PRELIMINARY

CYBLE-224116-01

EZ-BLE™ PSoC® XT/XR BT 4.2 Module

General Description

The Cypress CYBLE-224116-01 is a fully certified and qualified module supporting Bluetooth® Low Energy (BLE) wireless communication. The CYBLE-224116-01 is a turnkey solution that includes onboard power amplifier (PA), low noise amplifier (LNA), crystal oscillators, chip antenna, passive components, and the Cypress PSoC® 4 BLE. Refer to the PSoC® 4 BLE datasheet for additional details on the capabilities of the PSoC® 4 BLE device used on this module.

The EZ-BLE™ PSoC® XT/XR BT 4.2 module provides extended industrial temperature operation (XT) as well as extended communication range (XR). The EZ-BLE™ XT/XR BT 4.2 module is a scalable and reconfigurable platform architecture, combining programmable and reconfigurable analog and digital blocks with flexible automatic routing. The CYBLE-224116-01 also includes digital programmable logic, high-performance analog-to-digital conversion (ADC), opamps with comparator mode, and standard communication and timing peripherals.

The CYBLE-224116-01 includes a royalty-free BLE stack compatible with Bluetooth 4.2 and provides up to 25 GPIOs in a small 9.5 × 15.4 × 1.80 mm footprint.

Module Description

- Module size: 9.5 mm × 15.4 mm × 1.80 mm (with shield)
- Extended Range: Up to 400 meters line-of-sight
- Extended industrial temperature range: –40 °C to +105 °C
- Up to 25 GPIOs
- 256-KB flash memory, 32-KB SRAM memory
- Bluetooth 4.2 qualified single-mode module
- Certified to FCC, CE, MIC, KC, and IC regulations
- 32-bit processor (0.9 DMIPS/MHz) with single-cycle 32-bit multiply, operating at up to 48 MHz
- Watchdog timer with dedicated internal low-speed oscillator
- Two-pin SWD for programming

Power Consumption

- TX output power: –18 dbm to +9.5 dbm
- RX Receive Sensitivity: –95 dbm
- Received signal strength indicator (RSSI) with 1-dB resolution
- 1 Second connection interval with PA/LNA active: 26.3 µA
- TX current consumption:
  - BLE silicon: 15.6 mA (radio only, 0 dbm)
  - SE2438T: 20 mA (PA/LNA only, +9.5 dBm)
- RX current consumption of 16.4 mA (radio only)
  - BLE silicon: 16.4 mA (radio only)
  - SE2438T: 5.5 mA (PA/LNA only)
- Low power mode support
  - Deep Sleep: 1.3 µA with watch crystal oscillator (WCO) on
  - Hibernate: 150 nA with SRAM retention
  - Stop: 60 nA with XRES wakeup

Integrated PA/LNA

- Supports output power up to +9.5 dBm and RX_S of -95 dBm

Programmable Analog

- Four opamps with reconfigurable high-drive external and high-bandwidth internal drive, comparator modes, and ADC input buffering capability; can operate in Deep-Sleep mode
- 12-bit, 1-Msps SAR ADC with differential and single-ended modes; channel sequencer with signal averaging
- Two current DACs (IDACs) for general-purpose or capacitive sensing applications on any pin
- One low-power comparator that operate in Deep-Sleep mode

Programmable Digital

- Four programmable logic blocks called universal digital blocks, (UDBs), each with eight macrocells and datapath
- Cypress-provided peripheral Component library, user-defined state machines, and Verilog input

Capacitive Sensing

- Cypress CapSense Sigma-Delta (CSD) provides best-in-class SNR (> 5:1) and liquid tolerance
- Cypress-supplied software component makes capacitive-sensing design easy
- Automatic hardware-tuning algorithm (SmartSense™)

Segment LCD Drive

- LCD drive supported on all GPIOs (common or segment)
- Operates in Deep-Sleep mode with four bits per pin memory

Serial Communication

- Two independent runtime reconfigurable serial communication blocks (SCBs) with I^2C, SPI, or UART functionality

Timing and Pulse-Width Modulation

- Four 16-bit timer, counter, pulse-width modulator (TCPWM) blocks
- Center-aligned, Edge, and Pseudo-random modes
- Comparator-based triggering of Kill signals for motor drive and other high-reliability digital logic applications

Up to 25 Programmable GPIOs

- Any GPIO pin can be CapSense, LCD, analog, or digital
- Two overvoltage-tolerant (OVT) pins; drive modes, strengths, and slew rates are programmable

More Information

Cypress provides a wealth of data at www.cypress.com to help you to select the right module for your design, and to help you to quickly and effectively integrate the module into your design.

- Overview: EZ-BLE Module Portfolio, Module Roadmap
- EZ-BLE PSoC Product Overview
- PSoC 4 BLE Silicon Datasheet
- Application notes: Cypress offers a number of BLE application notes covering a broad range of topics, from basic to advanced level. Recommended application notes for getting started with EZ-BLE modules are:
  - AN96841 - Getting Started with EZ-BLE Module
  - AN94020 - Getting Started with PSoC® 4 BLE
  - AN97060 - PSoC® 4 BLE and PRoC™ BLE - Over-The-Air (OTA) Device Firmware Upgrade (DFU) Guide
  - AN91162 - Creating a BLE Custom Profile
  - AN91184 - PSoC 4 BLE - Designing BLE Applications
  - AN92584 - Designing for Low Power and Estimating Battery Life for BLE Applications
  - AN85951 - PSoC® 4 CapSense® Design Guide
  - AN95089 - PSoC® 4/PRoC™ BLE Crystal Oscillator Selection and Tuning Techniques
  - AN91445 - Antenna Design and RF Layout Guidelines
- Technical Reference Manual (TRM):
  - PSoC® 4 BLE Technical Reference Manual
  - PSOC(R) 4 BLE Registers Technical Reference Manual (TRM)
- Development Kits:
  - CYBLE-224116-EVAL, CYBLE-224116-01 Evaluation Board
  - CY8CKIT-042-BLE, Bluetooth® Low Energy (BLE) Pioneer Kit
  - CY8CKIT-002, PSoC® MiniProg3 Program and Debug Kit
- Test and Debug Tools:
  - CYSmart, Bluetooth® LE Test and Debug Tool (Windows)
  - CYSmart Mobile, Bluetooth® LE Test and Debug Tool (Android/iOS Mobile App)

PSoC® Creator™ Integrated Design Environment (IDE)

PSoC Creator is an Integrated Design Environment (IDE) that enables concurrent hardware and firmware editing, compiling and debugging of PSoC 3, PSoC 4, PSoC 5LP, PSoC 4 BLE, PRoC BLE and EZ-BLE module systems with no code size limitations. PSoC peripherals are designed using schematic capture and simple graphical user interface (GUI) with over 120 pre-verified, production-ready PSoC Components™.

PSoC Components are analog and digital “virtual chips,” represented by an icon that users can drag-and-drop into a design and configure to suit a broad array of application requirements.

Blutooth Low Energy Component

The Bluetooth Low Energy Component inside PSoC Creator provides a comprehensive GUI-based configuration window that lets you quickly design BLE applications. The Component incorporates a Bluetooth Core Specification v4.2 compliant BLE protocol stack and provides API functions to enable user applications to interface with the underlying Bluetooth Low Energy Sub-System (BLESS) hardware via the stack.

Technical Support

- Frequently Asked Questions (FAQs): Learn more about our BLE ECO System.
- Forum: See if your question is already answered by fellow developers on the PSoC 4 BLE and PRoC BLE forums.
- Visit our support page and create a technical support case or contact a local sales representatives. If you are in the United States, you can talk to our technical support team by calling our toll-free number: +1-800-541-4736. Select option 2 at the prompt.

Contents

Overview

Module Description

The CYBLE-224116-01 is an integrated wireless module designed to be soldered to the main host board.

Module Dimensions and Drawing

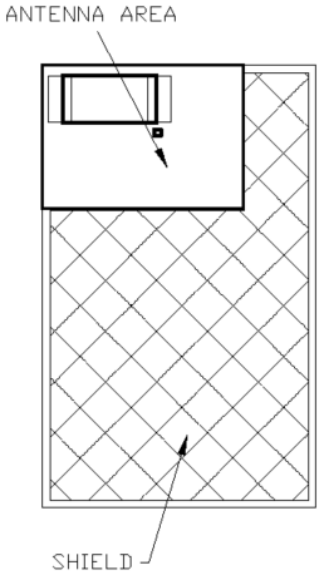
Cypress reserves the right to select components (including the appropriate BLE device) from various vendors to achieve the BLE module functionality. Such selections will guarantee that all height restrictions of the component area are maintained. Designs should be completed with the physical dimensions shown in the mechanical drawings in Figure 1. All dimensions are in millimeters (mm).

Table 1. Module Design Dimensions

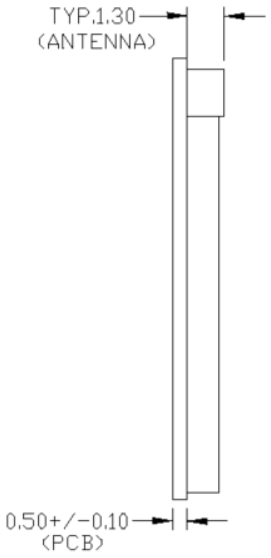
Dimension Item		Specification
Module dimensions	Length (X)	9.50 ± 0.15 mm
	Width (Y)	15.40 ± 0.15 mm
Antenna location dimensions	Length (X)	7.00 mm
	Width (Y)	5.00 mm
PCB thickness	Height (H)	0.50 ± 0.10 mm
Shield height	Height (H)	1.10 ± 0.10 mm
Maximum component height	Height (H)	1.30 mm typical (chip antenna)
Total module thickness (bottom of module to highest component)	Height (H)	1.80 mm typical

See Figure 1 on page 5 for the mechanical reference drawing for CYBLE-224116-01.

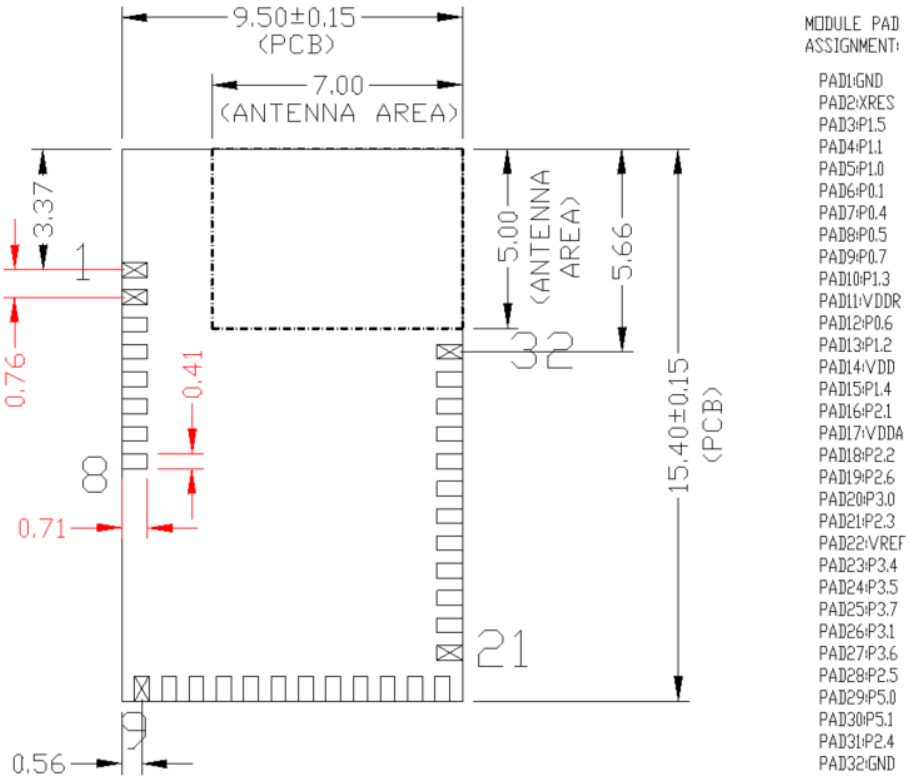
Figure 1. Module Mechanical Drawing



Top View (View from Top)



Side View



Bottom View (Seen from Bottom)

Note

1. No metal should be located beneath or above the antenna area. Only bare PCB material should be located beneath the antenna area. For more information on recommended host PCB layout, see Figure 3, Figure 4, Figure 5, and Figure 6 and Table 3.

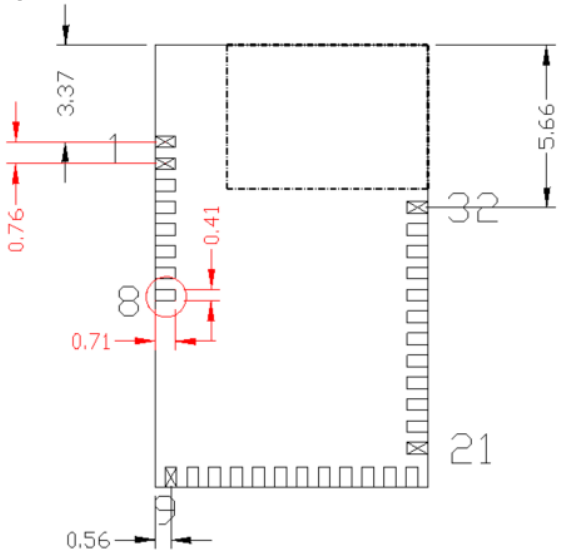
Pad Connection Interface

As shown in the bottom view of Figure 1 on page 5, the CYBLE-224116-01 connects to the host board via solder pads on the back of the module. Table 2 and Figure 2 detail the solder pad length, width, and pitch dimensions of the CYBLE-224116-01 module.

