# UG407: WFM200S Wi-Fi® Expansion Kit User's Guide

The WFM200S Wi-Fi Expansion Kit is an excellent way to explore and evaluate the WFM200S Wi-Fi Transceiver Module with a Raspberry Pi or an EFM32 MCU for your embedded application.

The WFM200S Wi-Fi Transceiver Module is an easy to use and easy to interface Wi-Fi Network Co-Processor (NCP). Most of the associated complexity of Wi-Fi and the protocol stack is offloaded to the NCP and allows for easy Wi-Fi integration into any embedded system.

The kit easily integrates and brings Wi-Fi connectivity to a compatible Silicon Labs MCU Starter Kit through the EXP header. The WFM200S Wi-Fi Expansion Kit has also been designed after the Raspberry Pi Hardware Attached on Top (HAT) board specification, allowing the WFM200S Wi-Fi Expansion Kit to connect to a Raspberry Pi.

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**WFM200S EXPANSION BOARD FEATURES**

- Selectable SPI or SDIO host interface
- EXP connector for interfacing Silicon Labs Starter Kits
  - Allows board detection and identification
- Raspberry Pi compatible HAT
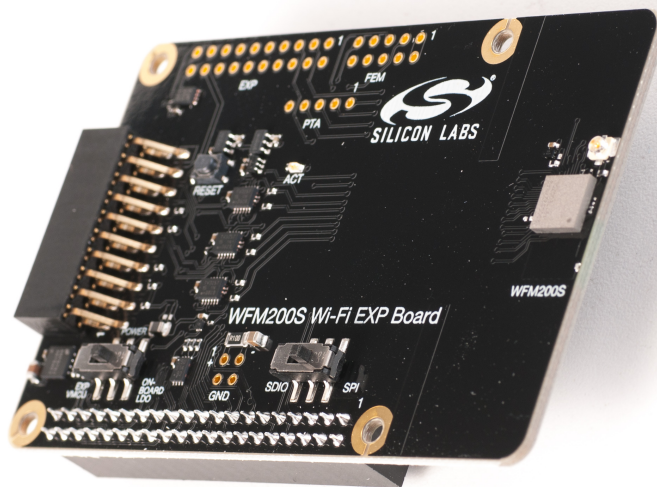  - 40-pin header
  - HAT EEPROM for identification

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# Table of Contents

# 1. Introduction

This user guide describes the WFM200S Wi-Fi Expansion Kit. The kit connects to either a Silicon Labs EFM32 MCU starter kit (STK), a Silicon Labs EFR32 wireless starter kit (WSTK) or a Raspberry Pi equipped with the 40-pin Raspberry Pi hardware-attached-on-top (HAT) connector. SDIO support is available only with selected hosts.

Figures 1.1 and 1.2 shows the kit connected to a Silicon Labs MCU STK through the Expansion Header and a Raspberry Pi, respectively.
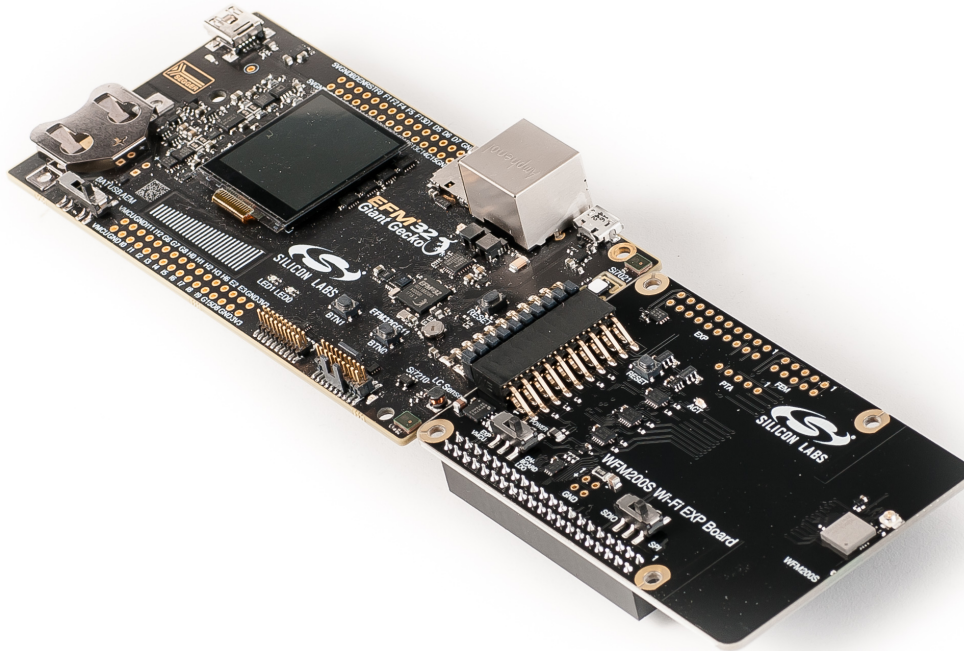


