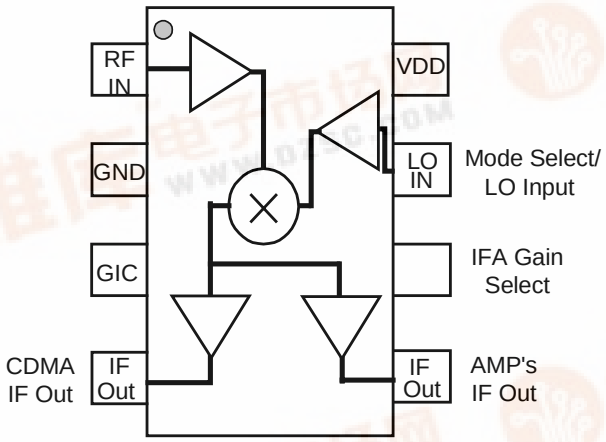
TriQuint SEMICONDUCTOR

WIRELESS COMMUNICATIONS DIVISION

TQ5131

DATA SHEET

3V Cellular Band CDMA/AMPS RFA/Mixer IC



Features

- *Small size: SOT23-8*
- *Single 3V operation*
- *Low-current operation*
- *Gain Select*
- *Mode Select*
- *High IP3 performance*
- *Few external components*

Applications

- *IS-95 CDMA Mobile Phones*
- *AMPS Mobile Phones*
- *Dual Mode CDMA Cellular application*

Product Description

The TQ5131 is a 3V, RFA/Mixer IC designed specifically for Cellular band CDMA/AMPS applications. It's RF performance meets the requirements of products designed to the IS-95 and AMPS standards. The TQ5131 is designed to be used with the TQ3131 (CDMA/AMPS LNA) which provides a complete CDMA receiver for 800MHz dual-mode phones.

The RFA/Mixer incorporates on-chip switches which determine CDMA, AMPS and bypass mode select. When used with the TQ3131 (CDMA/AMPS LNA), four gain steps are available. The RF input port is internally matched to 50 Ω, greatly simplifying the design and keeping the number of external components to a minimum. The TQ5131 achieves good RF performance with low current consumption, supporting long standby times in portable applications. Coupled with the very small SOT23-8 package, the part is ideally suited for Cellular band mobile phones.

Electrical Specifications[1]

Parameter	Min	Typ	Max	Units
Frequency		881		MHz
Gain		15.0		dB
Noise Figure		4.5		dB
Input 3rd Order Intercept		2.5		dBm
DC supply Current		15.0		mA

Note 1: Test Conditions: Vdd=2.8V, RF=881MHz, LO=966MHz, IF=85MHz, Ta=25C, CDMA High Gain state.

Electrical Characteristics

Parameter	Conditions	Min.	Typ/Nom	Max.	Units
RF Frequency	Cellular band	869	881	894	MHz
IF Frequency Range	High side LO	85		130	MHz
CDMA Mode-High Gain					
Gain		13.0	15.0		dB
Noise Figure			4.5	5.5	dB
Input IP3		0	2.5		dBm
Supply Current			15.0	18.0	mA
CDMA Mode-High Gain Low Linearity					
Gain		14.0	17.0		dB
Noise Figure			4.5	5.5	dB
Input IP3			-1.0		dBm
Supply Current			15.0		mA
CDMA Mode-Mid Gain					
Gain		1.0	3.5		dB
Noise Figure			11.0		dB
Input IP3			13.5		dBm
Supply Current			10.5		mA
CDMA Mode-Low Gain					
Gain		5.0	7.0		dB
Noise Figure			10.0		dB
Input IP3			10.0		dBm
Supply Current			10.5		mA
AMPS Mode					
Gain		9.5	12.0		dB
Noise Figure			5.0	6.0	dB
Input IP3		-5.0	-3.0		dBm
Supply Current			9.0	12.5	mA
Supply Voltage			2.8		V

Note 1: Test Conditions: Vdd=2.8V, RF=881MHz, LO=966MHz, IF=85MHz, T_C = 25° C, Min/Max limits are at +25°C case temperature, unless otherwise specified.

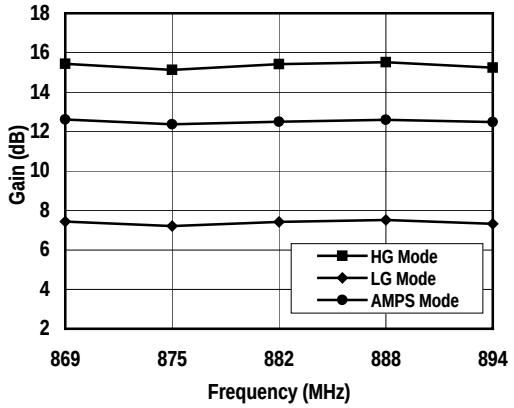
Absolute Maximum Ratings

Parameter	Value	Units
DC Power Supply	5.0	V
Power Dissipation	500	mW
Operating Temperature	-40 to 85	C
Storage Temperature	-60 to 150	C
Signal level on inputs/outputs	+20	dBm
Voltage to any non supply pin	+0.3	V

