Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

Freescale Semiconductor
Data Sheet: Advance Information

Document Number: MC13851
Rev. 2.0, 12/2010

VRoHS

MC13851

Package Information
Plastic Package:
MLPD-8
2.0 × 2.0 × 0.6 mm
Case: 2128-01

MC13851

General Purpose Low Noise Amplifier with Bypass Switch

Ordering Information

Device	Device Marking	Package
MC13851EP	851	MLPD-8

1 Introduction

The MC13851 is a cost-effective, high IP3 LNA with low noise figure. This is the smaller leadless package version of the MC13821 device. The MC13851 includes an integrated bypass switch to preserve high input intercept performance in variable signal strength environments and boosts dynamic range. On-chip bias circuitry offers low system cost. The input and output match are external to allow maximum design flexibility. An external resistor is used to set device current which allows balancing required linearity with low current consumption. Gain is optimized for applications greater than 1000 MHz. The MC13851 is fabricated with the advanced RF BiCMOS process using the eSiGe:C module and is available in the 2 × 2 mm MLPD-8 leadless package, offering a small, low height, easy-to-solder solution for applications with tight printed circuit board placement requirements.

Contents:

1 Introduction 1
2 Electrical Specifications .3
3 Application Information 9
4 Printed Circuit and Bill of Materials 20
5 Scattering and Noise Parameters 22
6 Packaging 32
7 Product Documentation 33
8 Revision History 33

This document contains information on a new product. Specifications and information herein are subject to change without notice.

freescale™ semiconductor

1.1 Features

The MC13851 is intended for applications from 1000 MHz to 2500 MHz and the MC13852 is for applications less than 1000 MHz.

- Gain: 18.7 dB (typical) at 1960 MHz and 17.7 dB (typical) at 2140 MHz
- Output third order intercept point (OIP3): 16 dBm at 1960 MHz and 17 dBm (typical) dBm at 2140 MHz
- Noise Figure (NF): 1.37 dB (typical) at 1960 MHz and 1.46 dB at 2140 MHz
- Output 1 dB compression point (P1dB): 8 dBm (typical) at 1960 MHz and 8 dBm (typical) at 2140 MHz
- IP3 Boost Circuitry from Freescale
- Bypass mode has return losses comparable to active mode, for use in systems with filters and duplexers
- Bypass mode improves dynamic range in variable signal strength environments
- Integrated logic-controlled standby mode with current drain < 1uA
- Total supply current variable from 2.5 mA–5 mA using an external bias resistor
- In a receiver system with 20% active mode and 80% bypass mode, the average current drain is < 0.6 mA
- On-chip bias sets the bias point
- Bias stabilized for device and temperature variations
- MLPD-8 leadless package with low parasitics
- 1575 MHz, 1960 MHz, 2140 MHz and 2500 MHz application circuit evaluation boards with characterization data are available
- Available in tape and reel packaging

1.2 Applications

Ideal for use in any RF product that operates between 1000 MHz and 2.5 GHz, and may be applied in:

- Buffer amplifiers
- Mixers
- IF amplifiers
- Voltage controlled oscillators (VCOs)
- Use with transceivers requiring external LNAs
- Smart metering
- Mobile—Cellular front end LNA, GPS, two-way radios
- Consumer—WLAN, 802.11 b/g
- Auto—GPS, active antenna, wireless security
- Low current drain/long standby time for extended battery life applications

Figure 1 shows a simplified block diagram of the MC13851 with the pinouts and location of the Pin 1 designator on the package.

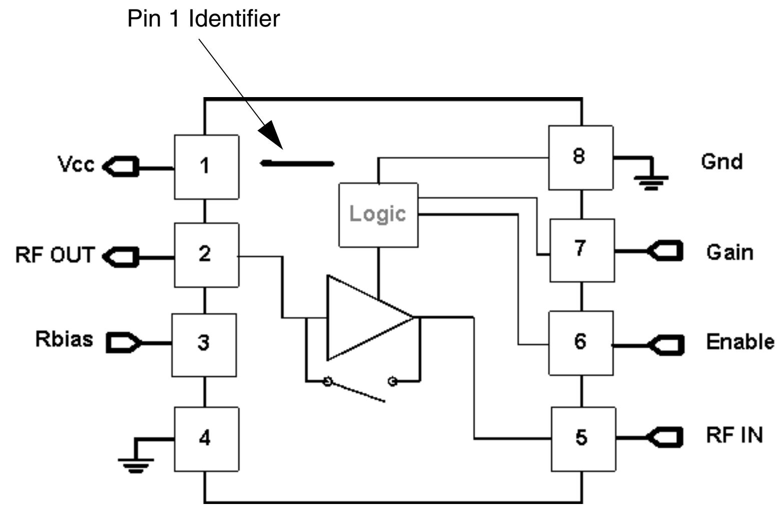


Figure 1. Functional Block Diagram

2 Electrical Specifications

Table 1. lists the maximum ratings for the device.

Table 1. Maximum Ratings (TA=25°C, unless otherwise noted)

Rating	Symbol	Value	Unit
Supply voltage	Vcc	3.3	Vdc
Storage temperature range	T_{stg}	-65–150	°C
Operating ambient temperature range	T_A	-30–85	°C
RF input power	P_{RF}	10	dBm
Power dissipation	Pdis	100	mW
Thermal resistance, junction to case	$R_{thetaJC}$	24	°C/W
Thermal resistance, junction to ambient, 4 layer board	$R_{thetaJA}$	90	°C/W
Note: Maximum ratings 1. Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the recommended Operating Conditions and Electrical Characteristics tables. 2. ESD (electrostatic discharge) immunity meets Human Body Model (HBM) ≤200V. Charge Device Model (CDM) ≤450V, and Machine Model (MM) ≤50V			

Table 2 lists the recommended operating conditions.

Table 2. Recommended Operating Conditions

Characteristic	Symbol	Min	Typ	Max	Unit
RF frequency range	f_{RF}	1000	—	2500	MHz
Supply voltage	V_{CC}	2.3	2.75	3	V

Table 2. Recommended Operating Conditions (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Logic voltage Input high voltage Input low voltage	—	 1.25 0	 1.8 0	 V_{CC} 0.80	 Vdc Vdc

Table 3 shows the use of the Gain and Enable pins to select Active mode (High Gain), Bypass mode (Low Gain) or Standby mode (Disable) operation.

Table 3. Truth Table

Pin Function	Pin Name	Enable		Disable	
		Low Gain	High Gain	Low Gain	High Gain
Logic Circuit Bias Vcc	Vcc	1	1	1	1
Toggles Gain Mode (Active or Bypass)	Gain	0	1	0	1
Toggles LNA On/Off	Enable	1	1	0	0
Notes: 1. Logic state 1 equals Vcc voltage. Logic state of 0 equals ground potential. 2. Vcc is inductively coupled to LNA Out pin and Vcc pin 3. Minimum logic state 1 for enable and gain pins is 1.25V 4. Maximum logic state 0 for enable and gain pins is 0.8V					

Table 4 lists the electrical characteristics associated with noise performance measured in a 50 Ω system. Additional noise parameters are listed in Table 15 and Table 16. Also listed are the typical Icc and RF turn on times for the device. Information and details on the boards are shown in Section 4, "Printed Circuit and Bill of Materials."