**Figure 1.1.   WFM200S Wi-Fi Expansion Kit Connected to a Silicon Labs EFM32GG11 MCU STK**
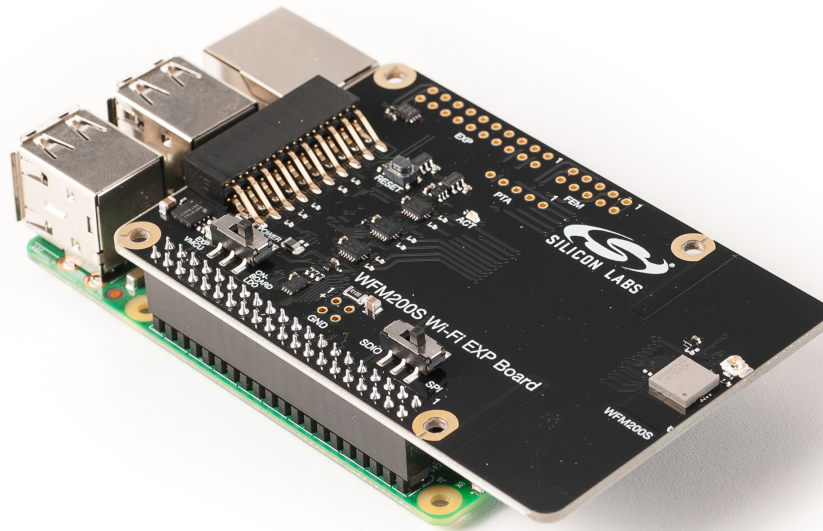
**Figure 1.2. WFM200S Wi-Fi Expansion Kit Connected to a Raspberry Pi**

**Note:** Do **not** connect the kit to both a Silicon Labs MCU STK and a Raspberry Pi at the same time.

## 1.1 Kit Contents

The WFM200S Wi-Fi Expansion Kit comes in two versions, which differs in what's included in the box:
- SLEXP8023A:
  - BRD8023A WFM200S Wi-Fi EXP Board
  - 8 GB Micro-SD card with software image for Raspberry Pi 2
- SLEXP8023C:
  - BRD8023A WFM200S Wi-Fi EXP Board
  - 8 GB Micro-SD card with software image for Raspberry Pi 2
  - Raspberry Pi 2 Model B Single-Board Computer
  - Raspberry Pi Power Supply 5.1 V, 2.5 A

# 2. Hardware Overview

## 2.1 Hardware Layout

The layout of the WFM200S Wi-Fi Expansion Kit is shown in the figure below.
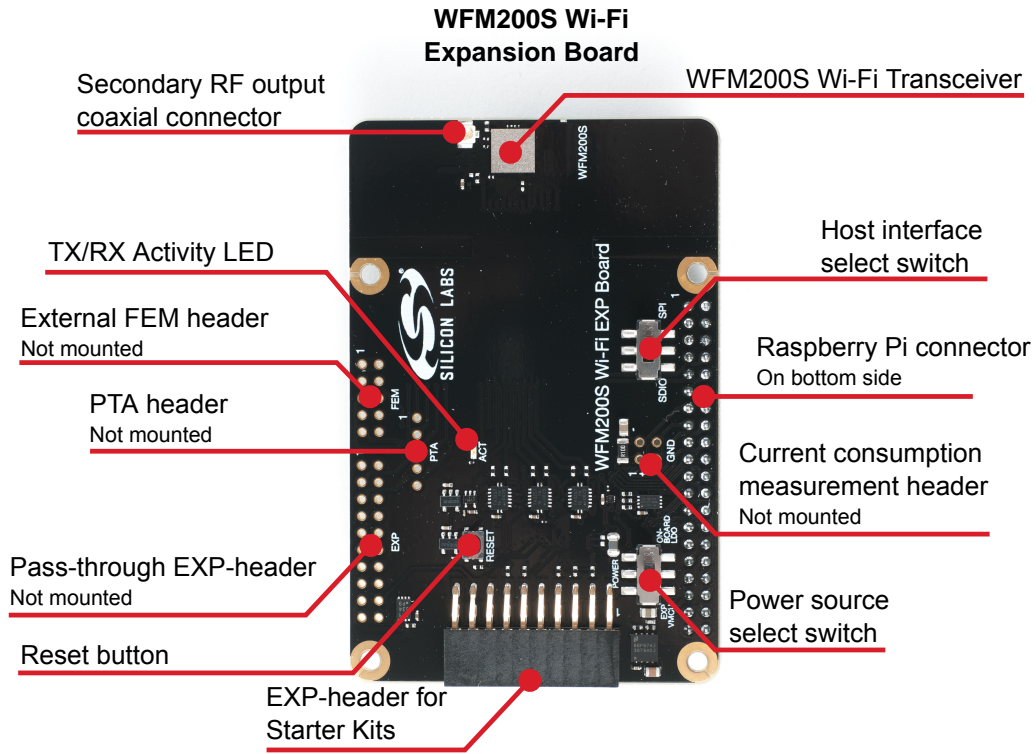


**Figure 2.1.  WFM200S Wi-Fi Expansion Kit Hardware Layout**

## 3. WFM200S Wi-Fi NCP Expansion Kit

The WFM200S Wi-Fi Transceiver Module is a Wi-Fi Network Co-Processor (NCP) transceiver from Silicon Labs.

