WF200 Data Sheet: Wi-Fi Network Co-Processor

This is a preliminary document and subject to change before final version is published.

The Silicon Labs WF200 is an Ultra Low Power Wi-Fi® transceiver or network co-processor (NCP) targeted for applications where optimal RF performance, low-power consumption, and secure end-to-end solution, together with fast time to market, are key requirements.

The WF200 integrates the Balun, T/R switch, LNA and PA for best possible RF performance. Co-existence with other external 2.4GHz radios is supported.

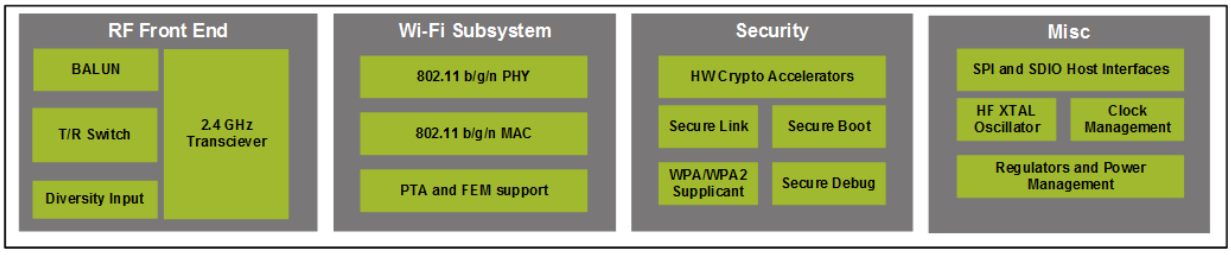
WF200 has been optimized for resource and power constrained devices at the RF, protocol and firmware levels. Power conscious devices can take advantage of these features in both active and idle/sleep modes

For security sensitive applications WF200 provides secure boot and a secure & encrypted host interface. Robust security is made possible with a native integrated True Random Number Generator and OTP memory for confidential encryption key storage.

The WF200 fits well with Linux-based and RTOS based host processors. WF200 supports both the 802.11 split MAC and the 802.11 full MAC architectures. It communicates with the external host controller over the SPI or SDIO interface

KEY POINTS

- IEEE 802.11 b/g/n compliant
- TX power: +17 dBm
- RX sensitivity: -96.5 dBm
- Integrated antenna diversity support
- Ultra low power consumption
- Secure and signed software
- Encrypted host interface communication
- Linux and RTOS host support
- 4x4 QFN32 package



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1. Features List

The key features of the WF200 Wi-Fi transceiver are listed below.

Applications

- Industrial, Home and Buidling automation
- Home appliances
- Security solutions
- Retail and Commercial
- Commercial transportation
- Consumer medical
- Sports and Fitness

Features

- 802.11 b/g/n Wi-Fi NCP including the radio, baseband, MAC, security and host interface
- Superior link budget with integrated LNA, PA and Balun
- OTP included removing the need for an external EEPROM
- Ultra low power optimized solution
- End-to-end security with hardware protected secure boot and encrypted host interface
- 802.11 split and full MAC architecture support
- Complete Network Co-Processor (NCP) support for Linux and Micrium RTOS external hosts

Standards/IEEE 802.11 and WFA

- b - symbol rates: up to 11 Mbps
- g - symbol rates: up to 54 Mbps
- n - symbol rates: up to 72.2Mbps
- d - regulatory domains
- e - QoS as per definition in WMM specification
- i - as per definition in WPA2 specification
- w - protected management frames
- WMM Power save
- WPA/WPA2 Personal
- Supported with Linux UMAC:
  - WPA2 Enterprise
  - WFD - Wi-Fi Direct Client and Group owner
  - WPS - Wi-Fi Protected Setup

Key MAC and Baseband Features

- 1x1 802.11n with full 802.11 b/g compatibility, 72.2Mbps
- Greenfield Tx/Rx for 802.11n optimal performance
- Short Guard Interval (SGI) for 802.11n optimal throughput
- Tx LDPC for improved range
- A-MPDU Rx and Tx for high MAC throughput
- Block acknowledgement for several frames
- Rx Defragmentation
- Roaming supported
- Client, SoftAP modes supported
- Concurrent AP + STA supported

RF Features

- Tx Power: +16 dBm
- Rx Sensitivity: -96.5 dBm
- 2 x 2.4GHz antenna pads for full antenna diversity support
- 2.4GHz co-existence; 2-, 3- and 4-wire PTA support
- Integrated Balun, T/R switch, LNA and PA for 2.4GHz

Power Consumption

- Rx (@1DSSS): 42.5mA
- Tx (16 dBm @1DSSS): 148mA
- Associated: DTIM3: TBD µA
- Idle: TBD
- Power off: 0.5µA

Security and Encryption Features

- Secure boot with roll-back prevention
- Encrypted host interface, dedicated hardware acceleration block
- Integrated True Random Number Generator
- Secure key storage using protected OTP technology
- AES/WEP hardware acceleration

Host Interfaces

- SDIO (1-bit and 4-bit SD mode @ 26MHz)
- SPI (1-bit @ 52MHz)

Peripheral Interfaces

- External 32kHz crystal for low power clock control
- GPIOs (including wake-up and Tx/Rx activity monitoring)

ROHS/REACH Compliant

Electrical Characteristics

- 1.8V - 3.6V

Packaging

- 4x4 QFN32
- Temperature range: -40°C to +105°C

2. Ordering Guide

Table 2.1. WF200 Ordering Information (R indicates full reel)

Part Number	Description
WF200C(R)	WF200 802.11bgn NCP, 4x4 QFN32
WF200SC(R)	WF200 802.11bgn NCP, Secure host interface, 4x4 QFN32

3. System Overview

3.1 Introduction

WF200 is a WiFi network co-processor optimized for RF performance, low energy, and low cost, with two antenna ports, Crystal Oscillator, One Time Programmable Memory, and several GPIOs for interfacing with multi-protocol and RF Front End Module controls.

