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TRX_120_01 RFE

(Radar Front End)

120 GHz Highly Integrated IQ Transceiver with Antennas in Package
(Silicon Germanium Technology)

Preliminary Data Sheet

Status: preliminary	Date: 5-Sep-16	Author: Silicon Radar GmbH	
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Features

- Radar frontend (RFE) with antennas in package for 122 GHz ISM band
- Dual supply voltage of 3.3V (RF-part) and 1.2V (CMOS)
- Fully ESD protected device
- Low power consumption of 380mW
- Integrated low phase noise Push-Push VCO
- Receiver with homodyne quadrature mixer
- RX and TX patch antennas
- Large bandwidth of up to 7GHz
- QFN-56 leadless plastic package 8x8mm²
- Pb-free (RoHS compliant) package
- IC is available as bare die as well (without antennas)

100% RoHS compliant

1.1 Overview

The RFE is an integrated transceiver circuit for the 122 GHz ISM-band with antennas in package. It includes a low-noise-amplifier (LNA), quadrature mixers, poly-phase filter, Voltage Controlled Oscillator with digital band switching, divide by 32 circuit power detectors and transmit and receive antenna (see Figure 1).
The TX-power level can be measured by two power detectors placed between the power amplifier and TX-output. 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 range up to ~10 meter. 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 7GHz.

2 Block Diagram

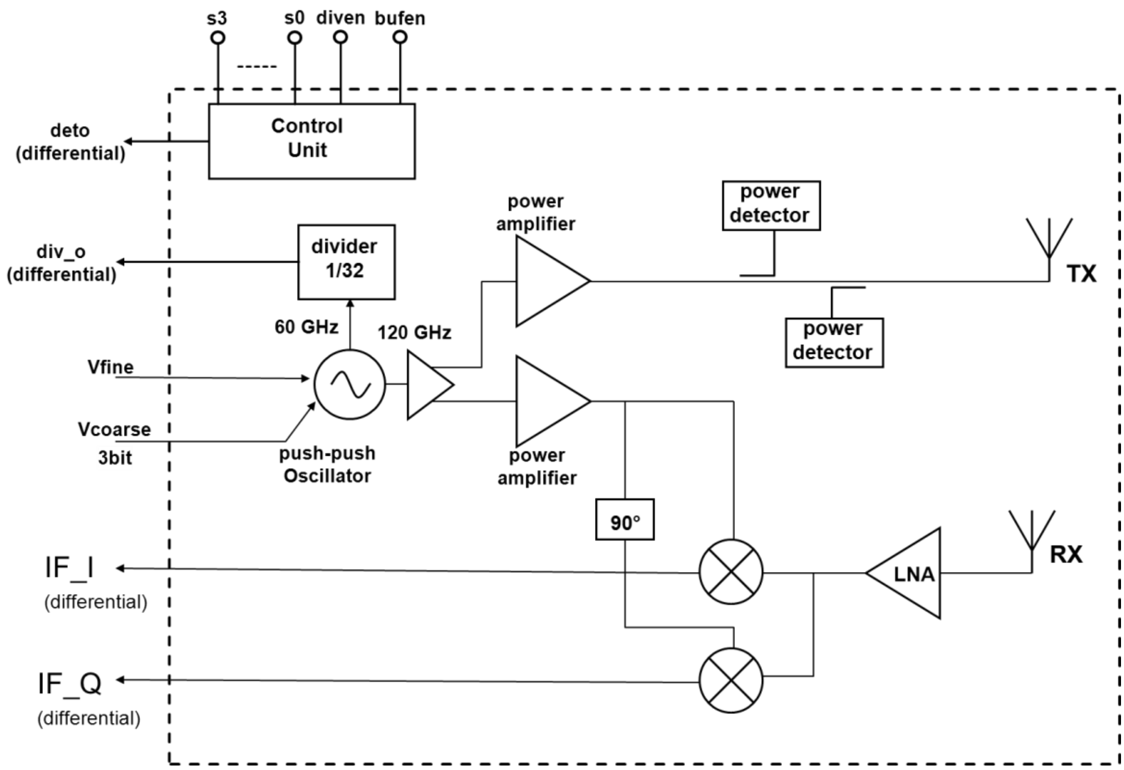


Figure 1 - TRX_120_06 Block Diagram

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

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks / Condition
Frequency range	f_{TX}	119.1	-	125.9	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

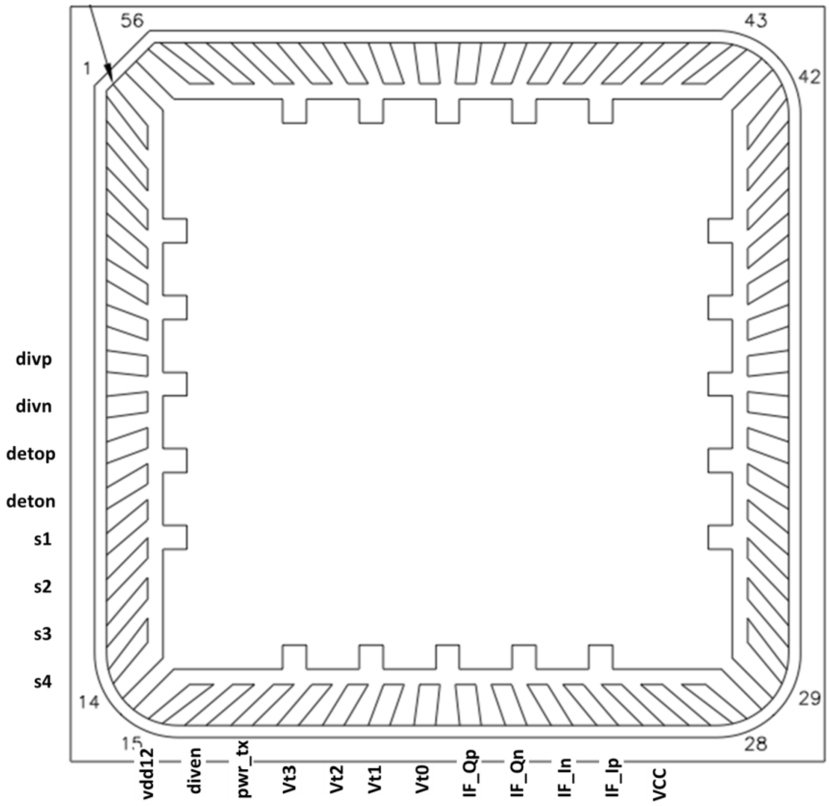


Figure 2 - TRX_120_06 QFN-package outline with signal indication (top view)

