|Silicon Radar GmbH
|Im Technologiepark 1
|15236 Frankfurt (Oder) |Germany

|fon +49.335.557 17 60
|fax +49.335.557 10 50
|http://www.siliconradar.com

TRXA_120_01 Radar Front End

120 GHz Highly Integrated IQ Transceiver with Antennas on Chip
in Silicon Germanium Technology

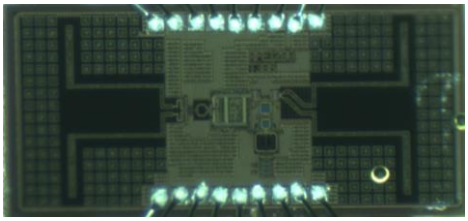
Preliminary Data Sheet

Status:	Date:	Author:	
preliminary	22-Mar-16	Silicon Radar GmbH	
Version:	Document number:	Filename:	Page:
0.4	TRXA_120_01	160226_Datenblatt_TRXA_120G.doc	1 of 15

Table of Contents

Features

- Radar frontend (RFE) with antennas on chip for 122 GHz ISM band
- Single supply voltage of 3.3V
- Fully ESD protected device
- Low power consumption of 380mW
- Integrated low phase noise Push-Push VCO
- Receiver with homodyne quadrature mixer
- RX and TX dipole antennas
- Large bandwidth of up to 7GHz
- QFN-32 leadless plastic package 5x5mm²
- Pb-free (RoHS compliant) package
- IC is available as bare die as well (without package)



1.1 Overview

The RFE is an integrated transceiver circuit for the 122 GHz ISM-band with antennas on chip. It includes a low-noise-amplifier (LNA), quadrature mixers, poly-phase filter, Voltage Controlled Oscillator with digital band switching, divide by 32 outputs, transmit and receive antennas (see Figure 1).
The RF-signal from oscillator is directed to RX-path via buffer circuits. The RX-signal is amplified by LNA and converted to baseband in two mixers with quadrature LO. The 120GHz oscillator has three analog coarse tuning inputs and one analog fine tuning input. The tuning inputs can be combined to obtain large tuning range and large bandwidth. The analog tuning inputs together with integrated frequency divider and external fractional-N PLL can be used for FMCW radar operation. With fixed oscillator frequency it can be used in CW-mode. Other modulation schemes are possible as well by utilizing analog tuning inputs.
The IC is fabricated in IHP SG13S SiGe BiCMOS technology of IHP.

1.2 Applications

Main application field of the 120GHz transceiver radar frontend (RFE) is in short range radar systems. With the use of dielectric lenses, the range can be increased considerably. The RFE can be used in FMCW mode as well in CW-mode. Although the chip is intended for use in ISM band 122GHz-123GHz, it is also possible to extend bandwidth to the full tuning range of almost 7GHz.

2 Block Diagram

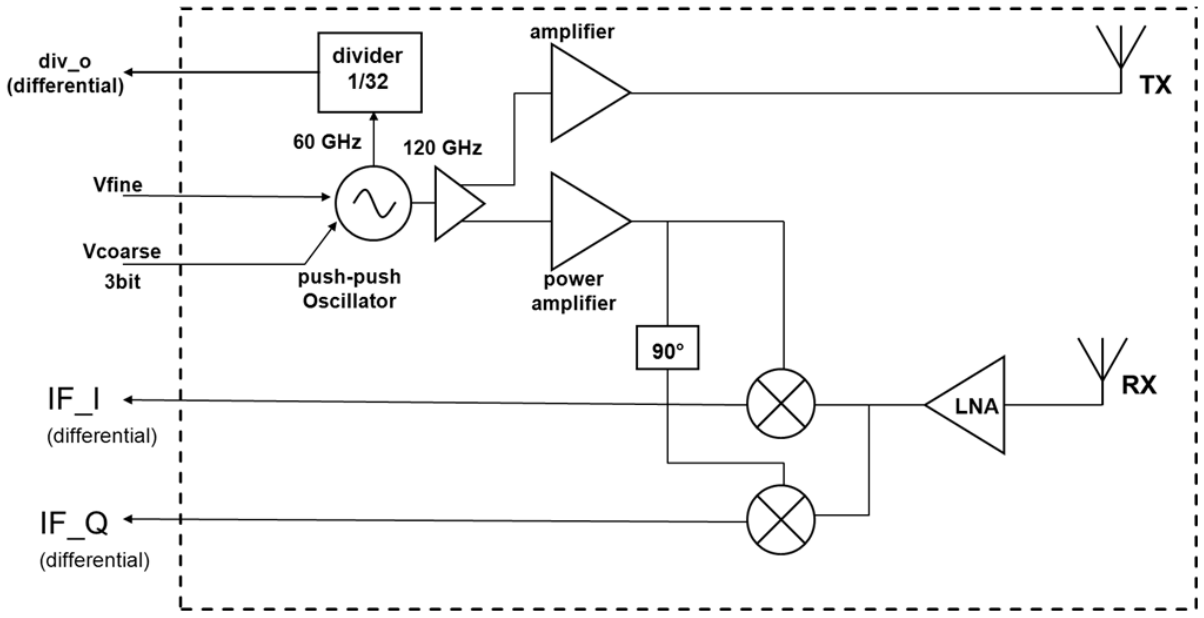


Figure 1 – TRXA_120_01 Block Diagram

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 TXout and Rxin
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}	-	-	5	dBm	
DC voltage at control inputs	V_{ctl}	0	-	3.3	V	Vt0, Vt1, Vt2, Vt3
Supply current consumption	I_{CC}	-	112	119	mA	@ 3.3V Vcc

