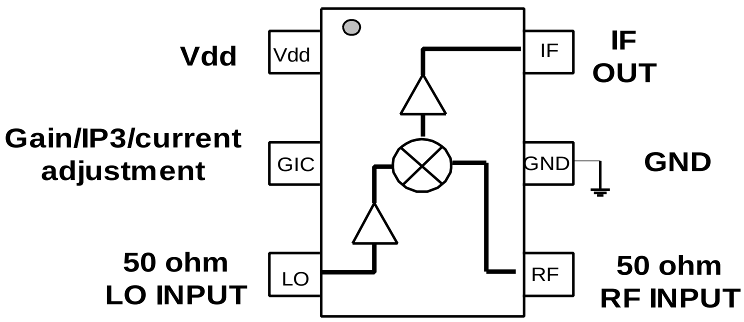
WIRELESS COMMUNICATIONS DIVISION

TQ5M31

DATA SHEET



3V Downconverter Mixer IC

Features

- *Single 3V Operation*
- *Adjustable Gain/IP3/Current*
- *Low Current Operation*
- *Few external components*
- *SOT23-6 plastic package*
- *High IP3*
- *Broadband Performance*

Applications

- *Cellular and PCS mobile applications worldwide*
- *Wireless data applications*
- *GPS/ISM/ general purpose*

Product Description

The TQ5M31 is a general purpose RFIC mixer downconverter designed for multiple applications including worldwide cellular and PCS mobile phones, ISM bands, GPS receivers, L band satellite terminals, WLAN and pagers. The TQ5M31 is usable for applications with an RF frequency range from 500 to 2500 MHz, and an IF output range from 45 to 500 MHz. The integrated circuit requires minimal off-chip matching, while allowing for the maximum application flexibility. Low current drain makes this part ideal for portable, battery operated applications. The output third order intercept efficiency is very high.

Electrical Specifications[1]

Parameter	Min	Typ	Max	Units
RF Frequency	500		2500	MHz
Conversion Gain		4.0		dB
Noise Figure		8.5		dB
Input 3rd Order Intercept		9.0		dBm
DC supply Current		6.2		mA

Note 1: Test Conditions: Vdd=2.8V, Ta=25C, RF=1960MHz, LO=1750MHz, IF=210MHz, LO input=-4dBm

Electrical Characteristics

Parameter	Conditions	Min.	Typ/Nom	Max.	Units
RF Frequency		500	1960	2500	MHz
LO Frequency		600	1750	2700	MHz
IF Frequency		45	210	500	MHz
LO input level		-7	-4	0	dBm
Supply voltage		2.7	2.8	4.0	V
Conversion Gain		3.0	4.0		dB
Input 3rd Order Intercept		6.5	9.0		dBm
Supply Current			6.2	8.5	mA

Note 1: Test Conditions (devices screened to the above test conditions): Vdd=2.8V, RF=1960MHz, LO=1750MHz, IF=210MHz, LO input=-4dBm, T_C = 25 °C, unless otherwise specified.

Absolute Maximum Ratings

Parameter	Value	Units
DC Power Supply	5.0	V
Power Dissipation	100	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	+.3	V

Cellular Band Typical Electrical Characteristics

Parameter	Conditions	Min.	Typ/Nom	Max.	Units
Conversion Gain			3.5		dB
Noise Figure			9.5		dB
Input 3rd Order Intercept			9.0		dBm
Return Loss	Mixer RF input	10			dB
	Mixer LO input	10			dB
Isolation	RF to IF; after IF match		33		dBm
	LO to IF; after IF match		40		dBm
IF Output Impedance	Mixer "On"		500		Ω
	Mixer "Off"		<50		Ω
Supply Current			4.5		mA

Note 1: Test Conditions: Vdd=2.8V, RF=881MHz, LO=991MHz, IF=85MHz, LO input=-4dBm, T_C = 25 °C, unless otherwise specified.

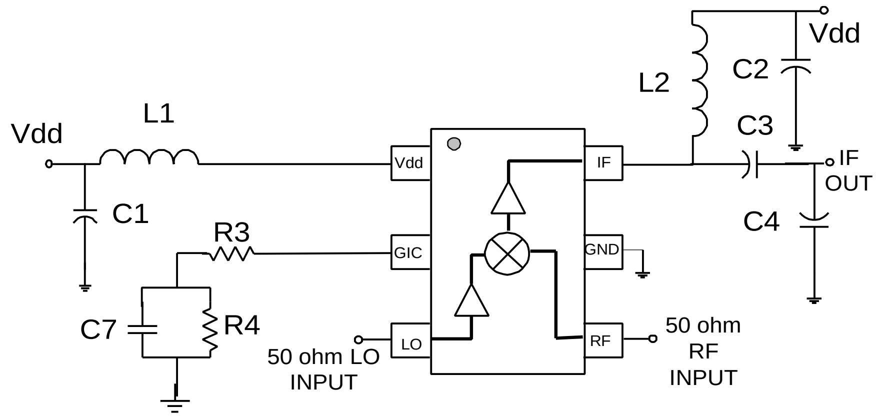
PCS Band Typical Electrical Characteristics

Parameter	Conditions	Min.	Typ/Nom	Max.	Units
Conversion Gain			4.0		dB
Noise Figure			9.5		dB
Input 3rd Order Intercept			9.0		dBm
Return Loss	Mixer RF input	10			dB
	Mixer LO input	10			dB
Isolation	RF to IF; after IF match		33		dBm
	LO to IF; after IF match		40		dBm
IF Output Impedance	Mixer "On"		500		Ω
	Mixer "Off"		<50		Ω
Supply Current			6.0		mA

Note 1: Test Conditions: Vdd=2.8V, RF=1960MHz, LO=1750MHz, IF=210MHz, LO input=-4dBm, T_C = 25 °C, unless otherwise specified.

