

Product Description

The TQ5633 is a 3V, RF Amplifier/Mixer IC designed specifically for PCS band CDMA applications. Its RF performance meets the requirements of products designed to the IS-95 standard. The TQ5633 is designed to be used with an IF frequency of 110MHz, and uses a balanced mixer to achieve 1/2 IF rejection. When used with the TQ3631 or TQ3632 (CDMA LNAs) it provides a complete CDMA receiver for 1900MHz phones.

The RF Amplifier/Mixer incorporates on-chip switches which determine two gain select states. The RF and LO input ports are internally matched to 50 Ω, greatly simplifying the design and keeping the number of external components to a minimum. The TQ5633 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 PCS band mobile phones.

Electrical Specifications¹

Parameter	Min	Typ	Max	Units
Frequency		1960		MHz
Gain		16.0		dB
Noise Figure		5.8		dB
Input 3 rd Order Intercept		-0.5		dBm
DC supply Current		23.0		mA

Note 1: Test Conditions: Vdd=2.8V, RF=1960MHz, LO=2070MHz, IF=110MHz, Ta=25C, LO input -4dBm, CDMA High Gain state.

TQ5633

DATA SHEET

**3V PCS Band CDMA
 RFA/Mixer IC**

Features

- Small size: SOT23-8
- Single 3V operation
- Low-current operation
- Gain Select
- High IP3 performance
- Few external components
- Excellent 1/2 IF rejection
- 110MHz IF Frequency
- 50 Ω RF and LO inputs

Applications

- IS-95 CDMA Mobile Phones
- Wireless Local Loop
- PCS Micro-cell

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Electrical Characteristics

Parameter	Conditions	Min.	Typ/Nom	Max.	Units
RF Frequency	PCS band	1930	1960	1990	MHz
IF Frequency		100	110	130	MHz
LO Frequency		2030	2070	2120	MHz
CDMA Mode-High Gain					
Gain		14.8	16.0		dB
Noise Figure			5.8	6.7	dB
Input IP3		-1.5	-0.5		dBm
½ IF IIP2			27		dBm
Supply Current			23.0	26.5	mA
CDMA Mode-Low Gain					
Gain		5.8	7.0		dB
Noise Figure			10.0		dB
Input IP3			9.5		dBm
½ IF IIP2			32		dBm
Supply Current			18.5		mA
Supply Voltage		2.7	2.8	2.9	V

Note 1: Test Conditions: Vdd=2.8V, RF=1960MHz, LO=2070MHz, IF=110MHz, Tc = 25°C, LO input -4dBm, unless otherwise specified.

