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Integrated 802.11 b/g WLAN Module

FEATURES

- IEEE 802.11 b/g compliant.
- Typical WLAN Transmit Power:
  - +20.0 dBm, 1 Mbps, CCK (b)
  - +16.9 dBm, 54 Mbps, OFDM (g)
- Typical WLAN Sensitivity:
  - - 85 dBm, 8% PER,11 Mbps
  - -75 dBm, 10% PER, 54 Mbps
- Miniature footprint: 14 mm x 21 mm
- Low height profile: 2.3 mm
- Operating Voltage: 2.9V to 3.6V
- Operating temperature: -40 to +85° C
- Embedded network stack
- Wireless Security WEP, WPA Personal, WPA2 Personal
- Terminal for PCB/Chip antenna feeds
- Compact design based on Texas Instruments CC3000 transceiver
- SPI host interface
- Simple integration with microcontrollers and microprocessors
- Worldwide acceptance: FCC (USA), IC (Canada), and CE (Europe)
- Modular certification allows reuse of LSR FCC ID and ETSI certification without repeating the expensive testing on your end product
- RoHS compliant
- Streamlined development with LSR design services

APPLICATIONS

- Thermostats, appliances, HVAC controller, and remote displays, Smart Energy
- Home entertainment control
- Sensor Networks
- Medical
- Home Monitoring
- Toys

DESCRIPTION

The TiWi-SL is a high performance 2.4 GHz WLAN module that contains an IP networking stack in a pre-certified footprint that simplifies the process of implementing internet connectivity.

The module includes the necessary PHY, MAC, and network layers to support WLAN applications through a simple SPI connection to host microcontrollers or other embedded processors.

Need to get to market quickly? Not an expert in 802.11. Need a custom antenna? Would you like to own the design? Would you like a custom design? Not quite sure what you need? Do you need help with your host board? LS Research Design Services will be happy to develop custom hardware or software, or assist with integrating the design. Contact us at sales@lsr.com or call us at 262-375-4400.

- Home automation
- Home Network aggregators
- Remote appliance diagnostics/support
- Home security
- Remote storage devices
- Home network appliance
- Cameras and video surveillance
- Fitness
- Cable replacement for medical and personal healthcare

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ORDERING INFORMATION

Order Number	Description
450-0067	TiWi-SL Module (Tray, SPQ = 50)
450-0067R	TiWi-SL Module (Tape and Reel, SPQ = 1000)
450-0089	TiWi-SL EM Board with Chip Antenna

Table 1 Orderable TiWi-SL Part Numbers

MODULE ACCESSORIES

	Order Number	Description
	001-0001	2.4 GHz Dipole Antenna with Reverse Polarity SMA Connector
	080-0001	U.FL to Reverse Polarity SMA Bulkhead Cable 105mm

Table 2 Module Accessories

APPLICABLE DOCUMENTS

- TiWi-SL EM Board User Guide (330-0086)
- TiWi-SL Antenna Design Guide (330-0092)

