

SRK2402

24GHz 2T4R FMCW Radar Transceiver

Data Sheet

Revision A1.3

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GENERAL DESCRIPTION

The SRK2402 is a fully integrated FMCW radar transceiver based on the state-of-art silicon germanium process. It operates in the 24 GHz ISM band from 24.00 to 24.25 GHz. It consists of two transmit chains featuring a 9 dBm output power, and four receive chains with a 29 dB conversion gain, a 9 dB noise figure and a high input compression point up to -5 dBm. On-chip baluns are included to provide single-ended RF and LO interfaces. The device is controlled via SPI interface. The radar transceiver is package in a compact 56-lead, 7 mm x 7 mm QFN package.

FEATURES

- ♦ 24 GHz ISM band fully integrated FMCW radar transceiver
- ♦ Integrated with 2 transmitters, 4 receivers and an LO buffer
- ♦ RX channel voltage conversion gain: 29 dB
- ♦ RX channel noise figure: 9 dB
- ♦ RX channel input P1dB: -14 dBm
- ♦ TX output power: 9 dBm
- ♦ LO input range: -8 dBm to 5 dBm
- ♦ Integrated balun for single-ended RF interfaces
- ♦ On-chip power and temperature sensors
- ♦ DC power rating: 3.3 V and 390 mA
- ♦ 56-lead, 7 mm x 7 mm QFN package
- ♦ Fully ESD protection