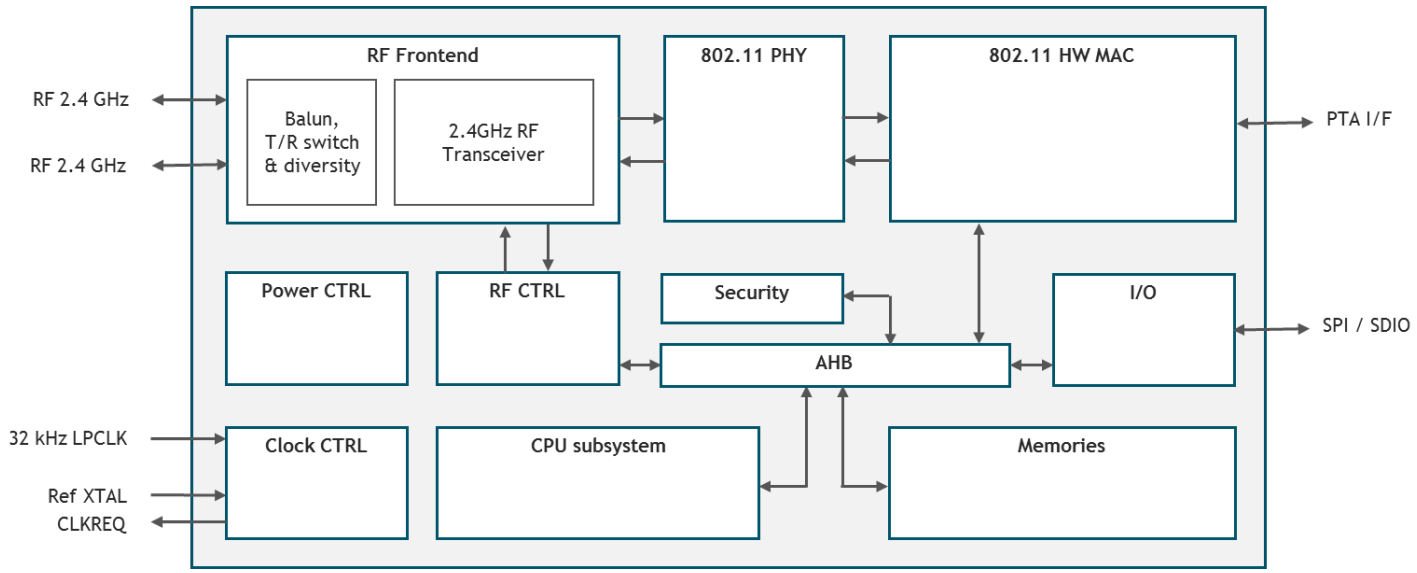


Figure 3.1. WF200 Block Diagram

3.2 WiFi Supported 2.4 GHz Bandwidth and Channels

Supported operating frequencies and bandwidth

Table 3.1. Supported WiFi Modulations, BW, and Channels

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Channel Center Frequency	CHAN	Subject to Regulatory Agency	2412		2484	MHz
Channel Bandwidth	BW		—	20	—	MHz

4. Electrical Specifications

All electrical parameters in all tables are specified under the following conditions, unless stated otherwise:

- Typical values are based on T_{AMB} = 25 °C; VDD_{IO}, VDD_D = 1.8 V; VDD_{PA}= 3.3V
- Radio performance numbers are measured in conducted mode, based on Silicon Labs reference designs

Refer to Section 4.2 Operating Conditions for more details about operational supply and temperature limits.

4.1 Absolute Maximum Ratings

Stresses above those listed below may cause permanent damage to the device. This is a stress rating only and functional operation of the devices at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability. For more information on the available quality and reliability data, see the Quality and Reliability Monitor Report at http://www.silabs.com/support/quality/pages/default.aspx.

Table 4.1. Absolute Maximum Ratings

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Maximum Junction temperature	TJ_{MAX}		-40	—	150	°C
Storage temperature	T_{STG}		-40	—	125	°C
Max RF power level at RF1 and RF2 pins	P_{RFMAX}		—	—	TBD	dBm
Maximum supply voltage to VDD_{PA}, VDD_{IO}, VDD_D	VDD_{MAX}		-0.3	—	3.7	V
Maximum voltage on XTAL_I and XTAL_O pins	VXO_{MAX}		-0.3	—	1.25	V
Maximum voltage on all other pins (GPIO, Host interface, FEM, PTA, etc.)	VG_{MAX}		-0.3	—	VDD_{IO} + 0.3 V	V
Maximum DC supply current into VDD_{PA} pin	$IVDD_{PAMAX}$		—	—	TBD	mA
Maximum DC supply current into VDD_{IO}, VDD_D pins	$IVDD_{MAX}$		—	—	TBD	mA
Maximum current into any GPIO pin	IO_{MAX}		TBD	—	TBD	mA
Maximum sum of current into all GPIO pins	IO_{ALLMAX}		TBD	—	TBD	mA
Range of load impedance at RF1 and RF2 pins during TX	$LOAD_{TX}$		—	—	TBD	VSWR

4.2 Operating Conditions

Table 4.2. Recommended Operating Conditions

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Ambient operating temperature	TA_{OP}		-40	—	105	°C
Junction operating temperature	TJ_{OP}		-40	—	125	°C
DC supply voltage to VDD_{PA}[1] [2]	VDD_{PA}		1.8	—	3.3	V
Nominal supply voltage to VDD_D[1]	VDD_D		1.8	—	3.3	V
Nominal supply voltage to VDD_{IO}	VDD_{IO}		1.8	—	3.3	V

Note:

1. VDD_{PA} must always be greater than or equal to VDD_D.
2. VDD_{PA} should be at least 3.0 V to achieve the rated RF transmitter output power levels.

4.3 Power Consumption

Unless otherwise indicated, VDD_PA = 3.3 V, VDD_D = VDD_RF = VDD_IO = 1.8 V.

Table 4.3. Power Consumption

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
TX mode current	I_{TX}	802.11.b: 11 Mbps	—	TBD	—	mA
		802.11.g: 6 Mbps	—	TBD	—	mA
		802.11.g: 54 Mbps	—	TBD	—	mA
		802.11.n: MCS = 0	—	TBD	—	mA
		802.11.n: MCS = 7	—	TBD	—	mA
		802.11.b: 1 Mbps	—	TBD	—	mA
RX mode current	I_{RX}	802.11.b: 11 Mbps	—	TBD	—	mA
		802.11.g: 6 Mbps	—	TBD	—	mA
		802.11.g: 54 Mbps	—	TBD	—	mA
		802.11.n: MCS = 0	—	TBD	—	mA
		802.11.n: MCS = 7	—	TBD	—	mA
		802.11.b: 1 Mbps	—	TBD	—	mA
Sleep current on power supply pins	I_{RX_SLEEP}	VDD_RF pin, VDD_RF = 3.3V	—	87	—	nA
		VDD_IO pin, VDD_IO = 3.3V	—	3.5	—	µA
		VDD_D pin, VDD_D = 3.3V	—	18.6	—	µA
		VDD_PA pin, VDD_PA = 3.3V	—	66	—	µA
Snooze current on power supply pins	I_{RX_SNOOZE}	VDD_RF pin, VDD_RF = 3.3V	—	536	—	µA
		VDD_IO pin, VDD_IO = 3.3V	—	51	—	µA
		VDD_D pin, VDD_D = 3.3V	—	610	—	µA
		VDD_PA pin, VDD_PA = 3.3V	—	66	—	nA
Active current on power supply pins	I_{RX_ACTIVE}	VDD_RF pin, VDD_RF = 3.3V	—	1.69	—	mA
		VDD_IO pin, VDD_IO = 3.3V	—	51	—	µA
		VDD_D pin, VDD_D = 3.3V	—	10.9	—	mA
		VDD_PA pin, VDD_PA = 3.3V	—	72	—	nA
Standby current on power supply pins	$I_{RX\_STANDBY}$	VDD_RF pin, VDD_RF = 3.3V	—	67.4	—	nA
		VDD_IO pin, VDD_IO = 3.3V	—	49	—	nA
		VDD_D pin, VDD_D = 3.3V	—	16.4	—	nA
		VDD_PA pin, VDD_PA = 3.3V	—	67	—	nA
Average current for DTIM=1 Interval Profile	I_{LP_DTIM1}	VDD_PA pin, VDD_PA= 1.8V	—	—	—	mA
		VDD_RF pin, VDD_RF = 1.8V	—	—	—	mA
		VDD_IO pin, VDD_IO = 1.8V	—	—	—	mA
		VDD_D pin, VDD_D = 1.8V	—	—	—	mA

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Average current for DTIM=3 Interval Profile	I_{LP_DTIM3}	VDD_PA pin, VDD_PA= 1.8V	—	—	—	mA
		VDD_RF pin, VDD_RF = 1.8V	—	—	—	mA
		VDD_IO pin, VDD_IO = 1.8V	—	—	—	mA
		VDD_D pin, VDD_D = 1.8V	—	—	—	mA
Average current for DTIM=10 Interval Profile	I_{LP_DTIMA}	VDD_PA pin, VDD_PA= 1.8V	—	—	—	mA
		VDD_RF pin, VDD_RF = 1.8V	—	—	—	mA
		VDD_IO pin, VDD_IO = 1.8V	—	—	—	mA
		VDD_D pin, VDD_D = 1.8V	—	—	—	mA

4.4 RF Transmitter General Characteristics

Unless otherwise indicated, typical conditions are: Operating Ambient Temp = 25 °C, VDD_{IO}, VDD_D = 1.8 V; VDD_{PA}= 3.3V,center frequency 2,442 MHz, and measured in 50 Ω test equipment attached at antenna port.