Table 2. Solder Pad Connection Description

Name	Connections	Connection Type	Pad Length Dimension	Pad Width Dimension	Pad Pitch
SP	32	Solder Pads	0.71 mm	0.41 mm	0.76 mm

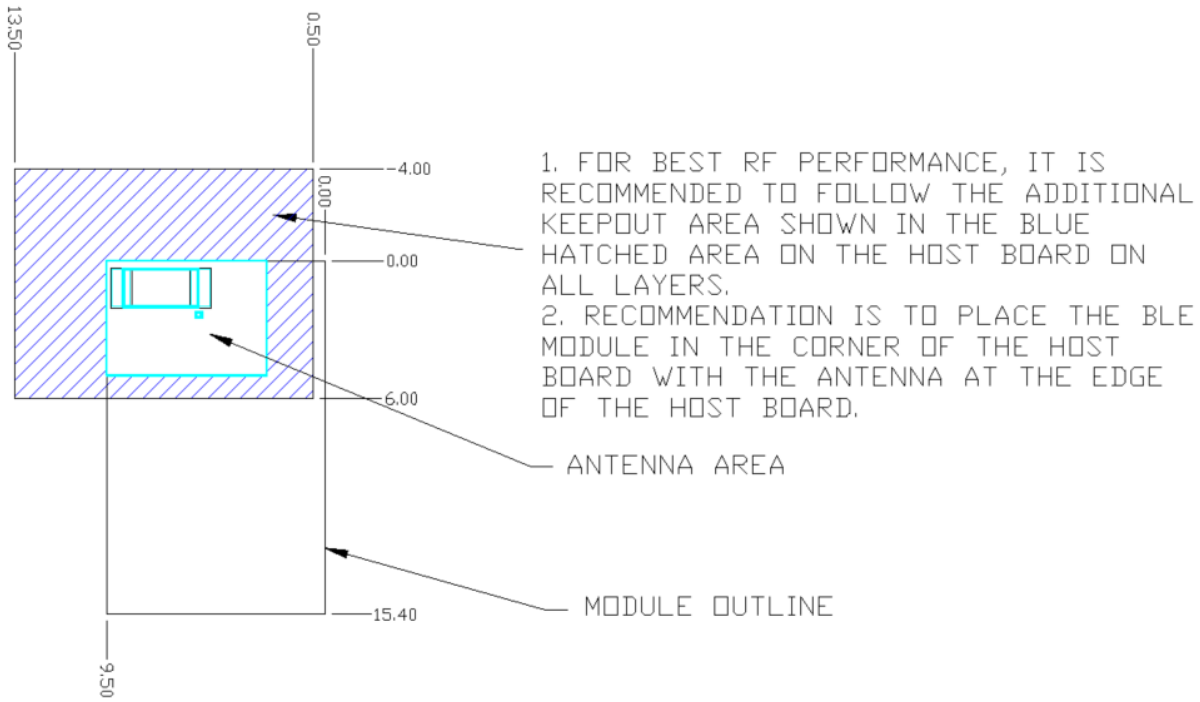
Figure 2. Solder Pad Dimensions (Seen from Bottom)



To maximize RF performance, the host layout should follow these recommendations:

1. The ideal placement of the Cypress BLE module is in a corner of the host board with the antenna located on the edge of the host board. This placement minimizes the additional recommended keep-out area shown in item 2. Please refer to AN96841 for module placement best practices.
2. To maximize RF performance, the area immediately around the Cypress BLE module trace antenna should contain an additional keep-out area, where no grounding or signal traces are contained. The keep-out area applies to all layers of the host board. The recommended dimensions of the host PCB keep-out area are shown in Figure 3 (dimensions are in mm).

Figure 3. Recommended Host PCB Keep-Out Area Around the CYBLE-224116-01 Trace Antenna



Host PCB Keep-Out Area Around Trace Antenna

Recommended Host PCB Layout

Figure 4, Figure 5, Figure 6, and Table 3 provide details that can be used for the recommended host PCB layout pattern for the CYBLE-224116-01. Dimensions are in millimeters unless otherwise noted. The minimum recommended host PCB pad length is 0.91 mm (0.455 mm from center of the pad to either side) is recommended as shown in Figure 6. The host PCB layout pattern can be completed using either Figure 4, Figure 5, or Figure 6. It is not necessary to use all figures to complete the host PCB layout pattern.

Figure 4. Host Layout Pattern for CYBLE-224116-01

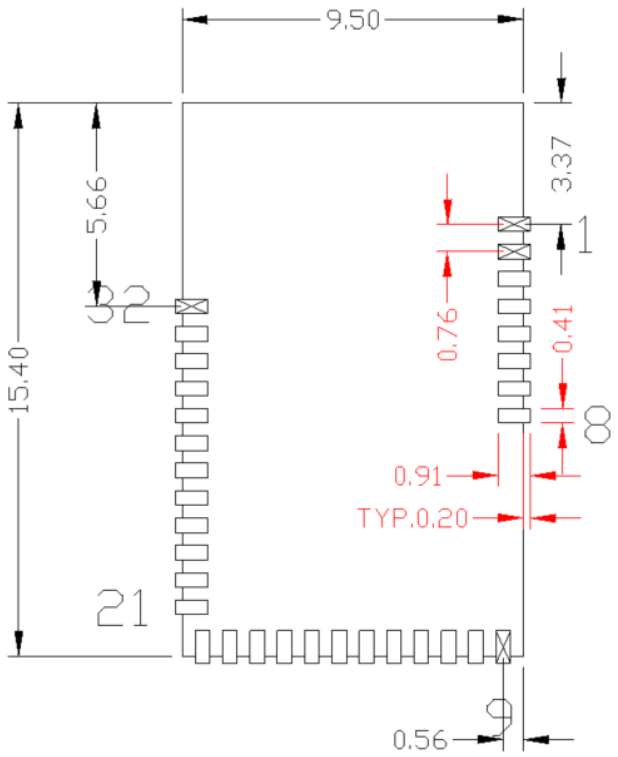


Figure 5. Module Pad Location from Origin

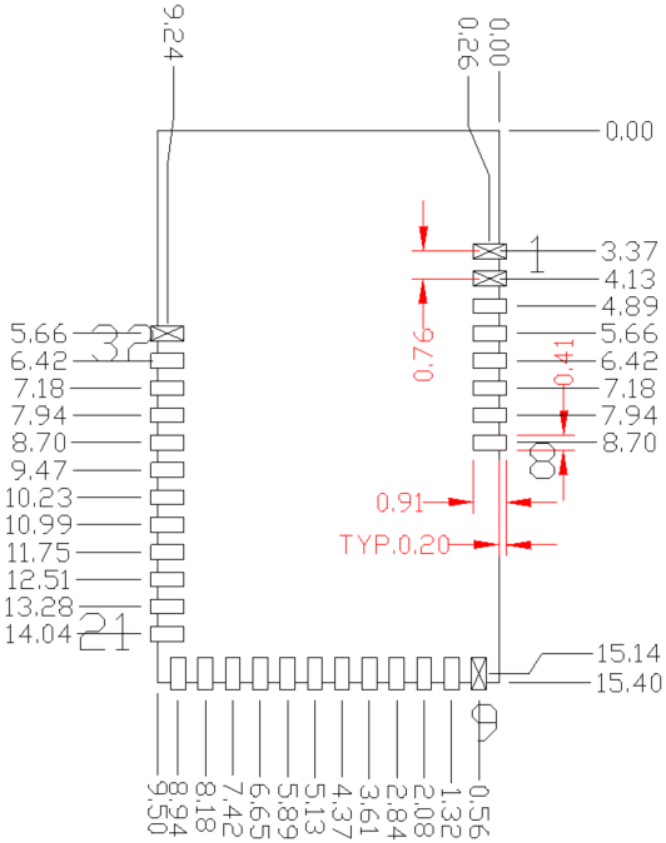


Table 3 provides the center location for each solder pad on the CYBLE-224116-01. All dimensions reference the to the center of the solder pad. Refer to Figure 6 for the location of each module solder pad.

Table 3. Module Solder Pad Location

Solder Pad (Center of Pad)	Location (X,Y) from Orign (mm)	Dimension from Orign (mils)
1	(0.26, 3.37)	(10.24, 132.68)
2	(0.26, 4.13)	(10.24, 162.68)
3	(0.26, 4.89)	(10.24, 192.68)
4	(0.26, 5.66)	(10.24, 222.68)
5	(0.26, 6.42)	(10.24, 252.68)
6	(0.26, 7.18)	(10.24, 282.68)
7	(0.26, 7.94)	(10.24, 312.68)
8	(0.26, 8.70)	(10.24, 342.68)
9	(0.56, 15.14)	(22.05, 596.06)
10	(1.32,15.14)	(51.97, 596.06)
11	(2.08, 15.14)	(81.89, 596.06)
12	(2.84,15.14)	(111.81, 596.06)
13	(3.61, 15.14)	(142.13, 596.06)
14	(4.37, 15.14)	(172.13, 596.06)
15	(5.13, 15.14)	(202.13, 596.06)
16	(5.89, 15.14)	(231.89, 596.06)
17	(6.65,15.14)	(261.81, 596.06)
18	(7.42, 15.14)	(292.13, 596.06)
19	(8.18, 15.14)	(322.05, 596.06)
20	(8.94, 15.14)	(351.97, 596.06)
21	(9.24, 14.04)	(363.78, 552.76)
22	(9.24, 13.28)	(363.78, 522.83)
23	(9.24, 12.51)	(363.78,492.52)
24	(9.24, 11.75)	(363.78, 462.60)
25	(9.24,10.99)	(363.78, 432.68)
26	(9.24,10.23)	(363.78, 402.76)
27	(9.24, 9.47)	(363.78, 372.83)
28	(9.24, 8.70)	(363.78, 342.52)
29	(9.24, 7.94)	(363.78, 312.60)
30	(9.24, 7.18)	(363.78, 282.68)
31	(9.24, 6.42)	(363.78, 252.76)
32	(9.24,5.66)	(363.78, 222.83)

Figure 6. Solder Pad Reference Location

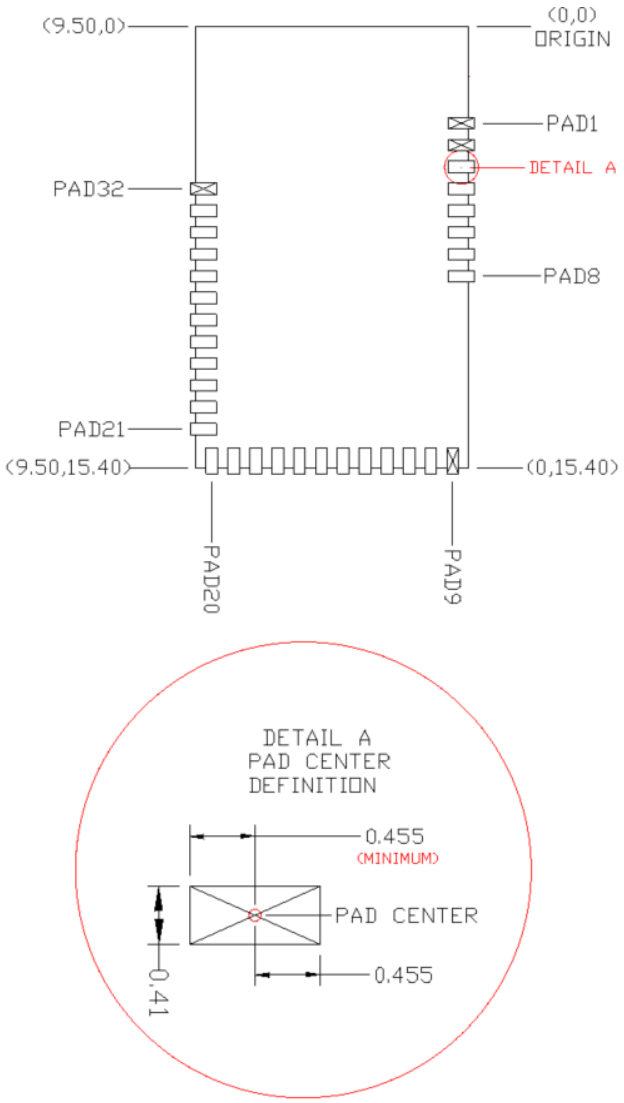


Table 4 and Table 5 detail the solder pad connection definitions and available functions for each connection pad. Table 4 lists the solder pads on CYBLE-224116-01, the BLE device port-pin, and denotes whether the digital function shown is available for each solder pad. Table 5 denotes whether the analog function shown is available for each solder pad. Each connection is configurable for a single option shown with a ✓.

