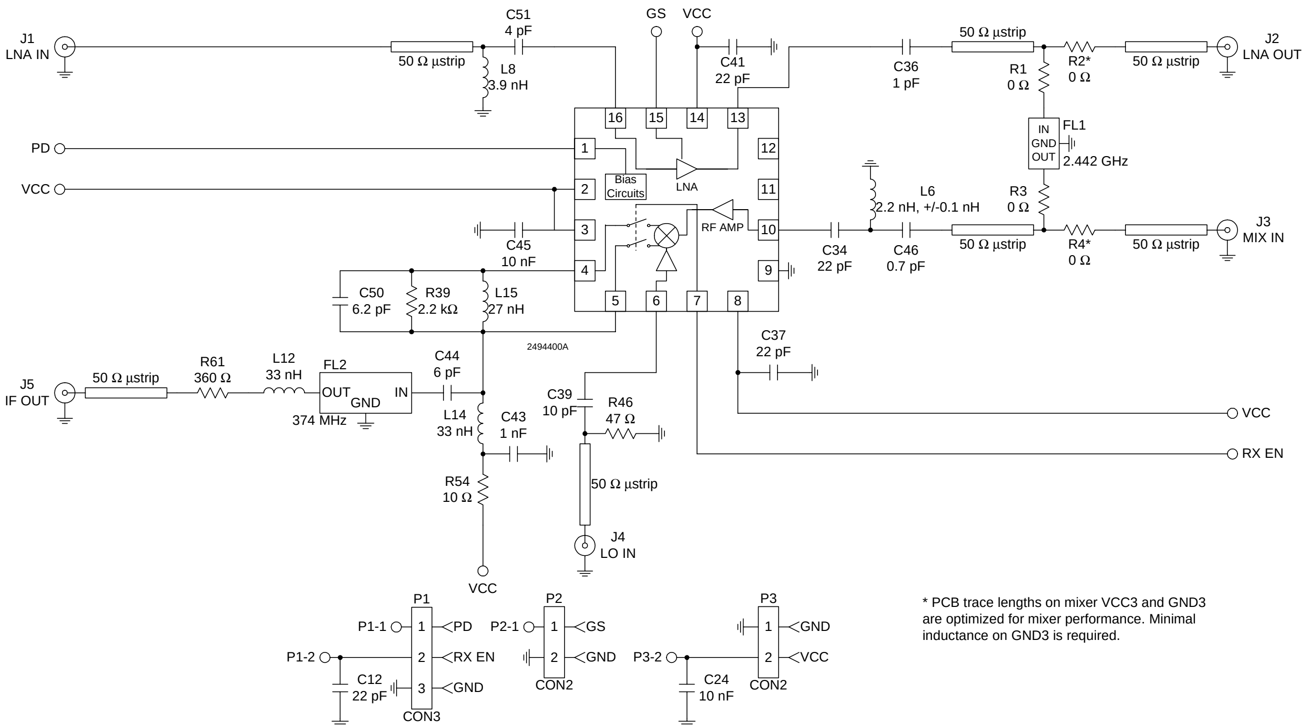
NOTE: When measuring IF OUT at connector J5 the mixer voltage conversion gain will be approximately 18dB LOWER than expected due to the presence of R61. R61 simulates the nominal load impedance seen by the SAW filter.

The cascaded voltage gain of the LNA/Mixer is 35dB, which after insertion loss in the image filter (~2dB) and IF SAW filter (~10dB), still gives 23dB of gain prior to the IF amps. Because of this, the noise figure of the IF amps should not significantly degrade system noise figure.

The LNA input should be matched for a good return loss for optimum gain and noise figure. To allow the designer to match each of these ports, 2-port s-parameter data is available for the LNA, and 1-port data is available for MIXER IN and LO IN. Care must be taken in using this data, as board layout profoundly effects these impedances. It is recommended that designers verify this data on prototype boards if any changes are made to the layout from RFMD’s recommended layouts.

