RF MICRO·DEVICES

RF9936

PCS LOW NOISE AMPLIFIER/MIXER

Typical Applications

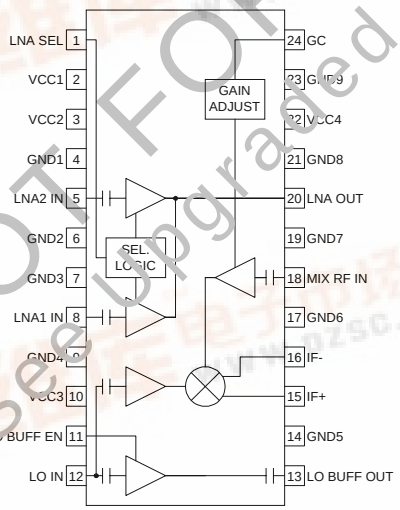
- CDMA/TDMA/DCS1900 PCS Systems
- PHS 1500/WLAN 2400 Systems
- Receivers Employing Diversity Antennas
- General Purpose Downconverter
- Micro-Cell PCS Base Stations
- Portable Battery Powered Equipment

Product Description

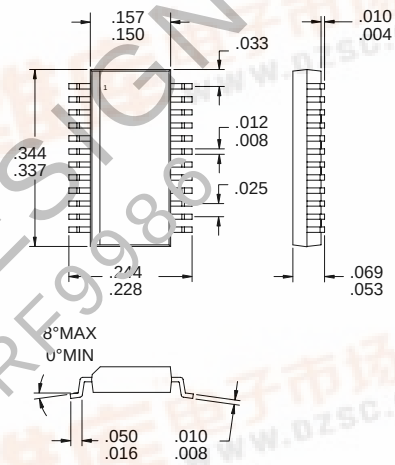
The RF9936 is a monolithic integrated receiver front-end for PCS applications. The IC contains all of the required components to implement the RF functions of the receiver front-end except for the passive filtering and LO generation. It contains two LNAs (low-noise amplifiers), a double-balanced Gilbert cell mixer, a balanced IF output, an LO isolation buffer amplifier, and an LO output buffer amplifier for providing the buffered LO signal as an output. On-chip digital logic is used to enable the appropriate LNA. The LNAs share a common output that permits insertion of a bandpass filter between the LNA output and the Mixer section. Analog gain adjustment is provided which allows 10dB variation in gain. The IC is designed to operate from a single 3.6V power supply.

Optimum Technology Matching® Applied

- ☐ Si BJT
- ☑ GaAs HBT
- ☐ GaAs MESFET
- ☐ Si Bi-CMOS
- ☐ SiGe HBT
- ☐ Si CMOS



Functional Block Diagram



Package Style: SSOP-24

Features

- Complete Receiver Front-End
- Analog RF Gain Control
- Single 3.6V Power Supply
- Digitally Selectable LNA Inputs
- Digitally Selectable Buffered LO Output
- 1500MHz to 2500MHz Operation

Ordering Information

RF9936	PCS Low Noise Amplifier/Mixer
RF9936 PCBA	Fully Assembled Evaluation Board

RF Micro Devices, Inc.
7625 Thorndike Road
Greensboro, NC 27409, USA
Tel (336) 664 1233
Fax (336) 664 0454
http://www.rfmd.com

8 FRONT-ENDS

RF9936

Absolute Maximum Ratings

Parameter	Rating	Unit
Supply Voltage	-0.5 to 7.0	V_{DC}
Input LO and RF Levels	+6	dBm
Ambient Operating Temperature	-40 to +85	°C
Storage Temperature	-40 to +150	°C

Caution! ESD sensitive device.

