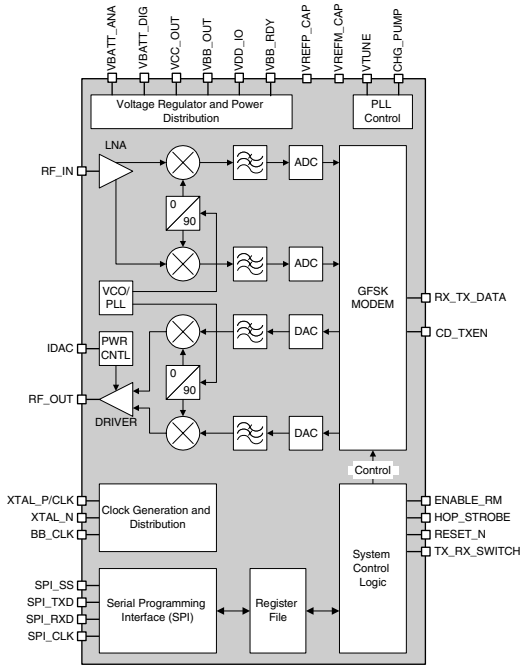
SiW1711

BLUETOOTH® RADIO MODEM

Bluetooth® Technology by Silicon Wave®

Features

- Single chip IC with 2.4 GHz transceiver and GFSK modem with digital interface to external baseband processor.
- Fully compliant with Bluetooth specification 1.1 and 1.2.
- Supports multiple external reference clocks or crystal frequencies with on-chip reference PLL.
- Direct-conversion architecture with no external channel filter or VCO resonator components.
- Single-ended RX/TX pins reduce system BOM cost by eliminating a balun. On-chip RX/TX switching eliminates external RX/TX switch.
- Typical -85 dBm receiver sensitivity with excellent interference rejection performance.
- Class 2 and 3 transmit output power up to +4 dBm with output power control loop for accurate power control.
- Hardware AGC dynamically adjusts receiver performance in changing environments.
- Low out-of-band spurious emissions prevents interference with mobile phone frequencies.
- Option for Class 1 designs with RX/TX switch control and multiple modes of gain control.
- On-chip voltage regulation simplifies voltage input requirement. Regulator bypass mode enables use of external regulator.
- 1.8 Volt analog and digital core voltages; 1.63 Volt to 3.63 Volt external I/O interface voltage.
- Low power consumption in active and standby modes.



Product Description

The SiW1711™ Radio Modem is Silicon Wave's third-generation radio modem for Bluetooth® wireless communications and is based on 0.18µm CMOS technology. This highly integrated transceiver was specifically designed to meet the rigorous RF performance required for integrating Bluetooth into mobile phone applications.

The SiW1711 Radio Modem combines a 2.4GHz radio transceiver and Gaussian Frequency Shift Keying (GFSK) modem with digital control functions. The IC also incorporates analog and digital voltage regulators, a reference Phase Lock Loop (PLL) to enable multiple input frequencies, and a power-on-reset (POR) circuit.

The SiW1711 Radio Modem uses direct conversion (zero-IF) architecture. This allows digital filtering for excellent interference rejection as compared to low IF solutions, and also results in fewer spurious responses. The receiver has excellent sensitivity due to a low noise RF design combined with an advanced modem design. A fast hardware AGC enables full discovery of any device within the dynamic range of the receiver (solves near-far issues). The transmitter can maintain a stable output power level up to +4dBm for class 2 operation, which in combination with the excellent receiver performance ensures the maximum possible range at the lowest system cost.

The device is available in a 32-pin QFN package with 5 x 5 x 1 mm dimensions. Known good die with bumps is also available. Operating temperature range is guaranteed from -40°C to +85°C with available extended high temperature range to 105°C.