Table 4. Electrical Characteristics (Vcc = 2.75 V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Insertion Gain	$\lvert S21\rvert^2$				dB
R1=1.2 kΩ, Freq=1.575 GHz		17.4	18.9	—	
R1=1.2 kΩ, Freq=2.14 GHz		14.5	16	—	
R1=1.5 kΩ, Freq=1.575 GHz		16.4	17.9	—	
R1=1.5 kΩ, Freq=2.14 GHz		14.9	16.4	—	
Maximum Stable Gain and/or Maximum Available Gain [Note1]	MSG, MAG				dB
R1=1.2 kΩ, Freq=1.575 GHz		21.1	22.6	—	
R1=1.2 kΩ, Freq=2.14 GHz		19.6	21.1	—	
R1=1.5 kΩ, Freq=1.575 GHz		19	20.5	—	
R1=1.5 kΩ, Freq=2.14 GHz		18.1	19.6	—	
Minimum Noise Figure	NFmin				dB
R1=1.2 kΩ, Freq=1.575 GHz		—	0.97	1.3	
R1=1.2 kΩ, Freq=2.14 GHz		—	1.07	1.4	
R1=1.5 kΩ, Freq=1.575 GHz		—	0.98	1.3	
R1=1.5 kΩ, Freq=2.14 GHz		—	1.1	1.4	

Table 4. Electrical Characteristics (Vcc = 2.75 V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Associated Gain at Minimum Noise Figure	Gnf				dB
R1=1.2 kΩ, Freq=1.575 GHz		20.5	22	—	
R1=1.2 kΩ, Freq=2.14 GHz		17	18.6	—	
R1=1.5 kΩ, Freq=1.575 GHz		20.5	22	—	
R1=1.5 kΩ, Freq=2.14 GHz		17.5	19	—	
Icc and RF Turn On Time Enable trigger total time of 1.8 µsecond from 0 to 2.75 V					µs
Icc rise time from 0 to 76% of final current level		—	6.4	—	
Icc rise time from 0 to 87% of final current level		—	9.6	—	
RF on time from leading edge of enable trigger to RF turn-on		—	1.37	—	
Note: Maximum Available Gain and Maximum Stable Gain are defined by the K factor as follows: MAG = |S21/S12(K ±sqrt(K2-1)) |, if K>1, MSG = |S21/S12|, if K<1					

Table 5 lists the electrical characteristics measured on evaluation boards tuned for typical application frequencies when Rbias is 1.2 kΩ. Further details on the application circuits are shown in Section 3, "Application Information"

Table 5. Electrical Characteristics Measured in Frequency Specific Tuned Circuits (Vcc = 2.75V, TA = 25°C, Rbias =1.2kΩ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
1575 MHz (Refer to Figure 7)					
Frequency	f	—	1575	—	MHz
Active RF Gain	G	18.4	19.4	—	dB
Active Noise Figure	NF	—	1.28	1.6	dB
Active Input Third Order Intercept Point	IIP3	-6.5	-5	—	dBm
Active Input 1dB Compression Point	P1dBoutput	6.3	7.4	—	dBm
Active Current @ 2.75V, Rbias=1.2kΩ	Icc	—	4.8	5.8	mA
Active Current @ 2.75V, Rbias=1.5kΩ	Icc	—	3.8	4.8	mA
Active Gain	S21	18	19	—	dB
Bypass RF Gain	G	-6.5	-5.5	—	dB
Bypass Noise Figure	NF	—	6	7	dB
Bypass Input Third Order Intercept Point	IIP3	24	25.5	—	dBm
Bypass Current	—	—	4	20	µA
Bypass Gain	S21	-7	-5.5	—	dB
1960 MHz (Refer to Figure 8)					
Frequency	f	—	1960	—	MHz
Active RF Gain	G	17.7	18.7	—	dB
Active Noise Figure	NF	—	1.37	1.65	dB
Active Input Third Order Intercept Point	IIP3	-4	-2.7	—	dBm
Active Input 1dB Compression Point	P1dBoutput	6	8	—	dBm

Table 5. Electrical Characteristics Measured in Frequency Specific Tuned Circuits (continued)
(Vcc = 2.75V, TA = 25°C, Rbias =1.2kΩ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Active Current @ 2.75V, Rbias=1.2kΩ	Icc	—	4.8	5.8	mA
Active Current @ 2.75V, Rbias=1.5kΩ	Icc	—	3.8	4.8	mA
Active Gain	S21	17.4	18.4	—	dB
Bypass RF Gain	G	-6.5	-4.9	—	dB
Bypass Noise Figure	NF	—	4.8	6.2	dB
Bypass Input Third Order Intercept Point	IIP3	24.5	26	—	dBm
Bypass Current	—	—	4	20	µA
Bypass Gain	S21	-6.5	-5	—	dB
2140 MHz (Refer to Figure 9)					
Frequency	f	—	2140	—	MHz
Active RF Gain	G	16.7	17.7	—	dB
Active Noise Figure	NF	—	1.46	1.75	dB
Active Input Third Order Intercept Point	IIP3	-3	-0.5	—	dBm
Active Input 1dB Compression Point	P1dBoutput	6.7	8	—	dBm
Active Current @ 2.75V, Rbias=1.2kΩ	Icc	—	4.8	5.8	mA
Active Current @ 2.75V, Rbias=1.5kΩ	Icc	—	3.8	4.8	mA
Active Gain	S21	16.5	17.6	—	dB
Bypass RF Gain	G	-5.8	-4.8	—	dB
Bypass Noise Figure	NF	—	4.9	5.9	dB
Bypass Input Third Order Intercept Point	IIP3	24.5	25.7	—	dBm
Bypass Current	—	—	4	20	µA
Bypass Gain	S21	-5.7	-4.7	—	dB
2400 MHz (Refer to Figure 10)					
Frequency	f	—	2400	—	MHz
Active RF Gain	G	15	16	—	dB
Active Noise Figure	NF	—	1.52	1.8	dB
Active Input Third Order Intercept Point	IIP3	-0.2	2	—	dBm
Active Input 1dB Compression Point	P1dBoutput	7	8.1	—	dBm
Active Current @ 2.75V, Rbias=1.2kΩ	Icc	—	4.8	5.8	mA
Active Current @ 2.75V, Rbias=1.5kΩ	Icc	—	3.8	4.8	mA
Active Gain	S21	14.7	15.7	—	dB
Bypass RF Gain	G	-6	-5	—	dB
Bypass Noise Figure	NF	—	5.2	5.8	dB
Bypass Input Third Order Intercept Point	IIP3	24	25.3	—	dBm
Bypass Current	—	—	4	20	µA
Bypass Gain	S21	-5.4	-5	—	dB

Figure 2 and Figure 3 show maximum stable and maximum available gain and forward insertion gain versus frequency for the packaged device in a 50 Ω system using bias resistors of 1.5 kΩ and 1.2 kΩ.