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	1.5	-	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

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

Table 4 Typical Characteristics (Preliminary)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Frequency range	f_{TX}	119	-	125.4	GHz	
Tuning voltage VCO	V_{ctrl}	0.0	3	3.3	V	
Tuning slope VCO, Vt0	$\Delta f_{TX}/\Delta V_{ctrl}$		400		MHz/V	In the middle of the band, vt0
Tuning slope VCO, Vt1			800		MHz/V	In the middle of the band, vt1
Tuning slope VCO, Vt2			1600		MHz/V	In the middle of the band, vt2
Tuning slope VCO, Vt3			3200		MHz/V	In the middle of the band, vt3
Tuning slope VCO, Full Bandwidth			6.4		GHz/V	Vt0, Vt1, vt2, vt3 are interconnected and driven
Number adjustable frequency bands		-	8	-	-	Vt1 – Vt3 used for band switching
Pushing VCO	$\Delta f_{TX}/\Delta V_{CC}$			27	MHz/V	
Phase Noise	P_N	-	-90	-88	dBc/Hz	@ 1MHz offset
Transmitter Output impedance	Z_{Txout}		50		Ω	
Transmitter output power	P_{TX}	-7	-3	1	dBm	measured without antennas
Divider division ratio of TX-signal	D_{div_o}	-	64	-		
Divider output power	P_{div_o}	-10		-7	dBm	Measured single-ended, Divider output loaded with 50Ω, external decoupling capacitors required. In application, no 50 Ohm match is required
Divider output frequency range	f_{div_o}	1.85		1.98	GHz	
Receiver input impedance	Z_{RXIN}		50		Ω	
Receiver Gain			8	10	dB	
IF frequency range	f_{IF}	0	-	200	MHz	
IF output impedance			500		Ω	Differential outputs
IQ amplitude imbalance			tbd		dB	
IQ phase imbalance			tbd		deg	
Noise figure (DSB)			tbd		dB	Simulated (Double side band @ fIF=1MHz)
Input Compression Point			-20		dBm	

**tbd: to be defined*

5 Application Circuit

5.1 Package Outline

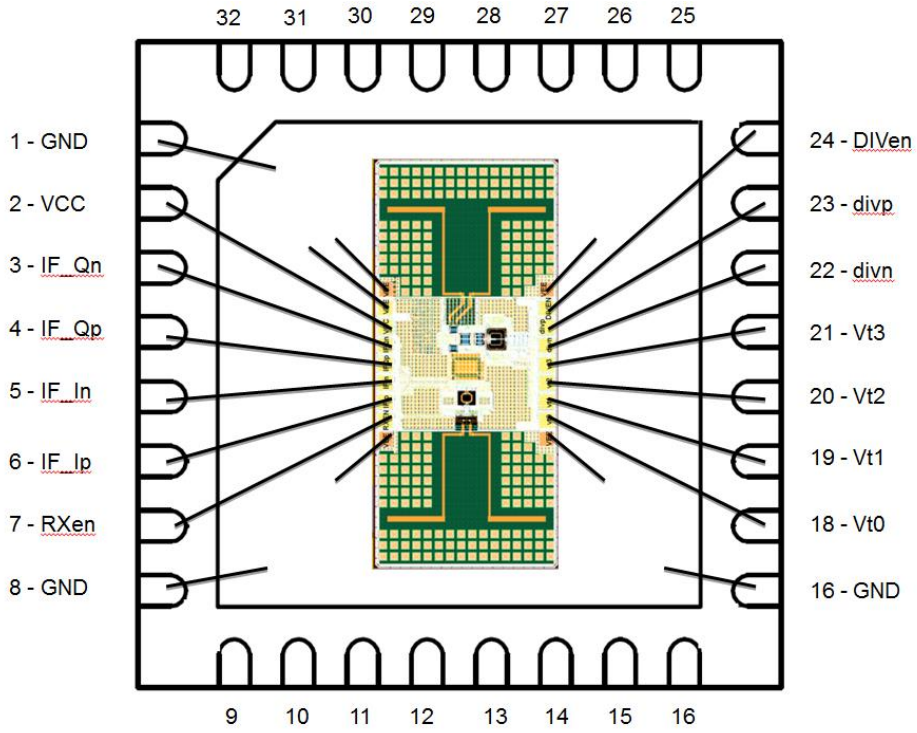


Figure 2 - TRXA_120_01 QFN-package outline with signal indication (top view)

5.2 Pin Description

Table 5 Pin Description

Pin No	Pad	Description
6	IF_Ip	Quadrature IF outputs, DCcoupled
5	IF_In	
4	IF_Qp	
3	IF_Qn	
23	divp	Divider output, 500Ω, DC coupled, external decoupling capacitor required
22	divn	
18	Vt0	VCO tuning inputs (0 – 3.3V)
19	Vt1	
20	Vt2	
21	Vt3	
24	DIVen	Divider enable (3.3V level), low active CMOS input, use of external pull-down resistor 100kOhm possible
2	VCC	Supply pins (3.3 V)
1, 8, 17, Pad	GND	Ground pins Exposed Pad of the QFN package must be soldered to GND
7	RXen	Receiver enable (3.3V level), low active CMOS input, use of external pull-down resistor 100kOhm possible
9 - 16, 25 - 32	NC	No Connection. These pins may be connected to GND. Performance will not be affected.