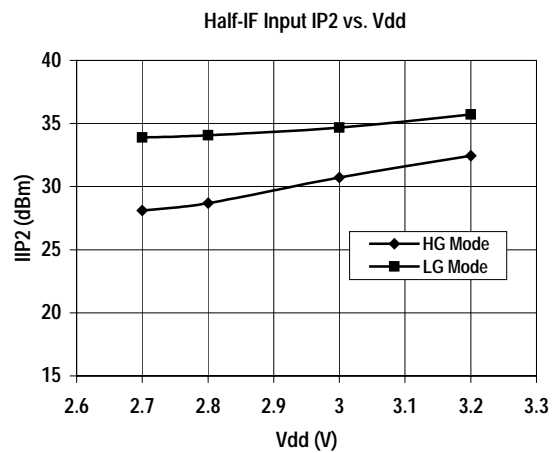
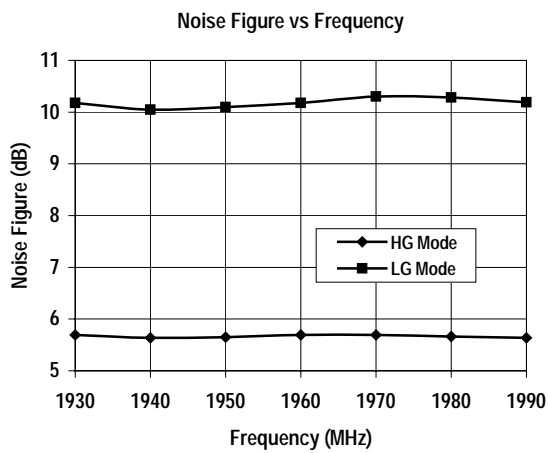
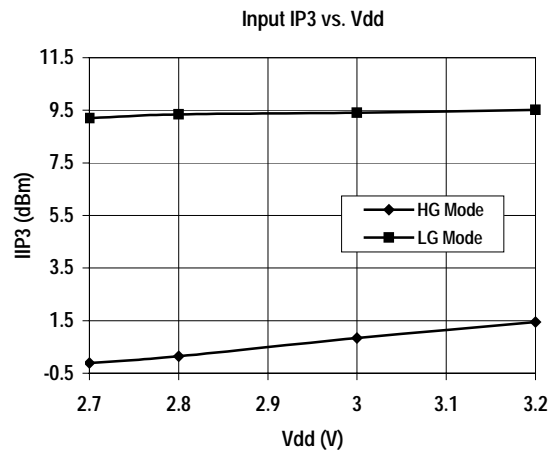
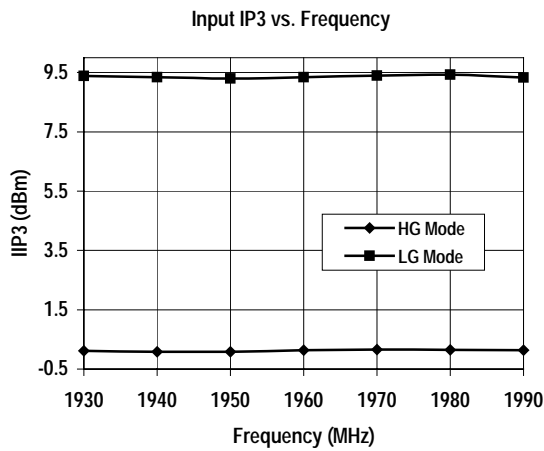
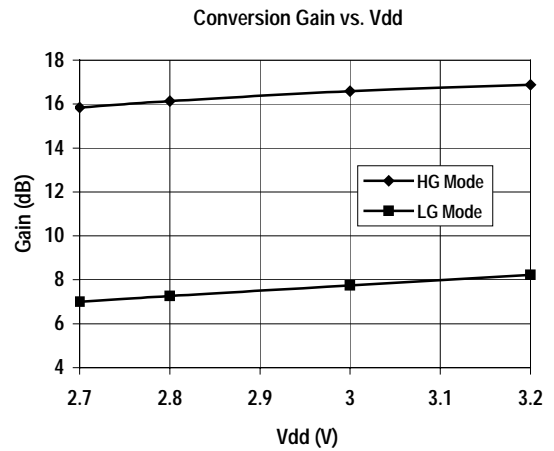
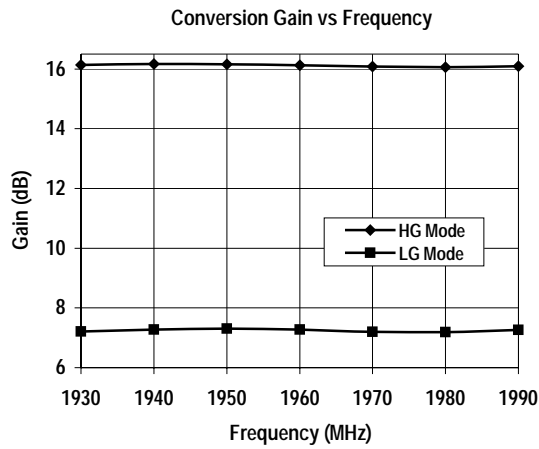
Note 2: Min/Max limits are at +25°C case temperature, unless otherwise specified.