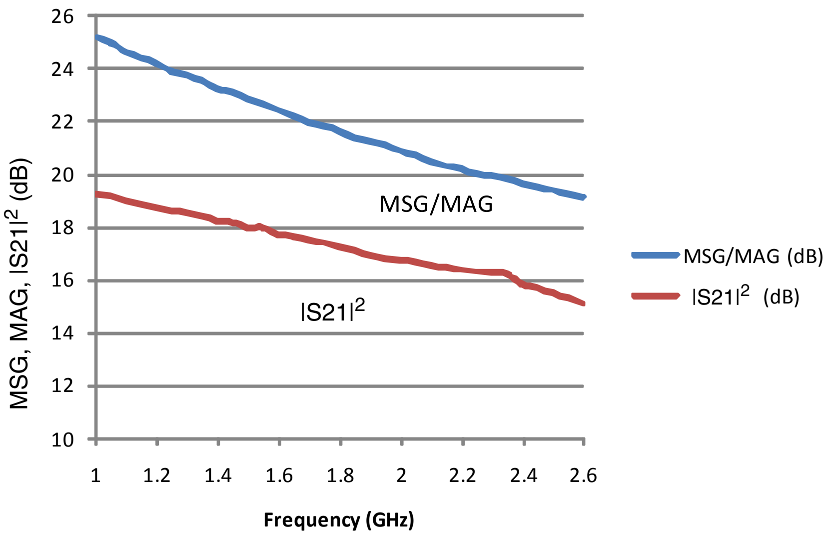


Figure 2. Maximum Stable/Available Gain and Forward Insertion Gain vs. Frequency (Rbias = 1.5kΩ)

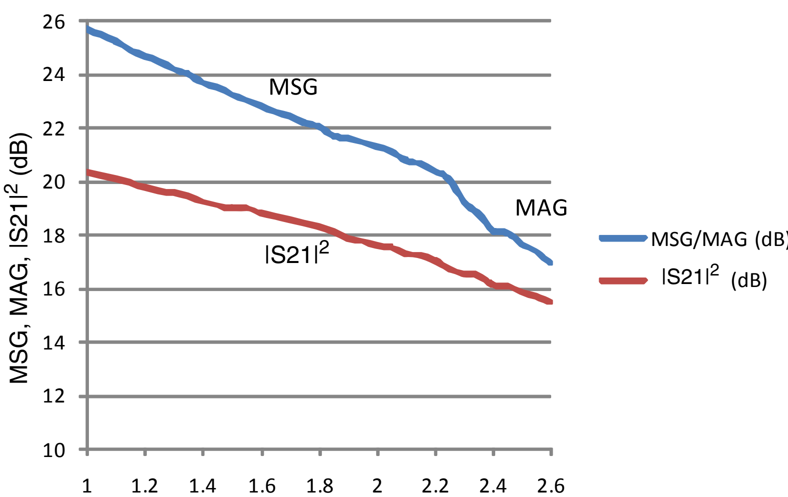


Figure 3. Maximum Stable/Available Gain and Forward Insertion Gain vs. Frequency (Rbias = 1.2 kΩ)

Figure 4 and Figure 5 show minimum noise figure and associated gain versus frequency for the packaged device in a 50 Ω system using bias resistors of 1.5 kΩ and 1.2 kΩ.

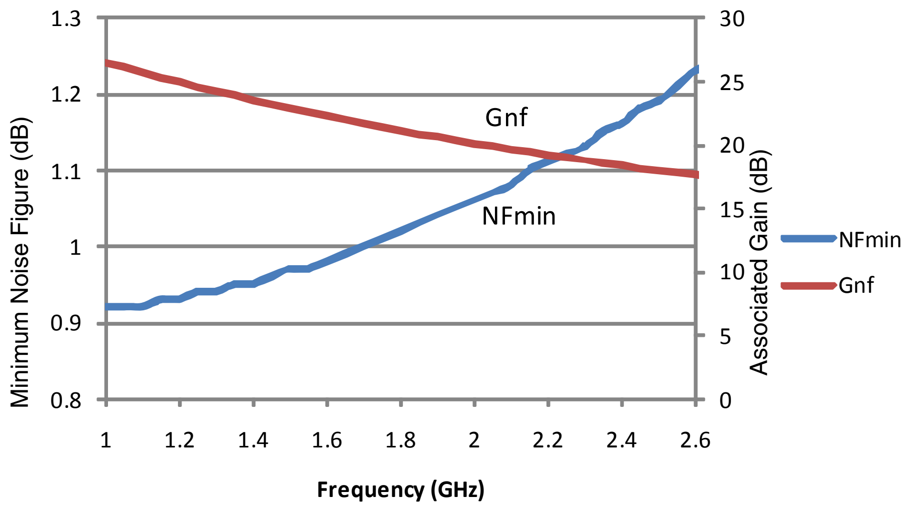


Figure 4. Minimum Noise Figure and Associated Gain vs. Frequency (Rbias = 1.5 kΩ)

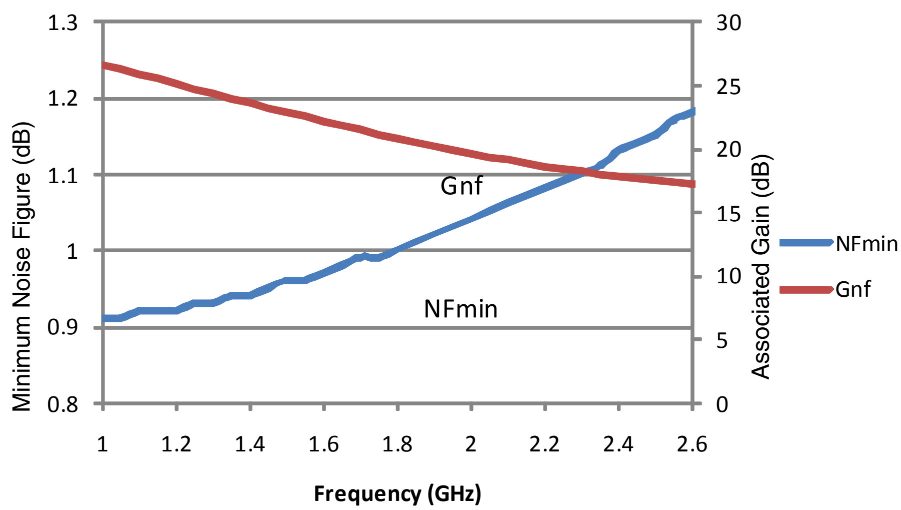


Figure 5. Minimum Noise Figure and Associated Gain vs. Frequency (Rbias = 1.2 kΩ)

Figure 6 shows the Icc current drain for a range of values for the external bias resistor Rbias.