5.3 Application Circuit Schematic

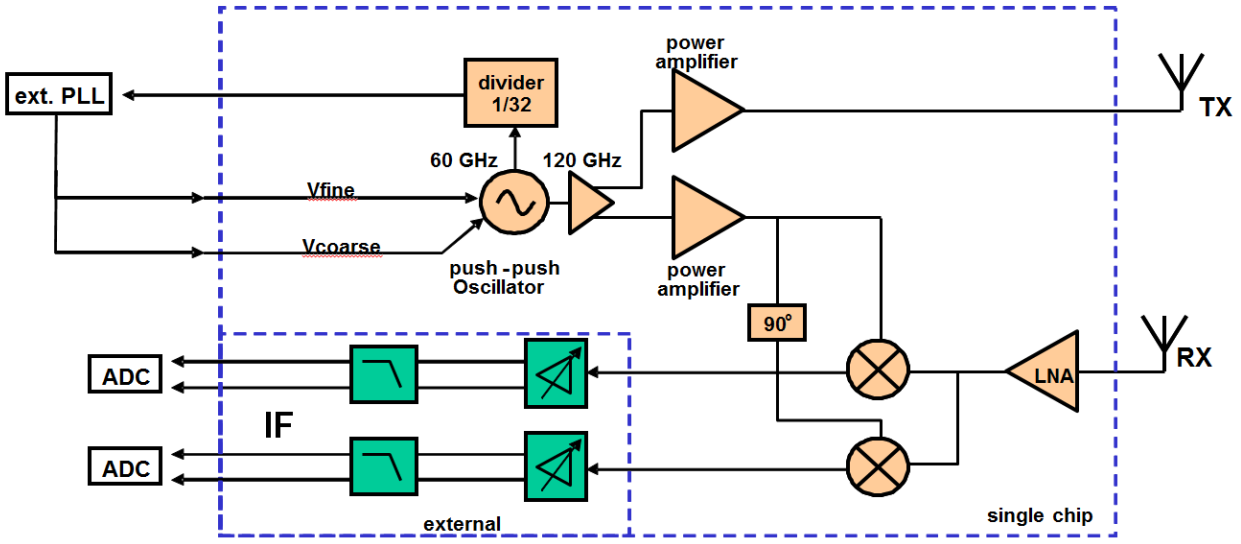


Figure 3 - TRXA_120_01 Application Circuit

5.4 Evaluation Boards

There are several TRXA_120_01 RFE based evaluation boards supplied by Silicon Radar GmbH. With these boards FMCW mode and CW mode of radar operation can be demonstrated.

6 Measurement Results

6.1 DC Current Consumption Measurements

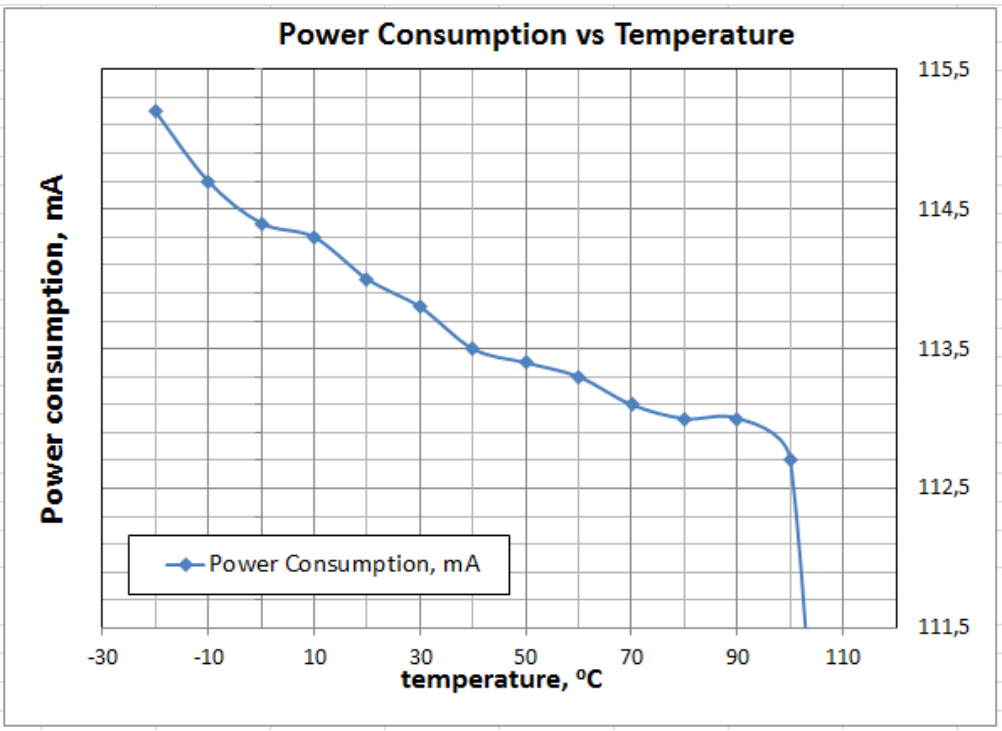


Figure 4 - Power Consumption vs Temperature (Preliminary)