Table 4. Digital Peripheral Capabilities

Pad Number	Device Port Pin	UART	SPI	I^2C	TCPWM[2]	Cap-Sense	WCO Out	ECO OUT	LCD	SWD	GPIO
1	GND[3]	Ground Connection									
2	XRES	External Reset Hardware Connection Input									
3	P1.5	✓(SCB0_TX)	✓(SCB0_MISO)	✓(SCB0_SCL)	✓(TCPWM2_N)	✓			✓		✓
4	P1.1		✓(SCB1_SS1)		✓(TCPWM0_N)	✓			✓		✓
5	P1.0				✓(TCPWM0_P)	✓			✓		✓
6	P0.1	✓(SCB1_TX)	✓(SCB1_MISO)	✓(SCB1_SCL)	✓(TCPWM0_N)	✓			✓		✓
7	P0.4	✓(SCB0_RX)	✓(SCB0_MOSI)	✓(SCB0_SDA)	✓(TCPWM1_P)	✓		✓	✓		✓
8	P0.5	✓(SCB0_TX)	✓(SCB0_MISO)	✓(SCB0_SCL)	✓(TCPWM1_N)	✓			✓		✓
9	P0.7	✓(SCB0_CTS)	✓(SCB0_SCLK)		✓(TCPWM2_N)	✓			✓	✓ (SWDCLK)	✓
10	P1.3		✓(SCB1_SS3)		✓(TCPWM1_N)	✓			✓		✓
11	V_{DDR}	Radio Power Supply (2.0V to 3.6V)									
12	P0.6	✓(SCB0_RTS)	✓(SCB0_SS0)		✓(TCPWM2_P)	✓			✓	✓ (SWDIO)	✓
13	P1.2		✓(SCB1_SS2)		✓(TCPWM1_P)	✓			✓		✓
14	V_{DD}	Digital Power Supply Input (1.71 to 5.5V)									
15	P1.4	✓(SCB0_RX)	✓(SCB0_MOSI)	✓(SCB0_SDA)	✓(TCPWM2_P)	✓			✓		✓
16	P2.1		✓(SCB0_SS2)			✓			✓		✓
17	V_{DDA}	Analog Power Supply Input (1.71 to 5.5V)									
18	P2.2		✓(SCB0_SS3)			✓			✓		✓
19	P2.6					✓			✓		✓
20	P3.0	✓(SCB0_RX)		✓(SCB0_SDA)	✓(TCPWM0_P)	✓			✓		✓
21	P2.3					✓	✓		✓		✓
22	V_{REF}	Reference Voltage Input									
23	P3.4	✓(SCB1_RX)		✓(SCB1_SDA)	✓(TCPWM2_P)	✓			✓		✓
24	P3.5	✓(SCB1_TX)		✓(SCB1_SCL)	✓(TCPWM2_N)	✓			✓		✓
25	P3.7	✓(SCB1_CTS)			✓(TCPWM3_N)	✓	✓		✓		✓
26	P3.1	✓(SCB0_TX)		✓(SCB0_SCL)	✓(TCPWM0_N)	✓			✓		✓
27	P3.6	✓(SCB1_RTS)			✓(TCPWM3_P)	✓			✓		✓
28	P2.5					✓			✓		✓
29	P5.0	✓(SCB1_RX)	✓(SCB1_SS0)	✓(SCB1_SDA)	✓(TCPWM3_P)	✓			✓		✓
30	P5.1	✓(SCB1_TX)	✓(SCB1_SCLK)	✓(SCB1_SCL)	✓(TCPWM3_N)	✓		✓	✓		✓
31	P2.4					✓			✓		✓
32	GND[3]	Ground Connection									

Notes
2. TCPWM stands for timer, counter, and PWM. If supported, the pad can be configured to any of these peripheral functions.
3. The main board needs to connect both GND connections (Pad 1 and Pad 32) on the module to the common ground of the system.

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Table 5. Analog Peripheral Capabilities

Pad Number	Device Port Pin	SARMUX	OPAMP	LPCOMP
1	GND[3]	Ground Connection		
2	XRES	External Reset Hardware Connection Input		
3	P1.5		✓(CTBm1_OA1_INP)	
4	P1.1		✓(CTBm1_OA0_INN)	
5	P1.0		✓(CTBm1_OA0_INP)	
6	P0.1			✓(COMP0_INN)
7	P0.4			✓(COMP1_INP)
8	P0.5			✓(COMP1_INN)
9	P0.7			
10	P1.3		✓(CTBm1_OA1_OUT)	
11	V_{DDR}	Radio Power Supply (2.0V to 3.6V)		
12	P0.6			
13	P1.2		✓(CTBm1_OA0_OUT)	
14	VDD	Digital Power Supply Input (1.71 to 5.5V)		
15	P1.4		✓(CTBm1_OA1_INN)	
16	P2.1		✓(CTBm1_OA0_INN)	
17	V_{DDA}	Analog Power Supply Input (1.71 to 5.5V)		
18	P2.2		✓(CTBm1_OA0_OUT)	
19	P2.6		✓(CTBm1_OA0_INP)	
20	P3.0	✓		
21	P2.3		✓(CTBm1_OA1_OUT)	
22	VREF	Reference Voltage Input (Optional)		
23	P3.4	✓		
24	P3.5	✓		
25	P3.7	✓		
26	P3.1	✓		
27	P3.6	✓		
28	P2.5		✓(CTBm0_OA1_INP)	
29	P5.0			
30	P5.1			
31	P2.4		✓(CTBm0_OA1_INN)	
32	GND	Ground Connection		

Power Supply Connections and Recommended External Components

Power Connections

The CYBLE-224116-01 contains three power supply connections, VDD, VDDA, and VDDR. The VDD and VDDA connections supply power for the digital and analog device operation respectively. VDDR supplies power for the device radio and PA/LNA.

VDD and VDDA accept a supply range of 1.71 V to 5.5 V. VDDR accepts a supply range of 2.0 V to 3.6 V. These specifications can be found in Table 12. The maximum power supply ripple for both power connections on the module is 100 mV, as shown in Table 10.

The power supply ramp rate of VDD and VDDA must be equal to or greater than that of VDDR when the radio is used.

Connection Options

Two connection options are available for any application:

1. Single supply: Connect VDD, VDDA, and VDDR to the same supply.
2. Independent supply: Power VDD, VDDA, and VDDR separately.

External Component Recommendation

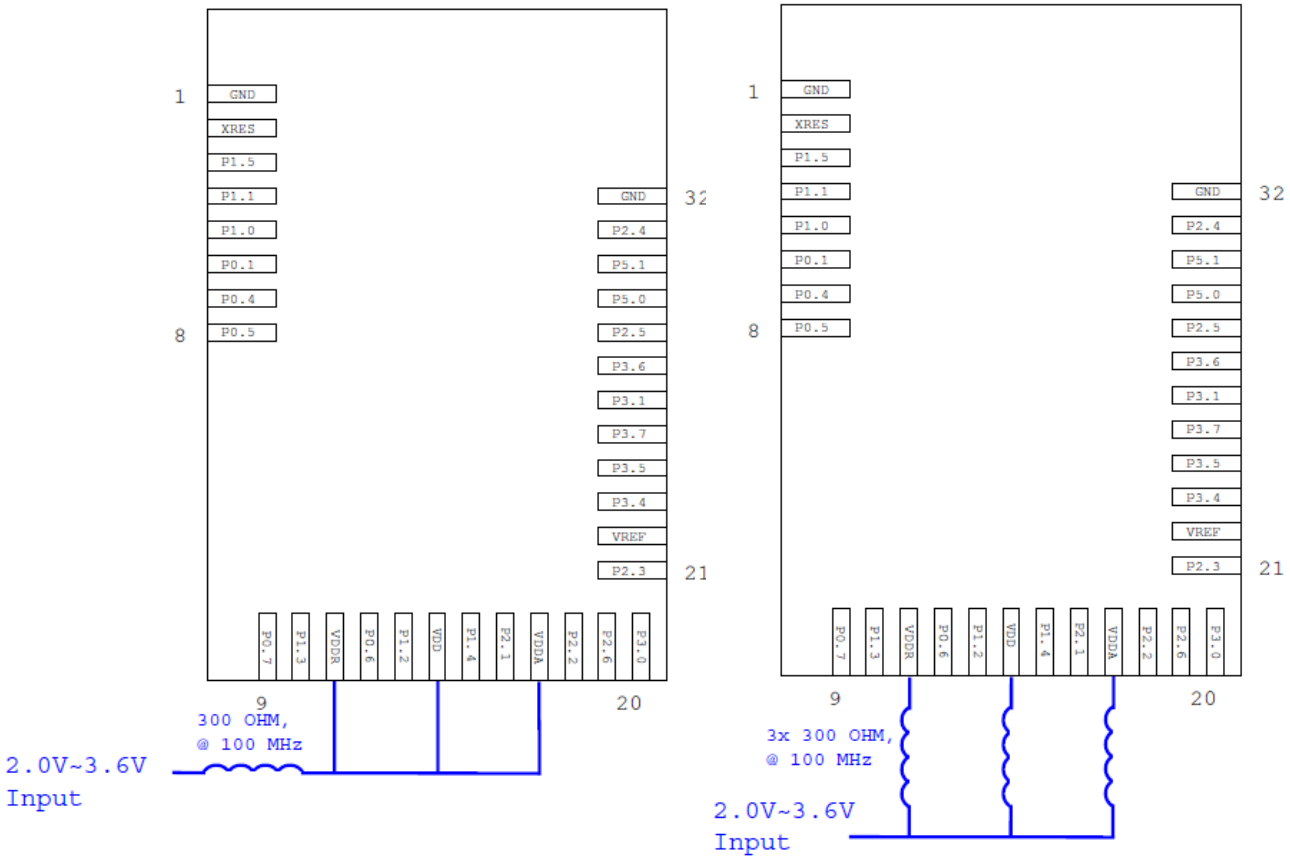
In either connection scenario, it is recommended to place an external ferrite bead between the supply and the module connection. The ferrite bead should be positioned as close as possible to the module pin connection.

Figure 7 details the recommended host schematic options for a single supply scenario. The use of one or three ferrite beads will depend on the specific application and configuration of the CYBLE-224116-01.

Figure 8 details the recommended host schematic for an independent supply scenario.

The recommended ferrite bead value is 330 Ω, 100 MHz. (Murata BLM21PG331SN1D).

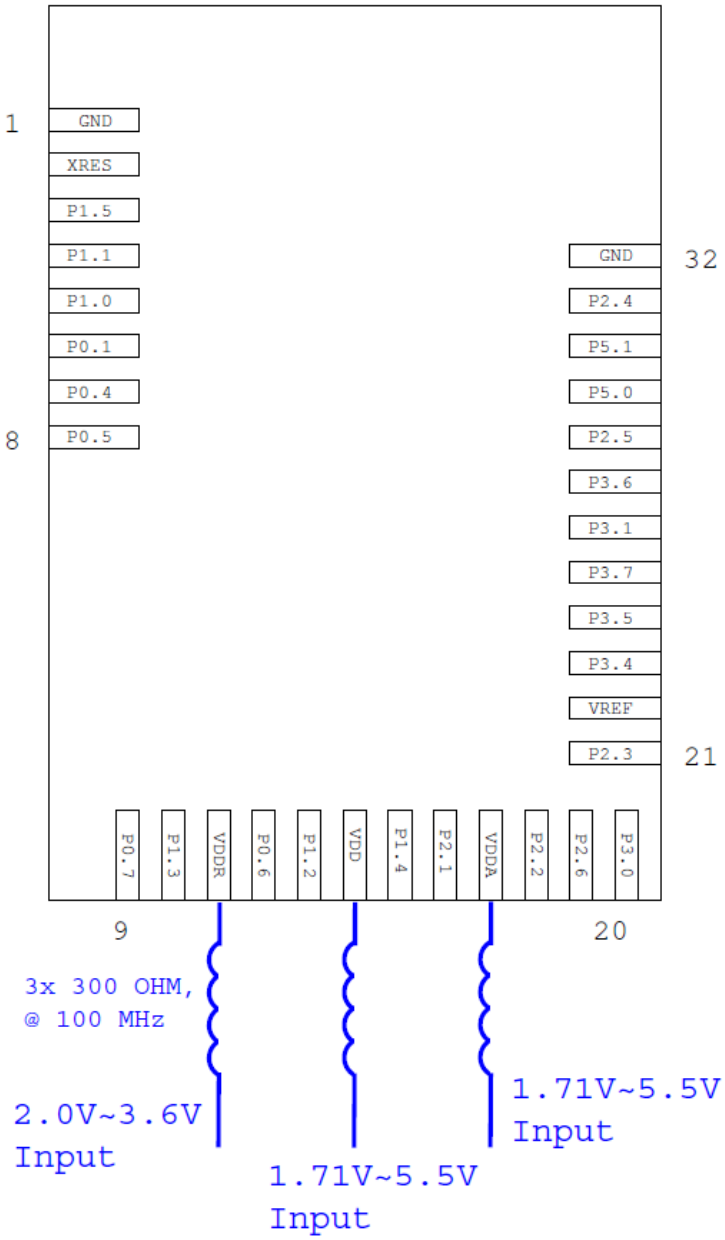
Figure 7. Recommended Host Schematic Options for a Single Supply Option