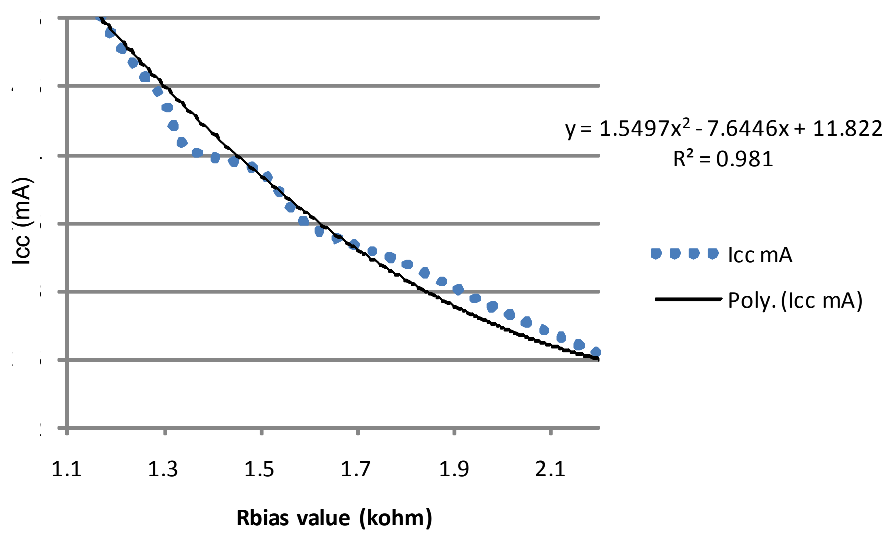


Figure 6. Icc vs. Bias Resistor R1 Value

3 Application Information

The MC13851 LNA is designed for applications in the 1000 MHz to 2.5 GHz range. It has three different modes: High Gain, Low Gain (bypass) and standby. The LNA is programmable through the Gain and Enable pins. The logic truth table is given in Table 3. The internal bypass switch is designed for broadband applications. One of the advantages of the MC13851 is the simplification of the matching network in both bypass and amplifier modes. The bypass switch is designed so that changes of input and output return losses between bypass mode and active mode are minimized and the matching network design is simplified. In these application examples a balance is made between the competing RF performance characteristics of Icc, NF, gain, IP3 and return losses with unconditional stability. Conjugate matching is not used for the input or output. Instead, matching which achieves a trade-off in RF performance qualities is used. For a particular application or specification requirement, the matching can be changed to achieve enhanced performance of one parameter. Measurements are made at a bias of Vcc=2.75 V. Frequency spacing for IP3 measurements is 200 kHz. Non-linear measurements are made at Pin = -30 dBm. Typical application circuits are provided for 1575 MHz, 1960 MHz, 2140 MHz and 2.4 GHz applications. Typical RF performance is shown for two values of bias resistor R1: 1.2 kΩ and 1.5 kΩ. These two current drain levels offer variations in intercept point, gain and noise figure. Included with each application are the schematics and electrical performance. Section 4, “Printed Circuit and Bill of Materials” provides the evaluation board layout and Bill of Material for the circuits. Section 5, “Scattering and Noise Parameters” provides Smith charts with gain and noise circles for each application frequency.

3.1 1575 MHz Application

This application was designed to provide typical NF = 1.28 dB, S21 gain = 19 dB, OIP3 =14.5 dBm with return losses better than -10 dB at 1575 MHz. Typical performance that can be expected from this circuit at 2.75V is listed in Table 6. The component values can be changed to enhance the performance of a particular parameter, but usually at the expense of another. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements. Inductor L3 provides bias to the logic circuit.

Figure 7 is the 1575 MHz application schematic with package pinouts and the circuit component topology.

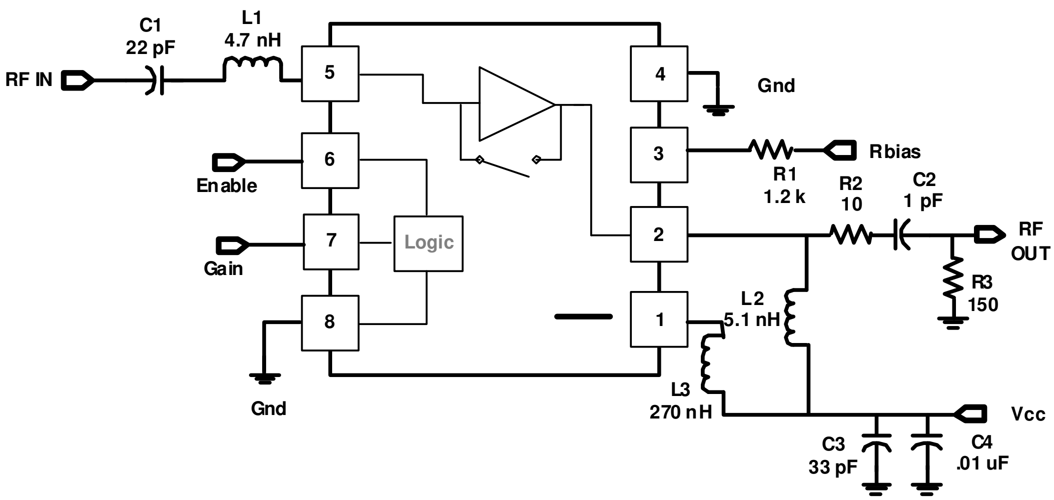


Figure 7. 1575 MHz Application Schematic

Table 6 shows the electrical characteristics for the 1575 MHz evaluation board.

Table 6. Typical 1575 MHz Evaluation Board Performance
(Vcc = 2.75V, T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
R1=1.2 KΩ					
Frequency	f	—	1575	—	MHz
RF Gain	G				dB
High Gain		18.4	19.4	—	
Bypass		-6.5	-5.5	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		13.2	14.5	—	
Bypass		19	20.3	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-6.5	-5	—	
Bypass		24	25.5	—	
Out Ref P1dB	P1dBout				dBm
High Gain		6.3	7.4	—	
In Ref P1dB	P1dBin				dBm
High Gain		-13.3	-12	—	
Noise Figure	NF				dB
High Gain		—	1.28	1.6	
Bypass		—	6	7	
Current Draw	Icc				
High Gain		—	4.8	5.8	mA
Bypass		—	4	20	µA
Rbias R1 Value	—	—	1.2	—	kΩ

Table 6. Typical 1575 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Return Loss	S11				dB
High Gain		—	-11	-8	
Bypass		—	-11	-8	
Gain	S21				dB
High Gain		18	19	—	
Bypass		-7	-5.5	—	
Reverse Isolation	S12				dB
High Gain		—	-27	-25	
Bypass		—	-5.7	-4.4	
Output Return Loss	S22				dB
High Gain		—	-14.9	-9	
Bypass		—	-18	-9	
R1=1.5 kΩ					
Frequency	f	—	1575	—	MHz
RF Gain	G				dB
High Gain		18	19	—	
Bypass		-6.5	-5.5	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		13.9	15.9	—	
Bypass		19	20.3	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-5.5	-3.2	—	
Bypass		24	26	—	
Out Ref P1dB	P1dBout				dBm
High Gain		6.6	7.6	—	
In Ref P1dB	P1dBin				dBm
High Gain		-13.5	-11.5	—	
Noise Figure	NF				dB
High Gain		—	1.27	1.6	
Bypass		—	5.9	6.9	
Current Draw	Icc				
High Gain		—	3.8	4.8	mA
Bypass		—	4	20	μA
Rbias R1 Value	—	—	1.5	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-10.6	-8.6	
Bypass		—	-11.5	-10	
Gain	S21				dB
High Gain		17.9	18.9	—	
Bypass		-6.5	-5.5	—	
Reverse Isolation	S12				dB
High Gain		—	-25.9	-24.5	
Bypass		—	-5.6	-4.6	

Table 6. Typical 1575 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Return Loss	S22				dB
High Gain		—	-13	-9	
Bypass		—	-18	-12	

3.2 1960 MHz Application

These application circuits are designed to demonstrate performance at 1960 MHz. Typical results of NF = 1.4 dB, S21 gain > 18 dB and OIP3 of 16 dBm. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements. Resistor R3 is used to de-Q output inductor L2 and adjust gain and return losses. Inductor L3 provides bias to the logic circuit. Reducing R3 lowers gain and improves return losses. Typical performance that can be expected from this circuit at 2.75 V is listed in Table 7.