Evaluation Board Schematic

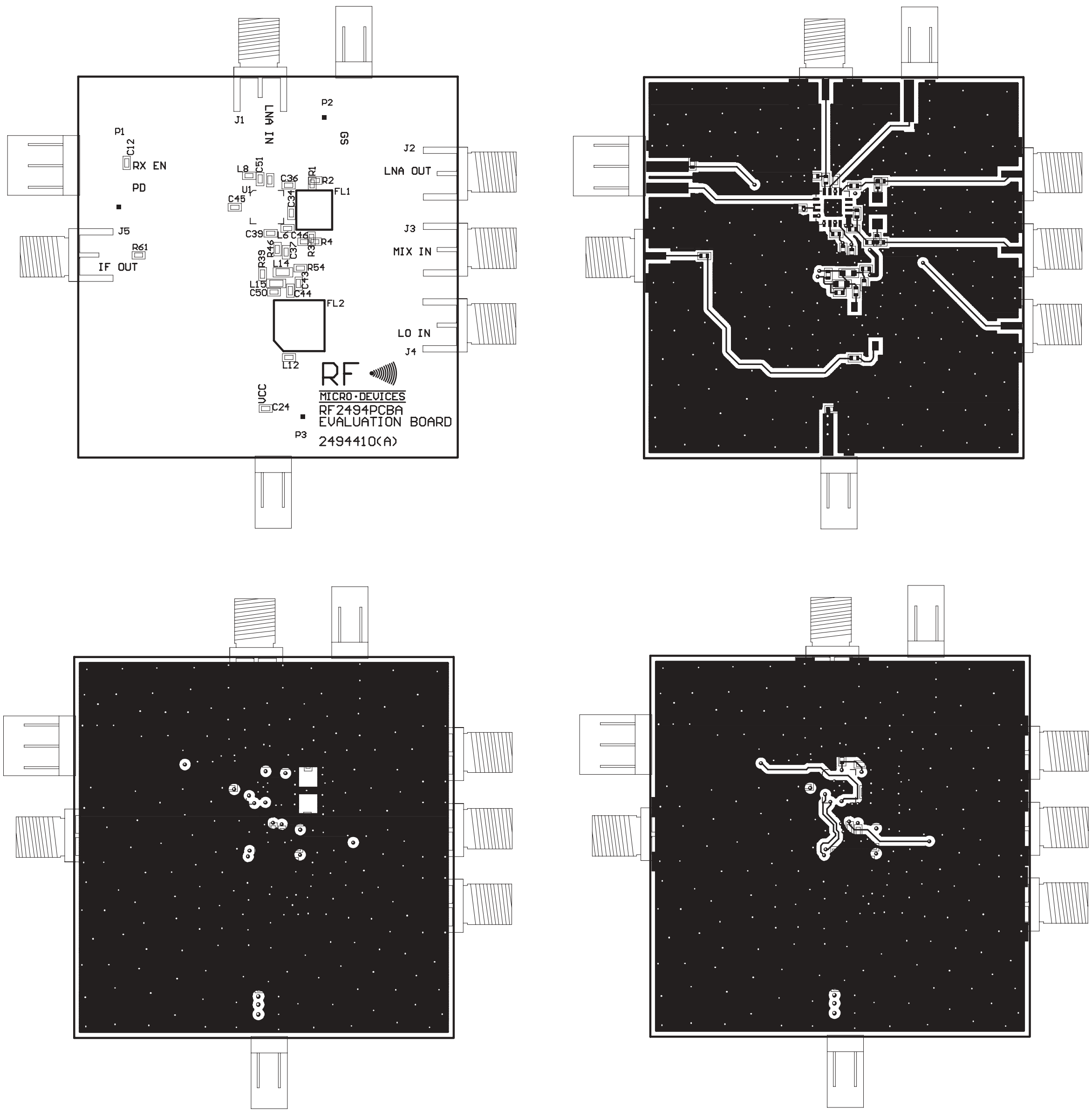
(Download Bill of Materials from www.rfmd.com.)