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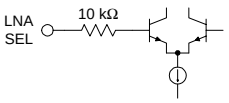
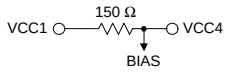
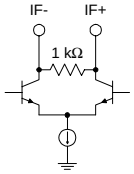
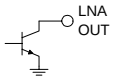
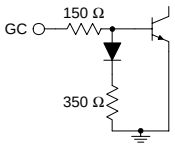
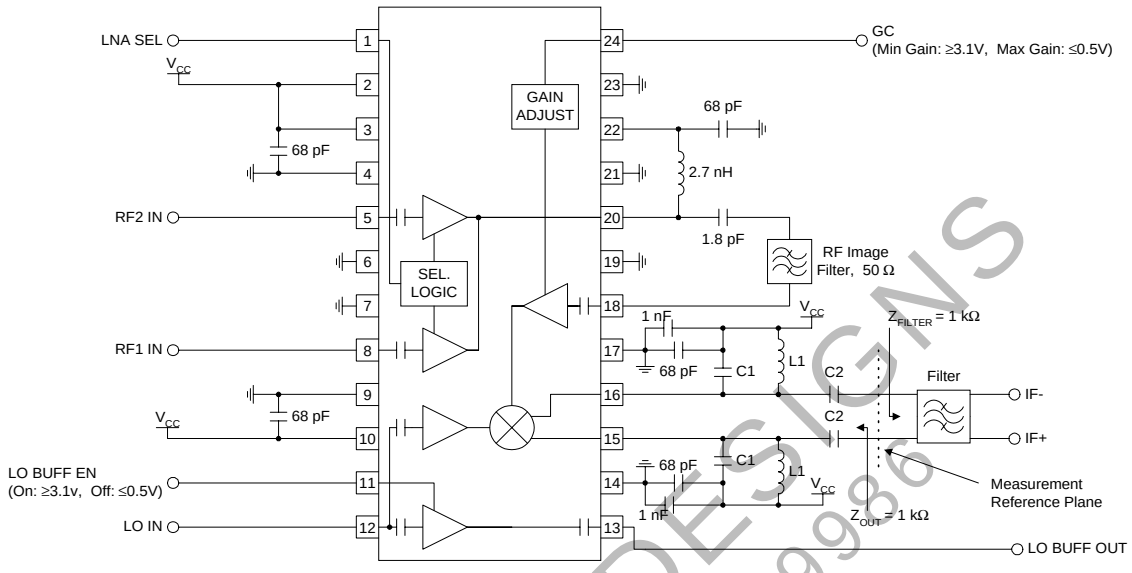
Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
Overall					T=25°C, V_{CC}=3.6V, RF=1959MHz, LO=1749MHz @ -2dBm
RF Frequency Range		1500 to 2500		MHz	
LO Frequency Range		1200 to 2500		MHz	
IF Frequency Range		DC to 500		MHz	
Cascaded Performance					1kΩ balanced load, 2.5dB Image Filter Loss. By varying the gain of the second stage, a trade-off of gain and noise figure against IP3 can be made.
Cascade Conversion Gain, Maximum		27.5		dB	$V_G \leq 0.5V$
Cascade Conversion Gain, Minimum		15.5		dB	$V_G \geq 2.5V$
Cascade Input IP3		-14		dBm	Maximum Gain
		-9		dBm	Minimum Gain
Cascade Noise Figure		2.5		dB	Single sideband, at Maximum Gain Setting
		5.1		dB	Single sideband, at Minimum Gain Setting
First Section (LNA)					The LNA section may be left unused. Power is not connected to pin 1. The performance is then as specified for the Second Section (Mixer).
Noise Figure		1.4		dB	
Input VSWR		<2.5:1			Input is internally matched for optimum noise figure from a 50Ω source.
Input IP3		+2		dBm	IP3 may be increased 10dB by connecting pin 22 to V_{CC} through the matching inductor. The LNA's current then increases by 10mA. Other in-between IP3 vs. I_{CC} trade-offs may be made. See pin description for pin 20.
Gain		13.5		dB	
Reverse Isolation		23		dB	
Output VSWR		<1.5:1			
Second Section (Mixer)					With 1kΩ balanced load. By varying the gain of the second stage, a trade-off of gain and noise figure against IP3 can be made. Please see data plots.
Noise Figure		6.5		dB	Single Sideband, at maximum gain
		13.5		dB	Single Sideband, at minimum gain
Input VSWR		1.5:1			
Input IP3		-3		dBm	At maximum gain
		+2		dBm	At minimum gain
Conversion Gain, Maximum		16		dB	$V_G \leq 0.2V$
Conversion Gain, Minimum		6		dB	$V_G \geq 2.5V$
Output Impedance		1		kΩ	Balanced