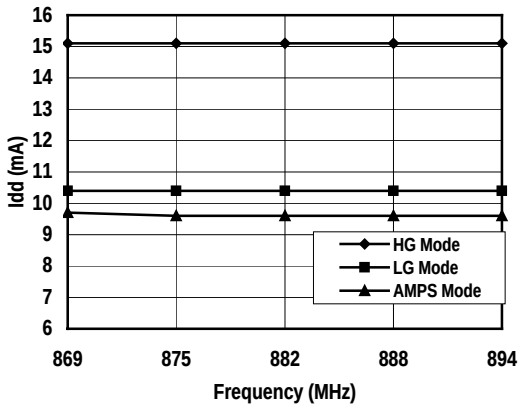
Typical Performance, Note: HG Mode=CDMA High Gain, LG Mode=CDMA Low Gain

Test Conditions, unless otherwise specified: Vdd=2.8V, Ta=25C, RF=881MHz, LO=966MHz, IF=85MHz, LO input=-4dBm

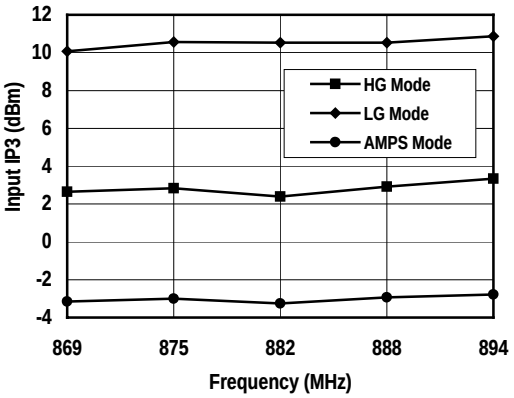
Gain vs. Frequency



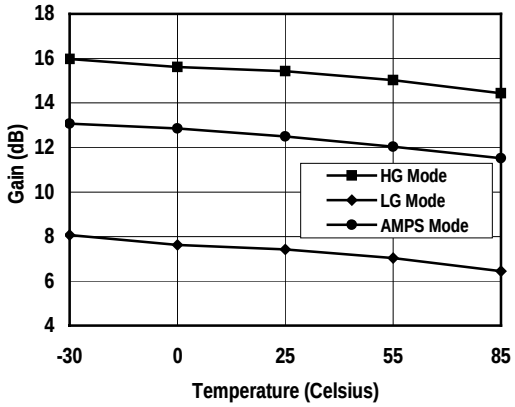
Idd vs. Frequency



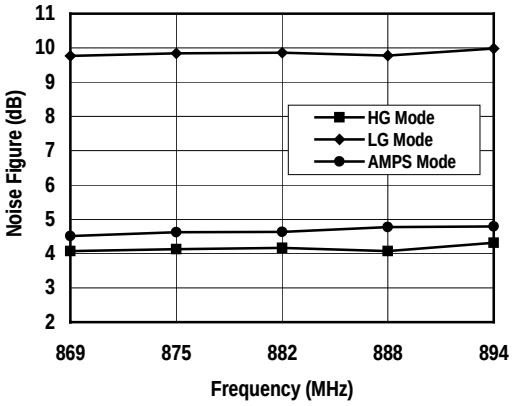
Input IP3 vs. Frequency



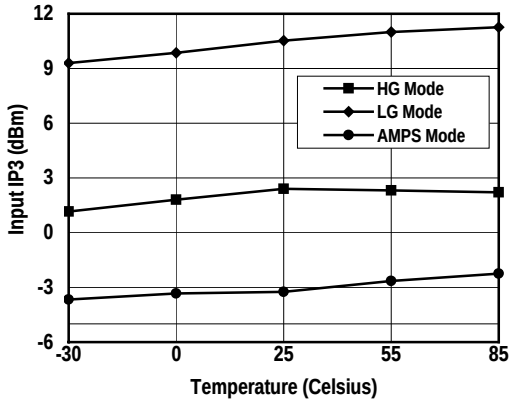
Gain vs. Temperature



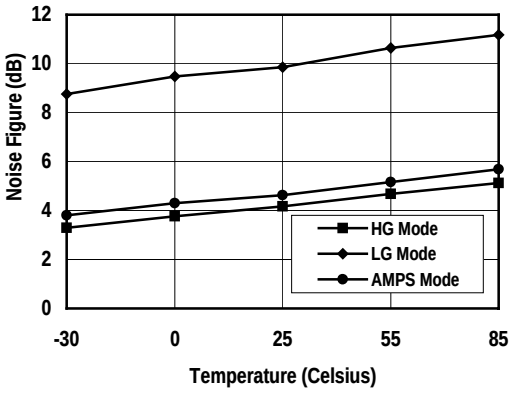
Noise Figure vs. Frequency



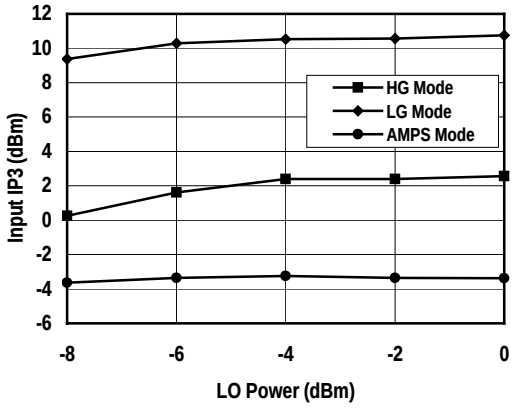
Input IP3 vs. Temperature



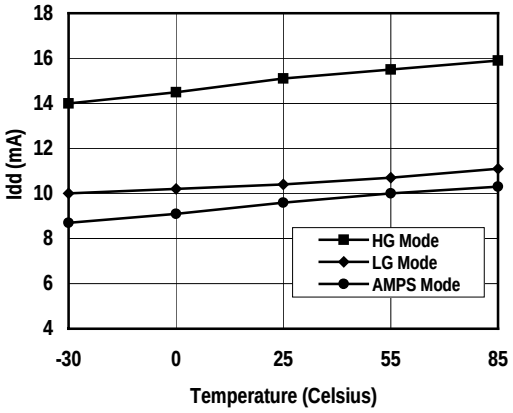
Noise Figure vs. Temperature



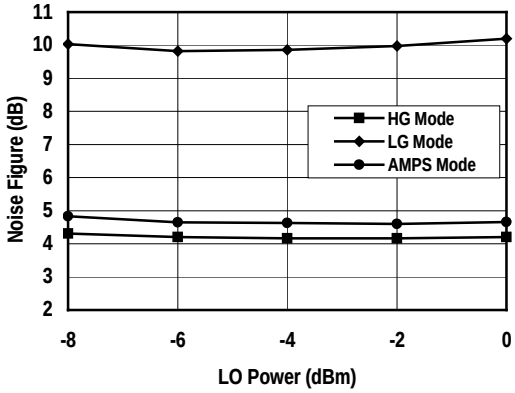
Input IP3 vs. LO Power



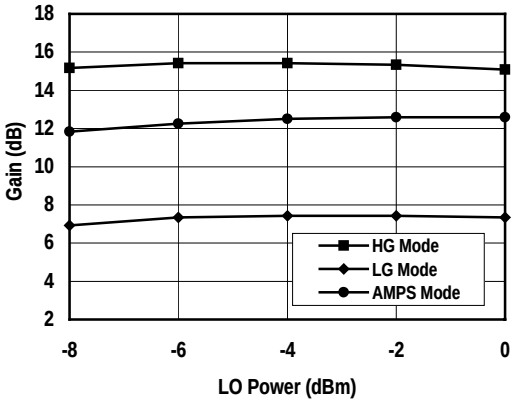
Idd vs. Temperature



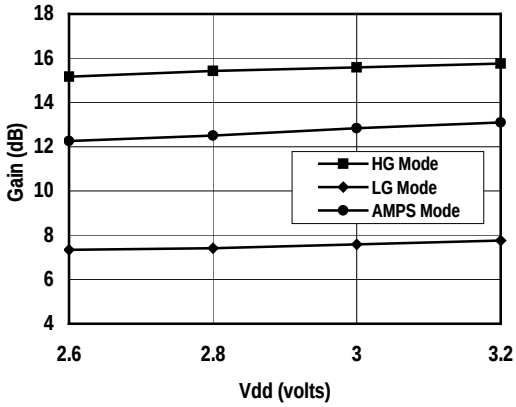
Noise Figure vs. LO Power



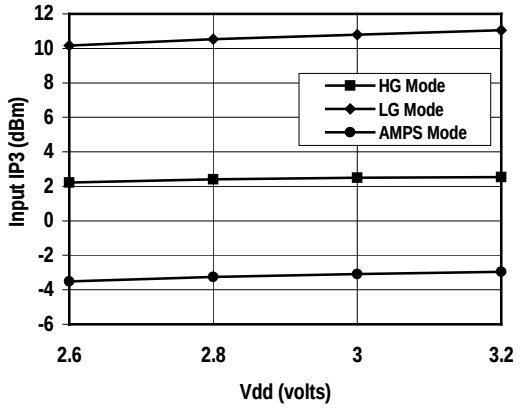
Gain vs. LO Power



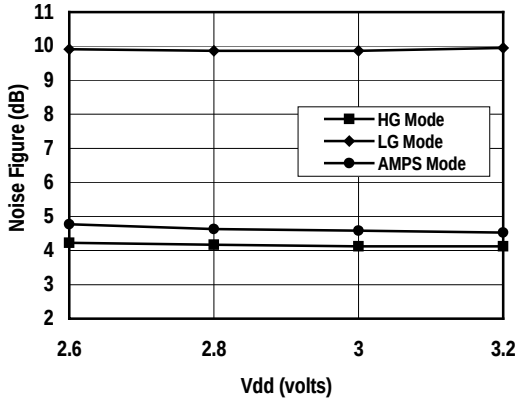
Gain vs. Vdd



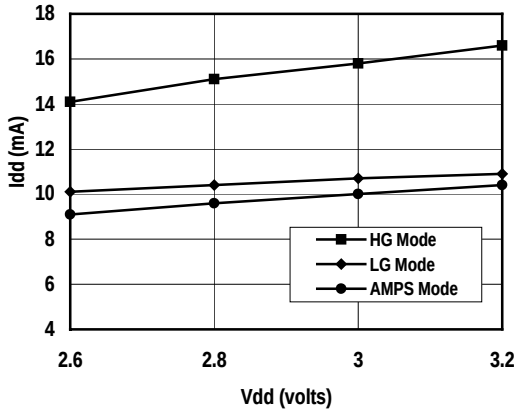
Input IP3 vs. Vdd

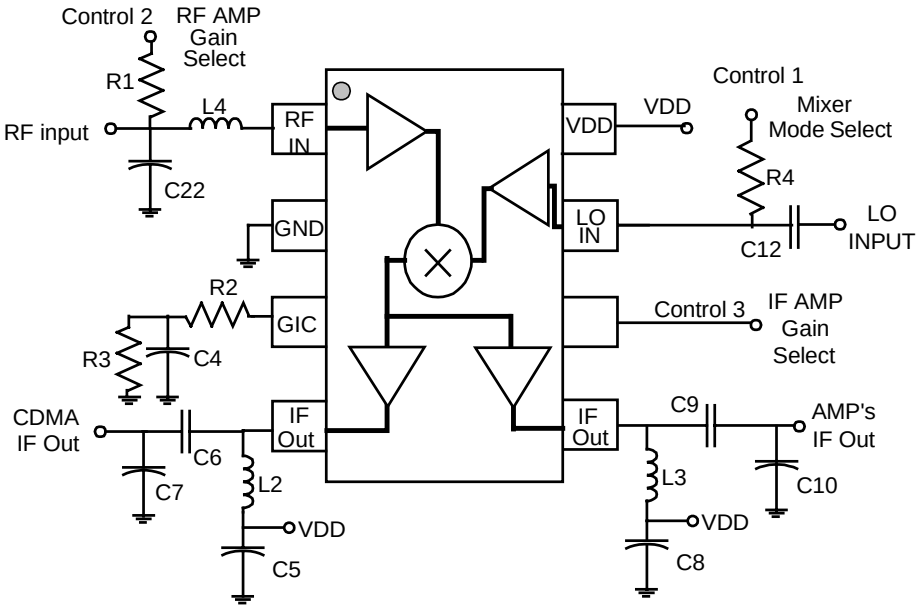