### 3.1 Host Interfaces

SPI and SDIO are the two available host interfaces (HIF) on the WFM200S Wi-Fi Expansion Kit. A slide switch, whose state is sampled during power-on reset or manually issued reset is used to select the interface. The slide switch must remain in the same position throughout the duration of the session since it also controls HIF selection multiplexer circuits.

When the WFM200S Wi-Fi Expansion Kit is connected to an EFM32/EFR32 starter kit through the EXP header, the state of the HIF selection switch can be read (but not controlled) by the kit mcu through a GPIO pin.

The WFM200S Wi-Fi Expansion Kit incorporates a set of multiplexer circuits which allows the user to use the same kit for evaluating the WFM200S in both applications requiring SPI or SDIO connectivity to the host. These circuits will normally not be needed in an end-user application since in most cases the interface to use will be fixed.

A simplified circuit diagram showing the host interface multiplexer circuits is shown below. The EXP_HEADER9 signal is connected to pin 9 on the EXP header, while the HIF_OEn output enable signal is controlled by the power-on reset circuit (explained later).
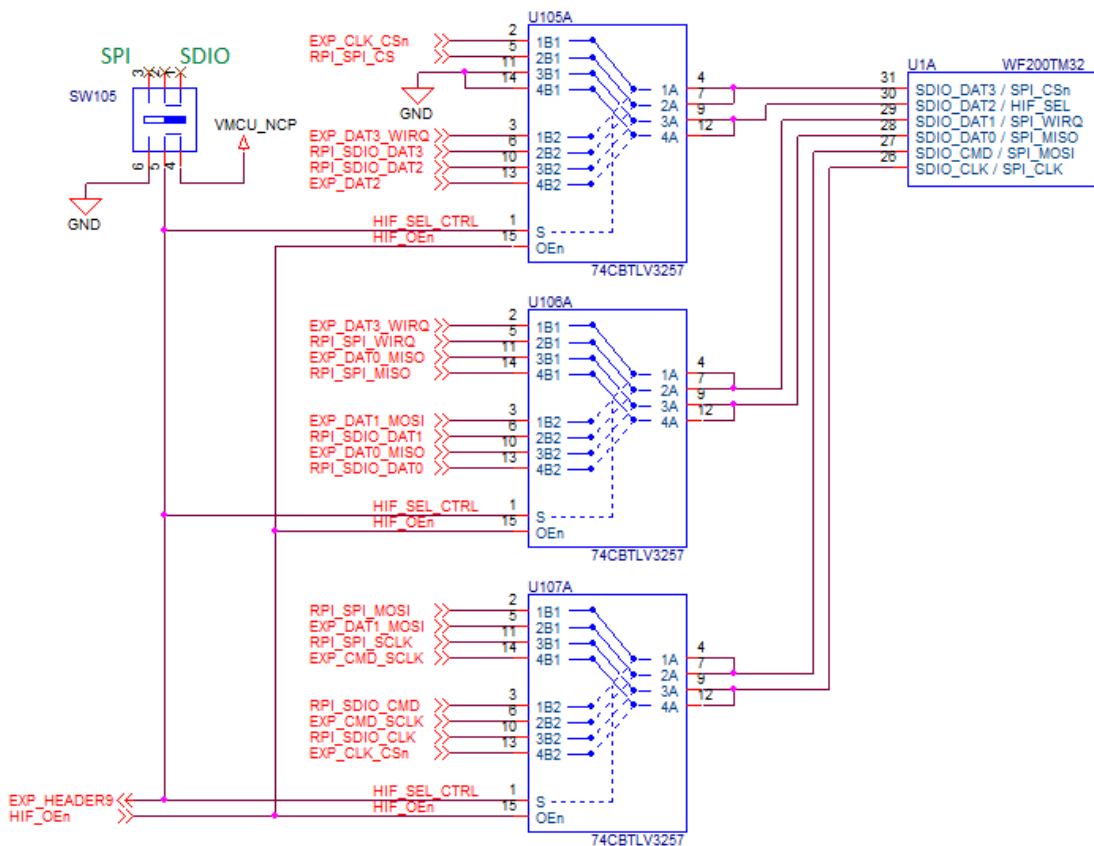


**Figure 3.1.  Host Interface Multiplexer Circuit**

### 3.2 Power-on and Manual Reset Circuit

To ensure that the state of the host interface selection signal is sampled correctly at the rising edge of the WFM200S RESETn signal, a power-on reset circuit has been added to the WFM200S Wi-Fi Expansion Kit. This circuit achieves this by

- Adding a delay of 1ms to the rising edge of the RESETn signal with respect to the rising edge of the power supply
- Isolating the host from the WFM200S DAT2/HIF_SEL pin during the rising edge of the RESETn signal

The figure below shows the circuit diagram for the power-on and manual reset circuit. Its functionality is as follows:

