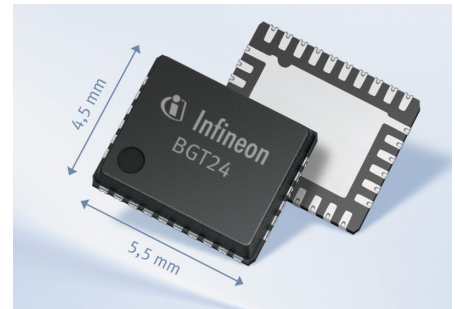


# BGT24AR4

## Silicon Germanium 24 GHz Quad Receiver MMIC

### Features

- Gilbert based quad homodyne 24 GHz downconverter with integrated IF filters and programmable gain base band amplifiers
- Single ended RF terminals
- Low single side band noise figure: NF<sub>ssb</sub> = 10 dB typ.
- High downconverter P1dB input compression point: -6 dBm typ.
- Low LO input power required: -6 dBm
- On chip LO level and temperature sensors
- Multiplexed output of analog sensor signals
- Integrated saturation detectors for downconverters and IF amplifiers
- Disable mode for downconverter and base band amplifiers via SPI
- IF chain testability
- Single supply voltage: 3.3 V typ.
- Low power consumption: 610 mW typ.
- 200 GHz bipolar SiGe:C technology b7hf200
- Fully ESD protected device
- VQFN-32-9 leadless plastic package including lead-tip-inspection (LTI) feature



### Description

The BGT24AR4 is a Silicon Germanium MMIC, accommodating four separate homodyne receiver chains. Each receiver consists of a downconverter operating in the 24 GHz ISM band. LO buffer amplifiers are included to relax LO drive requirements. IF signal filtering and amplification is provided on chip.

Saturation detectors for downconverter- and IF output signals as well as an IF chain test feature are integrated for monitoring purposes.

A temperature- and LO power sensor signal is accessible through a multiplexed analog output.

The following functionalities can be controlled via the 32 bit SPI bus:

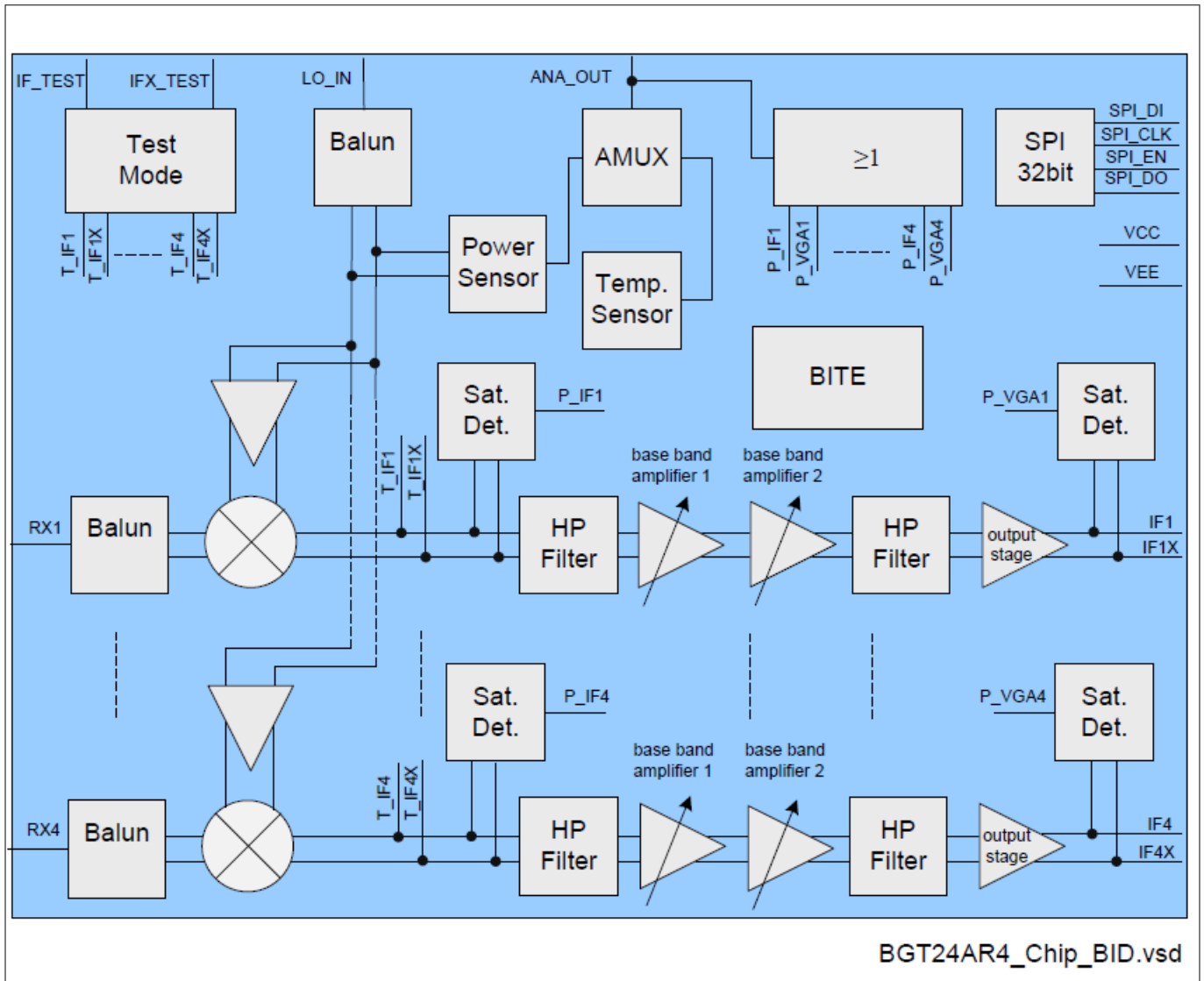
- Enabling of downconverter and base band amplifiers
- Selection of base band amplifiers' gain
- Selection of the sensor signal being available through the analog output