Typical Performance/Applications circuit for GIC tuning plots

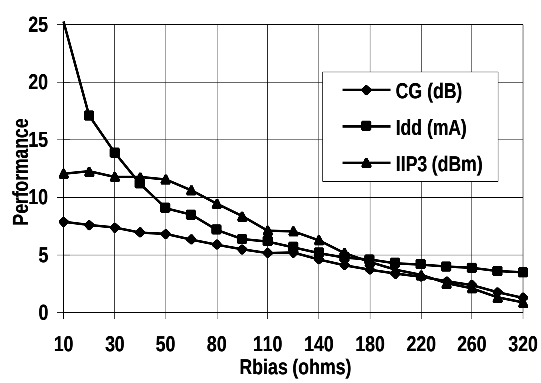
Test Conditions (Unless Otherwise Specified): Vdd=2.8V, Ta=25C, RF=1960MHz, LO=1750MHz, IF=210MHz,Current »6mA, Gain »4dB, IIP3 »+10dB



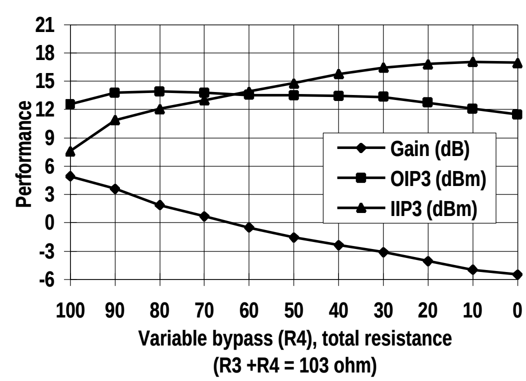
Bill of Material for TQ5M31 Downconverter Mixer for GIC tuning plots

Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5M31		SOT23-6	TriQuint Semiconductor
Capacitor	C1		470pF	0402	
Capacitor	C2		1000pF	0402	
Capacitor	C3		22pF	0402	
Capacitor	C4		27pF	0402	
Capacitor	C7		150 pF	0402	
Inductor	L1		2.2nH	0402	
Inductor	L2		39nH	0402	
Resistor	R3, R4		Select	0402	

Conversion Gain, Idd and IIP3 Vs Rbias
(Vdd = 2.8v, PLO = - 4dBm)



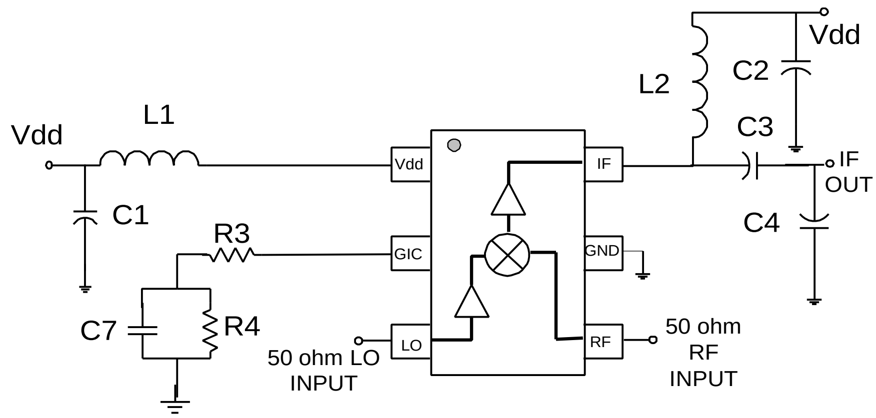
Performance Vs. Bypass DC Bias Resistance
(RF = 1960 MHz, Vdd = 2.8v, PLO = -4 dBm)



TriQuint SEMICONDUCTOR

Cellular Band Typical Performance/Applications circuit

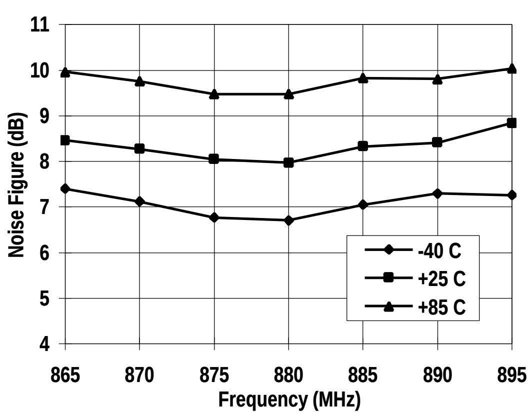
Test Conditions (Unless Otherwise Specified): Vdd=2.8V, Ta=25C, RF=881MHz, LO=966MHz, LO input –4dBm, IF=85MHz,Current »9mA, Gain »9dB, IIP3 »+10dB



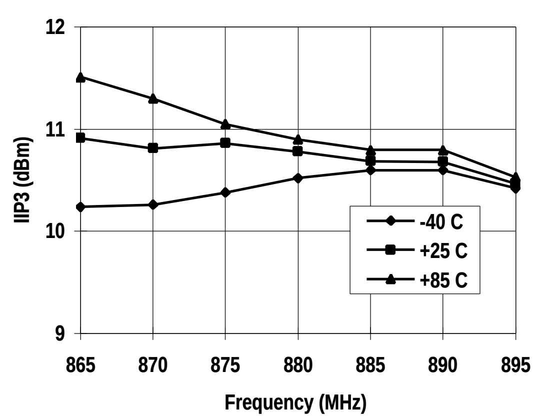
Bill of Material for TQ5M31 Downconverter Mixer Cellular band

Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5M31		SOT23-6	TriQuint Semiconductor
Capacitor	C1		1000pF	0402	
Capacitor	C2		1000pF	0402	
Capacitor	C3		20pF	0402	
Capacitor	C4		22pF	0402	
Capacitor	C7		150pF	0402	
Inductor	L1		2.2nH	0402	
Inductor	L2		39nH	0402	
Resistor	R3		3.3ohm	0402	
Resistor	R4		39ohm	0402	