Absolute Maximum Ratings

Parameter	Value	Units
DC Power Supply	3.6	V
Power Dissipation	500	mW
Operating Temperature	-30 to 85	C
Storage Temperature	-60 to 150	C
Signal level on inputs/outputs	+20	dBm
Voltage to any non supply pin	-0.5 to +0.5	V

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

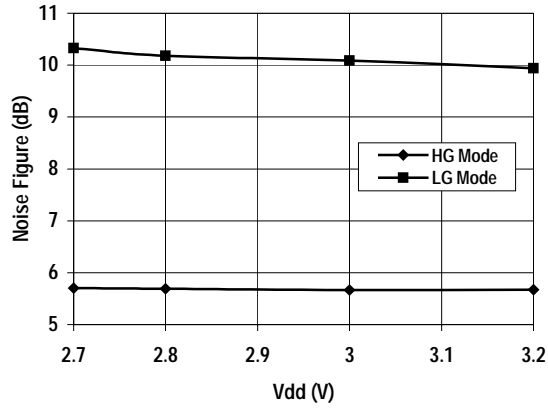
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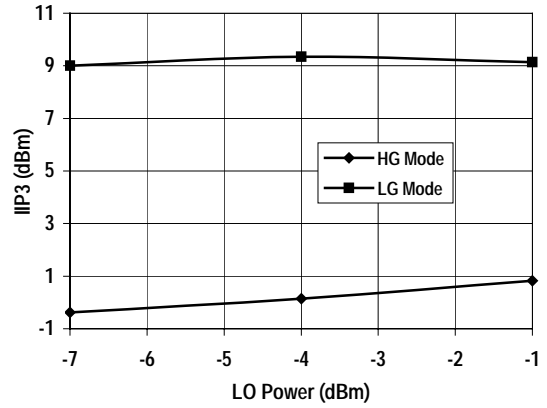
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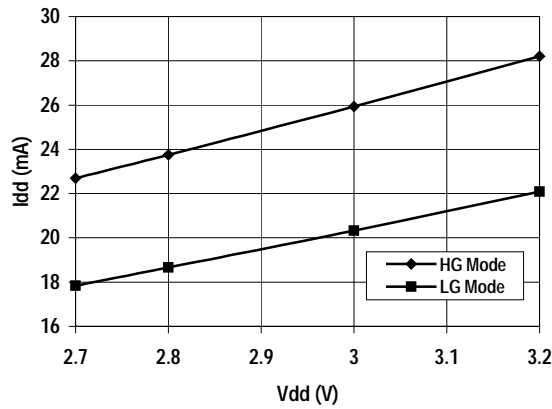
Noise Figure vs. Vdd