### Product Validation

Qualified for Automotive Applications. Product Validation according to AEC-Q100/101

Product Name	Package	Chip	Marking
BGT24AR4	VQFN32-9	T1825	BGT24AR4

**Revision History**



**Figure 1** BGT24AR4 Block Diagram

**Revision History**

**Revision History: 2019-12-05, Revision 3.4**

**Previous Revision: 2019-10-31, Revision 3.3**

Page	Subjects (major changes since last revision)
7	RF frequency range extended typ. and max. value
8	IF output impedance fixed min. value
10	LO frequency range extended typ. and max. value

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**1 Electrical Characteristics**

**1 Electrical Characteristics**

**1.1 Absolute Maximum Ratings**

**Table 1 Absolute Maximum Ratings**

$T_A = -40\text{ °C}$  to  $125\text{ °C}$ ; all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
Supply voltage	$V_{CC}$	-0.3	-	$V_{CC} + 0.3$	V	■	-
DC voltage at RF pins	$V_{DC_{RF}}$	-	-	0	V	■	MMIC provides short circuit to GND for LO_IN and RX1 to RX4 pins
RF input power	$P_{RF}$	-	-	0	dBm	■	-
LO input power	$P_{LO}$	-	-	12	dBm	■	-
Voltage applied to none-RF pins <sup>(1)</sup>	$V_{IO}$	-0.3	-	$V_{CC} + 0.3$	V	■	-
Total power dissipation	$P_{DISS}$	-	-	1200	mW	■	-
Junction temperature	$T_J$	-40	-	170	°C	■	-
Ambient temperature range	$T_A$	-40	-	125	°C	■	$T_A$ = temperature at package soldering point
Storage temperature range	$T_{STG}$	-50	-	125	°C	■	-

(1) For SPI\_EN, SPI\_DI, SPI\_CLK the applied voltage may exceed given ratings as long as current into these pins is limited to  $I_{SPI} = 1\text{ mA}$

**Attention:** Stresses exceeding the maximum values listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods of time may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

**Attention:** Integrated protection functions are designed to prevent IC destruction under fault conditions as described in the data sheet. Fault conditions are considered as “outside” normal operating range. Protection functions are not designed for continuous repetitive operation.

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

**Note:** No permanent damage of the device is possible due to an undefined SPI state

## 1 Electrical Characteristics

### 1.2 ESD Integrity

**Table 2 ESD Integrity**

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
ESD robustness HBM <sup>(1)</sup>	$V_{ESD-HBM}$	-1	-	1	kV	■	All pins
ESD robustness, CDM <sup>(2)</sup>	$V_{ESD-CDM}$	-500	-	500	V	■	All pins
		-750	-	750		■	Package corner pins

(1) According to ANSI/ESDA/JEDEC JS-001 (R = 1.5kOhm, C = 100pF) for Electrostatic Discharge Sensitivity Testing, Human Body Model (HBM)-Component Level

(2) According to JEDEC JESD22-C101 Field-Induced Charged Device Model (CDM), Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components.

Please note that this result is subject to:

- lot variations within the manufacturing process as specified by Infineon
- changes in the specific test setup

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

### 1.3 Power Supply

**Table 3 Electrical Characteristics**

$T_A = -40\text{ °C} \dots 125\text{ °C}$ , positive current flowing into pin (unless otherwise specified).