6.2 Conversion Gain Measurements

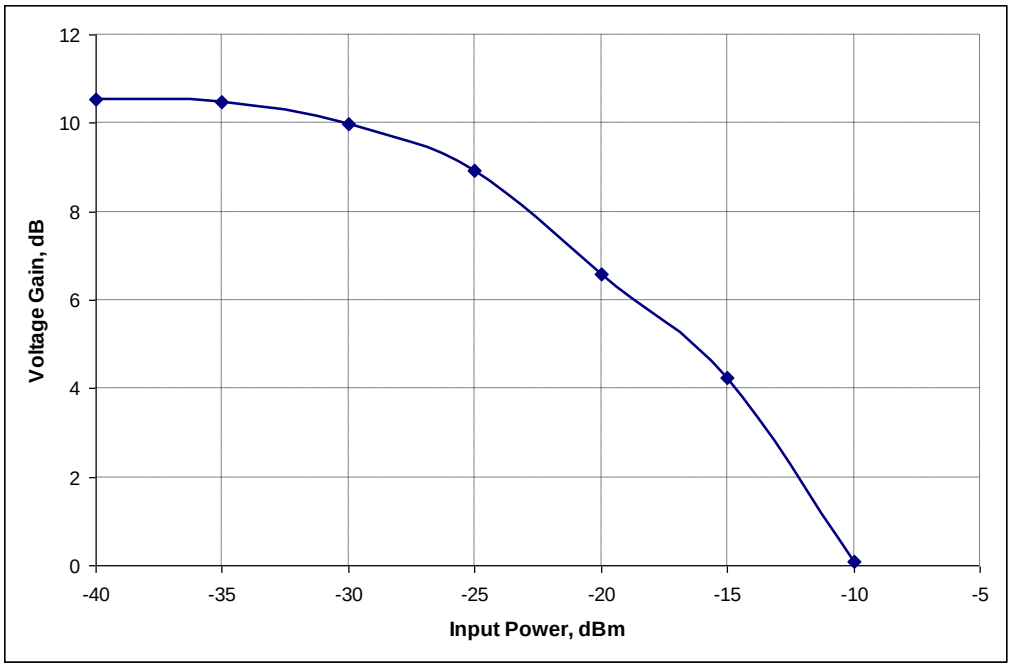


Figure 5 - Measured Conversion Gain of the Receiver (Preliminary)

6.3 Transmitter Frequency Measurements

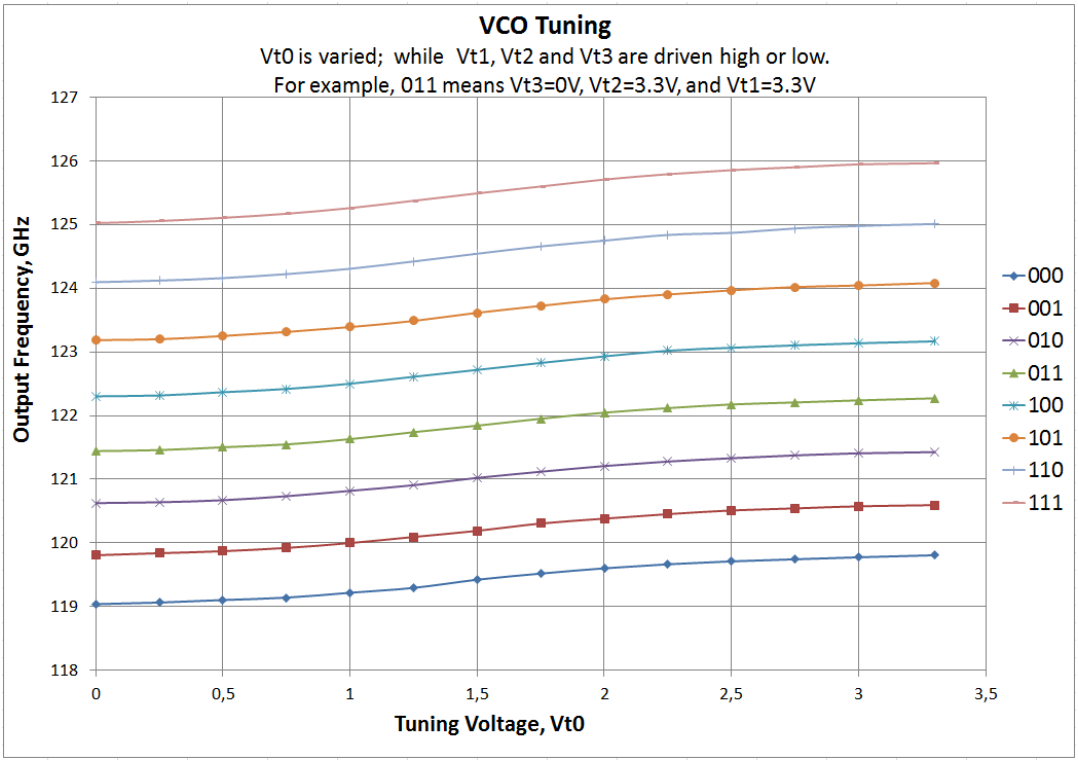


Figure 6 - VCO Tuning Curves (Preliminary)

