WI-FI SERIES

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MAR 2ND	Designing Low-Power Applications with Wi-Fi 6
MAR 30TH	Fast Track Your Wi-Fi 6 Device Certification
APR 27TH	Hardware Design with Silicon Labs' Multiprotocol Wi-Fi SoCs & Modules
MAY 25TH	Building Smart Home Devices with Always-On Wi-Fi 6
JUN 22ND	Developing Wi-Fi 6 Sensors Using SiWx917 and Matter

We will begin in: 0:00

SILICON LABS

2023 tech talks WEBINAR SERIES

Welcome

Hardware Design with Silicon Labs' Multiprotocol Wi-Fi SoCs & Modules

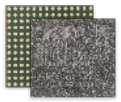
Vikas Thukuntla

SILICON LABS

Agenda

- Introduction
- Design Recommendations
- Referring Application Notes
- Certification Information
- SiWx917 Design Recommendations
- Wi-Fi Portfolio Summary
- Technical Support
- Q&A

Wi-Fi 4 and Wi-Fi 6 Supported Chip and Module Packages (91x Family)



	RS9116 QMS IC	RS9116 B00 Module	RS9116 CC0 Module	RS9116 CC1 Module	SiWx917M QMS IC
Package	QFN 84 pin	LGA 126	LGA 173	LGA 107	QFN 84 pin
Size	7 x 7 x 0.85 mm	4.63 x 7.9 x 0.9 mm	9.1 x 9.8 x 1.2 mm	15 x 15 .7 x 2.2 mm	7 x 7 x 0.85 mm
Format	SoC	SiP	SiP	PCB Module	SoC
Focus Market	Home, Industrial	Wearables	Industrial, Medical, Home	Industrial, Medical, Home	Home, Industrial
Wi-Fi Support	Wi-Fi 4 (B/G/N)	Wi-Fi 4 (B/G/N)	Wi-Fi 4 (A/B/G/N)	Wi-Fi 4 (A/B/G/N)	Wi-Fi 6 (B/G/N/AX)
Bluetooth Support	5.0 (BT + BLE)	5.0 (BT + BLE)	5.0 (BT + BLE)	5.0 (BT + BLE)	5.2 (BLE)
Antenna	No	No	No	Yes (PCB & U.FL)	No
Temperature Range	-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +85 °C	-40 °C to +85 °C
Regulatory Certifications	N/A	FCC, IC, CE, TELEC, UKCA	FCC, IC, CE, TELEC, UKCA	FCC, IC, CE, TELEC, UKCA	N/A
Compliance Certifications	BTSIG, WFA	BTSIG, WFA	BTSIG, WFA	BTSIG, WFA	BTSIG, WFA *

Wi-Fi 4 Single Band (2.4GHz) | **Wi-Fi 4 Dual Band (2.4/5GHz)** | **Wi-Fi 6 Single Band (2.4GHz)**

***Planned**

RS9116 – Design Flow and Supporting Documentation

QMS (IC)

XTAL Selection
AN1335 (Crystal Selection Guide)

Antenna Selection
Sec. 2 of AN1337 (Regulatory Certification)

Schematic Design
Ultra-librarian model, Sec. 5 (Ref schematics) of data sheet and AN1345 (Design Checklist)

Layout Design
AN1344 (Board Layout Guidelines)

Calibration
AN1336 (RS9116 QMS Calibration)

Certification
AN1337 (Regulatory Certification)

B00 (Module)

Antenna Selection
Sec. 2 of AN1337 (Regulatory Certification)

Schematic Design
Ultra-librarian model, Sec. 5 (Ref schematics) of data sheet and AN1345 (Design Checklist)

Layout Design
AN1343 (Board Layout Guidelines)

Certification (optional)
AN1337 (Regulatory Certification)

CC0 (Module)

Antenna Selection
Sec. 2 of AN1337 (Regulatory Certification)

Schematic Design
Ultra-librarian model, Sec. 5 (Ref schematics) of data sheet and AN1345 (Design Checklist)

Layout Design
AN1341 (Board Layout Guidelines)

Certification (optional)
AN1337 (Regulatory Certification)

CC1 (Module)

Antenna Selection (optional)
Sec. 2 of AN1337 (Regulatory Certification)

Schematic Design
Ultra-librarian model, Sec. 5 (Ref schematics) of data sheet and AN1345 (Design Checklist)

Layout Design
AN1342 (Board Layout Guidelines)

Certification (optional)
AN1337 (Regulatory Certification)

NOTE : For regulatory certification, customer can also look into AN1048 App Note for more details

Wi-Fi - Power Supply Design Recommendations (RS9116 & SiWx917)

- **Available supply voltage options**

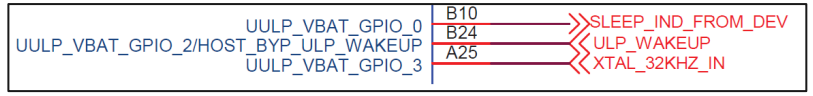
IC/Module	Supported Power Supply
B00, QMS	3.3V/1.85V (with 3.3V at PA2G_AVDD)
CC0, CC1	3.3V

- **Connect appropriate decoupling capacitors on the supply pins, close to IC/Module**
  - Reference table for RS9116 shown on right (per AN1345 App note)
- **Avoid connecting ferrite beads on the supply pins**
- **Check RF performance of the device at the chosen power supply value**
- **Applies to both RS9116 & SiWx917 based designs**

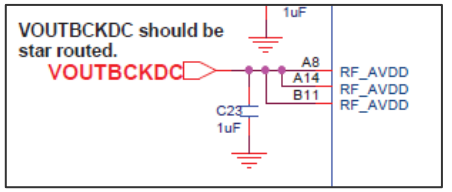
INPUT - Power Pin Name	Capacitor Value for SoC/Module Package			
	QMS	B00	CC0	CC1
VINBCKDC	10uF	10uF	10uF	
VIN_3P3				10uF
VINLDO1P8	No Capacitor	No Capacitor		
IO_VDD	0.1uF together (2 pins)	0.1uF together (4 pins)	0.1uF (1 pin)	
ULP_IO_VDD	0.1uF	0.1uF	0.1uF	0.1uF
C_VDD	No Capacitor (3 pins)	0.1uF together (3 pins)		
UULP_VBATT_1	No Capacitor	No Capacitor	No Capacitor	0.1uF
UULP_VBATT_2	1uF	1uF	1uF	
RF_VBATT	No Capacitor	No Capacitor	No Capacitor	
VINLDOSOC	0.1uF	0.1uF	0.1uF	
PA2G_AVDD	1uF (1 pin)	1uF (1 pin)	1uF (1 pin)	
PA5G_AVDD			1uF together (2 pins)	1uF (1 pin)
RF_AVDD	1uF together (3 pins)	1uF together (2 pins)	1uF (1 pin)	
FLASH_IO_VDD	No Capacitor			
SDIO_IO_VDD in RS9116	0.1uF	0.1uF	0.1uF	0.1uF
RF_AVDD33			0.1uF	0.1uF
AVDD_1P9_3P3			(0.1uF + 1uF) together (5 pins)	0.1uF (1 pin)
UULP_AVDD		0.1uF	0.1uF	0.1uF
RF_AVDD_BTTX		No Capacitor	No Capacitor	No Capacitor
AVDD_1P3		No Capacitor		
AVDD_1P2 (with 0ohm series resistor)			No Capacitor	No Capacitor
USB_AVDD_3P3	0.1uF if USB is used, else connect to GND directly			
USB_AVDD_1P1	0.1uF if USB is used, else connect to GND directly			
VOUTBCKDC	1uH* + 10uF	1uH* + 10uF	1uH* + 10uF	
VOUTLDOAFE	1uF	No Capacitor	No Capacitor	No Capacitor
AUX_AVDD	1uF			
VOUTLDO1P8	1uF		No Capacitor	No Capacitor
VOUTLDOSOC	1uF	No Capacitor	No Capacitor	No Capacitor
UULP_VOUTSCDC	2.2uF	No Capacitor	No Capacitor	No Capacitor
UULP_VOUTSCDC_RETN	1uF	No Capacitor	No Capacitor	No Capacitor

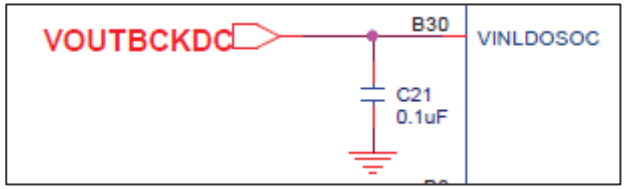
Wi-Fi – Ultra Low Power Design Recommendations (RS9116 & SiWx917)