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
Supply voltage	$V_{CC}$	3.135	3.3	3.465	V		-
Supply current	$I_{CC}$	-	185	220	mA		SPI state: 0025 CC25 Hex; no RF signal present
Supply current standby mode	$I_{CCstandby}$	-	-	35	mA		SPI state: 0000 CC00 Hex

### 1.4 RX Characteristics

**Table 4 Electrical Characteristics**

$V_{CC} = 3.135\text{ V to } 3.465\text{ V}$ ,  $T_A = -40\text{ °C to } 125\text{ °C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), parameters specified in the frequency range from 24 GHz to 24.3 GHz including a matching structure and package footprint provided by Infineon using the high frequency laminate Rogers 4350B (see AN358)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
RF frequency range	$f_{RF}$	24.00	24.15	24.3	GHz	■	-

**1 Electrical Characteristics**

**Table 4 Electrical Characteristics (continued)**

$V_{CC} = 3.135\text{ V to }3.465\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), parameters specified in the frequency range from 24 GHz to 24.3 GHz including a matching structure and package footprint provided by Infineon using the high frequency laminate Rogers 4350B (see AN358)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
RF input impedance	$Z_{RF}$	–	50	–	$\Omega$	■	Single ended including off chip compensation
Input return loss RF port RX1, RX4 RX2, RX3	$RL_{RF}$	12 9	– –	– –	dB	■	$V_{CC} = 3.3\text{ V}$ , $T_A = 25\text{ °C}$ , $P_{LO} = 0\text{ dBm}$
RF/RF isolation (channel separation)	$I_{RF,RF}$	35	–	–	dB	■	not valid for RX1/ RX2
RF <sub>RX1</sub> / RF <sub>RX2</sub> isolation (channel separation)	$I_{RF\_RX1,RF\_RX2}$	32	–	–	dB	■	–
LO/RF leakage	$L_{LO,RF}$	–	–	-27	dBm	■	$P_{LO} = 0\text{ dBm}$
Mixer's P1dB @ RF inputs	$P_{1dB\ IN}$	-7	-6	–	dBm	■	–
RX channel gain: power gain voltage gain	$G_P$ $G_V$	39.2 47	42.2 50	48.2 56	dB		At IF load 300 $\Omega$ differential
RX channel gain variation	$\Delta G$	-1	0	1	dB		Channel to channel
RX channel phase variation	$\Delta\phi$	-3	0	3	deg		Channel to channel
RX channel noise figure	$NF$	–	10.0	14.1	dB		At IF load 300 $\Omega$ differential
RX channel output full scale	$V_{RX}$	1.2	–	–	$V_{PP}$		At IF load 300 $\Omega$ differential
RX channel spurious free range at output full scale	$\alpha_{RX}$	50	–	–	dBc		–
IF VGA gain adjustment range	$R_{VGA}$	-18	–	0	dB		With 6 dB gain steps
IF high pass filter's cut off frequency	$f_{cut\ off}$	525	600	675	kHz		3 dB definition
IF high pass filter's lower slope order		–	2nd	–	–	■	–
IF output impedance	$Z_{IF}$	250	300	350	$\Omega$	■	–
IF test signal frequency	$f_{IF}$	100	–	5000	kHz	■	–
IF test signal level	$V_{IF}$	2	4	6	$mV_{RMS}$	■	–
IF test signal input impedance	$Z_{IF,test}$	500	1000	1400	$\Omega$	■	–



**1 Electrical Characteristics**

**Table 4 Electrical Characteristics (continued)**

$V_{CC} = 3.135\text{ V to }3.465\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), parameters specified in the frequency range from 24 GHz to 24.3 GHz including a matching structure and package footprint provided by Infineon using the high frequency laminate Rogers 4350B (see AN358)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
IF output common mode voltage	$V_{IF\_CM}$	1.4	–	2.4	V		At IF load 300 $\Omega$ differential, steady state
IF test voltage conversion gain	$G_{IF\_TEST}$	34	39	44	dB		At $f = 2\text{ MHz}$ , IF load 300 $\Omega$ differential, max. gain settings
Step response characteristics: Maximum overshoot voltage at single IF line in reference to GND	$V_{IF\_CM}^{max}$	–	–	$V_{IF\_CM} + 0.76$	V	■	At IF load 300 $\Omega$ differential
Step response characteristics: Minimum overshoot voltage at single IF line in reference to GND	$V_{IF\_CM}^{min}$	$V_{IF\_CM} - 0.93$	–	–	V	■	At IF load 300 $\Omega$ differential
Step response characteristics: Maximum slew rate	SR	–	–	106	V/ $\mu$ s	■	At IF load 300 $\Omega$ differential
Step response characteristics: Settling time	$T_S$	–	–	5.5	$\mu$ s	■	At $V_{IF\_CM} = \pm 10\text{ mV}$ , $P_{RFmax} = -20\text{ dBm}$ , IF load 300 $\Omega$ differential
Standby to ON mode transition slew rate at single IF line in reference to GND	SR_ON	–	–	55	V/ $\mu$ s	■	At IF load 300 $\Omega$ differential
IF power supply ripple rejection	PSRR <sub>IF</sub>	40	–	–	dB	■	$f_{IF} \leq 5\text{ MHz}$ $V_{CC} = 3.3\text{ V}$ , $T_A = 25\text{ °C}$