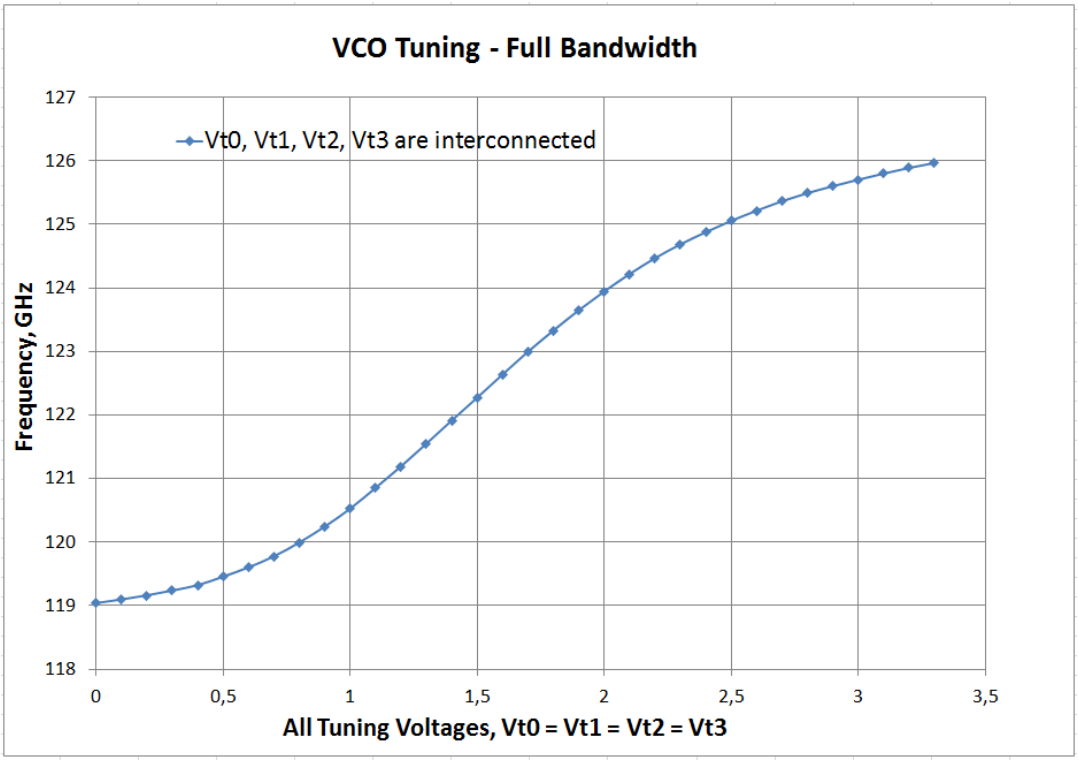


Figure 7 - Full Bandwidth VCO Tuning - All tuning voltages are swept together (Preliminary)

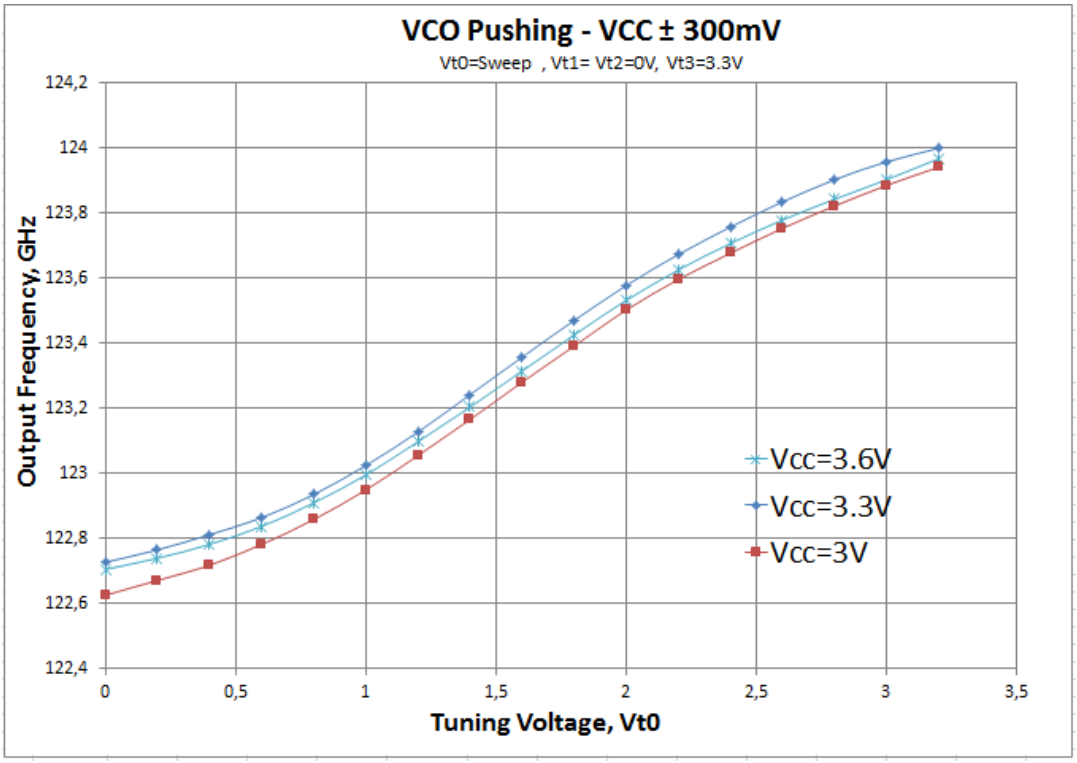


Figure 8 - VCO Pushing (Preliminary)