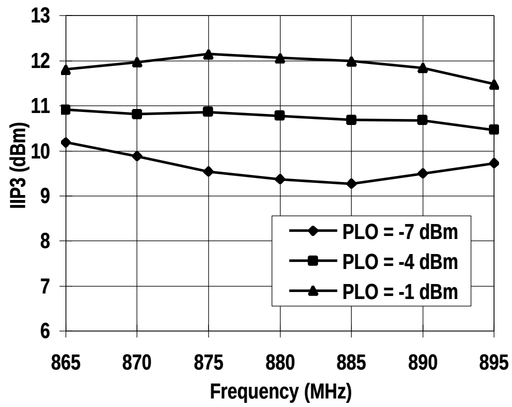
Noise Figure vs. Temperature vs. Frequency



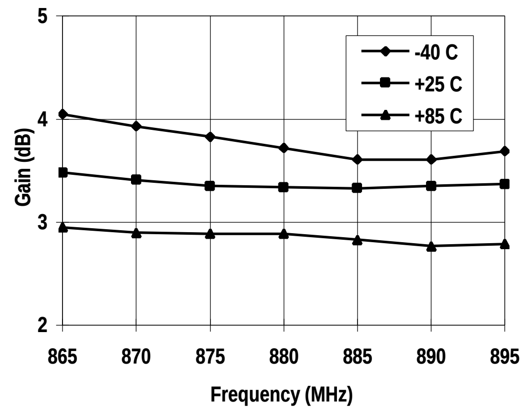
Input IP3 vs. Temperature vs. Frequency



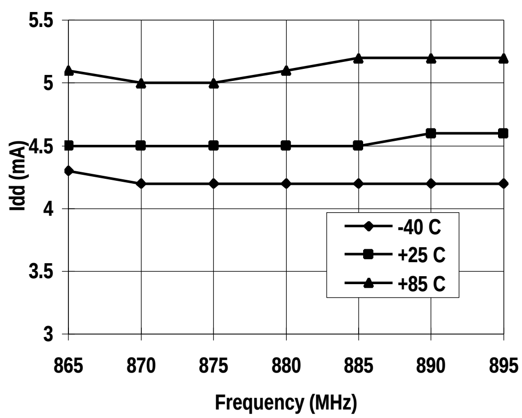
Input IP3 vs. LO Drive vs. Frequency



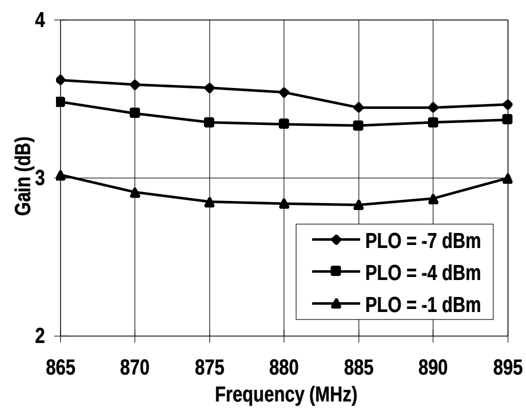
Conversion Gain vs. Temperature vs. Frequency



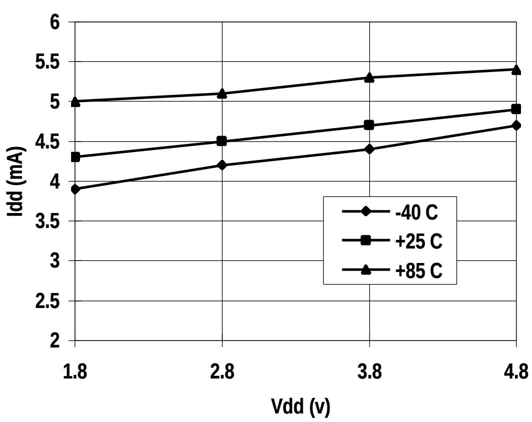
Idd vs. Temperature vs. Frequency



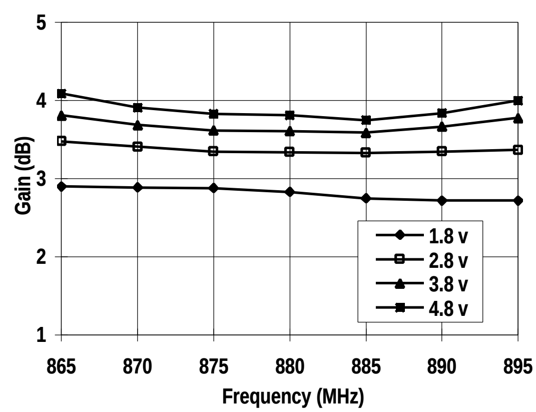
Conversion Gain vs. LO Drive vs. Frequency



Idd vs. Vdd vs. Temperature

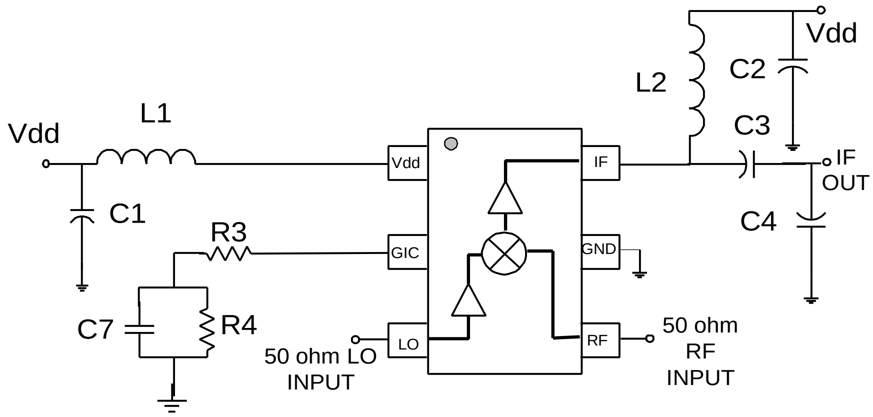


Conversion Gain vs. Vdd vs. Frequency



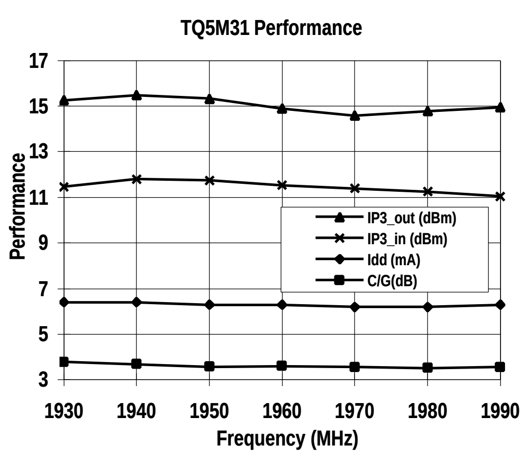
PCS Band Typical Performance/Applications circuit