- NCP_RESETn is the active-low reset signal of the WFM200S. The WFM200S RESETn pin has an internal pull-up of approximately 43 kOhms. The on-board reset button is connected to this signal.
- HIF_SEL_CTRL is the signal from the HIF selection switch
- HIF_OEn is the active-low output enable signal of the HIF multiplexer circuits
- WF_DAT2_HIF_SEL is the combined SDIO DAT2 signal and HIF selection signal of the WFM200S
- U114 is an open-drain active low output reset monitor which with the installed capacitor connected to the CD pin keeps NCP_RE-SETn tied to ground for about 1 ms after VMCU_NCP has exceeded the threshold voltage of 0.9 V
- U115 is a tri-state output buffer with an active low output enable signal connected to NCP_RESETn which pulls the CD pin of U116 low while NCP_RESETn is low
- U116 is a push-pull active high output reset monitor which drives HIF_OEn high for 1 ms after the output of U115 is disabled
- U109 is a tri-state output buffer with an active high output enable signal which connects the HIF_SEL_CTRL signal to the WF_DAT2_HIF_SEL signal as long as HIF_OEn is high

The NCP_RESETn signal is available on both the EXP header and the Raspberry Pi connector and can be used for issuing a manual reset sequence by pulling it low for at least 1 ms.

**Note:** Reset button is effective when board is not connected to MCU or Raspberry Pi boards. When connected, change of host interface is effective after reboot.
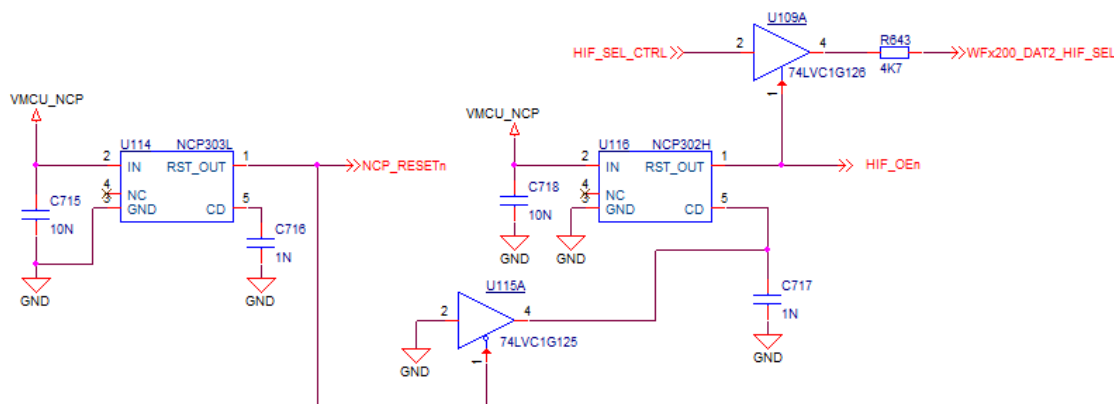


**Figure 3.2. Power-on and Manual Reset Circuit Diagram**

# 4. Connectors

This chapter gives an overview of the WFM200S Wi-Fi Expansion Kit connectivity and power connections.
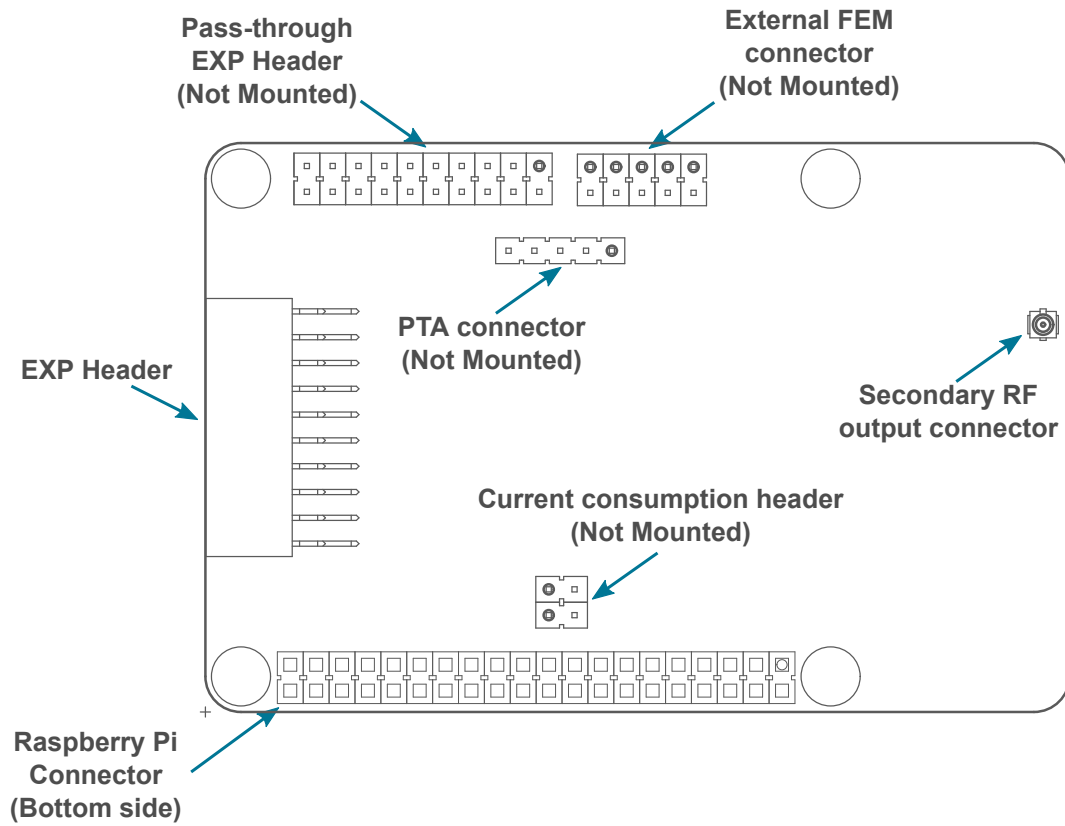