- Note:
- Test signal can be switched off (via SPI)
  - Test signal can be switched to one RX channel (via SPI)
  - Test signal can be switched to all RX channels (via SPI)

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

## 1 Electrical Characteristics

### 1.5 LO Characteristics

**Table 5 Electrical Characteristics**

$V_{CC} = 3.135\text{ V to }3.465\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), parameters specified in the frequency range from 24 GHz to 24.3 GHz include a matching structure and package footprint provided by Infineon using the high frequency laminate Rogers 4350B (see AN358)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
LO frequency range	$f_{LO}$	24.00	24.15	24.3	GHz	■	–
LO input power	$P_{LO}$	-6	–	3	dBm	■	–
Input return loss LO port	$RL_{LO}$	8	–	–	dB	■	$V_{CC} = 3.3\text{ V}$ , $T_A = 25\text{ °C}$ $P_{LO} = 0\text{ dBm}$
LO input impedance	$Z_{LO}$	–	50	–	$\Omega$	■	Single ended including off chip compensation

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

### 1.6 IF Saturation Detector

**Table 6 Electrical Characteristics**

$V_{CC} = 3.135\text{ V to }3.465\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , all voltages with respect to ground, positive current flowing into pin (unless otherwise specified), parameters specified in the frequency range from 24 GHz to 24.3 GHz include a matching structure and package footprint provided by Infineon using the high frequency laminate Rogers 4350B (see AN358)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
Input RX (RF) activation power level of mixer output saturation flag	$P_{SAT}$	$P_{1dB\ IN} -8$	$P_{1dB\ IN} -4$	$P_{1dB\ IN}$	dBm	■	–
VGA output activation voltage level of VGA saturation flag	$V_{SAT}$	–	1.3	1.55	$V_{PP}$		At IF load 300 $\Omega$ differential
Low level output	$Sat-Flag_{low}$	–	–	0.8	V		–
High level output	$Sat-Flag_{high}$	2.4	–	–	V		–
Load capacitance	$CL_{Sat-Flag}$	–	–	30	pF	■	–
Load resistance	$RL_{Sat-Flag}$	10	–	–	k $\Omega$	■	–
IF saturation flag setup time	$T_{setup_{Sat-Flag}}$	–	–	22.5	ns	■	–
IF saturation flag hold time	$T_{hold_{Sat-Flag}}$	–	–	22.5	ns	■	–

## 1 Electrical Characteristics

Note: All saturation detection signals are logical OR combined to one discrete output signal.

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

### 1.7 Sensor Multiplexer

**Table 7** Electrical Characteristics

$V_{CC} = 3.135\text{ V to }3.465\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , application and MMIC external circuit acc. to Application Note AN358, all voltages with respect to ground (unless otherwise specified)

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
Output impedance	$R_{OUTmux}$	–	20	40	$\Omega$	■	at pin ANA_OUT; multiplexer output activated

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

For more information on the sensor multiplexer refer to [Chapter 4](#) and to application note AN358.

### 1.8 Temperature Sensor

**Table 8** Electrical Characteristics

$V_{CC} = 3.3\text{ V}$ ,  $T_A = -40\text{ °C to }125\text{ °C}$ , application and MMIC external circuit acc. to Application Note AN358, all voltages with respect to ground (unless otherwise specified).

Parameter	Symbol	Values			Unit	Test	Note or Test Condition
		Min.	Typ.	Max.			
Temperature sensor operating range <sup>(1)</sup>	$T_{TSENS}$	-40	–	125	$^{\circ}\text{C}$	■	–
Output voltage	$V_{SENSE25}$	1.4	1.5	1.6	V		at $T_{Si} = 25\text{ °C}$
Sensitivity <sup>(1)</sup>	$S_{TSENS}$	4.3	4.7	5.1	mV/K	■	–
Setup time <sup>(1)</sup>	$t_{TSENS}$	–	–	20	$\mu\text{s}$	■	$C_{Load} \leq 30\text{ pF}$ , $R_{Load} \geq 10\text{ k}\Omega$
Power supply rejection ratio	$PSRR$	10	24	–	dB	■	measured at $T_{Si} = 25\text{ °C}$ and $V_{CC,MIN}/V_{CC,MAX}$

