

# Single-Chip Bluetooth Transceiver for Wireless Input Devices

The Cypress CYW20735B1 is a Bluetooth 5.0-compliant, SoC for IoT applications. Manufactured using the industry's advanced 40 nm CMOS low-power process, the CYW20735B1 employs high levels of integration to minimize external components, reducing the device footprint and the costs associated with implementing Bluetooth solutions.

The CYW20735B1 is the optimal solution for applications in wireless input devices including game controllers, remote controls, keyboards, and joysticks or any Bluetooth connected IoT application that needs 12 dBm transmit power such as lighting.

## Features

### Bluetooth Subsystem

- Complies with Bluetooth core specification version 5.0 with LE 2-Mbps support
- Supports Basic Rate (BR) and Bluetooth Low Energy (BLE)
- Supports Adaptive Frequency Hopping (AFH)
- Programmable TX power up to 12 dBm
- Rx sensitivity -94.5 dBm (BLE)
- Ultra-low-power radio
  - RX current 8 mA
  - TX current 18 mA @ 12 dBm

### Coexistence Support

- Support for Global Coexistence Interface for easy coexistence implementation with select Cypress Wi-Fi devices

### MCU Subsystem

- 96-MHz ARM Cortex-M4 microcontroller unit MCU with floating point unit (FPU)
- Supports serial wire debug (SWD)
- Runs Bluetooth stack and application

### Memory Subsystem

- 384 KB RAM
- 2 MB ROM that stores Bluetooth stack and drives and offloads flash for user applications

### Audio features and interfaces

- 1x I2S with master and slave modes
- 1x PCM
- PDM
- Analog front end for analog microphone

### Clocks

- On-chip 32 kHz oscillator
- On-chip 128 kHz oscillator
- 32 kHz crystal oscillator
- 24 MHz crystal oscillator

- 32-bit real time clock (RTC)

### Peripherals and communication

- 1x MIPI DMI-C interface
- 6x 16-bit PWMs
- Programmable key-scan matrix interface, up to 8x20 key-scanning matrix
- Quadrature decoder
- Watchdog timer
- 1x peripheral UART, 1x UART for programming and HCI
- 1x SPI (master or slave mode)
- 1x I2C master
- One ADC (10-ENoB for DC measurement and 12-ENoB for Audio measurement)
- Hardware security engine

### General Purpose Input Output (GPIO)

- 24 general purpose I/Os
- 2 dedicated pins for analog microphone
- Support 1.7 V to 3.63 V operation
- Four GPIOs support 16 mA and 8 mA source at 3.3 V and 1.8 V respectively

### Operating voltage and low-power support

- Wide operating voltage range - 1.625 V to 3.63V
- 4 power modes to implement ultra-low power application - managed by real time operating system
- 1 uA current in HID-Off mode

### Packages

- 7 mm x7 mm 60-pin quad flat no-lead (QFN)

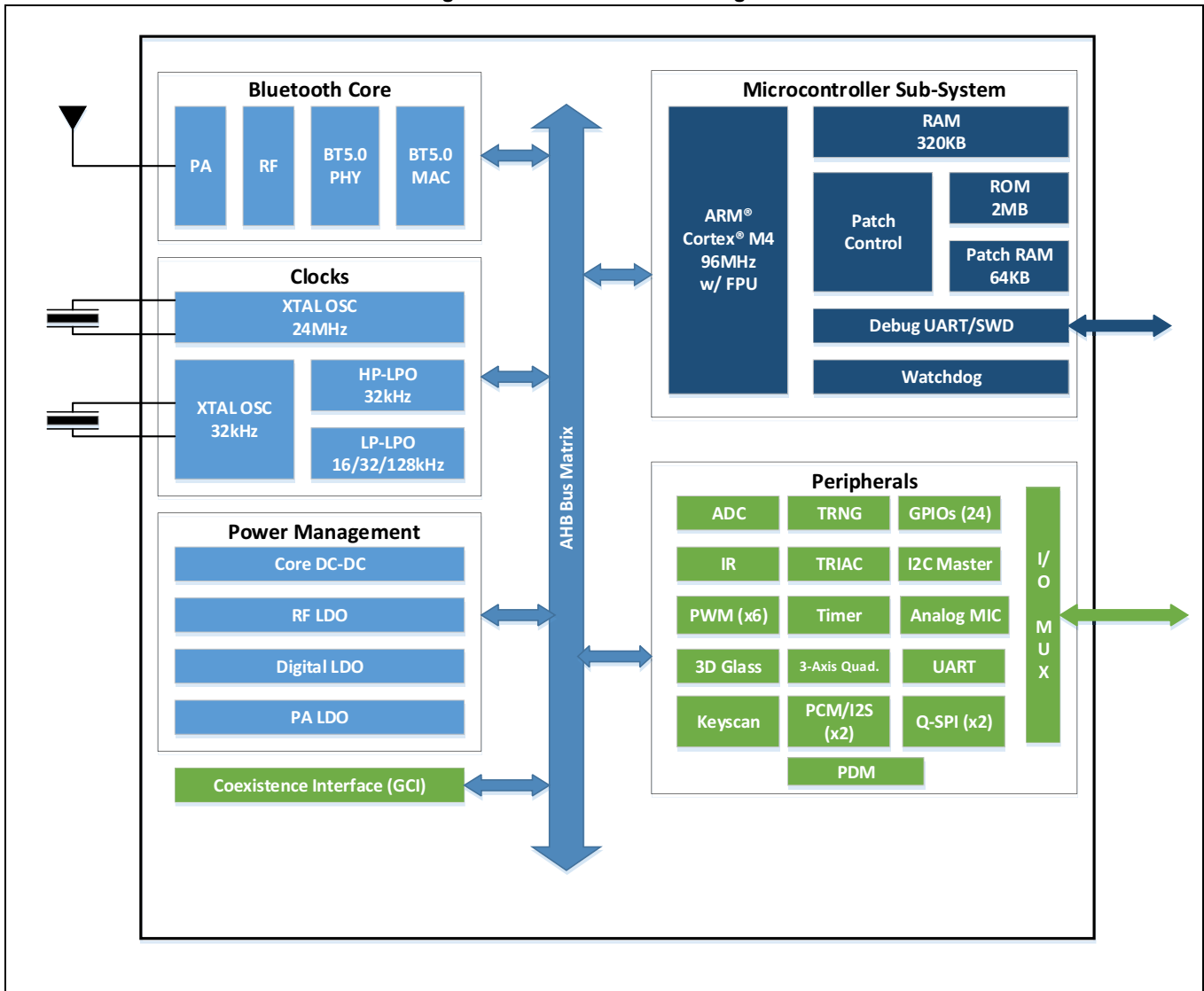
### Software Support

- WICED Studio

### Applications

- Game controllers
- Wireless pointing devices (mice)
- Remote controls
- Wireless keyboards
- Joysticks
- Home automation
- Point-of-sale input devices
- 3D glasses
- Blood pressure monitors
- Find-me devices
- Heart-rate monitors
- Proximity sensors
- Thermometers

Figure 1. Functional Block Diagram



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## 1. Bluetooth Baseband Core

The Bluetooth Baseband Core (BBC) implements all of the time-critical functions required for high-performance Bluetooth operation. The BBC manages the buffering, segmentation, and routing of data for all connections. It also buffers data that passes through it, handles data flow control, schedules ACL and TX/RX transactions, monitors Bluetooth slot usage, optimally segments and packages data into baseband packets, manages connection status indicators, and composes and decodes HCI packets. In addition to these functions, it independently handles HCI event types, and HCI command types.

**Table 1. Bluetooth Features**

| Bluetooth 1.0              | Bluetooth 1.2                | Bluetooth 2.0        |
|----------------------------|------------------------------|----------------------|
| Basic Rate                 | Interlaced Scans             | –                    |
| –                          | Adaptive Frequency Hopping   | –                    |
| Paging and Inquiry         | –                            | –                    |
| Page and Inquiry Scan      | –                            | –                    |
| Sniff                      | –                            | –                    |
| Bluetooth 2.1              | Bluetooth 3.0                | Bluetooth 4.0        |
| Secure Simple Pairing      | Unicast Connectionless Data  | Bluetooth Low Energy |
| Enhanced Inquiry Response  | Enhanced Power Control       | –                    |
| Sniff Subrating            | –                            | –                    |
| Bluetooth 4.1              | Bluetooth 4.2                |                      |
| Low Duty Cycle Advertising | Data Packet Length Extension |                      |
| Dual Mode                  | LE Secure Connection         |                      |
| LE Link Layer Topology     | Link Layer Privacy           |                      |

### 1.1 Link Control Layer

The link control layer is part of the Bluetooth link control functions that are implemented in dedicated logic in the link control unit (LCU). This layer consists of the command controller that takes commands from the software, and other controllers that are activated or configured by the command controller, to perform the link control tasks. Each task is performed in a different state or substate in the Bluetooth Link Controller.

- BLE states:
  - Advertising
  - Scanning
  - Connection
- Major states:
  - Standby
  - Connection
- Substates:
  - Page
  - Page Scan
  - Inquiry
  - Inquiry Scan
  - Sniff

## 1.2 Test Mode Support

The CYW20735B1 fully supports Bluetooth Test mode as described in Part I:1 of the Specification of the Bluetooth System Version 3.0. This includes the transmitter tests, normal and delayed loopback tests, and reduced hopping sequence.

In addition to the standard Bluetooth Test Mode, the CYW20735B1 also supports enhanced testing features to simplify RF debugging and qualification and type-approval testing. These features include:

- Fixed frequency carrier wave (unmodulated) transmission
  - Simplifies some type-approval measurements (Japan)
  - Aids in transmitter performance analysis
- Fixed frequency constant receiver mode
  - Receiver output directed to I/O pin
  - Allows for direct BER measurements using standard RF test equipment
  - Facilitates spurious emissions testing for receive mode
- Fixed frequency constant transmission
  - 8-bit fixed pattern or PRBS-9
  - Enables modulated signal measurements with standard RF test equipment

## 1.3 Frequency Hopping Generator

The frequency hopping sequence generator selects the correct hopping channel number based on the link controller state, Bluetooth clock, and device address.

## 1.4 Microprocessor Unit

The CYW20735B1 microprocessor unit runs software from the link control (LC) layer up to the host controller interface (HCI). The microprocessor is a Cortex-M4 32-bit RISC processor with embedded ICE-RT debug and serial wire debug (SWD) interface units. The microprocessor also includes 2 MB of ROM memory for program storage and 384 KB of RAM for data scratch-pad.