- **Choose between GPIO and message-based power save modes**
  - Available in NCP & RCP modes
  - Wakeup the device based on indication from host
  - GPIO based mode saves more power as compared to message based.
  - Message-based mode to be used if there is lack of GPIOs on Host side
  - Power Save GPIOs:
    - SLEEP_IND_FROM_DEV
    - ULP_WAKEUP
    - WAKEUP_FROM_DEV
    - HOST_WAKEUP_INDICATION

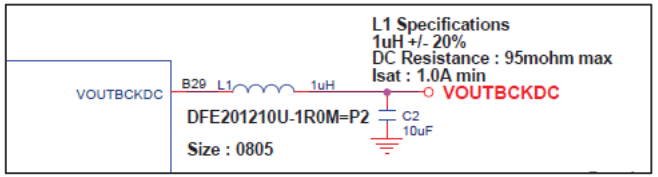


- **Do not use unnecessary pull-up or pull-down resistors on GPIOs**



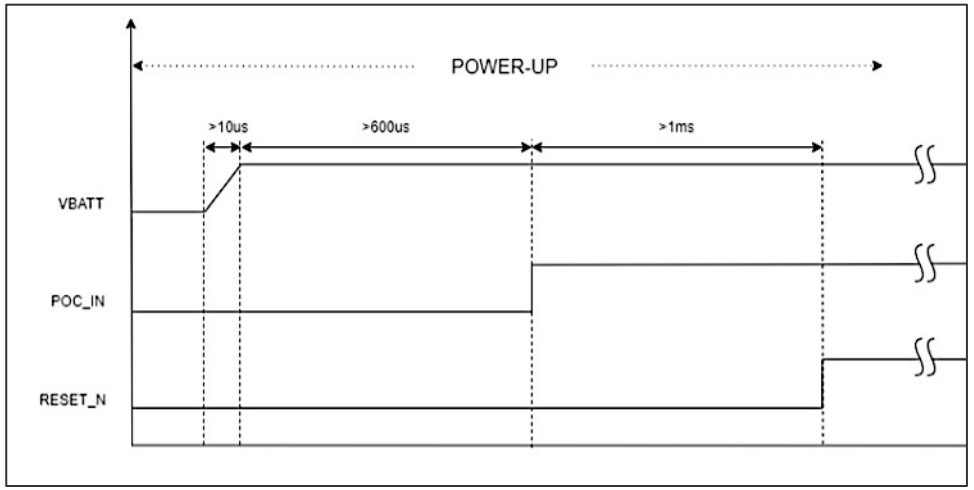


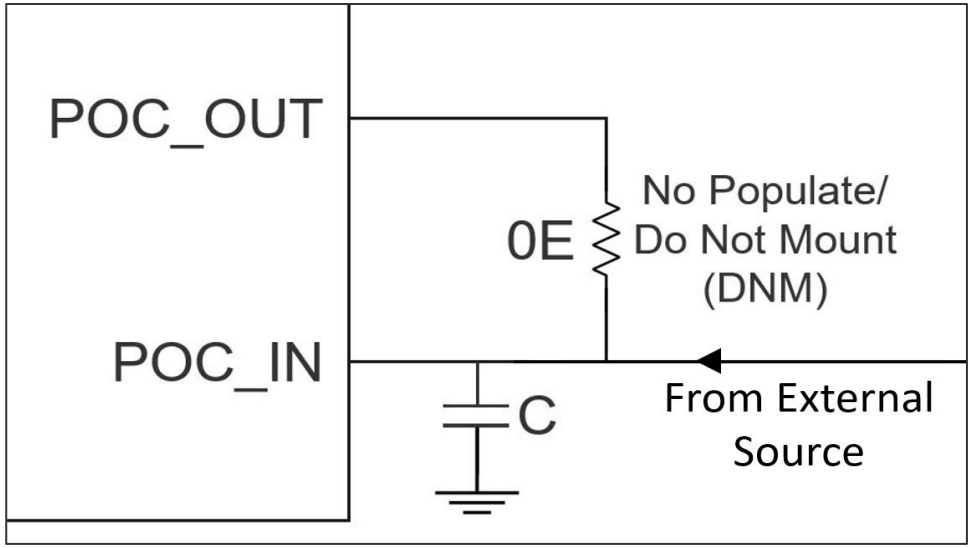
- **Reference schematics (snapshots on right) show some of the Ultra Low Power supplies using Internal regulators**
- **User has option to have external regulators, if needed**



RS9116 – RESET and POC Design Recommendations

- POC_IN, RESET_N signals : UULP_VBATT_1 domain
- Ensure RESET_N and POC_IN signals are within operating conditions (as per datasheet)
- Ensure POC_IN, POC_OUT and RESET_N follow the timing sequence requirements (as per datasheet)
- Not recommended to loopback POC_IN to POC_OUT; Use loopback for prototyping and debugging only



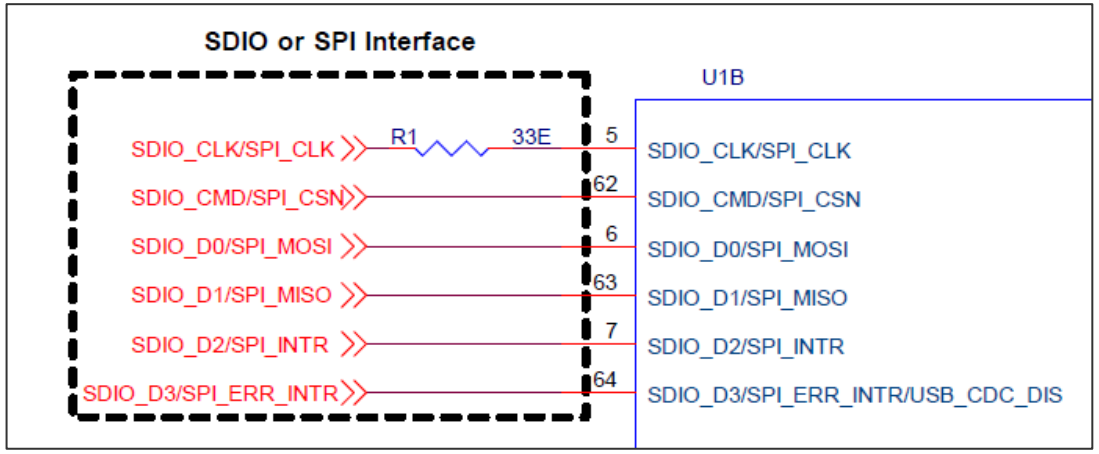


RS9116 – Host Interface Design Recommendations

- **Check the supported host interfaces based on device type**

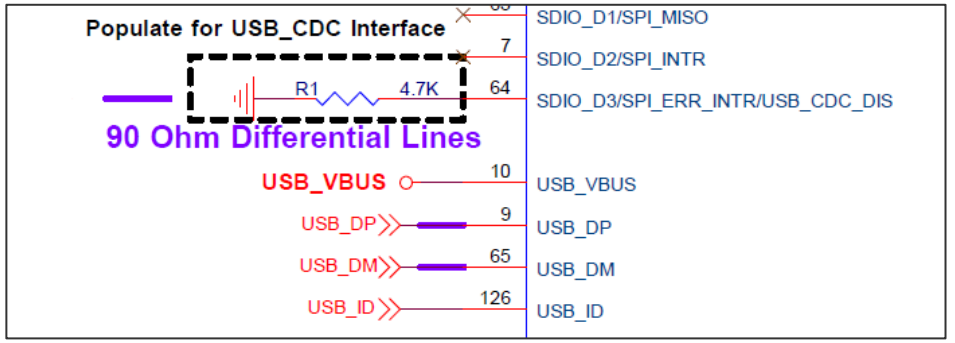
Device Type	Host Interfaces supported
nLink/Hosted Mode/RCP	USB, SDIO
WiSeConnect/Embedded Mode/NCP	SPI, UART, SDIO, USB-CDC

- **SDIO**
  - Connect pull-up resistors on CMD & data lines
  - Connect series resistor on CLK near the source of the signal
- **SPI**
  - Ensure CS and CLK signals are not floating
  - Connect series resistor on CLK near the source of the signal

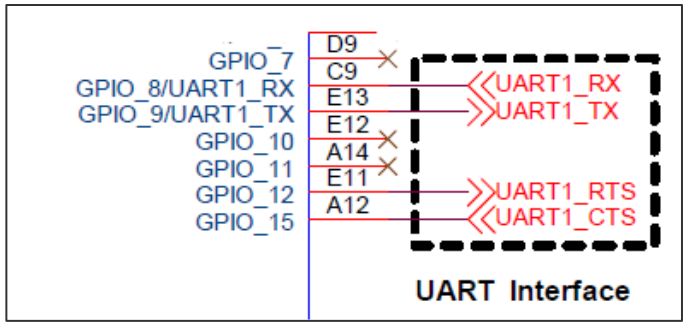


RS9116 – Host Interface Design Recommendations

- **USB and USB_CDC**
  - Ensure USB_DP and USB_DM signals are 90ohm differential lines
  - Connect USB_VBUS to 5V source
  - Connect USB_CDC_DIS with pull-down when using USB_CDC