APPLICATIONS

- ♦ Automotive radars
- ♦ Industrial radars
- ♦ IoT sensors

FUNCTIONAL BLOCK DIAGRAM

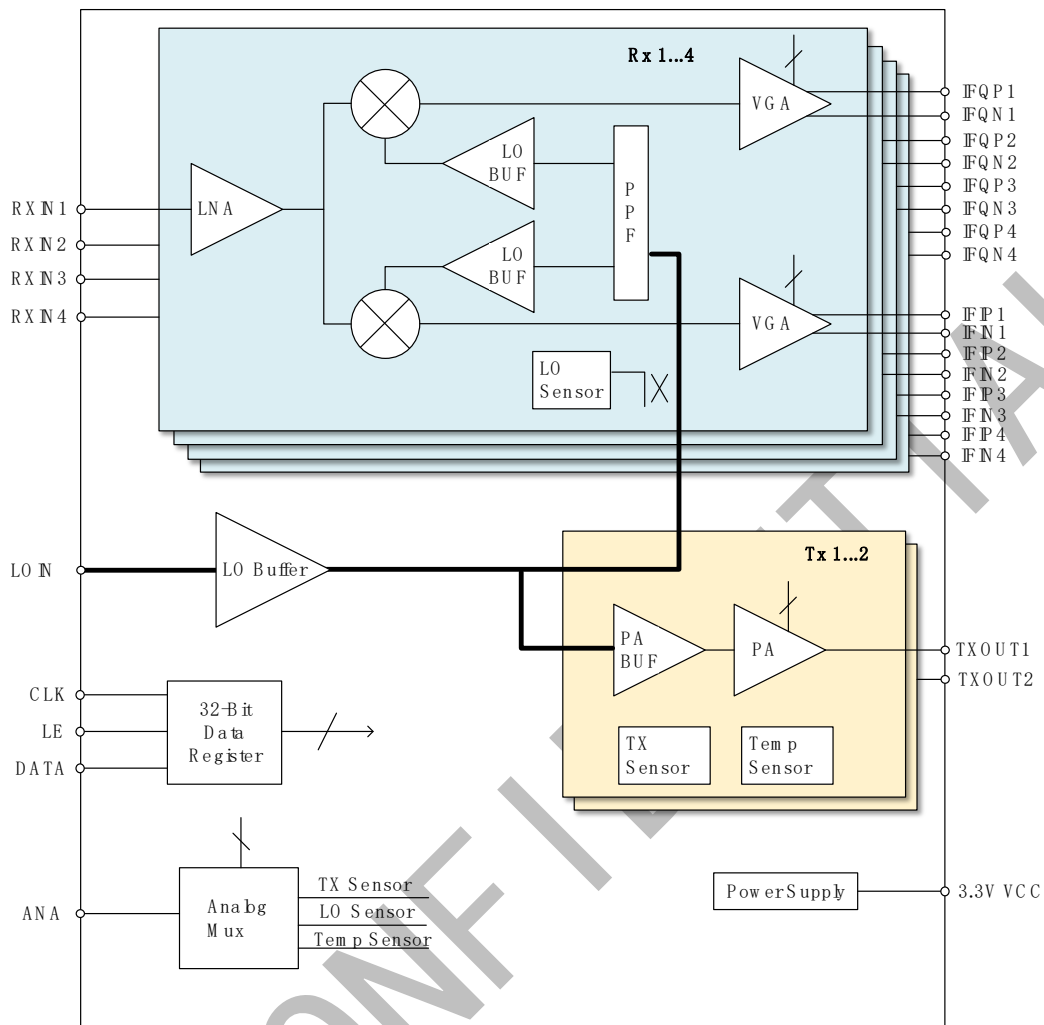


Figure 1 SOC Functional Block Diagram



SPECIFICATIONS

VCC = 3.3 V, GND = 0 V, dBm referred to 50 Ω , operating temperature is 25 °C, unless otherwise noted.

POWER SUPPLY

Table 1 Power Supply Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Note
Supply voltage	V _{CC}	3.135	3.3	3.465	V	AVDD,SDVDD,VCCTX/RX, VCCLO
Supply current	I _{CC}		390		mA	

TX SECTION

Table 2 TX Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Note
TXOUT frequency range	f _{TXOUT}	24.00		24.25	GHz	
TX port return loss	Γ_{TX}		-15		dB	with PCB matching
Max TX output power	P _{TX}		9		dBm	
TX output power tuning range			18		dB	

RX SECTION

Table 3 RX Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Note
RXIN frequency range	f _{RXIN}	24.00		24.25	GHz	
RXIN port return loss	Γ_{RXIN}		-15		dB	with PCB matching
IF frequency range	f _{IF}	0		10	MHz	
IF output impedance	Z _{IF}		1000		Ω	
TX/RX isolation			-40		dB	Based on SP test
RX/RX isolation			-35		dB	Based on SP test
Voltage conversion gain	G _c		29		dB	
DSB noise figure	NF		9		dB	
Input compression point	IP _{1dB}		-14		dBm	@max gain
IQ phase imbalance			5		Degree	
IQ amplitude imbalance			1		dB	
LOIN frequency range	f _{RXIN}	24.00		24.25	GHz	
LOIN port return loss	Γ_{RXIN}		-15		dB	with PCB matching
LO input power		-8		5	dBm	
TX/LO isolation			-40		dB	Based on SP test
RX/LO isolation			-35		dB	Based on SP test



TEMPERATURE SENSOR

Table 4 Temperature Sensor Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Note
Temperature range	T _A	-40		125	°C	
Output temperature voltage	V _{OUT,TEMP}		1.47		V	@ 25 °C , radar function off
Sensitivity			3.7		mV/°C	
Overall accuracy error				±15	°C	

POWER SENSOR

Table 5 Power Sensor Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Note
Power range		-10		15	dBm	
LO power sensor			1.18		V	@ 2 dBm



ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

GND = 0 V, dBm referred to 50 Ω , operating temperature is 25 °C, unless otherwise noted.

Table 6 Absolute Maximum Ratings

Parameter	Symbol	Min	Typ	Max	Units	Note
Supply voltage	V _{CC}	-0.3		3.6	V	AVDD, SDVDD, VCCTX/RX, VCCLO
Analog I/O voltage to GND		-0.3		V _{CC}	V	
Digital I/O voltage to GND		-0.3		V _{CC}	V	
Input power into RF ports	P _{RF}			0	dBm	RXIN1, RXIN2, RXIN3, RXIN4, LOIN
Storage temperature	T _{STG}	-40		150	°C	
Reflow soldering						
Peak temperature				260	°C	
Time at peak temperature				40	sec	

Attention: Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD INTEGRITY

Table 7 ESD Integrity

Parameter	Symbol	Min	Typ	Max	Units	Note
ESD robustness, HBM ¹⁾	V _{ESD_HBM}	-2		2	kV	All pins
ESD robustness, CDM ²⁾	V _{ESD_CDM}	-500		500	V	All pins