**Figure 4.1.  WFM200S Wi-Fi Expansion Kit Connector Layout**

**4.1 EXP Header**

On the left-hand side of the WFM200S Wi-Fi Expansion Kit, a right-angle female 20-pin EXP header is provided to connect to one of Silicon Labs' supported Starter Kits. The EXP header on the Starter Kits follows a standard which ensures that commonly used peripherals such as an SPI, a UART, and an I$^2$C bus, are available on fixed locations on the connector. Additionally, the VMCU, 3V3 and 5 V power rails are also available on the expansion header. For detailed information regarding the pinout to the expansion header on a specific Starter Kit, consult the accompanying user's guide.

The figure below shows how the WFM200S Wi-Fi Transceiver Module is connected to the connector and the peripheral functions that are available.
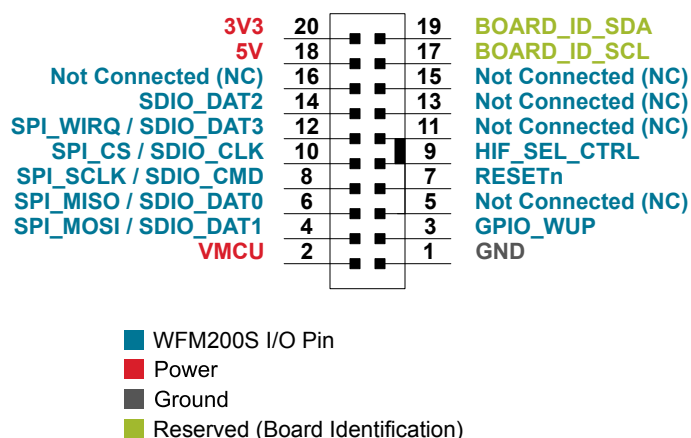


**Figure 4.2. Expansion Header**

**4.1.1 Pass-through EXP Header**

The WFM200S Wi-Fi Expansion Kit features a footprint for a secondary EXP header. All signals from the EXP header, including those that are not connected to any features on the WFM200S Wi-Fi Expansion Kit, are directly tied to the corresponding pins in the footprint, allowing daisy-chaining of additional expansion boards if a connector is soldered in.

**4.1.2 EXP Header Pinout**

The table below shows the pin assignments of the EXP header.

**Table 4.1. EXP Header Pinout**

| EXP Header | |
|---|---|
| Pin | Function |
| 2 | WFM200S voltage domain (power switch set to EXP VMCU) |
| 4 | SPI_MOSI / SDIO_DAT1 |
| 6 | SPI_MISO / SDIO_DAT0 |
| 8 | SPI_SCLK / SDIO_CMD |
| 10 | SPI_CS / SDIO_CLK |
| 12 | SPI_WIRQ / SDIO_DAT3 |
| 14 | SDIO_DAT2 |
| 16 | Not Connected |
| 18 | Board 5 V supply. Used to supply LDO regulator. |
| 20 | Board 3V3 supply. Only used for board identification. |
| | |
| 1 | Ground |
| 3 | GPIO (WFM200S WUP) |
| 5 | Not Connected |
| 7 | GPIO (WFM200S RESETn) |
| 9 | GPIO (HIF_SEL_CTRL read access) |
| 11 | Not Connected |
| 13 | Not Connected |
| 15 | Not Connected |
| 17 | Identification of expansion boards. |
| 19 | Identification of expansion boards. |

## 4.2 Raspberry Pi Connector

On the bottom side of the WFM200S Wi-Fi Expansion Kit, a dual row, female socket, 0.1" pitch connector is installed to allow the WFM200S Wi-Fi Expansion Kit to act as a Raspberry Pi Hardware Attached on Top (HAT) board.