Single Ferrite Bead Option

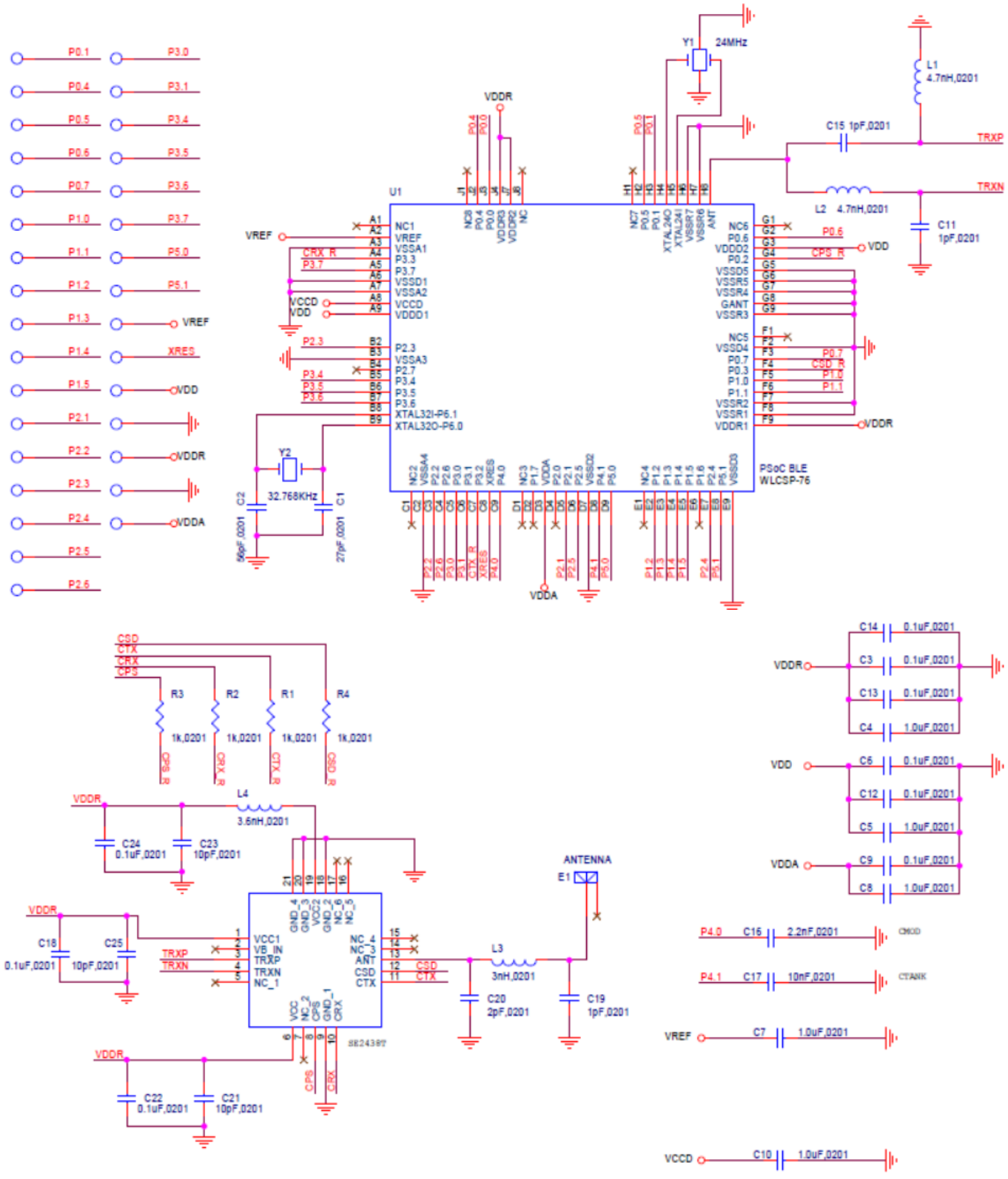
Three Ferrite Bead Option

Figure 8. Recommended Host Schematic for an Independent Supply Option



The CYBLE-224116-01 schematic is shown in Figure 9.

Figure 9. CYBLE-224116-01 Schematic Diagram



Critical Components List

Table 6 details the critical components used in the CYBLE-224116-01 module.

Table 6. Critical Component List

Component	Reference Designator	Description
Silicon	U1	76-pin WLCSP Programmable System-on-Chip (PSoC) with BLE
Crystal	Y1	24.000 MHz, 10PF
Crystal	Y2	32.768 kHz, 12.5PF

Antenna Design

Table 7 details the antenna used on the CYBLE-224116-01 module. The Cypress module performance improves many of these characteristics. For more information, see Table 11.

Table 7. Chip Antenna Specifications

Item	Description
Chip Antenna Manufacturer	Johanson Technology Inc.
Chip Antenna Part Number	2450AT18B100
Frequency Range	2400 – 2500 MHz
Peak Gain	0.5 dBi typical
Average Gain	-0.5 dBi typical
Return Loss	9.5 dB minimum

Power Amplifier (PA) and Low Noise Amplifier (LNA)

Table 8 details the PA/LNA that is used on the CYBLE-224116-01 module. For more information, see Table 11.

Table 8. Power Amplifier/Low Noise Amplifier Detailss

Item	Description
PA/LNA Manufacturer	Skyworks Inc.
PA/LNA Part Number	SE2438T
Power Supply Range	2.0V ~ 3.6V

Table 9 details the power consumption of the integrated PA/LNA used on the CYBLE-224116-01 module. Table 9 only details the current consumption of the SE2438T PA/LNA. VCC = VCC1 = VCC2 = 3 V, TA = +25 „°C, measured on the SE2438T evaluation board, unless otherwise noted.

Table 9. Power Amplifier/Low Noise Amplifier Current Consumption Specifications

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Total supply current	I_{CC}_Tx14	Tx mode P_{OUT} = +14 dBm	–	33	–	mA
Total supply current	I_{CC}_Tx12	Tx mode P_{OUT} = +12 dBm	–	25	–	mA
Total supply current	I_{CC}_Tx10	Tx mode P_{OUT} = +10 dBm	–	20	–	mA
Quiescent current	I_{CQ}_Tx	No RF	–	6	–	mA
Total supply current	I_{CC}_R_{XHG}	Rx Low Noise Amplifier (LNA) High Gain mode	–	5.5	–	mA
Total supply current	I_{CC}_R_{XLG}	Rx LNA Low Gain mode	–	2.7	–	mA
Total supply current	I_{CC}_$R_{XBypass}$	Rx Bypass mode	–	–	10	µA
Sleep supply current	I_{CC}_OFF	No RF	–	0.05	1.0	µA

Electrical Specification

Table 10 details the absolute maximum electrical characteristics for the Cypress BLE module.

Table 10. CYBLE-224116-01 Absolute Maximum Ratings

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{DDD_ABS}	V_{DD} or V_{DDA} supply relative to V_{SS} (V_{SSD} = V_{SSA})	–0.5	–	6	V	Absolute maximum
V_{DDR_ABS}	V_{DDR} supply relative to V_{SS} (V_{SSD} = V_{SSA})	-0.3	–	3.6	V	Restricted by SE2438T
V_{CCD_ABS}	Direct digital core voltage input relative to V_{SSD}	–0.5	–	1.95	V	Absolute maximum
V_{DDD_RIPPLE}	Maximum power supply ripple for V_{DD}, V_{DDA} and V_{DDR} input voltage	–	–	100	mV	3.0V supply Ripple frequency of 100 kHz to 750 kHz
V_{GPIO_ABS}	GPIO voltage	–0.5	–	V_{DD} +0.5	V	Absolute maximum
I_{GPIO_ABS}	Maximum current per GPIO	–25	–	25	mA	Absolute maximum
$I_{GPIO\_injection}$	GPIO injection current: Maximum for V_{IH} > V_{DD} and minimum for V_{IL} < V_{SS}	–0.5	–	0.5	mA	Absolute maximum current injected per pin
LU	Pin current for latch up	–200		200	mA	–

Table 11 details the RF characteristics for the Cypress BLE module.

Table 11. CYBLE-224116-01 RF Performance Characteristics

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
RF_{O1}	RF output power on ANT PA active	–8.5	0	9.5	dBm	Configurable via register settings. PA active.
RF_{O2}	RF output power on ANT PA bypassed	-18	0	3	dBm	Configurable via register settings. PA in bypass mode.
RX_{S1}	RF receive sensitivity on ANT LNA active	–	–95	–	dBm	Measured value
RX_{S2}	RF receive sensitivity on ANT LNA bypassed	–	–87	–	dBm	Measured value
F_R	Module frequency range	2400	–	2480	MHz	–
G_P	Peak gain	–	0.5	–	dBi	–
G_{Avg}	Average gain	–	–0.5	–	dBi	–
RL	Return loss	–	–10	–	dB	–

Table 12 through Table 52 list the module level electrical characteristics for the CYBLE-224116-01. All specifications are valid for –40 °C ≤ TA ≤ 85 °C and TJ ≤ 100 °C, except where noted. Specifications are valid for 1.71 V to 5.5 V, except where noted.

Table 12. CYBLE-224116-01 DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{DD1}	Power supply input voltage (V_{DD} = V_{DDA})	1.71	–	5.5	V	–
V_{DD2}	Power supply input voltage unregulated (V_{DD} = V_{DDA})	1.71	1.8	1.89	V	Internally unregulated supply
V_{DD3}	Power supply input voltage (V_{DD} = V_{DDA} = V_{DDR})	2.0	–	3.6	V	Restricted by SE2438T
V_{DDR1}	Radio supply voltage (radio on)	2.0	–	3.6	V	Restricted by SE2438T
V_{DDR2}	Radio supply voltage (radio off)	2.0	–	3.6	V	–
Active Mode, V_{DD} = 1.71 V to 5.5 V						
I_{DD3}	Execute from flash; CPU at 3 MHz	–	1.7	–	mA	T = 25 °C, V_{DD} = 3.3 V
I_{DD4}	Execute from flash; CPU at 3 MHz	–	–	–	mA	T = –40 °C to 85 °C

Table 12. CYBLE-224116-01 DC Specifications (continued)

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{DD5}	Execute from flash; CPU at 6 MHz	–	2.5	–	mA	T = 25 °C, V_{DD} = 3.3 V
I_{DD6}	Execute from flash; CPU at 6 MHz	–	–	–	mA	T = –40 °C to 85 °C
I_{DD7}	Execute from flash; CPU at 12 MHz	–	4	–	mA	T = 25 °C, V_{DD} = 3.3 V
I_{DD8}	Execute from flash; CPU at 12 MHz	–	–	–	mA	T = –40 °C to 85 °C
I_{DD9}	Execute from flash; CPU at 24 MHz	–	7.1	–	mA	T = 25 °C, V_{DD} = 3.3 V
I_{DD10}	Execute from flash; CPU at 24 MHz	–	–	–	mA	T = –40 °C to 85 °C
I_{DD11}	Execute from flash; CPU at 48 MHz	–	13.4	–	mA	T = 25 °C, V_{DD} = 3.3 V
I_{DD12}	Execute from flash; CPU at 48 MHz	–	–	–	mA	T = –40 °C to 85 °C
Sleep Mode, V_{DD} = 1.71 to 5.5 V						
I_{DD13}	IMO on	–	–	–	mA	T = 25 °C, V_{DD} = 3.3 V, SYSCLK = 3 MHz
Sleep Mode, V_{DD} and V_{DDR} = 1.9 to 5.5 V						
I_{DD14}	ECO on	–	–	–	mA	T = 25 °C, V_{DD} = 3.3 V, SYSCLK = 3 MHz
Deep-Sleep Mode, V_{DD} = 1.71 to 3.6 V						
I_{DD15}	WDT with WCO on	–	1.3	–	µA	T = 25 °C, V_{DD} = 3.3 V
I_{DD16}	WDT with WCO on	–	–	–	µA	T = –40 °C to 85 °C
I_{DD17}	WDT with WCO on	–	–	–	µA	T = 25 °C, V_{DD} = 5 V
I_{DD18}	WDT with WCO on	–	–	–	µA	T = –40 °C to 85 °C
Deep-Sleep Mode, V_{DD} = 1.71 to 1.89 V (Regulator Bypassed)						
I_{DD19}	WDT with WCO on	–	–	–	µA	T = 25 °C
I_{DD20}	WDT with WCO on	–	–	–	µA	T = –40 °C to 85 °C
Hibernate Mode, V_{DD} = 1.71 to 3.6 V						
I_{DD27}	GPIO and reset active	–	150	–	nA	T = 25 °C, V_{DD} = 3.3 V
I_{DD28}	GPIO and reset active	–	–	–	nA	T = –40 °C to 85 °C
Hibernate Mode, V_{DD} = 3.6 to 5.5 V						
I_{DD29}	GPIO and reset active	–	–	–	nA	T = 25 °C, V_{DD} = 5 V
I_{DD30}	GPIO and reset active	–	–	–	nA	T = –40 °C to 85 °C
Stop Mode, V_{DD} = 1.71 to 3.6 V						
I_{DD33}	Stop-mode current (V_{DD})	–	20	–	nA	T = 25 °C, V_{DD} = 3.3 V
I_{DD34}	Stop-mode current (V_{DDR})	–	40	–-	nA	T = 25 °C, V_{DDR} = 3.3 V
I_{DD35}	Stop-mode current (V_{DD})	–	–	–	nA	T = –40 °C to 85 °C
I_{DD36}	Stop-mode current (V_{DDR})	–	–	–	nA	T = –40 °C to 85 °C, V_{DDR} = 1.9 V to 3.6 V
Stop Mode, V_{DD} = 3.6 to 5.5 V						
I_{DD37}	Stop-mode current (V_{DD})	–	–	–	nA	T = 25 °C, V_{DD} = 5 V