The internal ROM provides flexibility during power-on reset to enable the same device to be used in various configurations. At power-up, the lower-layer protocol stack is executed from internal ROM.

External patches can be applied to the ROM-based firmware to provide flexibility for bug fixes and feature additions. The device also supports the integration of user applications and profiles.

### 1.4.1 Floating Point Unit

CYW20735B1 includes the CM4 single precision IEEE-754 compliant floating point unit. For details see the Cortex-M4 manual.

### 1.4.2 OTP Memory

The CYW20735B1 includes 2 KB of one-time programmable memory that can be used by the factory to store product-specific information.

**Note:** Use of OTP requires that a 3V supply be present at all times.

### 1.4.3 NVRAM Configuration Data and Storage

NVRAM contains configuration information about the customer application, including the following:

- Fractional-N information
- BD\_ADDR
- UART baud rate
- SDP service record
- File system information used for code, code patches, or data. The CYW20735B1 uses SPI flash for NVRAM storage.

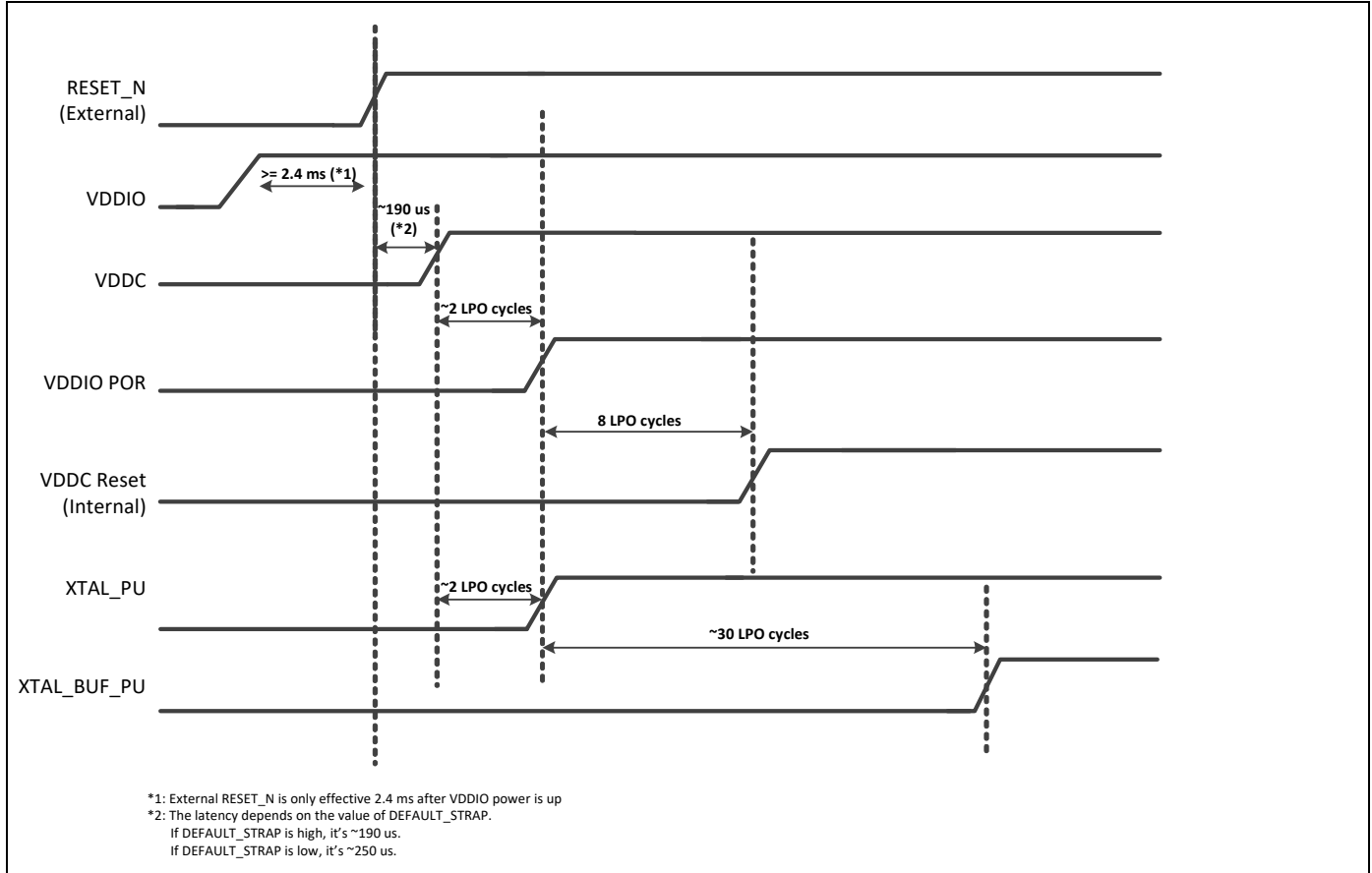
### 1.4.4 Power-On Reset

The CYW20735B1 includes POR logic to allow the part to initialize correctly when power is applied. [Figure 2](#) shows the sequence used by the CYW20735B1 during initialization. An small external cap may be used on RESET\_N to add delay as VDDIO ramps up.

### 1.4.5 External Reset

An external active-low reset signal, RESET\_N, can be used to put the CYW20735B1 in the reset state.

**Figure 2. Power-On Reset Timing**



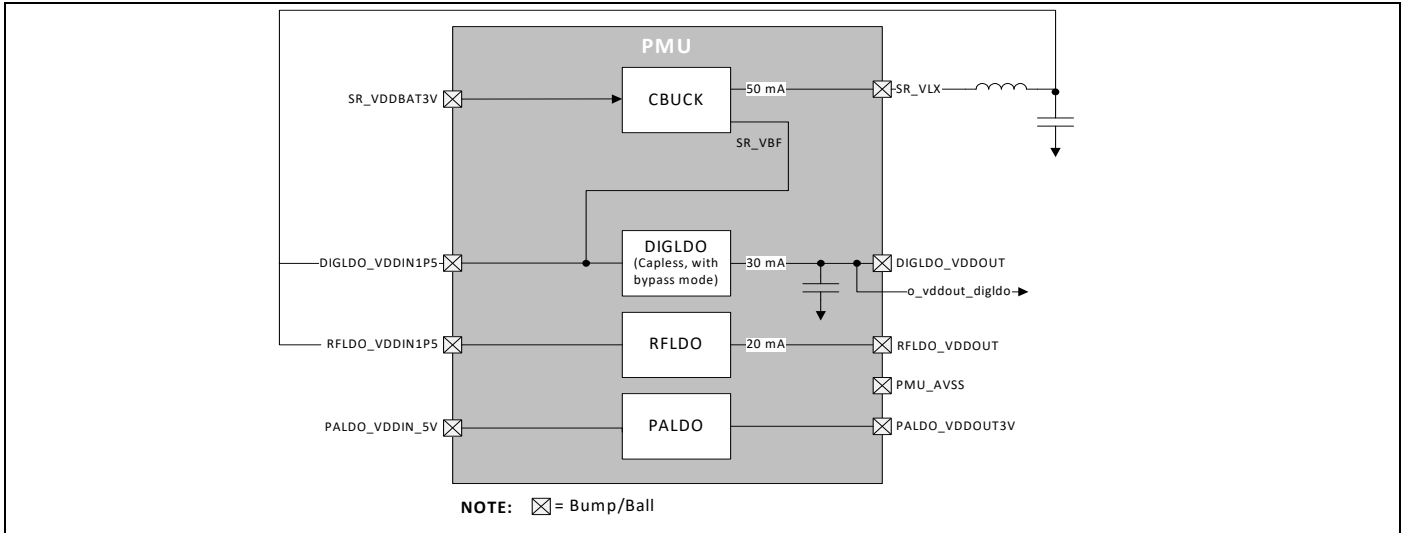
### 1.4.6 Brownout Detection

An external voltage detector reset IC may be used if brownout detection is required. The reset IC should release RESET\_N only after the VDDO supply voltage level has been at or above a minimum operating voltage for 50 ms or longer.

### 1.5 Power Management Unit

Figure 3 shows the CYW20735B1 power management unit (PMU) block diagram. The CYW20735B1 includes an integrated buck regulator, a capless LDO, PALDO and an additional 1.2V LDO for RF.

**Figure 3. Power Management Unit**





## 1.6 Integrated Radio Transceiver

The CYW20735B1 has an integrated radio transceiver that has been optimized for use in 2.4 GHz Bluetooth wireless systems. It has been designed to provide low-power, low-cost, robust communications for applications operating in the globally available 2.4 GHz unlicensed ISM band. The CYW20735B1 is fully compliant with the Bluetooth Radio Specification and meets or exceeds the requirements to provide the highest communication link quality of service.

### 1.6.1 Transmit Path

The CYW20735B1 features a fully integrated transmitter. The baseband transmit data is GFSK modulated in the 2.4 GHz ISM band.

### 1.6.2 Digital Modulator

The digital modulator performs the data modulation and filtering required for the GFSK signal. The fully digital modulator minimizes any frequency drift or anomalies in the modulation characteristics of the transmitted signal.

### 1.6.3 Power Amplifier

The CYW20735B1 has an integrated power amplifier (PA) that can transmit up to +10 dBm for class 1 operations.

### 1.6.4 Receiver Path

The receiver path uses a low-IF scheme to downconvert the received signal for demodulation in the digital demodulator and bit synchronizer. The receiver path provides a high degree of linearity, an extended dynamic range to ensure reliable operation in the noisy 2.4 GHz ISM band. The front-end topology, with built-in out-of-band attenuation, enables the CYW20735B1 to be used in most applications with minimal off-chip filtering.

### 1.6.5 Digital Demodulator and Bit Synchronizer

The digital demodulator and bit synchronizer takes the low-IF received signal and performs an optimal frequency tracking and bit-synchronization algorithm.

### 1.6.6 Receiver Signal Strength Indicator

The radio portion of the CYW20735B1 provides a receiver signal strength indicator (RSSI) signal to the baseband, so that the controller can take part in a Bluetooth power-controlled link by providing a metric of its own receiver signal strength to determine whether the transmitter should increase or decrease its output power.