Noise Figure vs. Vdd



Idd vs. Vdd





Application/Test Circuit

Bill of Material for TQ5131 RF AMP/Mixer

Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5131		SOT23-8	TriQuint Semiconductor
Capacitor	C4		.022µF	0402	
Capacitor	C10		18pF	0402	
Capacitor	C5,C8		1200pF	0402	
Capacitor	C6,C7		27pF	0402	
Capacitor	C9		12pF	0402	
Capacitor	C12		100pF	0402	
Capacitor	C22		2.7pF	0402	
Resistor	R1, R4		5.1K Ω	0402	
Resistor	R2		8.2 Ω	0402	
Resistor	R3		82Ω	0402	
Inductor	L2		180nH	0805	
Inductor	L3		270nH	0805	
Inductor	L4		18nH	0402	

TQ5131 Product Description

The TQ5131 is a miniature low noise mixer (downconverter) in a small SOT-23-8 package (2.9X2.8X1.14 mm) with operation at 2.8v. It is designed for cellular CDMA applications and dual-mode CDMA/AMPS mobile phones. The IC features excellent linearity with an input intercept point of +2.5dBm in its high gain mode and +10.0dBm in its low gain mode. It has a typical noise figure of 4.5 dB for CDMA and 5.0 for AMPS mode. For optimum performance the TQ5131 RF frequency of operation should be from 869 to 894 MHz. The IF range is from 85 to 130 MHz and its injection mode for the local oscillator is high side.

