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TRX_060_011

60GHz Highly Integrated Monostatic IQ Transceiver in Silicon Germanium Technology

Preliminary Data Sheet

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0.1	TRX_060_011	Bare die	NA	1 of 16

Version Control

Version	Changed section	Description of change	Reason for change
01		Initial version	

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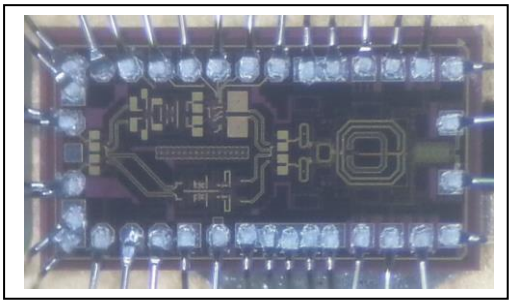
1 Features

- Radar transceiver for 60GHz ISM band
- Single antenna input
- Single supply voltage of 3.3V
- Fully ESD protected device
- Power consumption 630mW
- Integrated low phase noise Push-Push VCO
- Transmitter with power control
- Receiver with homodyne quadrature mixer
- Low-noise-amplifier (LNA) with gain control
- Differential TX/RX input/output
- IC is available as bare die



1.1 Overview

The IC is an integrated transceiver circuit for the 60GHz ISM band operating in the frequency range of 58.3GHz - 63.9GHz. It includes a low-noise-amplifier (LNA) with gain control, quadrature mixers, poly-phase filter, a power amplifier (PA) with gain control, Voltage Controlled Oscillator with digital band switching and divide-by-32 circuit. The output power of the transmitter can be controlled by pwr0 and pwr1 inputs. The IC is fabricated in SiGe BiCMOS technology by using the bipolar part and the CMOS part.

1.2 Applications

The main use of the transceiver IC is in radar systems for the ISM band from 57GHz to 64GHz. FMCW is the preferred radar principle to be used.