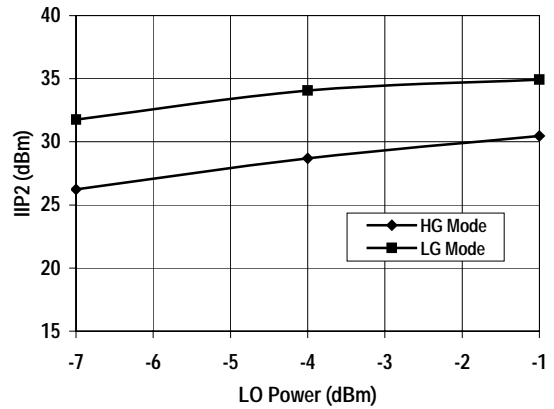
Input IP3 vs. LO Power



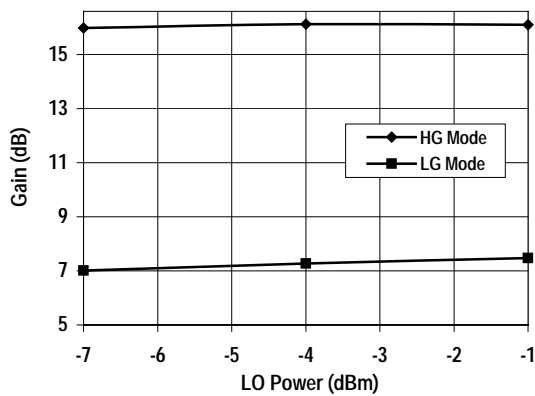
Idd vs. Vdd



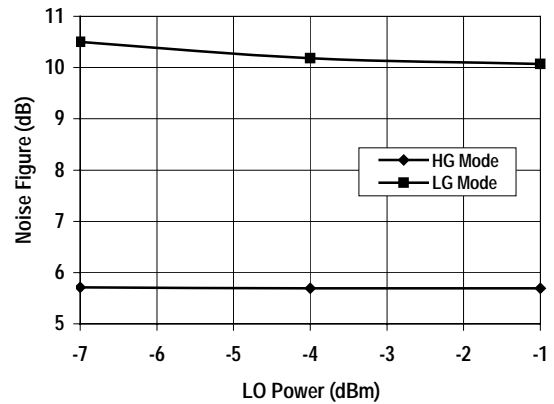
Half-IF Input IP2 vs. LO Power



Conversion Gain vs. LO Power

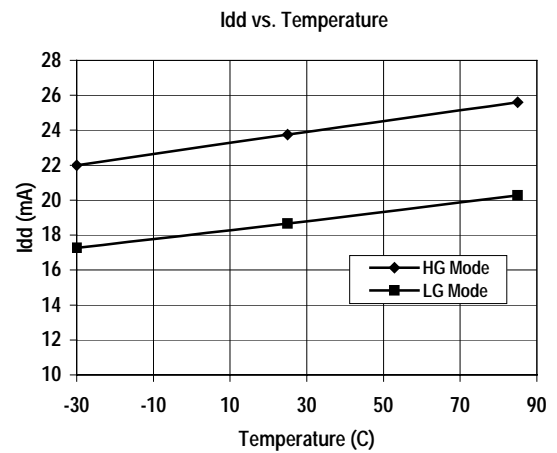
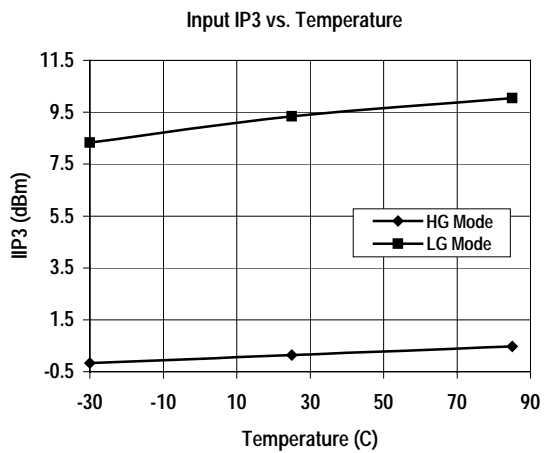
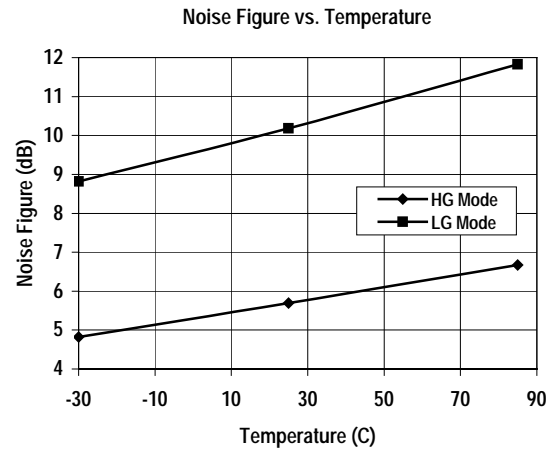
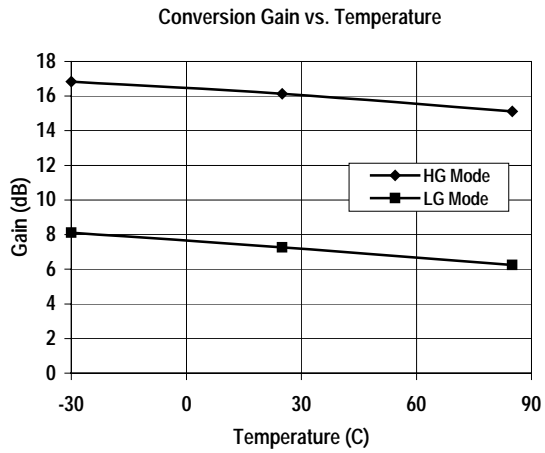
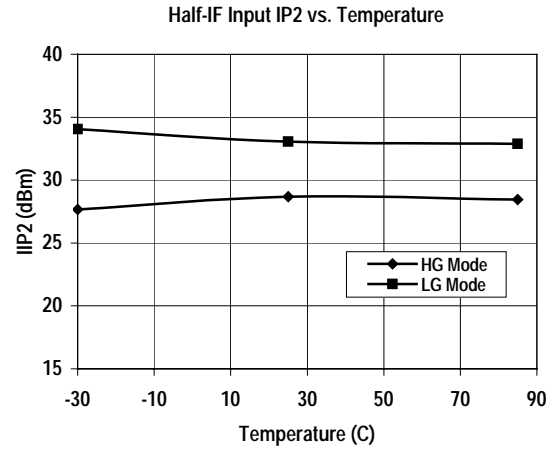
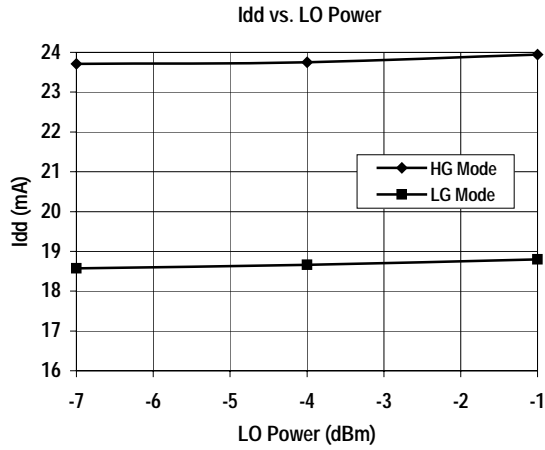