5.2 Pin Description

Table 5 Pin Description

Pin No.	Name	Description
1-6		Not connected
7	divp	Divider output, 500Ω, DC coupled, external decoupling capacitor required
8	divn	
9	detop	Multiplexer outputs (differential) – depending on multiplexer (input) settings
10	deton	
11	s1	Multiplexer control bits allowed settings (0 - 1.2V): 1000 – not used 0100 – power detector 2 0010 – temperature sensor 0001 – power detector 1
12	s2	
13	s3	
14	s4	
15	vdd12	Supply for power detector (1.2V, 2mA max.)
16	diven	Divider enable signal (ON = 1.2V, OFF = 0V), CMOS input, use of external pull-up resistor 100kOhm possible
17	pwr_tx	Transmitter enable (ON = 1.2V, OFF = 0V), CMOS input, use of external pull-up resistor 100kOhm possible

18	Vt3	VCO tuning inputs (0 – 3.3V)
19	Vt2	
20	Vt1	
21	Vt0	
22	IF_Qp	IF Outputs, DC coupled
23	IF_Qn	
24	IF_In	
25	IF_Ip	
26	Vcc	Supply voltage (3.3V, 115mA typ.)
	GND	
27-56	NC	Not connected
57	GND	Die attach pad to ground

5.3 Application Circuit Schematic

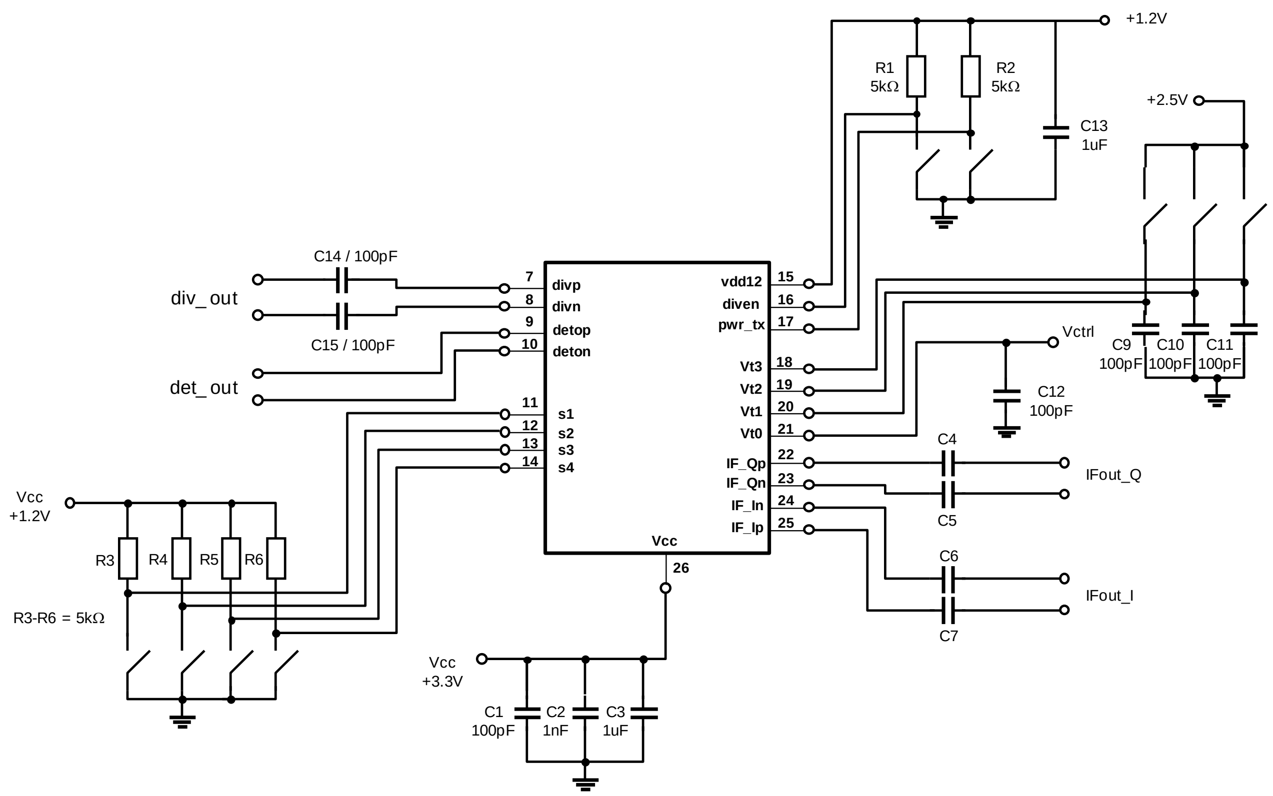


Figure 3 - TRX_120_06 Application Circuit

5.4 Evaluation Boards

There are several TRX_120 RFE based evaluation boards supplied by Silicon Radar GmbH. With the boards FMCW mode and CW mode of radar operation can be demonstrated.