### 1.6.7 Local Oscillator

A local oscillator (LO) generation provides fast frequency hopping (1600 hops/second) across the 79 maximum available channels. The CYW20735B1 uses an internal loop filter.

### 1.6.8 Calibration

The CYW20735B1 radio transceiver features a self-contained automated calibration scheme. No user interaction is required during normal operation or during manufacturing to provide optimal performance. Calibration compensates for filter, matching network, and amplifier gain and phase characteristics to yield radio performance within 2% of what is optimal. Calibration takes process and temperature variations into account, and it occurs transparently during normal operation and hop setting times.

## 1.7 Peripheral Transport Unit

### 1.7.1 I<sup>2</sup>C Compatible Master

The CYW20735B1 provides a 2-pin master I<sup>2</sup>C to communicate with peripherals such as trackball or touch-pad modules, and motion tracking ICs used in mouse devices. The BSC interface is compatible with I<sup>2</sup>C slave devices. I<sup>2</sup>C does not support multimaster capability or flexible wait-state insertion by either master or slave devices.

The following transfer clock rates are supported by I<sup>2</sup>C:

- 100 kHz
- 400 kHz
- 800 kHz (Not a standard I<sup>2</sup>C-compatible speed.)
- 1 MHz (Compatibility with high-speed I<sup>2</sup>C-compatible devices is not guaranteed.)

The following transfer types are supported by BSC:

- Read (Up to 8 bytes can be read.)
- Write (Up to 8 bytes can be written.)
- Read-then-Write (Up to 8 bytes can be read and up to 8 bytes can be written.)
- Write-then-Read (Up to 8 bytes can be written and up to 8 bytes can be read.)

Hardware controls the transfers, requiring minimal firmware setup and supervision.

The clock pin (SCL) and data pin (SDA) are both open-drain I/O pins. Pull-up resistors external to the CYW20735B1 are required on both the SCL and SDA pins for proper operation.

### 1.7.2 HCI UART Interface

The CYW20735B1 includes a UART interface for factory programming and when operating as a BT HCI device in a system with an external host. The UART physical interface is a standard, 4-wire interface (RX, TX, RTS, and CTS) with adjustable baud rates from 57600 bps to 6 Mbps. During initial boot, UART speeds may be limited to 750 kbps. The baud rate may be selected via a vendor-specific UART HCI command. The CYW20735B1 has a 1040-byte receive FIFO and a 1040-byte transmit FIFO to support enhanced data rates. The interface supports the Bluetooth UART HCI (H4) specification. The default baud rate for H4 is 115.2 kbaud.

The UART clock default setting is 24 MHz, and can be configured to run as high as 48 MHz to support up to 6 Mbps. The baud rate of the CYW20735B1 UART is controlled by two values. The first is a UART clock divisor (set in the DLBR register) that divides the UART clock by an integer multiple of 16. The second is a baud rate adjustment (set in the DHBR register) that is used to specify a number of UART clock cycles to stuff in the first or second half of each bit time. Up to eight UART cycles can be inserted into the first half of each bit time, and up to eight UART clock cycles can be inserted into the end of each bit time.

Table 2 on page 10 contains example values to generate common baud rates with a 24 MHz UART clock.

**Table 2. Common Baud Rate Examples, 24 MHz Clock**

| Baud Rate (bps) | Baud Rate Adjustment |            | Mode      | Error (%) |
|-----------------|----------------------|------------|-----------|-----------|
|                 | High Nibble          | Low Nibble |           |           |
| 3M              | 0xFF                 | 0xF8       | High rate | 0.00      |
| 2M              | 0xFF                 | 0xF4       | High rate | 0.00      |
| 1M              | 0X44                 | 0XFF       | Normal    | 0.00      |
| 921600          | 0x05                 | 0x05       | Normal    | 0.16      |
| 460800          | 0x02                 | 0x02       | Normal    | 0.16      |
| 230400          | 0x04                 | 0x04       | Normal    | 0.16      |
| 115200          | 0x00                 | 0x00       | Normal    | 0.16      |
| 57600           | 0x00                 | 0x00       | Normal    | 0.16      |

Table 3 contains example values to generate common baud rates with a 48 MHz UART clock.

**Table 3. Common Baud Rate Examples, 48 MHz Clock**

| Baud Rate (bps) | High Rate | Low Rate | Mode      | Error (%) |
|-----------------|-----------|----------|-----------|-----------|
| 6M              | 0xFF      | 0xF8     | High rate | 0         |
| 4M              | 0xFF      | 0xF4     | High rate | 0         |
| 3M              | 0x0       | 0xFF     | Normal    | 0         |
| 2M              | 0x44      | 0xFF     | Normal    | 0         |
| 1.5M            | 0x0       | 0xFE     | Normal    | 0         |
| 1M              | 0x0       | 0xFD     | Normal    | 0         |
| 921600          | 0x22      | 0xFD     | Normal    | 0.16      |
| 230400          | 0x0       | 0xF3     | Normal    | 0.16      |
| 115200          | 0x1       | 0xE6     | Normal    | -0.08     |
| 57600           | 0x1       | 0xCC     | Normal    | 0.04      |

Support for changing the baud rate during normal HCI UART operation is included through a vendor-specific command that allows the host to adjust the contents of the baud rate registers.

The CYW20735B1 UART operates correctly with the host UART as long as the combined baud rate error of the two devices is within  $\pm 5\%$ .

### 1.8 Peripheral UART Interface

The CYW20735B1 has a second UART that may be used to interface to peripherals. This peripheral UART is accessed through the optional I/O ports, which can be configured individually and separately for each functional pin. The CYW20735B1 can map the peripheral UART to any LHL GPIO. The peripheral UART clock is fixed at 24 MHz. Both TX and RX have a 256-byte FIFO (see [Table 2: “Common Baud Rate Examples, 24 MHz Clock,” on page 11](#)).

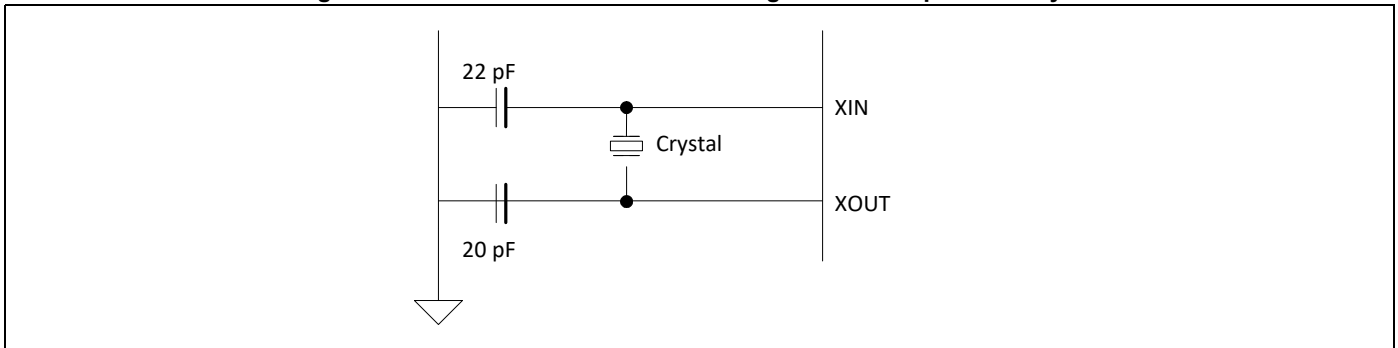
## 1.9 Clock Frequencies

The CYW20735B1 uses a 24 MHz crystal oscillator (XTAL).

### 1.9.1 Crystal Oscillator

The XTAL must have an accuracy of  $\pm 20$  ppm as defined by the Bluetooth specification. Two external load capacitors in the range of 5 pF to 30 pF are required to work with the crystal oscillator. The selection of the load capacitors is XTAL-dependent (see [Figure 4](#)).

**Figure 4. Recommended Oscillator Configuration—12 pF Load Crystal**



[Table 4](#) shows the recommended crystal specifications.

**Table 4. Reference Crystal Electrical Specifications**

| Parameter                     | Conditions    | Minimum     | Typical  | Maximum  | Unit     |
|-------------------------------|---------------|-------------|----------|----------|----------|
| Nominal frequency             | –             | 20          | 24       | 40       | MHz      |
| Oscillation mode              | –             | Fundamental |          |          | –        |
| Frequency tolerance           | @25°C         | –           | $\pm 10$ | –        | ppm      |
| Tolerance stability over temp | @0°C to +70°C | –           | $\pm 10$ | –        | ppm      |
| Equivalent series resistance  | –             | –           | –        | 60       | $\Omega$ |
| Load capacitance              | –             | –           | 12       | –        | pF       |
| Operating temperature range   | –             | 0           | –        | +70      | °C       |
| Storage temperature range     | –             | –40         | –        | +125     | °C       |
| Drive level                   | –             | –           | –        | 200      | $\mu W$  |
| Aging                         | –             | –           | $\pm 3$  | $\pm 10$ | ppm/year |
| Shunt capacitance             | –             | –           | –        | 2        | pF       |

### 1.9.2 HID Peripheral Block

The peripheral blocks of the CYW20735B1 all run from a single 128 kHz low-power RC oscillator. The oscillator can be turned on at the request of any of the peripherals. If the peripheral is not enabled, it shall not assert its clock request line.

The keyboard scanner is a special case, in that it may drop its clock request line even when enabled, and then reassert the clock request line if a keypress is detected.

1.9.3 32 kHz Crystal Oscillator

Figure 5 shows the 32 kHz XTAL oscillator with external components and Table on page 13 lists the oscillator’s characteristics. It is a standard Pierce oscillator using a comparator with hysteresis on the output to create a single-ended digital output. The hysteresis was added to eliminate any chatter when the input is around the threshold of the comparator and is ~100 mV. This circuit can be operated with a 32 kHz or 32.768 kHz crystal oscillator or be driven with a clock input at a similar frequency. The default component values are: R1 = 10 MΩ and C1 = C2 = ~10 pF. The values of C1 and C2 are used to fine-tune the oscillator.