Noise Figure vs. LO Power



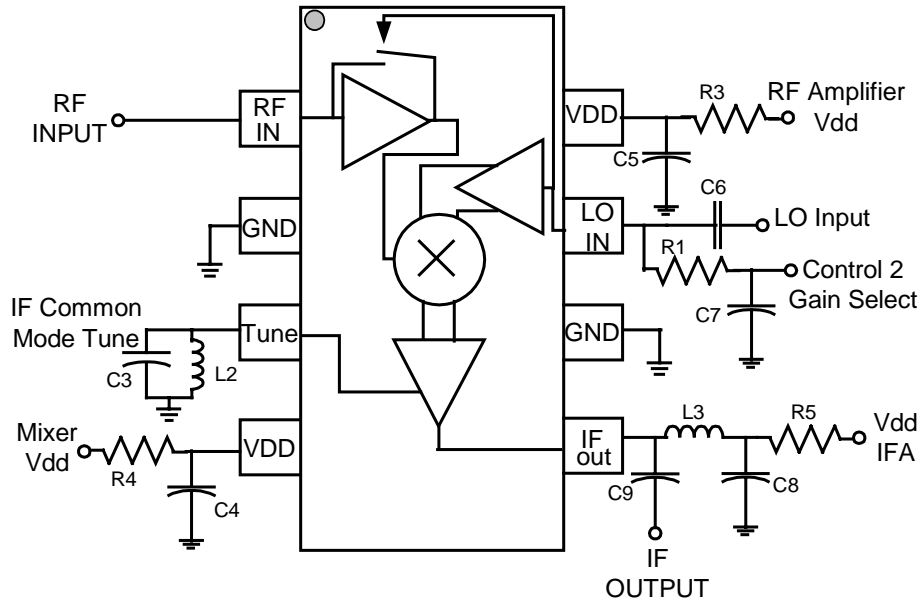
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Application/Test Circuit



Bill of Material for TQ5633 RF AMP/Mixer

Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5633		SOT23-8	TriQuint Semiconductor
Capacitor	C3		3.3pF	0603	
Capacitor	C4, C6, C8		1000pF	0603	
Capacitor	C5, C7		5.6pF	0603	
Capacitor	C9		10pF	0603	
Resistor	R1		2.2K Ω	0603	
Resistor	R3, R4, R5		3.3 Ω	0603	
Inductor	L2		470nH	0805	Toko
Inductor	L3		220nH	0805	Toko

TQ5631 Product Description

The TQ5633 is a balanced mixer down converter which integrates the gain step functions required for PCS CDMA handsets. The device requires minimal components and mates with the TQ3631 or TQ3632 series of high band LNAs. The TQ5633 was designed specifically for the needs of systems using a low IF in the range of 85MHz to 130MHz, as it provides a very high IP2. Some other outstanding features are 50ohm matches at the RF input and LO input in both modes.