6 Measurement Results

6.1 DC Current Consumption Measurements

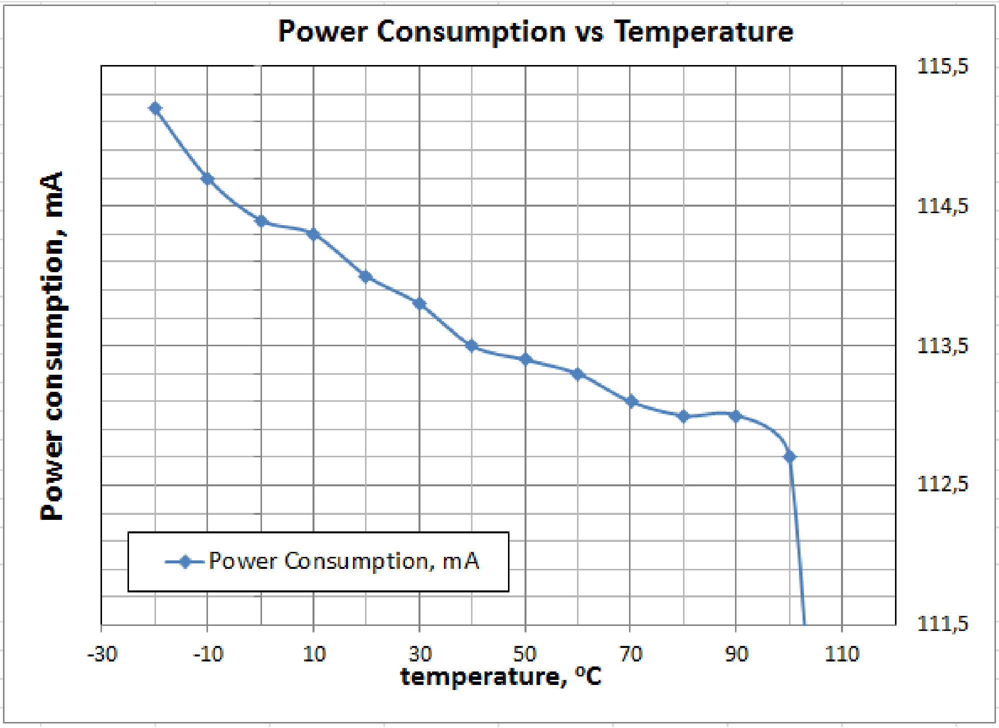


Figure 4 - Power Consumption vs Temperature

6.2 Conversion Gain Measurements

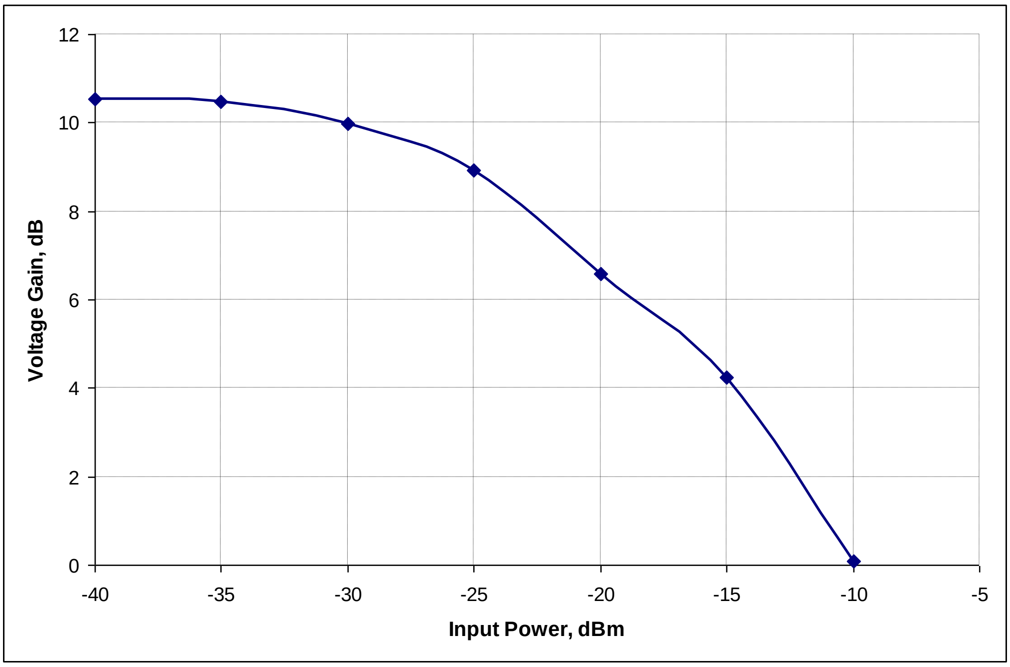


Figure 5 - Measured Conversion Gain of the Receiver