Operation

The TQ5131 is a single-ended mixer with switching capabilities for the various signal levels found in CDMA applications. It consists of a RF amplifier, followed by a single-ended mixer driven by a grounded gate LO buffer amplifier. The mixer output can be directed either to the CDMA IF amplifier or the AMPS IF amplifier via a switch. Pin 1 and 7 are used to control the RF amplifier gain select and the mixer mode select respectively.

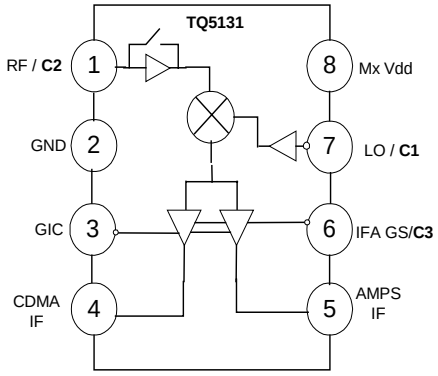


Figure 1. TQ5131 Block Diagram

Detailed Circuit Description: RF Amplifier

The TQ5131 has an integrated pre-amplifier stage in a cascode configuration. The output is internally matched to 50 ohms at 881MHz. Pin 1 requires an external match that is set to deliver a 2:1 VSWR in both the low and high gain modes (i.e. RFA is on or off). Figure 2 shows an approximated impedance at pin 1 (RFA input) to implement any desired match. The TQ5131 performance in TriQuint's demo board was achieved using the following source impedance **z = 1.86 + j2.41 Ω**(normalized to 50 Ω).