2 Block Diagram

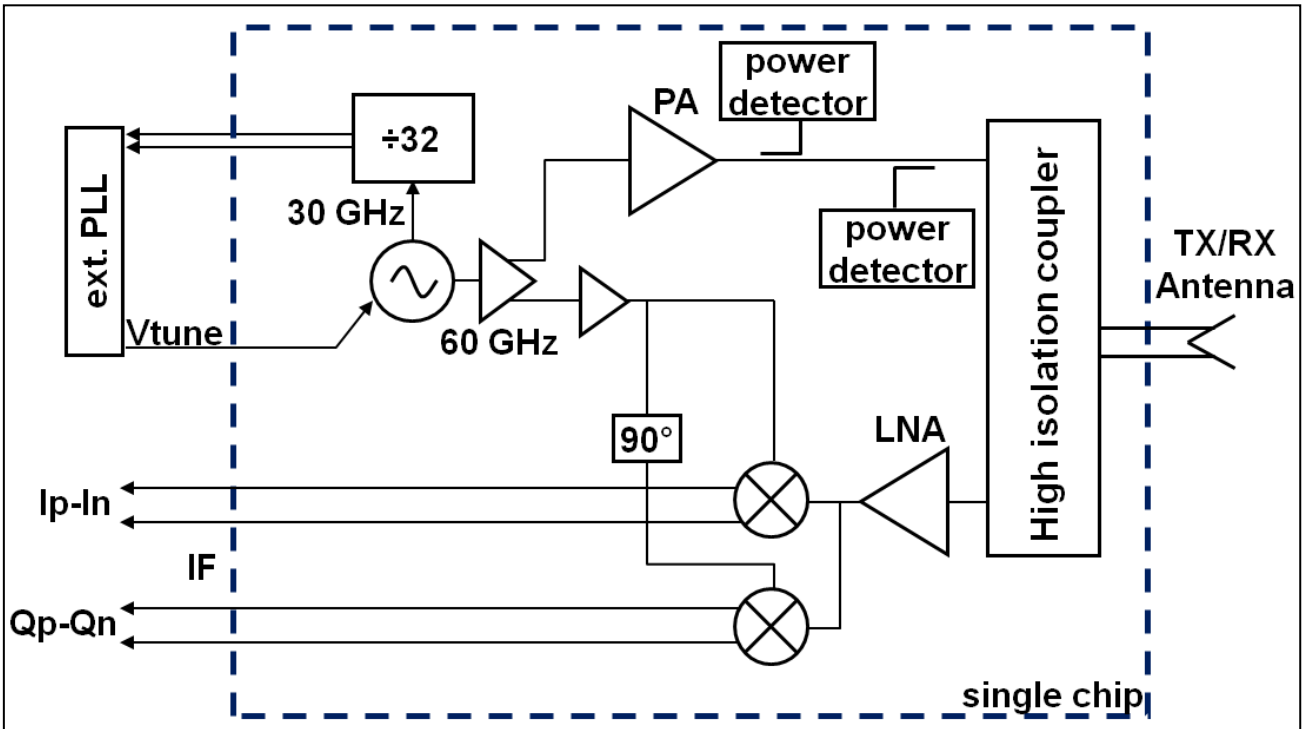


Figure 1 TRX_060_011 Block Diagram

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

T_A= 25°C unless otherwise noted

Table 1 Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Supply Voltage	V_{cc}	+3.0	+3.3	+3.6	V	to GND
DC voltage at RF Pins	V_{DCRF}	0	-	0.002	V	IC provides low ohmic circuit to GND for TX/RX out
Operating temperature range	T_{use}	-40	-	+85	°C	Industrial
Storage temperature range	T_{store}	-65	-	+150	°C	
Junction temperature	T_{junc}			+150	°C	
Input power into pin RFin	P_{IN}	-	-	0	dBm	
DC voltage at control inputs	V_{ctl}	0	-	3.3	V	vt0, vt1, vt2, Vctrl, PAvcc, LNAvcc
Supply current consumption	I_{CC}	-	190	220	mA	@ 3.3V Vcc (max cur. @ 3.6V)

Attempted operation outside the absolute maximum ratings of the part may cause permanent damage to the part. Actual performance of the IC is only guaranteed within the operational specifications, not at absolute maximum ratings.

3.2 Thermal Resistance

Table 2 Thermal Resistance

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Thermal resistance from junction to soldering point	R_{thJS}	-	-	50	K/W	see application notes

3.3 ESD Integrity

Table 3 ESD Integrity

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
ESD robustness of TXout, RFin	V_{ESD}	1,3	-	2	kV	All RF-Pins [1)]
ESD robustness of all low frequency and DC pins	V_{ESD}	1,3		2	kV	

1) According to ESDA/JEDEC Joint Standard for Electrostatic Discharge Sensitivity Testing, Human Body Model (HBM) Component Level, ANSI/ESDA/JEDEC JS-001-2011

4 RF Characteristics

4.1 Transmitter Section TX

T_A= -40°C + 85°C unless otherwise noted

Table 4 Typical Characteristics Transmitter Section

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Transmitter frequency range	f_{TX}	58.31		63.91	GHz	
Tuning voltage VCO	vt0, vt1, vt2	0.0	-	3.3	V	
Tuning slope VCO	$\Delta f_{TX}/\Delta V_{ctrl}$					
Number adjustable frequency bands		-	8	-	-	vt0 – vt2: VCO band switching
Pushing VCO	$\Delta f_{TX}/\Delta V_{CC}$				MHz/V	@ f = 61.11GHz
Phase Noise	P_N	-	-102	-105	dBc/Hz	@ 1MHz offset
Output impedance	Z_{TXout}		100		Ω	Differential 100 Ohm
Transmitter output power	P_{TX}	1.5	3.5	5.5	dBm	
Adjustable range output power	P_{TX_ADJ}	OFF		5.5	dBm	Adjustable TX Gain control through PAvcc pin 0.0V – OFF 3.3V – $P_{out\ max}$
Divider division ratio	$D_{div\ o}$	-	32	-	-	-
Divider output power	P_{div_o}	-8	-6	-4	dBm	Divider output loaded with 50Ω, DC coupled, external decoupling capacitor required (min 100pF)
Divider output frequency range	f_{div_o}	911.1		998.6	MHz	
Divider output voltage					V	
Divider output source current					mA	
Divider output sink current					mA	

4.2 Receiver Section RX

T_A= -40°C + 85°C unless otherwise noted

Table 5 Typical Characteristics Receiver Section

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Receiver frequency range	f_{RX}	58.31	-	63.91	GHz	
Receiver input impedance	Z_{RXIN}		100		Ω	Differential 100 Ohm
Adjustable gain mode		9 (OFF with 0.0V)		21	dB	Adjustable LNA gain control through LNAvcc pin 0.0V – OFF 2.0V – 12dB less gain 2.5V – 4dB less gain 3.3V – G_{max}
IF frequency range	f_{IF}	0	-	200	MHz	
IF output impedance			470		Ω	differential
IF 1/f corner frequency						tbd
IQ amplitude balance					dB	tbd
IQ phase balance					deg	tbd
Noise figure (DSB) high gain mode			14.3		dB	Simulated (Double side band @ f_{IF}=1MHz)
Noise figure (DSB) low gain mode			12	-	dB	Simulated
Input Compression Point		-17	-	-13	dBm	
Input 3rd order intercept point						tbd
Fine tune for high isolation coupler	V_{ctrl}	0	-	3.3	V	The tuning voltage swept to achieve highest possible TX / RX isolation