Measurements for this specification are made at the 50 Ω Antenna Port. See Section 5.1.1 Antenna Ports.

4.4.1 RF Transmitter Characteristics

Table 4.4. RF Transmitter Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Maximum RMS Output Power[1]	$POUT_{MAX\_RMS\_HPPA}$	802.11b: 1Mbps	—	16.4	—	dBm
		802.11b: 11Mbps	—	15.2	—	dBm
		802.11g: 6Mbps	—	15.7	—	dBm
		802.11g: 54Mbps	—	12	—	dBm
		802.11n: MCS=0	—	15.3	—	dBm
		802.11n: MCS=7	—	10.4	—	dBm
Second Harmonic Level for POUT_MAX_PA Setting	$H2_{MAX}$	802.11b: 1Mbps	—	-48.32	—	dBm
		802.11b: 11Mbps	—	-53.2	—	dBm
		802.11g: 6Mbps	—	-48.16	—	dBm
		802.11g: 54Mbps	—	-50.25	—	dBm
		802.11n: MCS=0	—	-48.43	—	dBm
		802.11n: MCS=7	—	-51.11	—	dBm
Carrier Suppression per 802.11-2012 for POUT_MAX PA setting	C_{SUP}	802.11b: 1Mbps	—	—	-15	dBr
		802.11b: 11Mbps	—	—	-15	dBr
		802.11g: 6Mbps	—	—	-15	dBr
		802.11g: 54Mbps	—	—	-15	dBr
		802.11n: MCS=0	—	—	-15	dBr
		802.11n: MCS=7	—	—	-15	dBr
POUT variation from VDD_PA=3.0V to 3.6V	$POUT_{MAX\_VAR\_V}$	PAVDD+ 3.0V to 3.6V	—	TBD	—	dB
POUT Variation across temperature	$POUT_{MAX\_VAR\_T}$	25C to 85C	—	TBD	—	dB
POUT variation from 50 Ω load specified VSWR	VSWR	up to 2:1 VSWR	—	TBD	—	dB
		up to 3:1 VSWR	—	TBD	—	dB
POUT varation due to diversity connection	$POUT_{MAX\_VAR\_D}$	2nd Antenna connected for Diversity	—	TBD	—	dB

Note:
1. VDD_{PA} should be at least 3.0 V to achieve the rated RF transmitter output power levels.

4.5 RF Receiver General Characteristics

Unless otherwise indicated, typical conditions are: Operating Ambient Temp = 25 °C, VDD_{IO}, VDD_D = 1.8 V; VDD_{PA}= 3.3V, center frequency = 2,441 MHz, and measured in 50 Ω test equipment attached at antenna port.

Measurements for this specification are made at the 50 Ω Antenna Port. See Section 5.1.1 Antenna Ports.

4.5.1 RF Receiver Characteristics

Table 4.5. RF Receiver Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RX Sensitivity for 8% FER (1024 Octet)	$SENS_B$	802.11b: 1Mbps	—	TBD	—	dBm
		802.11b: 11Mbps	—	-88.2	—	dBm
RX Sensitivity for 10% PER (1024 Octet)	$SENS_G$	802.11g: 6Mbps	—	-91.7	—	dBm
		802.11g: 54Mbps	—	-74.6	—	dBm
RX Sensitivity for 10% PER 4096 Octet	$SENSE_N$	802.11n: MCS=0	—	-91.2	—	dBm
		802.11n: MCS=7	—	-71.6	—	dBm
Adjacent Channel (± 30MHz) Selectivity with desired signal at 6dB abover refernce sesnsitivity for 8% FER (1024 Octet)	ACS_{WB}	802.11b: 11Mbps	—	TBD	—	dBc
Adjacent Channel (± 25MHz) Selectivity with desired signal at 3dB abover refernce sesnsitivity for 10% PER (1024 Octet)	ACS_{WG}	802.11g: 6Mbps	—	TBD	—	dBc
		802.11g: 54Mbps	—	TBD	—	dBc
Adjacent Channel (± 25MHz) Selectivity with desired signal at 3dB abover refernce sesnsitivity for 10% FER (4096 Octet)	ACS_{WN}	802.11n: MCS=0	—	TBD	—	dBc
		802.11n: MCS=7	—	TBD	—	dBc
2nd Adjacent Channel Selecitivity (± 50MHz) with desired at 6dB above reference sensitivity 8% FER (1024 Octet)	$A2CS_{WB}$	802.11b: 1Mbps	—	TBD	—	dBc
		802.11b: 11Mbps	—	TBD	—	dBc
2nd Adjacent Channel Selecitivity (± 50MHz) with desired at 3dB above reference sensitivity 10% PER (1024 Octet)	$A2CS_{WG}$	802.11g: 6Mbps	—	TBD	—	dBc
		802.11g: 54Mbps	—	TBD	—	dBc
2nd Adjacent Channel Selecitivity (± 50MHz) with desired at 3dB above reference sensitivity 10% PER (4096Octet)	$A2CS_{WN}$	802.11n: MCS=0	—	TBD	—	dBc
		802.11n: MCS=7	—	TBD	—	dBc
RX Max Strong Signal for 8% FER (1024 Octet)	RX_{SAT_B}	802.11b: 1Mbps	—	TBD	—	dBm
		802.11b: 11Mbps	—	TBD	—	dBm
RX Max Strong Signal for 10% PER (1024 Octet)	RX_{SAT_G}	802.11g: 54Mbps	—	TBD	—	dBm
RX Max Strong Signal for 10% PER (4096 Octet)	RX_{SAT_N}	802.11n: MCS=0	—	TBD	—	dBm
		802.11n: MCS=7	—	TBD	—	dBm

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
U/D wtih desired at 6dB above reference sensitivity for 8% FER (1024 Octet)	$OOBB_B$	802.11b: 1Mbps : GSM Blocker at 893.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : GSM Blocker at 960MHz	—	TBD	—	dB
		802.11b: 1Mbps : GSM Blocker at 1879.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : GSM Blocker at 1989.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : WCDMA Blocker at 893.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : WCDMA Blocker at 960MHz	—	TBD	—	dB
		802.11b: 1Mbps : WCDMA Blocker at 1879.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : WCDMA Blocker at 1989.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : LTE Blocker at 893.8MHz	—	TBD	—	dB
		802.11b: 1Mbps : LTE Blocker at 960MHz	—	TBD	—	dB
		802.11b: 1Mbps : LTE Blocker at 1879.8MHz	—	TBD	—	dB
U/D with desired at 3dB above reference senitivity for 10% PER (1024 Octet)	$OOBB_G$	802.11g: 6Mbps : GSM Blocker at 893.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : GSM Blocker at 960MHz	—	TBD	—	dB
		802.11g: 6Mbps : GSM Blocker at 1879.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : GSM Blocker at 1989.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : WCDMA Blocker at 893,8MHz	—	TBD	—	dB
		802.11g: 6Mbps : WCDMA Blocker at 960MHz	—	TBD	—	dB
		802.11g: 6Mbps : WCDMA Blocker at 1879.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : WCDMA Blocker at 1989.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : LTE Blocker at 893.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : LTE Blocker at 960MHz	—	TBD	—	dB
		802.11g: 6Mbps : LTE Blocker at 1879.8MHz	—	TBD	—	dB
		802.11g: 6Mbps : LTE Blocker at 1989.8MHz	—	TBD	—	dB