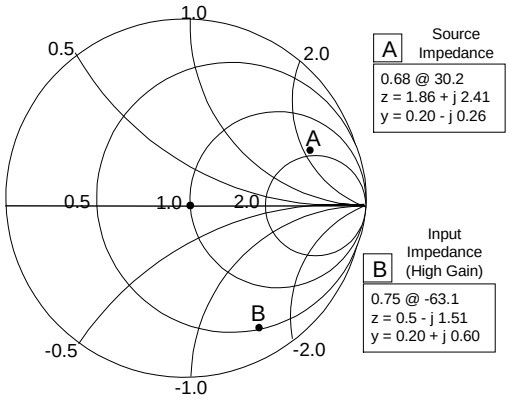


Figure 2. RFA Input and Source Impedance

LO Buffer Amplifier

The on-chip LO buffer amplifier is a grounded gate FET. The capacitor also serves as a DC block to the control voltage. The TQ5131 has internal LO tuning. This eases the work of the RF system designer and eliminates the need for the external tank circuit (inductor and capacitor) that would otherwise be needed to tune the frequency response of the LO buffer. The LO is limited to high-side injection mode and it operates from 950MHz to 1030MHz. The input to the LO buffer is through pin 7 which also feeds the control line **(C1)** that selects the mixer mode of operation, either CDMA or AMPS. Due to this logic control, the only external component required at the LO port is a series capacitor to prevent DC from traveling to other parts of the system. The LO drive level of operation should be between -7 and 0 dBm. Best performance is obtained between –6 and –2 dbm.

LO/filter/Mixer interaction

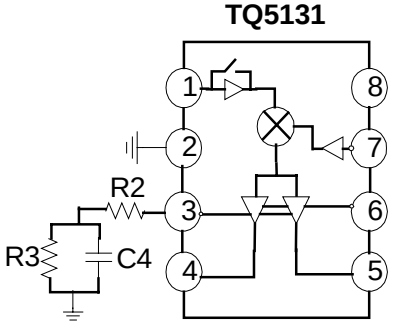
The physical position of the image reject filter is likely to have an effect on the performance of the mixer especially in the Low Gain mode where the RF amplifier is switched out. This is primarily due to self-mixing of the LO energy bouncing from the filter back into the mixer either out-of-phase or in-phase creating an offset in magnitude. To minimize this effect, TriQuint

recommends placing the image-reject filter as close to the IC as possible. In TriQuint's demo board its position is 42 mils from the pad of the matching inductor and 126 mils from the IC pad. This location for the image-reject filter works well.

CDMA IF Amplifier

The CDMA IF amplifier is an open drain stage with a gain step to adjust the output power levels according to the system requirement. The source of the CDMA IF amplifier is connected directly to pin 3. This allows the system designer to adjust gain, output intercept and current (GIC) by adding an external self-bias circuit at this pin (see figure 4a and b). Recommended capacitor value in the self-bias circuit is 0.022 uF or greater. In addition to the 0.5 to 1 dB more of input intercept obtained by using a large value capacitor, the effects of low frequency components present at this pin are also reduced.

Figure 4a. GIC Pin Self-Bias Circuit



C4 = 0.022uF
R2 = 8.2 Ω
R3 = 82 Ω

Note: These values were optimized for TriQuint's 5131 Demo board. The discrepancy between these values and those of the customer's application may differ due to board and component parasitics.

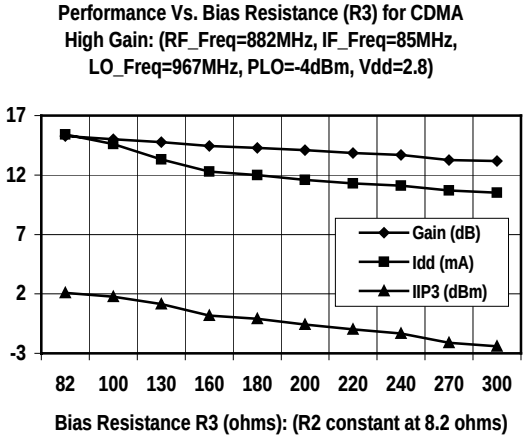


Figure 4b. Performance Vs. GIC Pin Bias Resistance, R3

AC degeneration of the CDMA IFA source has minimum or no effect on AMPS performance. Maximum gain is obtained when the total DC resistance (R2 + R3) at pin 3 is bypassed (see figure 4c).