- **UART**
  - Ensure RX and CTS signals are not floating



- **Ensure only one host interface is used after power up; Tri-state the other host interfaces**

RS9116 – Clock Design Recommendations

- **RS9116 has two primary clocks**

Clock frequency	Usage
40 MHz	ThreadArch® processor, baseband subsystem and the radio
32 kHz	Sleep management and RTC

- **User has option to use internal 32 kHz RC or external clocks at UULP_VBATT_GPIO_3/4**
  - Internal 32 kHz – Recommended for most Ultra Low Power designs, saves cost, Reduces BOM
  - External 32 kHz – Recommended if Bluetooth Audio (A2DP) is used with Ultra Low Power designs

Parameter	Parameter Description	Min	Typ	Max	Units
F_{osc}	Oscillator Frequency		32.768		kHz
F_{osc_Acc}	Frequency Variation with Temp and Voltage	-100		100	ppm
Duty cycle	Input duty cycle	30	50	70	%
V_{AC}	Input AC peak-peak voltage swing at input pin.	-0.3	-	VBATT +/- 10%	Vpp

Table 12. 32 kHz External Oscillator Specifications

RS9116 – Clock Design Recommendations

- **QMS users must choose external 40 MHz crystal**
  - Refer to AN1335 : RS9116 SoC Crystal Selection Guide
  - Place Crystal close to QMS pins; Follow Crystal part's design guidelines

Parameter	Parameter Description	Min	Typ	Max	Units
F_{osc}	Oscillator Frequency		40		MHz
Mode	Mode of Operation		Fundamental		
Resonance	Series or Parallel Resonance		Parallel		
Drive	Drive Level	100			uW
F_{osc_Acc}	Frequency Variation with Temp and Voltage	-20		20	ppm
ESR	Equivalent series resistance			60	Ω
Load cap	Load capacitance range	7		10	pF

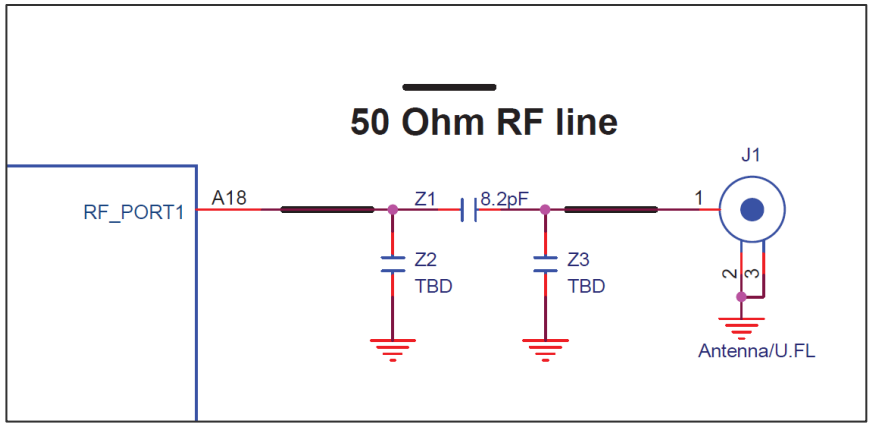
Table 13 40 MHz Crystal Specifications

Manufacturer	TXC	Epson	Transko
Frequency	40 MHz	40 MHz	40 MHz
Part Number	8Y40070013	FA-20H 40.0000MF10Z-K3	CS22-F1020CQ08-40.000M-TR
CL (pF)	8	10	8
ESR max (Ω)	30	40	60
Frequency Tolerance (PPM)	±8	±10	±10
Frequency Stability (PPM)	±16	±10	±20
Drive Level (µW) Maximum	200	200	300
Operating Temp (degC)	-40C to +105C	-20C to +75C	-40C to +85C

- **CC1, CC0 and B00 already have 40 MHz clock integrated**

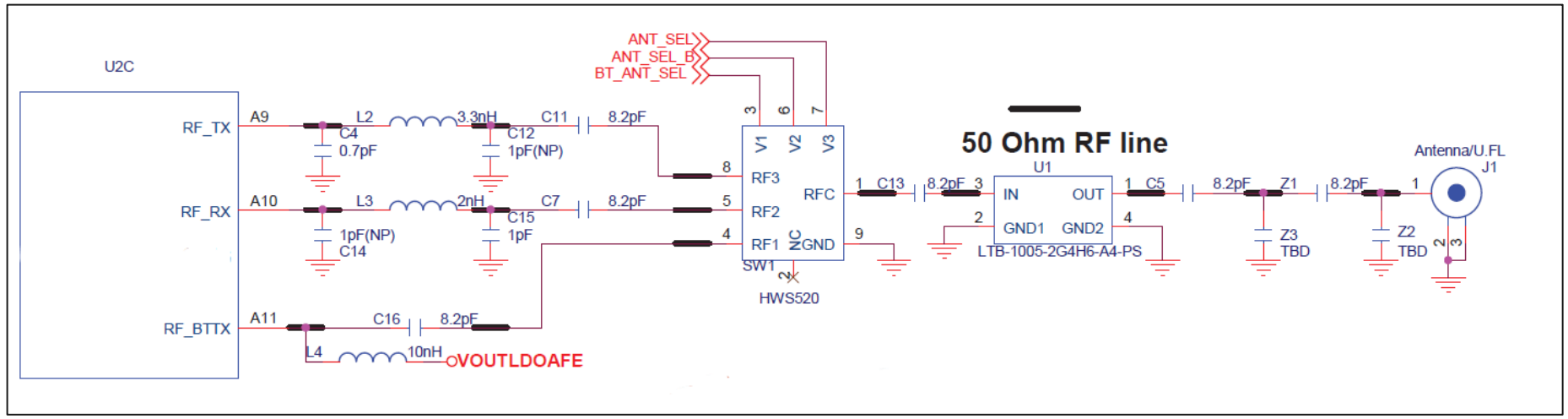
Wi-Fi – RF Design Recommendations (RS9116 & SiWx917)

- **RF front end**
  - Needs to be designed for SiWx917M QMS and RS9116 QMS, B00 and CC0 variants
  - CC1 doesn't need - it has internal PCB antenna & U.FL connector
- **Ensure 50-ohm characteristic impedance throughout RF path**
- **Ensure DC blocking cap of 8.2pF is present in the RF path**
- **Follow Reference schematics from latest datasheet**
- **Follow antenna part's design guidelines**
  - Antennas types – PCB, Chip, U.FL connector (Dipole, …), etc



RS9116 and SiWx917 QMS IC – RF Design Recommendations

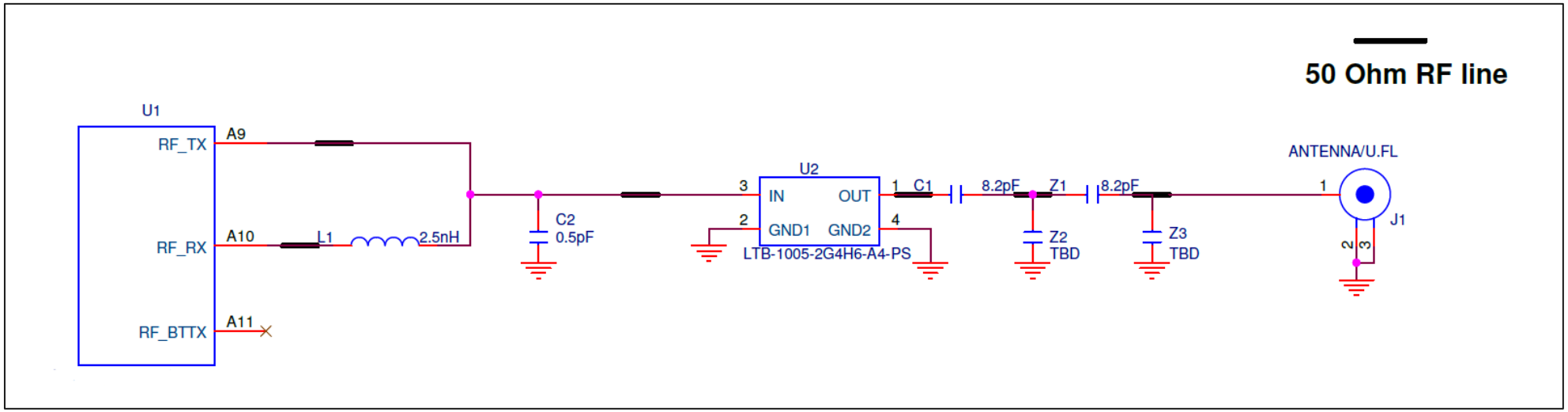
- **Use the appropriate RF switch and BPF while using RF_TX, RF_RX and RF_BTTX pins**
- **Use the recommended LC front-end on the QMS pin**
  - Ensure low tolerance and better specs parts are chosen
- **Design the antenna front-end based on antenna manufacturer's guidelines**