5 Application Circuit

5.1 Chip Outline

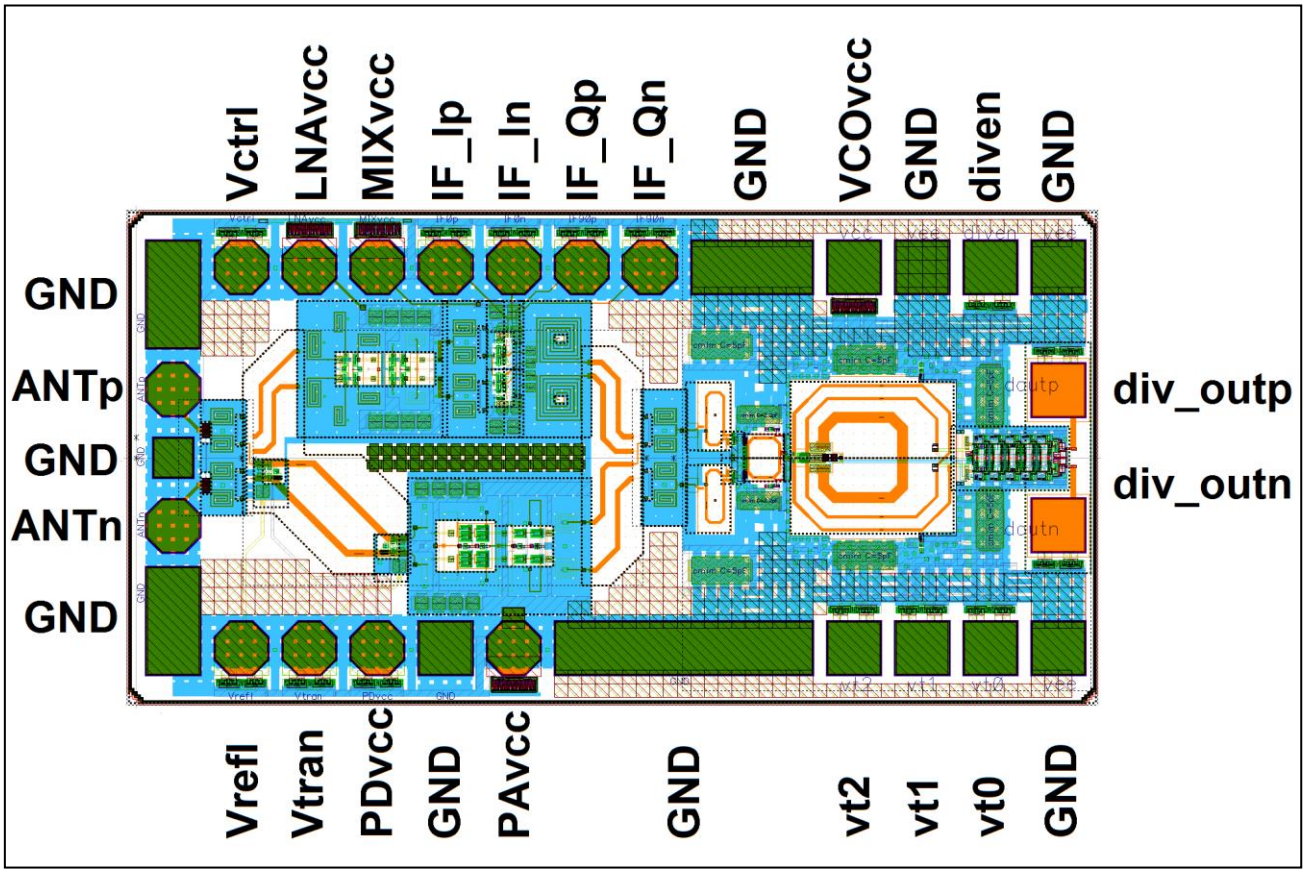


Figure 2 TRX_060_011 Chip outline (top view), 1.42 x 0.72mm²

5.2 Pin Description

Pad size is 80µm x 80µm with pad pitch of 100µm (except RX1p, RX1n. RX2p, RX2n, TXp, TXn of 60µm x 150µm and GND pads of different sizes).

Table 6 Pin Description

Pin No.	Name	Description
1	IF_Qp	IF Outputs, DC coupled, external AC coupling capacitors required
2	IF_Qn	
3	IF_Ip	
4	IF_In	
5	ANTp, ANTn	Receiver / Transmitter output, 100 differential
6	Vt2	VCO band switching (0.0V – 3.3V)
7	Vt1	
8	Vt0	
9	Vtran	Transmitted power from Power Amplifier through internal coupler and power detector
10	Vrefl	Reflected power from RX / TX output through internal coupler and power detector
11	PDvcc	Power Detector supply voltage, 3.3V

12	div_outp, div_outn	Divider output, 50Ω, DC coupled, external decoupling capacitor required (min 100pF)
13	LNAvcc	Low Noise Amplifier supply voltage of 3.3V
14	MIXvcc	Mixer supply voltage of 3.3V
15	VCOvcc	Voltage Controlled Oscillator supply voltage of 3.3V
16	PAvcc	Power Amplifier supply voltage of 3.3V
17	Diven	Divider enable (3.3V to enable)
18	Vctrl	Fine tuning voltage for high isolation coupler (0.0V – 3.3.V)
19	GND	Ground pads