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
U/D with desired at 3dB above reference senitivity for 10% PER (4096 Octet)	$OOBB_N$	802.11n: MCS=7 : GSM Blocker at 893.8MHz	—	TBD	—	dB
		802.11n: MCS=7 : GSM Blocker at 960MHz	—	TBD	—	dB
		802.11n: MCS=7: GSM Blocker at 1879.8MHz	—	TBD	—	dB
		802.11n: MCS=7: GSM Blocker at 1989.8MHz	—	TBD	—	dB
		802.11n: MCS=7 : WCDMA Blocker at 893,8MHz	—	TBD	—	dB
		802.11n: MCS=7 : WCDMA Blocker at 960MHz	—	TBD	—	dB
		802.11n: MCS=7 : WCDMA Blocker at 1879.8MHz	—	TBD	—	dB
		802.11n: MCS=7 : WCDMA Blocker at 1989.8MHz	—	TBD	—	dB
		802.11n: MCS=7: LTE Blocker at 893.8MHz	—	TBD	—	dB
		802.11n: MCS=7 : LTE Blocker at 960MHz	—	TBD	—	dB
		802.11n: MCS=7 : LTE Blocker at 1879.8MHz	—	TBD	—	dB
		802.11n: MCS=7 : LTE Blocker at 1989.8MHz	—	TBD	—	dB
Sensitivity Variation from VDD = 1.62V to 3.3V	$SENS_{VAR\_V}$	802.11b: 1Mbps	—	TBD	—	dB
		802.11g: 6Mbps	—	TBD	—	dB
		802.11n: MCS=7	—	TBD	—	dB
Sensitivity variation from ground 2nd harmonic to 2nd Antenna connected for Diversity	$SENS_{VAR\_D}$	802.11b: 1Mbps	—	TBD	—	dB
		802.11g: 6Mbps	—	TBD	—	dB
		802.11n: MCS=7	—	TBD	—	dB
RX Channel power Indicator Step Size	$RCPI_{STEP}$	802.11b: 1Mbps	—	TBD	—	dBm
		802.11g: 6Mbps	—	TBD	—	dBm
		802.11n: MCS=7	—	TBD	—	dBm

4.6 Reference Oscillator and Clock Characteristics

There are two options for the 38.4 MHz Reference Oscillator. Use an external oscillator like a TCXO, or use a crystal with the internal oscillator. The operating temperature range of the application will be limited by the selected component's operating temperature specification. To achieve low power operation during power save modes, a 32.768 KHz clock is also required.

4.6.1 Crystal Requirements for using Internal Oscillator

The choice of the crystal affects several parameters including control settings, RF performance, frequency accuracy, and average current consumption in applications that incorporate periodic wake and sleep states. Refer to Application Note (TBD) for list of recommended crystals. The frequency accuracy of the crystal is the main contributor to Wi-Fi frequency accuracy which must be within +/-25ppm tolerance for 802.11 b, g, and n, in 20MHz channel operation over all of the operating conditions. There are multiple sources of frequency variation that must be taken into account including in the crystal and device process and die temperature variations. Calibration and compensation functions are made available in the device to counteract some of these frequency variations. Refer to application note (TBD) for more details.

Table 4.6. Crystal Requirements for Using Internal Oscillator

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Nominal Frequency of HF Crystal Oscillator	$XTAL_{FNOM}$		—	38.4	—	MHz
Frequency tolerance of crystal over all conditions	$XTAL_{FTOL}$		-20	—	20	ppm
Crystal Load Cap	HFX_{CL}		8	10	12	pF
Equivalent Series Resistance	HFX_{ESR}		—	20	40	Ω
Motinal Inductance	HFX_{CM}		2	—	4	fF
Shunt Capacitance	HFX_{CS}		—	0.8	2	pF
Pulling Sensitivity	HFX_{PULL}		8	—	20	ppm/pF
Crystal withstanding drive strength	HFX_{DL}		—	—	200	uW
Quality Factor	HFX_{Q}		35000	—	—	
Insulation Resistance 100V	HFX_{IR}		500	—	—	MΩ

4.6.2 External Oscillator Required Characteristics

An external oscillator, like a TCXO, must provide a stable and high quality signal in order for this IC to meet its performance specifications. This section lists some of the requirements. If the host powers down the TCXO when going into a low power state, the host must also turn on the TCXO in advance of any transceiver activity.

Table 4.7. Reference Oscillator Requirements

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Nominal frequency of HF crystal oscillator	$TXCO_{FNOM}$		—	38.4	—	MHz
Frequency tolerance of HFXO over all conditions	$HFXO_{FTOL}$		-20	—	20	ppm
Load Resistance of HFXO	$HFXO_{RL}$		7	10	15	KOhm
Load capacitance of HFXO	$HFXO_{CL}$		6	10	15	pF
Output level of HFXO	$HFXO_{LEVEL}$		0.7	0.9	1.2	V p-p
Symmetry of HFXO	$HFXO_{SYMT}$		40	50	60	%
Max level of all harmonics of HFXO	$HFXO_{HARM}$		—	—	-5	dBc
Startup time of HFXO	$HFXO_{START}$		—	—	2	ms
SSB Phase Noise of HFXO	SSB1	10Hz offset	—	—	-100	dBc/Hz
SSB Phase Noise of HFXO	SSB2	100Hz offset	—	—	-110	dBc/Hz
SSB Phase Noise of HFXO	SSB3	1KHz offset	—	—	-130	dBc/Hz
SSB Phase Noise of HFXO	SSB4	10KHz offset	—	—	-145	dBc/Hz
SSB Phase Noise of HFXO	SSB5	100KHz offset	—	—	-150	dBc/Hz
SSB Phase Noise of HFXO	SSB6	1MHz offset	—	—	-150	dBc/Hz

4.6.3 Low Power 32.768 kHz Clock Input Requirements

Table 4.8. Low Power 32.768 kHz Clock Input Requirements

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Nominal Frequency of LF Crystal Oscillator	$FNOM_{LPCLK}$	As stated in table notes	—	32.768	—	KHz
Frequency Tolerance of LP_CLK over all conditions	$FTOL_{LPCLK}$	As stated in table notes	-100	—	100	ppm
Load impedance magnitude of LP_CLK pin	Z_{LPCLK}	As stated in table notes	—	10	15	KOhm
Input Level at LP_CLK	$SIGL_{LPCLK}$	As stated in table notes	—	TBD	TBD	V p-p
Symmetry of LP_CLK	$DUTY_{LPCLK}$	As stated in table notes	—	50	—	%
Jitter on LP_CLK input	JTR_{LPCLK}	As stated in table notes	—	TBD	—	ns

4.7 Interface Terminal Characteristics

Unless otherwise indicated, typical conditions are: Operating Ambient Temp = 25 °C, all VDD = 1.8 V, center frequency = 2,442 MHz, and measured by 50 Ω test equipment attached at antenna port.

4.7.1 Supply Terminal Specifications

There are three pins to attach to DC power sources: VDD_{PA}, VDD_D and VDD_{IO}.

Please refer to the section on 4.2 Operating Conditions for details on allowed voltages on these pins.