(1) Guaranteed by device design, not subject to production test

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

**2 Pin Description**

**2 Pin Description**

**Table 9 Pin Definition and Function**

Pin No.	Name	Function
1	IF_TEST	IF test signal
2	VCC	Supply voltage
3	n.c	connected to ground acc. to AN358
4	LO_IN	LO input signal
5	n.c.	connected to ground acc. to AN358
6	SPI_DO	SPI data output
7	SPI_EN	SPI enable
8	SPI_CLK	SPI clock
9	SPI_DI	SPI data input
10	ANA_OUT	Analog output signal / saturation flag
11	VEE	Ground
12	RX1	RF input receiver 1
13	n.c.	connected to ground acc. to AN358
14	IF2X	Complementary IF output receiver 2
15	IF2	IF output receiver 2
16	IF1X	Complementary IF output receiver 1
17	IF1	IF output receiver 1
18	n.c.	connected to ground acc. to AN358
19	RX2	RF input receiver 2
20	n.c.	connected to ground acc. to AN358
21	VEE.	Ground
22	IFX_TEST	Complementary IF test signal
23	n.c.	connected to ground acc. to AN358
24	RX3	RF input receiver 3
25	n.c.	connected to ground acc. to AN358
26	IF4	IF output receiver 4
27	IF4X	Complementary IF output receiver 4
28	IF3	IF output receiver 3
29	IF3X	Complementary IF output receiver 3
30	n.c.	connected to ground acc. to AN358
31	RX4	RF input receiver 4
32	VEE	Ground

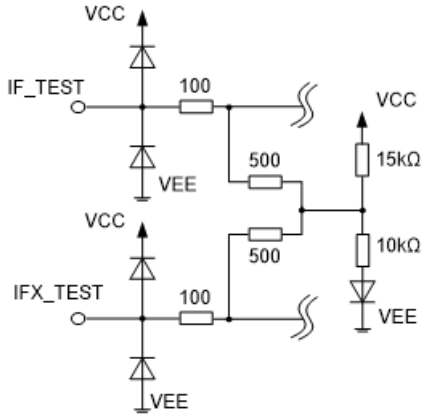
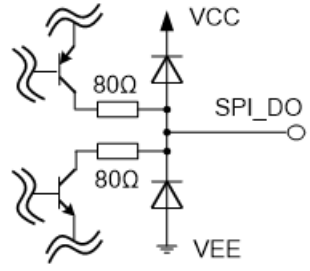
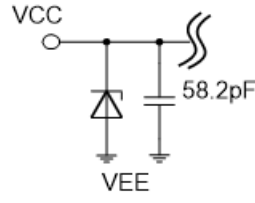
**2 Pin Description**

**Table 10 I/O internal circuits**

Pin No.	Name	I/O internal circuits
4, 12, 19, 24, 31	LO_IN, RX1, RX2, RX3, RX4	
14, 15, 16, 17, 26, 27, 28, 29	IF2X, IF2, IF1X, IF1, IF4, IF4X, IF3, IF3X	
9	SPI_DI	
7, 8	SPI_EN, SPI_CLK	
10	ANA_OUT	

**2 Pin Description**

**Table 10 I/O internal circuits (continued)**

Pin No.	Name	I/O internal circuits
1, 22	IF_TEST, IFX_TEST	
6	SPI_DO	
2	VCC	

**3 SPI**

**3 SPI**

Communication to the receiver is done via a Serial-Peripheral-Interface (SPI). The 32 bit SPI has a hardwired Power-On reset, which sets the output bits to a defined state after turning on the supply voltage. Data transmission is started by a negative edge on SPI\_EN. Data at SPI\_DI is then read at the falling edge of SPI\_CLK. The most significant bit (MSB) is read first.