Ordering Information

SiW1711	Bluetooth® Radio Modem

Optimum Technology Matching® Applied

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

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Description

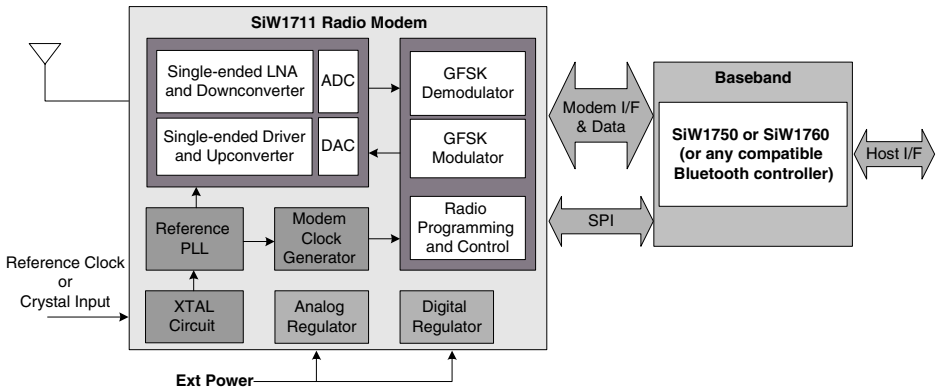
The following figure shows the SiW1711 Radio Modem functional block diagram. During the receive process, the radio signal is taken from the single ended RF input pin that feeds into the low noise amplifier (LNA). The signal from the LNA is directly down-converted to I/Q baseband, filtered with an anti-aliasing filter, and converted to digital 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 demodulator is programmable to support baseband ICs from multiple OEMs. Within the demodulator, data detection and timing recovery circuits convert the data for transfer to an external device. In addition, 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.

Note: Both regulators can be bypassed if external regulation is desired. 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 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.



Bluetooth Subsystem Using the SiW1711 Radio Modem

Radio Interface

The RF_IN and RF_OUT signals are combined using a simple matching circuit and then connected to a filter and the antenna. The signals are single-ended to save the cost and space of a balun.

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

For class 1 operation, the TX_RX_SWITCH and IDAC signals can be used to control a RX/TX switch and the gain of an external PA. This interface is programmable. Features include control of signal polarity, 3 modes of gain control and full programmability to linearize the PA gain control curve.

Modem Interface

The modem interface transfers the Bluetooth data between the SiW1711 Radio Modem and an external controller. For reference purposes, the pin description table provides a brief description of typical interface modes.

Clock Signals

Multiple reference clock frequencies (using either a crystal or an external reference source) 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 SiW1711 Radio Modem. The SPI is a synchronous serial interface that can be clocked to speeds up to 8 MHz.

Power

The SiW1711 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 SiW1711 Radio Modem's radio and modem interface, the serial programming interface (SPI), and a single clock input and supply voltage are required for proper operation. The following table provides detailed listings of pin descriptions arranged by functional groupings.

Name	Pad Type	Description
Radio Interface Signal Description		
RF_IN	Analog	RF signal input into the receiver.
RF_OUT	Analog	RF signal output from the transmitter.
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.
Modem Interface Description		
RX_TX_DATA	CMOS bi-directional	Received 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 SiW1711 Radio Modem from IDLE to SLEEP Mode, and to awaken the SiW1711 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): 12, 13, 16, 32, and 48. BB_CLK stops oscillating when ENABLE_RM is de-asserted (low).
Serial Programming Interface Description		
SPI_TXD	CMOS output	SPI data output port.
SPI_RXD	CMOS input	SPI data input port.
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 SiW1711 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. SiW1711 Radio Modem Pin List

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

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
T_{EOP}	Extended operating temperature	-40	+105	°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], human body model	2000 V
ESD	ESD protection - all pins, machine model	200 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}=3.0 V)

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}=3.0 V, C_{LOAD}=15 pF)

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	–	8	30	µA
I_{DD_IDLE}	Current during idle, synthesizer not running	–	3	5	mA
$I_{DD_TRANSMIT}$	Current during continuous transmit	–	55	65	mA
$I_{DD_RECEIVE}$	Current during continuous receive	–	68	75	mA

Digital Regulator Specification (T_{OP} = 25°C)