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BLOCK DIAGRAM

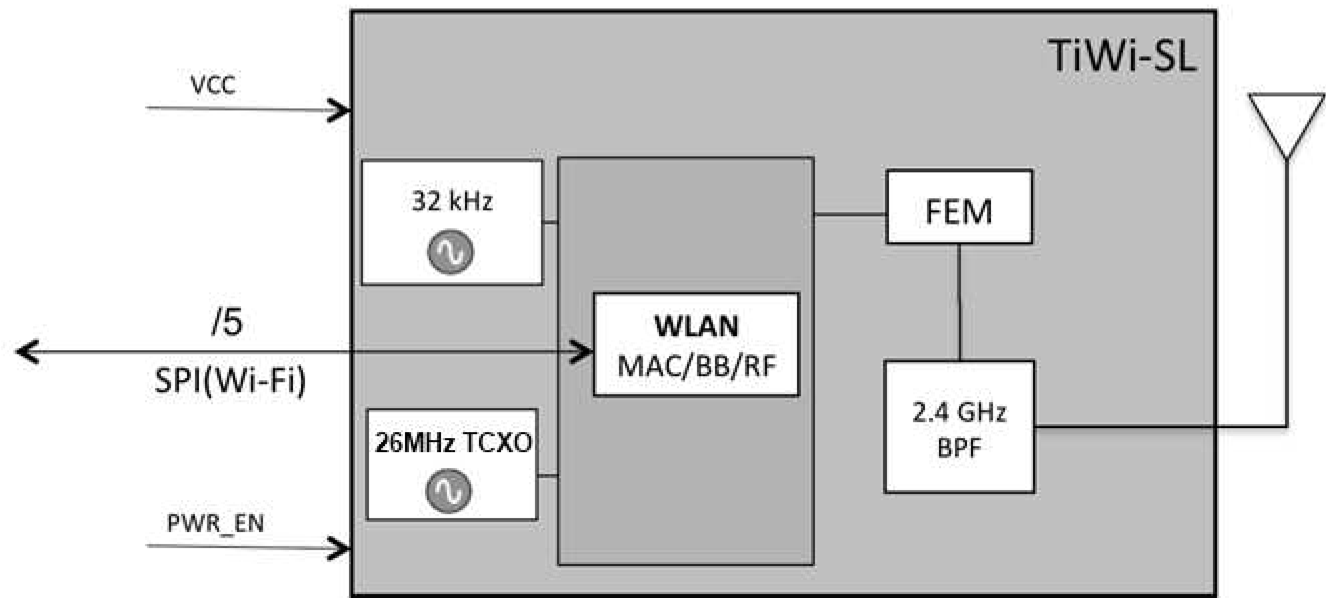

Figure 1 TiWi-SL Module Block Diagram – Top Level

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FUNCTIONAL BLOCK FEATURES

WLAN Features

- IEEE802.11b/g compliant WLAN MAC Baseband Processor and RF transceiver
- IEEE Std 802.11d,i PICS compliant
- Supports serial debug interface
- Supports Serial Peripheral Interface (SPI) Host Interface
- **Media Access Controller (MAC)**
    - Embedded ARM™ Central Processing Unit (CPU)
    - Hardware-Based Encryption/Decryption Using 64-, 128-Bit WEP, TKIP or AES Keys,
    - Supports requirements for Wireless Fidelity (Wi-Fi) Protected Access (WPA and WPA2.0) and IEEE
    - Std 802.11i [Includes Hardware-Accelerated Advanced-Encryption Standard (AES)]
- Baseband Processor
- **2.4GHz Radio**
    - Digital Radio Processor (DRP) implementation
    - Internal LNA
    - Supports : IEEE Std 802.11b, 802.11g, 802.11b/g

Network Stack Supported Protocols

- **Transport layer:**
    - TCP
    - UDP
- **Network layer:**
    - IPv4
    - Ping
    - DHCP
    - DNS Client
- **Link layer:**
    - ARP

Wireless Security System Features

- **Supported modes:**
    - Open (no security)
    - WEP
    - WPA-personal
    - WPA2-personal
- **Supported encryption types:**
    - WEP
    - TKIP
    - AES
    - Open

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TIWI-SL MODULE FOOTPRINT AND PIN DEFINITIONS

To apply the TiWi-SL module, it is important to use the module pins in your application as they are designated below, and in the corresponding pin definition table found on pages 8 and 9. Not all the pins on the TiWi-SL module may be used, as some are reserved.