* PCB trace lengths on mixer VCC3 and GND3 are optimized for mixer performance. Minimal inductance on GND3 is required.

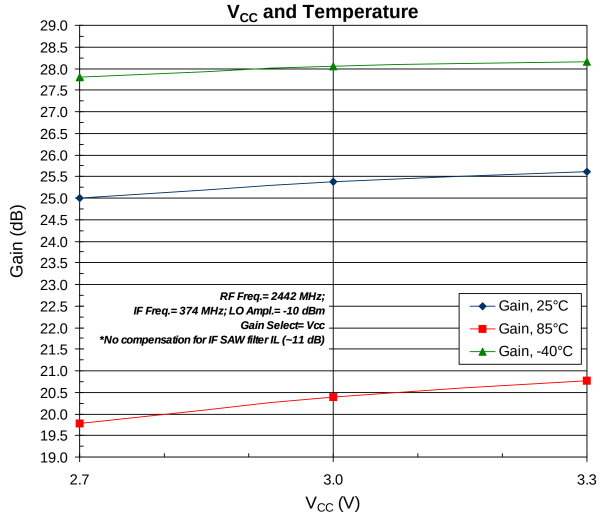
Evaluation Board Layout
Board Size 1.5” x 1.5”

Board Thickness 0.031”, Board Material FR-4, Multi-Layer

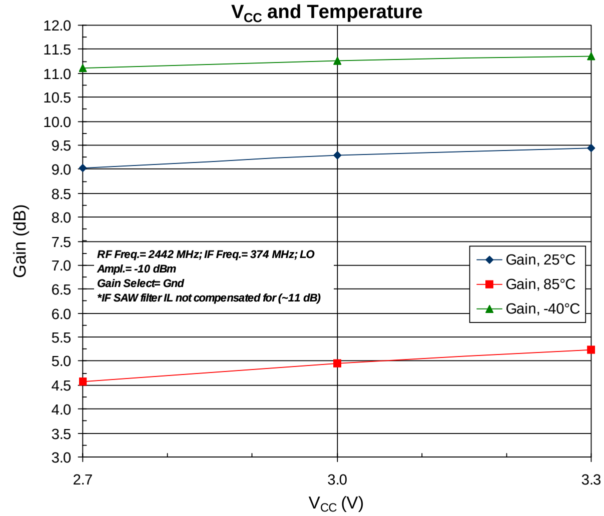


NOTE: In the following charts, all cascaded data measured with a bandpass filter inserted between LNA OUT and MIX IN, having cut frequencies: f_L=TBD, f_M=TBD, and insertion loss=TBD. 0

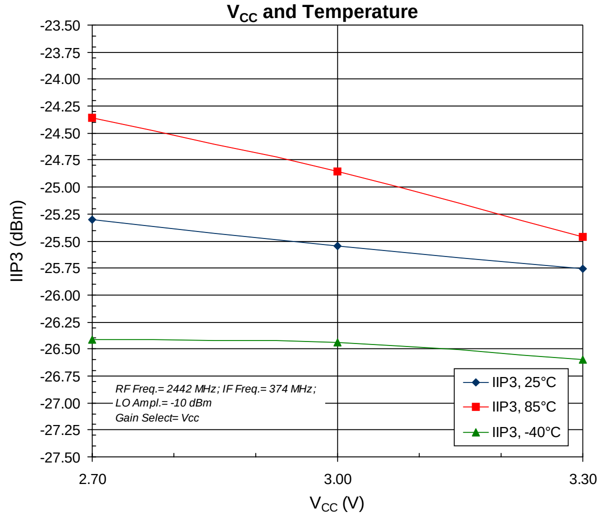
LNA + Mixer Gain High versus V_{CC} and Temperature