Parameter	Description	Min	Typ	Max	Unit
Output voltage	(I_{OUT} = 10 mA)	1.55	1.85	2.16	V
Line regulation	(I_{OUT} = 0 mA, V_{BATT_DIG} = 2.3 V to 3.63 V)	–	8.0	–	mV
Load regulation	(I_{OUT} = 3 mA to 80 mA)	–	9.0	–	mV
Dropout voltage	(I_{OUT} = 10 mA)	–	–	250	mV
Output maximum current	–	–	–	80	mA
Quiescent current	–	–	10	–	µA
Ripple rejection	f_{RIPPLE} = 400 Hz	–	40	–	dB

Internal Analog Voltage Regulator Specification (T_{OP}=+25°C, V_{BATT_ANA} = 3.3 V)

Parameter	Description	Min	Typ	Max	Unit
Output voltage (40 mA load)	–	1.71	1.80	1.89	V
Ripple rejection	–	–	20	–	dB

Radio Specification

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

RF Impedances

Parameter[1]	Description	Min	Typ	Max	Unit
RF impedance	TX On	–	448//0.6	–	Ω/pF
	TX Off	–	53.1//2.2	–	Ω/pF
	RX On	–	267//1.1	–	Ω/pF
	RX Off	–	23.4//0	–	Ω/pF

[1]The impedance values are for typical samples in 32-pin QFN package.

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	BER<0.1%	–	-85.0	-80.0	dBm
Maximum usable signal	BER<0.1%	-10	0	–	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]	30MHz to 2000MHz	-10	–	–	dBm
	2000MHz to 2399MHz	-27	–	–	dBm
	2498MHz to 3000MHz	-27	–	–	dBm
	3000MHz to 12.75GHz	-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	30MHz to 1GHz	–	–	-57	dBm
	1 GHz to 12.75 GHz	–	–	-47	dBm

[1]Measured with a proper matching circuit without bandpass filter.

[2]Nominal and extreme Bluetooth test conditions as defined by the Bluetooth Test and Interoperability Working Group published RF Test Specification 1.1.

[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	-2.0	+2.0	+6.0	dBm
Modulation Characteristics[2]	$\Delta f1_{avg}$	140.0	-155.0	-175.0	kHz
	$\Delta f2_{max}$ (For at least 99.9% of all $\Delta f2_{max}$)	-115.0	–	–	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	2MHz offset	–	-74.0	-55.0	dBm
	>3MHz offset	–	-74.0	-55.0	dBm
Out-of-band spurious emission	30MHz to 1GHz, operating mode	–	-70.0	-55.0	dBm
	1GHz to 12.75GHz, operating mode[3]	–	-70.0	-50.0	dBm
	1.8GHz to 1.9GHz	–	–	-62.0	dBm
	5.15GHz to 5.3GHz	–	–	-47.0	dBm

[1]Measured with a proper matching circuit without bandpass 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}=3.3V and extreme Bluetooth test conditions)

Parameter	Description	Min	Typ	Max	Units
Receiver sensitivity	BER<0.1%	–	-85.0	-75.0	dBm
Output RF transmit power	At maximum power output level	-4.0	+2.0	+6.0	dBm
Modulation Characteristics[2]	$\Delta f1_{avg}$	140.0	155.0	175.0	kHz
	$\Delta f2_{max}$ (For at least 99.9% of all $\Delta f2_{max}$)	115.0	–	–	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	2MHz offset	–	-74.0	-40.0	dBm
	>3MHz offset	–	-74.0	-55.0	dBm
Out-of-band spurious emission	30MHz to 1GHz, operating mode	–	-70.0	-55.0	dBm
	1GHz to 12.75GHz, operating mode[3]	–	-70.0	-40.0	dBm
	1.8GHz to 1.9GHz	–	–	-62.0	dBm
	5.15GHz to 5.3GHz	–	–	-47.0	dBm

[1]Measured with a proper matching circuit without bandpass 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 25 (XTAL_P/CLK) of the device. 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 MHz. 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