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
LO Input					
LO Input Range		-5 to +3		dBm	
LO Output Level		-5		dBm	Buffer On, -2dBm input
		-25		dBm	Buffer Off, -2dBm input
LO to RF (Mix In) Rejection		30		dB	
LO to IF1, IF2 Rejection		20		dB	
LO Input VSWR		<2:1			Single ended
Power Supply					
Voltage		3.6±5%		V	
Current Consumption		5		mA	LNA only
		46	50	mA	LNA + Mixer, LO Buffer On
		43	47	mA	LNA + Mixer, LO Buffer Off

Pin	Function	Description	Interface Schematic
1	LNA SEL	Selects which LNA (LNA1 or LNA2) is active. This is a digitally controlled input. A logic "high" (≥3.1V.) selects LNA2. A logic "low" (≤0.5V.) selects LNA1.	
2	VCC1	Supply Voltage for the Mixer and RF Buffer Amplifier. External RF bypassing is required. The trace length between the pin and the bypass capacitor should be minimized. The ground side of the bypass capacitor should connect immediately to ground plane.	
3	VCC2	Supply Voltage for the LNAs and associated select logic. External RF bypassing is required. The trace length between the pin and the bypass capacitor should be minimized. The ground side of the bypass capacitor should connect immediately to ground plane.	
4	GND1	Ground connection for LNA2. Keep traces physically short and connect immediately to ground plane for best performance.	
5	LNA2 IN	RF Input pin for LNA2. This pin is internally DC blocked and internally matched for minimum noise figure (NOT for minimum VSWR), given a 50Ω source impedance.	
6	GND2	Same as pin 4.	
7	GND3	Ground connection for LNA1. Keep traces physically short and connect immediately to ground plane for best performance.	
8	LNA1 IN	RF Input pin for LNA1. This pin is internally DC blocked and internally matched for minimum noise figure (NOT for minimum VSWR), given a 50Ω source impedance.	
9	GND4	Same as pin 7.	
10	VCC3	Supply voltage for both LO buffer amplifiers. External RF bypassing is required. The trace length between the pin and the bypass capacitor should be minimized. The ground side of the bypass capacitor should connect immediately to ground plane.	
11	LO BUFF EN	Enable pin for the LO output buffer amplifier. This is a digitally controlled input. A logic "high" (≥3.1V.) turns the buffer amplifier on, and the current consumption increases by 3mA (with -2dBm LO input). A logic "low" (≤0.5V.) turns the buffer amplifier off.	
12	LO IN	Mixer LO Input pin. This pin is internally DC blocked and matched to 50Ω.	
13	LO BUFF OUT	Optional Buffered LO Output. This pin is internally DC blocked and matched to 50Ω. The buffer amplifier is switched on or off by the voltage level at pin 11.	
14	GND5	Ground connection for both LO buffer amplifiers. Keep traces physically short and connect immediately to ground plane for best performance.	
15	IF+	Open-collector IF Output pin. This is a balanced output. The output impedance is set by an internal 1000Ω resistor to pin 16. Thus the differential IF output impedance is 1000Ω. The resistor sets the operating impedance, but an external choke or matching inductor to V_{CC} must be supplied in order to bias this output. This inductor is typically incorporated in the matching network between the output and IF filter. Because this pin is biased to V_{CC}, a DC blocking capacitor must be used if the IF filter input has a DC path to ground.	
16	IF-	Same as pin 15, except complementary output.	See pin 15.
17	GND6	Ground connection for the Mixer. Keep traces physically short and connect immediately to ground plane for best performance.	
18	MIX RF IN	Mixer RF Input Pin. This pin is internally DC blocked and matched to 50Ω.	
19	GND7	Same as pin 17.	