1): According to AEC-Q100-002-Rev-E

2): According to AEC-Q100-011-Rev-D

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

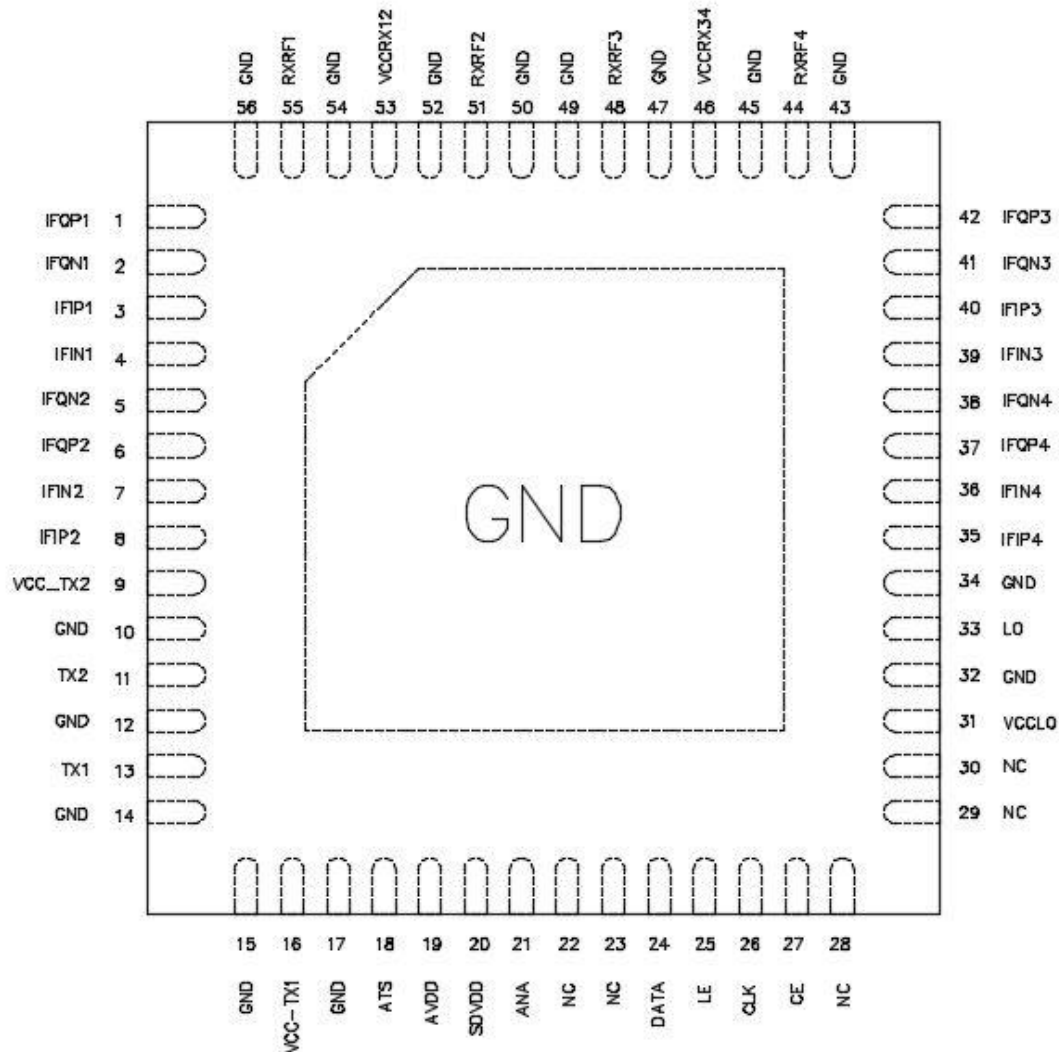


Figure 2 Pin Configuration

Table 8 Pin Function Descriptions

Pin No.	Mnemonic	Description
1	IFQP1	Quadrature phase IF output at RX1
2	IFQN1	Complementary quadrature phase IF output at RX1
3	IFIP1	In phase IF output at RX1
4	IFIN1	Complementary in phase IF output at RX1
5	IFQN2	Complementary quadrature phase IF output at RX2
6	IFQP2	Quadrature phase IF output at RX2
7	IFIN2	Complementary in phase IF output at RX2
8	IFIP2	In phase IF output at RX2
9	VCCTX2	Supply voltage for TX2



Table 8 Pin Function Descriptions (continued)