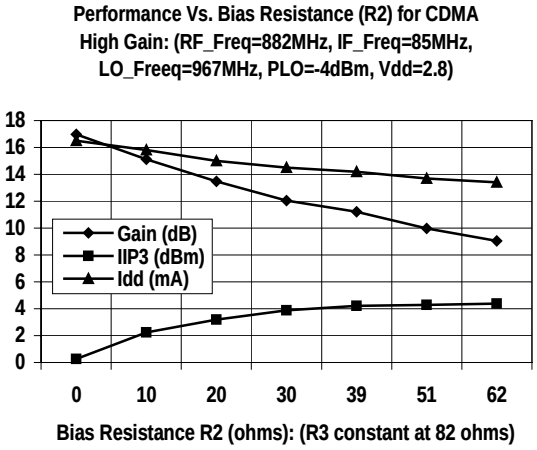


Figure 4c. Performance Vs. GIC Pin Bias Resistance, R2

Once the operating point is chosen, the designer still has flexibility to adjust gain and intercept by varying the ratio of the total bias resistance, R2 + R3. In figure 4d one can observe how gain and intercept change while the current remains approximately constant at 16mA.

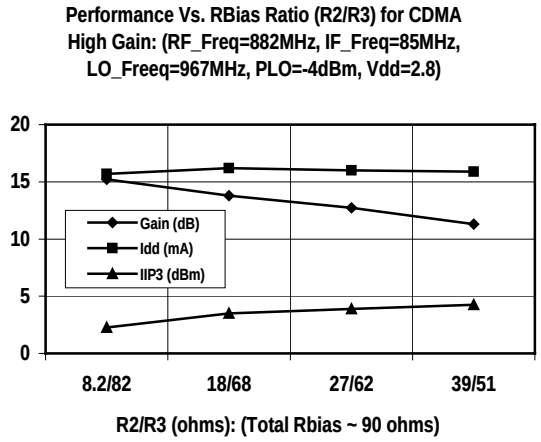


Figure 4d. Performance Vs. R2/R3 Ratio, Idd = 16mA

Similarly, figure 4e shows gain and input intercept variation while the current is fixed at 12mA.

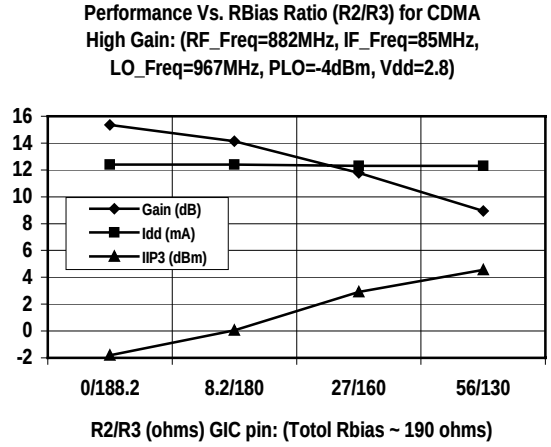
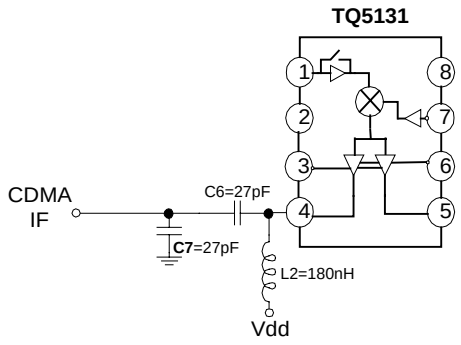


Figure 4e. Performance Vs. R2/R3 Ratio, Idd = 12.4mA

The normalized impedance at the CDMA IF output is **z = 5.0 – j 2.24 Ω**. There are several methods of measuring the port impedance of a device, this particular measurement was taken on the 5131 demo board by lifting pin 4 of the PCB pad and soldering the tip of a semirigid probe next to it. Care must be exercised when grounding the outer conductor of the semirigid probe. For the measurement to be valid the probe must be grounded very close to the pin. Before soldering the probe, its electrical length must be calculated and dialed in the network analyzer's port extension in order to move the calibration reference plane right at the tip of the probe. Keep in mind that the total DC bias resistance at the IF amplifier source must be selected before implementing the output match. Significant changes on this bias resistance might require a new match at the IF output. When designing the PCB, it is recommended to place the self bias circuit of the amplifier as close to the pin as possible to minimize possible loading effects that might cause an oscillation. Also the shunt capacitor of the IF match should be grounded close to the IC (see figure 4c).

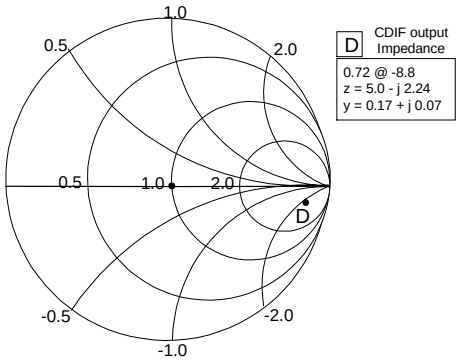
After designing the IF match in simulation using the given S-parameters, some adjustment might be needed when implementing the match on the bench. At this point remember that the mixer FET must be turned on since the IFA is directly coupled to it. Also make sure that the LO buffer amplifier is providing the proper drive level and that any unused ports are properly terminated. Figure 4 shows the circuit topology and component values designed for TriQuint's demo board. Verify that the match has a 2:1 VSWR in all modes. Figure 5 shows a typical CDMA IF output impedance.

Figure 4c. CDMA IF Output Match (IF = 85MHz)



Note: These values were optimized for TriQuint's 5131 Demo board. The discrepancy between these values and those of the customer's application may differ due to board and component parasitics.