6.3 Transmitter Frequency Measurements

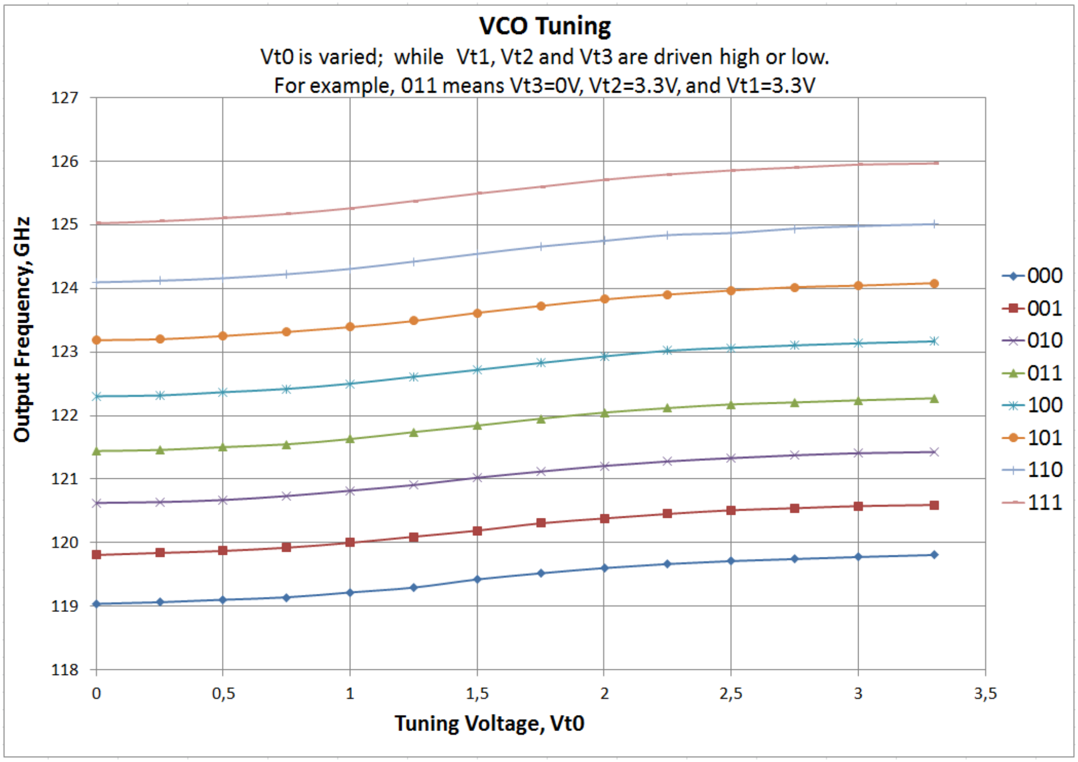


Figure 6 - VCO Tuning Curves

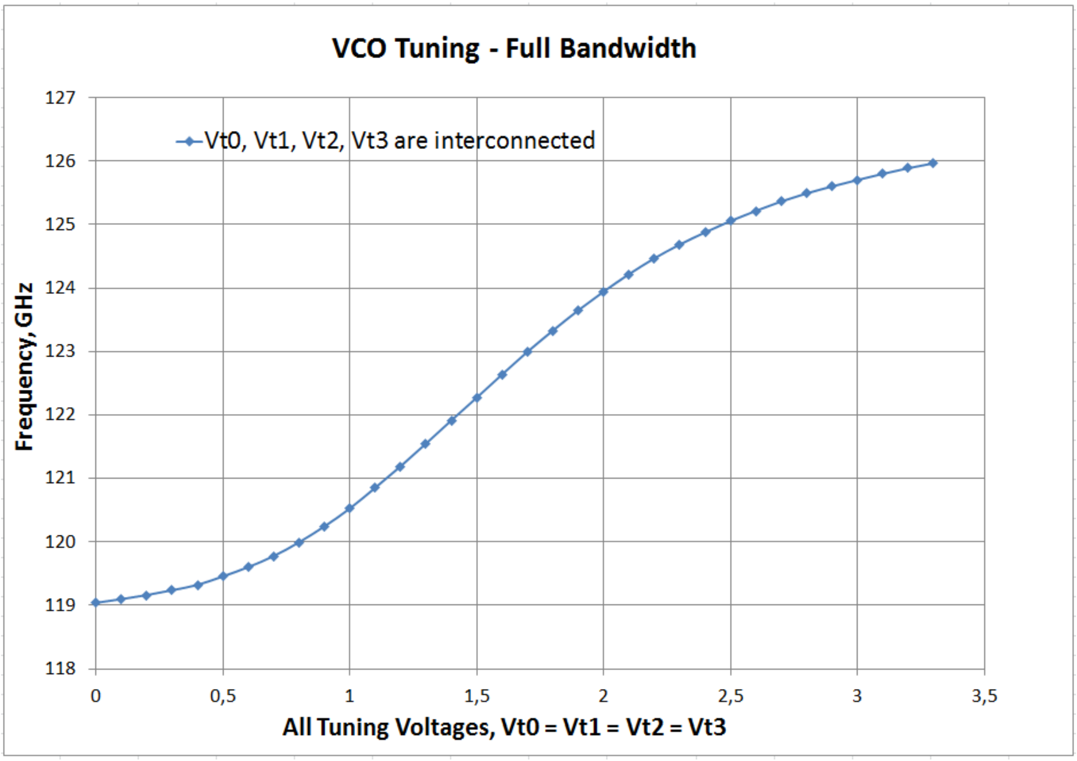


Figure 7 - Full Bandwidth VCO Tuning - All tuning voltages are swept together

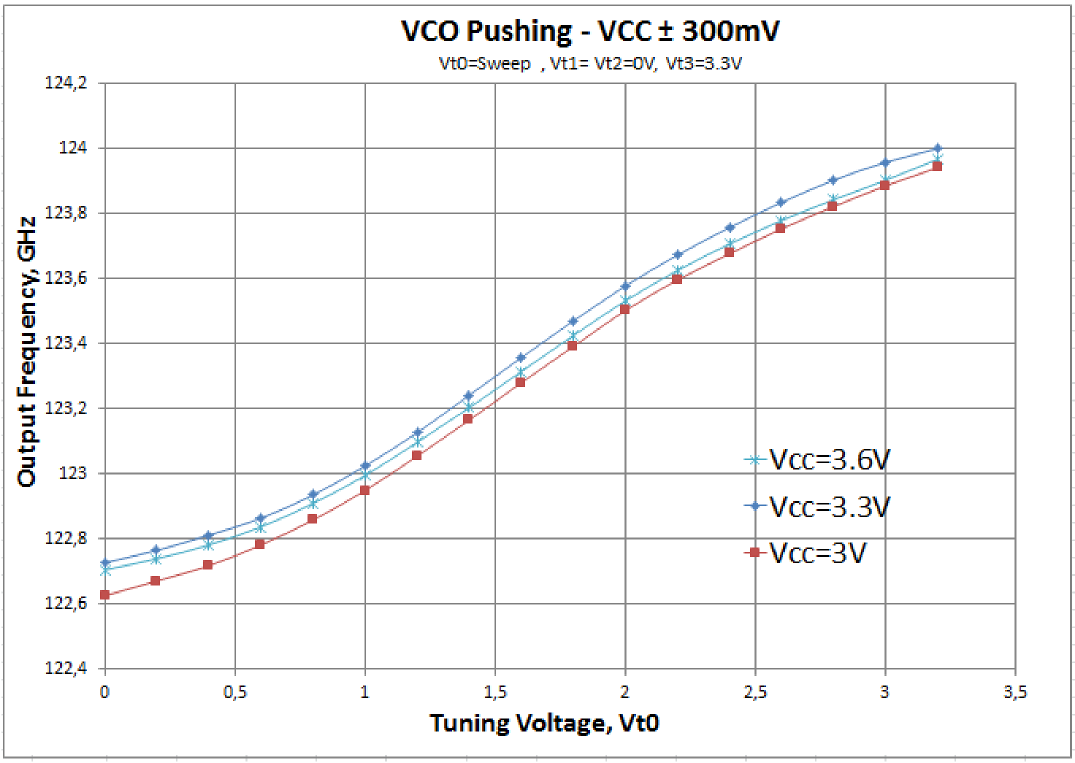