The figure below shows how the WFM200S Wi-Fi Transceiver Module is connected to the connector and the peripheral functions that are available.
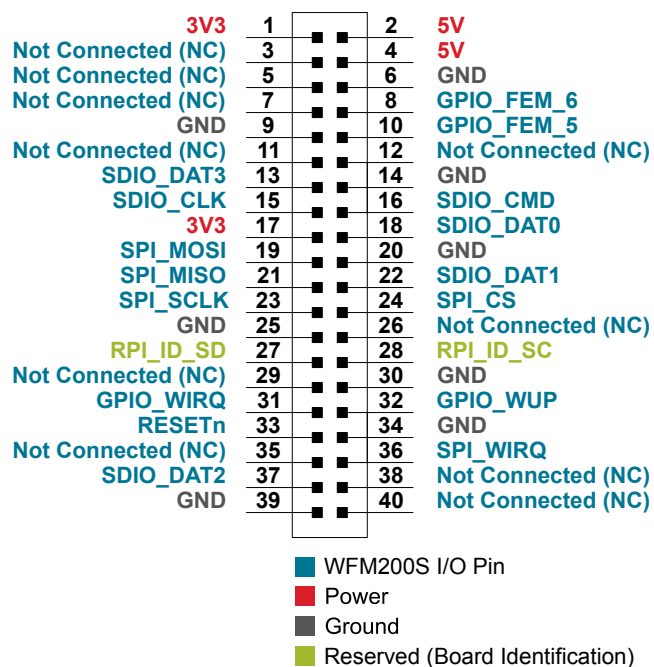
| | | | | |
|---|---|---|---|---|
| 3V3 | 1 | | 2 | 5V |
| Not Connected (NC) | 3 | | 4 | 5V |
| Not Connected (NC) | 5 | | 6 | GND |
| Not Connected (NC) | 7 | | 8 | GPIO_FEM_6 |
| GND | 9 | | 10 | GPIO_FEM_5 |
| Not Connected (NC) | 11 | | 12 | Not Connected (NC) |
| SDIO_DAT3 | 13 | | 14 | GND |
| SDIO_CLK | 15 | | 16 | SDIO_CMD |
| 3V3 | 17 | | 18 | SDIO_DAT0 |
| SPI_MOSI | 19 | | 20 | GND |
| SPI_MISO | 21 | | 22 | SDIO_DAT1 |
| SPI_SCLK | 23 | | 24 | SPI_CS |
| GND | 25 | | 26 | Not Connected (NC) |
| RPI_ID_SD | 27 | | 28 | RPI_ID_SC |
| Not Connected (NC) | 29 | | 30 | GND |
| GPIO_WIRQ | 31 | | 32 | GPIO_WUP |
| RESETn | 33 | | 34 | GND |
| Not Connected (NC) | 35 | | 36 | SPI_WIRQ |
| SDIO_DAT2 | 37 | | 38 | Not Connected (NC) |
| GND | 39 | | 40 | Not Connected (NC) |

■ WFM200S I/O Pin
■ Power
■ Ground
■ Reserved (Board Identification)

**Figure 4.3. Raspberry Pi Connector**

#### 4.2.1 Raspberry Pi Connector Pinout

The table below shows the pin assignments of the Raspberry Pi connector, and the port pins and peripheral functions that are available on the WFM200S Wi-Fi Expansion Kit.

**Table 4.2.  Raspberry Pi Connector Pinout**

| Raspberry Pi Connector | | |
|---|---|---|
| Pin(s) | Function | Raspberry Pi Pin |
| 1 | 3V3 | 3v3 Power |
| 2 | 5 V | 5 V Power |
| 3 | - | Not Connected |
| 4 | 5 V | 5 V Power |
| 5 | - | Not Connected |
| 6 | GND | Ground |
| 7 | - | Not Connected |
| 8 | GPIO (WFM200S FEM_6) | BCM 14 |
| 9 | GND | Ground |
| 10 | GPIO (WFM200S FEM_5) | BCM 15 |
| 11 | - | Not Connected |
| 12 | - | Not Connected |
| 13 | SDIO_DAT3 | BCM 27 |
| 14 | GND | Ground |
| 15 | SDIO_CLK | BCM 22 |
| 16 | SDIO_CMD | BCM 23 |
| 17 | 3V3 | 3v3 Power |
| 18 | SDIO_DAT0 | BCM 24 |
| 19 | SPI_MOSI | BCM 10 |
| 20 | GND | Ground |
| 21 | SPI_MISO | BCM 9 |
| 22 | SDIO_DAT1 | BCM 25 |
| 23 | SPI_SCLK | BCM 11 |
| 24 | SPI_CS | BCM 8 |
| 25 | GND | Ground |
| 26 | - | Not Connected |
| 27 | ID EEPROM SDA | BCM 0 |
| 28 | ID EEPROM SCL | BCM 1 |
| 29 | - | Not Connected |
| 30 | GND | Ground |
| 31 | GPIO (WFM200S WIRQ) | BCM 6 |
| 32 | GPIO (WFM200S WUP) | BCM 12 |

| Raspberry Pi Connector | | |
| --- | --- | --- |
| Pin(s) | Function | Raspberry Pi Pin |
| 33 | GPIO (WFM200S RESETn) | BCM 13 |
| 34 | GND | Ground |
| 35 | - | Not Connected |
| 36 | SPI_WIRQ | BCM 16 |
| 37 | SDIO_DAT2 | BCM 26 |
| 38 | - | Not Connected |
| 39 | GND | Ground |
| 40 | - | Not Connected |

## 4.3  External FEM Connector

The WFM200S Wi-Fi Expansion Kit features a 2x5-pin 0.1" pitch connector exposing the WFM200S Wi-Fi Transceiver Module's external front-end module (FEM) interface, which allows the connection of an external FEM board using a ribbon cable.