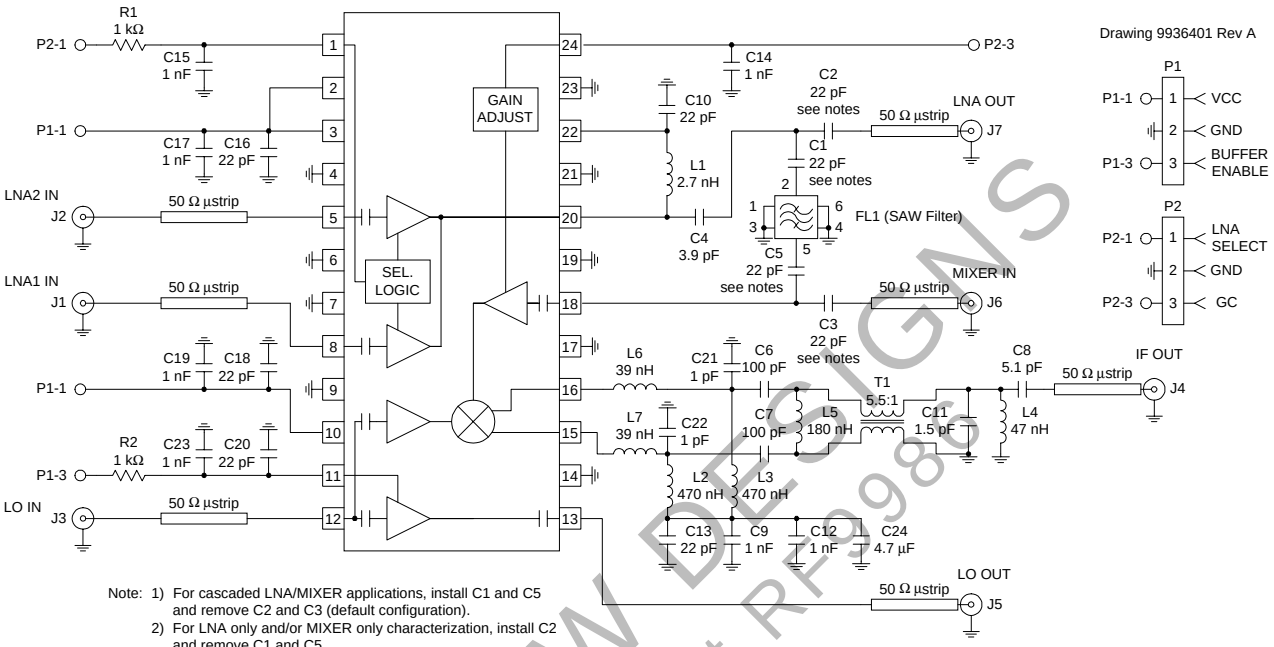
Pin	Function	Description	Interface Schematic
20	LNA OUT	LNA Output pin. This is an open-collector output. This pin is typically connected to pin 22 through a bias/matching inductor. This inductor, in conjunction with a series blocking/matching capacitor, forms a matching network to the 50Ω image filter and provides bias (see Application Example). The LNA's IP3 may be increased 10dB by connecting pin 20 to V_{CC} through the inductor. The LNA's current then increases by 10mA. Other in-between IP3 vs. I_{CC} trade-offs may be made by connecting resistance values between V_{CC} and the matching inductor. The two reference points for consideration are with 150Ω used, which is what connection to pin 22 achieves, the Input IP3 is +2dBm and the LNA I_{CC} is 5mA. Using no resistance, the Input IP3 is +12 dBm and the LNA I_{CC} is 15 mA. Desired operating points in between these values may be interpolated, roughly.	
21	GND8	Same as pin 17.	
22	VCC4	Output supply voltage for the LNA Output (pin 20). This pin should NOT be connected to a voltage supply. This pin should be connected to pin 20 through a bias/matching inductor (see Application Example). External RF bypassing is required. The trace length between the pin and the bypass capacitor should be minimized. The ground side of the bypass capacitor should connect immediately to ground plane.	See pin 2.
23	GND9	Same as pin 17.	
24	GC	Analog gain adjustment for RF buffer amplifier. Minimum gain is selected with 2.5V to 3.0V. Maximum gain is selected with 0V to 0.5 V. When operating the RF9936 at fixed maximum gain, this pin may be grounded.	