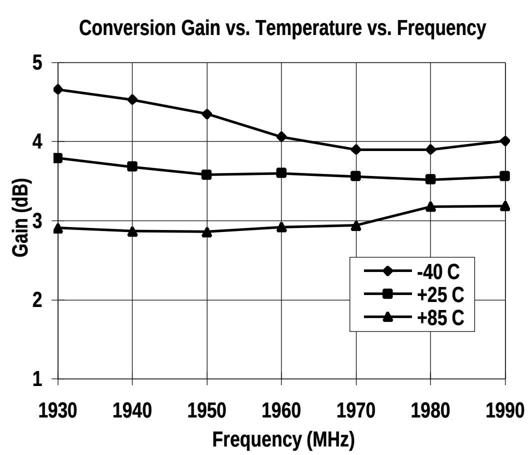
Test Conditions (Unless Otherwise Specified): Vdd=2.8V, Ta=25C, RF=1960MHz, LO=1750MHz, LO input –4dBm, IF=210MHz,Current »6mA, Gain »3dB, IIP3 »+10dB

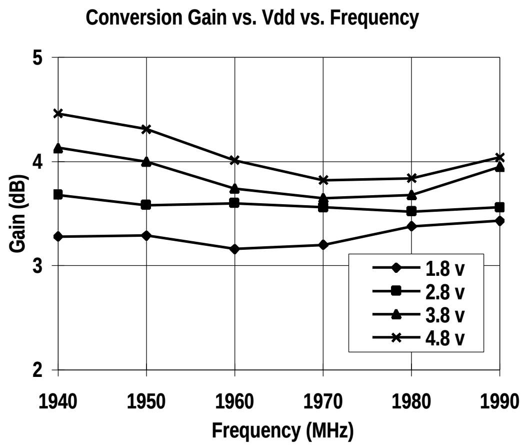


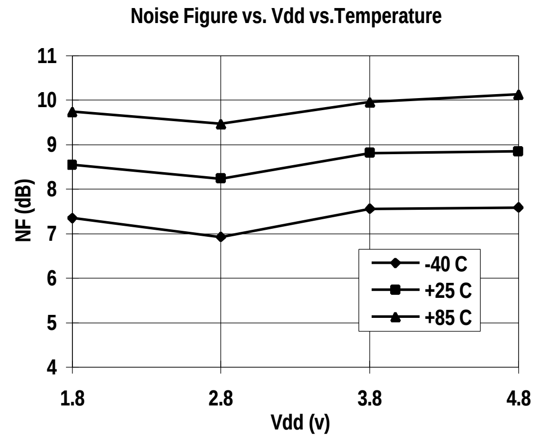
Bill of Material for TQ5M31 Downconverter Mixer PCS band

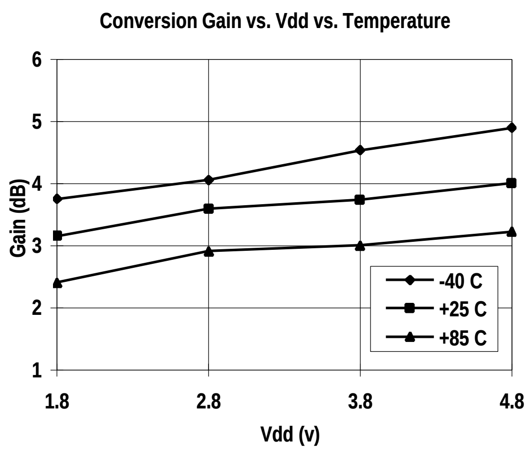
Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5M31		SOT23-6	TriQuint Semiconductor
Capacitor	C1		470pF	0402	
Capacitor	C2		1000pF	0402	
Capacitor	C3		22pF	0402	
Capacitor	C4		27pF	0402	
Capacitor	C7		150pF	0402	
Inductor	L1		2.2nH	0402	
Inductor	L2		39nH	0402	
Resistor	R3		12ohm	0402	
Resistor	R4		91ohm	0402	