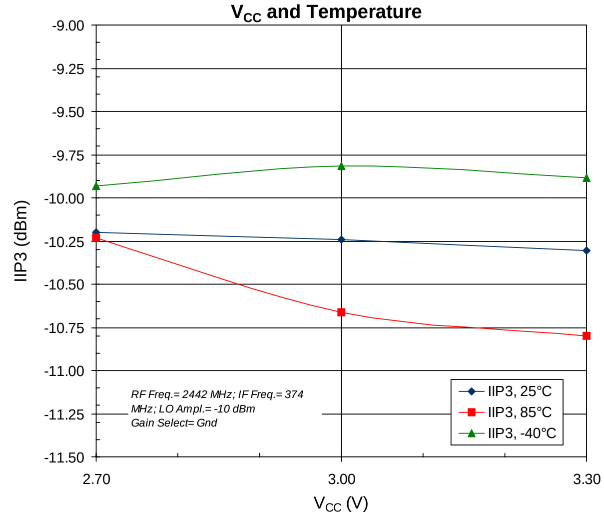
LNA + Mixer Gain Low versus V_{CC} and Temperature



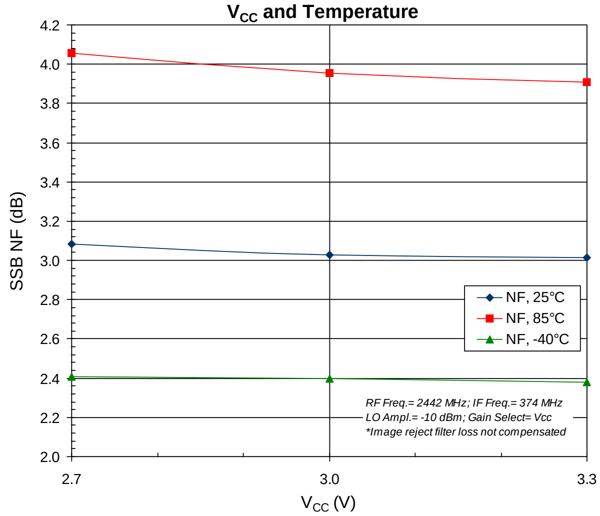
LNA + Mixer Input IP3 High versus V_{CC} and Temperature



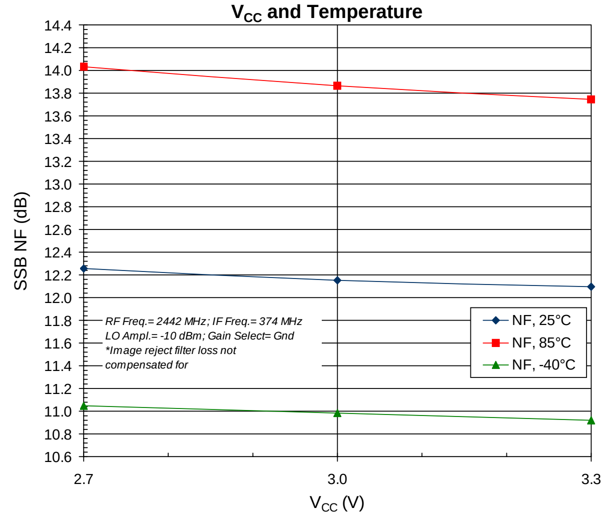
LNA + Mixer Input IP3 Low versus V_{CC} and Temperature