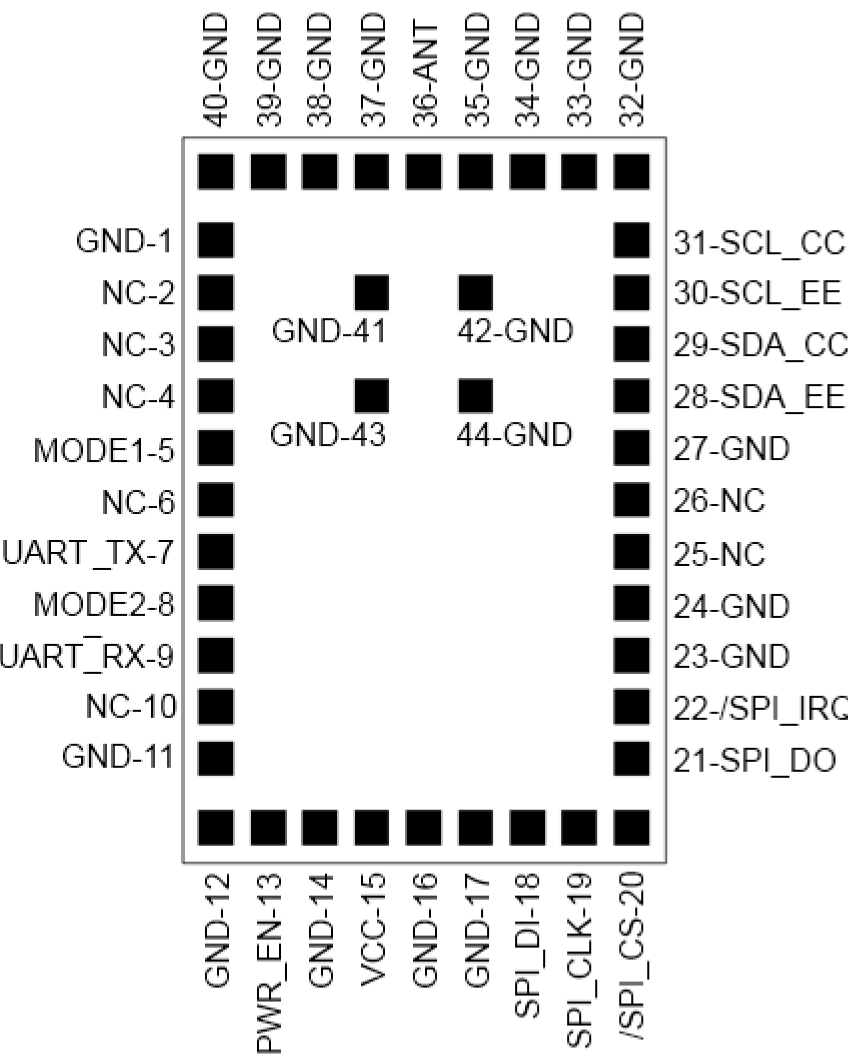

Figure 2 TiWi-SL Pinout

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PIN DESCRIPTIONS

Module Pin	Name	I/O Type	Buffer Type	Logic Level	Description
1	GND	GND	-	-	GROUND
2	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
3	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
4	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
5	MODE1	DI	-	-	MODE1 (SHORT TO MODE2 FOR NORMAL USE, SHORT TO GROUND FOR TEST USE)
6	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
7	UART_TX (1)	DO	-	1.8 VDC	TEST UART TX (1.8V LOGIC)
8	MODE2	DI	-	-	MODE2 (SHORT TO MODE1 FOR NORMAL USE, LEAVE OPEN FOR TEST USE)
9	UART_RX (1)	DI	-	1.8 VDC	TEST UART RX (1.8V LOGIC)
10	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
11	GND	GND	-	-	GROUND
12	GND	GND	-	-	GROUND
13	PWR_EN	DI	-	VCC	MODULE POWER ENABLE
14	GND	GND	-	-	GROUND
15	VCC	PI	-	-	POWER TO MODULE (2.9-3.6 VDC)
16	GND	GND	-	-	GROUND
17	GND	GND	-	-	GROUND
18	SPI_DI	DI	-	VCC	HOST INTERFACE SPI DATA IN
19	SPI_CLK	DI	-	VCC	HOST INTERFACE SPI CLOCK
20	/SPI_CS	DI	-	VCC	HOST INTERFACE SPI CHIP SELECT (ACTIVE LOW)
21	SPI_DO	DO	10mA	VCC	HOST INTERFACE SPI DATA OUT
22	/SPI_IRQ	DO	10mA	VCC	HOST INTERFACE SPI INTERRUPT (ACTIVE LOW)
23	GND	GND	-	-	GROUND
24	GND	GND	-	-	GROUND
25	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
26	NC	-	-	-	NO CONNECT (DO NOT CONNECT)
27	GND	GND	-	-	GROUND
28	SDA_EE (2)	DIO	-	1.8 VDC	I2C DATA LINE FROM EEPROM (1.8V LOGIC)
29	SDA_CC (2)	DIO	4mA	1.8 VDC	I2C DATA LINE FROM CC3000, PULLED UP INTERNALLY (1.8V LOGIC)
30	SCL_EE (3)	DI	-	1.8 VDC	I2C CLOCK LINE FROM EEPROM (1.8V LOGIC)

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Module Pin	Name	I/O Type	Buffer Type	Logic Level	Description
31	SCL_CC [(3)]	DO	4mA	1.8 VDC	I2C CLOCK LINE FROM CC3000, PULLED UP INTERNALLY (1.8V LOGIC)
32	GND	GND	-	-	GROUND
33	GND	GND	-	-	GROUND
34	GND	GND	-	-	GROUND
35	GND	GND	-	-	GROUND
36	ANT [(4)]	RF	-	-	ANTENNA, 50 OHMS
37	GND	GND	-	-	GROUND
38	GND	GND	-	-	GROUND
39	GND	GND	-	-	GROUND
40	GND	GND	-	-	GROUND
41	GND	GND	-	-	GROUND
42	GND	GND	-	-	GROUND
43	GND	GND	-	-	GROUND
44	GND	GND	-	-	GROUND

(1) These signals are test UART signals which are 1.8v logic, and they should be left unconnected for normal operation.
(2) The I2C data signals from the CC3000 and EEPROM must be connected together for normal operation.
(3) The I2C clock signals from the CC3000 and EEPROM must be connected together for normal operation.
(4) The antenna terminal presents a DC short circuit to ground.

PI = Power Input
DI = Digital Input
DO = Digital Output
DIO = Bi-directional Digital Port
RF = Bi-directional RF Port
GND=Ground

Table 3 TiWi-SL Module Pin Descriptions

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ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Power supply voltage (VCC)	-0.5	+3.8	V
Voltage on digital pins [1]	-0.5	VCC + 0.5	V
Voltage on EEPROM and UART test pins [2]	-0.5	2.1	V
RF input power, antenna port		+10	dBm
Operating temperature	-40	+85	ºC
Storage temperature	-55	+125	ºC

(1) This includes the SPI signals and the PWR_EN signal.
(2) These signals are not intended for general purpose use.

Table 4 Absolute Maximum Ratings

Recommended Operating Conditions

Parameter	Min	Typical	Max	Unit
VCC	2.9	3.3	3.6	V
Voltage on digital pins [1]	0	3.3	VCC	V
Voltage on EEPROM and UART test pins [2]	0		1.8	V
Ambient temperature range [3]	-30	25	75	ºC

(1) Applies to SPI signals.
(2) These signals are not intended for general purpose use.
(3) The device can be reliably operated for 5000 active hours cumulative at $T_{ambient}$ of 85C.