Figure 8 is the 1960 MHz application schematic with package pinouts and the circuit component topology.

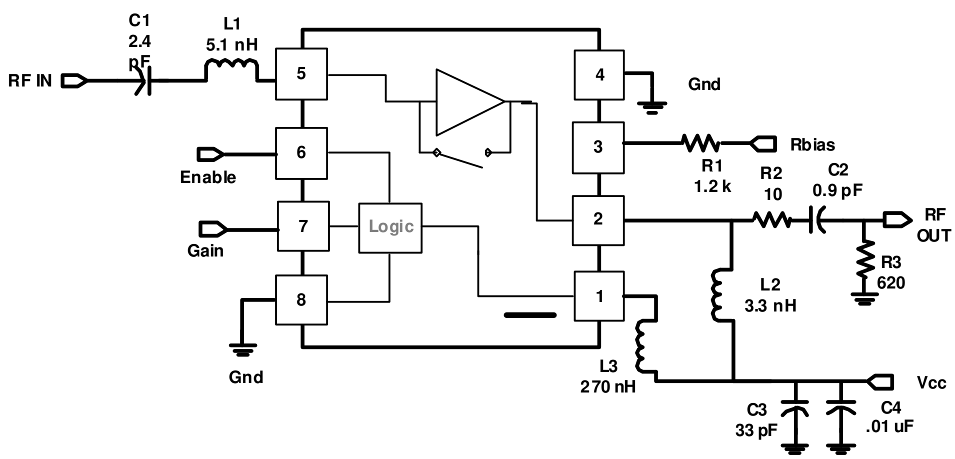


Figure 8. 1960 MHz Application Schematic

Table 7 shows the electrical characteristics for the 1960 MHz evaluation board.

Table 7. Typical 1960 MHz Evaluation Board Performance
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
R1=1.2 KΩ					
Frequency	f	—	1960	—	MHz
RF Gain	G				dB
High Gain		17.7	18.7	—	
Bypass		-6.5	-4.9	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		14	16	—	
Bypass		19.2	20.9	—	

Table 7. Typical 1960 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Third Order Intercept Point	IIP3				dBm
High Gain		-4	-2.7	—	
Bypass		24.5	26	—	
Out Ref P1dB	P1dBout				dBm
High Gain		6	8	—	
In Ref P1dB	P1dBin				dBm
High Gain		-13	-10.5	—	
Noise Figure	NF				dB
High Gain		—	1.37	1.65	
Bypass		—	4.8	6.2	
Current Draw	Icc				
High Gain		—	4.8	5.8	mA
Bypass		—	4	20	µA
Rbias R1 Value	—	—	1.2	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-10	-7	
Bypass		—	-11	-8	
Gain	S21				dB
High Gain		17.4	18.4	—	
Bypass		-6.5	-5	—	
Reverse Isolation	S12				dB
High Gain		—	-25	-23.5	
Bypass		—	-4.8	-3	
Output Return Loss	S22				dB
High Gain		—	-14	-8	
Bypass		—	-14.8	-10	
R1=1.5 kΩ					
Frequency	f	—	1960	—	MHz
RF Gain	G				
High Gain		17.5	18.5	—	dB
Bypass		-6.8	-5	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		16.1	17.1	—	
Bypass		19.1	20.9	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-3	-1.5	—	
Bypass		24.5	26	—	

Table 7. Typical 1960 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Out Ref P1dB	P1dBout				dBm
High Gain		5.6	8	—	
In Ref P1dB	P1dBin				dBm
High Gain		-13	-10.5	—	
Noise Figure	NF				dB
High Gain		—	1.35	1.65	
Bypass		—	4.9	6.2	
Current Draw	Icc				
High Gain		—	3.8	4.8	mA
Bypass		—	4	20	µA
Rbias R1 Value	—	—	1.5	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-9	-6.5	
Bypass		—	-11	-8	
Gain	S21				dB
High Gain		17	18	—	
Bypass		-6.5	-5	—	
Reverse Isolation	S12				dB
High Gain		—	-24.5	-22.5	
Bypass		—	-4.5	-4	
Output Return Loss	S22				dB
High Gain		—	-12.5	-7	
Bypass		—	-15	-10	

3.3 2140 MHz Application

These application circuits demonstrate performance at 2140 MHz. Matching component values can be changed to enhance a particular parameter. Typical performance expected from this circuit at 2.75V Vcc is listed in Table 8. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements. The same matching topology is used on each of the application circuits, with a highpass match on the output and a simple inductor-capacitor network on the LNA input. Resistor R3 is used to de-Q output inductor L2 and adjust gain and return losses. Lowering the value of R3 lowers gain and improves return losses.

Figure 9 is the 2140 MHz application schematic with package pinouts and the circuit component topology.

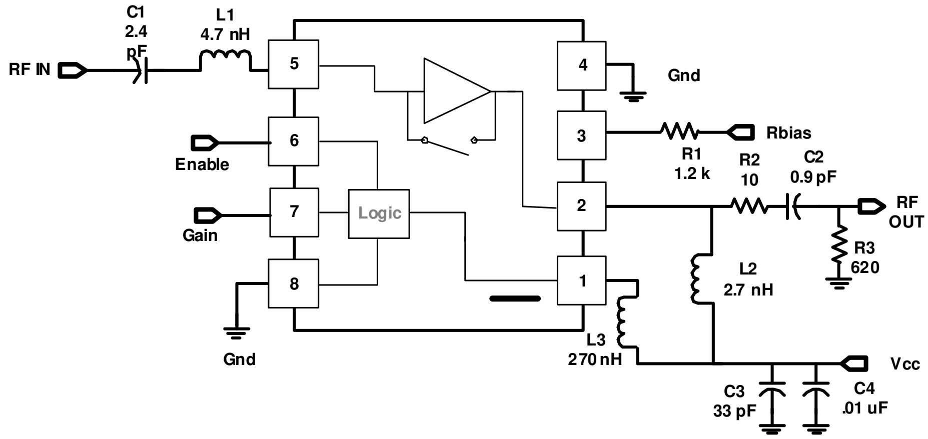


Figure 9. 2140 MHz Application Schematic

Table 8 shows the electrical characteristics for the 2140 MHz evaluation board.