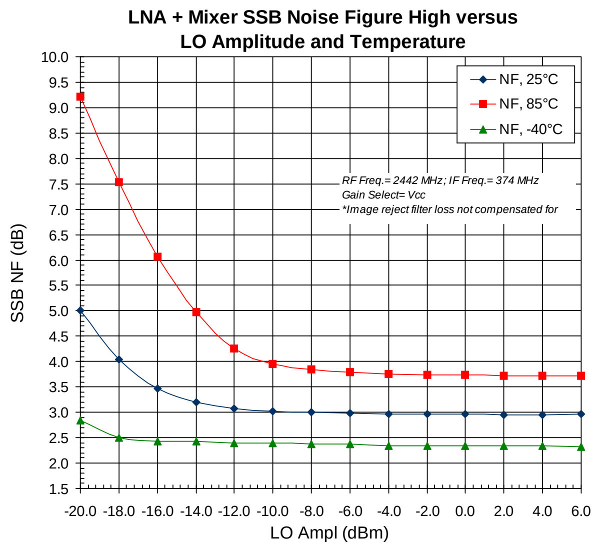


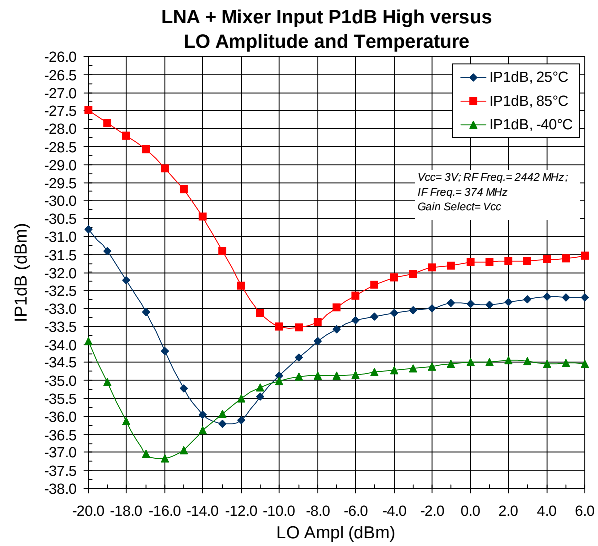
LNA + Mixer SSB Noise Figure High versus V_{CC} and Temperature

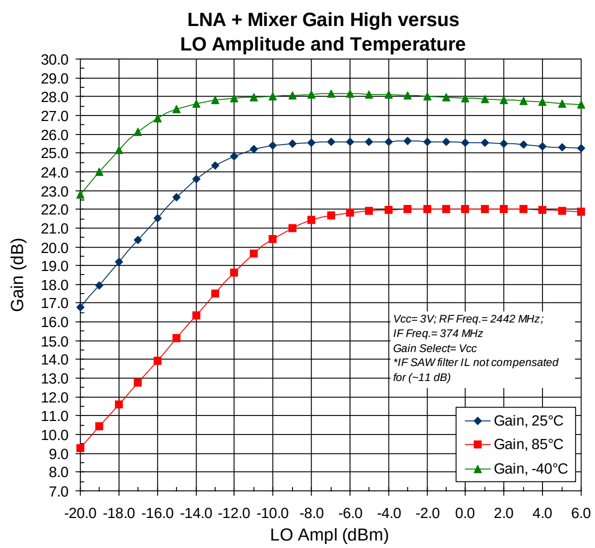


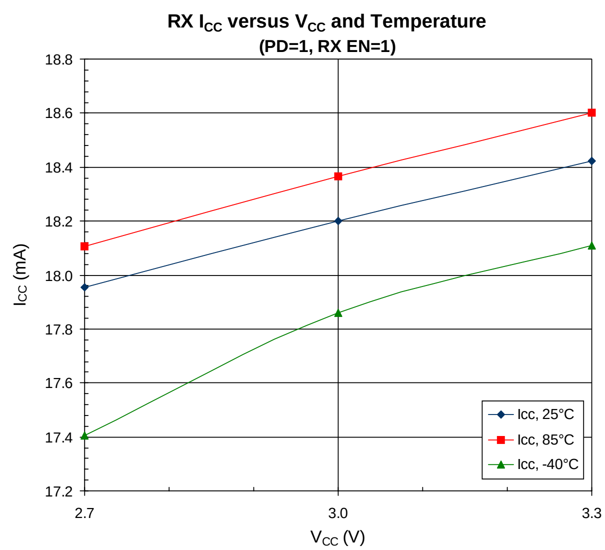
LNA + Mixer SSB Noise Figure Low versus V_{CC} and Temperature



