## Features

- Integrated RF transceiver and modem for Bluetooth wireless technology.

- Manufactured using low-power 0.18-micron CMOS process technology.

- Digital baseband interface connects directly to an integrated Bluetooth controller.

- Direct conversion RF architecture improves receiver-blocking performance.

- Low out-of-band spurious emissions minimize interference with mobile phone operations.

- Hardware AGC dynamically adjusts receiver performance in changing environments.

- 50 Ω RF I/O does not need additional external impedance matching components.

- On-chip voltage regulation simplifies system design.

- -88 dBm receiver sensitivity and +2 dBm transmitter power typical performance specifications.

- Bluetooth Specification V2.0 qualified. Complies with Bluetooth specifications V1.1, V1.2 and V2.0.

Applications

- Mobile phones with integrated controller for Bluetooth wireless technology.
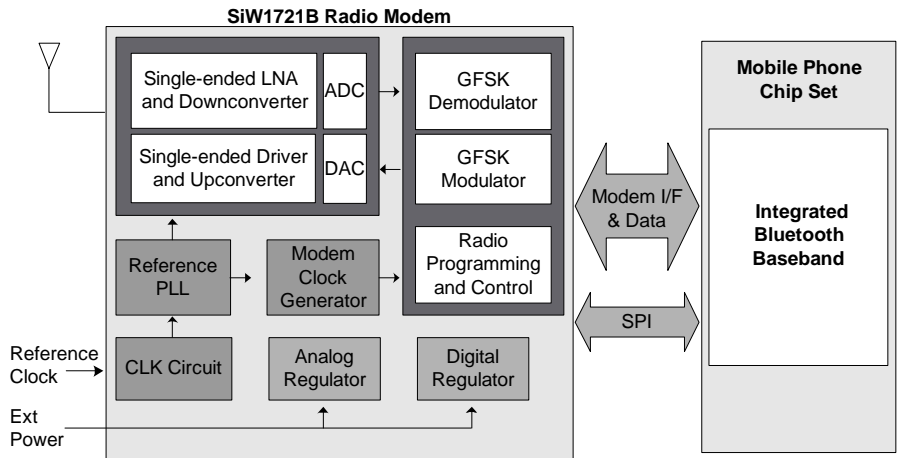
Bluetooth Subsystem Using the SiW1721B Radio Modem

Summary

The SiW1721B is a 2.4-GHz radio transceiver for Bluetooth wireless technology. This highly integrated transceiver is specifically designed for use with a third party Bluetooth baseband controller chipset requiring an external Bluetooth RF transceiver. Due to its low power CMOS process, the design minimizes current draw in both active and standby modes.

The SiW1721B combines a radio transceiver and Gaussian Frequency Shift Keying (GFSK) modem with digital control and interface logic. The IC also incorporates analog and digital voltage regulators and a reference Phase Lock Loop (PLL) capable of accepting various reference clock frequencies. The level of integration enables a low system cost with fewer external components.

The SiW1721B is packaged in a 5-by-5-mm, Pb-free, 32-pin QFN package that meets RoHS (Green) requirements. Operating temperature range is guaranteed from -40°C to +85°C.

Optimum Technology Matching® Applied

☐ Si BJT	☐ GaAs HBT	☐ GaAs MESFET
☐ Si Bi-CMOS	☐ SiGe HBT	☑ Si CMOS
☐ GaInP/HBT	☐ GaN HEMT	☐ SiGe Bi-CMOS

Ordering Information

SiW1721B   Bluetooth® Radio Modem   See page 12 for details.

RF Micro Devices, Inc.
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Greensboro, NC 27409, USA

Tel (336) 664 1233
Fax (336) 664 0454
http://www.rfmd.com

Description

The following figure shows the SiW1721B Radio Modem functional block diagram. During the receive process, the radio signal is taken from the single-ended RF input pin that feeds into the low noise amplifier (LNA). The signal from the LNA is directly down-converted to I/Q baseband, filtered with an anti-aliasing filter, and converted to a digital signal with a high resolution analog-to-digital converter. The critical channel filtering is done in the digital domain for stable and repeatable performance. The signal is then processed by a high performance GFSK demodulator. The IC has multiple internal self-calibration circuits to maintain stable and repeatable performance from part-to-part as well as over the full temperature range.

The IC has two fully integrated regulators: one for the radio (analog regulator) and one for the digital logic (digital regulator). The digital regulator can be used to supply a Bluetooth baseband controller. Both regulators can be bypassed if external regulation is desired.