5.3 Application Circuit Schematic

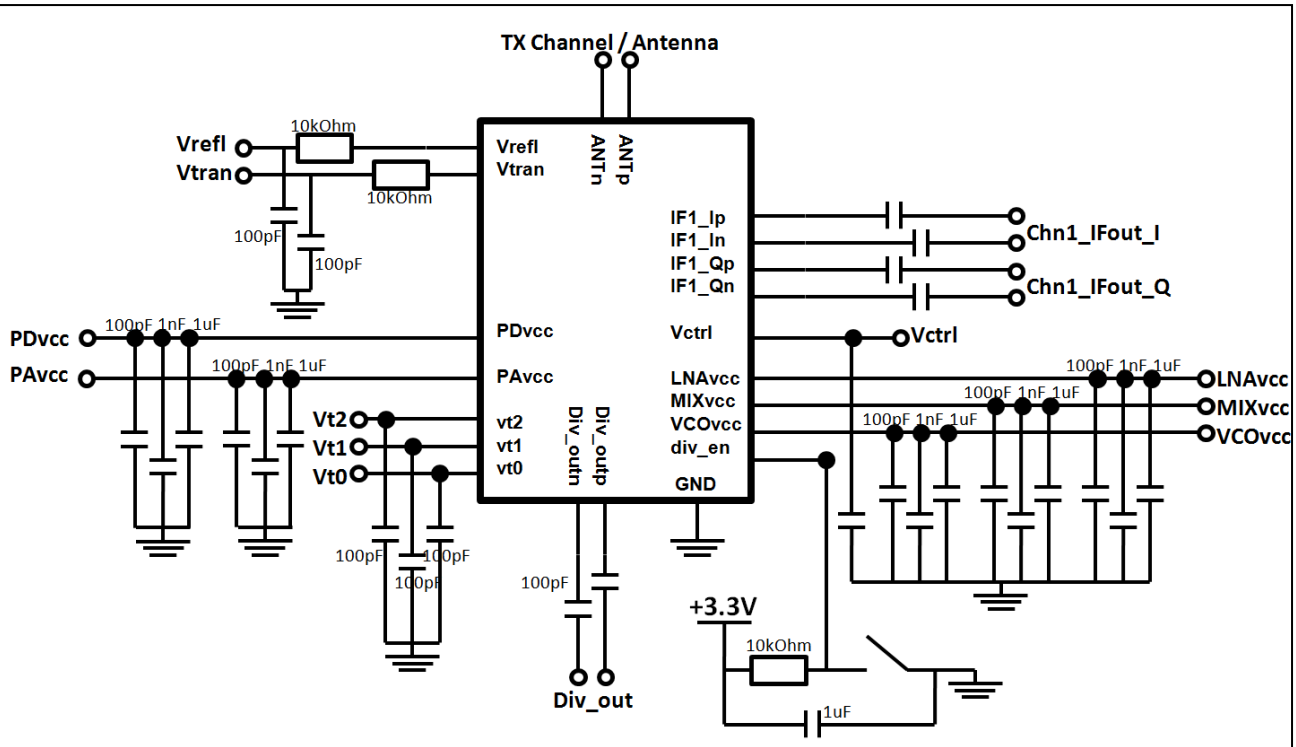


Figure 3 TRX_060_011 Application circuit

5.4 Evaluation Board

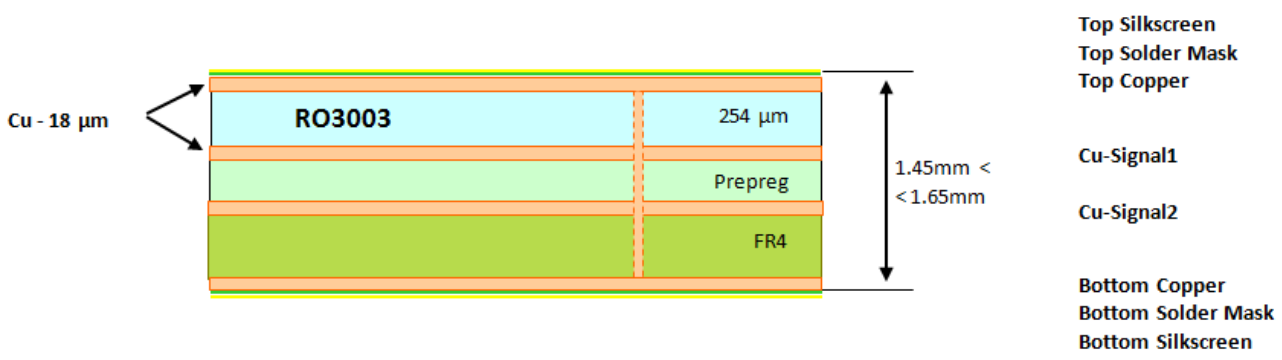