4.7.2 Digital I/O Terminal Specifications

Table 4.9. Digital I/O Terminal Specifications

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Voltage input low (relative to VDD_{IO}	V_{IL}		—	—	30	%
Voltage input high (relative to VDD_{IO}	V_{IH}		70	—	—	%
Logic low output voltage (relative to VDD_{IO}	V_{OL}	Sinking 3 mA, VDD_{IO} ≥ 1.8 V	—	—	25	%
Logic high output voltage (relative to VDD_{IO}	V_{OH}	Sourcing 3 mA, VDD_{IO} ≥ 1.8 V	75	—	—	%
Input leakage current	I_{Leak}		—	0.1	—	nA
Pullup resistance	R_{PU}		30	43	65	kΩ
Pulldown resistance	R_{PD}		30	43	65	kΩ
Output fall time from V_{OH} to V_{OL}	T_{OF}	10 pF load, VDD_{IO} = 1.8 V	—	6	TBD	ns
Output rise time from V_{OL} to V_{OH}	T_{OR}	10 pF load, VDD_{IO} = 1.8 V	—	10	TBD	ns

4.8 Host Interface

The host interface allows control of WF(M)200 by an MCU or SoC using either SPI or SDIO. Selection between SPI and SDIO is done upon the logic state on SDIO_DAT2/HIF_SEL pin during the rising edge of RESETn signal. If this signal is HIGH, the host interface is configured as SDIO, otherwise it is configured as SPI. The tables below summarizes the pin configurations for the two modes and the achievable speeds on both interfaces

Table 4.10. WF(M)200 SPI and SDIO interface pin configuration

WF(M)200 Pin Name	SPI Mode		SDIO Mode	
RESETn	0 -> 1	1	0 -> 1	1
SDIO_DAT2/HIF_SEL	0	x	1	SDIO_DAT2
SDIO_CLK/SPI_CLK	x	SPI_CLK	x	SDIO_CLK
SDIO_CMD/SPI_MOSI	x	SPI_MOSI	x	SDIO_CMD
SDIO_DAT0/SPI_MISO	x	SPI_MISO	x	SDIO_DAT0

WF(M)200 Pin Name	SPI Mode		SDIO Mode	
SDIO_DAT1/SPI_WIRQ	x	WIRQ (interrupt request to the SPI host)	x	SDIO_DAT1
SDIO_DAT3/SPI_CSn	x	SPI_CSn	x	SDIO_DAT3

Table 4.11. Host Interface Speeds

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
SDIO V2.0 clock rate with four bits	SD_{Rate}	Host Interface SDIO	—	26	—	MHz
SPI clock rate	SPI_{Rate}	Host Interface SPI	—	—	52	MHz

Besides host interface main signals, a couple of other pins also complement the host interface:

- The GPIO/WUP pin is used to exit sleep mode when power save is activated, using LP_CLK. This pin is programmable and if power save is not enabled on the device, this pin can be configured as a GPIO.
- GPIO/WIRQ can also optionally be used in SDIO mode to provide the interrupt request to the host in case a given host does not support in-band IRQ. In case this is not required, the pin can be configured as GPIO

5. Typical Applications and Connections

5.1 RF Connections

5.1.1 Antenna Ports

This device has two RF ports to allow antenna diversity using an internal switch. In applications with only one antenna, the un-used port can be shorted to GND through a 50 Ohm resistor. In applications desiring to use a Front End Module (FEM), one of these ports could be used for Transmit, and the other RF Port for Receive.

5.1.2 Antenna Diversity

In Applications where the main antenna is subject to obstruction or de-tuning, a second antenna can be used at the alternate antenna port. The location of this second antenna should be such that both cannot be prevented from operating satisfactorily by the same event. A firmware feature can be invoked to determine which antenna has a better path to the remote WiFi Device.

5.1.3 XTAL_I and XTAL_O connections for Crystal

Connect the signal pins of a 38.4MHz crystal to the XTAL_O and XTAL_I pins with very short traces. These traces on the PCB should have short length, and minimal parasitic load. There is normally no need for external parallel capacitors because this IC includes internal load capacitors which have programmable values. The value of these load capacitors will have to be determined which center the operating frequency for the design of the crystal and PCB. This value will have to be included in firmware. Firmware will program the prescribe load capacitance prior to startup, and the value should not change during operation. See Application note (TBD) for more details of the crystal connections to this IC.

5.1.4 XTAL_I and XTAL_O connections for TCXO

When using a TCXO to provide 38.4MHz clock input, a series 1000pF capacitor is required between the TCXO output pin and XTAL_I pin to block DC. The XTAL_O pin can be left unconnected.

5.1.5 LP_CLK Port

A 32.768KHz clock source should be supplied to LP_CLK pin to enable the lowest power operation in power save modes. The frequency tolerance of this source affects wake up scheduling.

5.2 Multi-Protocol Coexistence

In case an RF transceiver using the same 2.4 GHz band (e.g. Bluetooth, Zigbee, or Thread) is co-located with theWF(M)200 Wi-Fi transceiver, the Packet Traffic Arbitration (PTA) interface can be used to minimize mutual interference. In this case, PTA pins are connected to the other transceiver. The PTA interface is highly programmable and can use 1, 2, 3, or 4 pins upon configuration.

Depending on manufacturer, PTA signal names can vary and the table below shows some alternative naming:

Table 5.1. PTA Alternative Naming

WF(M) 200 Pin Name	Alternative Names
PTA_TX_CONF	GRANT, WL_ACTIVE, WL_DENY
PTA_RF_ACT	REQUEST, BT_ACTIVE
PTA_STATUS	PRIORITY, BT_STATUS
PTA_FREQ	FREQ, BT_FREQ

PTA interface configuration is also achieved via the configuration file.

See the dedicated application notes (TBD) for more information regarding PTA and co-existence on Silicon Labs' WF(M)200, EFR32BGx, and EFR32MGx devices supporting Wi-Fi, BLE, Zigbee, and Thread.

6. Pin Descriptions

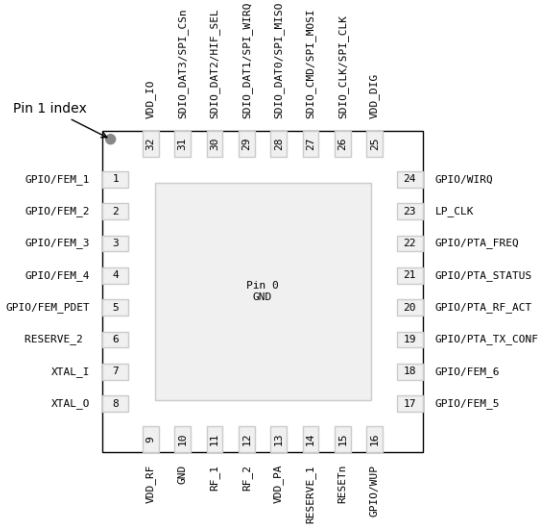


Figure 6.1. WF200 Pinout

Table 6.1. Pin Definitions

Pin #	Pin Name	I/O	Description / Default
1	GPIO/FEM_1	I/O	This pin can be used for dynamic control of an external front-end module (FEM), otherwise this can be used as GPIO.
2	GPIO/FEM_2	I/O	This pin can be used for dynamic control of an external front-end module (FEM), otherwise this can be used as GPIO.
3	GPIO/FEM_3	I/O	This pin can be used for dynamic control of an external front-end module (FEM), otherwise this can be used as GPIO.
4	GPIO/FEM_4	I/O	This pin can be used for dynamic control of an external Power amplifier detector output (Vdet) in case an external power amplifier or a FEM is used. Otherwise this can be used as GPIO.
5	GPIO/FEM_PDET	I/O	Programmable Pins / FEM Power detector Interface
6	RESERVE_2	I/O	Reserved. This pin should be left unconnected.
7	XTAL_I	I	XTAL or Reference Clock input
8	XTAL_O	O	Reference Clock Output
9	VDD_RF	I	RF power supply
10	GND	GND	Ground
11	RF_1	I/O	RF Port 1 to connect to main antenna
12	RF_2	I/O	RF Port 2 to connect to diversity antenna
13	VDD_PA	I	PA Power Supply
14	RESERVE_1	GND	Reserved. For normal operation, this pin must be grounded
15	RESETn	I	Reset pin, active low
16	GPIO/WUP	I/O	This pin can be used to wake up the device from sleep mode, or used as a GPIO