Note: When bypassing the analog regulator, the VBATT_ANA and VCC_OUT pins must be tied together and the external analog voltage (1.8 V) should be applied to the VBATT_ANA pin. When bypassing the digital regulator, the VBATT_DIG pin should be left unconnected and the external digital voltage (1.8 V) should be applied to the VBB_OUT pin.

The IC also provides power on reset and glitch-free clock start-up. A reference PLL can be enabled to support a number of different reference frequencies.

Digital control functions and a programming interface provide radio modem control and a flexible interface to external Bluetooth link controllers.

SiW1721B Block Diagram
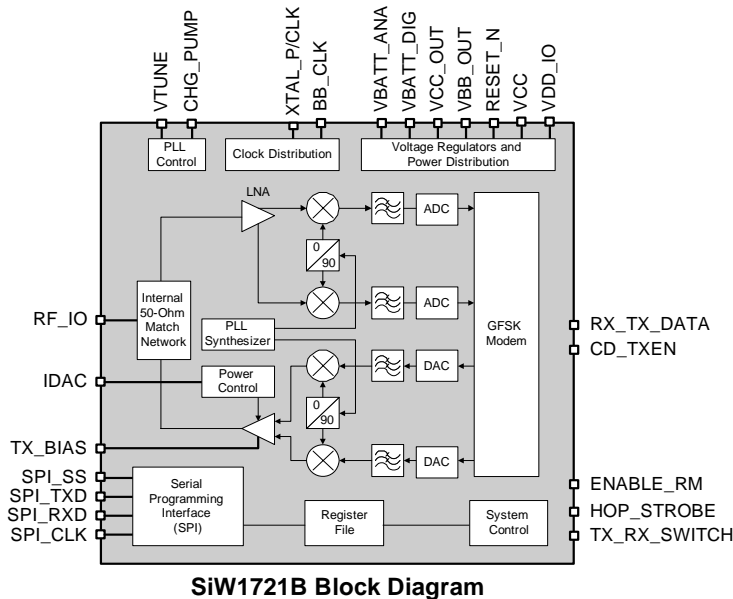
Radio Interface

An internal power control loop maintains a very stable RF_IO signal level over the full temperature range and from part to part. This means predictable and repeatable range at any temperature.

Modem Interface

The modem interface transfers the Bluetooth data between the SiW1721B Radio Modem and the ASIC. For reference purposes, the pin description table (Table 1) provides a brief description of typical interface modes.

Clock Signals

Multiple reference clock frequencies can be used as a reference for the RF circuits, to synthesize clocks for most of the internal digital circuits, and to supply external processors with timing signals.

Serial Programming Interface (SPI)

The serial programming interface (SPI) is used to access the internal registers of the SiW1721B Radio Modem. The SPI is a synchronous serial interface that can be clocked to a nominal speed of 8MHz.

Power

The SiW1721B Radio Modem includes both analog and digital voltage regulators. Input options are based on factors such as voltage source, where internal regulators are used, and I/O voltage.

Pin Description

The SiW1721B Radio Modem's radio and modem interface (SPI), a single clock input, and supply voltage are required for proper operation.