Figure 5. 32 kHz Oscillator Block Diagram

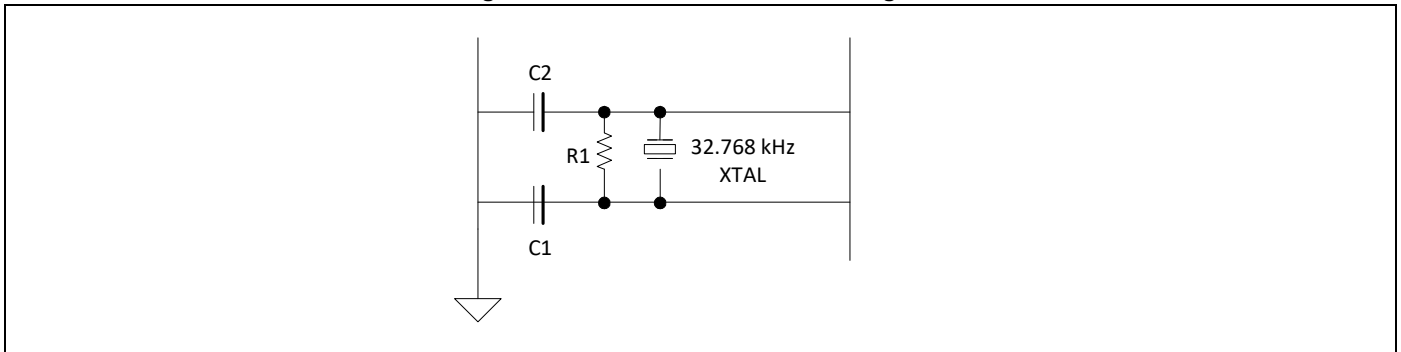


Table 5. XTAL Oscillator Characteristics

| Parameter              | Symbol        | Conditions            | Minimum | Typical | Maximum | Unit |
|------------------------|---------------|-----------------------|---------|---------|---------|------|
| Output frequency       | $F_{oscout}$  | –                     | –       | 32.768  | –       | kHz  |
| Frequency tolerance    | –             | Crystal-dependent     | –       | 100     | –       | ppm  |
| Start-up time          | $T_{startup}$ | –                     | –       | –       | 500     | ms   |
| XTAL drive level       | $P_{drv}$     | For crystal selection | 0.5     | –       | –       | μW   |
| XTAL series resistance | $R_{series}$  | For crystal selection | –       | –       | 70      | kΩ   |
| XTAL shunt capacitance | $C_{shunt}$   | For crystal selection | –       | –       | 1.3     | pF   |

1.10 GPIO Ports

GPIO ports for this device is shown in Table 7 on page 21.

The CYW20735B1 uses 40 general-purpose I/Os (GPIOs). All GPIOs support programmable pull-ups and are capable of driving up to 8 mA at 3.3V or 4 mA at 1.8V, except P26, P27, P28, and P29, which are capable of driving up to 16 mA at 3.3V or 8 mA at 1.8V.

**P0, P1, P8-P18, P21-23, P28-P38:** all of these pins can be programmed as ADC inputs.

**Port 26–Port 29:** all four of these pins are capable of sinking up to 16 mA for LEDs. These pins also have the PWM function, which can be used for LED dimming.

## 1.11 Keyboard Scanner

The keyboard scanner is designed to autonomously sample keys and store them into buffer registers without the need for the host microcontroller to intervene. The scanner has the following features:

- Ability to turn off its clock if no keys are pressed.
- Sequential scanning of up to 160 keys in an 8 × 20 matrix.
- Programmable number of columns from 1 to 20.
- Programmable number of rows from 1 to 8.
- 16-byte key code buffer (can be augmented by firmware).
- 128 kHz clock that allows scanning of full 160-key matrix in about 1.2 ms.
- N-key rollover with selective 2-key lockout if ghost is detected.
- Keys are buffered until host microcontroller has a chance to read it, or until overflow occurs.
- Hardware debouncing and noise/glitch filtering.
- Low-power consumption. Single-digit  $\mu$ A-level sleep current.

### 1.11.1 Theory of Operation

The key scan block is controlled by a state machine with the following states:

#### 1.11.2 Idle

The state machine begins in the idle state. In this state, all column outputs are driven high. If any key is pressed, a transition occurs on one of the row inputs. This transition causes the 128 kHz clock to be enabled (if it is not already enabled by another peripheral) and the state machine to enter the scan state. Also in this state, an 8-bit row-hit register and an 8-bit key-index counter is reset to 0.

#### 1.11.3 Scan

In the scan state, a row counter counts from 0 up to a programmable number of rows minus 1. After the last row is reached, the row counter is reset and the column counter is incremented. This cycle repeats until the row and column counters are both at their respective terminal count values. At that point, the state machine moves into the Scan-End state.

As the keys are being scanned, the key-index counter is incremented. This counter value is compared to the modifier key codes stored in RAM, or in the key code buffer if the key is not a modifier key. It can be used by the microprocessor as an index into a lookup table of usage codes.

Also, as the  $n$ th row is scanned, the row-hit register is ORed with the current 8-bit row input values if the current column contains two or more row hits. During the scan of any column, if a key is detected at the current row, and the row-hit register indicates that a hit was detected in that same row on a previous column, then a ghost condition may have occurred, and a bit in the status register is set to indicate this.

#### 1.11.4 Scan End

This state determines whether any keys were detected while in the scan state. If yes, the state machine returns to the scan state. If no, the state machine returns to the idle state, and the 128 kHz clock request signal is made inactive.

**Note:** The microcontroller can poll the key status register.

## 1.12 Mouse Quadrature Signal Decoder

The mouse signal decoder is designed to autonomously sample two quadrature signals commonly generated by an optomechanical mouse. The decoder has the following features:

- Three pairs of inputs for X, Y, and Z (typical scroll wheel) axis signals. Each axis has two options:
  - For the X axis, choose P2 or P32 as X0 and P3 or P33 as X1.
  - For the Y axis, choose P4 or P34 as Y0 and P5 or P35 as Y1.
  - For the Z axis, choose P6 or P36 as Z0 and P7 or P37 as Z1.
- Control of up to four external high-current GPIOs to power external optoelectronics:
  - Turn-on and turn-off time can be staggered for each HC-GPIO to avoid simultaneous switching of high currents and having multiple high-current devices on at the same time.
  - Sample time can be staggered for each axis.
  - Sense of the control signal can be active high or active low.
  - Control signal can be tristated for off condition or driven high or low, as appropriate.

### 1.12.1 Theory of Operation

The mouse decoder block has four 10-bit PWMs for controlling external quadrature devices and sampling the quadrature inputs at its core.

The GPIO signals may be used to control such items as LEDs, external ICs that may emulate quadrature signals, photodiodes, and photodetectors.

## 1.13 ADC Port

The ADC block is a single switched-cap  $\Sigma$ - $\Delta$  ADC core for audio and DC measurement. It operates at the 12 MHz clock rate and has 32 DC input channels, including 28 GPIO inputs. The internal bandgap reference has  $\pm 5\%$  accuracy without calibration. Different calibration and digital correction schemes can be applied to reduce ADC absolute error and improve measurement accuracy in DC mode.

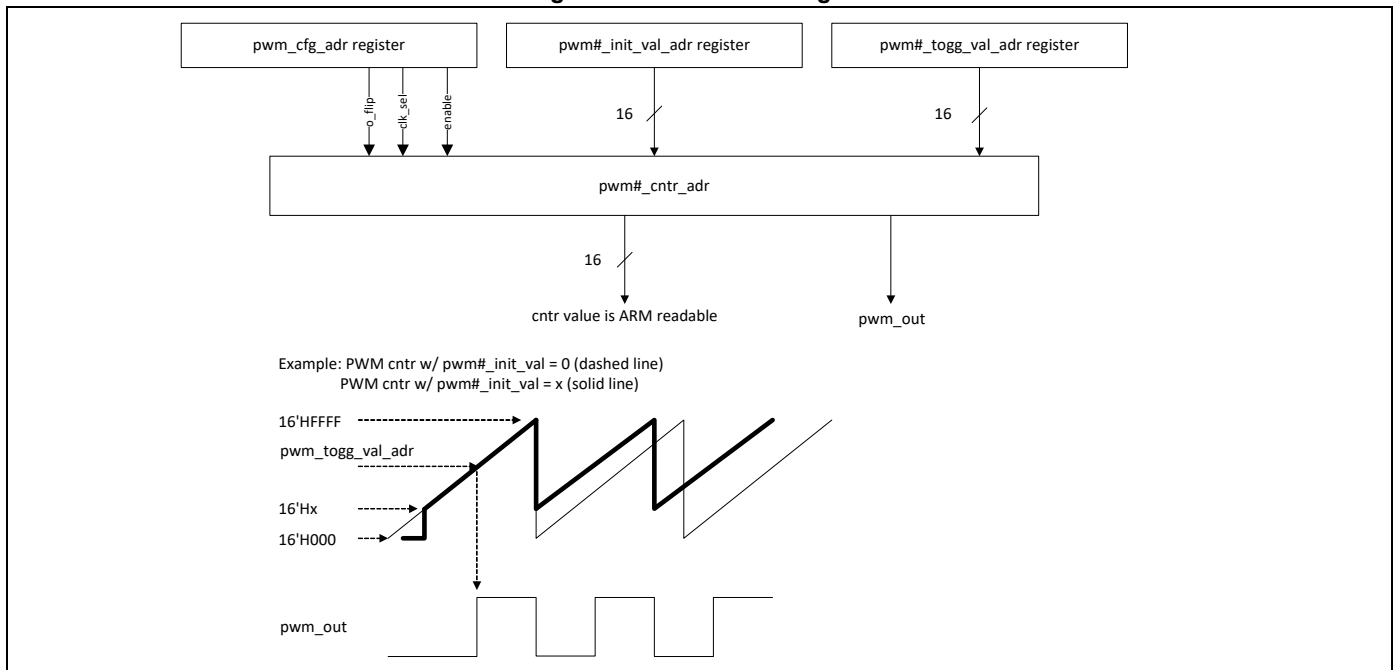
### 1.14 PWM

The CYW20735B1 has six internal PWMs. The PWM module consists of the following:

- PWM0–5. Each of the six PWM channels contains the following registers:
  - 16-bit initial value register (read/write)
  - 16-bit toggle register (read/write)
  - 16-bit PWM counter value register (read)
- PWM configuration register shared among PWM0–5 (read/write). This 18-bit register is used:
  - To configure each PWM channel
  - To select the clock of each PWM channel
  - To change the phase of each PWM channel

Figure 6 shows the structure of one PWM.