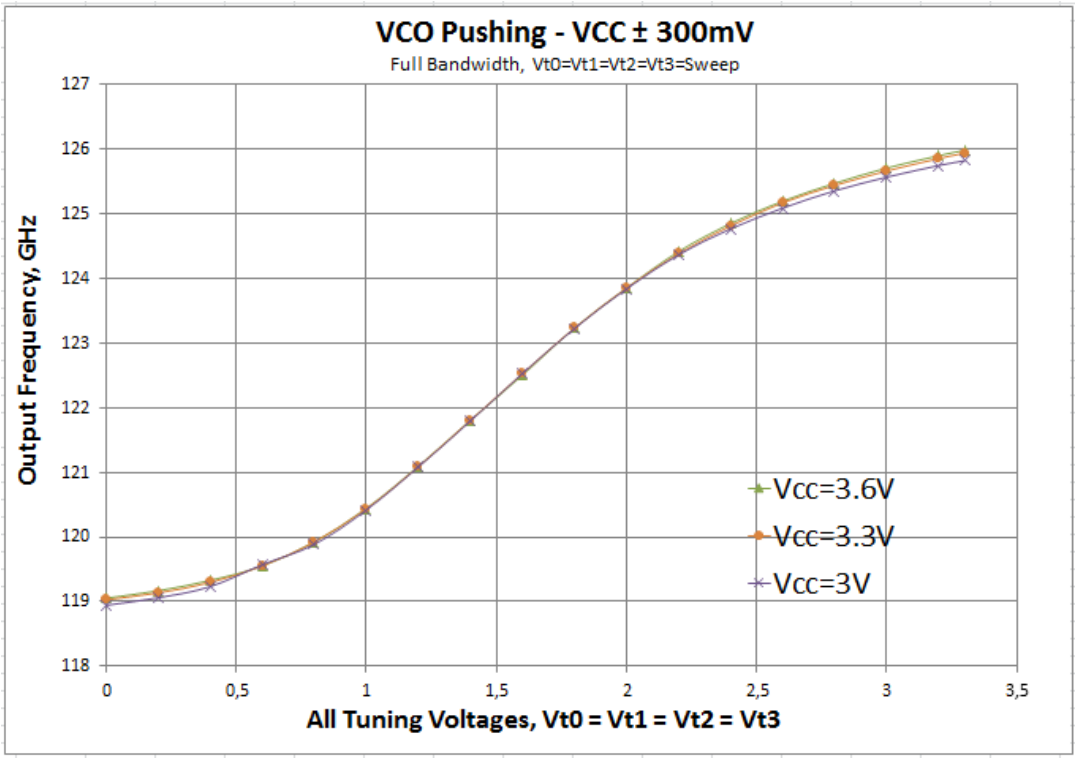


Figure 9 - VCO Pushing - Full Bandwidth Operation (Preliminary)

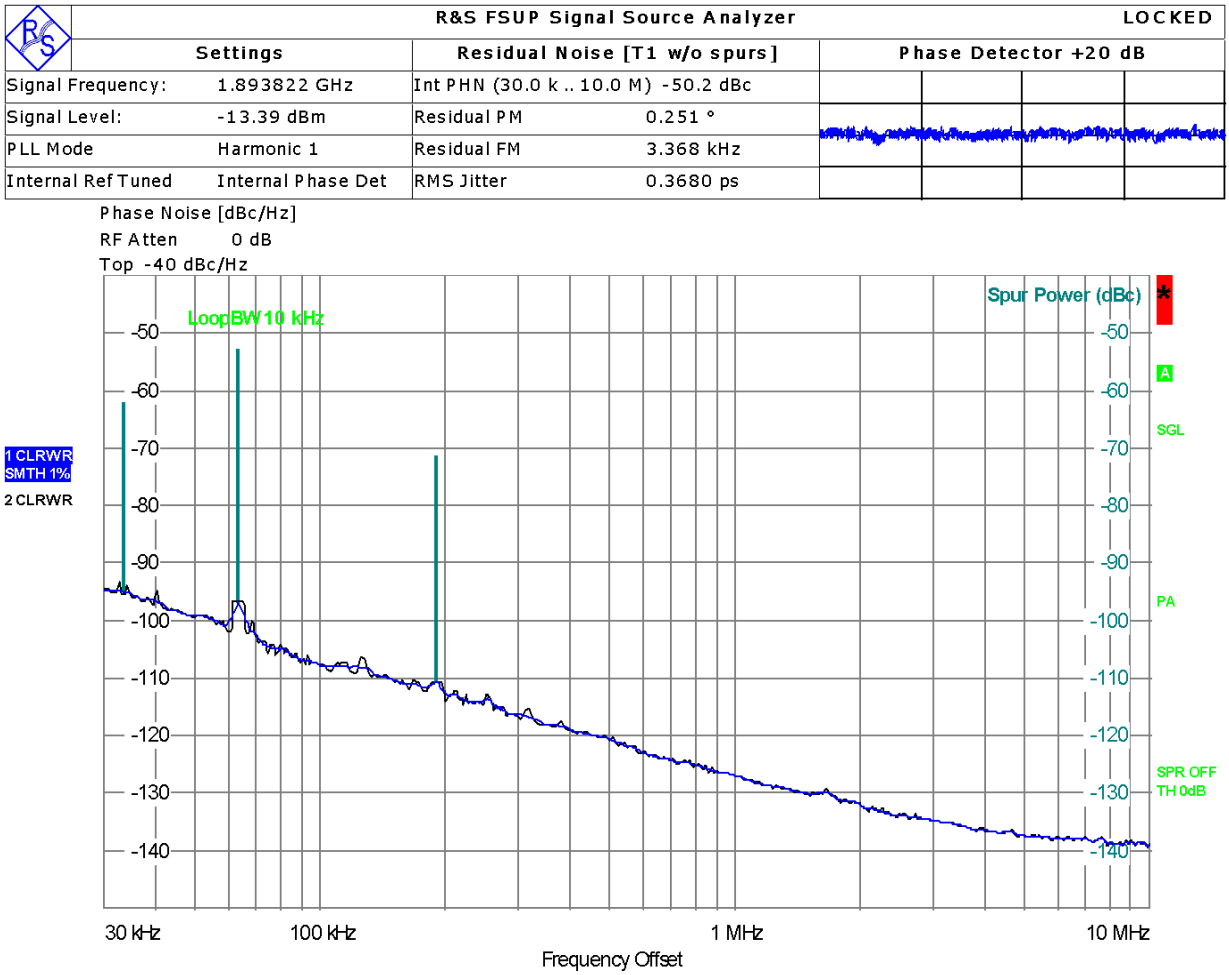


Figure 10 - Phase Noise of the Integrated Oscillator at Divider Output (1.89GHz) (Preliminary)