Simplified theory of operation

The TQ5633 contains a RF amplifier, balanced mixer, LO buffer, IF amplifier and gain step switches. Figure 1 shows a block diagram. In the high gain mode, the RF Amp is turned on and the bypass switch is turned off. RF signal enters pin 1 and is amplified by 10dB before arriving at the passive balanced mixer. Total conversion gain is approximately 16dB.

The LO input at pin 8 is amplified by a saturating balanced driver before being applied to the mixer. By using amplification the LO drive remains constant over some range of LO input power and temperature. The LO tuning is internal and centered around 2070MHz.

The mixer utilizes proprietary techniques for attaining a very high degree of balance. It converts the PCS band signal down to approximately 110MHz using a high side LO source. By utilizing a passive mixer it provides for excellent IP3 response.

The IF signal is taken off of the mixer and applied to an IF amplifier which provides gain. The source of the IF stage is brought out to pin 3 so an external tuned circuit can be used to optimize IP2. The tuned circuit works by providing a high IF impedance at the source of the output differential pair. High IF common-mode rejection and balance are achieved by using a high IF impedance.

The low gain mode differs in that the RF amplifier is turned off and passive switches route the RF input signal directly to the mixer. In that case the total conversion gain is approximately 7dB.

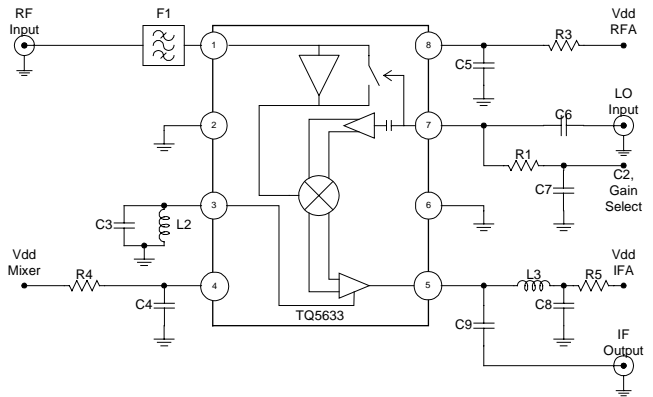


Figure 1 TQ5633 Simplified Block Diagram and Schematic

Logic truth table and logic control functions

The TQ5633 logic control was designed to mate with the TQ3631 or TQ3632 PCS Band LNAs. Although the TQ5633 has only one logic control line "C2", it's possible to obtain 4 different gain states when used in conjunction with the LNAs. Moreover, only two logic lines are needed. On the TQ5633 the "C2" control signal is superimposed on the LO input pin 7. A simple 2.2k ohm resistor and blocking capacitor serve as the decoupling network. Table 1 shows the logic control and device states for a TQ3631-TQ5633 combination.

Control Lines		System Mode	LNA State	TQ5633 State
C2	C3			
0	0	High Gain	High Gain	High Gain
0	1	High Gain, Low Linearity	High Gain, Low Linearity	High Gain
1	0	Mid Gain	High Gain	Low Gain
1	1	Low Gain	Bypass	Low Gain