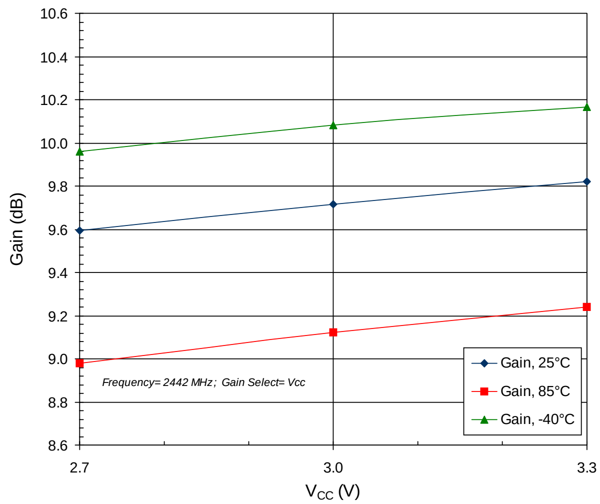

LNA + Mixer SSB Noise Figure High versus
LO Amplitude and Temperature
SSB NF (dB)
LO Ampl (dBm)
NF, 25°C
NF, 85°C
NF, -40°C
RF Freq.= 2442 MHz; IF Freq.= 374 MHz
Gain Select= Vcc
*Image reject filter loss not compensated for


LNA + Mixer Input P1dB High versus
LO Amplitude and Temperature
IP1dB (dBm)
LO Ampl (dBm)
IP1dB, 25°C
IP1dB, 85°C
IP1dB, -40°C
Vcc= 3V; RF Freq.= 2442 MHz;
IF Freq.= 374 MHz
Gain Select= Vcc

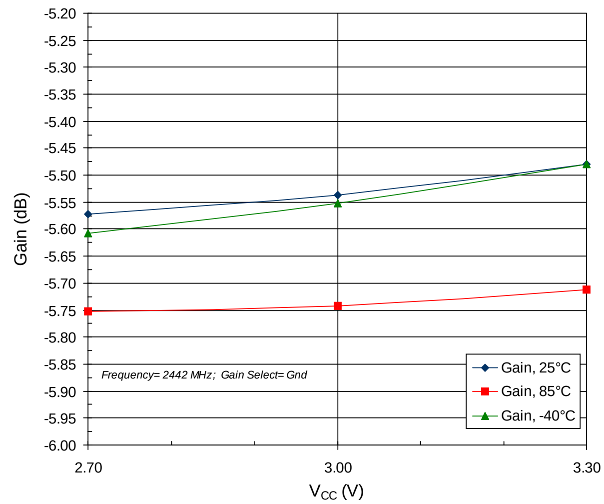

LNA + Mixer Gain High versus
LO Amplitude and Temperature
Gain (dB)
LO Ampl (dBm)
Vcc= 3V; RF Freq.= 2442 MHz;
IF Freq.= 374 MHz
Gain Select= Vcc
*IF SAW filter IL not compensated
for (~11 dB)
Gain, 25°C
Gain, 85°C
Gain, -40°C


RX ICC versus VCC and Temperature
(PD=1, RX EN=1)
ICC (mA)
VCC (V)
Icc, 25°C
Icc, 85°C
Icc, -40°C

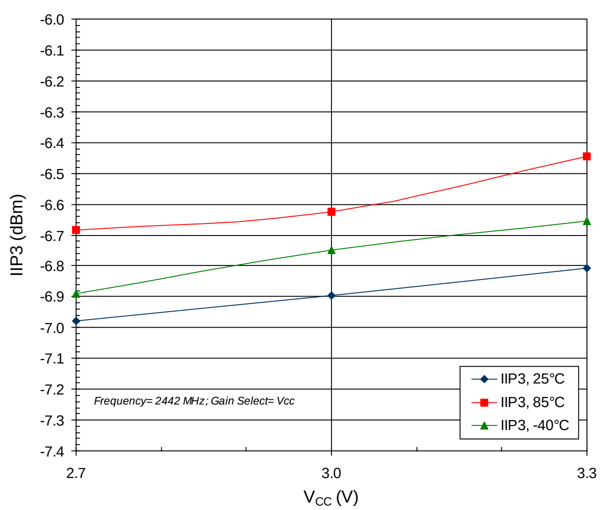
LNA Gain High versus V_{CC} and Temperature