Application Schematic



L1 and C2 serve dual purposes. L1 serves as an output bias choke, and C2 serves as a series DC block. In addition, the values of L1 and C2 may be chosen to form an impedance matching network if the IF filter's input impedance is not 100 Ω. Otherwise, the values of L1 and C1 are chosen to form a parallel-resonant tank circuit at the IF when the IF filter's input impedance is 100 Ω.

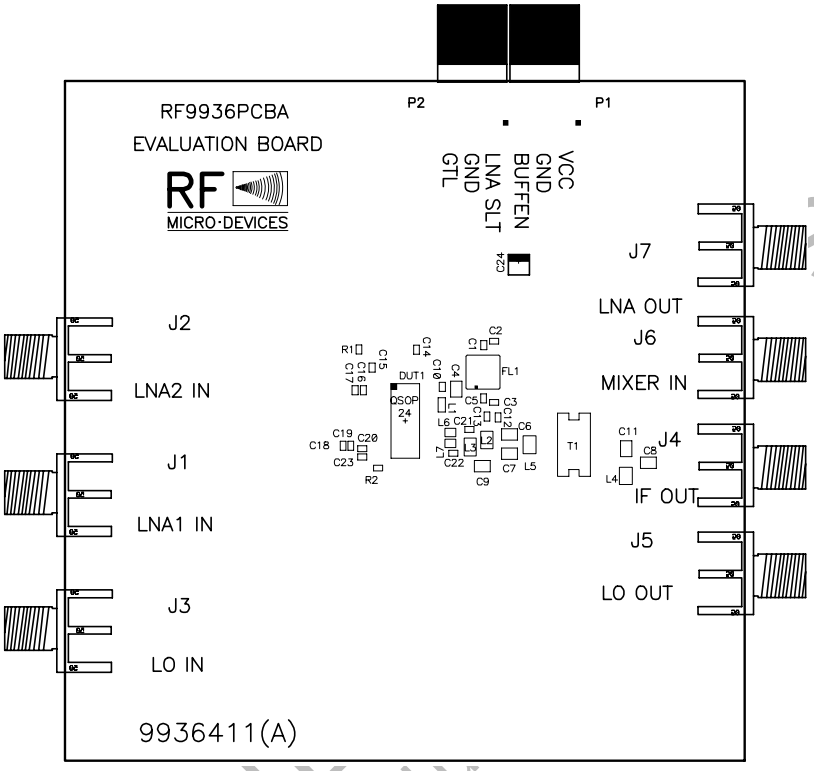
Evaluation Board Schematic
IF 210MHz
(Download Bill of Materials from www.rfmd.com.)