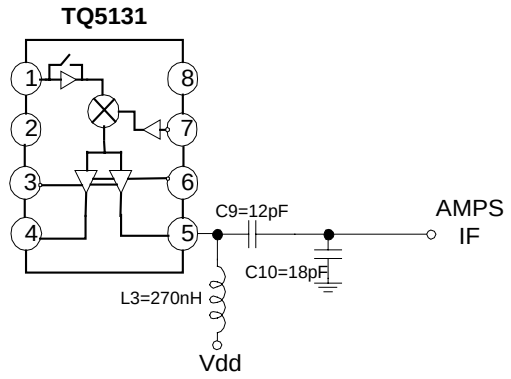
Figure 5. CDMA Output Impedance at Pin 4



AMPS IF Amplifier

This amplifier also uses an open drain stage with a self-bias circuit. No Quiescent current adjustments are possible in this mode since the bias circuit is on-chip. While the IF output can be tuned for frequencies as high as 500 MHz, the downconverter performance is limited by the internal tuned circuit of the LO buffer amplifier. The highest IF that can be used without significant deviation from typical performance is 130 MHz. This output is a high impedance open drain FET z = 5.42 – j 9.04 Ω (normalized). The match requires a RF choke to Vdd for proper biasing (see figure 6). Typical AMPS IF output impedance is shown in figure 7.

Figure 6. AMPS IF Output Match (IF = 85 MHz)



Note: These values were optimized for TriQuint's 5131 Demo board. The discrepancy between these values and those of the customer's application may differ due to board and component parasitics.

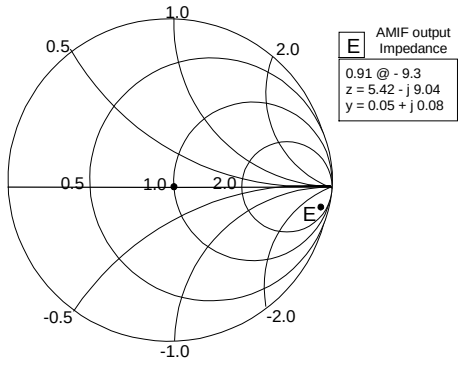


Figure 7. AMPS Output Impedance at Pin 5

Vdd Decoupling

External spurious signals at high and low frequencies can appear on the Vdd lines. Proper decoupling of these lines is required to eliminate unwanted noise. The recommended decoupling network has a PI configuration. On the main Vdd node, a large capacitor of 0.022 uF is use, followed by a 3.3 or 10 ohm resistor in series with the supply line, then another bypass cap that presents a low impedance to ground at the RF frequency of interest. The Vdd, pin 8, is bypassed on chip. Therefore, all that is needed is a series 3.3 to 10Ω resistor to the large capacitor, 0.022μFd.

Board Layout Recommendations

All ground pins should be kept close to the IC and have its own via to the ground plane to minimize inductance.

Most PC boards for portable applications have thin dielectric layers and very narrow line width which increase the board parasitic capacitance and inductance. To minimize these effects when implementing a matching network, it is recommended to relieve the ground underneath pads carrying RF signals whenever possible.

Control Line Description

The control lines can be toggled between high and low levels using CMOS logic circuitry. Control line C1 is used to switch between CDMA and AMPS IF output. The other two control lines C2 and C3, which are also tied to the LNA gain select and LNA mode respectively, set the various CDMA output levels required by the system.

Receiver State	*C1*	*C2*	*C3*
AMPS Mode	0	0	1
CDMA High Gain	1	0	0
CDMA HG, low lin	1	0	1
CDMA Mid Gain	1	1	0
CDMA Low Gain	1	1	1

Table 1. Downconverter Control Bits

C1 = Mixer Mode, C2 = RFA gain select and LNA gain select ,
C3 = IFA gain select and LNA mode select.

Receiver State	***RF AMP***	***IF AMP***
AMPS Mode	HG, AMPS Idd	HG, AMPS Output
CDMA High Gain	HG, CDMA Idd	LG, CDMA Output
CDMA HG, low lin	HG, CDMA Idd	HG, CDMA Output
CDMA Mid Gain	Bypass	LG, CDMA Output
CDMA Low Gain	Bypass	HG, CDMA Output

Table 2. Electrical States of RFA and IFA

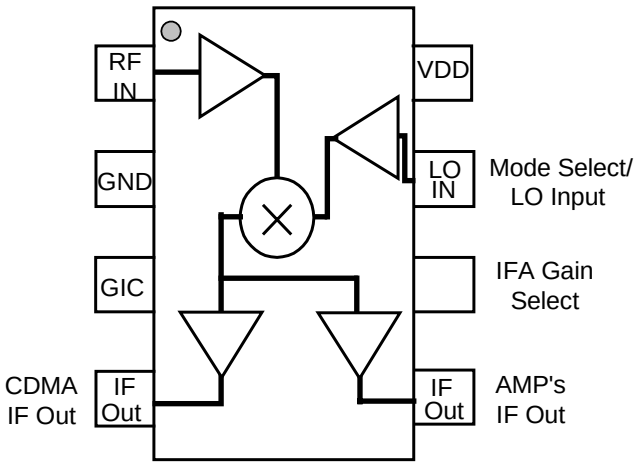
Rx SYSTEM PERFORMANCE

When measuring the mixer alone you will find that the low gain mode has a higher gain than the mid gain mode. These two modes describe the whole system (LNA + Mixer) spec rather than just the mixer. The difference between CDMA High-Gain (HG) and CDMA High-Gain-Low-Linearity (HGLL) is the input intercept of the LNA. In HG the LNA input intercept is +8dBm and so can withstand crossmodulation while transmitting. The HGLL mode is intended for standby phone operation where no transmission is taking place.