Crystal Requirements

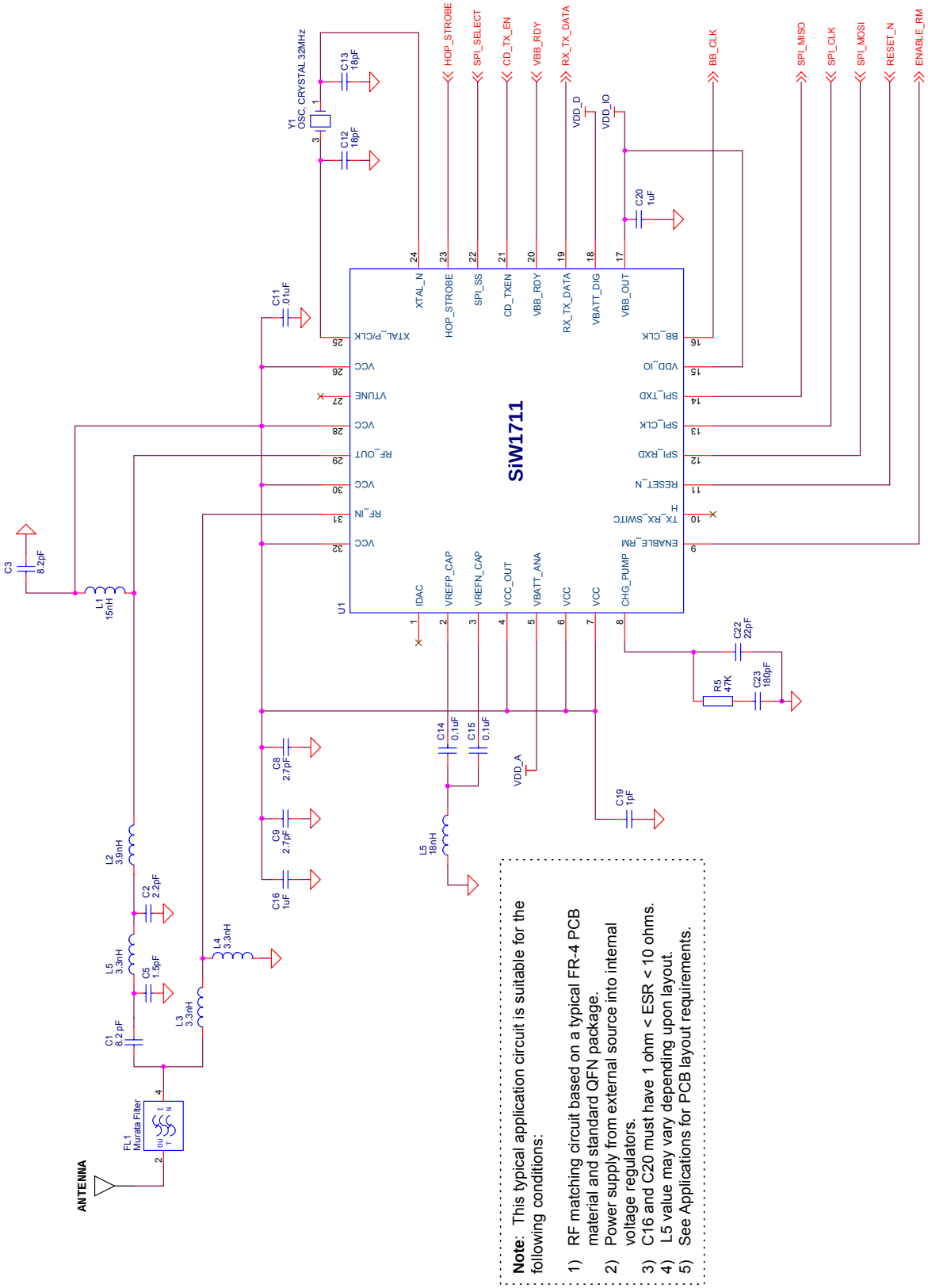
If using a crystal as the source for the reference frequency, the typical parameters are outlined below. The system clock crystal should operate in a fundamental, parallel resonant mode.

Parameter	Description	Min	Typ	Max	Units
Drive level	–	0.5	–	2.0	V_{P-P}
ESR	Effective serial resistance[1]	–	–	150	Ω
CO	Holder capacitance[2]	–	3.0	5.0	pF
CL	Load capacitance[2]	–	12.0	18.0	pF
CM	Motional capacitance	–	6.0	–	fF

[1]For 32MHz crystal.