Figure 6. PWM Block Diagram



### 1.15 Triac Control

The CYW20735B1 includes hardware support for zero-crossing detection and trigger control for up to four triacs. The CYW20735B1 detects zero-crossing on the AC zero detection line and uses that to provide a pulse that is offset from the zero crossing. This allows the CYW20735B1 to be used in dimmer applications, as well as any other applications that require a control signal that is offset from an input event.

The zero-crossing hardware includes an option to suppress glitches.

### 1.16 Serial Peripheral Interface

The CYW20735B1 has two independent SPI interfaces, both of which support single, dual, and quad mode SPI operations.

Either interface can be a master or a slave. Each interface has a 64-byte transmit buffer and a 64-byte receive buffer. To support more flexibility for user applications, the CYW20735B1 has optional I/O ports that can be configured individually and separately for each functional pin. The CYW20735B1 acts as an SPI master device that supports 1.8V or 3.3V SPI slaves. The CYW20735B1 can also act as an SPI slave device that supports a 1.8V or 3.3V SPI master.

**Note:** SPI voltage depends on VDDO/VDDM; therefore, it defines the type of devices that can be supported.

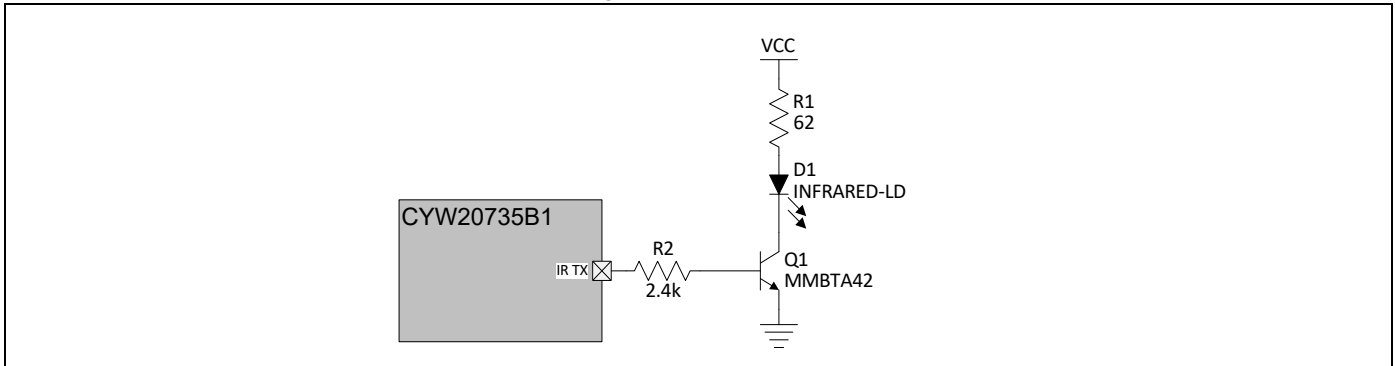


### 1.17 Infrared Modulator

The CYW20735B1 includes hardware support for infrared TX. The hardware can transmit both modulated and unmodulated waveforms. For modulated waveforms, hardware inserts the desired carrier frequency into all IR transmissions. IR TX can be sourced from firmware-supplied descriptors, a programmable bit, or the peripheral UART transmitter.

If descriptors are used, they include IR on/off state and the duration between 1–32767  $\mu$ sec. The CYW20735B1 IR TX firmware driver inserts this information in a hardware FIFO and makes sure that all descriptors are played out without a glitch due to underrun (see Figure 7).

**Figure 7. Infrared TX**



### 1.18 PDM Microphone

The CYW20735B1 accepts a  $\Sigma\Delta$ -based one-bit pulse density modulation (PDM) input stream and outputs filtered samples at either 8 kHz or 16 kHz sampling rates. The PDM signal derives from an external kit that can process analog microphone signals and generate digital signals. The digital signal passes through the chip IO and MUX inputs using an auxADC signal. The PDM shares the filter path with the auxADC. Two types of data rates can be supported:

- 8 kHz
- 16 kHz

The external digital microphone accepts a 2.4 MHz clock generated by the CYW20735B1 and outputs a PDM signal which is registered by the PDM interface with either the rising or falling edge of the 2.4 MHz clock selectable through a programmable control bit. The design can accommodate two simultaneous PDM input channels, so stereo voice is possible.

## 1.19 Security Engine

The CYW20735B1 includes a hardware security accelerator that greatly decreases the time required to perform typical security operations. These functions include:

- Public key acceleration (PKA) cryptography
- AES-CTR/CBC-MAC/CCM acceleration
- SHA2 message hash and HMAC acceleration
- RSA encryption and decryption of modulus sizes up to 2048 bits
- Elliptic curve Diffie-Hellman in prime field GF(p)
- Generic modular math functions

## 1.20 Power Management Unit

The Power Management Unit (PMU) provides power management features that can be invoked by software through power management registers or packet-handling in the baseband core.

### 1.20.1 RF Power Management

The BBC generates power-down control signals for the transmit path, receive path, PLL, and power amplifier to the 2.4 GHz transceiver, which then processes the power-down functions accordingly.

### 1.20.2 Host Controller Power Management

Power is automatically managed by the firmware based on input device activity. As a power-saving task, the firmware controls the disabling of the on-chip regulator when in HIDEOFF (deep sleep) mode.

### 1.20.3 BBC Power Management

There are several low-power operations for the BBC:

- Physical layer packet handling turns RF on and off dynamically within packet TX and RX.
- Bluetooth-specified low-power connection mode. While in these low-power connection modes, the CYW20735B1 runs on the Low Power Oscillator and wakes up after a predefined time period.

The CYW20735B1 automatically adjusts its power dissipation based on user activity. The following power modes are supported:

- Active mode
- Idle mode
- Sleep mode
- HIDEOFF (deep sleep) mode

The CYW20735B1 transitions to the next lower state after a programmable period of user inactivity. When user activity resumes, the CYW20735B1 immediately enters Active mode.

In HIDEOFF mode, the CYW20735B1 baseband and core are powered off by disabling power to VDDC\_OUT and PAVDD. The VDDO domain remains powered up and will turn the remainder of the chip on when it detects user events. This mode minimizes chip power consumption and is used for longer periods of inactivity.

## 2. Pin Assignments and GPIOs

### 2.1 Pin Assignments

**Table 6. Pin Assignments**

| Pin Name                           | QFN Pin | I/O   | Power Domain | Description   |
|------------------------------------|---------|-------|--------------|---|
| <b>Microphone</b>                  |         |       |              |   |
| MIC_AVDD                           | 48      | I     | MIC_AVDD     | Microphone supply   |
| MICBIAS                            | 45      | I     | MIC_AVDD     | Microphone bias supply  |
| MICN                               | 47      | I     | MIC_AVDD     | Microphone negative input   |
| MICP                               | 46      | I     | MIC_AVDD     | Microphone positive input   |
| <b>Baseband Supply</b>             |         |       |              |   |
| BT_VDDO                            | 36      | I     | VDDO         | I/O pad power supply  |
| BT_VDDC                            | 37      | I     | VDDC         | Baseband core power supply  |
| LHL_VDDO                           | 60      | I     | VDDO         | LHL PAD power supply: can be tied to BT_VDDO  |
| <b>RF Power Supply</b>             |         |       |              |   |
| BT_PAVDD2P5                        | 26      | I     | PAVDD2P5     | PA supply   |
| BT_PLLVDD1P2                       | 31      | I     | PLLVDD1P2    | RFPLL and crystal oscillator supply   |
| BT_VCOVDD1P2                       | 29      | I     | VCOVDD1P2    | VCO supply  |
| BT_IFVDD1P2                        | 28      | I     | IFVDD1P2     | IFPLL power supply  |
| <b>Onboard LDOs</b>                |         |       |              |   |
| DIGLDO_VDDIN1P5                    | 25      | I     | –            | Internal digital LDO input and feedback pin of switching regulator (CBUCK).               |
| RFLDO_VDDIN1P5                     | 24      | I     | –            | RF LDO input  |
| RFLDO_VDDOUT                       | 23      | O     | –            | RF LDO output   |
| PALDO_VDDIN_5V                     | 19      | I     | –            | PA LDO input  |
| PALDO_VDDOUT3V                     | 20      | O     | –            | PA LDO output   |
| SR_VDDBAT3V                        | 22      | I     | –            | Core buck input   |
| SR_VLX                             | 21      | O     | –            | Core buck output  |
| <b>Ground Pins</b>                 |         |       |              |   |
| HS-VSS                             | H       | I     | VSS          | Digital ground  |
| <b>UART</b>                        |         |       |              |   |
| UART_CTS_N                         | 44      | I, PU | VDDO         | CTS for HCI UART interface: NC if unused.   |
| UART_RTS_N                         | 43      | O, PU | VDDO         | RTS for HCI UART interface. NC if unused.   |
| UART_RXD                           | 41      | I     | VDDO         | UART serial input. Serial data input for the HCI UART interface.                          |
| UART_TXD                           | 42      | O, PU | VDDO         | UART serial input. Serial data input for the HCI UART interface.                          |
| <b>Serial Peripheral Interface</b> |         |       |              |   |
| SPI_MISO                           | 40      | I     | VDDO         | SPI Master In Slave Out   |
| SPI_MOSI                           | 39      | O     | VDDO         | SPI Master Out Slave In   |
| SPI_CSN                            | 38      | O     | VDDO         | SPI Chip Select   |
| SPI_CLK                            | 35      | O     | VDDO         | SPI Clock   |
| <b>Crystal</b>                     |         |       |              |   |
| BT_XTALI                           | 32      | I     | PLLVDD1P2    | Crystal oscillator input: see <a href="#">“Crystal Oscillator”</a> on page 12 for options |
| BT_XTALO                           | 33      | O     | PLLVDD1P2    | Crystal oscillator output   |