- **Based on application, user can choose to use RF_BTTX pin or not**
  - This pin is needed for BLE at higher power (8dBm)

RS9116 and SiWx917 QMS IC – RF Design Recommendations

- In case RF_BTTX is not used, there is no need to use external RF switch, internal switch will be used
- Use the recommended LC front-end on the QMS pin, and the antenna front-end based on antenna manufacturer's guidelines

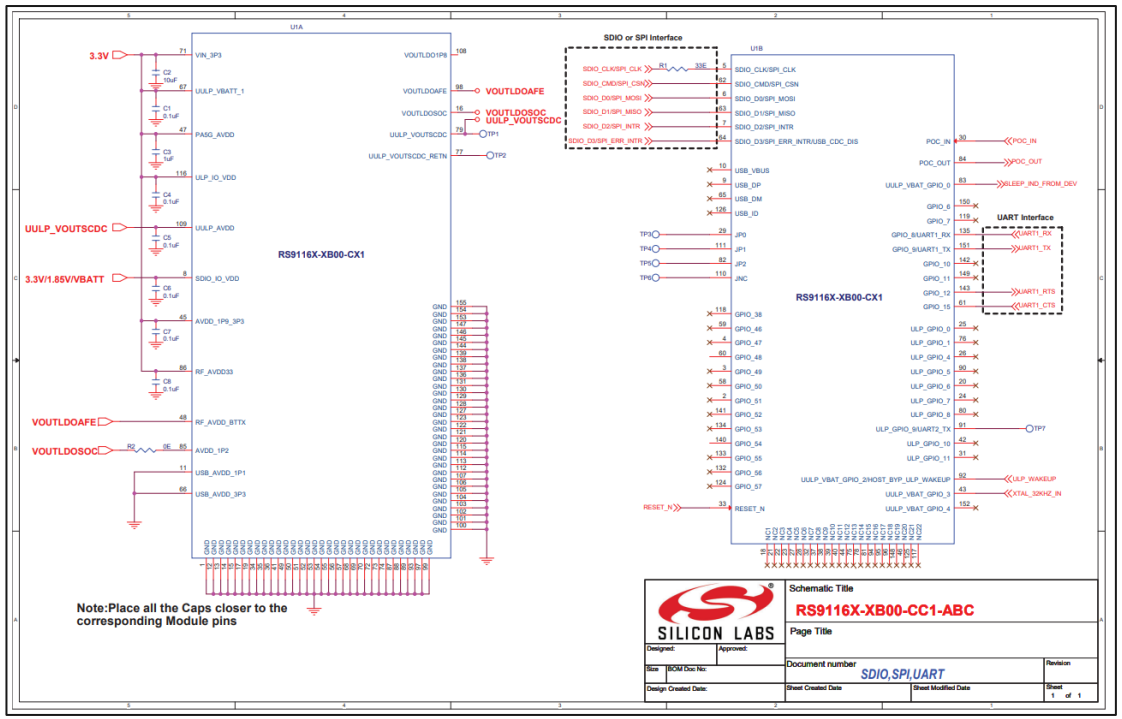


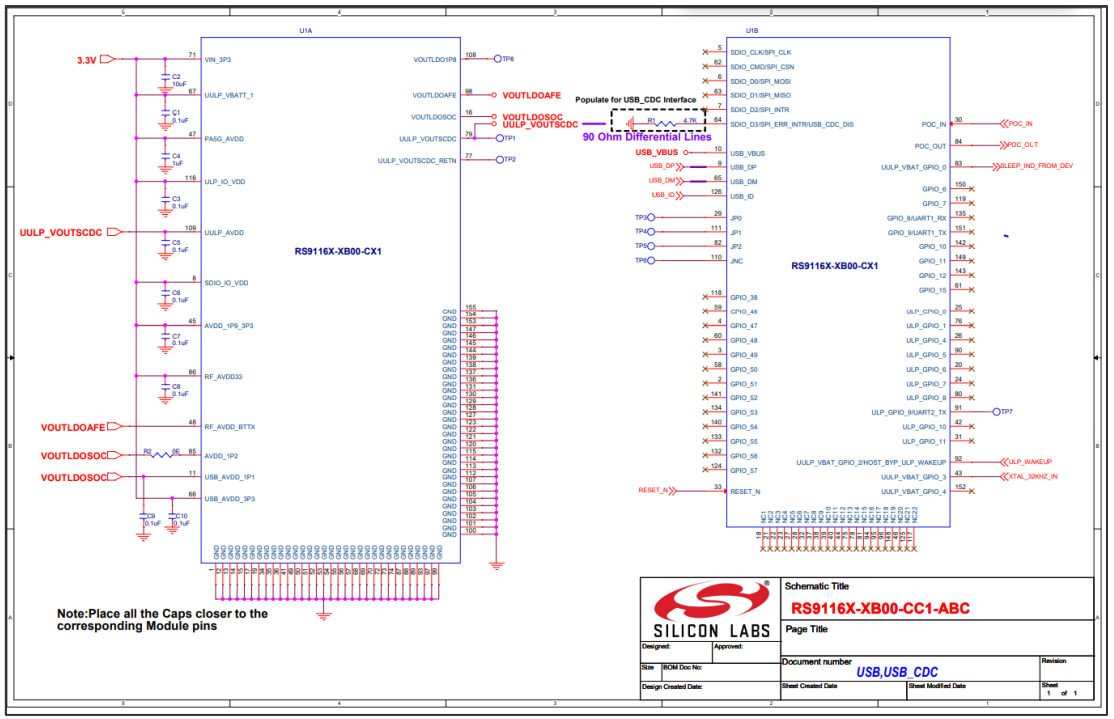
- There is slight degradation (~1dB) in performance while using this Internal Switch configuration

RS9116 – Schematic Design Recommendations

- Schematics available for SDIO, SPI, UART and USB, USB_CDC interfaces

- Ensure correctness of signals and match decoupling capacitor values to the reference schematic in latest datasheet





RS9116 – Layout Design Recommendations

- **Power Supply**
  - Follow star routing for power supply
  - Place decoupling capacitors close to RS9116 pins
  - Route power traces with at least 15mils trace width

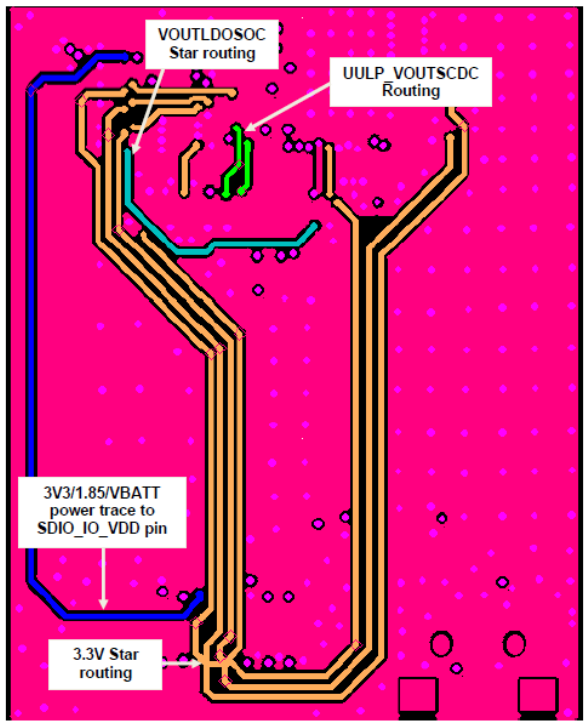


Figure 10: Power Supply Routing in Layer 3

- **Host Interfaces**
  - Match length of SPI/SDIO lines with max. 100mil tolerance
  - Keep SPI/SDIO lines away from noisy signals
  - Ensure 90-ohm differential lines for USB DP and DN
  - Keep USB signals far from high-speed signals