Name	Pad Type	Description
Radio Interface Signal Description		
RF_IO	Analog	Combined 50 Ω input and output pin in normal mode. Rx only in power class 1 mode.
IDAC	Analog	Power control to external power amplifier. This output provides a variable current source that can be used to control the external power amp. Leave unconnected if not used.
TX_RX_SWITCH	CMOS output	Output signal to indicate the current state of the radio. The polarity is programmable with the default set as: Low=Transmit mode. High=Non-transmit mode.
TX_BIAS	Analog	Bias for the output driver in normal mode, transmit output in power class 1 mode.
Modem Interface Description		
RX_TX_DATA	CMOS bi-directional	Received sliced-mode data from radio; or transmit data to radio.
CD_TXEN	CMOS bi-directional	Dual function carrier detect and transmit enable. This bi-directional signal can be enabled through internal registers. During transmit, this pin can be used as an INPUT to indicate valid transmit data (TXEN). During receive, this pin can be used as an OUTPUT to indicate carrier detect (CD). Input only, output, or bi-directional.
ENABLE_RM	CMOS input	Sleep/wake control signal from baseband controller. Used to command the SiW1721B Radio Modem from idle to sleep mode, and to awaken the SiW1721B Radio Modem from sleep mode.
HOP_STROBE	CMOS input	Signal generated by the baseband to indicate the start of TX or RX ramp-up.
RESET_N	CMOS input	Reset for digital circuits only. State machines and internal registers reset to their default state. This signal is an asynchronous input with a minimum pulse width requirement of 10 µs.
Clock Signals Description		
XTAL_P/CLK	Analog	System clock crystal positive input or reference clock input. For additional information see the "Crystal Requirements" and "External Reference Requirements" sections.
XTAL_N	Analog	System clock crystal negative input. If a reference clock frequency is used, this pin should be left unconnected.
BB_CLK	CMOS output	Selectable clock output to external baseband controller. Five frequencies are supported (in MHz): reference frequency, reference frequency/2, 12, 13, 16, 32, 48, and 52. BB_CLK stops oscillating when ENABLE_RM is de-asserted (low).
Serial Programming Interface Description		
SPI_TXD	CMOS output	SPI data output from SiW1721B.
SPI_RXD	CMOS input	SPI data input to SiW1721B.
SPI_CLK	CMOS input	Clock input used for synchronous data transfer on the SPI bus.
SPI_SS	CMOS input	SPI slave select that enables the SiW1721B Radio Modem as the target.
Power Signals Description		
VBATT_ANA	Power	Supply voltage to internal analog voltage regulator.
VBATT_DIG	Power	Supply voltage to internal digital voltage regulator.
VCC_OUT	Power	Regulated output from internal analog regulator.
VBB_OUT	Power	Regulated output from internal digital regulator.
VCC	Power	Supply voltage to on-chip analog circuits.
VDD_IO	Power	Supply voltage to on-chip I/O interface. I/O pins: BB_CLK, CD_TXEN, ENABLE_RM, HOP_STROBE, RESET_N, RX_TX_DATA, SPI_CLK, SPI_RXD, SPI_SS, SPI_TXD, TX_RX_SWITCH.
VBB_RDY	CMOS output	This signal is used to indicate that the internal digital regulator is stable (VBB_OUT).
Other I/O Description		
VREFP_CAP	Analog	Decoupling capacitor for voltage reference for the internal A/D converter.
VREFN_CAP	Analog	Decoupling capacitor for voltage reference for the internal A/D converter.
VTUNE	Analog	Pin for reference PLL loop filter.
CHG_PUMP	Analog	Pin for RF PLL loop filter.

Table 1. SiW1721B Radio Modem Pin List

SiW1721B

System Specifications
Absolute Maximum Ratings

Parameter	Description	Min	Max	Unit
V_{CC}	Analog circuit supply voltage	-0.3	3.63	V
V_{DD_IO}	I/O supply voltage	-0.3	3.63	V
V_{BATT_ANA}	Analog regulator supply voltage	-0.3	3.63	V
V_{BATT_DIG}	Digital regulator supply voltage	-0.3	3.63	V
T_{ST}	Storage temperature	-55	+125	°C
RF_{MAX}	Maximum RF input level	–	+5	dBm

Note: Absolute maximum ratings indicate limits beyond which the useful life of the device may be impaired or damage may occur.

Recommended Operating Conditions

Parameter	Description	Min	Max	Unit
T_{OP}	Operating temperature (industrial grade)	-40	+85	°C
V_{BATT_ANA}	Supply for internal analog voltage regulator	2.3	3.63	V
V_{BATT_DIG}	Supply for internal digital voltage regulator	2.3	3.63	V
V_{CC}	Analog supply voltage	1.71	1.89	V
V_{DD_IO}	Digital interface I/O supply voltage	1.62	3.63	V

ESD Rating

Symbol	Description	Rating
ESD	ESD protection - all pins[1]	2000 V

[1]This device is a high performance RF integrated circuit with an ESD rating of 2,000 volts (HBM conditions per Mil-Std-883, Method 3015). Handling and assembly of this device should only be done using appropriate ESD controlled processes.