Figure 4 TRX_060_011 Evaluation board stack-up

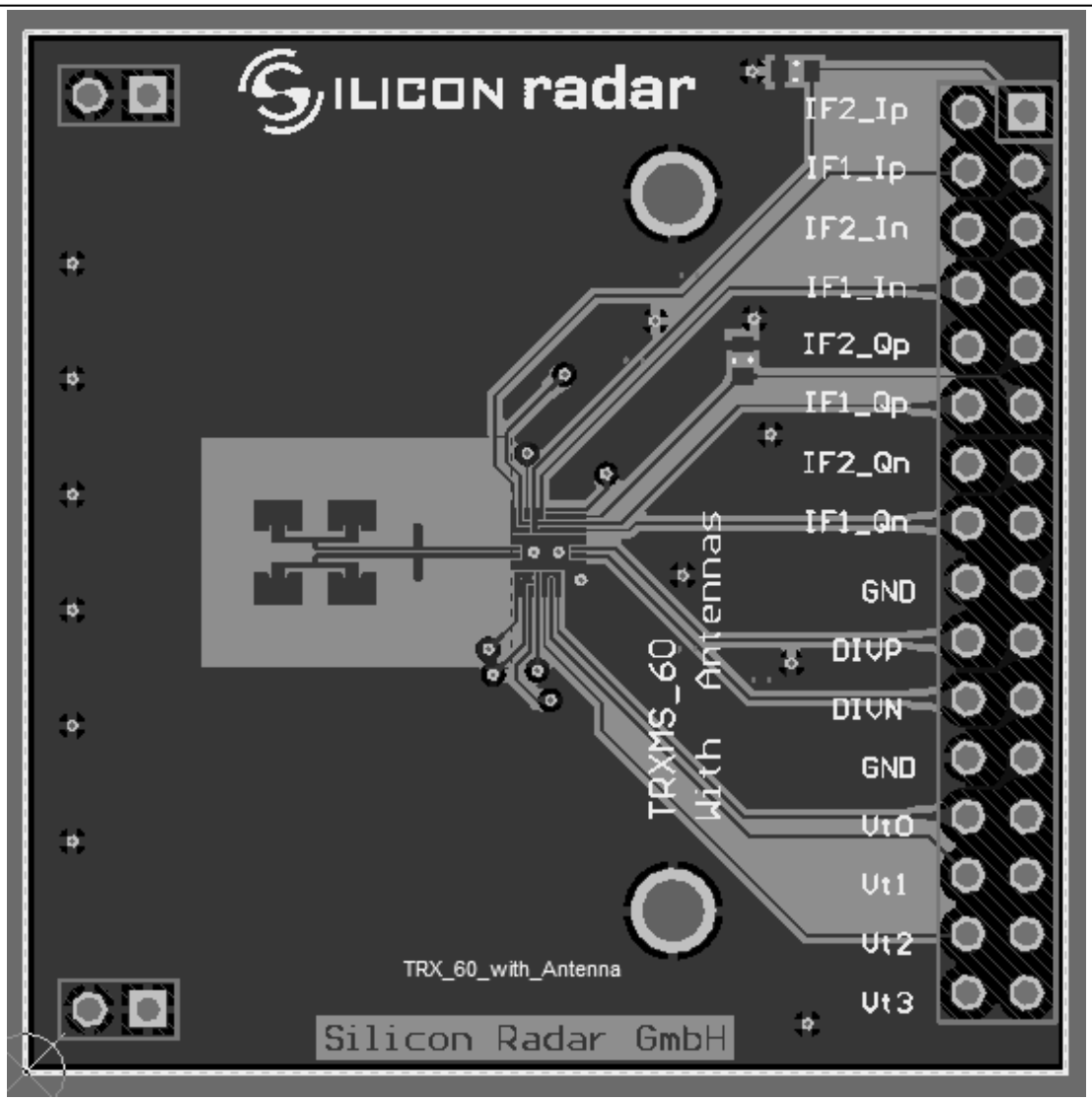
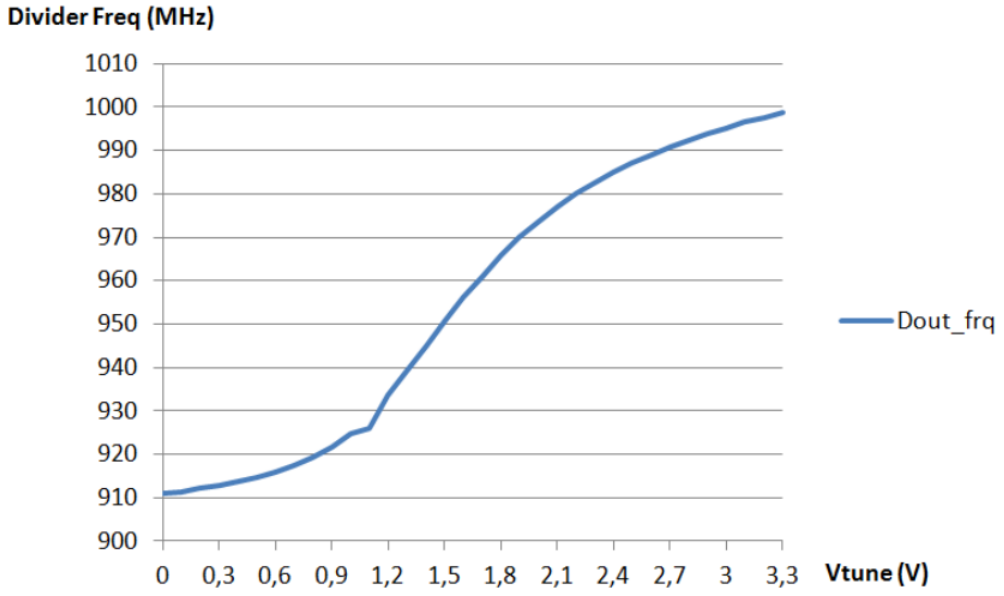
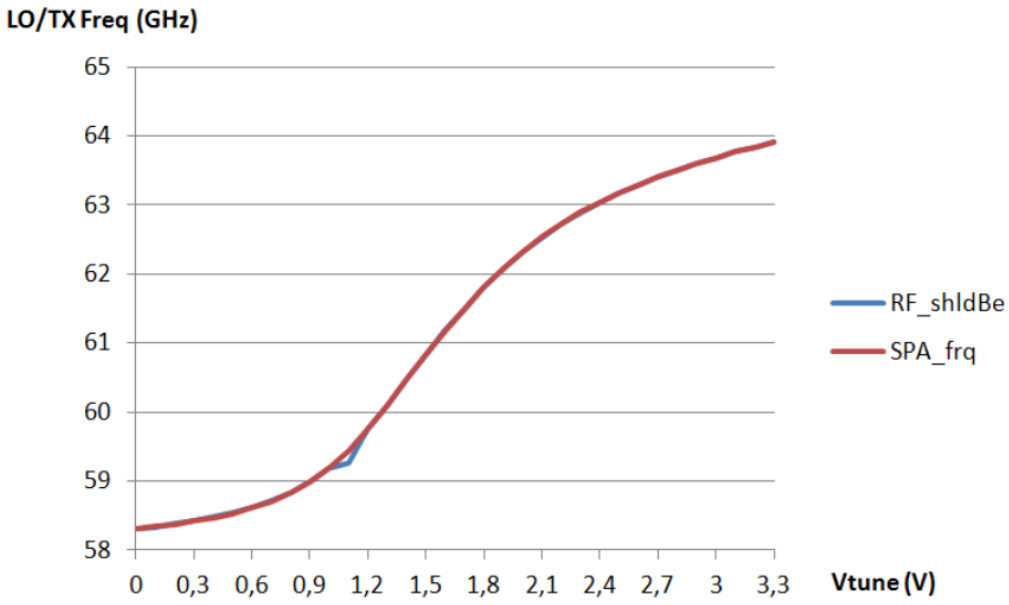