Logic Table 1

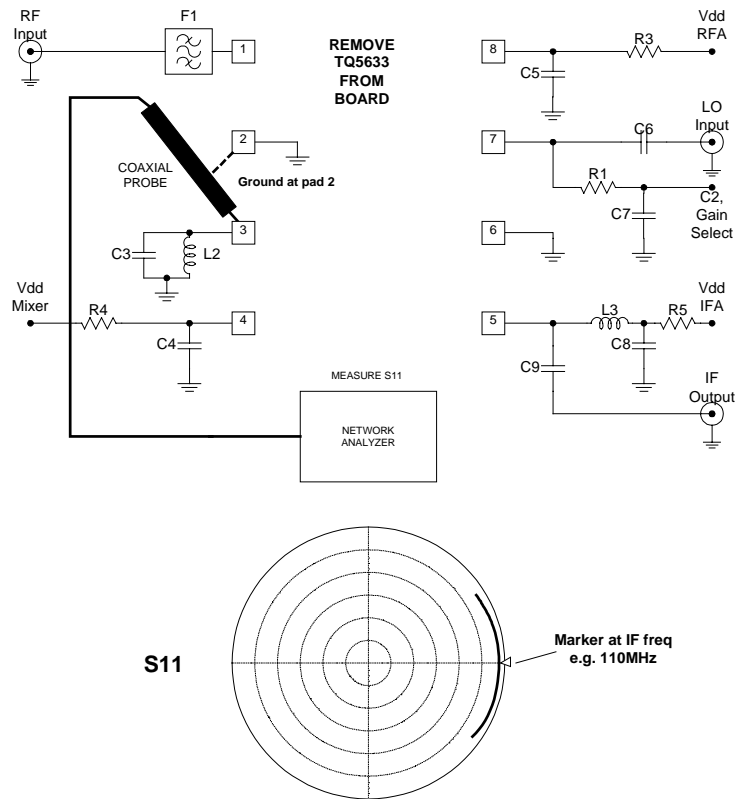
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TUNING:

IF Amplifier- The IF amplifier output at pin 5 requires a match down to 50 ohms in addition to a source of DC bias. A simple matching network that performs well for both functions is a shunt-L series-C type. See Figure 1. The L3 inductor provides DC bias to the IF amplifier while functioning as part of the IF matching network. The C9 capacitor provides a DC block and functions as the second AC matching component. During the design phase it is usually fairly easy to empirically determine these components by attaching a network analyzer to the 50ohm side of the IF network, and vary L3 and C9 until good return loss at the IF frequency is obtained. Typical values for L3 will be 180nH to 270nH and typical values of C9 are from 4.7pF to 15pF. Note that unlike a single-ended mixer type design, a shunt-C element at the output is not required. The TQ5633 leaks only a small amount of LO energy out of the RF port, so no additional shunt-C filtering is required.

IF Tank Circuit- As discussed in the introduction, the parallel LC circuit on pin 3 functions by creating a high IF impedance at the sources of the IF amplifier, improving common mode rejection. Once a prototype phone board layout is finished there remains the task of assigning the values of these components.

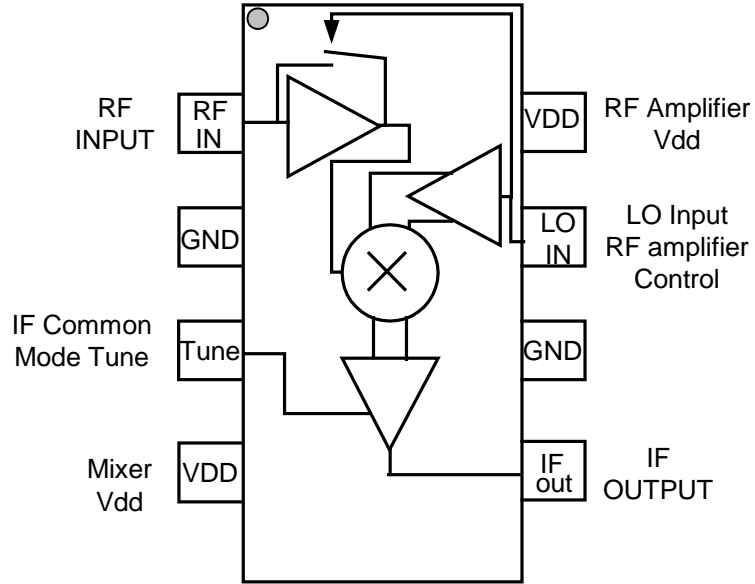
For a parallel circuit $R_p = Q \times X_p$. Thus the higher Q and X_p (i.e. L_p) are, the better IP2 will be. However, too high of a value for L2 will make the circuit more prone to parasitic capacitances. A good compromise would be to follow the evaluation board example and start with a 3.3pF capacitor for C3. Then using a network analyzer probe measure the impedance at the pin 3 pad with the TQ5633 absent. Adjust L2 until the network analyzer measures S11 as close as possible to $\Gamma = 1$ at an angle of 0° (i.e. an open circuit). In practice an $|S11|$ of 7.5k ohms is attainable with a 0805 size 470nH inductor. Smaller package 0603 and 0402 inductors may not be obtainable in such high values so that some compromises will have to be made if inductor size is an issue. See Figure 2.