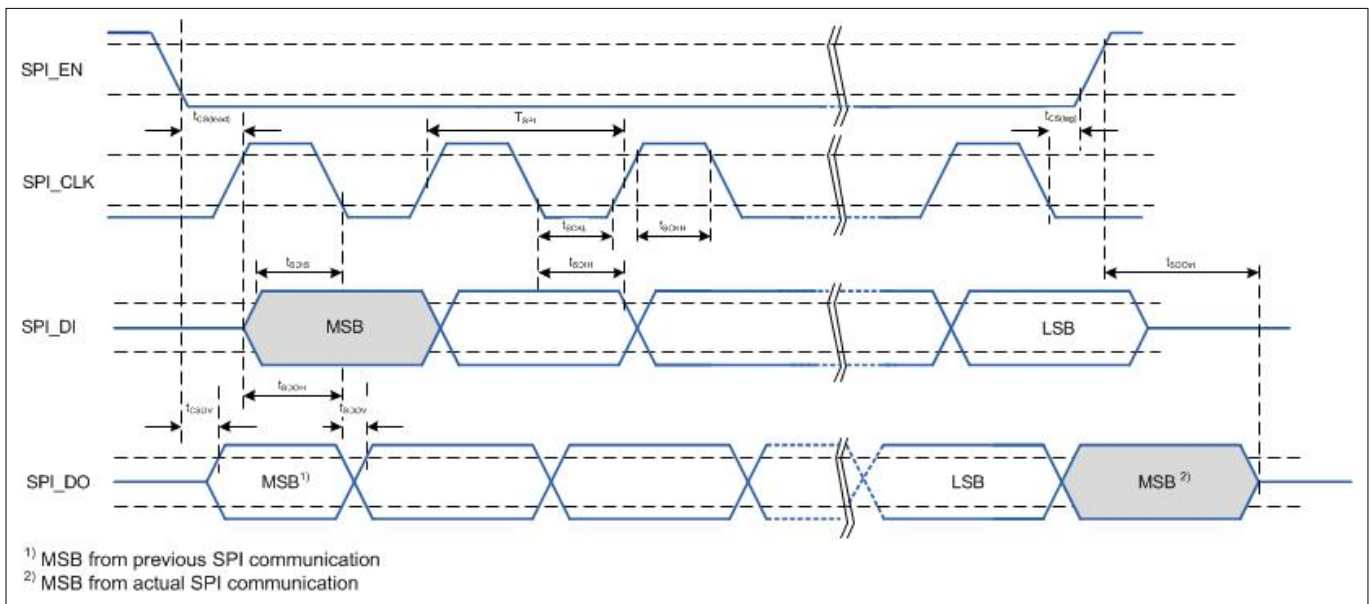
**Table 11 SPI Data Bit Description**

<b>Data Bit</b>	<b>Name</b>	<b>Description (Logic High)</b>	<b>Power ON Reset State</b>
0 (LSB)	EN_34	Enables mixer and base band amplifier output stage and supporting functions (for RX3 and RX4)	Low
1	LG1_34	Activates 6dB gain stage of base band amplifier 1 (for RX3 and RX4)	Low
2	HG1_34	Activates 12dB gain stage of base band amplifier 1 (for RX3 and RX4)	Low
3	LG2_34	Activates 6dB gain stage of base band amplifier 2 (for RX3 and RX4)	Low
4	MG2_34	Activates 12dB gain stage of base band amplifier 2 (for RX3 and RX4)	Low
5	HG2_34	Activates 18dB gain stage of base band amplifier 2 (for RX3 and RX4)	Low
6	IFTEST4	Activates test signal for IF channel 4	Low
7	IFTEST3	Activates test signal for IF channel 3	Low
8	IFTEST2	Activates test signal for IF channel 2	Low
9	IFTEST1	Activates test signal for IF channel 1	Low
10	PC1	Test bit	High
11	PC2	Test bit	High
12	EN_RF14	Test bit	Low
13	EN_RF23	Test bit	Low
14	DIS_DIV	Test bit	High
15	DIS_LO	Test bit	High
16	EN_12	Enables mixer and base band amplifier output stage and supporting functions (for RX1 and RX2)	Low
17	LG1_12	Activates 6dB gain stage of base band amplifier 1 (for RX1 and RX2)	Low
18	HG1_12	Activates 12dB gain stage of base band amplifier 1 (for RX1 and RX2)	Low
19	LG2_12	Activates 6dB gain stage of base band amplifier 2 (for RX1 and RX2)	Low
20	MG2_12	Activates 12dB gain stage of base band amplifier 2 (for RX1 and RX2)	Low

**3 SPI**

**Table 11 SPI Data Bit Description (continued)**

Data Bit	Name	Description (Logic High)	Power ON Reset State
21	HG2_12	Activates 18dB gain stage of base band amplifier 2 (for RX1 and RX2)	Low
22	AMUX_SEL0	Sets analog multiplexer	Low
23	AMUX_SEL1	Sets analog multiplexer	Low
24	AMUX_SEL2	MSB to set analog multiplexer	Low
25	SAT_FLAG_HIZ	Sets sat flag output into high impedance state and enables multiplexer output to be active	Low
26	DCO_3	Test bit	Low
27	SENSOR_SEL0	Selects power sensor signal	Low
28	SENSOR_SEL1	MSB to select power sensor signal	Low
29	DCO_0	Test bit	Low
30	DCO_1	Test bit	Low
31 (MSB)	DCO_2	Test bit	Low



**Figure 2 Timing Diagram of the SPI**

**Table 12 SPI Interface**

Parameter	Symbol	Values			Unit	Test
		Min.	Typ.	Max.		
SPI_CLK period	$t_{SPI}$	50	-	-	ns	
SPI_CLK low time	$t_{SCKL}$	$0.45 t_{SPI}$	$0.5 t_{SPI}$	$0.55 t_{SPI}$	ns	■
SPI_CLK high time	$t_{SCKH}$	$0.45 t_{SPI}$	$0.5 t_{SPI}$	$0.55 t_{SPI}$	ns	■
Chip select lead time	$t_{CS(lead)}$	20	-	-	ns	■



**3 SPI**

**Table 12 SPI Interface (continued)**

Parameter	Symbol	Values			Unit	Test
		Min.	Typ.	Max.		
Time between falling edge of SPI_CLK and SPI_DO valid	$t_{SDOV}$	–	–	10	ns	■
Setup time of SPI_DI before falling edge of SPI_CLK	$t_{SDIS} = t_{SI(su)}$	10	–	–	ns	■
Hold time of SPI_DI after falling edge of SPI_CLK	$t_{SI(h)}$	10	–	–	ns	■
Hold time of SPI_DO after rising edge of SPI_CLK	$t_{SDOH}$	$t_{SCKH}$ -10ns	–	–	ns	■
Hold time of SPI_EN after last falling edge of SPI_CLK	$t_{CS(lag)}$	30	–	–	ns	■
Delay between rising edge of SPI_EN and SPI_DO tristate (leakage current < 12µA)	$t_{SDOtri}$	–	–	100	ns	■
Delay between falling edge of SPI_EN and MSB at SPI_DO tristate valid	$t_{CSDV}$	–	–	125	ns	■
Minimum time between two SPI commands	$t_{min2SPI}$	5	–	–	µs	■