Figure 8 - VCO Pushing

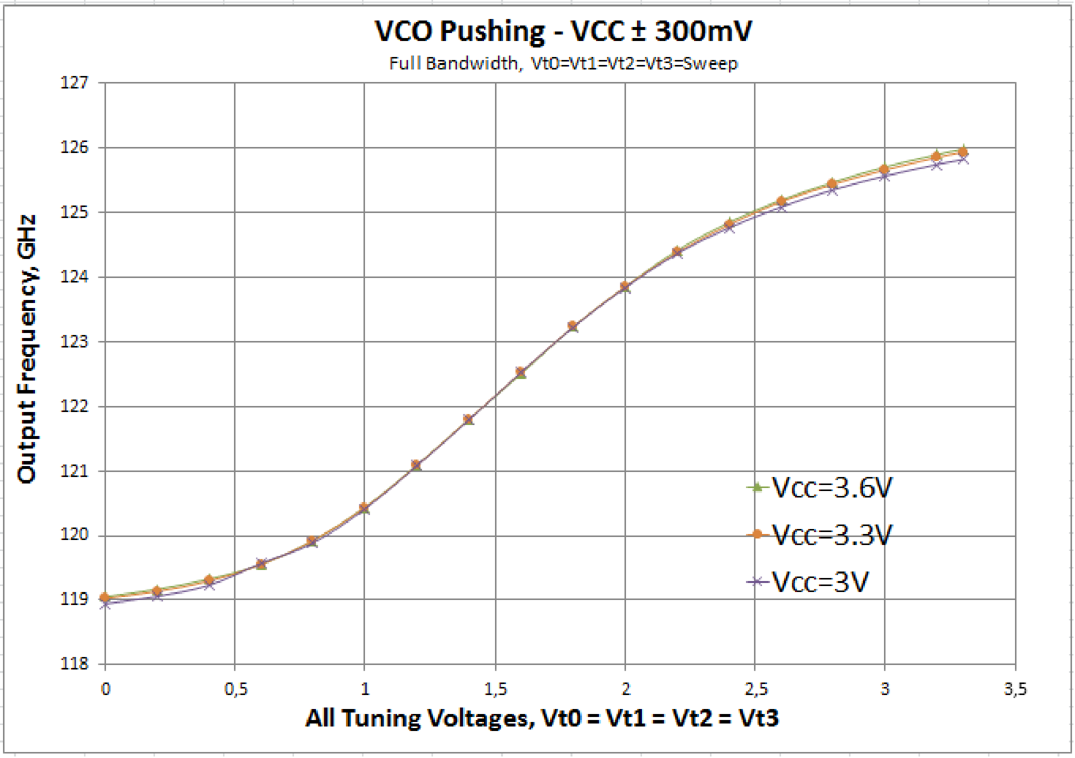


Figure 9 - VCO Pushing - Full Bandwidth Operation

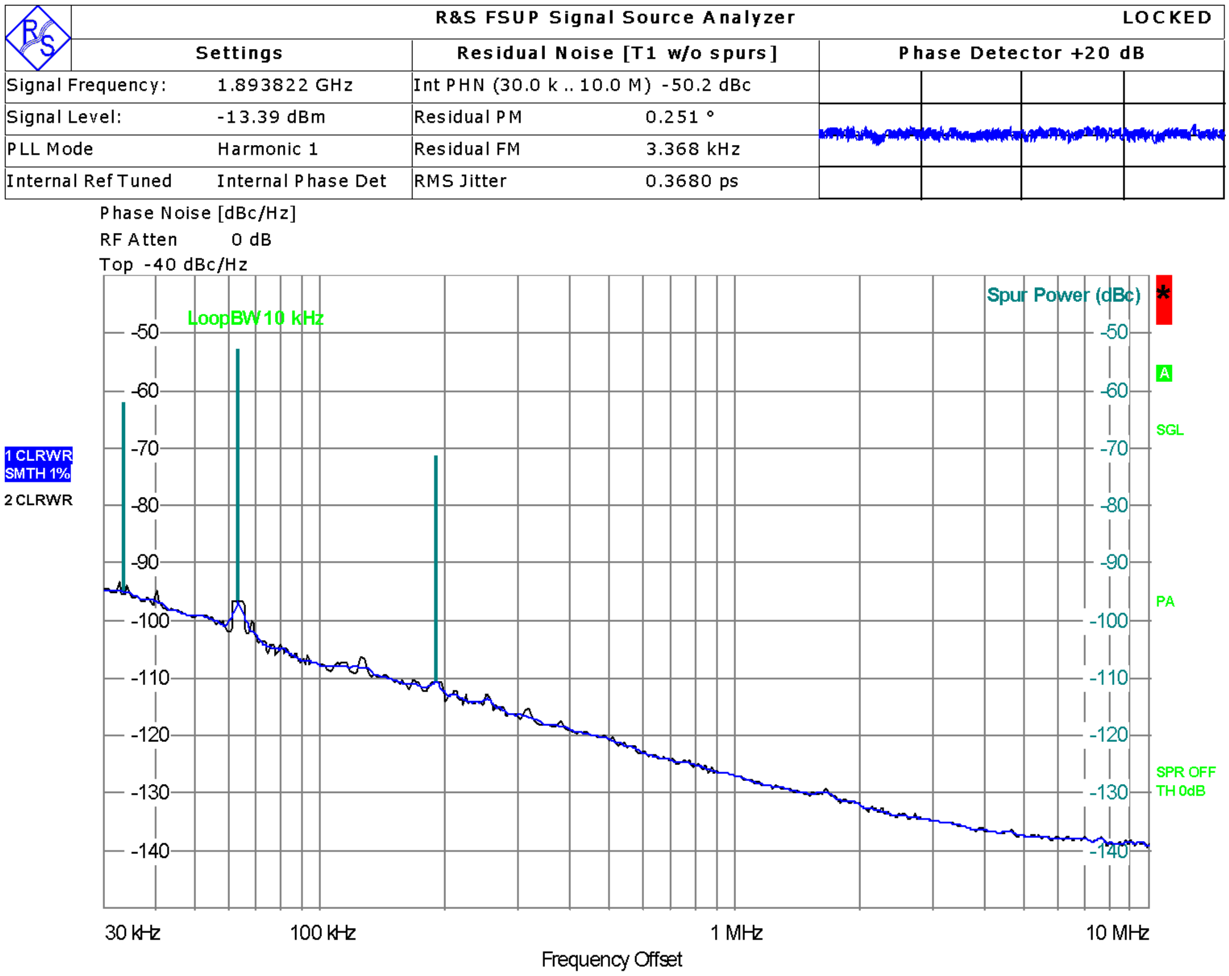


Figure 10 - Phase Noise of the Integrated Oscillator Measured at Divider Output (1.89GHz)