**Table 6. Pin Assignments (Cont.)**

| Pin Name      | QFN Pin | I/O | Power Domain | Description  |
|---------------|---------|-----|--------------|--|
| XTALI_32K     | 50      | I   | VDDO         | Low-power oscillator input   |
| XTALO_32K     | 49      | O   | VDDO         | Low-power oscillator output  |
| <b>Others</b> |         |     |              |  |
| DEFAULT_STRAP | 18      | I   | VDDO         | Connect to VDDO  |
| BT_HOST_WAKE  | 34      | O   | VDDO         | <p>Host wake-up. This is a signal from the Bluetooth device to the host indicating that the Bluetooth device requires attention.</p> <ul style="list-style-type: none"> <li>■ Asserted: Host device must wake up or remain awake.</li> <li>■ Deasserted: Host device may sleep when sleep criteria is met.</li> </ul> <p>The polarity of this signal is software configurable and can be asserted high or low.</p> |
| BT_RF         | 27      | I/O | PAVDD2P5     | RF antenna port  |
| JTAG_SEL      | 17      | –   | –            | ARM JTAG debug mode control: connect to GND for all applications   |
| RST_N         | 16      | I   | VDDO         | Active-low system reset with open-drain output and internal pull-up resistor   |
| NC            | 30      |     |              | Leave floating   |

## 2.2 GPIO Pin Descriptions

Table 7. GPIO Pin Descriptions<sup>ab</sup>

| QFN Pin Number | Pin Name    | Default Direction | POR State | Power Domain | Default Alternate Function Description  |
|----------------|-------------|-------------------|-----------|--------------|---|
| 8              | P0          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P0</li> <li>■ A/D converter input 29</li> </ul> <b>Note:</b> Not available during TM1 = 1. |
| 9              | P1          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P1</li> <li>■ A/D converter input 28</li> </ul>  |
| 52             | P2          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P2</li> </ul>  |
| 53             | P3          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P3</li> </ul>  |
| 54             | P4          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P4</li> </ul>  |
| 55             | P5          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P5</li> </ul>  |
| 56             | P6          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P6</li> </ul>  |
| 57             | P7          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P7</li> </ul>  |
| 58             | P8          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P8</li> <li>■ A/D converter input 27</li> </ul>  |
| 1              | P9          | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P9</li> <li>■ A/D converter input 26</li> </ul>  |
| 2              | P10         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P10</li> <li>■ A/D converter input 25</li> </ul>   |
| 3              | P11         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P11</li> <li>■ A/D converter input 24</li> </ul>   |
| 4              | P12         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P12</li> <li>■ A/D converter input 23</li> </ul>   |
| 5              | P13         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P13</li> <li>■ A/D converter input 22</li> </ul>   |
| 59             | P14         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P14</li> <li>■ A/D converter input 21</li> </ul>   |
| 50             | P15         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P15</li> <li>■ A/D converter input 20</li> </ul>   |
| 51             | P16         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P16</li> <li>■ A/D converter input 19</li> </ul>   |
| 13             | P26<br>PWM0 | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P26</li> <li>■ Current: 16 mA sink</li> </ul>  |
| 14             | P27<br>PWM1 | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P27</li> <li>■ Current: 16 mA sink</li> </ul>  |
| 6              | P28<br>PWM2 | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P28</li> <li>■ A/D converter input 11</li> <li>■ Current: 16 mA sink</li> </ul>            |

**Table 7. GPIO Pin Descriptions<sup>ab</sup> (Cont.)**

| QFN Pin Number | Pin Name    | Default Direction | POR State | Power Domain | Default Alternate Function Description   |
|----------------|-------------|-------------------|-----------|--------------|--|
| 7              | P29<br>PWM3 | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P29</li> <li>■ A/D converter input 10</li> <li>■ Current: 16 mA sink</li> </ul> |
| 15             | P32         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P32</li> <li>■ A/D converter input 7</li> </ul>                                 |
| 10             | P34         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P34</li> <li>■ A/D converter input 5</li> </ul>                                 |
| 11             | P38         | Input             | Floating  | VDDO         | <ul style="list-style-type: none"> <li>■ GPIO: P38</li> <li>■ A/D converter input 1</li> </ul>                                 |
| 12             | P39         | Input             | Floating  | VDDO         | Reserved for system use. Leave this GPIO unconnected   |

a. All GPIOs are supermux. All GPIOs can be programmed for any alternative functions. For example, key scan, SPI, I<sup>2</sup>C, IR\_TX, quadrature, peripheral UART, ADC, etc.

b. During power-on reset, all inputs are disabled.

**Table 8. GPIO Supermux Input/Output Function List**

| Function    | Function    | Function    | Function    |
|-------------|-------------|-------------|-------------|
| SPI_1: CLK  | SPI_1: CS   | SPI_1: MOSI | SPI_1: MISO |
| SPI_1: INT  | SPI_2: CLK  | SPI_2: CS   | SPI_2: MOSI |
| SPI_2: MISO | SPI_2: INT  | SPI_3: CLK  | SPI_3: CS   |
| SPI_3: MOSI | SPI_3: MISO | SPI_3: INT  | UART_RX     |
| UART_CTS    | UART_TX     | UART_RTS    | PUART_RX    |
| PUART_CTS   | PUART_TX    | PUART_RTS   | SCL         |
| SDA         | SCL2        | SDA2        | PCM_IN      |
| PCM_OUT     | PCM_CLK     | PCM_SYNC    | I2S_DO      |
| I2S_DI      | I2S_WS      | I2S_CLK     | IR_TX       |
| kso0        | kso1        | kso2        | kso3        |
| kso4        | kso5        | kso6        | kso7        |
| kso8        | kso9        | kso10       | kso11       |
| kso12       | kso13       | kso14       | kso15       |
| kso16       | kso17       | kso18       | kso19       |
| PWM0        | PWM1        | PWM2        | PWM3        |
| PWM4        | PWM5        | aclk0       | aclk1       |
| pa_ramp     | tx_pd       | ~tx_pd      | -           |

### 2.3 Pinouts

#### 2.3.1 60-Pin QFN Package

The 60-pin QFN package is shown in [Figure 8](#).

**Figure 8. CYW20735B1 60-Pin QFN Package**

|    |     |   |          |               |                |                |        |             |              |                |                 |               |           |             |              |      |              |  |
|----|-----|---|----------|---------------|----------------|----------------|--------|-------------|--------------|----------------|-----------------|---------------|-----------|-------------|--------------|------|--------------|--|
|    |     | 60  | 59       | 58            | 57             | 56             | 55     | 54          | 53           | 52             | 51              | 50            | 49        | 48          | 47           | 46   |              |  |
|    |     | LHL_VDDO  | P14      | P8            | P7             | P6             | P5     | P4          | P3           | P2             | P16             | P15/XTAL1_32K | XTALO_32K | MIC_AVDD    | MICN         | MICP |              |  |
| 1  | P9  | <div style="border: 1px solid black; width: 100%; height: 100%; display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;"> <p>H</p> <p>HS-VSS</p> </div> </div> |          |               |                |                |        |             |              |                |                 |               |           |             |              | 45   | MICBIAS      |  |
| 2  | P10 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 44   | UART_CTS_N   |  |
| 3  | P11 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 43   | UART_RTS_N   |  |
| 4  | P12 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 42   | UART_TXD     |  |
| 5  | P13 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 41   | UART_RXD     |  |
| 6  | P28 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 40   | SPI_MISO     |  |
| 7  | P29 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 39   | SPI_MOSI     |  |
| 8  | P0  |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 38   | SPI_CSN      |  |
| 9  | P1  |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 37   | BT_VDDC      |  |
| 10 | P34 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 36   | BT_VDDO      |  |
| 11 | P38 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 35   | SPI_CLK      |  |
| 12 | P39 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 34   | BT_HOST_WAKE |  |
| 13 | P26 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 33   | BT_XTALO     |  |
| 14 | P27 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 32   | BT_XTALI     |  |
| 15 | P32 |   |          |               |                |                |        |             |              |                |                 |               |           |             |              | 31   | BT_PLLVDD1P2 |  |
|    |     | RST_N   | JTAG_SEL | DEFAULT_STRAP | PALDO_VDDIN_5V | PALDO_VDDOUT3V | SR_VLX | SR_VDDBAT3V | RFLDO_VDDOUT | RFLDO_VDDIN1P5 | DIGLDO_VDDIN1P5 | BT_PAVDD2P5   | BT_RF     | BT_IFVDD1P2 | BT_VCOVDD1P2 | ---  |              |  |
| 16 | 17  | 18  | 19       | 20            | 21             | 22             | 23     | 24          | 25           | 26             | 27              | 28            | 29        | 30          |              |      |              |  |

**Note:** Pin H is a ground pin that is used for the signal name HS-VSS.



### 3. Specifications

#### 3.1 Electrical Characteristics

**Caution!** The absolute maximum ratings in the following table indicate levels where permanent damage to the device can occur, even if these limits are exceeded for only a brief duration. Functional operation is not guaranteed under these conditions. Operation at absolute maximum conditions for extended periods can adversely affect long-term reliability of the device

**Table 9. Absolute Maximum Ratings**

| Requirement Parameter        | Specification |      |       | Unit |
|------------------------------|---------------|------|-------|------|
|                              | Min.          | Nom. | Max.  |      |
| Maximum Junction Temperature | –             | –    | 125   | °C   |
| VDD IO                       | –0.5          | –    | 3.795 | V    |
| VDD RF                       | –0.5          | –    | 1.38  | V    |
| VddbAT3V                     | –0.5          | –    | 3.795 | V    |
| DIGLDO_VDDIN1P5              | –0.5          | –    | 1.65  | V    |
| RFLDO_VDDIN1P5               | –0.5          | –    | 1.65  | V    |
| PALDO_VDDIN_5V               | –0.5          | –    | 3.795 | V    |
| MIC_AVDD                     | –0.5          | –    | 3.795 | V    |
| OTP_3P3V                     | –0.5          | –    | 3.795 | V    |

**Table 10. ESD/Latchup**

| Requirement Parameter | Specification |      |      | Unit |
|-----------------------|---------------|------|------|------|
|                       | Min.          | Nom. | Max. |      |
| ESD Tolerance HBM     | –2000         | –    | 2000 | V    |
| ESD Tolerance CDM     | –500          | –    | 500  | V    |
| Latch-up              | –             | 200  | –    | mA   |

**Table 11. Environmental Ratings**

| Characteristic        | Value       | Units |
|-----------------------|-------------|-------|
| Operating Temperature | –30 to +85  | °C    |
| Storage Temperature   | –40 to +150 | °C    |

**Table 12. Recommended Operating Conditions**

| Parameter             | Specification |      |      | Unit |
|-----------------------|---------------|------|------|------|
|                       | Min.          | Typ. | Max. |      |
| VDD IO <sup>a</sup>   | $V_{SHUT}^b$  | 3.0  | 3.63 | V    |
| VDDRF                 | 1.14          | 1.2  | 1.26 | V    |
| VddbAT3V <sup>a</sup> | $V_{SHUT}^b$  | 3.0  | 3.63 | V    |
| PALDO_VDDIN_5V        | 2.5           | 3.3  | 3.63 |      |
| DIGLDO_VDDIN1P5       | 1.3           | 1.35 | 1.5  | V    |
| RFLDO_VDDIN1P5        | 1.3           | 1.35 | 1.5  | V    |
| MIC_AVDD              | $V_{SHUT}^b$  | 3.0  | 3.63 | V    |
| OTP_3P3V              | 3.0           | 3.3  | 3.63 | V    |

a. VDDIO must be greater or equal to  $V_{BAT}$ .

b. See [Table 13](#).