Electrical Characteristics

DC Specification (T_{OP}=+25°C, V_{DD_IO}=3.0V)

Symbol	Description	Min.	Typ.	Max.	Unit
V_{IL}	Input low voltage	GND-0.1	–	$0.3*V_{DD\_IO}$	V
V_{IH}	Input high voltage	$0.7*V_{DD\_IO}$	–	V_{DD_IO}	V
V_{OL}	Output low voltage	GND	–	$0.2*V_{DD\_IO}$	V
V_{OH}	Output high voltage	$0.8*V_{DD\_IO}$	–	V_{DD_IO}	V
I_{OH}	Output high current	–	500	–	µA
	Output high current (pins 16, 19)	–	4	–	mA
I_{OL}	Output low current	–	500	–	µA
	Output low current (pins 16, 19)	–	4	–	mA
I_{ILI}	Input leakage current	–	<1	1	µA

AC Characteristics (T_{OP}=+25°C, V_{DD_IO}=3.0V, C_{LOAD}=15pF)

Symbol	Description	Min.	Typ.	Max.	Unit
t_r	Rise time	–	–	30	ns
	Rise time (pins 16, 19)	–	–	16	ns
t_f	Fall time	–	–	24	ns
	Fall time (pins 16, 19)	–	–	13	ns

Current Consumption (T_{OP}=+25°C, V_{BATT_ANA}, V_{BATT_DIG} = 3.3 V)

Symbol	Description	Min.	Typ.	Max.	Unit
I_{DD_SLEEP}	Current during sleep mode	–	15	25	µA
I_{DD_IDLE}	Current during idle, synthesizer not running	–	2	–	mA
$I_{DD\_TRANSMIT}$	Current during continuous transmit	–	41	45	mA
$I_{DD\_RECEIVE}$	Current during continuous receive	–	41	45	mA

Radio Specification

Parameter	Description	Min	Typ	Max	Unit
VCO operating range	Frequency	2402	–	2480	MHz
PLL lock time	–	–	55	100	µs

Receiver Specification[1]
(V_{BATT_ANA}, V_{BATT_DIG}=3.3V, V_{CC}=int. analog reg. output, and nominal[2] Bluetooth test conditions)

Parameter	Description	Min	Typ	Max	Unit
Receiver sensitivity	Measured based on BER<0.1%	–	-88	-82	dBm
Maximum usable signal	Measured based on BER<0.1%	-10	+5	–	dBm
C/I co-channel (0.1% BER)	Co-channel selectivity	–	8.0	11.0	dB
C/I 1MHz (0.1% BER)	Adjacent channel selectivity	–	-4.0	0	dB
C/I 2MHz (0.1% BER)	2nd adjacent channel selectivity	–	-38.0	-35.0	dB
C/I ≥3MHz (0.1% BER)	3rd adjacent channel selectivity	–	-43	-40	dB
Out-of-band blocking[3]	30 MHz to 2000 MHz	-10	–	–	dBm
	2000 MHz to 2399 MHz	-27	–	–	dBm
	2498 MHz to 3000 MHz	-27	–	–	dBm
	3000 MHz to 12.75 GHz	-10	–	–	dBm
Intermodulation	Max interferer level to maintain 0.1% BER, interference signals at 3 MHz and 6 MHz offset.	-39	-36	–	dBm
Receiver spurious emission	30 MHz to 1 GHz	–	–	-57	dBm
	1 GHz to 12.75 GHz	–	–	-47	dBm

[1]Measured into the chip with a 50 Ω source and no band pass filter.

[2]Nominal and extreme Bluetooth test conditions as defined by the Bluetooth Test Specification.

[3]Out-of-band blocking guaranteed by design.

Transmitter Specification[1]
(V$_{BATT\_ANA}$, V$_{BATT\_DIG}$ = 3.3 V, V$_{CC}$ = int. analog reg. output, and nominal Bluetooth test conditions)

Parameter	Description	Min	Typ	Max	Units
Output RF transmit power	At maximum power output level	-2	+2	+6	dBm
Modulation characteristics[2]	$\Delta f1_{avg}$	140	155	175	kHz
	$\Delta f2_{max}$ (For at least 99.9% of all $\Delta f2_{max}$)	115	–	–	kHz
	$\Delta f1_{avg}/\Delta f2_{avg}$	0.8	–	–	kHz
Initial carrier frequency accuracy	–	-75.0	–	+75.0	kHz
Carrier frequency drift	One slot packet	-25.0	–	+25.0	kHz
	Two slot packet	-40.0	–	+40.0	kHz
	Five slot packet	-40.0	–	+40.0	kHz
	Max drift rate	–	–	400	Hz/µs
20 dB occupied bandwidth	Bluetooth specification	–	900	1000	kHz
In-band spurious emission	2 MHz offset	–	-74	-55.0	dBm
	>3 MHz offset	–	-74	-55.0	dBm
Out-of-band spurious emission	30 MHz to 1 GHz, operating mode	–	-70	-55.0	dBm
	1 GHz to 12.75 GHz, operating mode[3]	–	-70	-50.0	dBm
	1.8 GHz to 1.9 GHz	–	–	-62.0	dBm
	5.15 GHz to 5.3 GHz	–	–	-47.0	dBm

[1]Measured into the chip with a 50 Ω source and no band pass filter.