Pin No.	Mnemonic	Description
10,12,14,32,34,43 45,47,49,50,52,54 56	RFGND	RF Ground pins
11	TX2	RF output at TX2
13	TX1	RF output at TX1
15,17,22,23,28,29 30	GND	Analog Ground pins
16	VCCTX1	Supply voltage for TX1
18	ATS	Analog output of temperature sensor
19	AVDD	Analog supply voltage
20	SDVDD	Digital supply voltage
21	ANA	Analog output
24	DATA	Serial data input
25	LE	SPI load enable, low active
26	CLK	Serial clock input
27	CE	Chip enable
31	VCCLO	Supply voltage for LO buffer
33	LOIN	RF input at LO buffer
35	IFIP4	In phase IF output at RX4
36	IFIN4	Complementary in phase IF output at RX4
37	IFQP4	Quadrature phase IF output at RX4
38	IFQN4	Complementary quadrature phase IF output at RX4
39	IFIN3	Complementary in phase IF output at RX3
40	IFIP3	In phase IF output at RX3
41	IFQN3	Complementary quadrature phase IF output at RX3
42	IFQP3	Quadrature phase IF output at RX3
44	RXIN4	RF input at RX4
46	VCCR2	Supply voltage for RX3 and RX4
48	RXIN3	RF input at RX3
51	RXIN2	RF input at RX2
53	VCCR1	Supply voltage for RX1 and RX2
55	RXIN1	RF input at RX1

APPLICATIONS

RECOMMENDED CONFIGURATION FOR SRK2402

Reference hexadecimal codes are listed below. In this configuration, four receivers, RX1-RX4, are turned on with their highest sensitivity. Four DCOCs are off not to adjust DC voltage on IF output ports. TX1 is on, with its maximum output, while TX2 is off. The temperature sensor is on with its DC voltage reading on pin “ATS”. Power sensor of PA buffer input in TX1 is on with its reading on pin “ANA”.

Table 9 Recommended SPI Control Bits

Registers	Codes in HEX	Functions
R7	0xB7FDBFC7	RX3=MAX; RX4=MAX
R6	0xB7FDBFC6	RX1=MAX; RX2=MAX
R5	0x000020FD	TS=ON; TX1=MAX ; TX2=OFF
R4	0x00021784	Power sensor of PA buffer input in TX1=ON
R3	0x00000003	RX4 DCOC=OFF
R2	0x00000002	RX3 DCOC=OFF
R1	0x00000001	RX2 DCOC=OFF
R0	0x00000000	RX1 DCOC=OFF

CASCADING SRK2401 AND SRK2402 FOR AN MIMO RADAR

Fig. 5 shows how to cascade SRK2401 and SRK2402. With one SRK2401 chip as the master, eight SRK2402 chips as slaves, an 16T32R MIMO radar is achieved with very small angle resolution. With SRK2401 outputs its maximum power on pin “TXOUT”, the signal is then fed to several SRK2402 chips ($1 \leq n \leq 8$) on pin “LOIN”. Signal “CLK” can be shared between all chips and a reference TCXO is recommended. Signal “DATA” and “LE” are from the control unit which can be DSP, MCU, FPGA and etc.

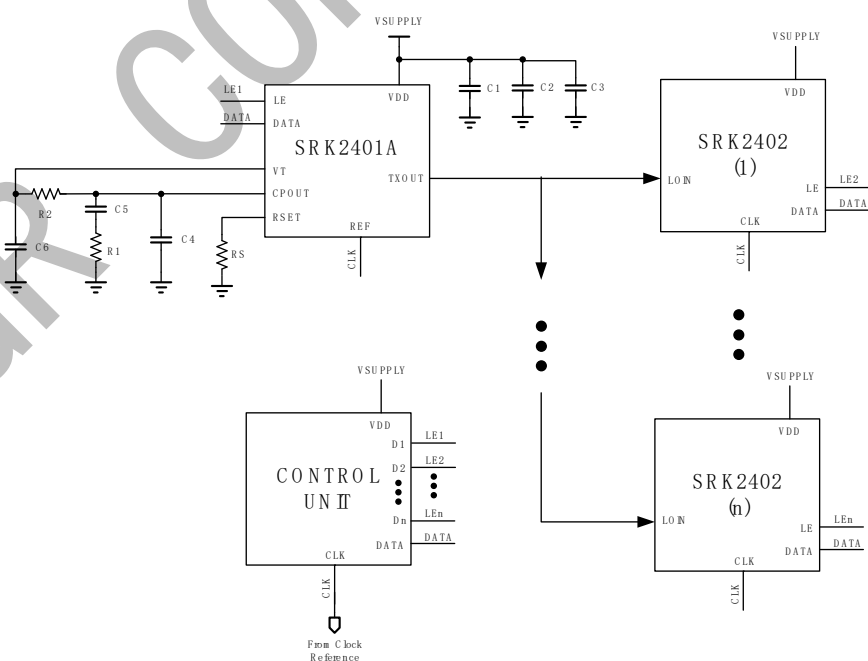
Figure 3 Block Diagram of Sample MIMO Radar ($1 \leq n \leq 8$)