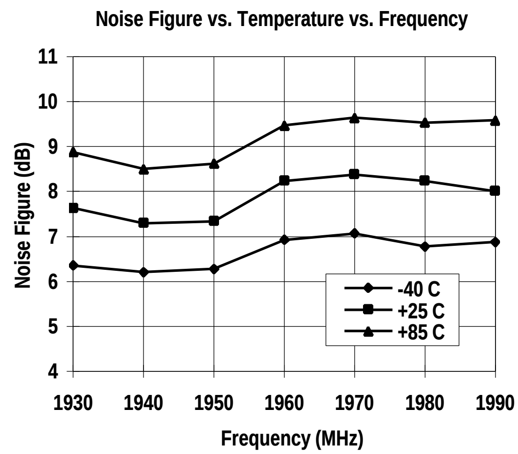


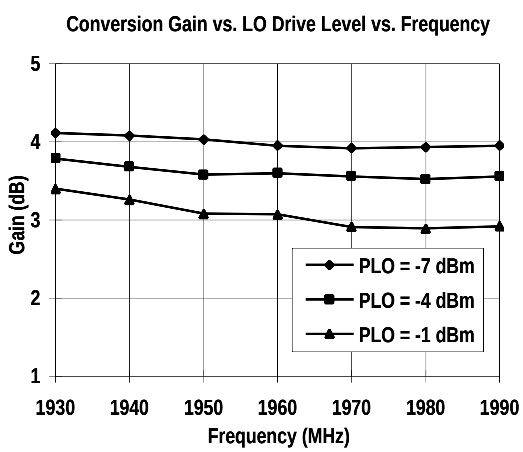


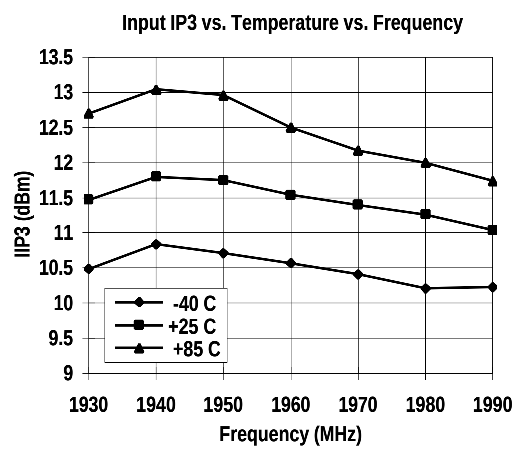

Conversion Gain vs. Vdd vs. Frequency
Gain (dB)
Frequency (MHz)
1.8 v
2.8 v
3.8 v
4.8 v

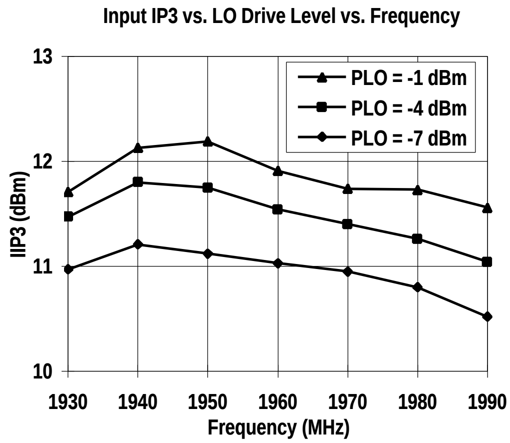

Noise Figure vs. Vdd vs.Temperature
NF (dB)
Vdd (v)
-40 C
+25 C
+85 C

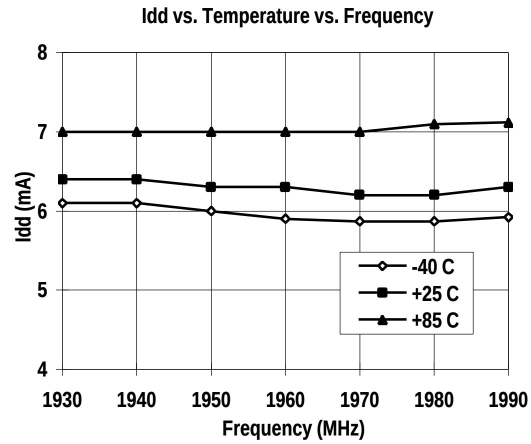

Conversion Gain vs. Vdd vs. Temperature
Gain (dB)
Vdd (v)
-40 C
+25 C
+85 C

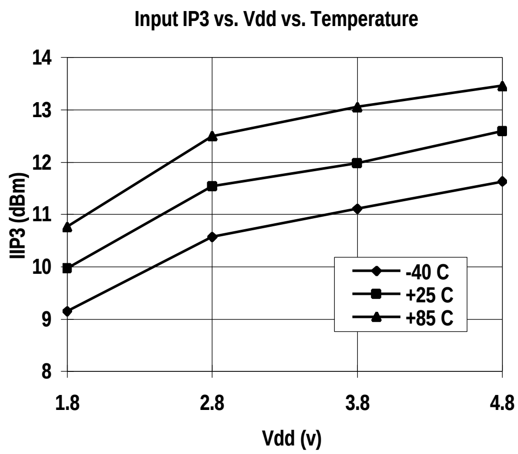

Noise Figure vs. Temperature vs. Frequency
Noise Figure (dB)
Frequency (MHz)
-40 C
+25 C
+85 C

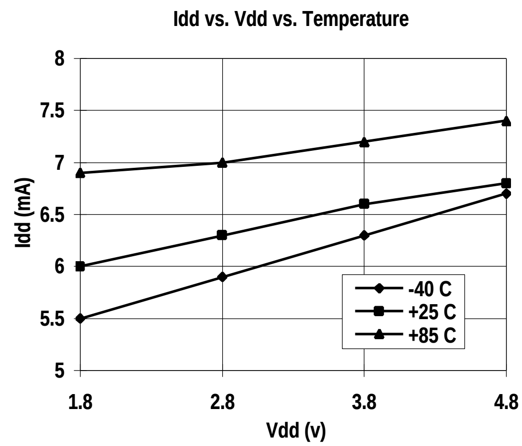

Conversion Gain vs. LO Drive Level vs. Frequency
Gain (dB)
Frequency (MHz)
PLO = -7 dBm
PLO = -4 dBm
PLO = -1 dBm


Input IP3 vs. Temperature vs. Frequency
IIP3 (dBm)
Frequency (MHz)
-40 C
+25 C
+85 C


Input IP3 vs. LO Drive Level vs. Frequency
PLO = -1 dBm
PLO = -4 dBm
PLO = -7 dBm
IIP3 (dBm)
13
12
11
10
1930
1940
1950
1960
1970
1980
1990
Frequency (MHz)

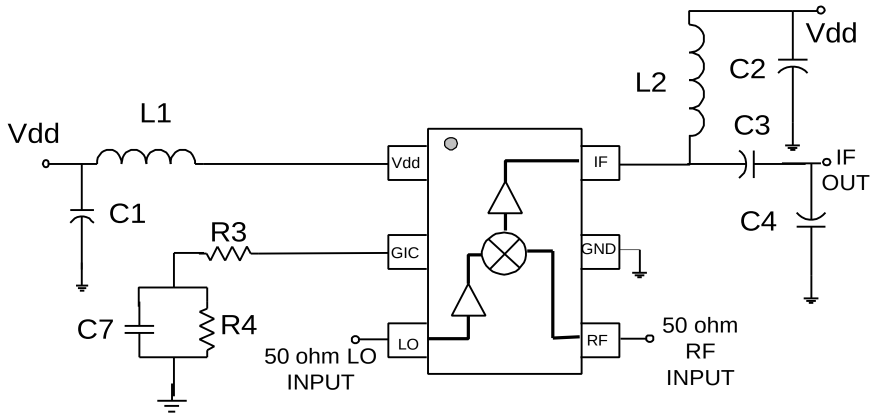

Idd vs. Temperature vs. Frequency
Idd (mA)
8
7
6
5
4
-40 C
+25 C
+85 C
1930
1940
1950
1960
1970
1980
1990
Frequency (MHz)