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

**Table 13 Specification for SPI pins**

Parameter	Symbol	Values			Unit	Test
		Min.	Typ.	Max.		
High level input voltage	$V_{I\_high}$	2.0	–	–	V	■
Low level input voltage	$V_{I\_low}$	–	–	0.8	V	■
Input voltage hysteresis	$V_{hys}$	50	–	–	mV	■
Input current	$I_{IN}$	-150	–	150	µA	
Input capacitance (EN, CLK, DI)	$CS_{IN}$	–	–	2	pF	■
SPI_DO output high voltage (VCC=3.3V, $I_{SDO} = 1mA$ )	$V_{O\_high}$	2.4	–	–	V	
SPI_DO output low voltage (VCC=3.3V, $I_{SDO} = 1mA$ )	$V_{O\_low}$	–	–	0.8	V	
SPI_DO load capacitance	$CSL_{DO}$	–	–	30	pF	■
SPI_DO load resistance	$RSL_{DO}$	10	–	–	kΩ	■

**4 Sensor Multiplexer**

**Table 13** Specification for SPI pins (continued)

Parameter	Symbol	Values			Unit	Test
		Min.	Typ.	Max.		
Pull Up resistor (SPI_DI) $T_A = 25\text{ °C}$	RPL_SPI_DI	78	98	118	kΩ	■
Pull Up resistor (SPI_CLK, SPI_EN) $T_A = 25\text{ °C}$	RPL_SPI_CLK, RPL_SPI_EN	39	49	59	kΩ	■
Leakage current @ SPI_DO in high Z state (Testvoltage 2.4 V)	IL DO	–	–	12	μA	

**Attention:** Test ■ means that the parameter is not subject to production test. It was verified by design / characterization.

**4 Sensor Multiplexer**

Output signals of the temperature and LO output level sensor are provided multiplexed at the output pin ANA\_OUT using an analog multiplexer (AMUX) circuit.

Additionally, a MMIC internal band gap reference voltage can be read out.

For more information on the sensor multiplexer refer to application note AN358.

**Table 14** Truth Table AMUX<sup>(1)</sup>

Output signal ANA_OUT	AMUX1_SEL2	AMUX1_SEL1	AMUX1_SELO
Temperature sensor output voltage	0	0	X
Sensor Output (see <a href="#">Table 15</a> )	0	1	0
Band gap voltage	1	0	0

(1) No valid output for deviating states

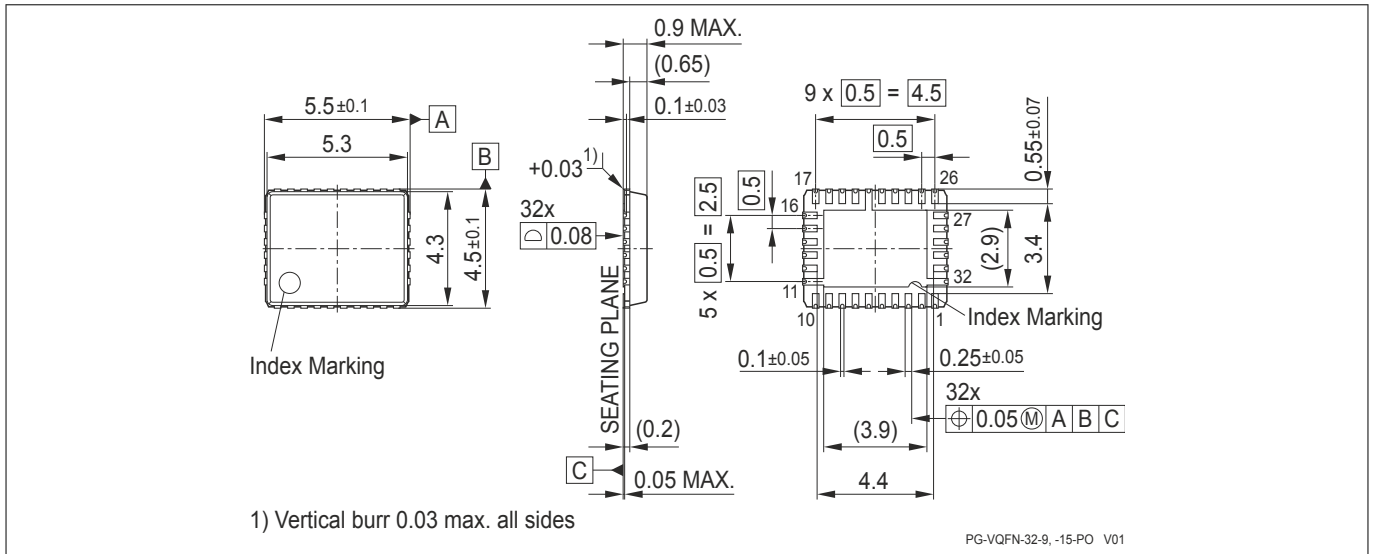
**Table 15** Sensor Configuration<sup>(1)</sup>