Table 8. Typical 2140 MHz Evaluation Board Performance

(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
R1=1.2 KΩ (Refer to Figure 9)					
Frequency	f	—	2140	—	MHz
RF Gain					
High Gain	G	16.7	17.7	—	dB
Bypass		-5.8	-4.8	—	
Output Third Order Intercept Point					
High Gain	OIP3	15.5	17.1	—	dBm
Bypass		20	21	—	
Input Third Order Intercept Point					
High Gain	IIP3	-3	-0.5	—	dBm
Bypass		24.5	25.7	—	
Out Ref P1dB	P1dB				dBm
High Gain		6.7	8	—	
In Ref P1dB	P1dB				dBm
High Gain		-11	-9.6	—	
Noise Figure					
High Gain	NF	—	1.46	1.75	dB
Bypass		—	4.9	5.9	
Current Draw					
High Gain	Icc	—	4.8	5.8	mA
Bypass		—	4	20	µA
Rbias R1 Value	—	—	1.2	—	kΩ

Table 8. Typical 2140 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Return Loss	S11				dB
High Gain		—	-10.5	-7	
Bypass		—	-13.5	-10	
Gain	S21				dB
High Gain		16.5	17.6	—	
Bypass		-5.7	-4.7	—	
Reverse Isolation	S12				dB
High Gain		—	-24.7	-23.7	
Bypass		—	-4.5	-4	
Output Return Loss	S22				dB
High Gain		—	-11	-8	
Bypass		—	-20.8	-10	
R1=1.5 KΩ (Refer to Figure 9)					
Frequency	f	—	2140	—	MHz
RF Gain	G				dB
High Gain		16.4	17.4	—	
Bypass		-5.8	-4.8	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		16	18	—	
Bypass		19.5	21	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-2	0.9	—	
Bypass		24.7	25.7	—	
Out Ref P1dB	P1dB				dBm
High Gain		7	8	—	
In Ref P1dB	P1dB				dBm
High Gain		-10.3	-9.3	—	
Noise Figure	NF				dB
High Gain		—	1.46	1.75	
Bypass		—	4.7	5.3	
Current Draw	Icc				
High Gain		—	3.8	4.8	mA
Bypass		—	4	20	µA
Rbias R1 Value	—	—	1.5	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-9.6	-8	
Bypass		—	-13	-9	

Table 8. Typical 2140 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Gain	S21				dB
High Gain		16.5	17.4	—	
Bypass		-5.4	-4.7	—	
Reverse Isolation	S12				dB
High Gain		—	-24	21.6	
Bypass		—	-4.6	4.1	
Output Return Loss	S22				dB
High Gain		—	-10.6	-8	
Bypass		—	-21	-10	

3.4 2400 MHz Application

This application was designed to provide NF =1.5 dB, S21 gain > 16 dB, OIP3 of 17.5 dBm with return losses better than -9 dB at 2400 MHz. Typical performance that can be expected from this circuit at 2.7V is listed in Table 9. Two values of bias resistor R1 are shown to demonstrate performance for different IP3 and Icc requirements. Resistor R3 is used to de-Q output inductor L2 and adjust gain and return losses. Lowering the value of R3 lowers gain and improves return losses.

Figure 9 is the 2400 MHz application schematic with package pinouts and the circuit component topology.

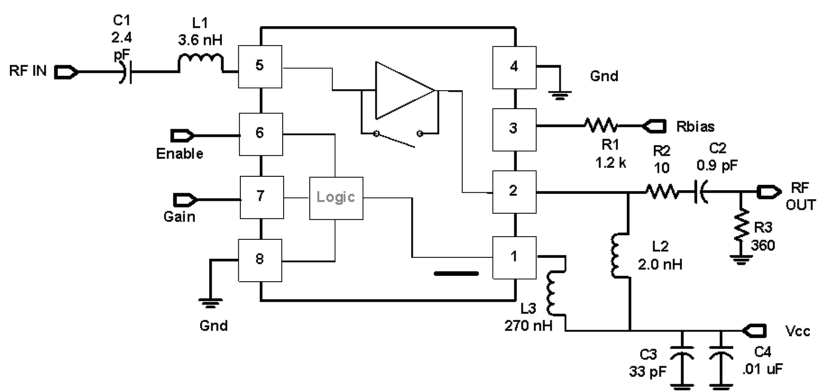


Figure 10. 2400 MHz Application Schematic

Table 9 shows the electrical characteristics for the 2400 MHz evaluation board.

Table 9. Typical 2400 MHz Evaluation Board Performance
(Vcc = 2.75V, Ta = 25°C)

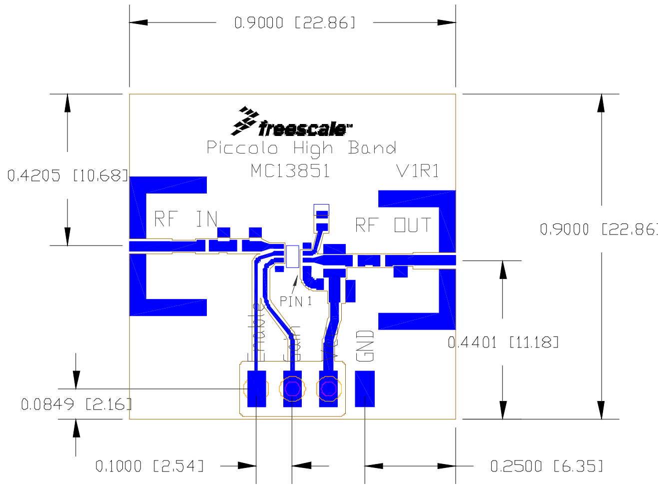
Characteristic	Symbol	Min	Typ	Max	Unit
R1=1.2 KΩ (Refer to Figure 10)					
Frequency	f		2400		MHz
RF Gain	G				dB
High Gain		15	16	—	
Bypass		-5.5	-5	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		16	17.5	—	
Bypass		18.5	20	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-0.2	1.3	—	
Bypass		24	25.3	—	
Out Ref P1dB	P1dB				dBm
High Gain		7	8.1	—	
In Ref P1dB	P1dB				dBm
High Gain		-9	-8	—	
Noise Figure	NF				dB
High Gain		—	1.51	1.8	
Bypass		—	5.2	5.8	
Current Draw	Icc				
High Gain		—	4.8	5.8	mA
Bypass		—	4	20	μA
Rbias R1 Value	—	—	1.2	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-12.5	-9	
Bypass		—	-14	-10	
Gain	S21				dB
High Gain		14.7	15.7	—	
Bypass		-5.4	-5	—	
Reverse Isolation	S12				dB
High Gain		—	-23.6	-22.6	
Bypass		—	-5.5	-4.5	
Output Return Loss	S22				dB
High Gain		—	-12	-9	
Bypass		—	-22.5	-20	

Table 9. Typical 2400 MHz Evaluation Board Performance (continued)
(Vcc = 2.75V, Ta = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
R1=1.5 KΩ (Refer to Figure 10)					
Frequency	f	—	2400	—	MHz
RF Gain	G				dB
High Gain		14.9	15.9	—	
Bypass		-6	-5	—	
Output Third Order Intercept Point	OIP3				dBm
High Gain		16	18	—	
Bypass		19.2	20.4	—	
Input Third Order Intercept Point	IIP3				dBm
High Gain		-0.2	2	—	
Bypass		24.3	25.3	—	
Out Ref P1dB	P1dB				dBm
High Gain		7	7.9	—	
In Ref P1dB	P1dB				dBm
High Gain		-8.8	-7.8	—	
Noise Figure	NF				dB
High Gain		—	1.52	1.8	
Bypass		—	5.2	6	
Current Draw	Icc				
High Gain		—	3.8	4.8	mA
Bypass		—	4	20	μA
Rbias R1 Value	—	—	1.5	—	kΩ
Input Return Loss	S11				dB
High Gain		—	-10.7	-9	
Bypass		—	-14.5	-12	
Gain	S21				dB
High Gain		14.4	15.4	—	
Bypass		-6	-5.1	—	
Reverse Isolation	S12				dB
High Gain		—	-23.3	-22	
Bypass		—	-5.5	-4.5	
Output Return Loss	S22				dB
High Gain		—	-11.3	-8.5	
Bypass		—	-21.9	-15	

4 Printed Circuit and Bill of Materials

Figure 11 is the drawing of the printed circuit board. Figure 13 is the drawing of the evaluation board used for each of the application frequency designs described in Section 3, "Application Information." These drawings show the boards with the circuit matching components placed and identified.