Input IP3 vs. Vdd vs. Temperature
IIP3 (dBm)
14
13
12
11
10
9
8
-40 C
+25 C
+85 C
1.8
2.8
3.8
4.8
Vdd (v)


Idd vs. Vdd vs. Temperature
Idd (mA)
8
7.5
7
6.5
6
5.5
5
-40 C
+25 C
+85 C
1.8
2.8
3.8
4.8
Vdd (v)

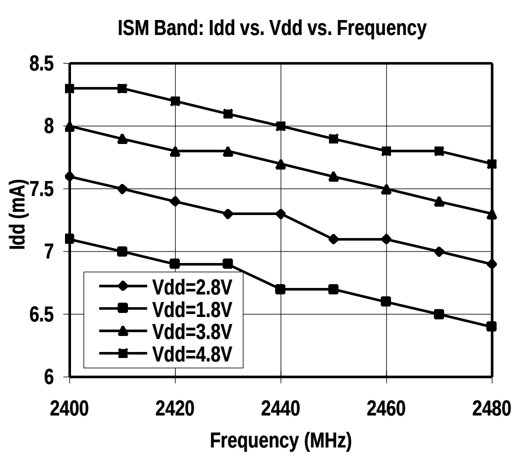
ISM Band Typical Performance/Applications circuit

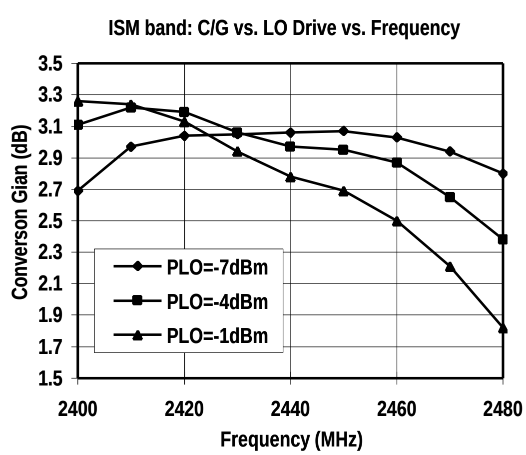
Test Conditions (Unless Otherwise Specified): Vdd=2.8V, Ta=25C, RF=2443MHz, LO=2203MHz, LO input –4dBm, IF=240MHz,Current »7mA, Gain »2.5dB, IIP3 »+9dB



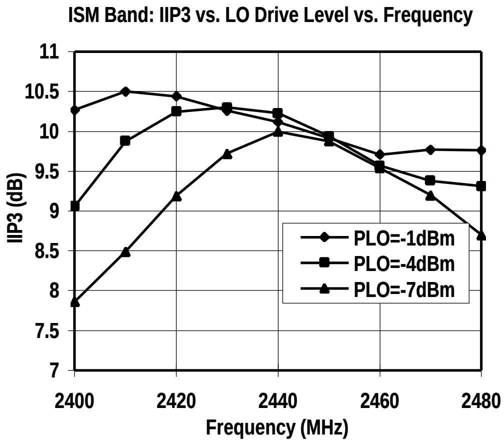
Bill of Material for TQ5M31 Downconverter Mixer PCS band

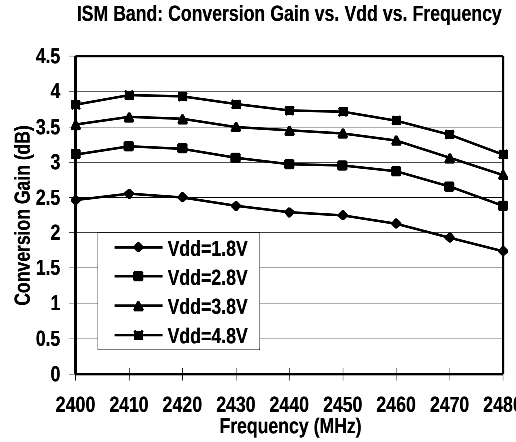
Component	Reference Designator	Part Number	Value	Size	Manufacturer
Receiver IC	U1	TQ5M31		SOT23-6	TriQuint Semiconductor
Capacitor	C1		220pF	0402	
Capacitor	C2		1000pF	0402	
Capacitor	C3		12pF	0402	
Capacitor	C4		10pF	0402	
Capacitor	C7		150pF	0402	
Inductor	L1		1.8nH	0402	
Inductor	L2		47nH	0402	
Resistor	R3		20ohm	0402	
Resistor	R4		47ohm	0402	





TriQuint SEMICONDUCTOR


ISM Band: IIP3 vs. LO Drive Level vs. Frequency
IIP3 (dB)
Frequency (MHz)
PLO=-1dBm
PLO=-4dBm
PLO=-7dBm
11
10.5
10
9.5
9
8.5
8
7.5
7
2400
2420
2440
2460
2480


ISM Band: Conversion Gain vs. Vdd vs. Frequency
Conversion Gain (dB)
Frequency (MHz)
Vdd=1.8V
Vdd=2.8V
Vdd=3.8V
Vdd=4.8V
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2400
2410
2420
2430
2440
2450
2460
2470
2480

General Description

TQ5M31 is a general purpose RFIC mixer downconverter designed for multiple applications. The mixer is implemented with a single common-source GaAs MESFET and is designed to operate with supply voltages from 1.8 to 5 Volts. To use the TQ5M31, tuning components must be selected for the LO buffer amplifier and the mixer IF port. An external shunt inductor on the output of the LO Buffer is needed to resonate with on-chip capacitance to shape the frequency response and roll off unwanted noise which might otherwise be injected into the mixer. The "*open-drain*" IF output allows for flexibility in matching to various IF frequencies and filter impedances.