[2]The modulation characteristic is measured as per test TRM/CA/07/C defined in the Bluetooth Test Specification.

[3]Except transmit harmonics.

Industrial Temperature Performance[1]
(V$_{BATT\_ANA}$, V$_{BATT\_DIG}$ = 3.3 V and extreme Bluetooth test conditions)

Parameter	Description	Min	Typ	Max	Unit
Receiver sensitivity	Measured based on BER<0.1%	–	-88	-78	dBm
Output RF transmit power	At maximum power output level	-4	+2	+6	dBm
Modulation characteristics[2]	$\Delta f1_{avg}$	140	155	175	kHz
	$\Delta f2_{max}$ (For at least 99.9% of all $\Delta f2_{max}$)	115	–	–	kHz
	$\Delta f1_{avg}/\Delta f2_{avg}$	0.8	–	–	kHz
Initial carrier frequency accuracy	–	-75.0	–	+75.0	kHz
Carrier frequency drift	One slot packet	-25.0	–	+25.0	kHz
	Two slot packet	-40.0	–	+40.0	kHz
	Five slot packet	-40.0	–	+40.0	kHz
	Max drift rate	–	–	+400	Hz/µs
20 dB occupied bandwidth	Bluetooth specification	–	900	1000	kHz
In-band spurious emission	2 MHz offset	–	-74	-40.0	dBm
	>3 MHz offset	–	-74	-55.0	dBm
Out-of-band spurious emission	30 MHz to 1 GHz, operating mode	–	-70	-55.0	dBm
	1 GHz to 12.75 GHz, operating mode[3]	–	-70	-40.0	dBm
	1.8 GHz to 1.9 GHz	–	–	-62.0	dBm
	5.15 GHz to 5.3 GHz	–	–	-47.0	dBm

[1]Measured into the chip with a 50 Ω source and no band pass filter.

[2]The modulation characteristic is measured as per test TRM/CA/07/C defined in the Bluetooth Test Specification.

[3]Except transmit harmonics.

External Reference Requirements

It is possible to provide a number of reference frequencies that are typical on most cellular phones directly into pin 26 (XTAL_P/CLK) of the SiW1721BFIG. The following reference frequencies (in MHz) can be used: 3.84, 9.6, 12, 12.8, 13, 14.4, 15.36, 16, 16.8, 19.2, 19.68, 19.8, 26, 32, 38.4, and 48. For other frequencies, please contact applications support.

Parameter	Description	Min	Max	Unit
Phase noise	100 kHz offset	–	-100	dBc/Hz
	1 kHz offset	–	-120	dBc/Hz
	10 kHz offset	–	-140	dBc/Hz
Drive level	AC coupled amplitude	0.5	V_{CC}	V_{P-P}
	DC coupled low peak voltage	0	0.3	V
	DC coupled high peak voltage	V_{CC} - 0.3	V_{CC}	V

Pin Out

(Top View)

SiW1721BFIG (32-pin QFN)

Note: NC indicates "no connect" or unused pins.
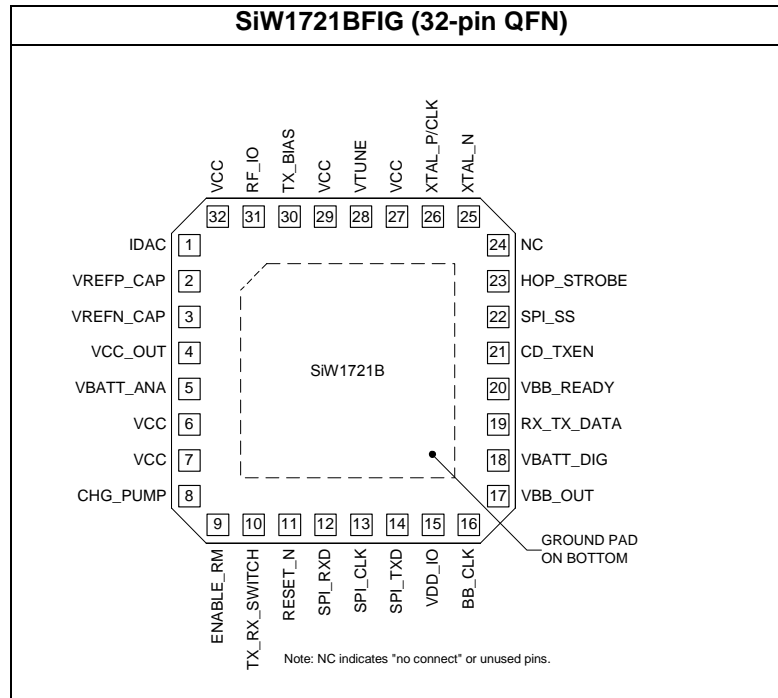
Pin Assignments