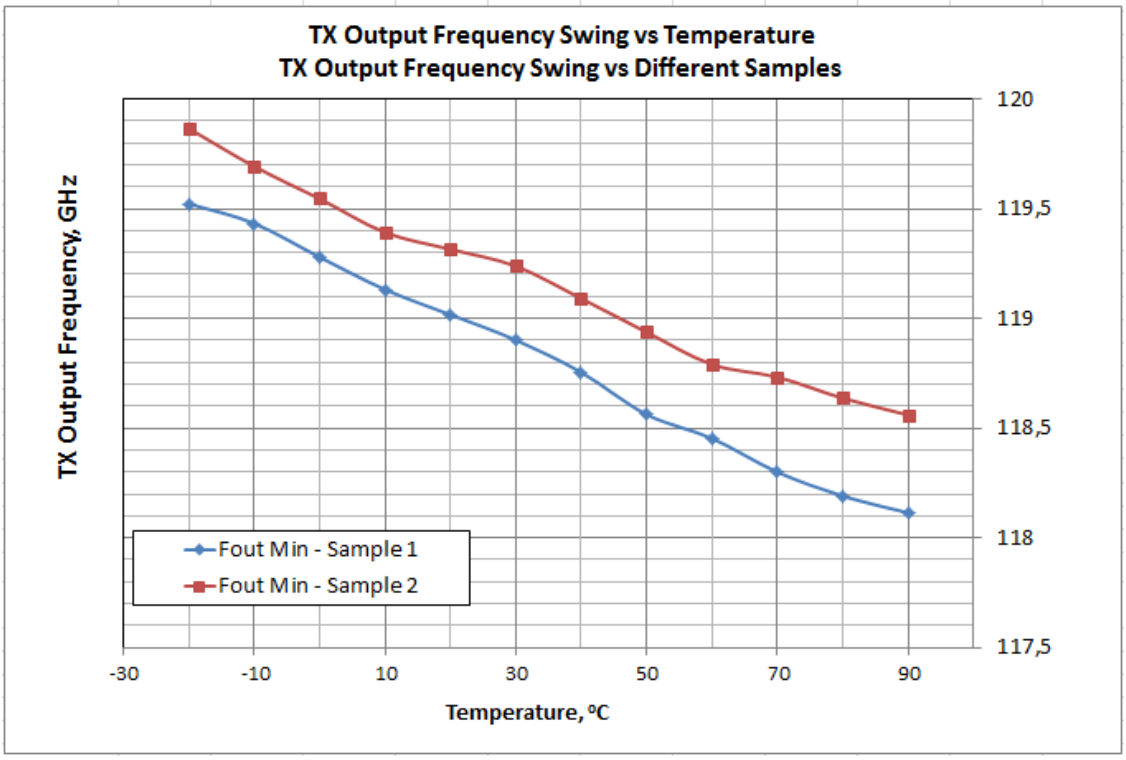


Figure 11 - Output Frequency vs. Temperature (Preliminary)

6.4 Transmitter Power Measurements

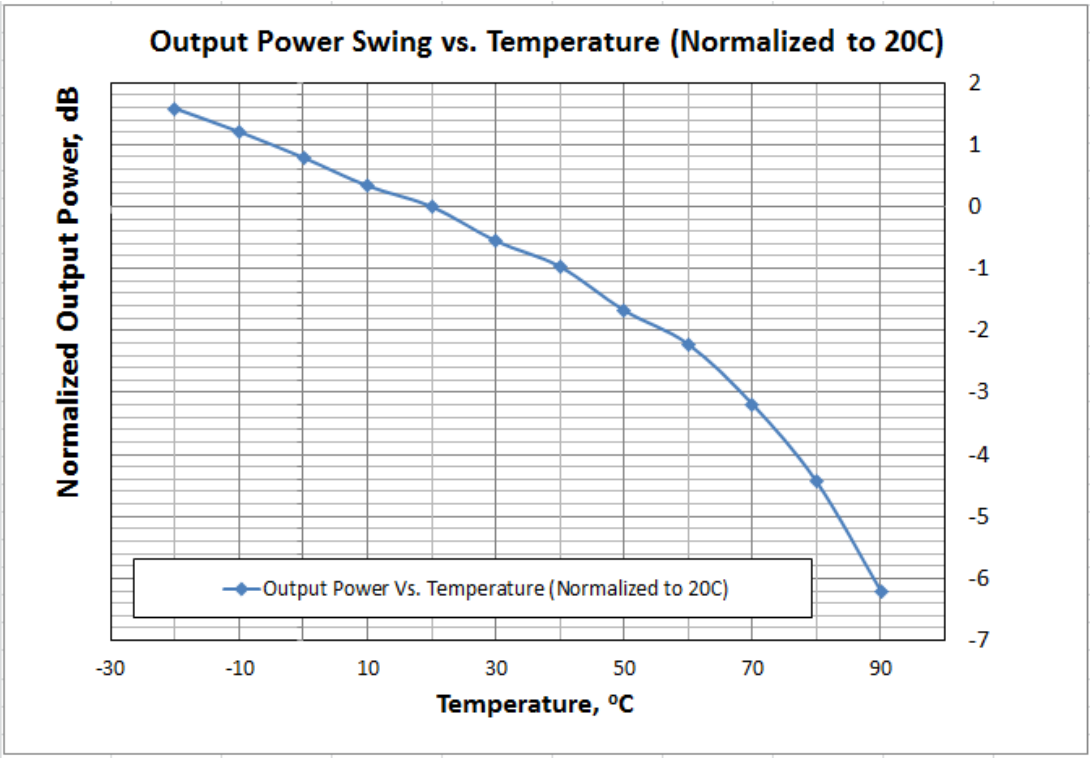


Figure 12 - Output Power vs. Temperature (Preliminary)