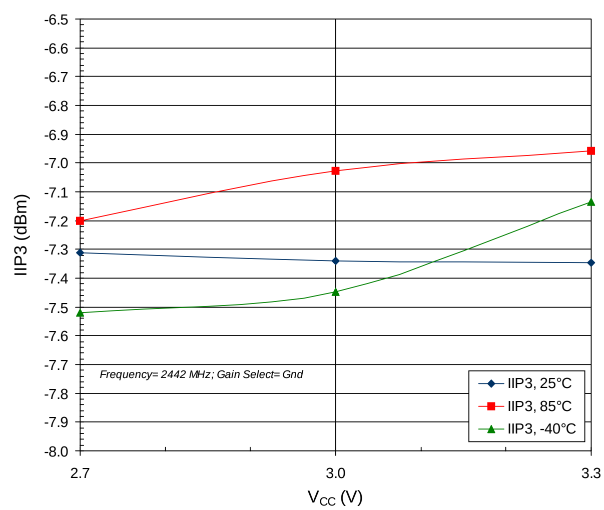
LNA Gain Low versus V_{CC} and Temperature



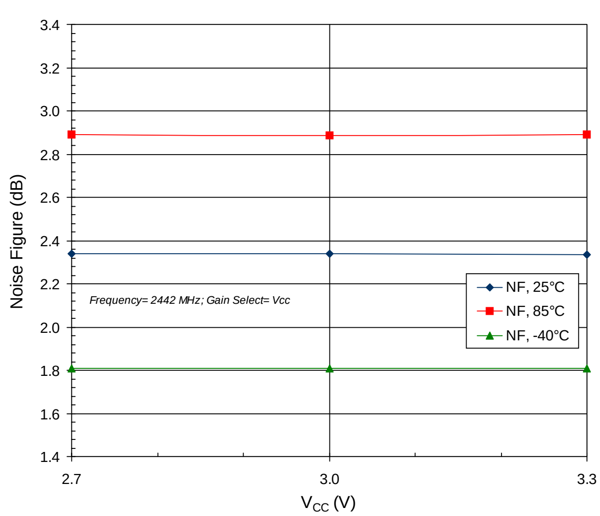
LNA Input IP3 High versus V_{CC} and Temperature



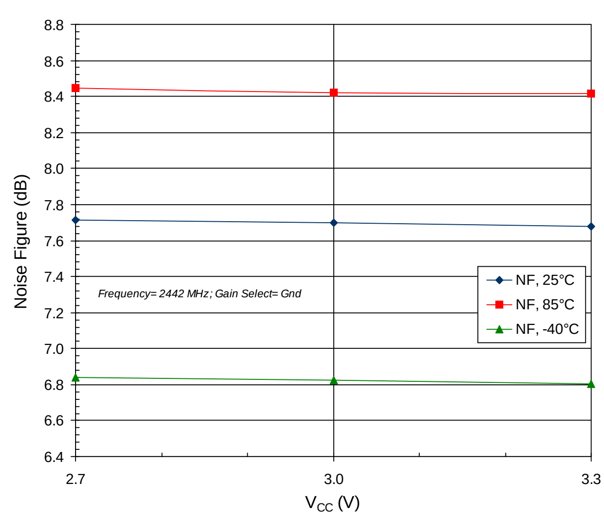
LNA Input IP3 Low versus V_{CC} and Temperature