Access to the GIC pin allows flexibility in Gain, Third Order Intercept, and Power Supply Current. By configuring the GIC pin with one or two external resistors and a capacitor, the part can be used in a wide variety of wireless receiver systems.

The TQ5M31 is in a miniature, low cost, 6 lead package (SOT-23-6). Total dimensions are 2.9 by 2.8 mm with a height of 1.14 mm.

The LO and RF ports have internal DC blocking capacitors and are internally matched to 50Ω. This simplifies the design and keeps the number of external components to a minimum.

Applications

Please refer to the above applications circuit.

LO Buffer Tune (Pin 1)

The broadband input match of the LO buffer amplifier, may cause thermal and induced noise at other frequencies to be amplified and injected directly into the LO port of the mixer. Noise at the IF frequency, and at (LO +/- IF) frequency will be downconverted and emerge at the IF port, degrading the downconverter noise figure.

The output node of the L0 buffer amplifier is brought out to Pin 1 and connected to a shunt inductor to ground. This inductor is selected to resonate with internal capacitance at the L0 frequency in order to roll off out-of-band gain and improve noise performance. This approach allows selectivity in the L0 buffer amplifier along with the ability to use the TQ5M31 with multiple applications.

Calculation of Nominal L Value for LO pin

The proper inductor value must be determined during the design phase. The internal capacitance at Pin 1 is approximately 1 pF. Stray capacitance on the board surrounding Pin 1 will add to the internal capacitance, so the nominal value of inductance can be calculated, but must be confirmed with measurements on a board approximating the final layout.

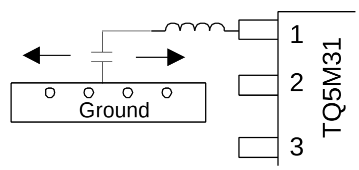


Figure 3. LO Tuning

The inductor is selected to resonate with the total capacitance at the LO frequency using the following equation:

$$L = \frac{1}{C(2\Pi f)^2}, where \ \ C = 1.0 \ \ pF$$

Verification of Proper LO Buffer Amp Tuning Using a Network Analyzer

Procedure:

Connect port 1 of the network analyzer to the L0 input (Pin 3) of the TQ5M31 with the source power set to -4 dBm. Connect a coaxial probe to Port 2 of the network analyzer and attach the probe approximately 0.1 inch away from either Pin 1 or the inductor. The magnitude of S21 represents the LO buffer frequency response (figure 4).

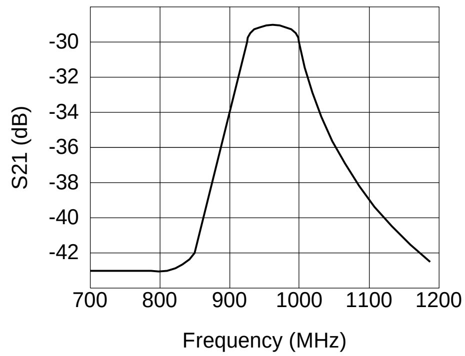


Figure 4. LO Buffer Response

The absolute value isn't important, since it depends on the probe's distance from the pin (it is usually around -30 dB), but the peak of the response should be centered in the middle of the L0 frequency band. Increasing the inductance will lower the center frequency, and vice versa.

GIC Pin (Pin 2)

To tune the TQ-5M31 to a specific Gain, IP3, and DC Current configuration, the designer should follow these steps:

1] Choose the desired OIP3. The OIP3 should be less than 18dBm.

2] Determine how much current is required to achieve the desired OIP3 from table 1. Data presented in these tables are approximate. The designer is only to use these tables as a guideline, keeping in mind that gain roll off will occur at higher RF and IF frequencies.

3] From the same table, determine the required total resistance for the GIC pin (R3+R4) in the figure below.

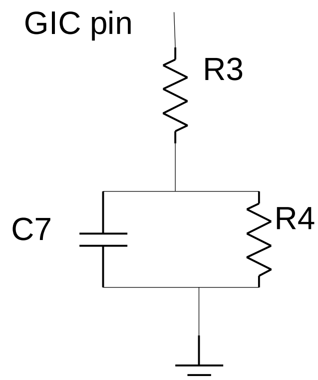
Table 1: OIP3 vs. total resistance (R3+R4)

OIP3 (dBm)	Idd (mA)	Resistance (ohms)
18	15	20
15	7	80
12	5.5	130
9	5	160
6	4	240
3	3.5	320

4] The designer should start with a "reasonably high" capacitor for C7 bypass, typical value 150pF. For an IF in the range of 85 to 210 Mhz, a 150 pF capacitor is acceptable.

5] Note that R3 is the unbypassed resistor on the GIC pin. Since the total resistance for R3+R4 has been chosen, the only parameter to decide is the ratio of R3 to R4. This ratio determines the gain of the mixer. While keeping R3+R4 constant, decreasing R3 while increasing R4 will result in more gain. For maximum gain, R3 can be replaced with a wire, and all of the R3+R4 resistance would reside on R4. This results in a single resistor in parallel with a capacitor on the GIC pin. In general, most applications result in R4 > R3. The designer can determine experimentally in very short order which resistor configuration to use.

See performance curves, page 4, "GIC tuning plot".



6] After the components on the GIC pin have been determined, the IF matching should be evaluated.

Mixer LO Port (Pin 3)

A common gate buffer amplifier between the LO port and the mixer FET gate provides a good impedance for the VCO and to allows operation at lower LO drive levels. The buffer amplifier provides enough voltage gain to drive the gate of the mixer FET while consuming very little current (~1mA).

Because of the good broadband 50Ω input impedance of the buffer amplifier, and the internal DC blocking capacitor, the user's VCO can be directly connected to the LO input via a 50Ω line with no additional components. The physical length of this connection is not critical.

LO Power Level

The TQ5M31 performance is specified with an LO power of -4 dBm. However, satisfactory performance can be achieved with LO drive levels in the range of -7 dBm to 0 dBm. Gain and input IP3 can be traded off by varying the LO input power. At lower LO drive levels, the gain increases and the input IP3 decreases or vise versa. DC current and output IP3 remain approximately constant.