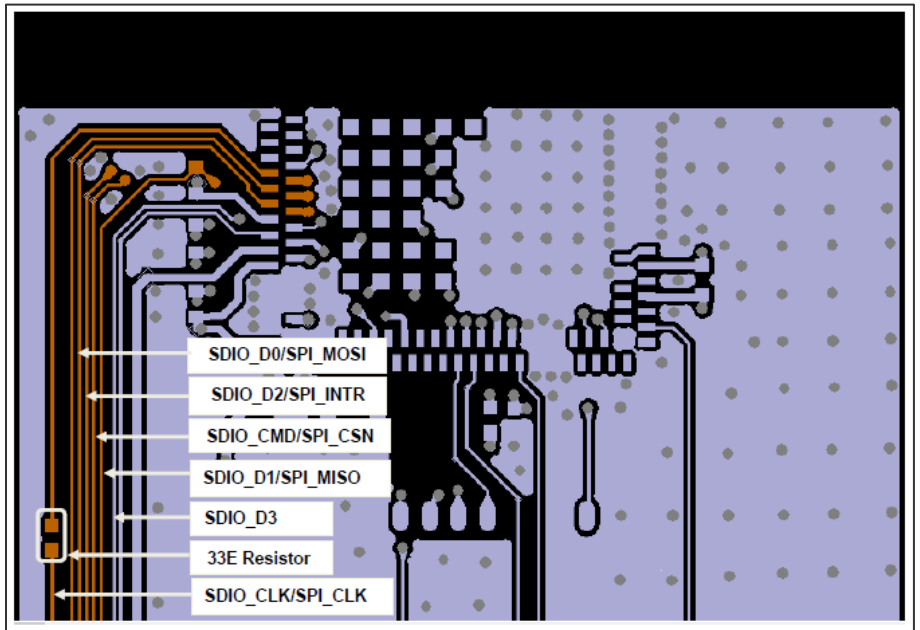


Figure 4: SDIO/SPI Signals Routing in Layer 1

RS9116 – Layout Design Recommendations

- **RF**
  - Route RF circuitry in the same plane as RS9116, without vias
  - Ensure 50-ohm characteristic impedance throughout the path
  - Use multiple GND vias around RF path

- **Crystal**
  - If Crystal is used, follow layout guidelines from its vendor
  - Route traces as short as possible without any vias
  - Pour GND all around the crystal

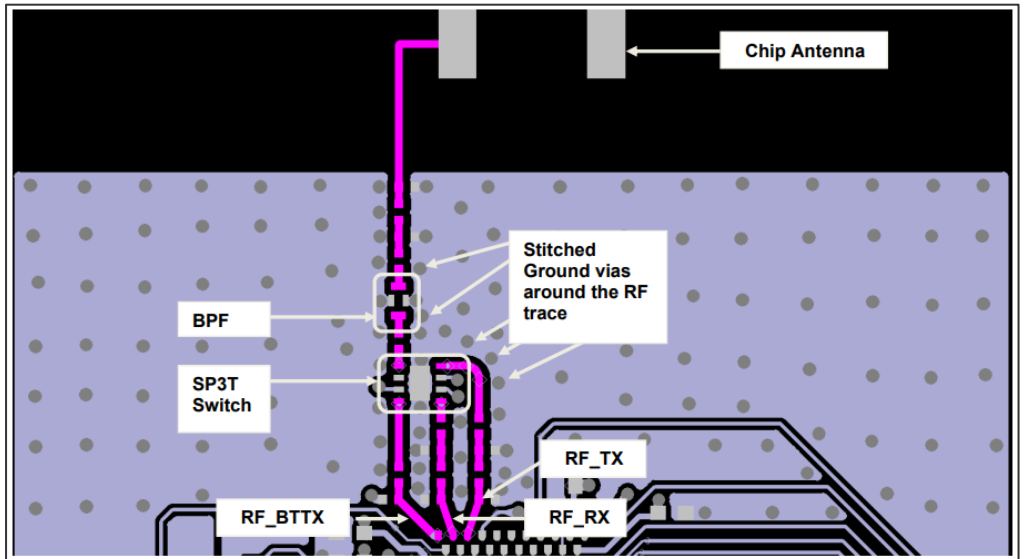


Figure 2: RF Circuitry Routing in Layer 1

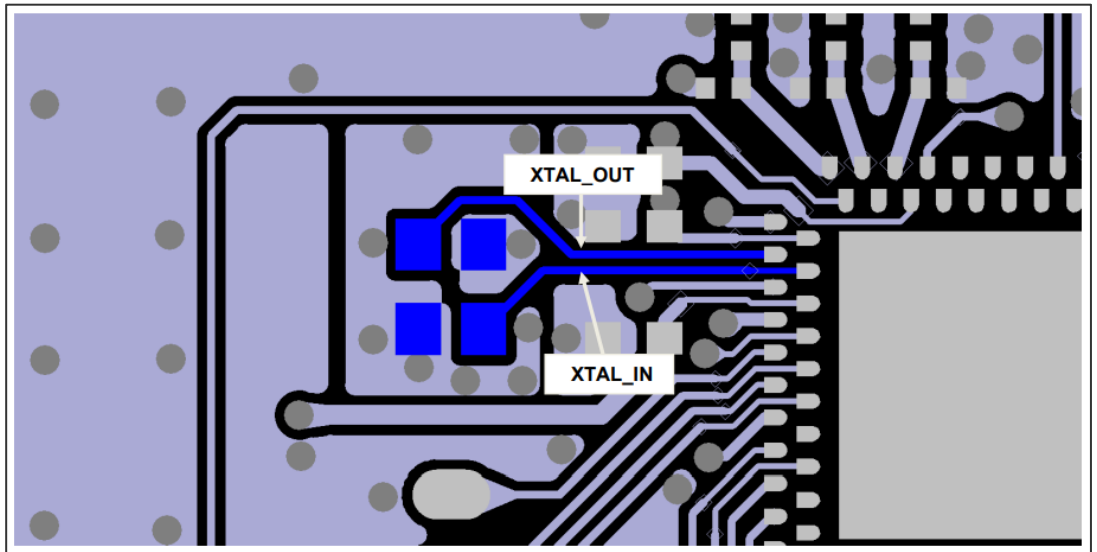


Figure 4: 40 MHz Crystal Routing in Layer 1

RS9116 – Soldering guidelines

- Check the landing patterns and package outlines given in the datasheet
- Follow AN1223 Manufacturing Guide App note for reflow and soldering recommendations

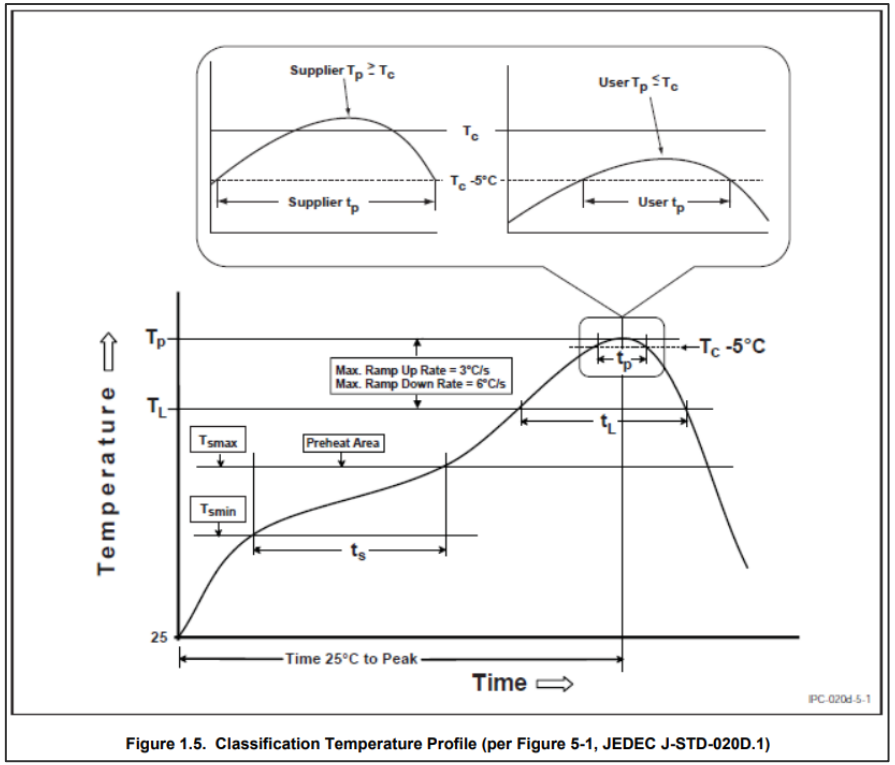


Figure 1.5. Classification Temperature Profile (per Figure 5-1, JEDEC J-STD-020D.1)