Table 10 Bill of Materials in Fig. 5

Designation	Part Type	Value	Package	Manufacturer
C1	Capacitor	10 pF	0402	Various
C2	Capacitor	1 nF	0402	Various
C3	Capacitor	100 nF	0402	Various
C4	Capacitor	1 nF	0402	Various
C5	Capacitor	22 nF	0402	Various
C6	Capacitor	200 pF	0402	Various
R1	Resistor	390 ohm	0402	Various
R2	Resistor	2 kohm	0402	Various
RS	Resistor	5.1 kohm	0402	Various

PACKAGE DIMENSIONS

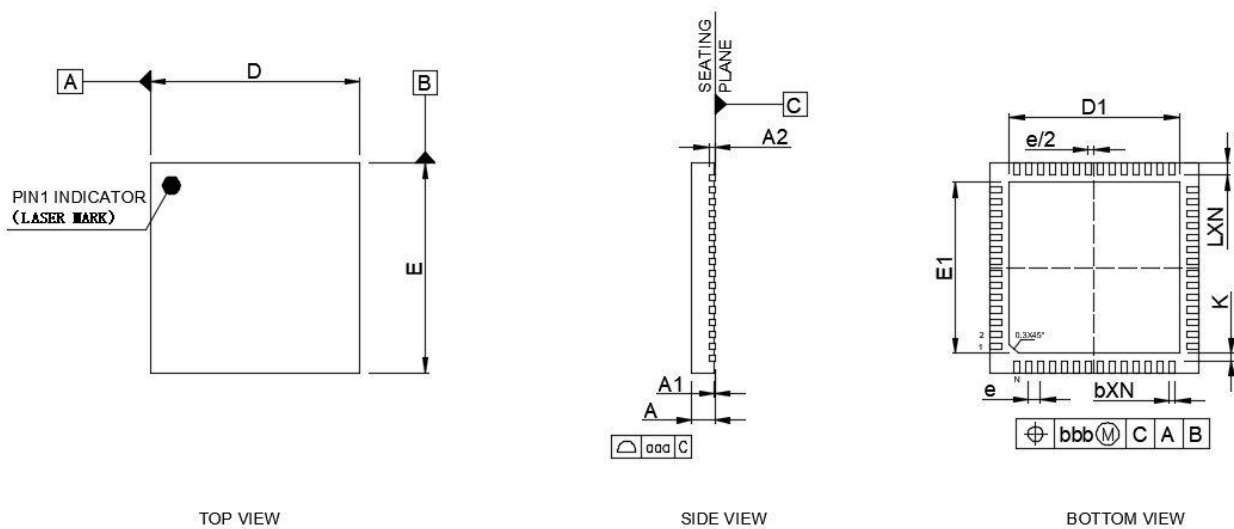


Figure 4 56-Lead QFN Package Dimensions

Table 11 Package Dimensions

		SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS		A	0.7	0.75	0.8
STAND OFF		A1	0.00	0.02	0.05
L/F THICKNESS		A2	0.20 REF		
LEAD WIDTH		b	0.15	0.2	0.25
BODY SIZE	X	D	6.95	7.00	7.05
	Y	E	6.95	7.00	7.05
LEAD PITCH		e	0.40 BSC		
EP SIZE	X	D1	5.60	5.70	5.80
	Y	E1	5.60	5.70	5.80
LEAD LENGTH		L	0.30	0.40	0.50
LEAD TIP TO EXPOSED PAD EDGE		K	0.25 REF		
		N	56		
PACKAGE EDGE TOLERANCE		aaa	0.10		
		bbb	0.07		