Figure 5 TRX_060_011 Evaluation board layout (top view)

6 Measurement Results

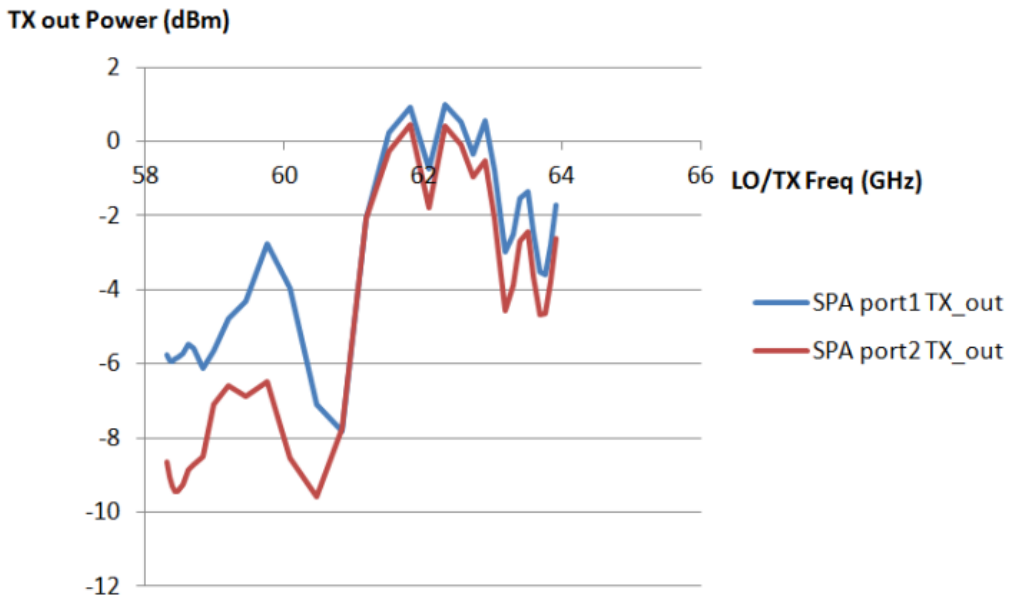


Divider output frequency with respect to VCO tuning voltages swept from 0 - 3.3V.