Mixer RF (Pin 4)

The Mixer RF port of the TQ-5M31 provides a good, broadband match to 50 ohms over the entire RF frequency range. This minimizes IF leakage, and more importantly, prevents noise and unwanted signals at or near the IF frequency from being injected and degrading noise performance.

Ground (Pin 5)

Connect to an adequate RF and DC ground.

Mixer IF Port (Pin 6)

The Mixer IF output is an "open-drain" configuration, allowing efficient matching to various filter types at various IF frequencies. An optimum lumped-element matching network must be designed for maximum power gain and output third order intercept.

While tuning for the IF frequency, one has to consider the source impedance of the IF Amplifier. The IF frequency can be tuned from 45 to 500 MHz by varying component values of the IF output circuit. Pin 6 also provides bias injection.

It is recommended that the value of C3 be kept between 12 and 20 pF to optimize the IF match. For good isolation, the value of C4 should be no less than 22 pF. Decoupling components for the power supply are included on the evaluation board.

The decoupling components consist of a 10Ω resistor, and 0.01µF shunt capacitors. These components prevent reflected noise or other spurious signals from leaking through the Vdd line onto other ports.

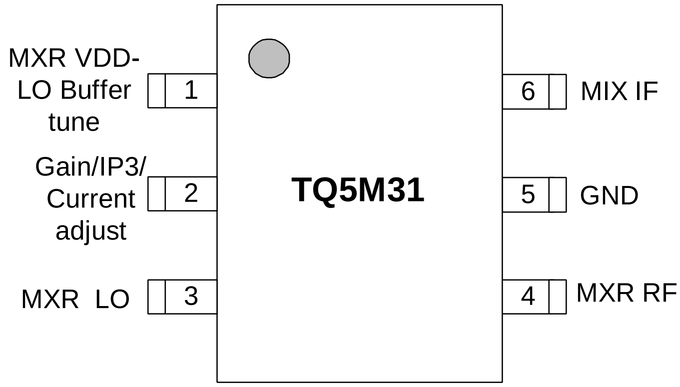
In the user's application, the IF output is most commonly connected to a narrow band SAW or crystal filter with impedances from 300 -1000Ω with 1 - 2 pF of capacitance. A conjugate match to the higher filter impedances is generally less sensitive than matching to 50Ω. When verifying or adjusting the matching circuit on the prototype circuit board, the LO drive should be injected at Pin 3 at the nominal power level (-4 dBm), since the LO level affects the IF port impedance.

Suggested IF Matching Network

There are several networks that can be used to properly match the IF port to the SAW or crystal IF filter. The mixer supply voltage is applied through the IF port, so the matching circuit topology must contain either an RF choke or shunt inductor.

The shunt L, series C, shunt C configuration is the simplest and requires the fewest components. DC current can be easily injected through the shunt inductor and the series C provides a DC block, if needed. The shunt C, in particular can be used to improve the return loss and to reduce the LO leakage.

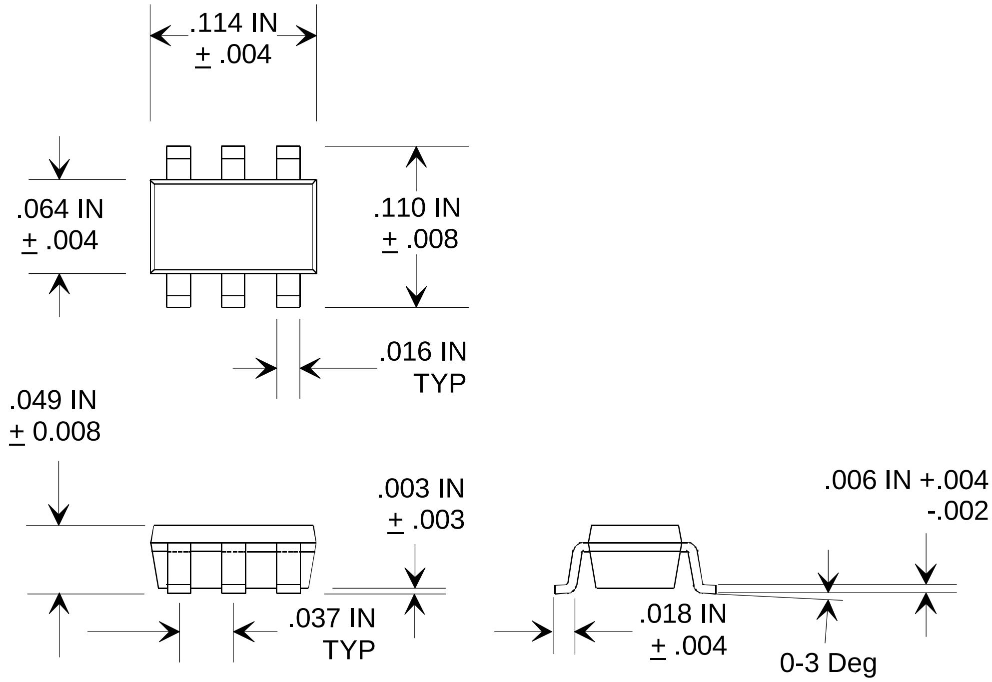
Package Pinout



Pin Descriptions

Pin Name	Pin #	Description and Usage
MXR Vdd	1	LO buffer supply voltage. Series inductor required for LO buffer tuning. Local bypass capacitor required.
GIC	2	Capacitor and resistor required for Gain/IP3/Current adjust.
MXR LO	3	DC blocked mixer LO input. Matched to 50Ω.
MXR RF	4	DC blocked mixer RF input. Matched to 50Ω.
GND	5	Ground connection. Very important to place multiple via holes immediately adjacent to the pins. Provides thermal path for heat dissipation and RF grounding.
MXR IF	6	Mixer open drain IF output. Connection to Vdd required. External matching is required.

Package Type: SOT23-6 Plastic Package



All dimensions in inches.

Additional Information

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

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