Pin	Pin Name	Pin	Pin Name
1	IDAC	17	VBB_OUT
2	VREFP_CAP	18	VBATT_DIG
3	VREFN_CAP	19	RX_TX_DATA
4	VCC_OUT	20	VBB_READY
5	VBATT_ANA	21	CD_TXEN
6	VCC	22	SPI_SS
7	VCC	23	HOP_STROBE
8	CHG_PUMP	24	NC
9	ENABLE_RM	25	XTAL_N
10	TX_RX_SWITCH	26	XTAL_P/CLK
11	RESET_N	27	VCC
12	SPI_RXD	28	VTUNE
13	SPI_CLK	29	VCC
14	SPI_TXD	30	TX_BIAS
15	VDD_IO	31	RF_IO
16	BB_CLK	32	VCC

Note: NC indicates no connect.

Radio Modem Application Circuit for Plastic QFN Package (SiW1721BFIG)

Place L1 close to pin 30 of the SiW1721B. Place C1 as close as possible to L1 and ensure the ground of C1 is as close as possible to the paddle of the SiW1721B.

Keep the traces from C2 and C3 to pins 25 and 26 of the SiW1721B short.

C4 and C9 must have 1 ohm < ESR < 10 ohms.

The ground for C10 needs to be as close as possible to the paddle of the SiW1721B. Keep the traces from R2 and C10 to pin 8 of the SiW1721B short.

C4 and C9 must have 1 ohm < ESR < 10 ohms.

ANTENNA

FL1
LFB312G45SG2A509
OUT IN

C1 8.2pF
L1 2.7nH
Y1 OSC, CRYSTAL 32MHz
C2 18pF
C3 18pF

C4 1uF
C5 2.7pF

L2 2.2nH
C6 0.1uF
C7 0.1uF

VDD_A

C8 1pF

C10 22pF
C11 180pF
R2 47K

U1
SiW1721B
5 mm x 5 mm

Pin 1 IDAC
Pin 2 VREFP_CAP
Pin 3 VREFN_CAP
Pin 4 VCC_OUT
Pin 5 VBATT_ANA
Pin 6 VCC
Pin 7 VCC
Pin 8 CHG_PUMP

Pin 32 VCC
Pin 31 RF_IO
Pin 30 TX_BIAS
Pin 29 VCC
Pin 28 VTUNE
Pin 27 VCC
Pin 26 XTAL_P/CLK
Pin 25 XTAL_N

Pin 24 NC
Pin 23 HOP_STROBE
Pin 22 SPI_SS
Pin 21 CD_TXEN
Pin 20 VBB_READY
Pin 19 RX_TX_DATA
Pin 18 VBATT_DIG
Pin 17 VBB_OUT

Pin 9 ENABLE_RM
Pin 10 TX_RX_SWITCH
Pin 11 RESET_N
Pin 12 SPI_RXD
Pin 13 SPI_CLK
Pin 14 SPI_TXD
Pin 15 VDD_IO
Pin 16 BB_CLK