The WFM200S Wi-Fi Expansion Kit also features a TX/RX activity indicator LED which is connected to the FEM_5 signal. By default, to optimize power consumption, TX/RX activity LED is not enabled. PDS sections PROG_PINS_CFG and FEM_CFG should be updated to enable this functionality.

The pinout of the connector is illustrated in the figure below.
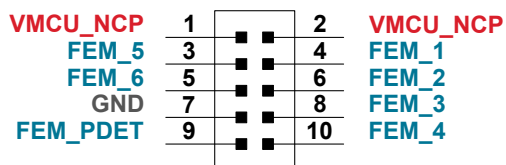


**Figure 4.4.  External FEM Connector**

### 4.3.1  External FEM Connector Pinout

The pin assignment of the external FEM connector on the board is given in the table below.

**Table 4.3.  External FEM Connector Pin Descriptions**

| Pin Number | WFM200S Connection |
| --- | --- |
| 1 | VMCU_NCP |
| 2 | VMCU_NCP |
| 3 | FEM_5 |
| 4 | FEM_1 |
| 5 | FEM_6 |
| 6 | FEM_2 |
| 7 | GND |
| 8 | FEM_3 |
| 9 | FEM_PDET |
| 10 | FEM_4 |

## 4.4 PTA Connector

The WFM200S' packet transfer arbitration (PTA) interface for managing coexistence in a multi-transceiver application is exposed on a 1x5-pin 0.1" pitch header on the WFM200S Wi-Fi Expansion Kit.

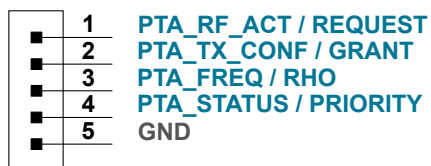The pinout of the connector is illustrated in the figure below.

```
  1   PTA_RF_ACT / REQUEST
  2   PTA_TX_CONF / GRANT
  3   PTA_FREQ / RHO
  4   PTA_STATUS / PRIORITY
  5   GND
```

**Figure 4.5. PTA Connector**

### 4.4.1 PTA Connector Pinout

The pin assignment of the PTA connector on the board is given in the table below.

**Table 4.4. PTA Connector Pin Descriptions**

| Pin Number | WFM200S Connection |
|---|---|
| 1 | PTA_RF_ACT / REQUEST |
| 2 | PTA_TX_CONF / GRANT |
| 3 | PTA_FREQ / RHO |
| 4 | PTA_STATUS / PRIORITY |
| 5 | GND |

## 4.5 Secondary RF Connector

The WFM200S' secondary RF output is exposed on the WFM200S Wi-Fi Expansion Kit through a Hirose u.FL coaxial connector.

For connecting the secondary RF output to an RF measurement instrument, 50 ohms resistor R641 shall be removed and a u.FL to SMA adapter cable (not included with the kit) can be used. Examples of such adapter cables are the Taoglas CAB.721 (100 mm) or CAB.720 (200 mm) cable assemblies.

#### 4.6  Power Supply

There are two ways to provide power to the kit:

• The kit can be connected to, and powered by, a Silicon Labs MCU STK
• The kit can be connected to, and powered by, a Raspberry Pi

**Note:** Connecting the WFM200S Wi-Fi Expansion Kit to both an EFM32/EFR32 STK and a Raspberry Pi at the same time is not a valid option.

When connected to a Silicon Labs MCU STK, the WFM200S Wi-Fi Transceiver Module can either be powered by the VMCU rail present on the EXP header or through an LDO regulator on board the WFM200S Wi-Fi Expansion Kit. If connected to the VMCU rail of the starter kit, the current consumption of the WFM200S Wi-Fi Transceiver Module will be included in the starter kit's on-board Advanced Energy Monitor (AEM) measurements. The LDO regulator draws power from the 5V net, and, hence, the power consumption of the WFM200S Wi-Fi Transceiver Module will not be included in any AEM measurements performed by the MCU STK.

A mechanical power switch on the WFM200S Wi-Fi Expansion Kit is used to select between Low Power (AEM) mode and High Power (LDO) mode. When the switch is set to Low Power (AEM) mode, the WFM200S Wi-Fi Transceiver Module is connected to the VMCU net on the Expansion Header. When the switch is set to High Power (LDO) mode, the WFM200S Wi-Fi Transceiver Module is connected to the output of the LDO. For applications requiring high power consumption or when the WFM200S Wi-Fi Expansion Kit is connected to a Raspberry Pi, the power switch must be set to High Power (LDO) mode.