[2]The actual values for CO and CL are dependent on the crystal manufacturer and can be compensated for by an internal crystal calibration capability.

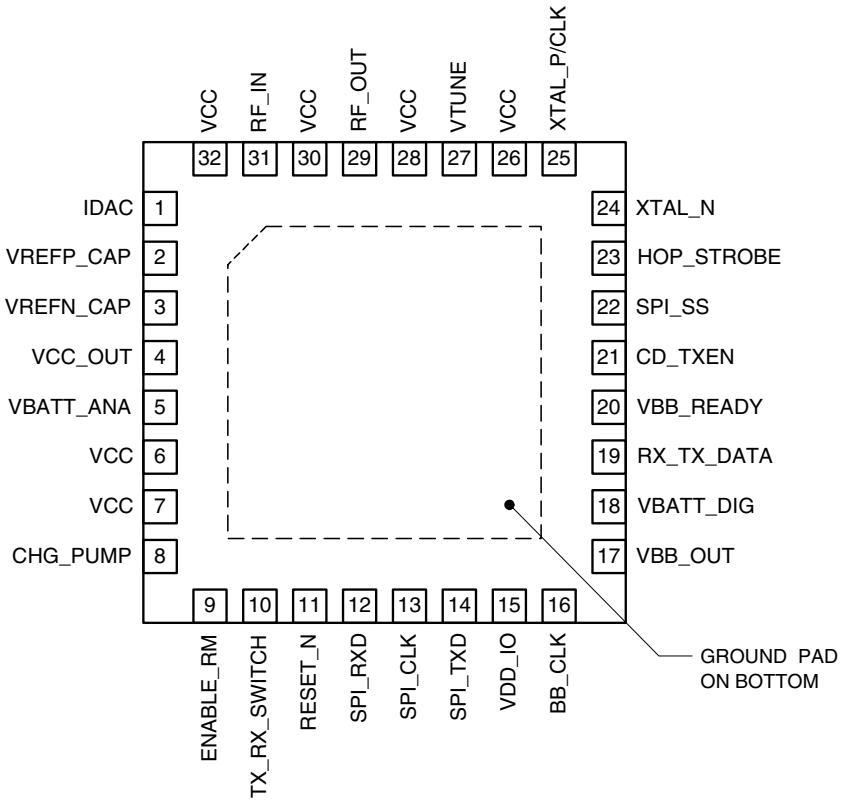
Radio Modem Application Circuit



Note: This typical application circuit is suitable for the following conditions:

1) RF matching circuit based on a typical FR-4 PCB material and standard QFN package.
2) Power supply from external source into internal voltage regulators.
3) C16 and C20 must have 1 ohm < ESR < 10 ohms.
4) L5 value may vary depending upon layout.
5) See Applications for PCB layout requirements.

Pin Out
(Top View)