MODE	***IDD***	***GAIN***	***NF***	***IIP3***
	(mA)	(dB)	(dB)	(dBm)
AMPS	14	21.5	2.3	-13
High Gain	27.8	26	1.74	-8.9
HGLL	20.9	27.2	2.08	-10.6
Mid Gain	23	14.9	3.54	2
Low Gain	12.7	3.4	14.12	17.2

Table 3. TQ3131_5131 System Performance

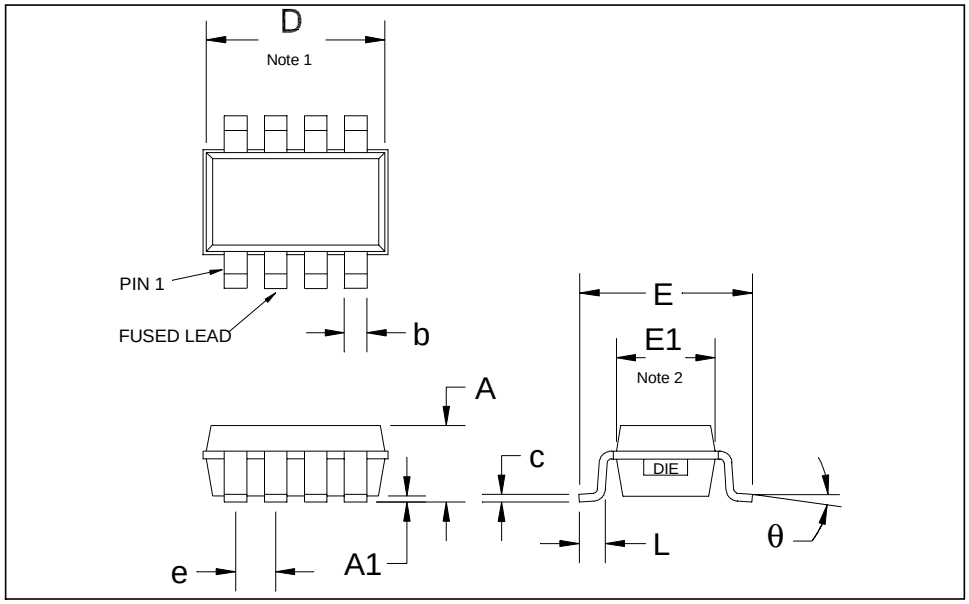
Package Pinout



Pin Descriptions

Pin Name	Pin #	Description and Usage
RF IN	1	RF Input, RF amplifier gain select, Logic Control 2
GND	2	Ground, paddle
GIC	3	Off chip tuning for gain/IP3/current
IF OUT	4	CDMA IF Output
IF OUT	5	AMPS IF Output
IFA Gain	6	IF amplifier gain select, Logic Control 3
LO IN	7	LO Input, mode select (CDMA/AMPS), Logic Control 1
Vdd	8	LNA Vdd, typical 2.8V

Package Type: SOT23-8 Plastic Package



DESIGNATION	DESCRIPTION	METRIC		ENGLISH		NOTE
A	OVERALL HEIGHT	1.20	+/-.25 mm	0.05	+/-.250 in	3
A1	STANDOFF	.100	+/-.05 mm	.004	+/-.002 in	3
b	LEAD WIDTH	.365	mm TYP	.014	in	3
c	LEAD THICKNESS	.127	mm TYP	.005	in	3
D	PACKAGE LENGTH	2.90	+/-.10 mm	.114	+/-.004 in	1,3
e	LEAD PITCH	.65	mm TYP	.026	in	3
E	LEAD TIP SPAN	2.80	+/-.20 mm	.110	+/-.008 in	3
E1	PACKAGE WIDTH	1.60	+/-.10 mm	.063	+/-.004 in	2,3
L	FOOT LENGTH	.45	+/-.10 mm	.018	+/-.004 in	3
Theta	FOOT ANGLE	1.5	+/-1.5 DEG	1.5	+/-1.5 DEG	

Notes
1. The package length dimension includes allowance for mold mismatch and flashing.
2. The package width dimension includes allowance for mold mismatch and flashing.
3. Primary dimensions are in metric millimeters. The English equivalents are calculated and subject to rounding error.

Additional Information

For latest specifications, additional product information, worldwide sales and distribution locations, and information about TriQuint:

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Email: info_wireless@tqs.com **Fax: (503) 615-8900**

For technical questions and additional information on specific applications:

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