Table 12. CYBLE-224116-01 DC Specifications (continued)

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{DD38}	Stop-mode current (V_{DDR})	–	–	–	nA	T = 25 °C, V_{DDR} = 5 V
I_{DD39}	Stop-mode current (V_{DD})	–	–	–	nA	T = –40 °C to 85 °C
I_{DD40}	Stop-mode current (V_{DDR})	–	–	–	nA	T = –40 °C to 85 °C

Table 13. AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
F_{CPU}	CPU frequency	DC	–	48	MHz	1.71 V ≤ V_{DD} ≤ 5.5 V
T_{SLEEP}	Wakeup from Sleep mode	–	0	–	µs	Guaranteed by characterization
$T_{DEEPSLEEP}$	Wakeup from Deep-Sleep mode	–	–	25	µs	24-MHz IMO. Guaranteed by characterization
$T_{HIBERNATE}$	Wakeup from Hibernate mode	–	–	800	µs	Guaranteed by characterization
T_{STOP}	Wakeup from Stop mode	–	–	2	ms	XRES wakeup

GPIO

Table 14. GPIO DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{IH}[4]	Input voltage HIGH threshold	0.7 × V_{DD}	–	–	V	CMOS input
	LVTTL input, V_{DD} < 2.7 V	0.7 × V_{DD}	–	–	V	–
	LVTTL input, V_{DD} ≥ 2.7 V	2.0	–	–	V	–
V_{IL}	Input voltage LOW threshold	–	–	0.3 × V_{DD}	V	CMOS input
	LVTTL input, V_{DD} < 2.7 V	–	–	0.3× V_{DD}	V	–
	LVTTL input, V_{DD} ≥ 2.7 V	–	–	0.8	V	–
V_{OH}	Output voltage HIGH level	V_{DD} –0.6	–	–	V	I_{OH} = 4 mA at 3.3-V V_{DD}
	Output voltage HIGH level	V_{DD} –0.5	–	–	V	I_{OH} = 1 mA at 1.8-V V_{DD}
V_{OL}	Output voltage LOW level	–	–	0.6	V	I_{OL} = 8 mA at 3.3-V V_{DD}
	Output voltage LOW level	–	–	0.6	V	I_{OL} = 4 mA at 1.8-V V_{DD}
	Output voltage LOW level	–	–	0.4	V	I_{OL} = 3 mA at 3.3-V V_{DD}
R_{PULLUP}	Pull-up resistor	3.5	5.6	8.5	kΩ	–
$R_{PULLDOWN}$	Pull-down resistor	3.5	5.6	8.5	kΩ	–
I_{IL}	Input leakage current (absolute value)	–	–	2	nA	25 °C, V_{DD} = 3.3 V
I_{IL_CTBM}	Input leakage on CTBm input pins	–	–	4	nA	–
C_{IN}	Input capacitance	–	–	7	pF	–
V_{HYSTTL}	Input hysteresis LVTTL	25	40	–	mV	V_{DD} > 2.7 V
$V_{HYSCMOS}$	Input hysteresis CMOS	0.05 × V_{DD}	–	–	1	–
I_{DIODE}	Current through protection diode to V_{DD}/V_{SS}	–	–	100	µA	–
I_{TOT_GPIO}	Maximum total source or sink chip current	–	–	200	mA	–

Note
4. V_{IH} must not exceed V_{DD} + 0.2 V.

Table 15. GPIO AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
T_{RISEF}	Rise time in Fast-Strong mode	2	–	12	ns	3.3-V V_{DDD}, C_{LOAD} = 25 pF
T_{FALLF}	Fall time in Fast-Strong mode	2	–	12	ns	3.3-V V_{DDD}, C_{LOAD} = 25 pF
T_{RISES}	Rise time in Slow-Strong mode	10	–	60	ns	3.3-V V_{DDD}, C_{LOAD} = 25 pF
T_{FALLS}	Fall time in Slow-Strong mode	10	–	60	ns	3.3-V V_{DDD}, C_{LOAD} = 25 pF
$F_{GPIOUT1}$	GPIO Fout; 3.3 V ≤ V_{DD} ≤ 5.5 V Fast-Strong mode	–	–	33	MHz	90/10%, 25 pF load, 60/40 duty cycle
$F_{GPIOUT2}$	GPIO Fout; 1.7 V≤ V_{DD} ≤ 3.3 V Fast-Strong mode	–	–	16.7	MHz	90/10%, 25 pF load, 60/40 duty cycle
$F_{GPIOUT3}$	GPIO Fout; 3.3 V ≤ V_{DD} ≤ 5.5 V Slow-Strong mode	–	–	7	MHz	90/10%, 25 pF load, 60/40 duty cycle
$F_{GPIOUT4}$	GPIO Fout; 1.7 V ≤ V_{DD} ≤ 3.3 V Slow-Strong mode	–	–	3.5	MHz	90/10%, 25 pF load, 60/40 duty cycle
F_{GPIOIN}	GPIO input operating frequency 1.71 V ≤ V_{DD} ≤ 5.5 V	–	–	48	MHz	90/10% V_{IO}

XRES

Table 16. XRES DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{IH}	Input voltage HIGH threshold	0.7 × V_{DDD}	–	–	V	CMOS input
V_{IL}	Input voltage LOW threshold	–	–	0.3 × V_{DDD}	V	CMOS input
R_{PULLUP}	Pull-up resistor	3.5	5.6	8.5	kΩ	–
C_{IN}	Input capacitance	–	3	–	pF	–
$V_{HYSXRES}$	Input voltage hysteresis	–	100	–	mV	–
I_{DIODE}	Current through protection diode to V_{DD}/V_{SS}	–	–	100	µA	–

Table 17. XRES AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{RESETWIDTH}$	Reset pulse width	1	–	–	µs	–

Analog Peripherals

Opamp

Table 18. Opamp Specifications

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
I_{DD} (Opamp Block Current. V_{DD} = 1.8 V. No Load)						
I_{DD_HI}	Power = high	–	1000	1300	µA	
I_{DD_MED}	Power = medium	–	500	–	µA	
I_{DD_LOW}	Power = low	–	250	350	µA	
GBW (Load = 20 pF, 0.1 mA. V_{DDA} = 2.7 V)						
GBW_HI	Power = high	6	–	–	MHz	
GBW_MED	Power = medium	4	–	–	MHz	
GBW_LO	Power = low	–	1	–	MHz	
I_{OUT_MAX} (V_{DDA} ≥ 2.7 V, 500 mV from Rail)						

Table 18. Opamp Specifications (continued)

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
$I_{OUT\_MAX\_HI}$	Power = high	10	–	–	mA	
$I_{OUT\_MAX\_MID}$	Power = medium	10	–	–	mA	
$I_{OUT\_MAX\_LO}$	Power = low	–	5	–	mA	
I_{OUT} (V_{DDA} = 1.71 V, 500 mV from Rail)						
$I_{OUT\_MAX\_HI}$	Power = high	4	–	–	mA	
$I_{OUT\_MAX\_MID}$	Power = medium	4	–	–	mA	
$I_{OUT\_MAX\_LO}$	Power = low	–	2	–	mA	
V_{IN}	Charge pump on, $V_{DDA} \geq 2.7$ V	–0.05	–	$V_{DDA} – 0.2$	V	
V_{CM}	Charge pump on, $V_{DDA} \geq 2.7$ V	–0.05	–	$V_{DDA} – 0.2$	V	
V_{OUT} ($V_{DDA} \geq 2.7$ V)						
V_{OUT_1}	Power = high, I_{LOAD}=10 mA	0.5	–	$V_{DDA} – 0.5$	V	
V_{OUT_2}	Power = high, I_{LOAD}=1 mA	0.2	–	$V_{DDA} – 0.2$	V	
V_{OUT_3}	Power = medium, I_{LOAD}=1 mA	0.2	–	$V_{DDA} – 0.2$	V	
V_{OUT_4}	Power = low, I_{LOAD}=0.1 mA	0.2	–	$V_{DDA} – 0.2$	V	
V_{OS_TR}	Offset voltage, trimmed	1	±0.5	1	mV	High mode
V_{OS_TR}	Offset voltage, trimmed	–	±1	–	mV	Medium mode
V_{OS_TR}	Offset voltage, trimmed	–	±2	–	mV	Low mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–10	±3	10	µV/C	High mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–	±10	–	µV/C	Medium mode
$V_{OS\_DR\_TR}$	Offset voltage drift, trimmed	–	±10	–	µV/C	Low mode
CMRR	DC	65	70	–	dB	V_{DDD} = 3.6 V, High-power mode
PSRR	At 1 kHz, 100-mV ripple	70	85	–	dB	V_{DDD} = 3.6 V
Noise						
V_{N1}	Input referred, 1 Hz–1 GHz, power = high	–	94	–	µVrms	
V_{N2}	Input referred, 1 kHz, power = high	–	72	–	nV/rtHz	
V_{N3}	Input referred, 10 kHz, power = high	–	28	–	nV/rtHz	
V_{N4}	Input referred, 100 kHz, power = high	–	15	–	nV/rtHz	
C_{LOAD}	Stable up to maximum load. Performance specs at 50 pF	–	–	125	pF	
Slew_rate	Cload = 50 pF, Power = High, $V_{DDA} \geq 2.7$ V	6	–	–	V/µsec	
T_op_wake	From disable to enable, no external RC dominating	–	300	–	µsec	
Comp_mode (Comparator Mode; 50-mV Drive, T_{RISE} = T_{FALL} (Approx.)						
T_{PD1}	Response time; power = high	–	150	–	nsec	
T_{PD2}	Response time; power = medium	–	400	–	nsec	
T_{PD3}	Response time; power = low	–	2000	–	nsec	
Vhyst_op	Hysteresis	–	10	–	mV	
Deep-Sleep Mode (Deep-Sleep mode operation is only guaranteed for V_{DDA} > 2.5 V)						
GBW_DS	Gain bandwidth product	–	50	–	kHz	
IDD_DS	Current	–	15	–	µA	
Vos_DS	Offset voltage	–	5	–	mV	

Table 18. Opamp Specifications (continued)

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
Vos_dr_DS	Offset voltage drift	–	20	–	µV/°C	
Vout_DS	Output voltage	0.2	–	V_{DD}–0.2	V	
Vcm_DS	Common mode voltage	0.2	–	V_{DD}–1.8	V	

Table 19. Comparator DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
$V_{OFFSET1}$	Input offset voltage, Factory trim	–	–	±10	mV	
$V_{OFFSET2}$	Input offset voltage, Custom trim	–	–	±6	mV	
$V_{OFFSET3}$	Input offset voltage, ultra-low-power mode	–	±12	–	mV	
V_{HYST}	Hysteresis when enabled	–	10	35	mV	
V_{ICM1}	Input common mode voltage in normal mode	0	–	V_{DDD} –0.1	V	Modes 1 and 2
V_{ICM2}	Input common mode voltage in low-power mode	0	–	V_{DDD}	V	
V_{ICM3}	Input common mode voltage in ultra low-power mode	0	–	V_{DDD} –1.15	V	
CMRR	Common mode rejection ratio	50	–	–	dB	$V_{DDD} \geq 2.7$ V
CMRR	Common mode rejection ratio	42	–	–	dB	$V_{DDD} \leq 2.7$ V
I_{CMP1}	Block current, normal mode	–	–	400	µA	
I_{CMP2}	Block current, low-power mode	–	–	100	µA	
I_{CMP3}	Block current in ultra-low-power mode	–	6	–	µA	
Z_{CMP}	DC input impedance of comparator	35	–	–	MΩ	

Table 20. Comparator AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
T_{RESP1}	Response time, normal mode, 50-mV overdrive	–	38	–	ns	50-mV overdrive
T_{RESP2}	Response time, low-power mode, 50-mV overdrive	–	70	–	ns	50-mV overdrive
T_{RESP3}	Response time, ultra-low-power mode, 50-mV overdrive	–	2.3	–	µs	200-mV overdrive

Temperature Sensor

Table 21. Temperature Sensor Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{SENSACC}$	Temperature-sensor accuracy	–5	±1	5	°C	–40 to +85 °C

SAR ADC

Table 22. SAR ADC DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
A_RES	Resolution	–	–	12	bits	

Table 22. SAR ADC DC Specifications

A_CHNIS_S	Number of channels - single-ended	–	–	8		8 full-speed
A-CHNKS_D	Number of channels - differential	–	–	4		Diff inputs use neighboring I/O
A-MONO	Monotonicity	–	–	–		Yes
A_GAINERR	Gain error	–	–	±0.1	%	With external reference
A_OFFSET	Input offset voltage	–	–	2	mV	Measured with 1-V V_{REF}
A_ISAR	Current consumption	–	–	1	mA	
A_VINS	Input voltage range - single-ended	V_{SS}	–	V_{DDA}	V	
A_VIND	Input voltage range - differential	V_{SS}	–	V_{DDA}	V	
A_INRES	Input resistance	–	–	2.2	kΩ	
A_INCAP	Input capacitance	–	–	10	pF	
VREFSAR	Trimmed internal reference to SAR	–1	–	1	%	Percentage of Vbg (1.024 V)