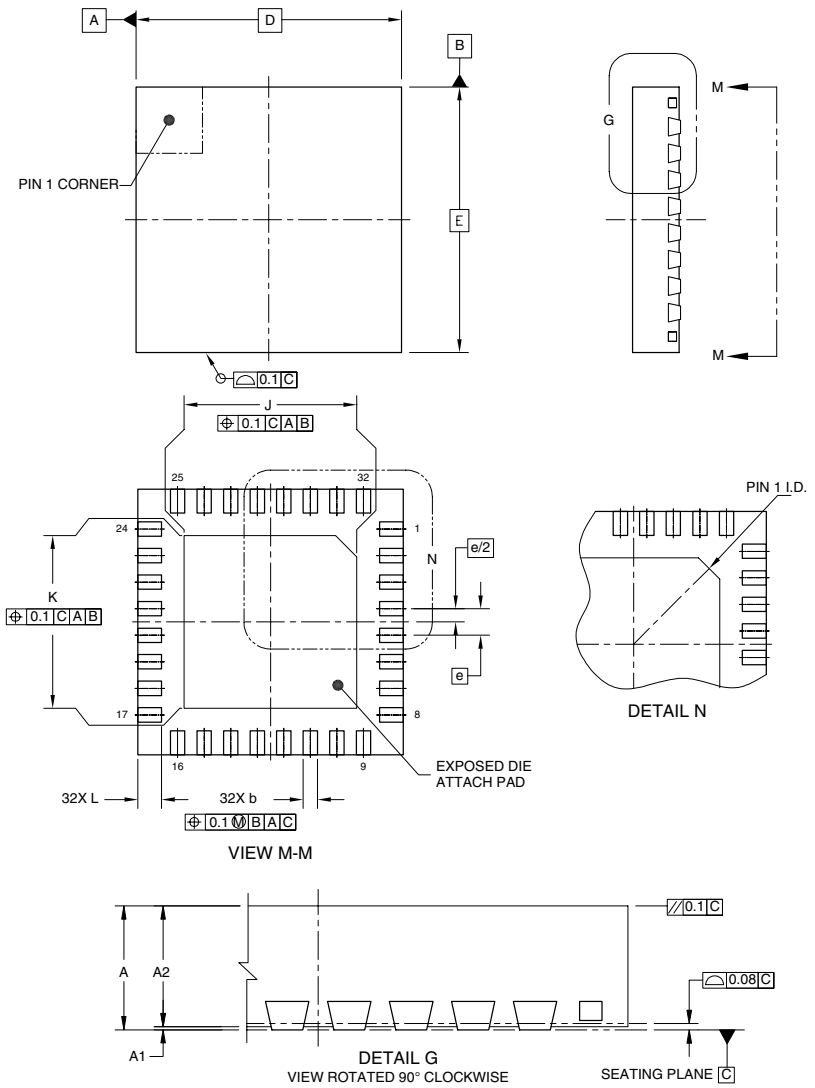
Pin Assignments

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	XTAL_N
9	ENABLE_RM	25	XTAL_P/CLK
10	TX_RX_SWITCH	26	VCC
11	RESET_N	27	VTUNE
12	SPI_RXD	28	VCC
13	SPI_CLK	29	RF_OUT
14	SPI_TXD	30	VCC
15	VDD_IO	31	RF_IN
16	BB_CLK	32	VCC

Packaging and Product Marking

Package Drawing

32-Pin, QFN Drawing and Dimensions



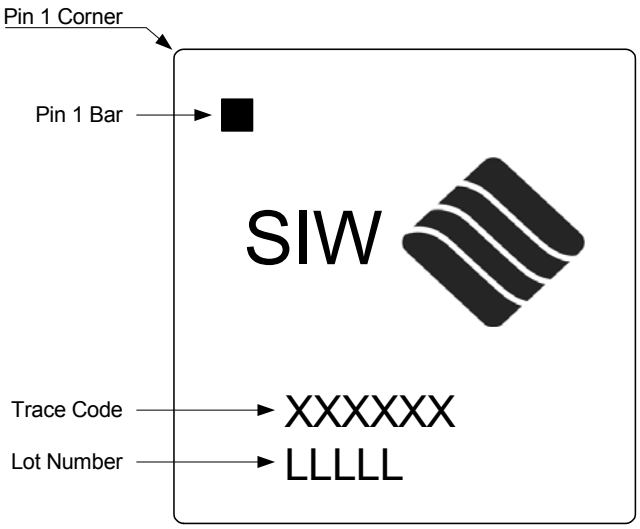
Symbol	Min	Nom	Max
A	0.8	–	1.0
A1	0	–	0.05
A2	0.75	–	1.0
b	0.18	0.25	0.3
D	5 BSC		
E	5 BSC		
e	0.5 BSC		
J	3.52	3.62	3.72
K	3.52	3.62	3.72
L	0.35	0.4	0.45

Notes:

1. Coplanarity applies to leads, corner leads, and die attach pads.
2. All dimensions in mm.

Product Marking

32-Pin, QFN Drawing



Part Number	Operational Temperature Range[1]	Package	Ordering Quantity
SiW1711FIF	Industrial	32-pin QFN	490 per tray
SiW1711FIF-T13	Industrial	32-pin QFN	5,000 on 13” reel
SiW1711DIF-B	Industrial	KGD with bumps	100 per waffle pack
SiW1711DIF-T13	Industrial	KGD with bumps	5,000 on 13” reel

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

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