Note: Dimensions are in inches and [mm].
Soldering Note: The center flag under the part must be soldered to board.

Figure 11. Printed Circuit Board

Figure 11 is a picture of a typical assembled evaluation board similar to the ones in the evaluation kits.

Figure 12. Typical Assembled Evaluation Board with SMA Connectors

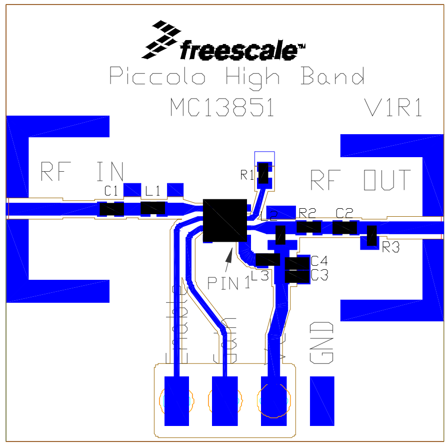


Figure 13. 1575-, 1960-, 2140-, 2400 MHz Application Board

The bill of materials for each of the application frequency circuit boards is listed in Table 10. The value, case size, manufacturer and circuit function of each component are shown.

Table 10. Bill of Materials for the Application Circuit Boards

Component	Value	Case	Manufacturer	Comments
1575 MHz Application Circuit (see Figure 7)				
C1	22 pF	402	Murata	DC block, input match
C2	1 pF	402	Murata	DC block, output match
C3	33 pF	402	Murata	RF bypass
C4	0.1 µF	402	Murata	Low frequency bypass
L1	4.7 nH	402	Murata	Input match
L2	5.1 nH	402	Murata	Output match, bias decouple
L3	270 nH	402	Murata	Bias couple to logic
R1	1.2 kΩ	402	KOA	Bias set point
R2	10 Ω	402	KOA	Stability
R3	150 Ω	402	KOA	L2 de-Q, gain adjust
1900 MHz Application Circuit (see Figure 8)				
C1	2.4pF	402	Murata	Input match
C2	0.9 pF	402	Murata	Output match
C3	33 pF	402	Murata	RF bypass
C4	.01 µF	805	Murata	Low frequency bypass
L1	5.1 nH	402	Murata	Input match
L2	3.3 nH	402	Murata	Output match
L3	270 nH	402	Murata	Bias couple to logic
R1	1.2 kΩ	402	KOA	LNA bias
R2	15 Ω	402	KOA	Stability
R3	620	402	KOA	De-Q L2, adjust gain, RLs

Table 10. Bill of Materials for the Application Circuit Boards (continued)

Component	Value	Case	Manufacturer	Comments
2140 MHz Application Circuit (see Figure 9)				
C1	2.4pF	402	Murata	Input match
C2	0.9 pF	402	Murata	Output match
C3	33 pF	402	Murata	RF bypass
C4	.01 μF	805	Murata	Low frequency bypass
L1	4.7 nH	402	Murata	Input match
L2	2.7	402	Murata	Output match
L3	270 nH	402	Murata	Bias couple to logic
R1	1.2 kΩ	402	KOA	LNA bias
R2	10 Ω	402	KOA	Stability
R3	620	402	KOA	De-Q L2, adjust gain, RLs
2400 MHz Application Circuit (see Figure 10)				
C1	2.4pF	402	Murata	Input match
C2	0.9 pF	402	Murata	Output match
C3	33 pF	402	Murata	RF bypass
C4	.01 μF	805	Murata	Low frequency bypass
L1	3.6 nH	402	Murata	Input match
L2	2	402	Murata	Output match
L3	270 nH	402	Murata	Bias couple to logic
R1	1.2 kΩ	402	KOA	LNA bias
R2	10 Ω	402	KOA	Stability
R3	620	402	KOA	De-Q L2, adjust gain, RLs

5 Scattering and Noise Parameters

Table 11 through Table 14 list the S parameters for the packaged part in a 50 Ω system for each of the modes of operation and for two values of the external bias resistor.

Table 11. Scattering Parameters, Active Mode, Rbias=1.2kΩ
(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1000	0.712	-19.7	10.508	145.3	0.027	94.1	0.913	9.6
1050	0.696	-20.3	10.318	144.3	0.029	94.3	0.904	10.0
1100	0.679	-21.2	10.132	143.1	0.030	94.8	0.896	10.5
1150	0.663	-21.7	9.947	142.2	0.031	94.8	0.886	10.7
1200	0.651	-21.9	9.742	141.0	0.033	95.1	0.875	10.8
1250	0.634	-22.2	9.552	140.2	0.034	95.6	0.870	11.0
1300	0.619	-22.4	9.413	139.3	0.035	96.4	0.861	11.2

Table 11. Scattering Parameters, Active Mode, Rbias=1.2kΩ (continued)

(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1350	0.607	-22.9	9.242	138.3	0.036	97.3	0.854	11.5
1400	0.597	-23.3	9.069	138.0	0.038	98.5	0.851	11.6
1450	0.587	-23.6	8.977	137.0	0.040	99.3	0.847	11.4
1500	0.576	-23.9	8.813	136.2	0.042	100.3	0.845	11.1
1550	0.571	-24.4	8.806	135.9	0.044	101.5	0.846	10.2
1600	0.571	-26.2	8.693	134.7	0.049	100.1	0.840	8.2
1650	0.556	-28.2	8.583	133.0	0.050	97.4	0.802	7.2
1700	0.538	-29.7	8.420	131.8	0.051	96.5	0.779	7.4
1750	0.519	-31.3	8.284	130.8	0.052	96.4	0.764	7.2
1800	0.505	-33.5	8.129	129.5	0.054	96.1	0.751	6.8
1850	0.486	-35.7	8.009	128.3	0.057	95.2	0.737	5.6
1900	0.448	-37.5	7.735	126.4	0.058	91.7	0.700	5.2
1950	0.435	-37.8	7.564	126.2	0.058	92.2	0.688	5.5
2000	0.415	-41.7	7.421	124.4	0.061	90.4	0.662	4.1
2050	0.376	-45.4	7.155	122.5	0.063	86.6	0.618	3.7
2100	0.313	-44.8	6.708	121.6	0.059	80.1	0.569	6.2
2150	0.28	-37.0	6.321	121.8	0.052	79.7	0.541	11.7
2200	0.251	-29.5	5.956	125.2	0.044	78.1	0.561	18.1
2250	0.309	-16.2	6.073	130.1	0.037	100.5	0.648	20.3
2300	0.367	-24.7	6.554	129.3	0.050	110.1	0.694	14.8
2350	0.364	-30.5	6.756	126.9	0.058	108.1	0.678	9.3
2400	0.351	-35.0	6.542	124.4	0.062	104.0	0.648	8.3
2450	0.338	-37.9	6.459	122.8	0.065	102.4	0.627	7.8
2500	0.323	-40.5	6.304	121.6	0.066	100.3	0.613	8.1
2550	0.319	-41.4	6.168	120.6	0.067	100.7	0.608	8.1
2600	0.308	-43.6	6.047	119.6	0.068	99.4	0.606	7.1