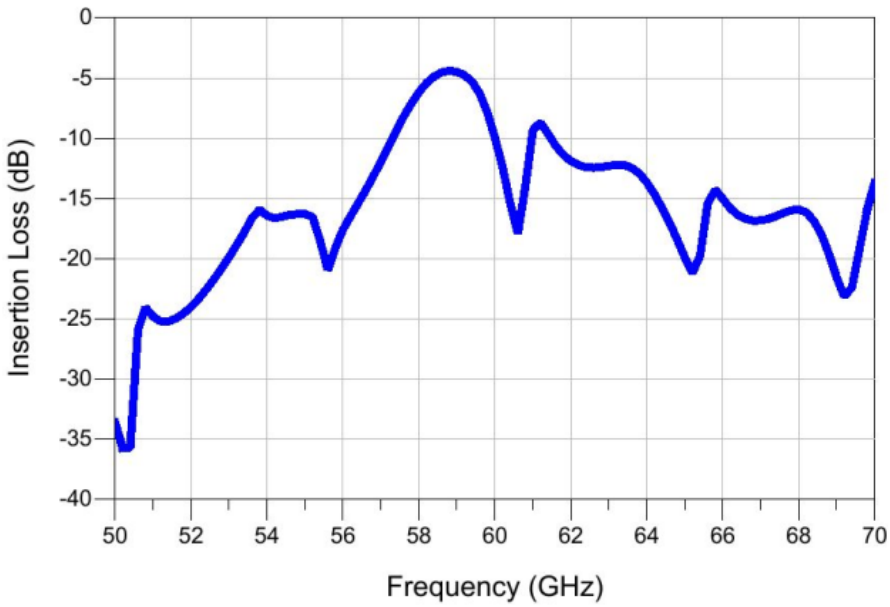
TX output frequency with respect to VCO tuning voltages swept from 0 - 3.3V, observed in Spectrum Analyzer.

Figure 6 TRX_060_011 Divider & TX output frequency measurement results



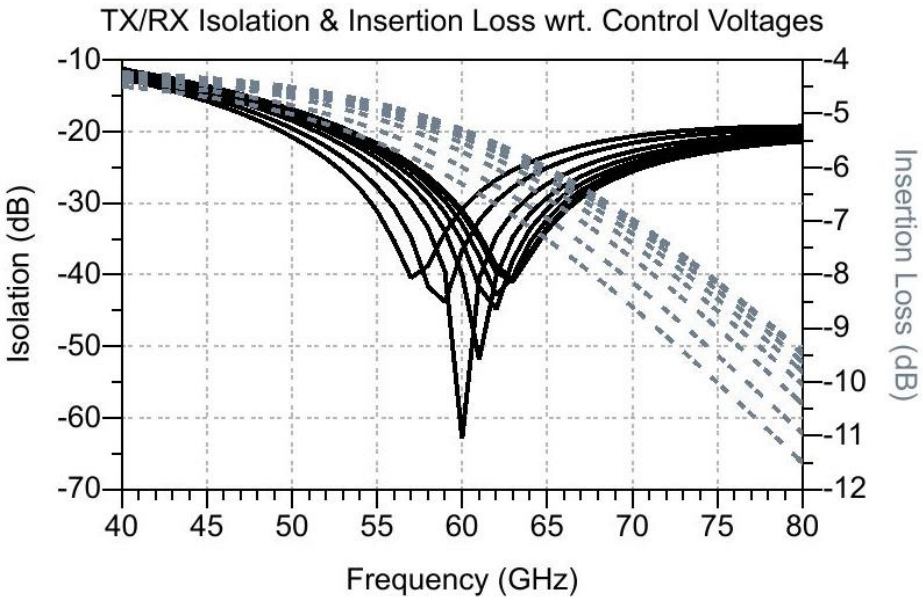
TX output power (excluding high isolation coupler performance metrics – de-embedding required – see Figure 9). The two curves highlight the measurement from each connector. The difference is because of the unequal wirebond lengths. The output power level is greatly affected by the test board losses (see below figure), de-embedding is required.

Figure 7 TRX_060_011 TX output power



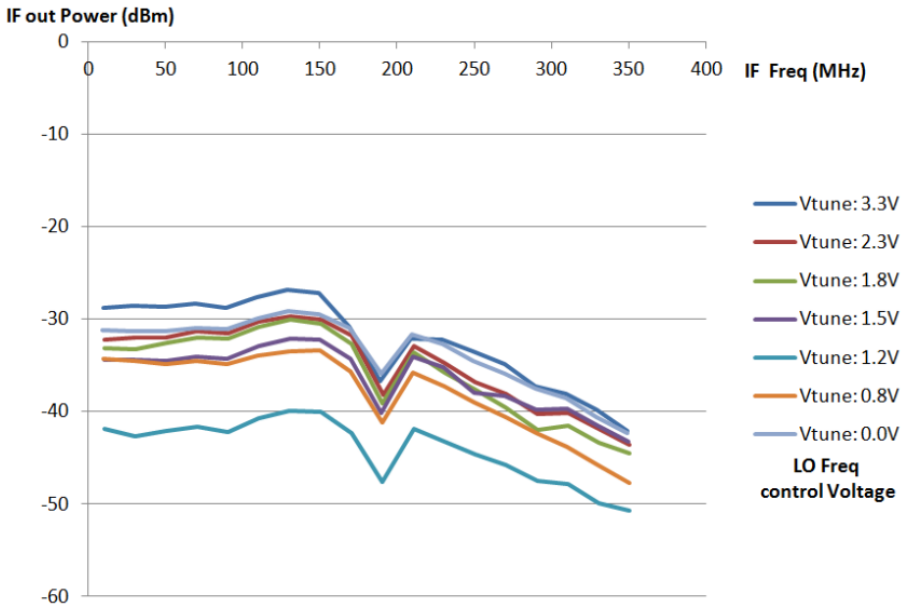
Insertion loss of TX / RX section transmission line on board for de-embedding (shifted frequency response is achieved in measurements)