Table 23. SAR ADC AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
A_PSRR	Power-supply rejection ratio	70	–	–	dB	Measured at 1-V reference
A_CMRR	Common-mode rejection ratio	66	–	–	dB	
A_SAMP	Sample rate	–	–	1	Msps	
Fsarintref	SAR operating speed without external ref. bypass	–	–	100	Ksps	12-bit resolution
A_SNR	Signal-to-noise ratio (SNR)	65	–	–	dB	F_{IN} = 10 kHz
A_BW	Input bandwidth without aliasing	–	–	A_SAMP/2	kHz	
A_INL	Integral nonlinearity. V_{DD} = 1.71 V to 5.5 V, 1 Msps	–1.7	–	2	LSB	V_{REF} = 1 V to V_{DD}
A_INL	Integral nonlinearity. V_{DDD} = 1.71 V to 3.6 V, 1 Msps	–1.5	–	1.7	LSB	V_{REF} = 1.71 V to V_{DD}
A_INL	Integral nonlinearity. V_{DD} = 1.71 V to 5.5 V, 500 Ksps	–1.5	–	1.7	LSB	V_{REF} = 1 V to V_{DD}
A_dnl	Differential nonlinearity. V_{DD} = 1.71 V to 5.5 V, 1 Msps	–1	–	2.2	LSB	V_{REF} = 1 V to V_{DD}
A_DNL	Differential nonlinearity. V_{DD} = 1.71 V to 3.6 V, 1 Msps	–1	–	2	LSB	V_{REF} = 1.71 V to V_{DD}
A_DNL	Differential nonlinearity. V_{DD} = 1.71 V to 5.5 V, 500 Ksps	–1	–	2.2	LSB	V_{REF} = 1 V to V_{DD}
A_THD	Total harmonic distortion	–	–	–65	dB	F_{IN} = 10 kHz

CSD

CSD Block Specifications

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
V_{CSD}	Voltage range of operation	1.71	–	5.5	V	
IDAC1	DNL for 8-bit resolution	–1	–	1	LSB	

CSD Block Specifications (continued)

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
IDAC1	INL for 8-bit resolution	–3	–	3	LSB	
IDAC2	DNL for 7-bit resolution	–1	–	1	LSB	
IDAC2	INL for 7-bit resolution	–3	–	3	LSB	
SNR	Ratio of counts of finger to noise	5	–	–	Ratio	Capacitance range of 9 pF to 35 pF, 0.1-pF sensitivity. Radio is not operating during the scan
I_{DAC1_CRT1}	Output current of IDAC1 (8 bits) in High range	–	612	–	µA	
I_{DAC1_CRT2}	Output current of IDAC1 (8 bits) in Low range	–	306	–	µA	
I_{DAC2_CRT1}	Output current of IDAC2 (7 bits) in High range	–	305	–	µA	
I_{DAC2_CRT2}	Output current of IDAC2 (7 bits) in Low range	–	153	–	µA	

Digital Peripherals

Timer

Table 24. Timer DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{TIM1}	Block current consumption at 3 MHz	–	–	42	µA	16-bit timer
I_{TIM2}	Block current consumption at 12 MHz	–	–	130	µA	16-bit timer
I_{TIM3}	Block current consumption at 48 MHz	–	–	535	µA	16-bit timer

Table 25. Timer AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{TIMFREQ}$	Operating frequency	F_{CLK}	–	48	MHz	
$T_{CAPWINT}$	Capture pulse width (internal)	$2 \times T_{CLK}$	–	–	ns	
$T_{CAPWEXT}$	Capture pulse width (external)	$2 \times T_{CLK}$	–	–	ns	
T_{TIMRES}	Timer resolution	T_{CLK}	–	–	ns	
$T_{TENWIDINT}$	Enable pulse width (internal)	$2 \times T_{CLK}$	–	–	ns	
$T_{TENWIDEXT}$	Enable pulse width (external)	$2 \times T_{CLK}$	–	–	ns	
$T_{TIMRESWINT}$	Reset pulse width (internal)	$2 \times T_{CLK}$	–	–	ns	
$T_{TIMRESEXT}$	Reset pulse width (external)	$2 \times T_{CLK}$	–	–	ns	

Counter

Table 26. Counter DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{CTR1}	Block current consumption at 3 MHz	–	–	42	µA	16-bit counter
I_{CTR2}	Block current consumption at 12 MHz	–	–	130	µA	16-bit counter
I_{CTR3}	Block current consumption at 48 MHz	–	–	535	µA	16-bit counter

Table 27. Counter AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{CTRFREQ}$	Operating frequency	F_{CLK}	–	48	MHz	
$T_{CTRPWINT}$	Capture pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{CTRPWEXT}$	Capture pulse width (external)	2 × T_{CLK}	–	–	ns	
T_{CTRES}	Counter Resolution	T_{CLK}	–	–	ns	
$T_{CENWIDINT}$	Enable pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{CENWIDEXT}$	Enable pulse width (external)	2 × T_{CLK}	–	–	ns	
$T_{CTRRESWINT}$	Reset pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{CTRRESWEXT}$	Reset pulse width (external)	2 × T_{CLK}	–	–	ns	

Pulse Width Modulation (PWM)

Table 28. PWM DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{PWM1}	Block current consumption at 3 MHz	–	–	42	µA	16-bit PWM
I_{PWM2}	Block current consumption at 12 MHz	–	–	130	µA	16-bit PWM
I_{PWM3}	Block current consumption at 48 MHz	–	–	535	µA	16-bit PWM

Table 29. PWM AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{PWMFREQ}$	Operating frequency	F_{CLK}	–	48	MHz	
$T_{PWMPWINT}$	Pulse width (internal)	2 × T_{CLK}	–	–	ns	
T_{PWMEXT}	Pulse width (external)	2 × T_{CLK}	–	–	ns	
$T_{PWMKILLINT}$	Kill pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{PWMKILLEXT}$	Kill pulse width (external)	2 × T_{CLK}	–	–	ns	
$T_{PWMEINT}$	Enable pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{PWMENEXT}$	Enable pulse width (external)	2 × T_{CLK}	–	–	ns	
$T_{PWMRESWINT}$	Reset pulse width (internal)	2 × T_{CLK}	–	–	ns	
$T_{PWMRESWEXT}$	Reset pulse width (external)	2 × T_{CLK}	–	–	ns	

LCD Direct Drive

Table 30. LCD Direct Drive DC Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID228	I_{LCDLOW}	Operating current in low-power mode	–	17.5	–	µA	16 × 4 small segment display at 50 Hz
SID229	C_{LCDCAP}	LCD capacitance per segment/common driver	–	500	5000	pF	
SID230	LCD_{OFFSET}	Long-term segment offset	–	20	–	mV	
SID231	I_{LCDOP1}	LCD system operating current V_{BIAS} = 5 V	–	2	–	mA	32 × 4 segments. 50 Hz at 25 °C
SID232	I_{LCDOP2}	LCD system operating current V_{BIAS} = 3.3 V	–	2	–	mA	32 × 4 segments 50 Hz at 25 °C

Table 31. LCD Direct Drive AC Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID233	F_{LCD}	LCD frame rate	10	50	150	Hz	

Serial Communication

Table 32. Fixed I²C DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{I2C1}	Block current consumption at 100 kHz	–	–	50	µA	–
I_{I2C2}	Block current consumption at 400 kHz	–	–	155	µA	–
I_{I2C3}	Block current consumption at 1 Mbps	–	–	390	µA	–
I_{I2C4}	I²C enabled in Deep-Sleep mode	–	–	1.4	µA	–

Table 33. Fixed I²C AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
F_{I2C1}	Bit rate	–	–	400	kHz	

Table 34. Fixed UART DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{UART1}	Block current consumption at 100 kbps	–	–	55	µA	–
I_{UART2}	Block current consumption at 1000 kbps	–	–	312	µA	–

Table 35. Fixed UART AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
F_{UART}	Bit rate	–	–	1	Mbps	–

Table 36. Fixed SPI DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{SPI1}	Block current consumption at 1 Mbps	–	–	360	µA	–
I_{SPI2}	Block current consumption at 4 Mbps	–	–	560	µA	–
I_{SPI3}	Block current consumption at 8 Mbps	–	–	600	µA	–

Table 37. Fixed SPI AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
F_{SPI}	SPI operating frequency (master; 6x over sampling)	–	–	8	MHz	–

Table 38. Fixed SPI Master Mode AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
T_{DMO}	MOSI valid after SCLK driving edge	–	–	18	ns	–
T_{DSI}	MISO valid before SCLK capturing edge Full clock, late MISO sampling used	20	–	–	ns	Full clock, late MISO sampling
T_{HMO}	Previous MOSI data hold time	0	–	–	ns	Referred to Slave capturing edge

Table 39. Fixed SPI Slave Mode AC Specifications

Parameter	Description	Min	Typ	Max	Units
T_{DMI}	MOSI valid before SCLK capturing edge	40	–	–	ns
T_{DSO}	MISO valid after SCLK driving edge	–	–	$42 + 3 \times T_{CPU}$	ns
T_{DSO_ext}	MISO Valid after SCLK driving edge in external clock mode. $V_{DD} < 3.0$ V	–	–	50	ns
T_{HSO}	Previous MISO data hold time	0	–	–	ns
$T_{SSELSCK}$	SSEL valid to first SCK valid edge	100	–	–	ns

Memory

Table 40. Flash DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{PE}	Erase and program voltage	1.71	–	5.5	V	–
T_{WS48}	Number of Wait states at 32–48 MHz	2	–	–		CPU execution from flash
T_{WS32}	Number of Wait states at 16–32 MHz	1	–	–		CPU execution from flash
T_{WS16}	Number of Wait states for 0–16 MHz	0	–	–		CPU execution from flash

Table 41. Flash AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{ROWWRITE}$[5]	Row (block) write time (erase and program)	–	–	20	ms	Row (block) = 256 bytes
$T_{ROWERASE}$[5]	Row erase time	–	–	13	ms	–
$T_{ROWPROGRAM}$[5]	Row program time after erase	–	–	7	ms	–
$T_{BULKERASE}$[5]	Bulk erase time (256 KB)	–	–	35	ms	–
$T_{DEVPROG}$[5]	Total device program time	–	–	25	seconds	–
F_{END}	Flash endurance	100 K	–	–	cycles	–
F_{RET}	Flash retention. $T_A \le 55$ °C, 100 K P/E cycles	20	–	–	years	–
F_{RET2}	Flash retention. $T_A \le 85$ °C, 10 K P/E cycles	10	–	–	years	–

System Resources

Power-on-Reset (POR)

Table 42. POR DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$V_{RISEIPOR}$	Rising trip voltage	0.80	–	1.45	V	–
$V_{FALLIPOR}$	Falling trip voltage	0.75	–	1.40	V	–
$V_{IPORHYST}$	Hysteresis	15	–	200	mV	–

Table 43. POR AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
T_{PPOR_TR}	Precision power-on reset (PPOR) response time in Active and Sleep modes	–	–	1	µs	–

Table 44. Brown-Out Detect

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$V_{FALLPPOR}$	BOD trip voltage in Active and Sleep modes	1.64	–	–	V	–
$V_{FALLDPSLP}$	BOD trip voltage in Deep Sleep	1.4	–	–	V	–

Table 45. Hibernate Reset

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$V_{HBRTRIP}$	BOD trip voltage in Hibernate	1.1	–	–	V	–

Note

5. It can take as much as 20 ms to write to flash. During this time, the device should not be reset, or flash operations will be interrupted and cannot be relied on to have completed. Reset sources include the XRES pin, software resets, CPU lockup states and privilege violations, improper power supply levels, and watchdogs. Make certain that these are not inadvertently activated.