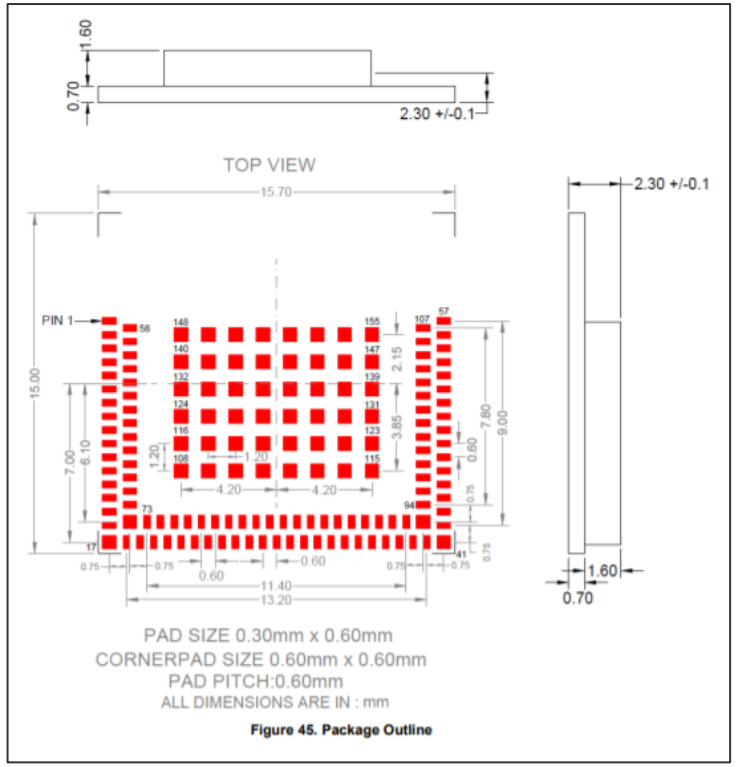


Figure 45. Package Outline

RS9116 – Application Notes and Design Documents

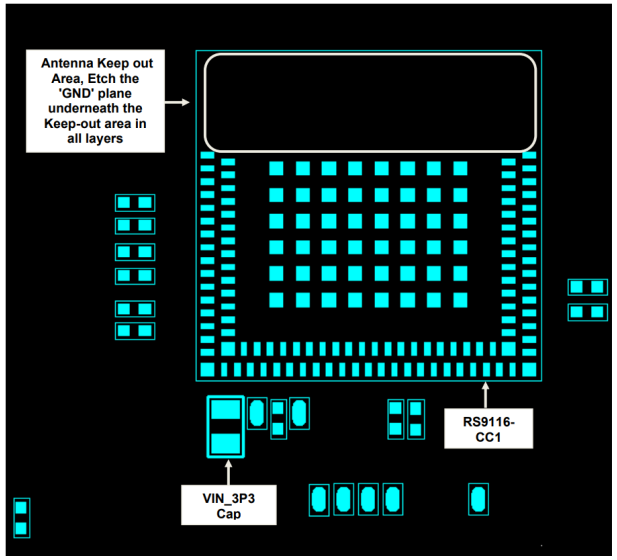
- **AN1335: RS9116 SoC Crystal Selection Guide**
  - Guidelines for selecting the 40 MHz crystal oscillator.
  - Basics of Oscillator Theory.
  - List of recommended crystals for these devices.
  - **Note**: RS9116 requires an external 32 kHz clock for certain applications. Customers are advised to check RS9116 datasheet for details about the external 32 kHz clock requirements.

Manufacturer	TXC	Epson	Transko
Frequency	40 MHz	40 MHz	40 MHz
Part Number	8Y40070013	FA-20H 40.0000MF10Z-K3	CS22-F1020CQ08-40.000M-TR
CL (pF)	8	10	8
ESR max (Ω)	30	40	60
Frequency Tolerance (PPM)	±8	±10	±10
Frequency Stability (PPM)	±16	±10	±20
Drive Level (µW) Maximum	200	200	300
Operating Temp (degC)	-40C to +105C	-20C to +75C	-40C to +85C

- **AN1337: RS9116 Regulatory Certification Application Note**
  - Certification process details – FCC, IC, ETSI, TELEC
  - Gain tables
  - RF power values
  - Cross Reference Guide

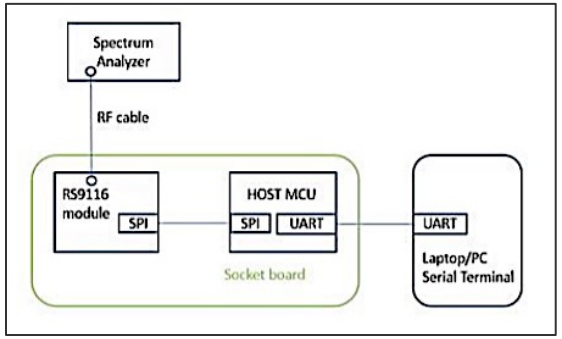
RS9116 – Application Notes and Design Documents

- **AN1342: RS9116 CC1 Board Layout Guidelines**
  - Placement guidelines: 4-layer stack-up
  - Routing Guidelines:
    - Host interfaces: SPI/SDIO, UART, USB
    - Power supply
    - Ground
- **AN1341: RS9116 CC0 Board Layout Guidelines**
- **AN1343: RS9116 B00 Board Layout Guidelines**
- **AN1344: RS9116 QMS Board Layout Guidelines**
  - Placement and routing guidelines for the modules, similar to the guideline of the CC1 module as discussed above.



RS9116 – Application Notes and Design Documents

- **AN1336: RS9116 QMS IC Calibration Application Note**
  - During production, calibration is done for the Power Management Unit, Transmission path, Receiver path and few other
  - Customer has to calibrate external 40 MHz crystal and RF front-end circuit, based on the crystal part and RF circuit used on-board
  - Description of the calibration procedure for the RS9116 QMS package to arrive at the right value for **carrier frequency offset** and **Tx gain offset**
  - The setup and procedure:
    - Reading values off the spectrum analyzer
    - Entering updated commands in the PC controlling the host
  - Frequency offset correction: *rsi_freq_offset* command
  - Gain offset correction*: gain_offset = observed_power_level + cable_loss - configured_power_level*
  - *rsi_calib_write* command is used for both
  - The calibration procedure is required to be run on each board built
    - Customers should implement this in an automated flow



Parameter	Description		
target	**Value**	**Macro**	**Description**
	0	BURN_INTO_EFUSE	Burns calibration data to EFuse
	1	BURN_INTO_FLASH	Burns calibration data to Flash
flags	**BIT**	**Macro**	**Description**
	0	BURN_GAIN_OFFSET	1- Update gain offset to calibration data 0 - Skip gain offset update
	1	BURN_FREQ_OFFSET	1 - Update XO Ctune to calibration data 0 - Skip XO Ctune update
	2	SW_XO_CTUNE_VALID	1- Use XO Ctune provided as argument to update calibration data 0 -Use XO Ctune value as read from hardware register.
	7 -3		Reserved
gain_offset	gain offset as observed in dBm		
xo_ctune	This field allows user to directly update xo_ctune value to calibration data bypassing the freq offset loop, valid only when BURN_FREQ_OFFSET & SW_XO_CTUNE_VALID of flags is set.		

RS9116 – Design Checklist

- **AN1345: RS9116 Hardware Design Checklist**
  - Checklist to be used before finalizing the design
    - Follow Schematics Checklist
    - Follow Layout Checklist
    - Power pin decoupling capacitor

- **Follow latest versions of product data sheet and documentation**
  - Data Sheets
  - Schematics and Design files
  - 3D Models