Figure 8 TRX_060_011 TX insertion loss (the transmission lines and wirebonds connecting chip to SMA connectors) on evaluation board



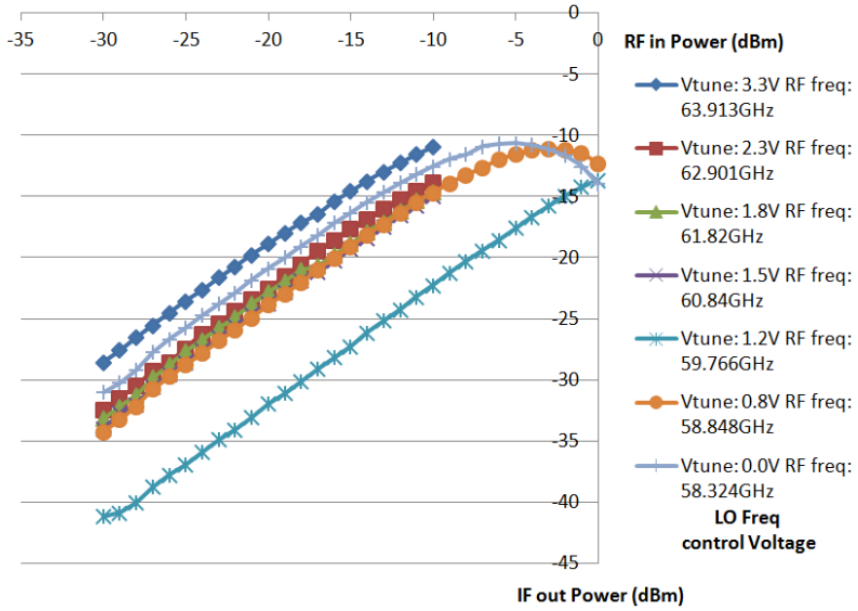
Simulated TX / RX isolation & insertion Loss with respect to control voltages – Vctrl. The isolation of coupler is controlled through resonance shifting mechanism and TX to RX leakage can be improved. The insertion loss of this coupler should be used in the de-embedding process of other measurements.

Figure 9 TRX_060_011 Simulated TX / RX isolation & insertion loss of high isolation coupler.



RX conversion gain extracted from single IF output (one of I_N, I_P, Q_N, Q_P In-phase and Quadrature outputs) with respect to different LO frequencies. RF input frequency from RX channel 1 is -30dBm. De-embedding of the board and high isolation coupler performance parameters are required. IF output termination is 50Ohm single-ended due to Spectrum Analyzer.

Figure 10 TRX_060_011 RX conversion gain on evaluation board



RX input referred linearity extracted from single IF output (one of I_N, I_P, Q_N, Q_P In-phase and Quadrature outputs) with respect to different LO frequencies. IF output frequency is set to 10MHz. De-embedding of the board and high isolation coupler performance parameters. IF output termination is 50Ohm single-ended due to Spectrum Analyzer.

Figure 11 TRX_060_011 RX linearity on evaluation board

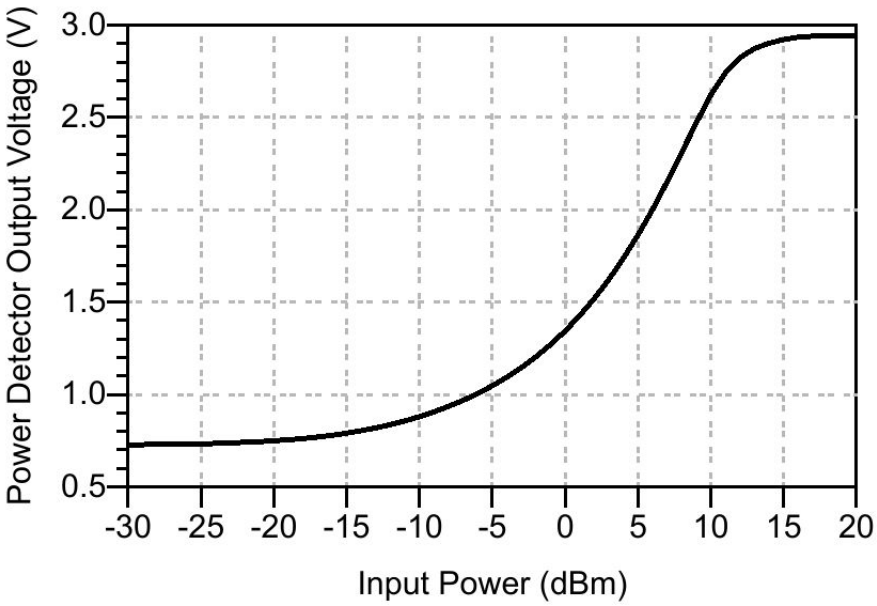


Figure 12 TRX_060_011 Simulated power detector output (Vtran) vs. PA output power

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