Sensor Output	Sensor_SEL1	Sensor_SELO
LO Power sensor	0	0

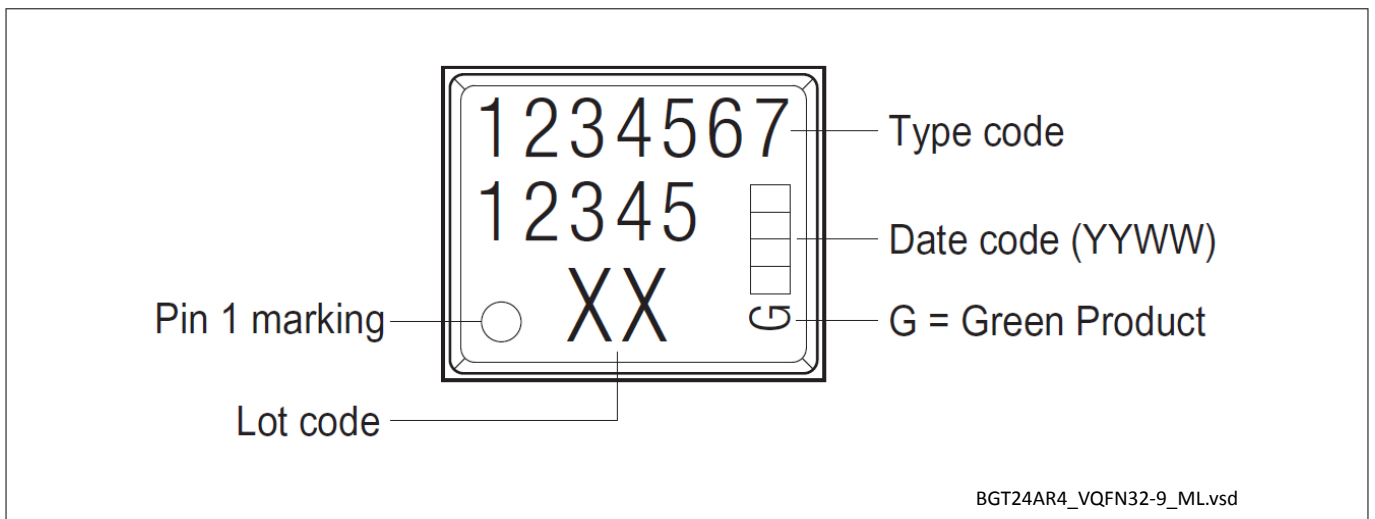
(1) No valid output for deviating states

**5 Package Dimensions**

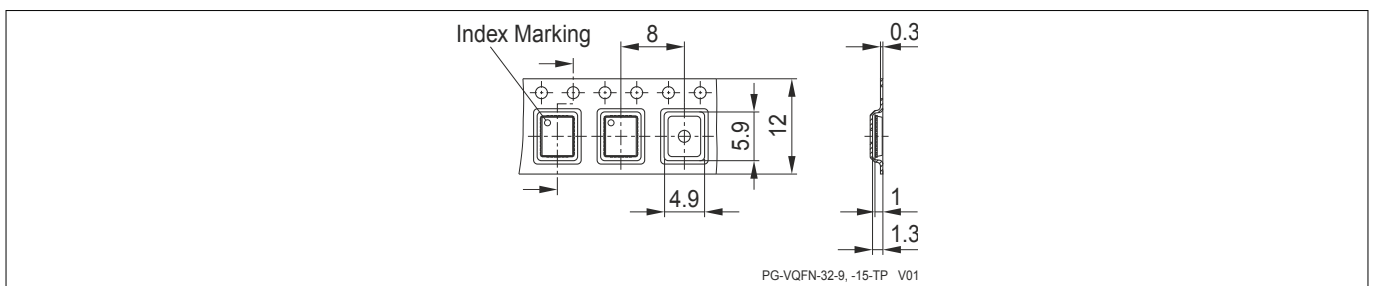
**5 Package Dimensions**



**Figure 3 Package Outline (Top, Side and Bottom View) of VQFN32-9**



**Figure 4 Marking Layout VQFN32-9 (example)**



**Figure 5 Tape of VQFN32-9, Ø Reel: 330 mm, Pieces / Reel: 3000, Reels / Box: 1**

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