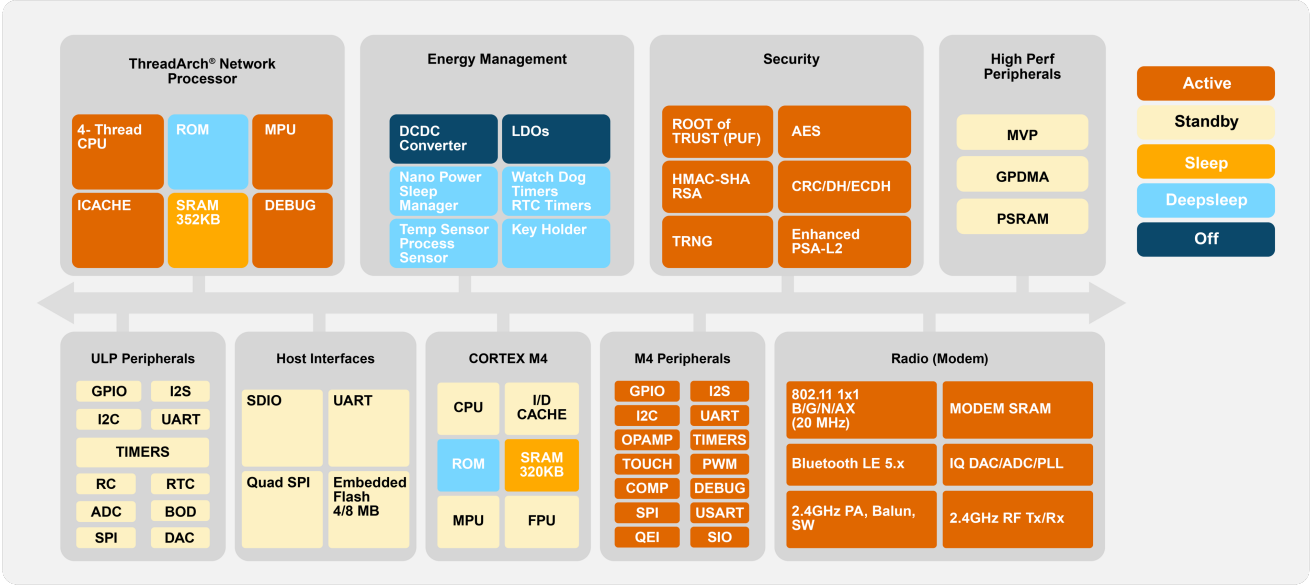
RS9116 – Certification Information

- **AN1337: RS9116 Regulatory Certification Application Note**
  - Module Certifications
- Regulatory testing is mandated by various governmental and non-governmental organizations
  - FCC (USA)
  - IC (CANADA)
  - ETSI (EUROPE)
  - TELEC (JAPAN)
- Primary regulatory testing procedures:
  - EMC, Safety, and RF (Radio Frequency aka Wireless).
- Focus of the document
  - RF testing (EMC and Safety is common across all electronic products)
- Customer antennas
  - Antenna not from our specified list – Class I Permissive Change
  - Antenna with specifications not equivalent any of the qualified antennas – Class II Permissive Change
- RS9116 IC – QMS
  - For SoC-based design, the customer needs to do full certification as per the applicable regulatory standard

Module	Model Name used in Certification	Silicon Version
CC0 / CC1	M7DB6	1.3
CC0 / CC1	M7DB	1.4
B00	RS9116-B00	1.5
B00	RS9116-B0014	1.4

SiWx917M Hardware Overview

- **Modes of operation:**
  - SoC Mode – with ARM® Cortex® M4 Processor
  - NCP Mode
  - RCP Mode
- **Power Supply Design**
  - Can be powered by 1.85V/3.3V source
- **RF Design**
  - Use external or internal RF switch based on use case
  - Design LC front-end based on recommendations



- **Ultra Low Power Supply Design Recommendations**
  - NCP & RCP mode – GPIO based and message based, GPIO based mode saves more power
- **Debugging capabilities – SoC Mode**
  - ETM trace, JTAG, Serial Wire Debug, In system programming available

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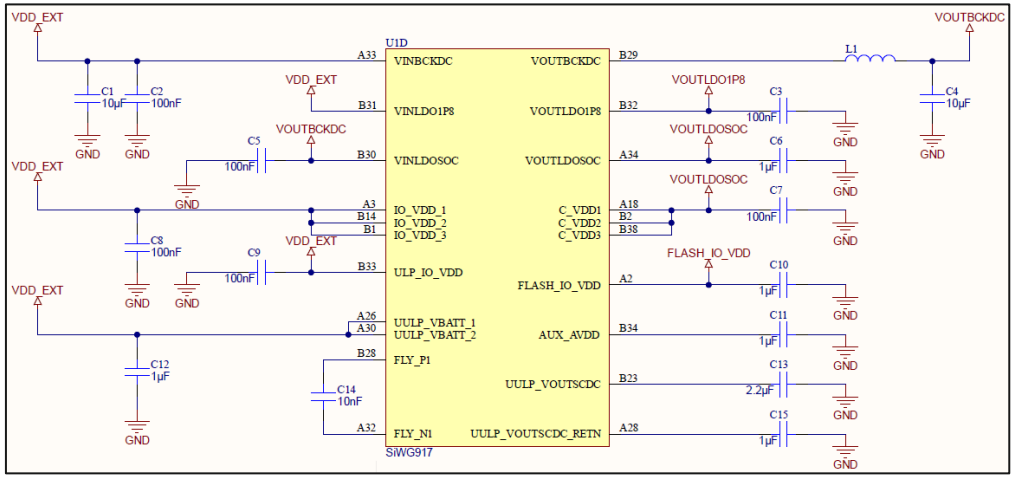
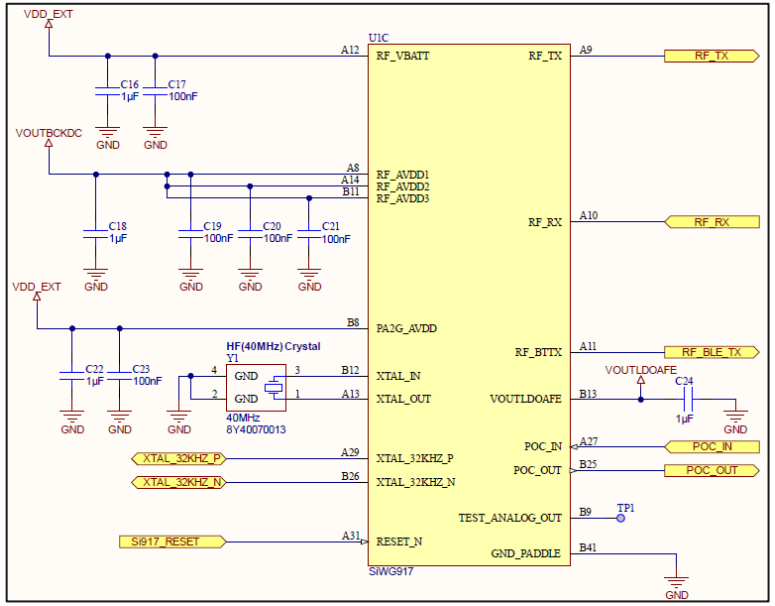
SiWx917M (QMS IC) – Power Supply and other Design aspects

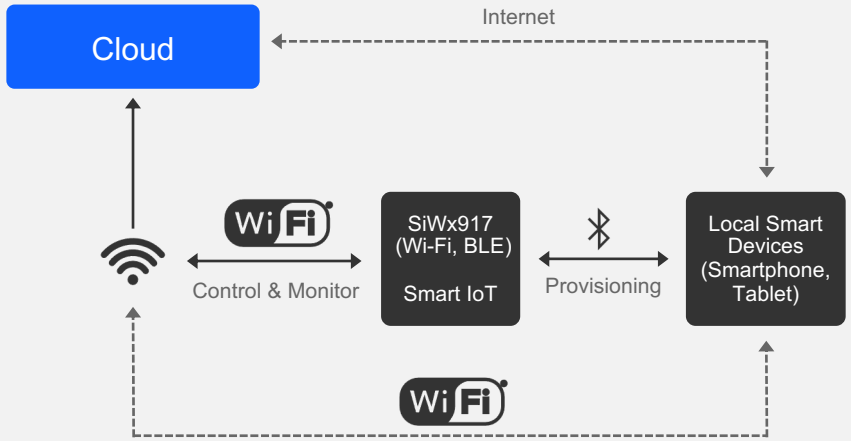
- **Operating Supply Voltage Scenarios**
  - VBATT input from Power Management Unit
  - 3.3V or 1.8V or 1.85V-3.3V range
  - IO domain can be either 1.85V or 3.3V
  - Scenarios
    - Single rail system either at 3.3V or 1.85V
    - Dual rail 1.85V for VBATT, 3.3V for Power Amplifier
- **Supports External Flash & PSRAM on GPIO pins**
- **Peripheral Interfaces – SPI, SDIO, UART, I2C, ...**