Pin #	Pin Name	I/O	Description / Default
17	GPIO/FEM_5	I/O	This pin can be used to dynamically control an external front-end module (FEM), otherwise this can be used as GPIO.
18	GPIO/FEM_6	I/O	This pin can be used to dynamically control an external front-end module (FEM), otherwise this can be used as GPIO.
19	PTA_TX_CONF	I/O	As part of PTA interface, this pin can be used to manage co-existence with another 2.4 GHz radio or can be used as a GPIO
20	PTA_RF_ACT	I/O	As part of PTA interface, this pin can be used to manage co-existence with another 2.4 GHz radio or can be used as a GPIO
21	PTA_STATUS	I/O	As part of PTA interface, this pin can be used to manage co-existence with another 2.4 GHz radio or can be used as a GPIO
22	PTA_FREQ	I/O	As part of PTA interface, this pin can be used to manage co-existence with another 2.4 GHz radio or can be used as a GPIO
23	LP_CLK	I	Low Power clock input. This pin is typically connected to the 32 KHz reference clock.
24	GPIO_WIRQ	I/O	This pin can be used as an IRQ to host for SDIO, or can be used as a GPIO.
25	VDD_DIG	I	Digital Power Supply
26	SDIO_CLK/ SPI_CLK	I	Host interface: SDIO_CLK or SPI_CLK
27	SDIO_CMD/ SPI_MOSI	I/O	Host interface: SDIO_CMD or SPI_MOSI
28	SDIO_DAT0/ SPI_MISO	I/O	Host interface: SDIO_DAT0 or SPI_MISO
29	SDIO_DAT1 / SPI_WIRQ	I/O	Host interface: SDIO_DAT1 or WIRQ
30	SDIO_DAT2/ HIF_SEL	I/O	Host interface selection: Used to select the host interface during reset rising edge. If Low, selects SPI interface. When High, selects SDIO interface and this pin becomes SDIO_DAT2
31	SDIO_DAT3/ SPI_CSn	I/O	Host interface: SDIO_DAT3 or SPI_CSn
32	VDD_IO	I	IO Power Supply
0	GND	GND	Exposed Die Pad

7. Package Outline

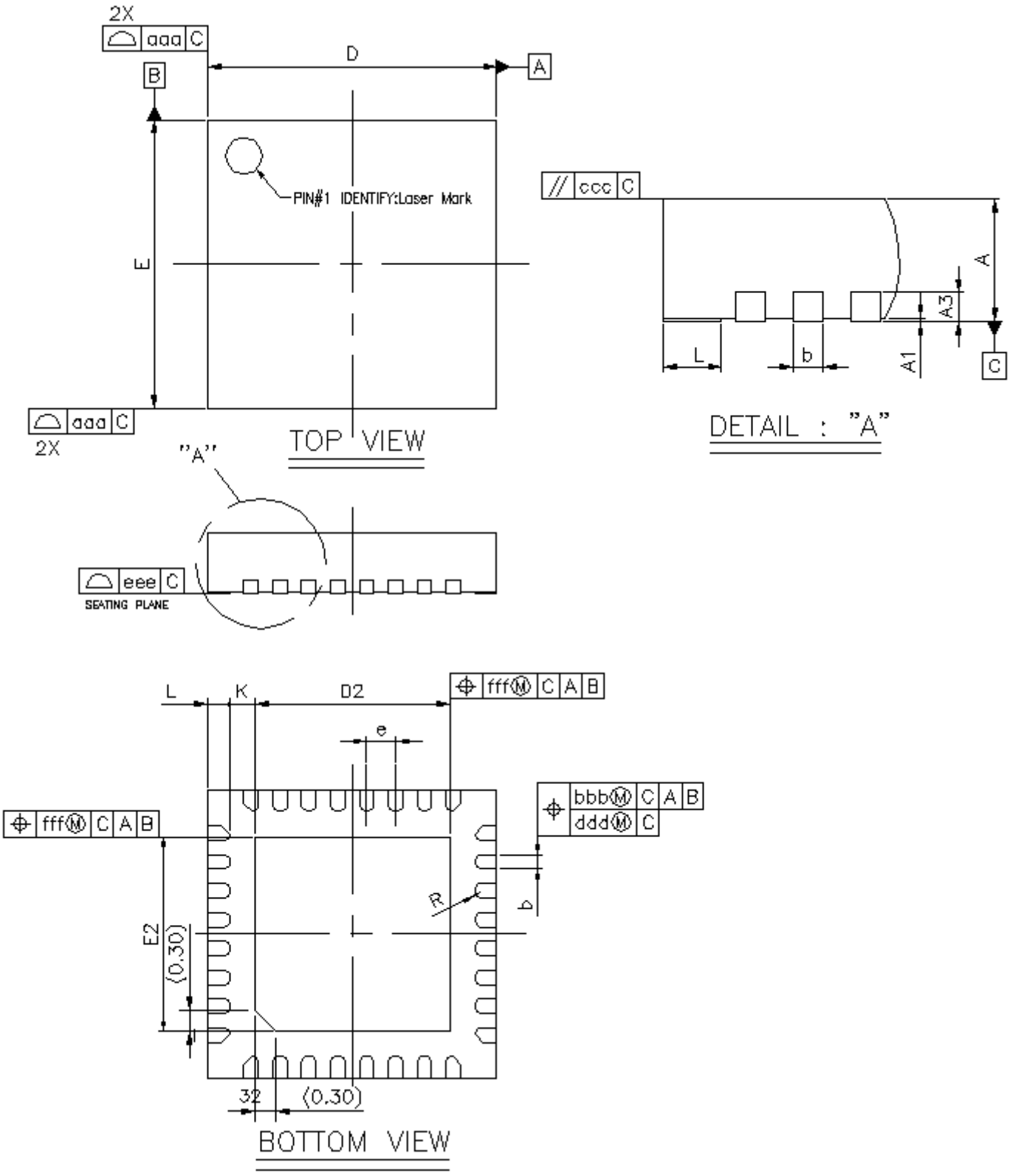


Figure 7.1. WF200 Package Outline

8. Land Pattern

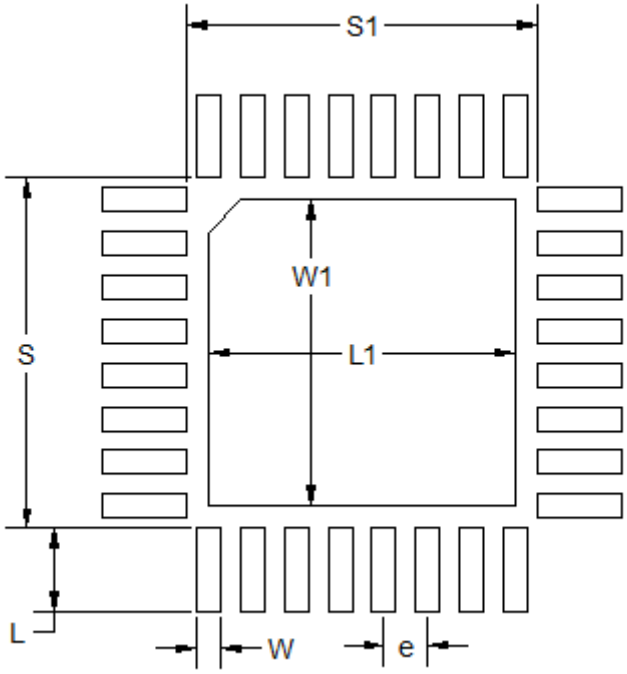


Figure 8.1. WF200 Land Pattern

9. Top Marking

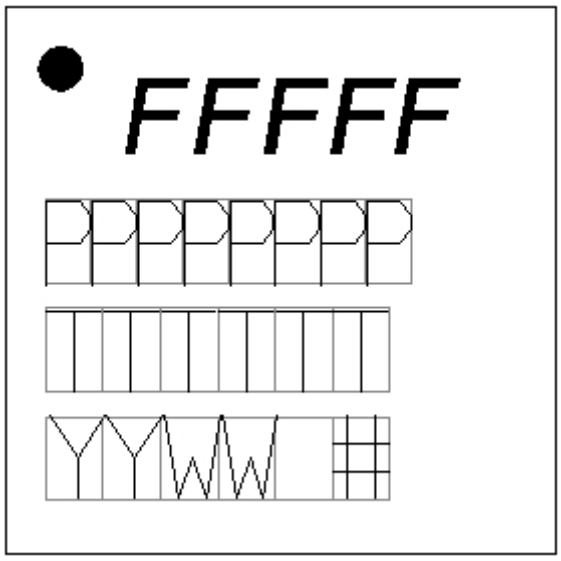


Figure 9.1. WF200 Top Marking

10. Software Reference

This section gives a short overview of the software involved to run applications based on this device.