HOP_STROBE
SPI_SS
CD_TXEN
VBB_READY
RX_BB/TX_BB
VDD_D
C9 1uF

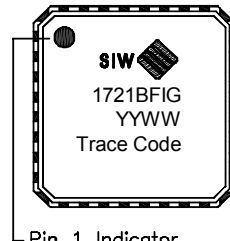CLK_REF
SPI_MIS0
SPI_CLK
SPI_MOSI
RESET_N
ENABLE_RM

Packaging and Product Marking
Package Drawing
32-Pin QFN Drawing and Dimensions

NOTES:
1. SHADED AREA INDICATES PIN 1 LOCATION.
2. ALL UNITS ARE IN MILLIMETERS.
3. TOLERANCES: .XX = ± AS SHOWN
   .XXX = ± AS SHOWN
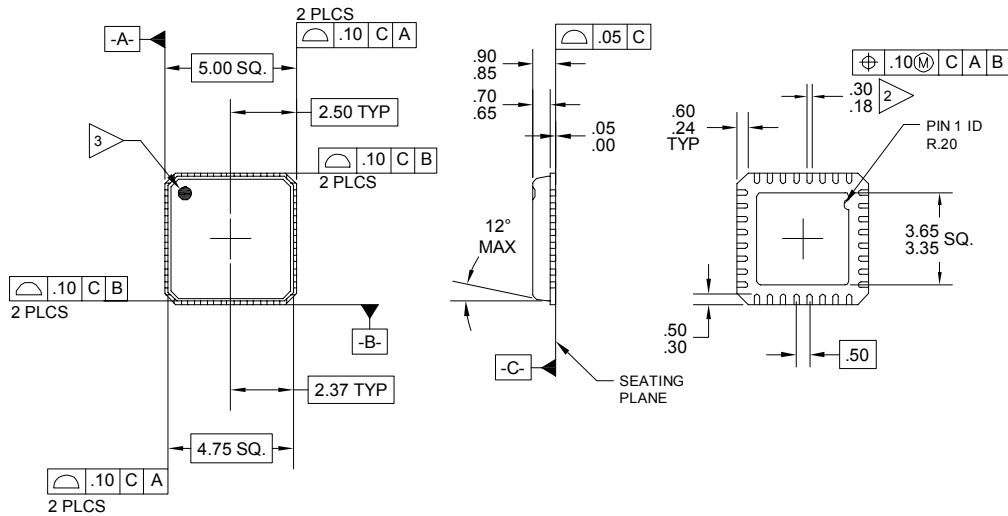
Product Marking
32-Pin QFN Drawing

5 x 5 mm, 32-Pin QFN

SIW

1721BFIG
YYWW
Trace Code

Pin 1 Indicator
Fill in the YYWW Notation
with the Date Code
YY = Year
WW = Week
Refer to P.O. for Trace
Code

Carriers
Tape and Reel
SiW1721BFIG, 5 X 5 mm, 32-Pin QFN, Tape and Reel Details

Carrier tape basic dimensions are based on EIA 481. The pocket is designed to hold the part for shipping and loading onto SMT manufacturing equipment, while protecting the body and the solder terminals from damaging stresses. The individual pocket design can vary from vendor to vendor, but width and pitch will be consistent.

Carrier tape is wound or placed onto a shipping reel either 330 mm (13 inches) in diameter or 178 mm (7 inches) in diameter. The center hub design is large enough to ensure the radius formed by the carrier tape around it does not put unnecessary stress on the parts.

Prior to shipping, moisture sensitive parts (MSL level 2a-5a) are baked and placed into the pockets of the carrier tape. A cover tape is sealed over the top of the entire length of the carrier tape. The reel is sealed in a moisture barrier ESD bag, which is placed in a cardboard shipping box. It is important to note that unused moisture sensitive parts need to be resealed in the moisture barrier bag. If the reels exceed the exposure limit and need to be baked, most carrier tape and shipping reels are not rated as bakeable at 125°C. If baking is required, devices may be baked according to section 4, table 4-1, column 8, of the Joint Industry Standard IPC/JEDEC J-STD-033A.

The following tables provide useful information for carrier tape and reels used for shipping the devices described in this document.
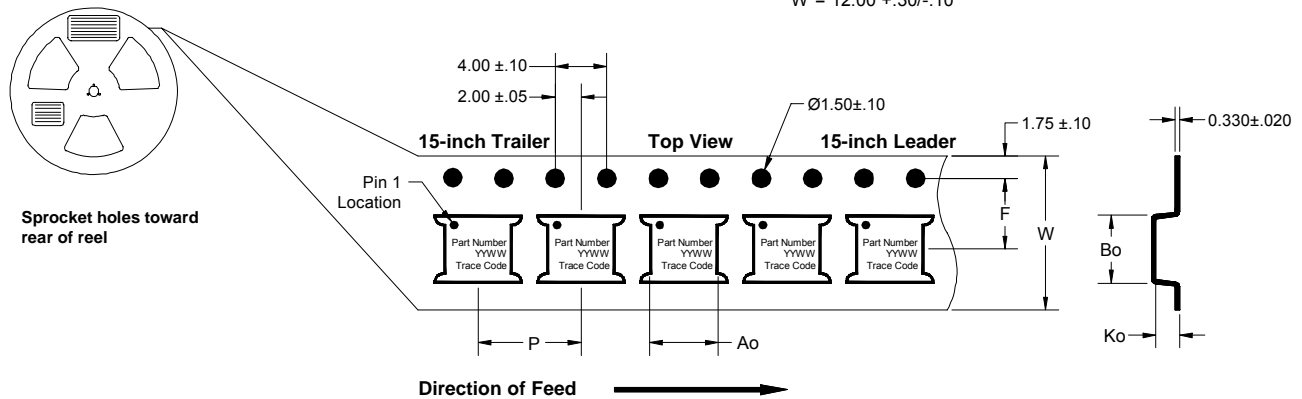
RFMD Part Number	Reel Diameter Inch (mm)	Hub Diameter Inch (mm)	Width (mm)	Pocket Pitch (mm)	Feed	Units
SiW1721BFIG-TR13	13 (330)	4 (102)	12	8	Single	2500/reel
SiW1721BFIGSR	7 (178)	2.4 (61)	12	8	Single	100/reel