The CYW20735B1 uses an onboard low voltage detector to shut down the part when supply voltage (VDDBAT3V) drops below operating range.

**Table 13. Shutdown Voltage**

| Parameter         | Specification |      |       | Unit |
|-------------------|---------------|------|-------|------|
|                   | Min.          | Typ. | Max.  |      |
| V <sub>SHUT</sub> | 1.625         | 1.7  | 1.775 | V    |

### 3.1.1 Core Buck Regulator

**Table 14. Core Buck Regulator**

| Parameter                         | Conditions  | Min. | Typ. | Max. | Unit |
|-----------------------------------|---|------|------|------|------|
| Input supply voltage DC, VBAT     | DC voltage range  | 1.62 | 3.0  | 3.63 | V    |
| CBUCK output current              | –   | –    | –    | 65   | mA   |
| Output voltage range              | Programmable, 30mV/step<br>default = 1.35V (bits = 0000)  | 1.2  | 1.35 | 1.5  | V    |
| Output voltage DC accuracy        | Includes load and line regulation   | –4   | –    | +4   | %    |
| LPOM ripple voltage, static       | Measured with 20 MHz bandwidth limit, static load. Max ripple based on VBAT = 3V, Vout = 1.35V<br>Inductor:<br>0806 inch-size, Tmax = 1 mm,<br>2.2 μH ±25%, DCR = 114 mΩ ±20%, ACR<1Ω (for frequency <1 MHz)<br>Capacitor:<br>1 μF ±10%, 6.3V, 0603 inch, X5R, MLCC capacitor + board total-ESR < 20 mΩ | –    | –    | 30   | mVpp |
| Efficiency (high load)            | 10–50 mA load current, Vout = 1.35V, Vbat = 3V @25°C<br>Inductor:<br>0806 inch-size, Tmax = 1 mm,<br>2.2 μH ±25%, DCR = 114 mΩ ±20%, ACR<1Ω (for frequency <1 MHz)<br>Capacitor:<br>1 μF ±10%, 6.3V, 0603 inch, X5R, MLCC capacitor + board total-ESR < 20 mΩ   | –    | 85   | –    | %    |
| Efficiency (low load)             | 1–5 mA load current, Vout = 1.35V, Vbat = 3V @25°C<br>Inductor:<br>0806 inch-size, Tmax = 1 mm,<br>2.2 μH ±25%, DCR = 114 mΩ ±20%, ACR<1Ω (for frequency <1 MHz)<br>Capacitor:<br>1 μF ±10%, 6.3V, 0603 inch, X5R, MLCC capacitor + board total-ESR < 20 mΩ   | –    | 80   | –    | %    |
| Startup time                      | See <a href="#">Table 15 on page 27</a> .   | –    | –    | –    | –    |
| External inductor L               | 2.2 μH ±25%, DCR = 114 mΩ ±20%, ACR<1Ω (for frequency <1 MHz)   | –    | 2.2  | –    | μH   |
| External output capacitor, Cout   | 1 μF ±10%, 6.3V, 0603 inch, X5R, MLCC capacitor + board total-ESR < 20 mΩ   | 0.7  | 1    | 1.1  | μF   |
| External input capacitor, Cin     | For SR_VDDBAT 3V pin<br>Ceramic, X5R, 0402, ESR<30 mΩ at 4 MHz, +/-20%, 6.3V, 4.7 μF  | 0.7  | 4.7  | 5.64 | μF   |
| Input supply voltage ramp-up time | 0 to 3.3V   | 40   | –    | –    | μs   |

- Minimum capacitor value refers to residual capacitor value after taking into account part-to-part tolerance, DC-bias, temperature, and aging.
- Maximum capacitor value refers to the total capacitance seen at a node where the capacitor is connected. This also includes any decoupling capacitors connected at the load side, if any.

**3.1.2 Digital LDO**
**Table 15. Digital LDO**

| Parameter                      | Conditions   | Min.             | Typ.  | Max.  | Unit    |
|--------------------------------|--|------------------|-------|-------|---------|
| Input supply voltage, $V_{in}$ | Minimum $V_{in} = V_o + 0.12V$ requirement must be met under maximum load.   | 1.3              | 1.35  | 1.5   | V       |
| Nominal output voltage, $V_o$  | Internal default bit setting   | –                | 1.2   | –     | V       |
| Output voltage programmability | Range  | 0.9              | –     | 1.25  | V       |
|                                | Step size  | –                | 10    | –     | mV      |
|                                | Accuracy at any step (including line/load regulation)  | –4               | –     | +4    | %       |
| Dropout voltage                | At maximum load  | –                | –     | 120   | mV      |
| Output current                 | DC load  | 0.2 <sup>a</sup> | –     | 40    | mA      |
| Output loading capacitor       | Internal, including the decoupling capacitor to be placed next to the load and the equivalent loading capacitor by the core. | 4                | –     | 10    | nF      |
| Quiescent current              | At no load, excluding main bandgap $I_q$   | –                | 90    | 120   | $\mu A$ |
| Line regulation                | $V_{in}$ from ( $V_o+0.12V$ ) to 1.5V; 40 mA load  | –                | –     | 5     | mV/V    |
| Load regulation                | Load from 1 mA to 25 mA; $V_{in}$ ( $V_o+0.12V$ )  | –                | 0.025 | 0.045 | mV/mA   |
| Leakage current                | In full power-down mode or bypass mode:<br>Junction temperature: 25°C<br>Junction temperature: 125°C                         | –                | 0.05  | 0.2   | $\mu A$ |
|                                |  | –                | 1.1   | 5.0   | $\mu A$ |
| PSRR                           | @1 kHz, $V_{in}$ , $V_o+0.12V$<br>Output cap of 4 nF~10 nF   | 40               | –     | –     | dB      |
| LDO turn-on time               | LDO turn-on time when balance of chip is up  | –                | –     | 22    | $\mu s$ |
| External input capacitor       | Only use an external input capacitor at VDD_DIGL-DO1P5 pin if it is not supplied from CBUCK output.                          | –                | 1     | 2.2   | $\mu F$ |

a. By default, an internal loading of ~0.2 mA resides inside the LDO. This is to ensure the LDO is stable with zero loading from the core. After the core is up, digital logic can disable this internal loading by setting `i_ido_cntl<8:7>` to 00.

## 3.1.3 PA LDO

**Table 16. PA LDO**

| Specification                  | Notes   | Min. | Typ. | Max. | Units  |
|--------------------------------|---|------|------|------|--------|
| Input supply voltage           | Min = 3.0 + 0.1V = 3.1V<br>Dropout voltage requirement must be met under max load for performance specs | 2.5  | 3.3  | 3.63 | V      |
| Output current                 | Junction temperature 125°C  | –    | –    | 50   | mA     |
| Output voltage (Vo)            | Default = 3.0V  | 2.4  | 3.0  | 3.4  | V      |
| Dropout voltage                | At max. load  | –    | –    | 100  | mV     |
| Output voltage DC accuracy     | Include line/load regulation  | –5   |      | +5   | %      |
| Quiescent current              | No load   | –    | 8    | –    | µA     |
| Line regulation                | Vin from (Vo + 0.1V) to 4.8V, max load  | –0.2 |      | +0.2 | %Vo/V  |
| Load regulation                | Load from 1 mA to 50 mA   |      | 0.02 | 0.05 | %Vo/mA |
| Leakage current                | In Power-Down mode at 25°C junction temp  | –    | 0.3  | –    | µA     |
| PSRR                           | Vbat 3.6V, Vo = 2.5V, Co = 1 µF, max load, 100 Hz to 100 kHz  | 20   | –    |      | dB     |
| LDO turn-on time               | LDO turn-on time when the rest of the chip is up  | –    | –    | 100  | µs     |
| In-rush current during turn-on | From its output cap in the fully-discharged state   | –    | –    | 70   | mA     |
| External output capacitor (Co) | Ceramic, X5R, 0402,<br>(ESR: 30m–200 mΩ), ±10%, 6.3V  | 0.44 | 1    | –    | µF     |
| External input capacitor       | For PALDO_VDDIN_5V pin<br>Ceramic, X5R, 0402, (ESR: 30m-200 mΩ), ±10%, 6.3V                             | –    | 1    | –    | µF     |