10.1 Host and Device Software

This device is intended to be used as a Network Co-Processor (NCP) which means that it requires a host processor to run the application. Depending on architecture choices based on required throughput, host memory size and power, the MAC layer can be split between WF(M)200 and its host or fully ran in WF(M)200.

10.1.1 Split MAC

The so-called split MAC is the case where WF(M)200 runs the Lower MAC section while the host processor runs the Upper MAC. This is a use case that typically fits the Linux application as MAC802.11 is provided with Linux

For such an application, Silicon Labs provides the embedded Firmware implementing the Lower MAC as well as needed configuration tasks. An example of WF(M)200 core driver for Linux is also provided.

The figure below shows the typical software architecture in Full MAC implementations.

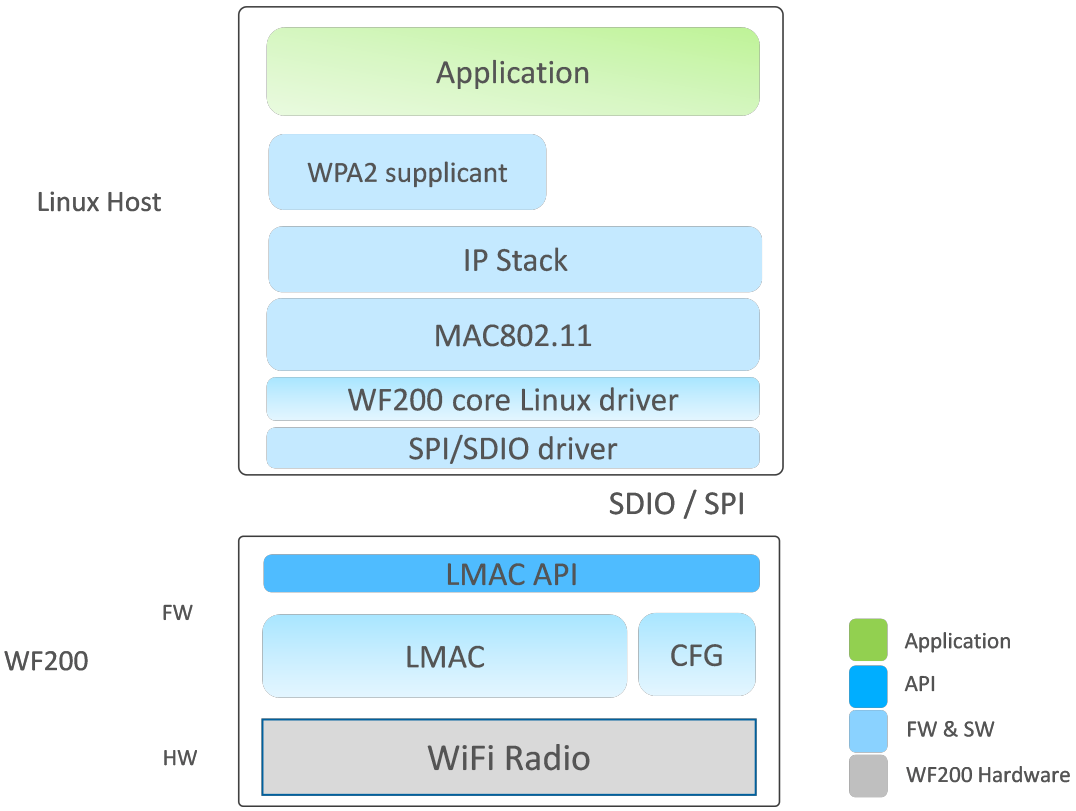


Figure 10.1. Split MAC Implementation

10.1.2 Full MAC

In this scenario,both the lower MAC and upper MAC are running in WF(M)200. The WF(M)200 contains a WPA supplicant, allowing it to handle full MAC responsibilities without utilizing the host MCU. The host recieves an IP packet, and implements all stack layers necessary above it.

The figure below shows the typical software architecture in Full MAC implementations.

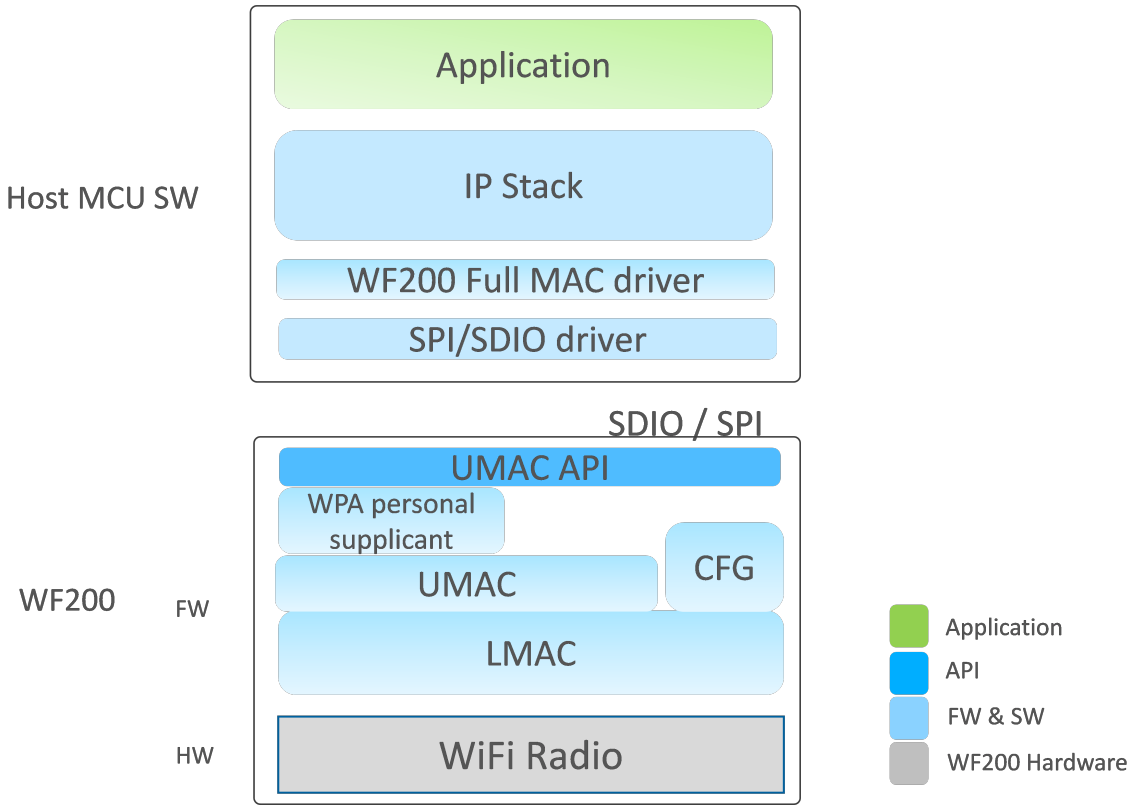


Figure 10.2. Full MAC Implementation

Note: The WPA supplicant on WF(M)200 does not support WPA enterprise. If WPA-enterprise is required, then it should be implemented above the IP stack in the host MCU software.