**Figure 2 IF Tank Tuning
Further Improving IP2:**

Although the TQ5633 is exceptional in its isolation of the LO signal from the RF port, there is still a miniscule amount of LO energy present, typically -40dBc . That energy tends to bounce off of the image filter and reenter the downconverter where, depending on its phase, it creates a very small DC offset in the mixer. The phenomena occurs in the Low Gain mode where it can create 4 to 5 dBm variation in IP2 depending on how closely the image filter is located to the TQ5633. Thus for applications demanding the highest Half-IF spur rejection, higher IP2 can possibly be obtained by tailoring the length of the transmission line between the filter and chip. The specific line length will depend upon board layout and will vary between filter types. If it appears that the needed length will be long, the line can be "U" shaped in order to conserve space. Measurements have indicated that there is some reduction in gain at the optimum line length.

Package Pinout

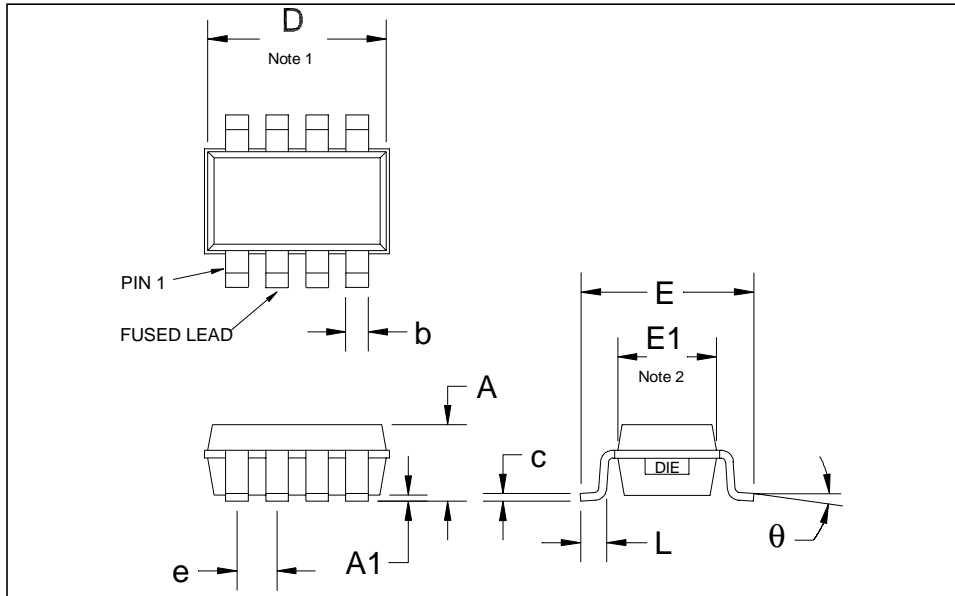


Pin Descriptions

Pin Name	Pin #	Description and Usage
RF INPUT	1	RF Amplifier Input
GND	2	Ground
Tune	3	IF Amplifier Common Mode Point
Vdd	4	Mixer Vdd
IF OUT	5	IF Output and IF Amplifier Vdd
GND	6	LO Common Mode Ground
LO INPUT	7	LO Input and RF Amplifier Gain Select
Vdd	8	RF Amplifier Vdd

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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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For technical questions and additional information on specific applications:

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