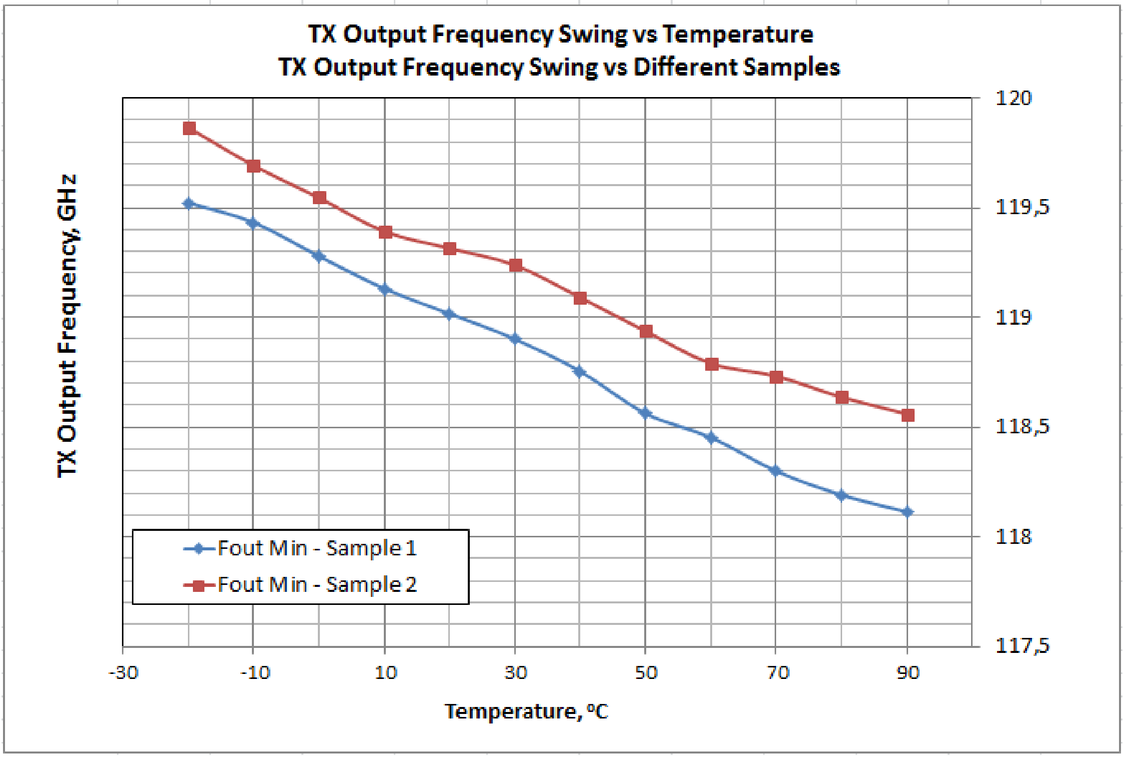


Figure 11 - Output Frequency vs. Temperature

6.4 Power detector and Transmitter Power Measurements

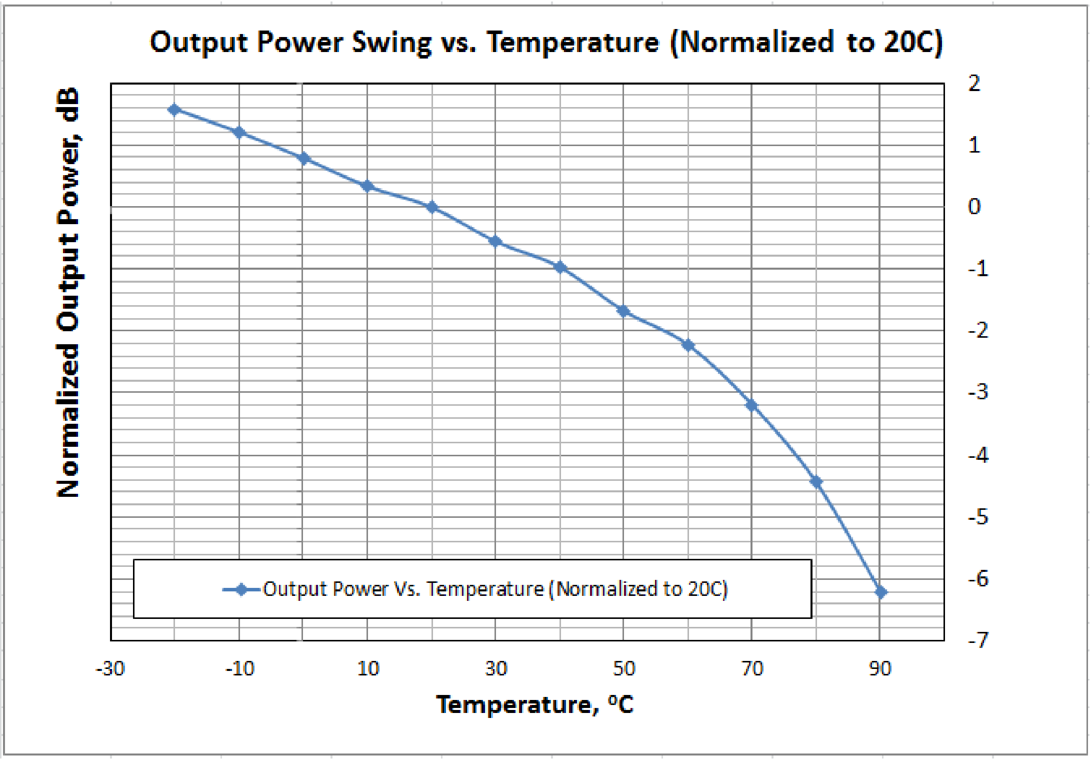


Figure 12 - Output Power vs. Temperature

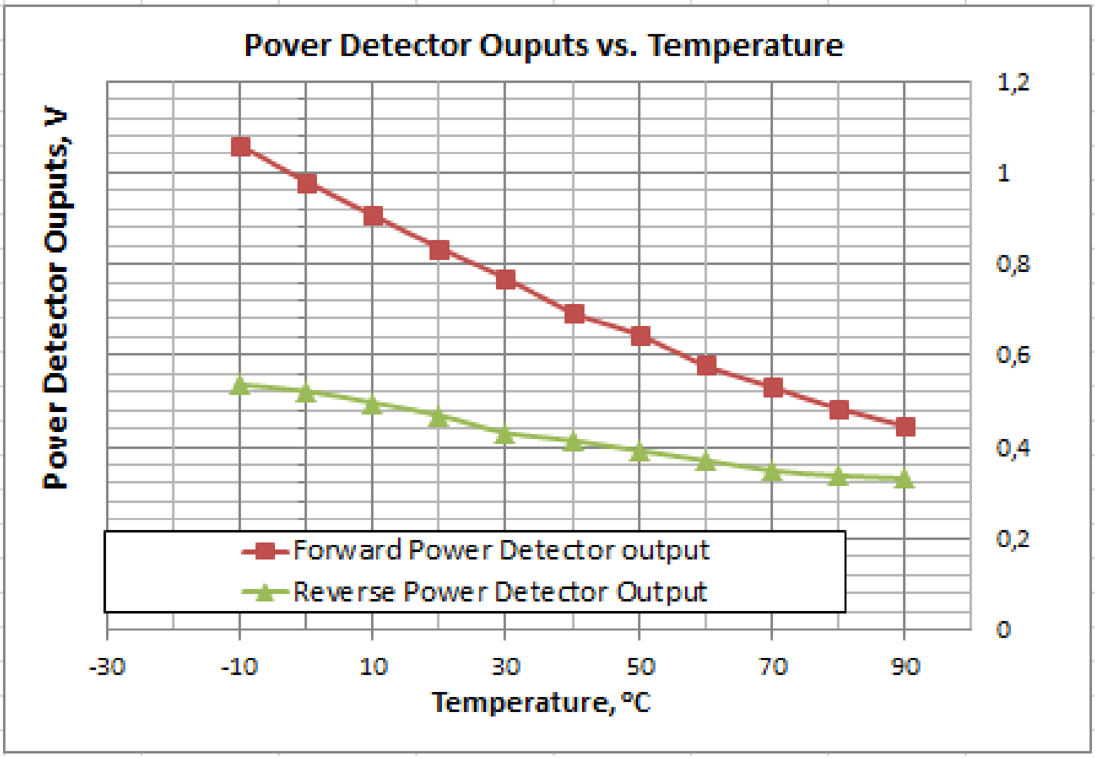


Figure 13 - Power Detector Outputs vs. Temperature