Table 5 Recommended Operating Conditions

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General Characteristics

DC Characteristics – UART/EEPROM I/O

Parameter	Test Conditions	Min	Typical	Max	Unit
Logic input low, V_{IL}		0	-	0.63	V
Logic input high, V_{IH}		1.7	-	1.8	V
Logic output low, V_{OL}	8mA	0	-	0.45	V
Logic output high, V_{OH}	8mA	1.4	-	1.8	V

Table 6 DC Characteristics General Purpose I/O

DC Characteristics – General Purpose I/O

Parameter	Test Conditions	Min	Typical	Max	Unit
Logic input low, V_{IL}		0	-	0.8	V
Logic input high, V_{IH}		2.0	-	VCC	V
Logic output low, V_{OL}	12mA	0	-	0.8	V
Logic output high, V_{OH}	12mA	2.3	-	VCC	V

Applies to the SPI signals and the PWR_EN signal.

Table 7 DC Characteristics General Purpose I/O

RF Characteristics

Parameter	Min	Typical	Max	Unit
RF frequency range	2412		2472	MHz
RF data rate	1	802.11 b/g rates supported	54	Mbps

Table 8 RF Characteristics

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TCP and UDP Throughput

Traffic Type	Privacy	Throughput (Mbps)
UDP Tx	Open	6.9
UDP Rx	Open	5.5
TCP Tx	Open	3.5
TCP Rx	Open	2.6
UDP Tx	WEP128	6.6
UDP Rx	WEP128	5.5
TCP Tx	WEP128	3.2
TCP Rx	WEP128	2.5
UDP Tx	WPAv1	6.5
UDP Rx	WPAv1	5.5
TCP Tx	WPAv1	3.3
TCP Rx	WPAv1	2.4
UDP Tx	WPAv2	6.8
UDP Rx	WPAv2	5.5
TCP Tx	WPAv2	3.3
TCP Rx	WPAv2	2.5

Table 9 TCP and UDP Throughput

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Power Consumption

Parameter	Test Conditions	Min	Typical	Max	Unit
DSSS (b) TX Current	2437 MHz, VCC = 3.3V, T_{amb} = +25°C Po = 19 dBm, 1 Mbps BPSK L = 1200 bytes, t_{delay} (idle) = 40 uS	-	269	-	mA
DSSS (b) TX Current	2437 MHz, VCC = 3.3V, T_{amb} = +25°C Po = 19 dBm, 11 Mbps CCK L = 1200 bytes, t_{delay} (idle) = 40 uS	-	269	-	mA
OFDM (g) TX Current	2437 MHz, VCC = 3.3V, T_{amb} = +25°C Po = 17 dBm, 18 Mbps QPSK L = 1200 bytes, t_{delay} (idle) = 4 uS	-	223	-	mA
OFDM (g) TX Current	2437 MHz, VCC = 3.3V, T_{amb} = +25°C Po = 15 dBm, 54 Mbps 64-QAM L = 1200 bytes, t_{delay} (idle) = 4 uS	-	187	-	mA
DSSS (b) RX Current		-	92	-	mA
OFDM (g) RX Current		-	92	-	mA
Power Down Mode [1]		-	<1	-	uA

[1] Total Current from VCC when PWR_EN is low and VCC is present.

Table 10 WLAN Power Consumption

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RF Characteristics

WLAN Transmitter Characteristics
(TA = +25°C, VCC = 3.3 V)

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) TX Output Power	1 Mbps BPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	20.2	-	dBm
2 Mbps DSSS (b) TX Output Power	2 Mbps QPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	20.2	-	dBm
11 Mbps DSSS (b) TX Output Power	11 Mbps CCK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	20.0	-	dBm
6 Mbps OFDM (g) TX Output Power	6 Mbps BPSK 802.11(g) Mask Compliance -5 dB EVM RMS power over TX packet	-	18.7	-	dBm
9 Mbps OFDM (g) TX Output Power	9 Mbps BPSK 802.11(g) Mask Compliance -8 dB EVM RMS power over TX packet	-	18.7	-	dBm
18 Mbps OFDM (g) TX Output Power	18 Mbps QPSK 802.11(g) Mask Compliance -13 dB EVM RMS power over TX packet	-	18.7	-	dBm
36 Mbps OFDM (g) TX Output Power	36 Mbps 16-QAM 802.11(g) Mask Compliance -19 dB EVM RMS power over TX packet	-	17.4	-	dBm
54 Mbps OFDM (g) TX Output Power	54 Mbps 64-QAM 802.11(g) Mask Compliance -25 dB EVM RMS power over TX packet	-	16.9	-	dBm

Table 11 WLAN Transmitter RF Characteristics

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WLAN Transmitter Characteristics
(TA = +85°C, VCC = 3.3 V)