A 0.1 ohm current sense resistor accompanied by a 2x2-pin 0.1" unpopulated header is provided to measure the current consumption of the WFM200S Wi-Fi Transceiver Module whenever AEM is not available or when the current consumption exceeds the measurement range of AEM.

The power topology is illustrated in the figure below.
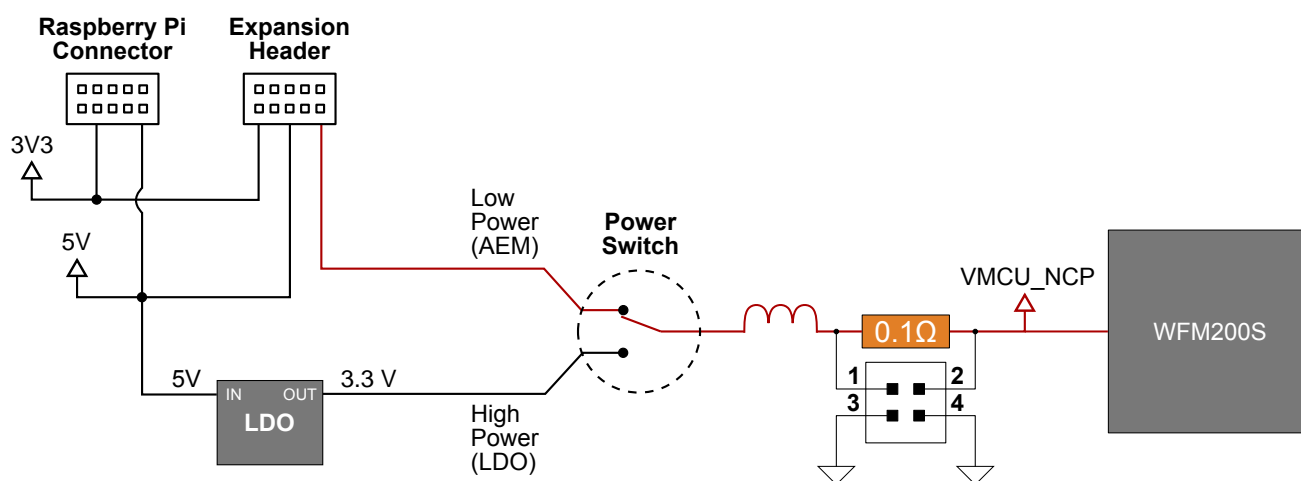


**Figure 4.6.  WFM200S Wi-Fi Expansion Kit Power Topology**

## 5. Schematics, Assembly Drawings, and BOM

Schematics, assembly drawings, and bill of materials (BOM) are available through Simplicity Studio when the kit documentation package has been installed. They are also available from the Silicon Labs website and kit page.

## 6. Kit Revision History

The kit revision can be found printed on the kit packaging label, as outlined in the figure below.
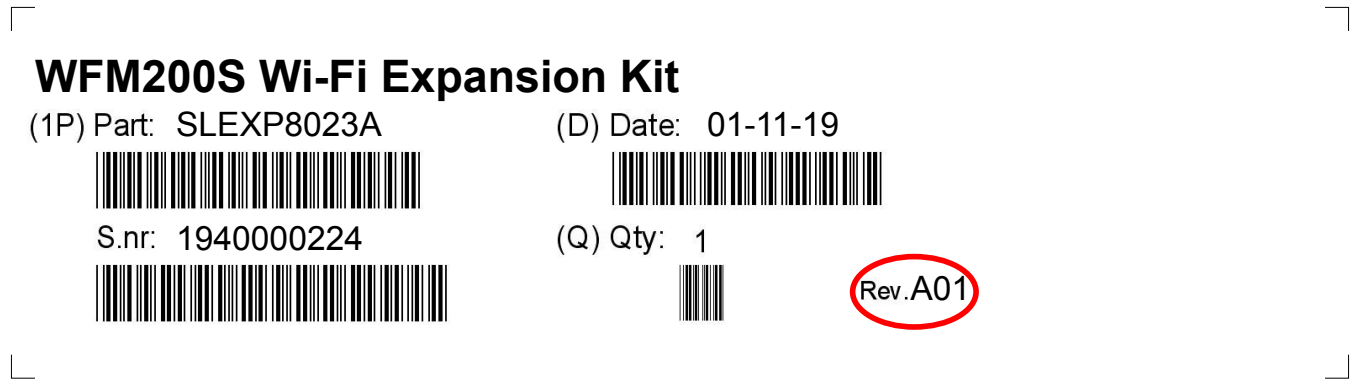


**Figure 6.1. Kit Label**

### 6.1 SLEXP8023A Revision History

| Kit Revision | Released | Description |
| --- | --- | --- |
| A01 | 2019-11-01 | Initial release. |

### 6.2 SLEXP8023C Revision History

| Kit Revision | Released | Description |
| --- | --- | --- |
| A00 | 2019-11-01 | Initial release. |

## 7. Document Revision History

**Revision 1.0**

2019-11-01
- Initial document revision.

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