Peel Test	Peel Angle	Cover Tape	Leader	Trailer	Peel Speed
10–50 grams	165-180º	RS Standard (anti-static)	500 mm (minimum 400 mm)	250 mm (minimum 160 mm)	300 mm/minute

Notes:
1. All dimensions are in millimeters (mm).
2. Unless otherwise specified, all dimension tolerances per EIA-481.

Ao = 5.30 ±.10
Bo = 5.30 ±.10
F = 5.50 ±.05
Ko = 1.83 ±.10
P = 8.00 ±.10
W = 12.00 +.30/-.10

SiW1721B

DETAIL "A"

- LOCK FEATURE 6 PLACES
- COUNTRY OF ORIGIN IF OTHER THAN USA
- SEE DETAIL "A"

330.00 +0.25 -4.00

102.0 REF

WIDTH (AT HUB)

Ø20.2 MIN
Ø13.0 +0.5 -0.2
2.0±0.5

ALL DIMENSIONS IN MILLIMETERS
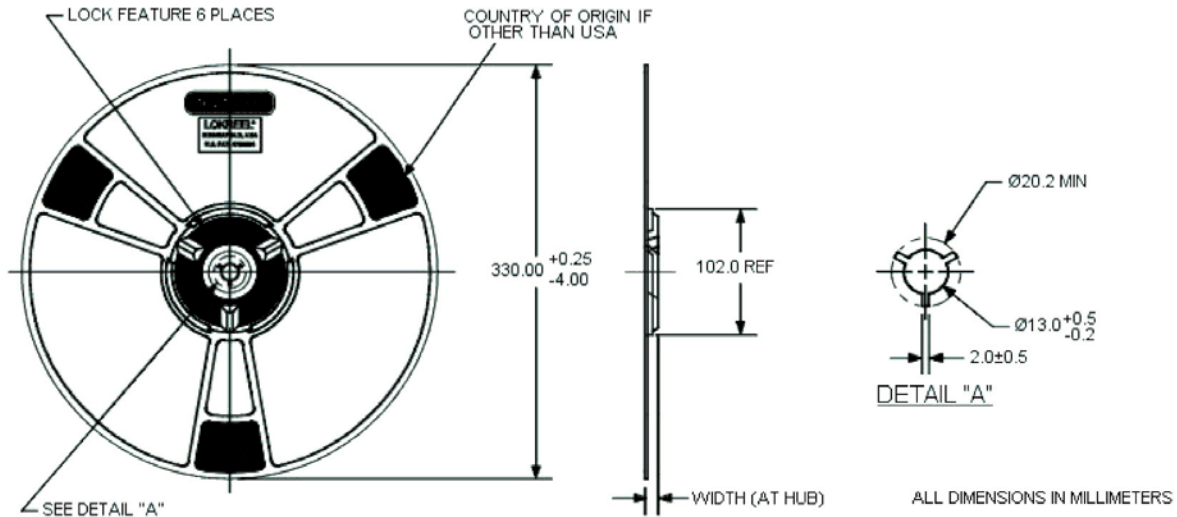
Ordering Information

Part Number	Operational Temperature Range[1]	Package	Ordering Quantity
SiW1721BFIG-T13	Industrial	32-pin QFN	2500/reel
SiW1721BFIGSR	Industrial	32-pin QFN	100/reel
SiW1721BFIG	Industrial	32-pin QFN	25/sample bag
SiW1721BFIGSB	Industrial	32-pin QFN	5/sample bag

[1] Industrial temperature range: -40°C to +85°C.