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) TX Output Power	1 Mbps BPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	20.0	-	dBm
2 Mbps DSSS (b) TX Output Power	2 Mbps QPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	20.0	-	dBm
11 Mbps DSSS (b) TX Output Power	11 Mbps CCK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	19.9	-	dBm
6 Mbps OFDM (g) TX Output Power	6 Mbps BPSK 802.11(g) Mask Compliance -5 dB EVM RMS power over TX packet	-	18.4	-	dBm
9 Mbps OFDM (g) TX Output Power	9 Mbps BPSK 802.11(g) Mask Compliance -8 dB EVM RMS power over TX packet	-	18.4	-	dBm
18 Mbps OFDM (g) TX Output Power	18 Mbps QPSK 802.11(g) Mask Compliance -13 dB EVM RMS power over TX packet	-	18.4	-	dBm
36 Mbps OFDM (g) TX Output Power	36 Mbps 16-QAM 802.11(g) Mask Compliance -19 dB EVM RMS power over TX packet	-	17.1	-	dBm
54 Mbps OFDM (g) TX Output Power	54 Mbps 64-QAM 802.11(g) Mask Compliance -25 dB EVM RMS power over TX packet	-	16.7	-	dBm

Table 12 WLAN Transmitter RF Characteristics

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WLAN Transmitter Characteristics
(TA = -40°C, VCC = 3.3 V)

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) TX Output Power	1 Mbps BPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	19.8	-	dBm
2 Mbps DSSS (b) TX Output Power	2 Mbps QPSK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	19.8	-	dBm
11 Mbps DSSS (b) TX Output Power	11 Mbps CCK 802.11(b) Mask Compliance 35% EVM RMS power over TX packet	-	19.5	-	dBm
6 Mbps OFDM (g) TX Output Power	6 Mbps BPSK 802.11(g) Mask Compliance -5 dB EVM RMS power over TX packet	-	18.7	-	dBm
9 Mbps OFDM (g) TX Output Power	9 Mbps BPSK 802.11(g) Mask Compliance -8 dB EVM RMS power over TX packet	-	18.7	-	dBm
18 Mbps OFDM (g) TX Output Power	18 Mbps QPSK 802.11(g) Mask Compliance -13 dB EVM RMS power over TX packet	-	18.7	-	dBm
36 Mbps OFDM (g) TX Output Power	36 Mbps 16-QAM 802.11(g) Mask Compliance -19 dB EVM RMS power over TX packet	-	17.5	-	dBm
54 Mbps OFDM (g) TX Output Power	54 Mbps 64-QAM 802.11(g) Mask Compliance -25 dB EVM RMS power over TX packet	-	17.0	-	dBm

Table 13 WLAN Transmitter RF Characteristics

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WLAN Receiver Characteristics
(TA = +25°C, VCC = 3.3V) [1]

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) RX Sensitivity	8% PER	-	-98.4	-	dBm
2 Mbps DSSS (b) RX Sensitivity	8% PER	-	-95.0	-	dBm
11 Mbps DSSS (b) RX Sensitivity	8% PER	-	-88.3	-	dBm
6 Mbps OFDM (g) RX Sensitivity	10% PER	-	-91.6	-	dBm
9 Mbps OFDM (g) RX Sensitivity	10% PER	-	-90.8	-	dBm
18 Mbps OFDM (g) RX Sensitivity	10% PER	-	-88.0	-	dBm
36 Mbps OFDM (g) RX Sensitivity	10% PER	-	-81.3	-	dBm
54 Mbps OFDM (g) RX Sensitivity	10% PER	-	-75.3	-	dBm
1 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
2 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
11 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
9 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
18 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
36 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
54 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm

[1] Up to 2 dB degradation at Channel 13 for 11g modes and up to 2 dB degradation at Channel 14 for 11b/g modes.

Table 14 WLAN Receiver RF Characteristics

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WLAN Receiver Characteristics
(TA = +85°C, VCC = 3.3V) [1]

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) RX Sensitivity	8% PER	-	-97.0	-	dBm
2 Mbps DSSS (b) RX Sensitivity	8% PER	-	-93.7	-	dBm
11 Mbps DSSS (b) RX Sensitivity	8% PER	-	-88.0	-	dBm
6 Mbps OFDM (g) RX Sensitivity	10% PER	-	-90.5	-	dBm
9 Mbps OFDM (g) RX Sensitivity	10% PER	-	-89.5	-	dBm
18 Mbps OFDM (g) RX Sensitivity	10% PER	-	-86.1	-	dBm
36 Mbps OFDM (g) RX Sensitivity	10% PER	-	-80.1	-	dBm
54 Mbps OFDM (g) RX Sensitivity	10% PER	-	-74.3	-	dBm
1 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
2 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
11 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
9 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
18 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
36 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
54 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm

[1] Up to 2 dB degradation at Channel 13 for 11g modes and up to 2 dB degradation at Channel 14 for 11b/g modes.