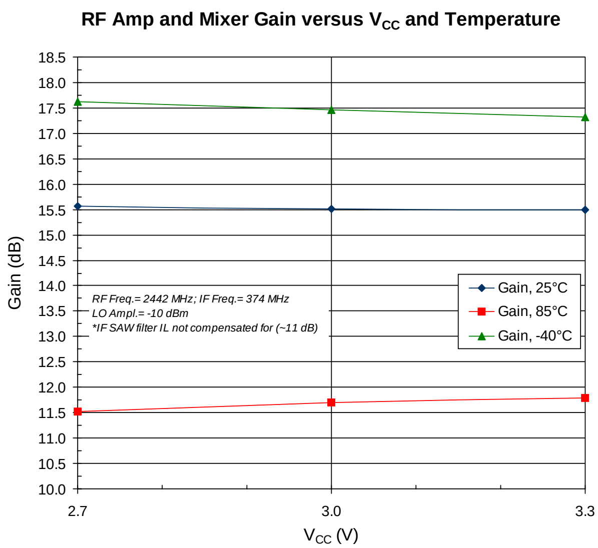


LNA Noise Figure High versus V_{CC} and Temperature



LNA Noise Figure Low versus V_{CC} and Temperature




RF Amp and Mixer Gain versus V_{CC} and Temperature
Gain (dB)
V_{CC} (V)
RF Freq.= 2442 MHz; IF Freq.= 374 MHz
LO Ampl.= -10 dBm
*IF SAW filter IL not compensated for (~11 dB)
Gain, 25°C
Gain, 85°C
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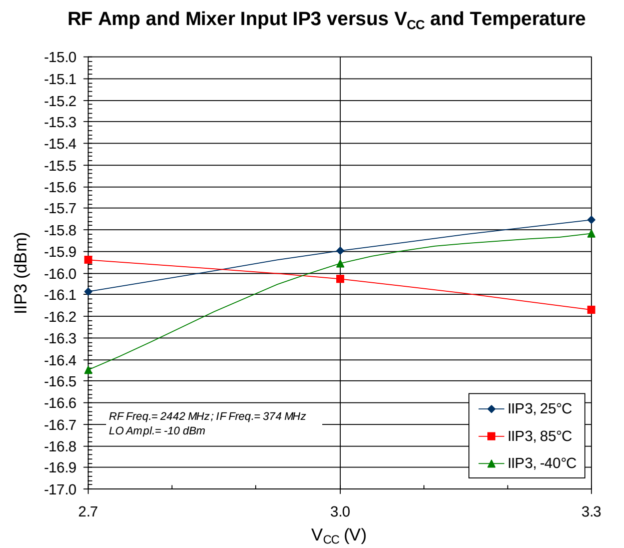
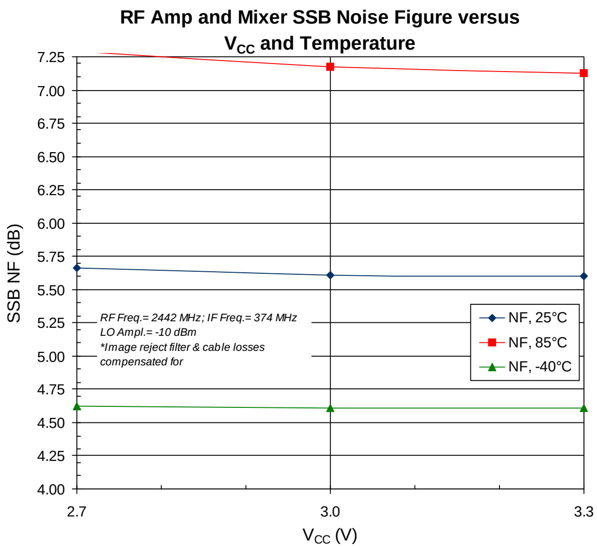

RF Amp and Mixer Input IP3 versus V_{CC} and Temperature
IIP3 (dBm)
V_{CC} (V)
RF Freq.= 2442 MHz; IF Freq.= 374 MHz
LO Ampl.= -10 dBm
IIP3, 25°C
IIP3, 85°C
IIP3, -40°C


RF Amp and Mixer SSB Noise Figure versus V_{CC} and Temperature
SSB NF (dB)
V_{CC} (V)
RF Freq.= 2442 MHz; IF Freq.= 374 MHz
LO Ampl.= -10 dBm
*Image reject filter & cable losses compensated for
NF, 25°C
NF, 85°C
NF, -40°C