Table 12. Scattering Parameters, Active Mode, Rbias=1.5kΩ

(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1000	0.754	-17.9	9.171	150.9	0.028	94.9	0.941	10.7
1050	0.739	-18.6	9.055	149.8	0.029	95.2	0.933	11.1
1100	0.721	-19.4	8.902	148.7	0.031	95.0	0.927	11.7
1150	0.709	-19.9	8.774	147.9	0.032	95.4	0.918	11.8
1200	0.698	-20.3	8.629	146.8	0.033	95.6	0.910	12.0
1250	0.682	-20.6	8.517	146.2	0.035	96.3	0.907	12.2

Table 12. Scattering Parameters, Active Mode, Rbias=1.5kΩ (continued)
(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1300	0.667	-21.2	8.444	145.1	0.036	96.3	0.897	12.2
1350	0.654	-21.9	8.318	144.0	0.037	96.4	0.888	12.4
1400	0.640	-22.5	8.150	143.8	0.039	97.1	0.884	12.6
1450	0.625	-22.8	8.093	142.6	0.040	97.3	0.876	12.6
1500	0.611	-23.0	7.908	141.9	0.041	97.6	0.871	12.6
1550	0.595	-23.1	7.910	141.3	0.043	98.2	0.863	12.2
1600	0.591	-23.1	7.668	140.8	0.044	98.5	0.861	11.8
1650	0.586	-24.0	7.619	139.9	0.046	99.0	0.841	11.5
1700	0.577	-25.1	7.505	139.2	0.048	99.0	0.829	11.8
1750	0.560	-26.7	7.410	138.5	0.049	99.1	0.821	11.9
1800	0.548	-28.0	7.283	137.6	0.050	99.4	0.813	11.7
1850	0.528	-28.8	7.154	136.9	0.052	99.6	0.807	11.5
1900	0.513	-28.8	7.006	136.3	0.053	98.7	0.794	11.4
1950	0.509	-29.0	6.929	136.3	0.054	99.8	0.789	11.5
2000	0.500	-31.2	6.861	135.6	0.056	100.1	0.781	11.1
2050	0.489	-32.4	6.832	134.8	0.058	101.1	0.773	10.7
2100	0.475	-33.9	6.707	134.5	0.060	100.5	0.770	10.2
2150	0.467	-34.2	6.660	133.1	0.062	101.1	0.750	9.6
2200	0.454	-37.8	6.588	133.3	0.063	99.6	0.745	9.2
2250	0.436	-39.4	6.538	132.1	0.065	100.1	0.730	8.6
2300	0.409	-41.7	6.508	130.5	0.066	98.0	0.714	8.4
2350	0.390	-40.9	6.467	129.7	0.067	98.2	0.693	7.3
2400	0.378	-41.5	6.181	128.3	0.067	97.2	0.671	8.6
2450	0.369	-42.2	6.079	127.5	0.068	97.5	0.659	9.7
2500	0.359	-43.2	5.945	126.8	0.068	97.6	0.651	10.7
2550	0.356	-44.0	5.825	126.3	0.069	97.8	0.652	11.4
2600	0.348	-44.7	5.680	125.7	0.069	98.1	0.652	11.9

Table 13. Scattering Parameters, Bypass Mode, Rbias=1.2kΩ and 1.5kΩ
(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1000	0.356	-25.9	0.658	25.8	0.646	25.2	0.402	-12.4
1050	0.340	-24.6	0.663	24.9	0.651	24.3	0.387	-11.3
1100	0.327	-23.0	0.667	24.0	0.655	23.5	0.373	-9.9
1150	0.312	-21.4	0.671	23.3	0.659	22.7	0.359	-8.2
1200	0.298	-20.3	0.674	22.6	0.662	22.0	0.347	-6.5

Table 13. Scattering Parameters, Bypass Mode, Rbias=1.2kΩ and 1.5kΩ (continued)
(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1250	0.288	-18.7	0.677	21.8	0.665	21.4	0.336	-4.7
1300	0.275	-16.7	0.678	21.2	0.667	20.7	0.326	-3.4
1350	0.263	-14.8	0.679	20.6	0.668	20.1	0.318	-1.9
1400	0.253	-12.6	0.678	20.0	0.667	19.6	0.311	-0.7
1450	0.248	-10.0	0.675	19.9	0.664	19.5	0.306	-0.3
1500	0.250	-9.6	0.680	20.0	0.669	19.6	0.289	0.9
1550	0.244	-10.4	0.687	19.5	0.676	19.1	0.279	2.1
1600	0.235	-10.0	0.689	18.9	0.678	18.5	0.272	3.7
1650	0.226	-10.2	0.690	18.5	0.680	18.0	0.267	4.9
1700	0.220	-9.5	0.690	17.8	0.680	17.3	0.260	6.3
1750	0.211	-8.5	0.689	17.4	0.679	17.0	0.253	6.9
1800	0.197	-6.2	0.685	16.9	0.675	16.4	0.245	6.8
1850	0.199	-1.7	0.682	17.3	0.673	16.9	0.235	7.3
1900	0.202	-3.2	0.688	17.0	0.679	16.6	0.229	8.5
1950	0.194	-5.0	0.688	16.5	0.678	16.1	0.223	9.4
2000	0.186	-4.4	0.687	16.1	0.677	15.8	0.213	8.4
2050	0.182	-3.6	0.682	16.2	0.673	15.8	0.204	8.1
2100	0.180	-4.2	0.686	16.3	0.676	15.9	0.198	9.5
2150	0.185	-4.3	0.689	16.2	0.680	15.9	0.192	11.2
2200	0.185	-5.5	0.695	15.7	0.685	15.4	0.186	10.4
2250	0.187	-8.3	0.695	15.2	0.685	14.9	0.185	9.3
2300	0.186	-10.1	0.697	14.6	0.688	14.3	0.178	7.5
2350	0.185	-12.0	0.694	14.2	0.685	13.8	0.173	7.0
2400	0.181	-14.1	0.696	13.7	0.686	13.4	0.168	4.1
2450	0.178	-16.8	0.695	13.1	0.681	12.5	0.159	2.0
2500	0.177	-19.8	0.694	12.5	0.680	11.9	0.155	-1.7
2550	0.174	-23.6	0.691	11.8	0.677	11.2	0.150	-5.6
2600	0.171	-27.4	0.686	11.2	0.673	10.6	0.143	-9.1

Table 14. Scattering Parameters, Standby Mode, Rbias=1.2kΩ and 1.5kΩ
(Vcc = 2.75V, 25°C, 50 Ω system)

f (MHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
1000	0.939	2.1	0.031	104.0	0.031	103.1	0.991	12.9
1050	0.935	2.2	0.033	104.4	0.033	103.8	0.990	13.3
1100	0.934	2.5	0.035	104.8	0.034	104.2	0.988	13.5
1150	0.931	2.7	0.037	105.2	0.036	104.4	0.986	14.0