Table 15 WLAN Receiver RF Characteristics

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WLAN Receiver Characteristics
(TA = -40°C, VCC = 3.3V) [1]

Parameter	Test Conditions	Min	Typ	Max	Unit
1 Mbps DSSS (b) RX Sensitivity	8% PER	-	-99.6	-	dBm
2 Mbps DSSS (b) RX Sensitivity	8% PER	-	-96.1	-	dBm
11 Mbps DSSS (b) RX Sensitivity	8% PER	-	-90.4	-	dBm
6 Mbps OFDM (g) RX Sensitivity	10% PER	-	-92.8	-	dBm
9 Mbps OFDM (g) RX Sensitivity	10% PER	-	-91.9	-	dBm
18 Mbps OFDM (g) RX Sensitivity	10% PER	-	-88.4	-	dBm
36 Mbps OFDM (g) RX Sensitivity	10% PER	-	-82.4	-	dBm
54 Mbps OFDM (g) RX Sensitivity	10% PER	-	-76.3	-	dBm
1 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
2 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
11 Mbps DSSS (b) RX Overload Level	8% PER	-10	-	-	dBm
9 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
18 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
36 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm
54 Mbps OFDM (g) RX Overload Level	10% PER	-17	-	-	dBm

[1] Up to 2 dB degradation at Channel 13 for 11g modes and up to 2 dB degradation at Channel 14 for 11b/g modes.

Table 16 WLAN Receiver RF Characteristics

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SPI HOST CONTROLLER INTERFACE

The main interface to the TiWi-SL Module is a Serial Peripheral Interface (SPI).

This section describes the SPI Host Controller interface (HCI).

Overview

The SPI interface provides high-speed data transfer capability with low power consumption for mobile electronic devices. The SPI bus was designed to operate on a point-to-multipoint basis by providing a separate, active-low chip select (CS) per device.

- Supported clock rate = 0-16MHz
- The device interface is always an SPI Slave, host is always an SPI Master

SPI Interface Description

The SPI is based on the five-line, master/slave communication model see Figure 3

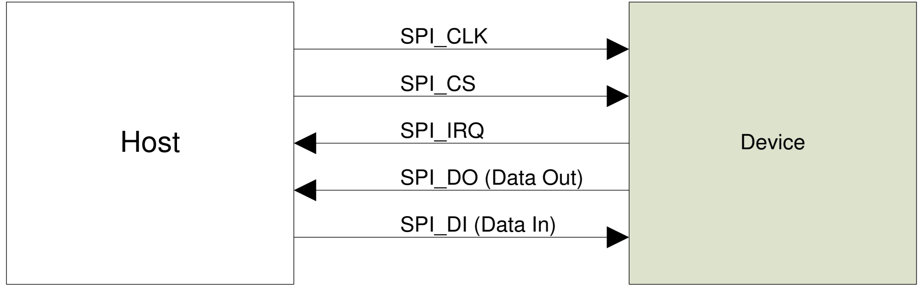

Figure 3 SPI Interface Signals

SPI Line Description

Port Name	Input/Output	Description
SPI_CLK	Input	Clock (0 MHz to 16MHz) from host to device
SPI_DI	Input	Data from host to device (MOSI)
SPI_CS(1)	Input	CS signal from host to device (active low)
SPI_IRQ(2)	Output	Interrupt from device to host
SPI_DO	Output	Data from device to host (MISO)

Table 17 SPI Interface Signals Description

(1) SPI_CS selects the device, indicating that the host wants to communicate to the device.
(2) SPI_IRQ is a dual purpose device to host direction line. When SPI communication is in an idle state (no data transfer), driving SPI_IRQ low indicates to the host the TiWi-SL module has data to pass to it. Driving SPI_IRQ low following a SPI_CS deassertion indicates that the TiWi-SL module is ready to receive data.