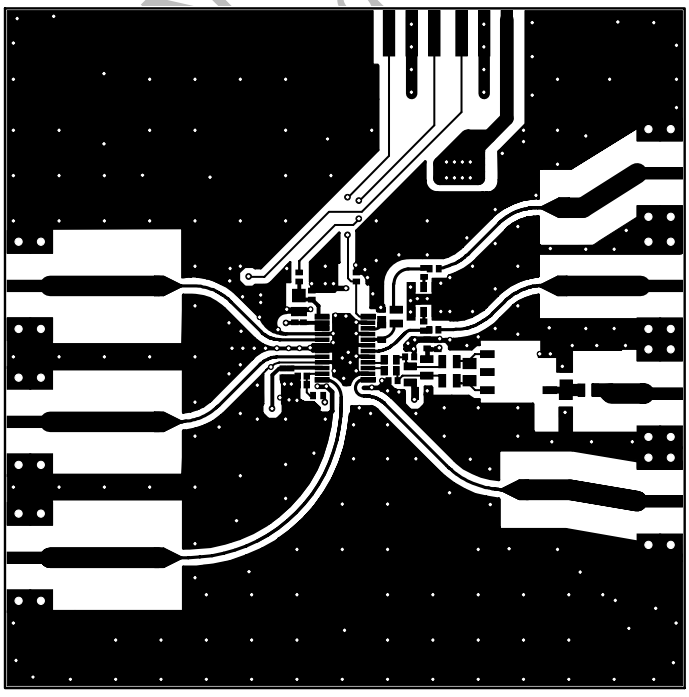


Note: 1) For cascaded LNA/MIXER applications, install C1 and C5 and remove C2 and C3 (default configuration).
2) For LNA only and/or MIXER only characterization, install C2 and remove C1 and C5.
3) L5 select value 180 nH to 220 nH.
4) Do not install C2, C3 in normal cascade operation.

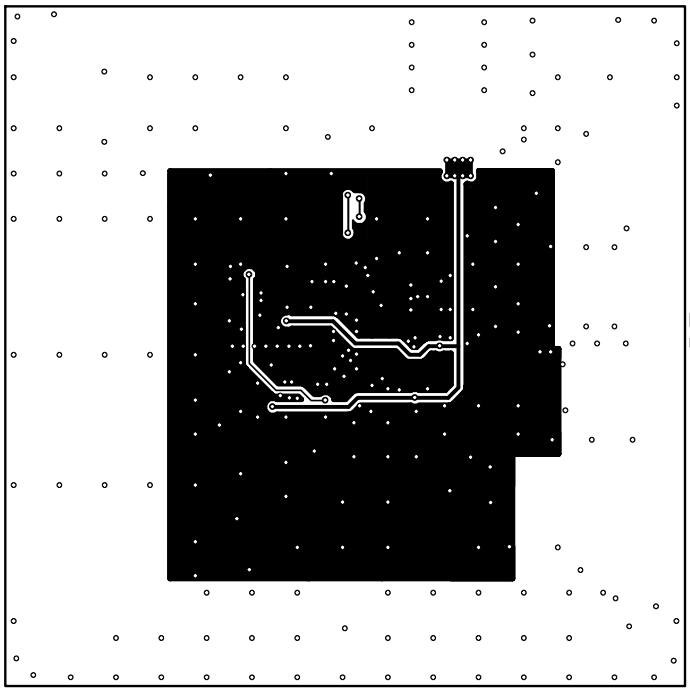
Evaluation Board Layout

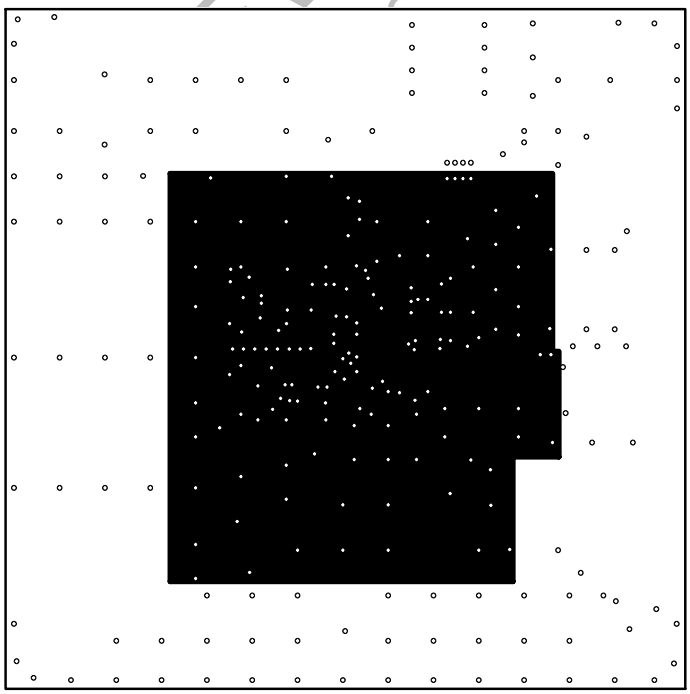
(Assembly, Top layer, Mid-signal layer, Internal Ground layer)





Evaluation Board Layout cont'd





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