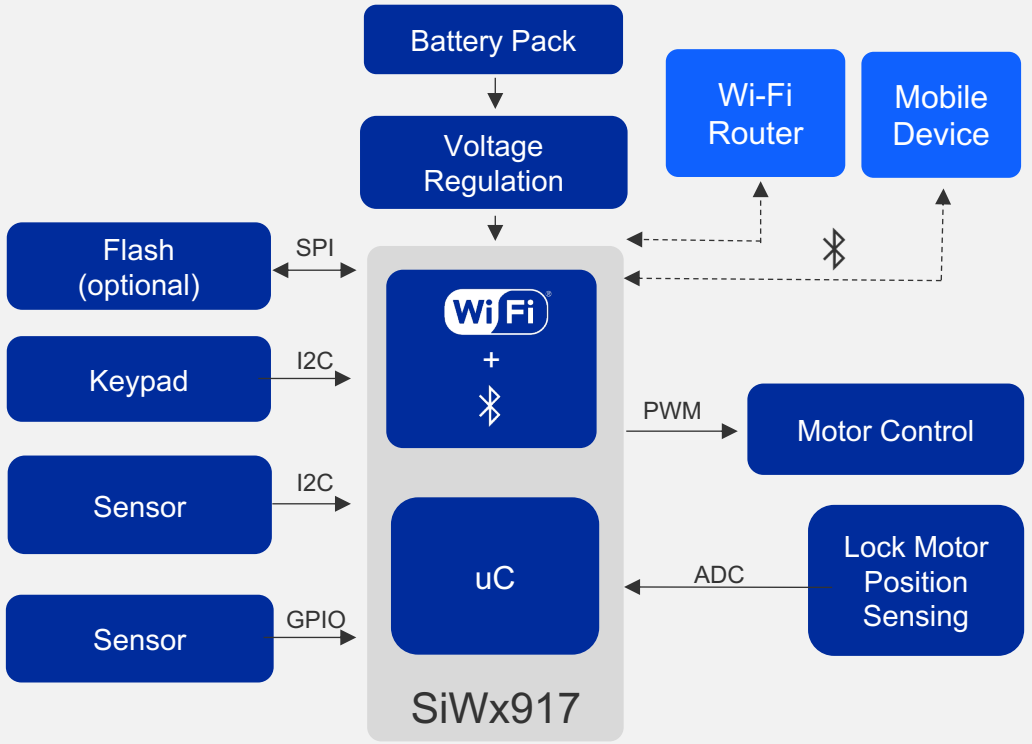
Typical SiWx917 SoC Usage and System Block Diagram (ex: Smart Lock)

SiWx917 Usage



- Remote control and monitoring at any-time via mobile APP through cloud service.
- Wi-Fi provisioning via BLE Mobile APP.
- Always-on using Wi-Fi with one second latency cloud connectivity using MQTT protocol
- Dynamic control of listen interval to optimize power consumption
- MCU Peripherals connected to SiWx917

System Block Diagram



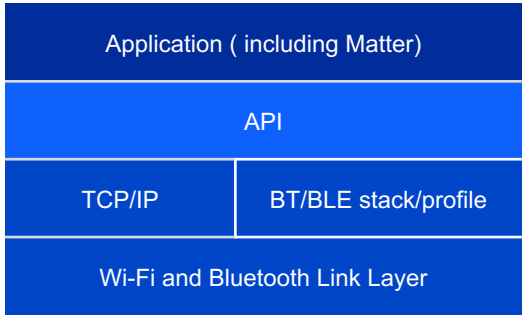
Silicon Labs' Wi-Fi SoC Portfolio Summary

Features	WF200	RS9116	SiWx917
			
Wi-Fi (2.4 GHz)	**Wi-Fi 4**	**Wi-Fi 4**	**Wi-Fi 6**
BT Low Energy (LE)		✓	✓
BT Classic (Audio)		✓	
Low Power Modes	**PS-POLL**	**PS-POLL, Listen Interval**	**PS-POLL, Listen Interval, TWT**
Wi-Fi Features	**OFDM**	**ODFM**	**OFDM, OFDMA, MU-MIMO**
Wi-Fi WPA3 Security	✓	✓	✓
ARM® Apps MCU (SoC Mode)			✓
ML Accelerator, PSRAM Interface, MCU Security (PSA-L2)			✓
Ultra Low Power		✓	✓
Matter	✓	✓	✓

Silicon Labs - Complete Solution for Enabling Wi-Fi Products

SoCS AND MODULES

Industry leading Ultra Low Power Wi-Fi 4 and Wi-Fi 6 SoCs and pre-certified modules

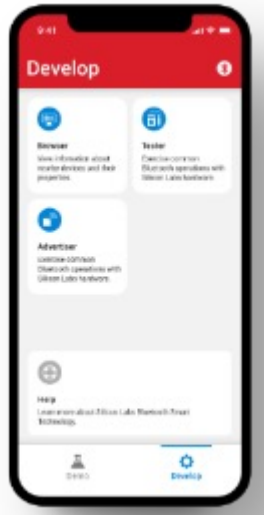


EMBEDDED SOFTWARE

Wi-Fi SDK with Integrated Wi-Fi, BT/BLE and IP networking stacks and Matter Support

DEVELOPMENT TOOLS

Evaluation Kit hardware and Studio software simplify development and speed time to market



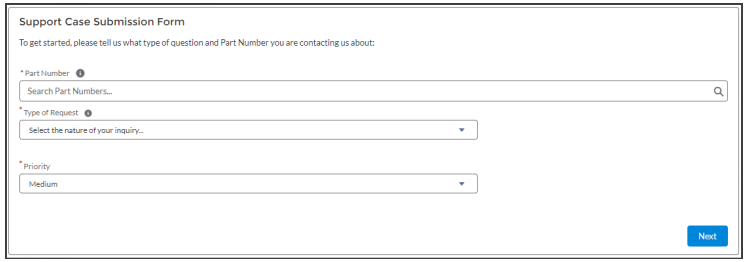
MOBILE APPLICATIONS

EFR Connect for Wi-Fi Provisioning using BLE

Technical Support

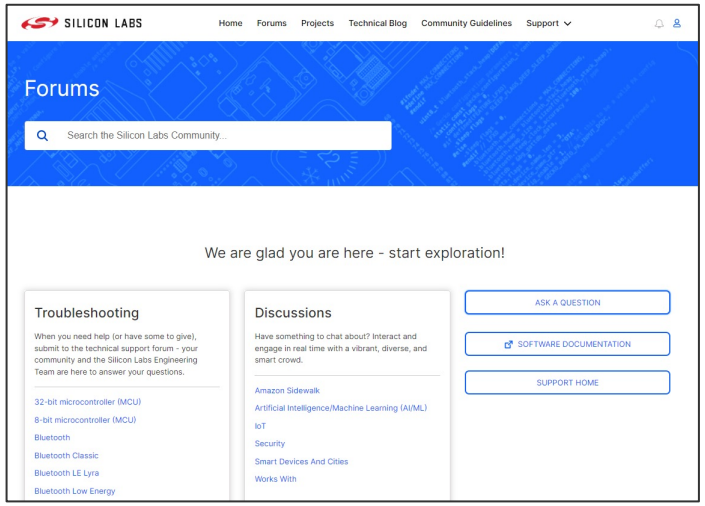
Salesforce Ticketing Support

- Support for technical queries and debugging
- Support for certification and C2PC
- Case routed through Field Application Engineers or Sales team



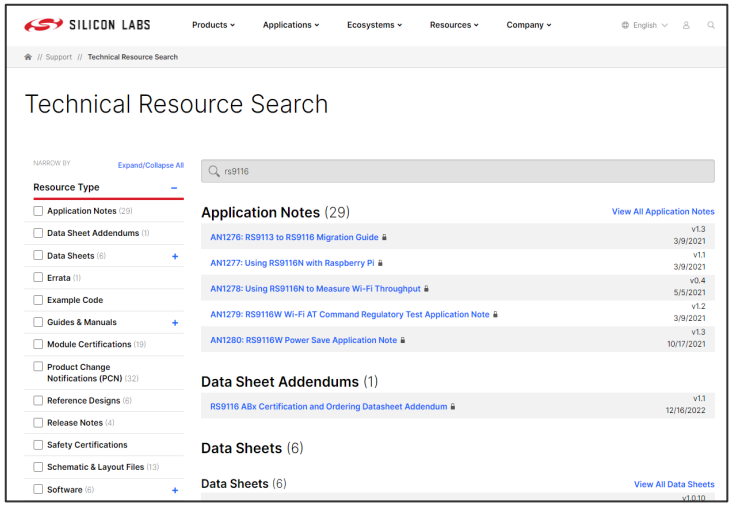
Silabs Community

- Support for technical queries and debugging
- Open and accessible to all



Technical Documents

- Datasheets
- Application Notes
- Guides
- Checklists
- Programming Reference Manuals



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Q&A

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tech talks

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FEB 2ND	Wi-Fi 6 Benefits for IoT Applications
MAR 2ND	Designing Low-Power Applications with Wi-Fi 6
MAR 30TH	Fast Track Your Wi-Fi 6 Device Certification
APR 27TH	Hardware Design with Silicon Labs' Multiprotocol Wi-Fi SoCs & Modules
MAY 25TH	Building Smart Home Devices with Always-On Wi-Fi 6
JUN 22ND	Developing Wi-Fi 6 Sensors Using SiWx917 and Matter

2023 tech talks
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Thank You

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