Voltage Monitors (LVD)

Table 46. Voltage Monitor DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
V_{LVI1}	LVI_A/D_SEL[3:0] = 0000b	1.71	1.75	1.79	V	–
V_{LVI2}	LVI_A/D_SEL[3:0] = 0001b	1.76	1.80	1.85	V	–
V_{LVI3}	LVI_A/D_SEL[3:0] = 0010b	1.85	1.90	1.95	V	–
V_{LVI4}	LVI_A/D_SEL[3:0] = 0011b	1.95	2.00	2.05	V	–
V_{LVI5}	LVI_A/D_SEL[3:0] = 0100b	2.05	2.10	2.15	V	–
V_{LVI6}	LVI_A/D_SEL[3:0] = 0101b	2.15	2.20	2.26	V	–
V_{LVI7}	LVI_A/D_SEL[3:0] = 0110b	2.24	2.30	2.36	V	–
V_{LVI8}	LVI_A/D_SEL[3:0] = 0111b	2.34	2.40	2.46	V	–
V_{LVI9}	LVI_A/D_SEL[3:0] = 1000b	2.44	2.50	2.56	V	–
V_{LVI10}	LVI_A/D_SEL[3:0] = 1001b	2.54	2.60	2.67	V	–
V_{LVI11}	LVI_A/D_SEL[3:0] = 1010b	2.63	2.70	2.77	V	–
V_{LVI12}	LVI_A/D_SEL[3:0] = 1011b	2.73	2.80	2.87	V	–
V_{LVI13}	LVI_A/D_SEL[3:0] = 1100b	2.83	2.90	2.97	V	–
V_{LVI14}	LVI_A/D_SEL[3:0] = 1101b	2.93	3.00	3.08	V	–
V_{LVI15}	LVI_A/D_SEL[3:0] = 1110b	3.12	3.20	3.28	V	–
V_{LVI16}	LVI_A/D_SEL[3:0] = 1111b	4.39	4.50	4.61	V	–
LVI_IDD	Block current	–	–	100	µA	–

Table 47. Voltage Monitor AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{MONTRIP}$	Voltage monitor trip time	–	–	1	µs	–

SWD Interface

Table 48. SWD Interface Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
F_SWDCLK1	3.3 V ≤ V_{DD} ≤ 5.5 V	–	–	14	MHz	SWDCLK ≤ 1/3 CPU clock frequency
F_SWDCLK2	1.71 V ≤ V_{DD} ≤ 3.3 V	–	–	7	MHz	SWDCLK ≤ 1/3 CPU clock frequency
T_SWDI_SETUP	T = 1/f SWDCLK	0.25 × T	–	–	ns	–
T_SWDI_HOLD	T = 1/f SWDCLK	0.25 × T	–	–	ns	–
T_SWDO_VALID	T = 1/f SWDCLK	–	–	0.5 × T	ns	–
T_SWDO_HOLD	T = 1/f SWDCLK	1	–	–	ns	–

Internal Main Oscillator

Table 49. IMO DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{IMO1}	IMO operating current at 48 MHz	–	–	1000	µA	–
I_{IMO2}	IMO operating current at 24 MHz	–	–	325	µA	–
I_{IMO3}	IMO operating current at 12 MHz	–	–	225	µA	–
I_{IMO4}	IMO operating current at 6 MHz	–	–	180	µA	–
I_{IMO5}	IMO operating current at 3 MHz	–	–	150	µA	–

Table 50. IMO AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$F_{IMOTOL3}$	Frequency variation from 3 to 48 MHz	–	–	±2	%	With API-called calibration
$F_{IMOTOL3}$	IMO startup time	–	12	–	µs	–

Internal Low-Speed Oscillator

Table 51. ILO DC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
I_{ILO2}	ILO operating current at 32 kHz	–	0.3	1.05	µA	–

Table 52. ILO AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
$T_{STARTILO1}$	ILO startup time	–	–	2	ms	–
$F_{ILOTRIM1}$	32-kHz trimmed frequency	15	32	50	kHz	–

Table 53. ECO Trim Value Specification

Parameter	Description	Value	Details/Conditions
ECO_{TRIM}	24-MHz trim value (firmware configuration)	0x00003FFA	Optimum trim value that needs to be loaded to register CY_SYS_XTAL_BLERD_BB_XO_CAPTRIM_REG

Table 54. UDB AC Specifications

Parameter	Description	Min	Typ	Max	Units	Details/Conditions
Data Path performance						
$F_{MAX-TIMER}$	Max frequency of 16-bit timer in a UDB pair	–	–	48	MHz	
$F_{MAX-ADDER}$	Max frequency of 16-bit adder in a UDB pair	–	–	48	MHz	
F_{MAX_CRC}	Max frequency of 16-bit CRC/PRS in a UDB pair	–	–	48	MHz	
PLD Performance in UDB						
F_{MAX_PLD}	Max frequency of 2-pass PLD function in a UDB pair	–	–	48	MHz	
Clock to Output Performance						
$T_{CLK\_OUT\_UDB1}$	Prop. delay for clock in to data out at 25 °C, Typical	–	15	–	ns	
$T_{CLK\_OUT\_UDB2}$	Prop. delay for clock in to data out, Worst case	–	25	–	ns	

Table 55. BLE Subsystem

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
RF Receiver Specification						
RXS, DIRTY	RX sensitivity with dirty transmitter	–	–95	–	dBm	With LNA active
RXS, LOWGAIN	RX sensitivity in low-gain mode with idle transmitter	–	–87	–	dBm	LNA in bypass mode
RXS, HIGHGAIN	RX sensitivity in high-gain mode with idle transmitter	–	–95	–	dBm	With LNA active
PRXMAX	Maximum input power	–10	–1	–	dBm	RF-PHY Specification (RCV-LE/CA/06/C)
CI1	Cochannel interference, Wanted signal at –67 dBm and Interferer at FRX	–	9	21	dB	RF-PHY Specification (RCV-LE/CA/03/C)
CI2	Adjacent channel interference Wanted signal at –67 dBm and Interferer at FRX ±1 MHz	–	TBD	–	dB	RF-PHY Specification (RCV-LE/CA/03/C)
CI3	Adjacent channel interference Wanted signal at –67 dBm and Interferer at FRX ±2 MHz	–	TBD	–	dB	RF-PHY Specification (RCV-LE/CA/03/C)
CI4	Adjacent channel interference Wanted signal at –67 dBm and Interferer at ≥FRX ±3 MHz	–	TBD	–	dB	RF-PHY Specification (RCV-LE/CA/03/C)
CI5	Adjacent channel interference Wanted Signal at –67 dBm and Interferer at Image frequency (F_{IMAGE})	–	TBD	–	dB	RF-PHY Specification (RCV-LE/CA/03/C)
CI3	Adjacent channel interference Wanted signal at –67 dBm and Interferer at Image frequency (F_{IMAGE} ± 1 MHz)	–	TBD	–	dB	RF-PHY Specification (RCV-LE/CA/03/C)
OBB1	Out-of-band blocking, Wanted signal at –67 dBm and Interferer at F = 30–2000 MHz	–	TBD	–	dBm	RF-PHY Specification (RCV-LE/CA/04/C)
OBB2	Out-of-band blocking, Wanted signal at –67 dBm and Interferer at F = 2003–2399 MHz	–	TBD	–	dBm	RF-PHY Specification (RCV-LE/CA/04/C)
OBB3	Out-of-band blocking, Wanted signal at –67 dBm and Interferer at F = 2484–2997 MHz	–	TBD	–	dBm	RF-PHY Specification (RCV-LE/CA/04/C)
OBB4	Out-of-band blocking, Wanted signal a –67 dBm and Interferer at F = 3000–12750 MHz	–	TBD	–	dBm	RF-PHY Specification (RCV-LE/CA/04/C)
IMD	Intermodulation performance Wanted signal at –64 dBm and 1-Mbps BLE, third, fourth, and fifth offset channel	–	TBD	–	dBm	RF-PHY Specification (RCV-LE/CA/05/C)
RXSE1	Receiver spurious emission 30 MHz to 1.0 GHz	–	TBD	–	dBm	100-kHz measurement bandwidth ETSI EN300 328 V1.8.1
RXSE2	Receiver spurious emission 1.0 GHz to 12.75 GHz	–	TBD	–	dBm	1-MHz measurement bandwidth ETSI EN300 328 V1.8.1

Table 55. BLE Subsystem (continued)

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
RF Transmitter Specifications						
TXP, ACC	RF power accuracy	–	±1	–	dB	
TXP, RANGE	RF power control range	–	30	–	dB	
TXP, 0dBm	Output power, 0-dB Gain setting (PA7)	–	–	-6	dBm	
TXP, MAX	Output power, maximum power setting (PA10)	–	9.5	–	dBm	
TXP, MIN	Output power, minimum power setting (PA1)	–	–18	–	dBm	
F2AVG	Average frequency deviation for 10101010 pattern	185	–	–	kHz	RF-PHY Specification (TRM-LE/CA/05/C)
F1AVG	Average frequency deviation for 11110000 pattern	225	250	275	kHz	RF-PHY Specification (TRM-LE/CA/05/C)
EO	Eye opening = ΔF2AVG/ΔF1AVG	TBD	–	–		RF-PHY Specification (TRM-LE/CA/05/C)
FTX, ACC	Frequency accuracy	–150	–	150	kHz	RF-PHY Specification (TRM-LE/CA/06/C)
FTX, MAXDR	Maximum frequency drift	–50	–	50	kHz	RF-PHY Specification (TRM-LE/CA/06/C)
FTX, INITDR	Initial frequency drift	–20	–	20	kHz	RF-PHY Specification (TRM-LE/CA/06/C)
FTX, DR	Maximum drift rate	–20	–	20	kHz/ 50 µs	RF-PHY Specification (TRM-LE/CA/06/C)
IBSE1	In-band spurious emission at 2-MHz offset	–	–	TBD	dBm	RF-PHY Specification (TRM-LE/CA/03/C)
IBSE2	In-band spurious emission at ≥3-MHz offset	–	–	TBD	dBm	RF-PHY Specification (TRM-LE/CA/03/C)
TXSE1	Transmitter spurious emissions (average), <1.0 GHz	–	–	TBD	dBm	FCC-15.247
TXSE2	Transmitter spurious emissions (average), >1.0 GHz	–	–	TBD	dBm	FCC-15.247
RF Current Specifications						
IRX	Receive current in normal mode	–	18.7	–	mA	Radio only
IRX_RF	Radio receive current in normal mode	–	16.4	–	mA	Radio only
IRX, HIGHGAIN	Receive current in high-gain mode	–	21.5	–	mA	Radio only
ITX, 3dBm	TX current at 3-dBm setting (PA10)	–	20	–	mA	Radio only
ITX, 0dBm	TX current at 0-dBm setting (PA7)	–	16.5	–	mA	Radio only
ITX_RF, 0dBm	Radio TX current at 0 dBm setting (PA7)	–	15.6	–	mA	Radio only
ITX_RF, 0dBm	Radio TX current at 0 dBm excluding Balun loss	–	14.2	–	mA	Guaranteed by design simulation
ITX,-3dBm	TX current at –3-dBm setting (PA4)	–	15.5	–	mA	Radio only
ITX,-6dBm	TX current at –6-dBm setting (PA3)	–	14.5	–	mA	Radio only
ITX,-12dBm	TX current at –12-dBm setting (PA2)	–	13.2	–	mA	Radio only
ITX,-18dBm	TX current at –18-dBm setting (PA1)	–	12.5	–	mA	Radio only

Table 55. BLE Subsystem (continued)

Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
Iavg_1sec, 0dBm	Average current at 1-second BLE connection interval	–	26.3	–	µA	TXP: +9.5 dBm; ±20-ppm master and slave clock accuracy. For empty PDU exchange PA/LNA active
Iavg_4sec, 0dBm	Average current at 4-second BLE connection interval	–	TBD	–	µA	TXP: +9.5 dBm; ±20-ppm master and slave clock accuracy. For empty PDU exchange PA/LNA active
General RF Specifications						
FREQ	RF operating frequency	2400	–	2482	MHz	
CHBW	Channel spacing	–	2	–	MHz	
DR	On-air data rate	–	1000	–	kbps	
IDLE2TX	BLE.IDLE to BLE. TX transition time	–	120	140	µs	
IDLE2RX	BLE.IDLE to BLE. RX transition time	–	75	120	µs	
RSSI Specifications						
RSSI, ACC	RSSI accuracy	–	±5	–	dB	
RSSI, RES	RSSI resolution	–	1	–	dB	
RSSI, PER	RSSI sample period	–	6	–	µs	

Environmental Specifications

Environmental Compliance

This Cypress BLE module is built in compliance with the Restriction of Hazardous Substances (RoHS) and Halogen Free (HF) directives. The Cypress module and components used to produce this module are RoHS and HF compliant.

RF Certification

The CYBLE-224116-01 module is certified under the following RF certification standards:

- FCC ID: WAP4110
- CE
- IC: 7922A-4110
- MIC
- KC

Environmental Conditions

Table 56 describes the operating and storage conditions for the Cypress BLE module.

Table 56. Environmental Conditions for CYBLE-224116-01

Description	Minimum Specification	Maximum Specification
Operating temperature	-40 °C	105 °C
Operating humidity (relative, non-condensation)	5%	85%
Thermal ramp rate	–	3 °C/minute
Storage temperature	–40 °C	105 °C
Storage temperature and humidity	–	105 ° C at 85%
ESD: Module integrated into system Components[6]	–	15 kV Air 2.2 kV Contact

ESD and EMI Protection

Exposed components require special attention to ESD and electromagnetic interference (EMI).

A grounded conductive layer inside the device enclosure is suggested for EMI and ESD performance. Any openings in the enclosure near the module should be surrounded by a grounded conductive layer to provide ESD protection and a low-impedance path to ground.

Device Handling: Proper ESD protocol must be followed in manufacturing to ensure component reliability.

Note
6. This does not apply to the RF pins (ANT, XTALI, and XTALO). RF pins (ANT, XTALI, and XTALO) are tested for 500-V HBM.

Regulatory Information

FCC

FCC NOTICE:

The device CYBLE-224116-01 complies with Part 15 of the FCC Rules. The device meets the requirements for modular transmitter approval as detailed in FCC public Notice DA00-1407. Transmitter Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

CAUTION:

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Cypress Semiconductor may void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates and can radiate radio frequency energy and, if not installed and used in accordance with the instructions,ê may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help

LABELING REQUIREMENTS:

The Original Equipment Manufacturer (OEM) must ensure that FCC labelling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate Cypress Semiconductor FCC identifier for this product as well as the FCC Notice above. The FCC identifier is FCC ID: WAP4110.

In any case the end product must be labeled exterior with "Contains FCC ID: WAP4110"

ANTENNA WARNING:

This device is tested with a standard SMA connector and with the antennas listed in Table 7 on page 15. When integrated in the OEMs product, these fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Any antenna not in the following table must be tested to comply with FCC Section 15.203 for unique antenna connectors and Section 15.247 for emissions.

RF EXPOSURE:

To comply with FCC RF Exposure requirements, the Original Equipment Manufacturer (OEM) must ensure to install the approved antenna in the previous.