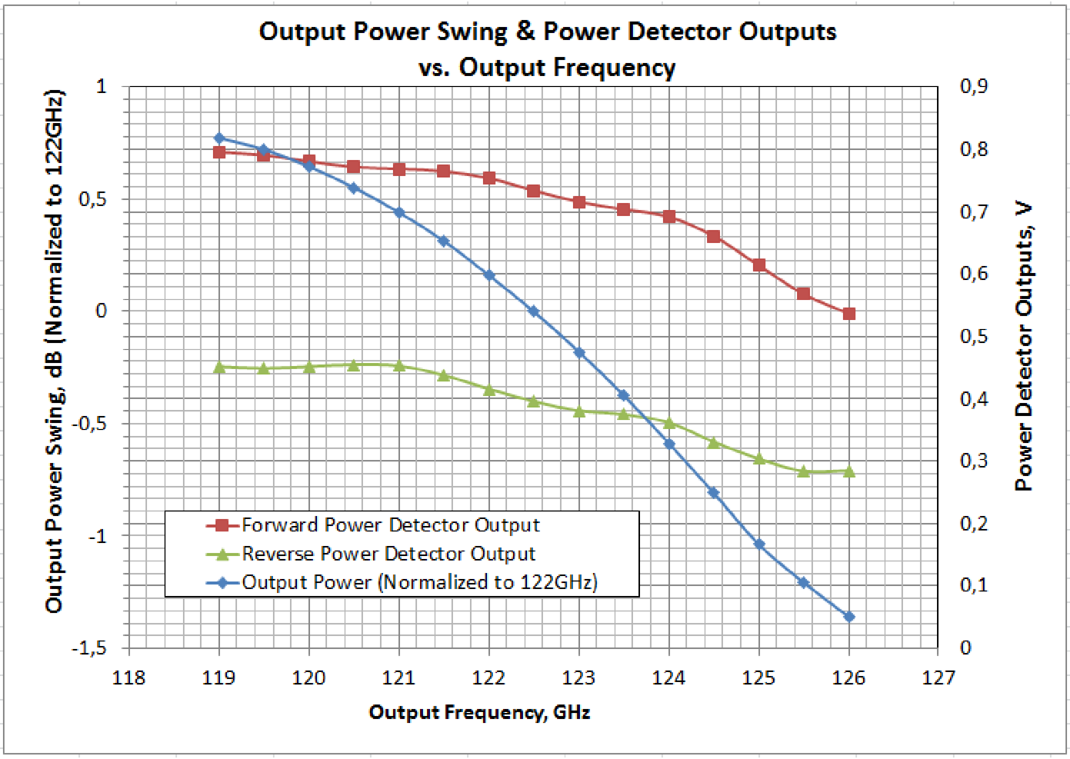


Figure 14 - Output Power vs. Output Frequency

6.5 Antenna Pattern Measurements

Measurement Setup: Partner - Karlsruhe Institute of Technology

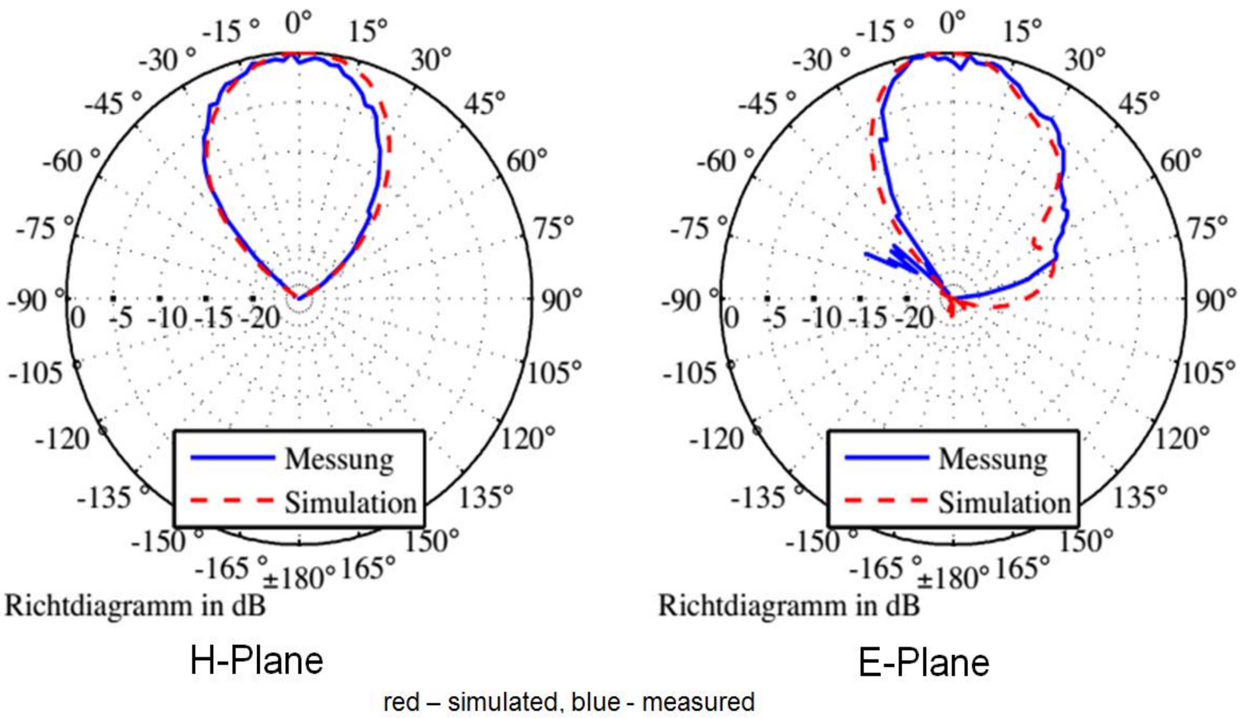
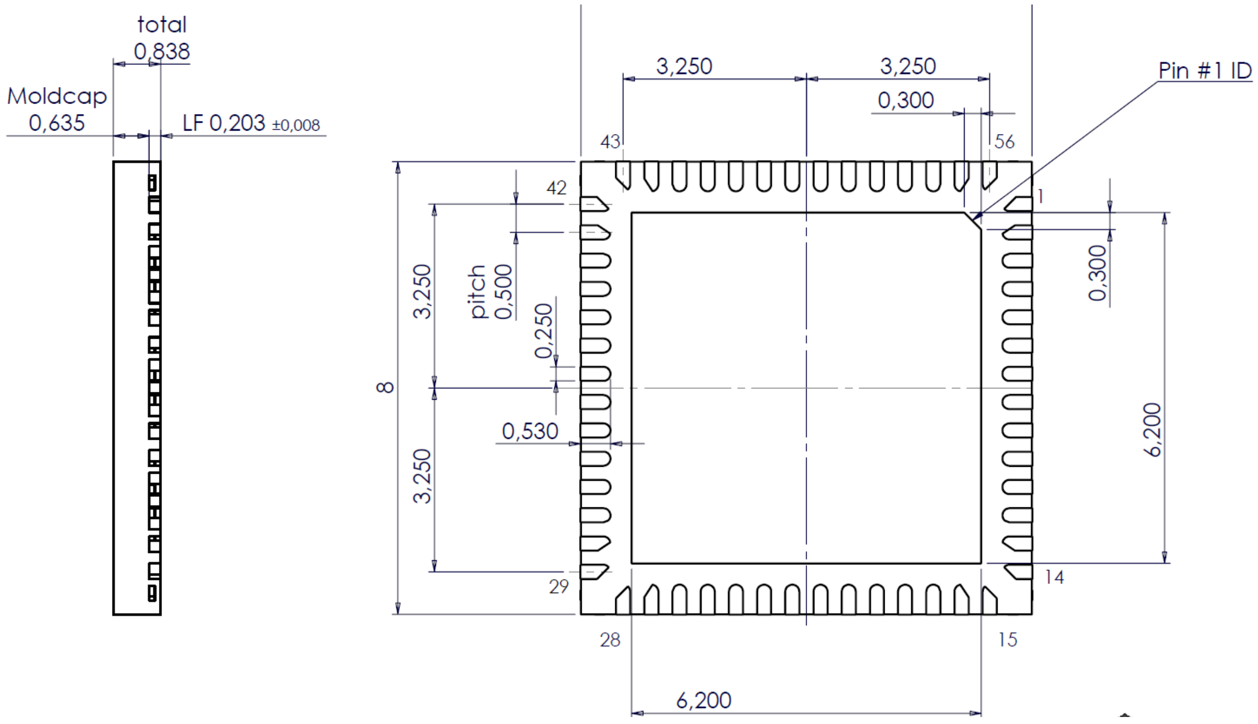


Figure 15 - Radiation Pattern Measurements of Patch Antennas

7 Physical Characteristics

7.1 Mechanical Data QFN



Note:
- Leadframe: Alloy 194, NiPdAu plated
- Moldcap: Semiconductor EMC
- General dimensions: ±0.05mm unless otherwise specified
- Offset package to leadframe: 0.07mm max
- Jedec MO-220

Figure 16 - QFN-56, 0.5mm pitch, 8x8mm drawing

8 Disclaimer