6.5 Antenna Pattern Measurements

tbd

Figure 13 - Radiation Pattern Measurements of Patch Antennas

7 Physical Characteristics

7.1 Mechanical Data QFN

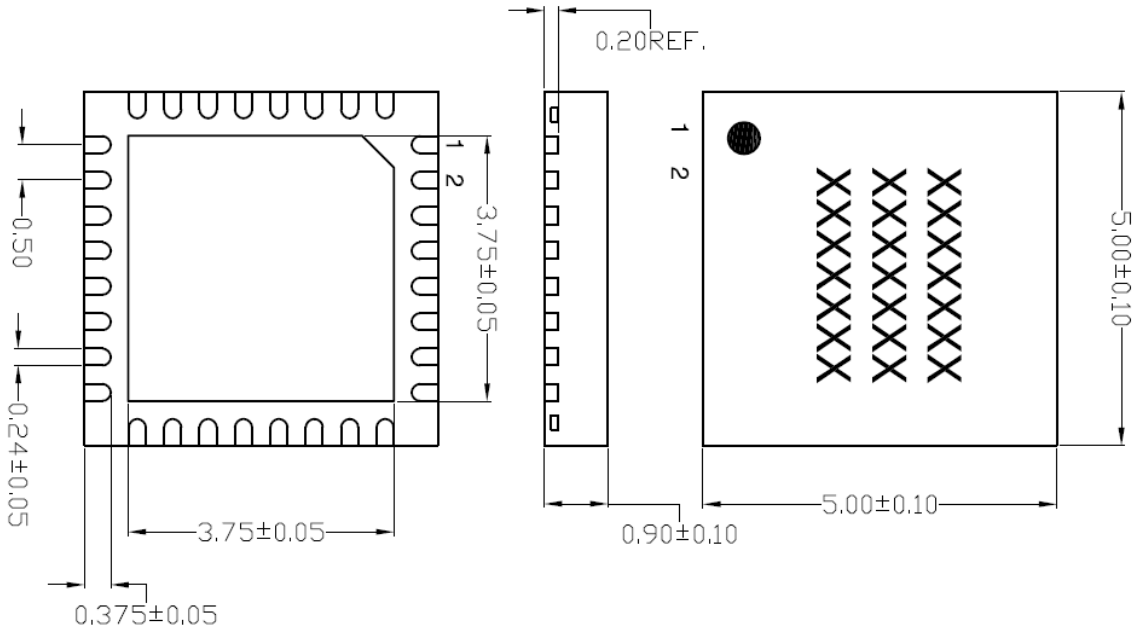


Figure 14 - QFN-32, 0.5mm pitch, 5x5mm drawing

8 Disclaimer

Silicon Radar GmbH 2015. The information contained herein is subject to change at any time without notice.
Silicon Radar GmbH assumes no responsibility or liability for any loss, damage or defect of a Product which is caused in whole or in part by

(i) use of any circuitry other than circuitry embodied in a Silicon Radar GmbH product,
(ii) misuse or abuse including static discharge, neglect or accident,
(iii) unauthorized modification or repairs which have been soldered or altered during assembly and are not capable of being tested by Silicon Radar GmbH under its normal test conditions, or
(iv) improper installation, storage, handling, warehousing or transportation, or (v) being subjected to unusual physical, thermal, or electrical stress.

Disclaimer: Silicon Radar GmbH makes no warranty of any kind, express or implied, with regard to this material, and specifically disclaims any and all express or implied warranties, either in fact or by operation of law, statutory or otherwise, including the implied warranties of merchantability and fitness for use or a particular purpose, and any implied warranty arising from course of dealing or usage of trade, as well as any common-law duties relating to accuracy or lack of negligence, with respect to this material, any Silicon Radar product and any product documentation. products sold by Silicon Radar are not suitable or intended to be used in a life support application or component, to operate nuclear facilities, or in other mission critical applications where human life may be involved or at stake. all sales are made conditioned upon compliance with the critical uses policy set forth below.

CRITICAL USE EXCLUSION POLICY BUYER AGREES NOT TO USE SILICON RADAR GMBH'S PRODUCTS FOR ANY APPLICATION OR IN ANY COMPONENTS USED IN LIFE SUPPORT DEVICES OR TO OPERATE NUCLEAR FACILITIES OR FOR USE IN OTHER MISSION-CRITICAL APPLICATIONS OR COMPONENTS WHERE HUMAN LIFE OR PROPERTY MAY BE AT STAKE.

Silicon Radar GmbH owns all rights, title and interest to the intellectual property related to Silicon Radar GmbH's products, including any software, firmware, copyright, patent, or trademark. The sale of Silicon Radar GmbH products does not convey or imply any license under patent or other rights. Silicon Radar GmbH retains the copyright and trademark rights in all documents, catalogs and plans supplied pursuant to or ancillary to the sale of products or services by Silicon Radar GmbH. Unless otherwise agreed to in writing by Silicon Radar GmbH, any reproduction, modification, translation, compilation, or representation of this material shall be strictly prohibited.