10.1.3 Software Documentation

Documentation required for software implementation is provided in a set of Application Notes which are provided upon request(TBD).

10.2 Security

Security is a major item for wireless communications. WF(M)200 implements several security features as listed below.

More details on security items and ways to enable each of them are provided in a forthcoming application note on security.

10.2.1 Secure Device

WF(M)200 diasables access to all debug ports, and no low level register access is available. This feature has no impact on host software.

10.2.2 Secure Boot

Secure Boot includes several features related to boot and firmware security. Firmware authentication and encryption do not have any impact on host software, whereas firmware roll back prevention requires more flexibility and is managed by each customer through software.

- Firmware authentication: The downloaded firmware is authenticated such that only Firmware provided by Silicon Labs can run in WF(M)200.
- Firmware encryption: The downloaded firmware is encrypted when generated by Silicon Labs, and is decrypted inside WF(M)200 during firmware download.
- Firmware roll back prevention: If a security threat is discovered, Silicon Labs has the ability to increment in its firmware an anti-roll-back tag. This can be used by the customer to prevent the part from starting with a firmware having a tag lower than a specified one. This mechanism is managed by each customer on a case by case and is described with full details in a forthcoming application note.

10.2.3 Secure Link

Secure Link (also called Secure Host) refers to the capability to have encrypted SPI/SDIO communication between the host and WF200. This feature requires the host and WF200 to exchange a key that is stored in WF(M)200 and the host.

There are 3 possible cases for secure link:

- Secure link is not used. In this scenario, the part does not encrypt any communication with the host.
- Secure link is temporary enabled: Secure Link can be activated through software, with a software key which is not stored in WF(M)200. Doing this allows to assess the performance and consumption impacts of secure link. In this mode, Secure Link is achieved as long as the part is not reset. Next restart of WF200 will make it start in Non-Secure Link mode.
- Permanent Secure Link: This mode is activated by software and the key exchanged is permanently stored in WF200 non-volatile memory. Once configured in this mode, WF200 only understands host interface messages which have been encrypted with the stored key.

Once a secure link has been established, the host can choose to only encrypt certain API messages between the host and the WF(M)200 to reduce the power and latency overhead of encryption.

10.3 PTA Co-existance and FEM Firmware settings

The details regarding PTA and FEM configuration are provided within a forthcoming application note

10.4 Startup, Sleep and Standby

10.4.1 Power On, Reset and Boot

When RESETn pin is set HIGH, WF(M)200 is getting out of its reset mode. All supply voltages should be settled within the operational range before the rising edge of RESETn pin. Then the boot sequence can be initiated by the host software with following sequence:

- Some registers describing the required configuration before firmware download are written by the driver
- The driver initiate the boot
- The driver downloads the embedded firmware into WF(M)200
- The driver configures WF(M)200 upon the hardware platform and requested features with a dedicated configuration file

10.4.2 Sleep and Snooze Modes

The sleep mode can be used by the host in case the Wi-Fi feature is not needed for a given period of time. This mode highly reduces power consumption while maintaining all configuration and context, so that the device can be quickly back to normal operation. A WF(M)200 driver command is used to set the device in sleep mode.

The part wake-up is achieved by asserting the GPIO/WUP pin.

The sleep mode requires a 32 KHz clock to be provided on LP_CLK pin.

In case a 32 KHz clock is not available, the part can be set in a snooze mode which is functionally equivalent but draws more current.

10.4.3 Standby Mode

The stand-by mode can be used if the Wi-Fi feature is not needed for a long period of time. This mode achieves the lowest current consumption on the device but requires a full power-up reset and boot sequence to come back to the operational mode. This mode should be initiated by the host. Note that similar behavior could be achieved by asserting RESETn pin low, but would draw more current.

11. Revision History

Revision 0.2

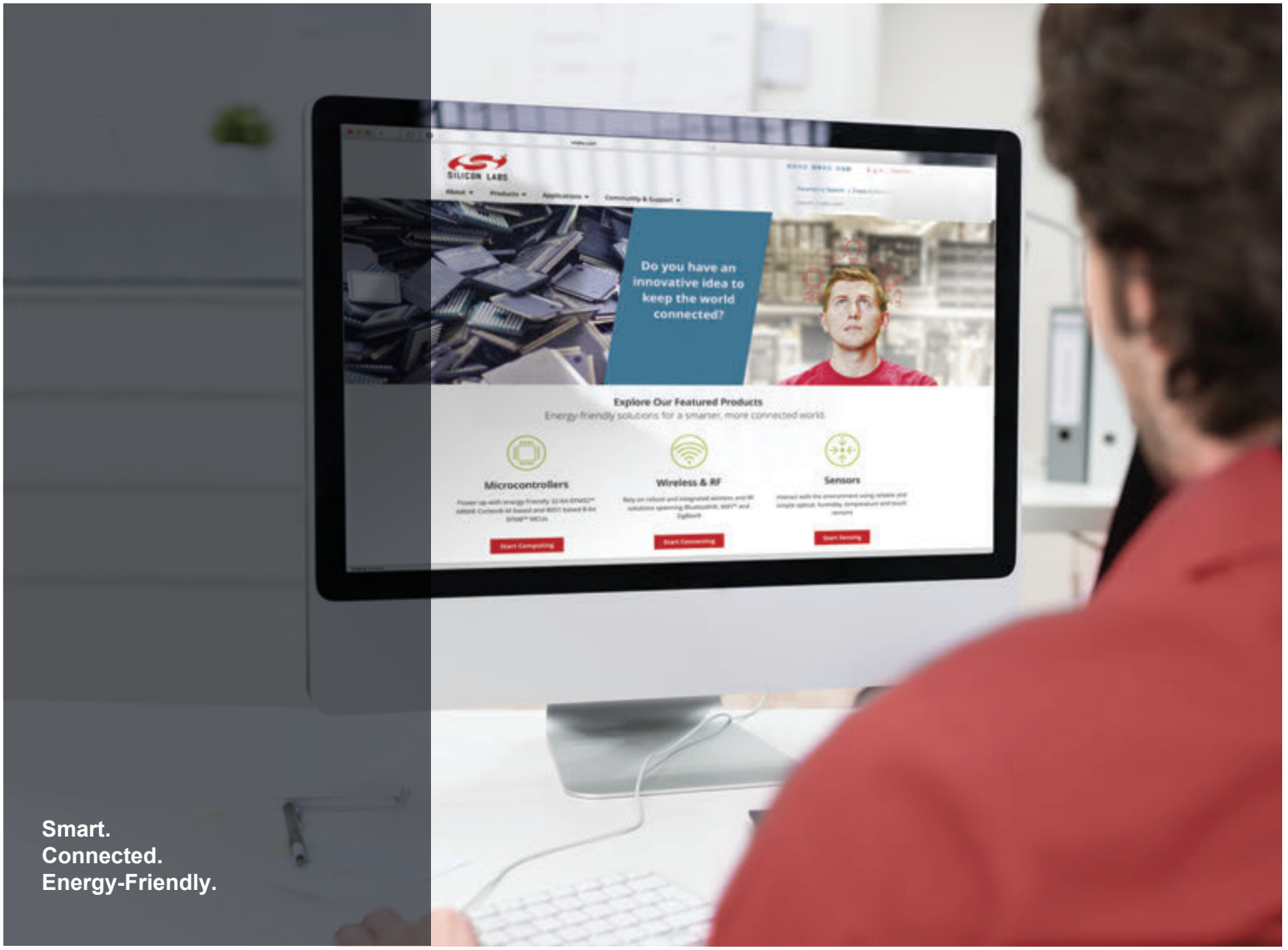
July 20, 2018

- Updated TX, RX specifications
- Updated front matter and features list

Revision 0.1

April 4, 2018

- Initial Release



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