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SPI Timing

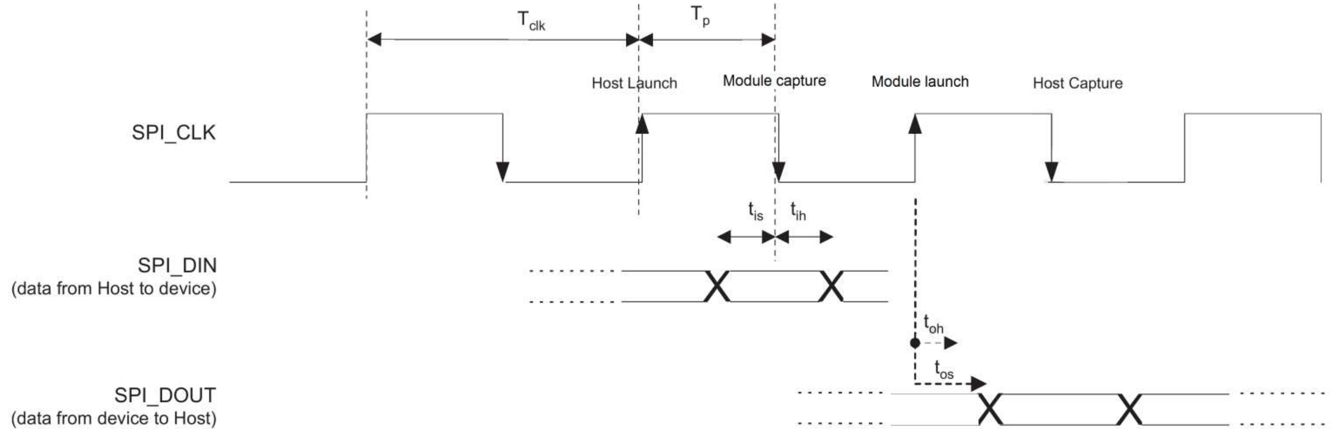

Figure 5 SPI Timing

Symbol	Parameter	Min	Max	Unit
Tclk	Clock period, CLK	62.5		ns
Tp	High Pulse width (including jitter and duty cycle)	25(2)	37.5	ns
tis	RX setup time; minimum time in which data is stable before edge capture	5		ns
T_{in}	RX hold time; minimum time in which data is stable after edge capture	5		ns
T_{os}	TX setup propagation time; maximum time from launch edge until data is stable		10.2	ns
T_{oh}	TX hold propagation time; minimum time of stable data after launch edge	3		ns
C_L	Capacitive load on I/F		13	pF

Table 18 SPI Clock Switching Characteristics

(1) SPI_CS is considered asynchronous.

(2) 40%-60% dc (valid for the minimum clock period)

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DEVICE POWER-UP AND ENABLE

Normal operation mode requirements:

1. The MODE1 and MODE2 signals need to be shorted together.

The normal SPI host write sequence is SPI_CS low (host → module), followed by SPI_IRQ low (module → host), indicating that the device is ready to accept data.

At Power-up, the sequence is slightly different. SPI_IRQ will go low (module → host) indicating the module has completed the power up sequence. The Host must wait an additional time (T2) from the assertion of SPI_CS (that is, bring SPI_CS low) before sending the first SPI packet.

Power-up sequence timing requirements:

1. Apply power to the module through the VCC input.
2. Wait for the module to power-up and stabilize (T0). This is to allow onboard oscillators to stabilize.
3. Enable the module through the PWR_EN input.
4. Wait for SPI_IRQ to be brought low by module (T1) before asserting CS.
5. Wait an additional time (T2) for the module to be ready before sending first packet.

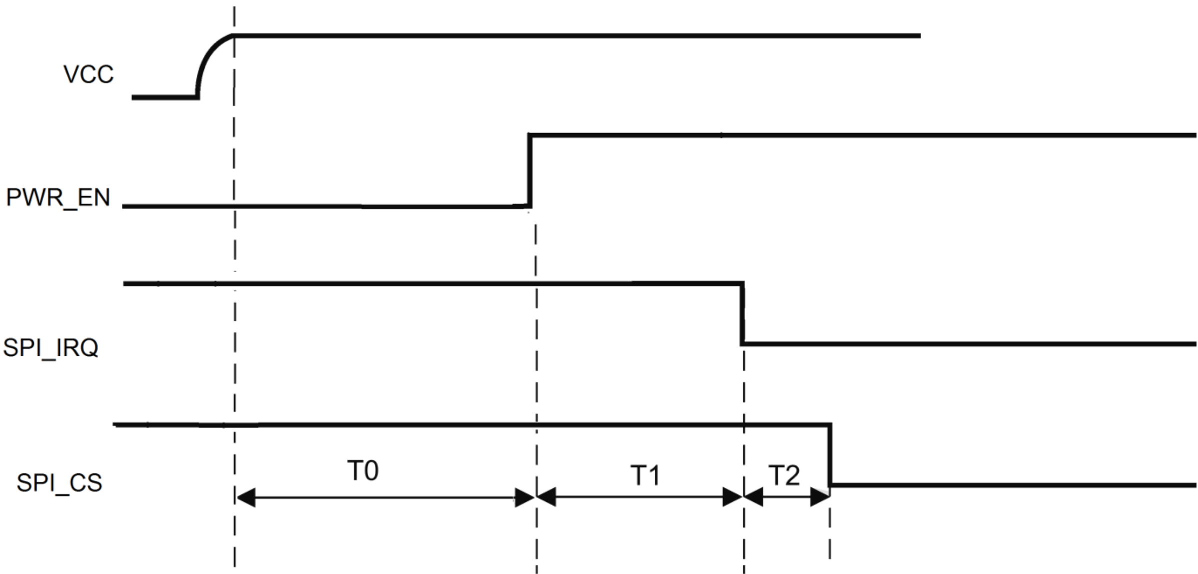

Figure 4 Device Power-Up Timing

Timing Parameter	Symbol	Max	Unit
VCC to PWR_EN Delay	T0	1000	ms
PWR_EN to SPI_IRQ	T1	53	ms
SPI_IRQ to SPI_CS	T2	7	ms

Table 19 Device Power-Up Timing

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DEVICE POWER-DOWN

Normal operation power-down requirements:

1. Disable the module through the PWR_EN input.
2. Remove power to the module through the VCC input.

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SOLDERING RECOMMENDATIONS

Recommended Reflow Profile for Lead Free Solder

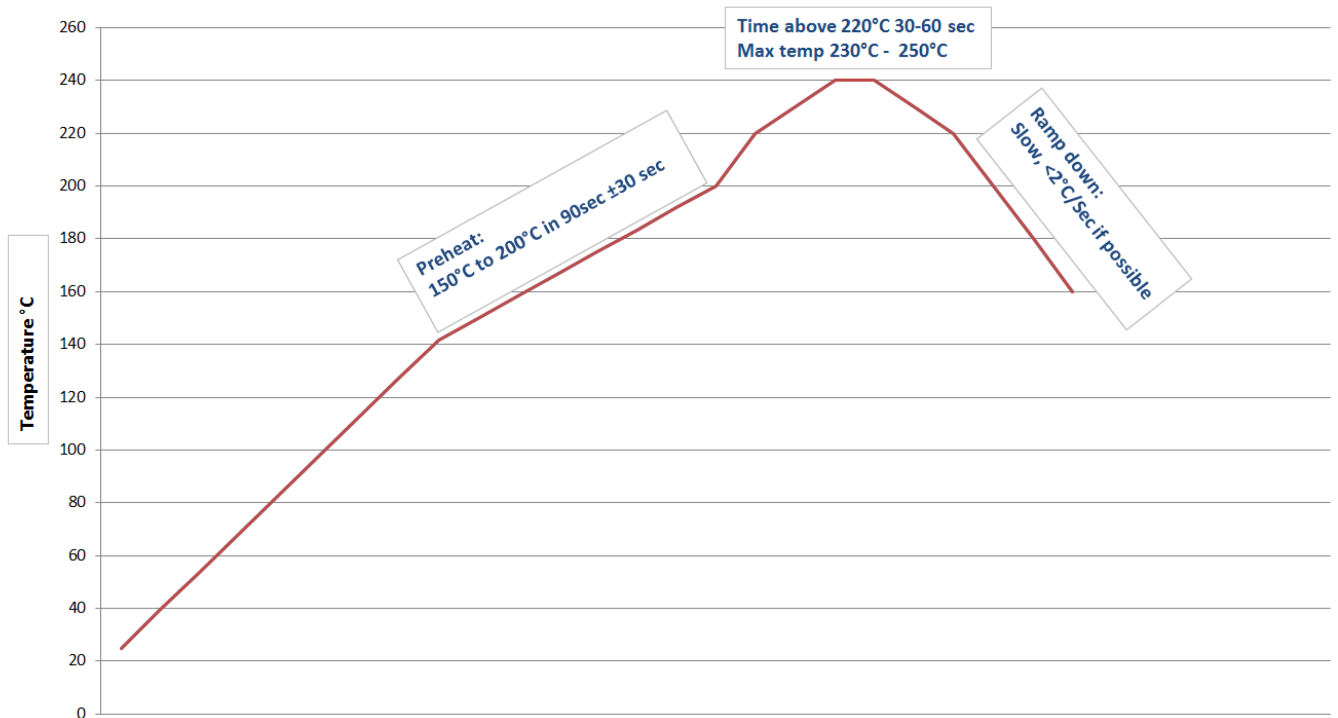

Figure 5 Recommended Soldering Profile

Note: The quality of solder joints on the surface mount pads where they contact the host board should meet the appropriate IPC Specification. See IPC-A-610-D Acceptability of Electronic Assemblies, section 8.2.1 "Bottom Only Terminations."

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CLEANING

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the RF shield, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

OPTICAL INSPECTION

After soldering the Module to the host board, consider optical inspection to check the following:

- Proper alignment and centering of the module over the pads.
- Proper solder joints on all pads.
- Excessive solder or contacts to neighboring pads, or vias.

REWORK

The TiWi-SL module can be unsoldered from the host board if the Moisture Sensitivity Level (MSL) requirements are met as described in this datasheet.

Never attempt a rework on the module itself, e.g. replacing individual components. Such actions will terminate warranty coverage.

SHIPPING, HANDLING, AND STORAGE

Shipping

Bulk orders of the TiWi-SL modules are delivered in trays of 50 or reels of 1,000.

Handling

The TiWi-SL modules contain a highly sensitive electronic circuitry. Handling without proper ESD protection may damage the module permanently.

Moisture Sensitivity Level (MSL)

Per J-STD-020, devices rated as MSL 4 and not stored in a sealed bag with desiccant pack should be baked prior to use.

After opening packaging, devices that will be subjected to reflow must be mounted within 72 hours of factory conditions (<30°C and 60% RH) or stored at <10% RH.

Bake devices for 48 hours at 125°C.

Storage

Please use this product within 6 months after receipt. Any product used after 6 months of receipt needs to have solderability confirmed before use.

The product shall be stored without opening the packing under the ambient temperature from 5 to 35deg.C and humidity from 20 to 70%RH. (Packing materials, in particular, may be deformed at the temperatures above this range.)

Do not store in salty air or in an environment with a high concentration of corrosive gas, such as Cl2, H2S, NH3, SO2, or NOX.

Do not store in direct sunlight.

The product should not be subject to excessive mechanical shock.

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