The preceding statement must be included as a CAUTION statement in manuals, for products operating with the approved antennas in Table 7 on page 15, to alert users on FCC RF Exposure compliance. Any notification to the end user of installation or removal instructions about the integrated radio module is not allowed.

The radiated output power of CYBLE-224116-01 is far below the FCC radio frequency exposure limits. Nevertheless, use CYBLE-224116-01 in such a manner that minimizes the potential for human contact during normal operation.

End users may not be provided with the module installation instructions. OEM integrators and end users must be provided with transmitter operating conditions for satisfying RF exposure compliance.

Industry Canada (IC) Certification

CYBLE-224116-01 is licensed to meet the regulatory requirements of Industry Canada (IC),

License: IC: 7922A-4110

Manufacturers of mobile, fixed or portable devices incorporating this module are advised to clarify any regulatory questions and ensure compliance for SAR and/or RF exposure limits. Users can obtain Canadian information on RF exposure and compliance from www.ic.gc.ca.

This device has been designed to operate with the antennas listed in Table 7 on page 15, having a maximum gain of 0.5 dBi. Antennas not included in this list or having a gain greater than 0.5 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

IC NOTICE:

The device CYBLE-224116-01 complies with Canada RSS-GEN Rules. The device meets the requirements for modular transmitter approval as detailed in RSS-GEN. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

IC RADIATION EXPOSURE STATEMENT FOR CANADA

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

LABELING REQUIREMENTS:

The Original Equipment Manufacturer (OEM) must ensure that IC labelling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate Cypress Semiconductor IC identifier for this product as well as the IC Notice above. The IC identifier is 7922A-4110. In any case, the end product must be labeled in its exterior with "Contains IC: 7922A-4110".

European R&TTE Declaration of Conformity

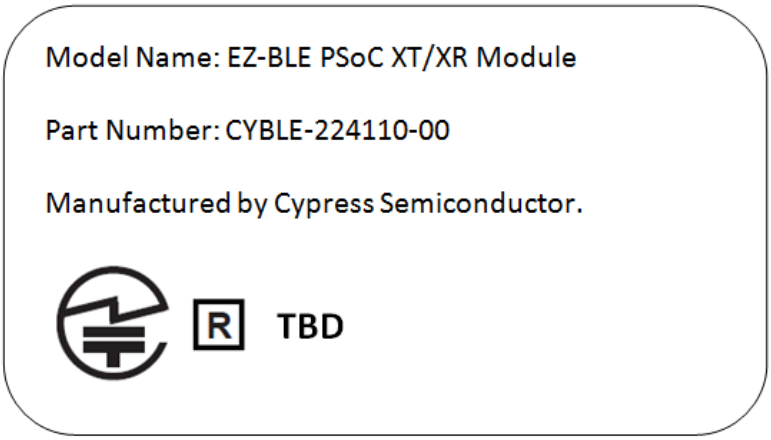
Hereby, Cypress Semiconductor declares that the Bluetooth module CYBLE-224116-01 complies with the essential requirements and other relevant provisions of Directive 1999/5/EC. As a result of the conformity assessment procedure described in Annex III of the Directive 1999/5/EC, the end-customer equipment should be labeled as follows:

All versions of the CYBLE-224116-01 in the specified reference design can be used in the following countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, The Netherlands, the United Kingdom, Switzerland, and Norway.

MIC Japan

CYBLE-224116-01 is certified as a module with type certification number **TBD**. End products that integrate CYBLE-224116-01 do not need additional MIC Japan certification for the end product.

End product can display the certification label of the embedded module.



KC Korea

CYBLE-224116-01 is certified for use in Korea with certificate number **TBD**.

한국 인증 세부정보:

해당 무선설비는 전파혼신 가능성이 있으므로 인명안전과 관련된 서비스는 할 수 없습니다.

Packaging

Table 57. Solder Reflow Peak Temperature

Module Part Number	Package	Maximum Peak Temperature	Maximum Time at PeakTemperature	No. of Cycles
CYBLE-224116-01	32-pad SMT	260 °C	30 seconds	2

Table 58. Package Moisture Sensitivity Level (MSL), IPC/JEDEC J-STD-2

Module Part Number	Package	MSL
CYBLE-224116-01	32-pad SMT	MSL 3

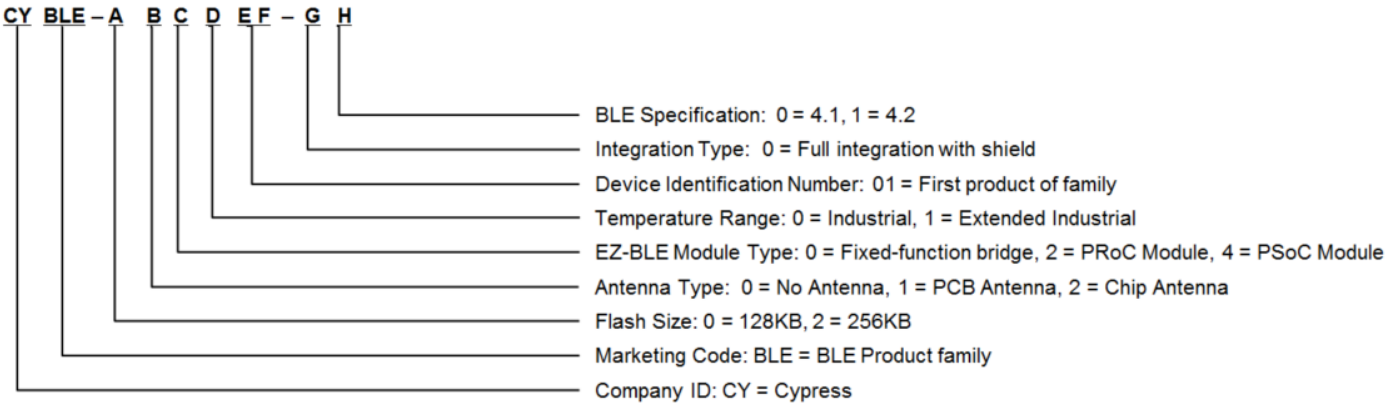
Ordering Information

The CYBLE-224116-01 part number and features are listed in the following table.

MPN	Features																Package
	Max CPU Speed (MHz)	Flash (KB)	SRAM (KB)	Power Amplier (PA)	Low Noise Amplifier (LNA)	UDB	Opamp (CTBm)	CapSense	Direct LCD Drive	12-bit SAR ADC	LP Comparators	TCPWM Blocks	SCB Blocks	PWMs (using UDBs)	I2S (using UDB)	GPIO	
CYBLE-224116-01	48	256	32	✓	✓	4	4	✓	✓	1 Msps	1	4	2	4	✓	25	32-SMT

Part Numbering Convention

The part numbers are of the form CYBLE-ABCDEF-GH where the fields are defined as follows.



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Acronyms

Table 59. Acronyms Used in this Document

Acronym	Description
ABUS	analog local bus
ADC	analog-to-digital converter
AG	analog global
AHB	AMBA (advanced microcontroller bus architecture) high-performance bus, an ARM data transfer bus
ALU	arithmetic logic unit
AMUXBUS	analog multiplexer bus
API	application programming interface
APSR	application program status register
ARM®	advanced RISC machine, a CPU architecture
ATM	automatic thump mode
BLE	Bluetooth Low Energy
Bluetooth SIG	Bluetooth Special Interest Group
BW	bandwidth
CAN	Controller Area Network, a communications protocol
CE	European Conformity
CSA	Canadian Standards Association
CMRR	common-mode rejection ratio
CPU	central processing unit
CRC	cyclic redundancy check, an error-checking protocol
DAC	digital-to-analog converter, see also IDAC, VDAC
DFB	digital filter block
DIO	digital input/output, GPIO with only digital capabilities, no analog. See GPIO.
DMIPS	Dhrystone million instructions per second
DMA	direct memory access, see also TD
DNL	differential nonlinearity, see also INL
DNU	do not use
DR	port write data registers
DSI	digital system interconnect
DWT	data watchpoint and trace
ECC	error correcting code
ECO	external crystal oscillator
EEPROM	electrically erasable programmable read-only memory
EMI	electromagnetic interference

Table 59. Acronyms Used in this Document (continued)

Acronym	Description
EMIF	external memory interface
EOC	end of conversion
EOF	end of frame
EPSR	execution program status register
ESD	electrostatic discharge
ETM	embedded trace macrocell
FCC	Federal Communications Commission
FET	field-effect transistor
FIR	finite impulse response, see also IIR
FPB	flash patch and breakpoint
FS	full-speed
GPIO	general-purpose input/output, applies to a PSoC pin
HCI	host controller interface
HVI	high-voltage interrupt, see also LVI, LVD
IC	integrated circuit
IDAC	current DAC, see also DAC, VDAC
IDE	integrated development environment
I^2C, or IIC	Inter-Integrated Circuit, a communications protocol
IC	Industry Canada
IIR	infinite impulse response, see also FIR
ILO	internal low-speed oscillator, see also IMO
IMO	internal main oscillator, see also ILO
INL	integral nonlinearity, see also DNL
I/O	input/output, see also GPIO, DIO, SIO, USBIO
IPOR	initial power-on reset
IPSR	interrupt program status register
IRQ	interrupt request
ITM	instrumentation trace macrocell
KC	Korea Certification
LCD	liquid crystal display
LIN	Local Interconnect Network, a communications protocol.
LNA	low noise amplifier
LR	link register
LUT	lookup table
LVD	low-voltage detect, see also LVI
LVI	low-voltage interrupt, see also HVI

Table 59. Acronyms Used in this Document (continued)

Acronym	Description
LVTTL	low-voltage transistor-transistor logic
MAC	multiply-accumulate
MCU	microcontroller unit
MIC	Ministry of Internal Affairs and Communications (Japan)
MISO	master-in slave-out
NC	no connect
NMI	nonmaskable interrupt
NRZ	non-return-to-zero
NVIC	nested vectored interrupt controller
NVL	nonvolatile latch, see also WOL
Opamp	operational amplifier
PA	power amplifier
PAL	programmable array logic, see also PLD
PC	program counter
PCB	printed circuit board
PGA	programmable gain amplifier
PHUB	peripheral hub
PHY	physical layer
PICU	port interrupt control unit
PLA	programmable logic array
PLD	programmable logic device, see also PAL
PLL	phase-locked loop
PMDD	package material declaration data sheet
POR	power-on reset
PRES	precise power-on reset
PRS	pseudo random sequence
PS	port read data register
PSoC®	Programmable System-on-Chip™
PSRR	power supply rejection ratio
PWM	pulse-width modulator
QDID	qualification design ID
RAM	random-access memory
RISC	reduced-instruction-set computing
RMS	root-mean-square
RTC	real-time clock
RTL	register transfer language
RTR	remote transmission request
RX	receive
SAR	successive approximation register

Table 59. Acronyms Used in this Document (continued)

Acronym	Description
SC/CT	switched capacitor/continuous time
SCL	I^2C serial clock
SDA	I^2C serial data
S/H	sample and hold
SINAD	signal to noise and distortion ratio
SIO	special input/output, GPIO with advanced features. See GPIO.
SMT	surface-mount technology; a method for producing electronic circuitry in which the components are placed directly onto the surface of PCBs
SOC	start of conversion
SOF	start of frame
SPI	Serial Peripheral Interface, a communications protocol
SR	slew rate
SRAM	static random access memory
SRES	software reset
STN	super twisted nematic
SWD	serial wire debug, a test protocol
SWV	single-wire viewer
TD	transaction descriptor, see also DMA
THD	total harmonic distortion
TIA	transimpedance amplifier
TN	twisted nematic
TRM	technical reference manual
TTL	transistor-transistor logic
TUV	Germany: Technischer Überwachungs-Verein (Technical Inspection Association)
TX	transmit
UART	Universal Asynchronous Transmitter Receiver, a communications protocol
UDB	universal digital block
USB	Universal Serial Bus
USBIO	USB input/output, PSoC pins used to connect to a USB port
VDAC	voltage DAC, see also DAC, IDAC
WDT	watchdog timer
WOL	write once latch, see also NVL
WRES	watchdog timer reset
XRES	external reset I/O pin
XTAL	crystal

Document Conventions

Units of Measure

Table 60. Units of Measure

Symbol	Unit of Measure
°C	degrees Celsius
dB	decibel
dBm	decibel-milliwatts
fF	femtofarads
Hz	hertz
KB	1024 bytes
kbps	kilobits per second
Khr	kilohour
kHz	kilohertz
kΩ	kilo ohm
ksps	kilosamples per second
LSB	least significant bit
Mbps	megabits per second
MHz	megahertz
MΩ	mega-ohm
Msps	megasamples per second
µA	microampere
µF	microfarad
µH	microhenry
µs	microsecond
µV	microvolt
µW	microwatt
mA	milliampere
ms	millisecond
mV	millivolt
nA	nanoampere
ns	nanosecond
nV	nanovolt
Ω	ohm
pF	picofarad
ppm	parts per million
ps	picosecond
s	second
sps	samples per second
sqrtHz	square root of hertz
V	volt

Document History Page

Document Title: CYBLE-224116-01 EZ-BLE™ PSoC® XT/XR Module Document Number: 002-12524				
Revision	**ECN**	**Orig. of Change**	**Submission Date**	**Description of Change**
PRELIM-INARY	PRELIM-INARY	DSO	05/16/2016	Preliminary datasheet for CYBLE-224116-01 module.

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