**3.1.4 RFLDO**
**Table 17. RF LDO**

| Parameter                        | Conditions  | Min. | Typ.  | Max.  | Unit            |
|----------------------------------|---|------|-------|-------|-----------------|
| Input supply voltage, $V_{in}$   | Min $V_{in} = V_o + 0.15V = 1.35V$ (for $V_o = 1.2V$ )<br>Dropout voltage requirement must be met under maximum load. | 1.3  | 1.35  | 1.5   | V               |
| Nominal output voltage, $V_o$    | Internal default bit setting 000  | –    | 1.2   | –     | V               |
| Output voltage programmability   | Range   | 1.1  | –     | 1.275 | V               |
|                                  | Step size   | –    | 25    | –     | mV              |
|                                  | Accuracy at any step (including line/load regulation)   | –4   | –     | +4    | %               |
| Dropout voltage                  | At maximum load   | –    | –     | 150   | mV              |
| Output current                   | Operating voltage range   | 0.1  | –     | 25    | mA              |
| Quiescent current                | No load   | –    | 44    | –     | $\mu A$         |
| Line regulation                  | $V_{in}$ from ( $V_o+0.15V$ ) to 1.5V; 25 mA load   | –    | –     | 5.5   | mV/V            |
| Load regulation                  | Load from 1 mA to 25 mA; $V_{in} \geq (V_o+0.15V)$  | –    | 0.025 | 0.045 | mV/mA           |
| Load step error                  | Load step from 1 mA–25 mA in 1 $\mu s$ and 25 mA–1 mA in 1 $\mu s$ ; $V_{in}(V_o+0.15V)$ ; $C_o = 2.2 \mu F$          | –    | –     | 35    | mV              |
| Leakage current                  | Power-down junction temperature: 85°C   | –    | –     | 10    | $\mu A$         |
| Output noise                     | @30 kHz, 25 mA load, $C_o = 2.2 \mu F$  | –    | –     | 60    | nV/ $\sqrt{Hz}$ |
|                                  | @100 kHz, 25 mA load, $C_o = 2.2 \mu F$   | –    | –     | 35    | nV/ $\sqrt{Hz}$ |
| PSRR                             | @1kHz, Input > 1.35V, $C_o = 2.2 \mu F$ , $V_o = 1.2V$  | 20   | –     | –     | dB              |
| LDO turn-on time                 | LDO turn-on time when balance of chip is up   | –    | 140   | 180   | $\mu s$         |
| In-rush current                  | $V_{in} = V_o+0.15V$ to 1.5V, $C_o = 2.2 \mu F$ , no load   | –    | –     | 100   | mA              |
| External output capacitor, $C_o$ | Total ESR (trace/cap): 5 m–240 m $\Omega$   | 0.5  | 2.2   | 4.7   | $\mu F$         |
| External input capacitor         | Only use an external input capacitor at RFLDO_VD-DIN1P5 pin if it is not supplied from CBUCK output.                  | –    | 1     | 2.2   | $\mu F$         |

**Note:** Minimum capacitor value refers to residual capacitor value after taking into account part-to-part tolerance, DC-bias, temperature, and aging.

### 3.1.5 Digital I/O Characteristics

**Table 18. Digital I/O Characteristics**

| Characteristics                                    | Symbol   | Minimum     | Typical | Maximum | Unit    |
|--|----------|-------------|---------|---------|---------|
| Input low voltage (VDDO = 3.3V)                    | $V_{IL}$ | –           | –       | 0.8     | V       |
| Input high voltage (VDDO = 3.3V)                   | $V_{IH}$ | 2.0         | –       | –       | V       |
| Input low voltage (VDDO = 1.8V)                    | $V_{IL}$ | –           | –       | 0.6     | V       |
| Input high voltage (VDDO = 1.8V)                   | $V_{IH}$ | 1.1         | –       | –       | V       |
| Output low voltage                                 | $V_{OL}$ | –           | –       | 0.4     | V       |
| Output high voltage                                | $V_{OH}$ | VDDO – 0.4V | –       | –       | V       |
| Input low current                                  | $I_{IL}$ | –           | –       | 1.0     | $\mu$ A |
| Input high current                                 | $I_{IH}$ | –           | –       | 1.0     | $\mu$ A |
| Output low current (VDDO = 3.3V, $V_{OL}$ = 0.4V)  | $I_{OL}$ | –           | –       | 2.0     | mA      |
| Output high current (VDDO = 3.3V, $V_{OH}$ = 2.9V) | $I_{OH}$ | –           | –       | 4.0     | mA      |
| Output high current (VDDO = 1.8V, $V_{OH}$ = 1.4V) | $I_{OH}$ | –           | –       | 2.0     | mA      |
| Input capacitance                                  | $C_{IN}$ | –           | –       | 0.4     | pF      |

### 3.1.6 Current Consumption

In [Table 19](#), current consumption measurements are taken at VBAT with the assumption that VBAT is connected to VDDIO and LDOIN.

**Table 19. BLE Current Consumption**

| Operational Mode    | Conditions  | Typical | Unit    |
|---------------------|---|---------|---------|
| Receiving           | Receiver and baseband are both operating, 100% ON.    | 8       | mA      |
| Transmitting@12 dBm | Transmitter and baseband are both operating, 100% ON. | 18      | mA      |
| Advertising         | 1.28s direct advertising in low power idle mode       | 30      | $\mu$ A |
| Scanning            | TBD   | TBD     | mA      |
| Connecting          | 1-second connection interval in low power idle mode   | 25      | $\mu$ A |
| HIDOFF (Deep Sleep) | –   | 1       | $\mu$ A |

**3.2 ADC Electrical Characteristics**
**Table 20. ADC Electrical Characteristics**

| Parameter                          | Symbol    | Conditions/Comments  | Min. | Typ. | Max. | Unit |
|------------------------------------|-----------|--|------|------|------|------|
| Analog supply voltage              | avddBAT   | Battery and I/O supply   | 1.62 | –    | 3.6  | V    |
| Analog core supply                 | AVDDC     | ±10%   | 1.08 | 1.2  | 1.32 | V    |
| Audio supply                       | Mic_avdd  | Only available for audio application                                     | 1.8  | 2.5  | 3.3  | V    |
| Current consumption                | $I_{TOT}$ | –  | –    | 2    | 3    | mA   |
| Power down current                 | –         | At room temperature  | –    | 1    | –    | µA   |
| <b>ADC Core Specification</b>      |           |  |      |      |      |      |
| ADC reference voltage              | VREF      | From BG with ±3% accuracy  | –    | 0.85 | –    | V    |
| ADC sampling clock                 | –         | –  | –    | 12   | –    | MHz  |
| Absolute error                     | –         | Includes gain error, offset and distortion. Without factory calibration. | –    | –    | 5    | %    |
|                                    |           | Includes gain error, offset and distortion. After factory calibration.   | –    | –    | 2    | %    |
| ENOB                               | –         | For audio application  | 12   | 13   | –    | Bit  |
|                                    |           | For static measurement   | 10   | –    | –    |      |
| ADC input full scale               | FS        | For audio application  | –    | 1.6  | –    |      |
|                                    |           | For static measurement   | 1.8  | –    | 3.6  |      |
| Conversion rate                    | –         | For audio application  | 8    | 16   | –    | kHz  |
|                                    |           | For static measurement   | 16   | 20   | –    |      |
| Signal bandwidth                   | –         | For audio application  | 20   | –    | 8K   | Hz   |
|                                    |           | For static measurement   | –    | DC   | –    |      |
| Input impedance                    | $R_{IN}$  | For audio application  | 10   | –    | –    | KΩ   |
|                                    |           | For static measurement   | 500  | –    | –    |      |
| Startup time                       | –         | For audio application  | –    | 10   | –    | ms   |
|                                    |           | For static measurement   | –    | 20   | –    | µs   |
| <b>MIC PGA Specifications</b>      |           |  |      |      |      |      |
| MIC PGA gain range                 | –         | –  | 0    | –    | 42   | dB   |
| MIC PGA gain step                  | –         | –  | –    | 1    | –    | dB   |
| MIC PGA gain error                 | –         | Includes part-to-part gain variation                                     | –1   | –    | 1    | dB   |
| PGA input referred noise           | –         | At 42 dB PGA gain A-weighted   | –    | –    | 4    | µV   |
| Passband gain flatness             | –         | PGA and ADC, 100 Hz–4 kHz  | –0.5 | –    | 0.5  | dB   |
| <b>MIC Bias Specifications</b>     |           |  |      |      |      |      |
| MIC bias output voltage            | –         | At 2.5V supply   | –    | 2.1  | –    | V    |
| MIC bias loading current           | –         | –  | –    | –    | 3    | mA   |
| MIC bias noise                     | –         | Refers to PGA input 20 Hz to 8 kHz, A-weighted                           | –    | –    | 3    | µV   |
| MIC bias PSRR                      | –         | at 1 kHz   | 40   | –    | –    | dB   |
| ADC SNR                            | –         | A-weighted 0 dB PGA gain   | 78   | –    | –    | dB   |
| ADC THD + N                        | –         | –3 dBFS input 0 dB PGA gain  | 74   | –    | –    | dB   |
| GPIO input voltage                 | –         | Always lower than avddBAT  | –    | –    | 3.6  | V    |
| GPIO source impedance <sup>a</sup> | –         | Resistance   | –    | –    | 1    | kΩ   |
|                                    |           | Capacitance  | –    | –    | 10   | pF   |

a. Conditional requirement for the measurement time of 10 µs. Relaxed with longer measurement time for each GPIO input channel.

### 3.3 RF Specifications

**Note:** Table 21 and Table 22 on page 42 apply to single-ended industrial temperatures. Unused inputs are left open.

**Table 21. Receiver RF Specifications**

| Parameter  | Conditions   | Minimum | Typical <sup>a</sup> | Maximum | Unit   |
|--|--------------|---------|----------------------|---------|--------|
| <b>General</b>   |              |         |                      |         |        |
| Frequency range  | –            | 2402    | –                    | 2480    | MHz    |
| RX sensitivity <sup>b</sup>                              | –            | –       | –91.5                | –       | –      |
| Maximum input  | GFSK, 1 Mbps | –       | –                    | –20     | dBm    |
| <b>Interference Performance</b>                          |              |         |                      |         |        |
| TBD  |              |         |                      |         |        |
| <b>Out-of-Band Blocking Performance (CW)<sup>c</sup></b> |              |         |                      |         |        |
| 30 MHz–2000 MHz  | 0.1% BER     | –       | –10.0                | –       | dBm    |
| 2000–2399 MHz  | 0.1% BER     | –       | –27                  | –       | dBm    |
| 2498–3000 MHz  | 0.1% BER     | –       | –27                  | –       | dBm    |
| 3000 MHz–12.75 GHz                                       | 0.1% BER     | –       | –10.0                | –       | dBm    |
| <b>Intermodulation Performance<sup>d</sup></b>           |              |         |                      |         |        |
| BT, Df = 4 MHz   | –            | –39.0   | –                    | –       | dBm    |
| <b>Spurious Emissions<sup>e</sup></b>                    |              |         |                      |         |        |
| 30 MHz to 1 GHz  | –            | –       | –                    | –62     | dBm    |
| 1 GHz to 12.75 GHz                                       | –            | –       | –                    | –47     | dBm    |
| 65 MHz to 108 MHz  | FM RX        | –       | –147                 | –       | dBm/Hz |
| 746 MHz to 764 MHz                                       | CDMA         | –       | –147                 | –       | dBm/Hz |
| 851–894 MHz  | CDMA         | –       | –147                 | –       | dBm/Hz |
| 925–960 MHz  | EDGE/GSM     | –       | –147                 | –       | dBm/Hz |
| 1805–1880 MHz  | EDGE/GSM     | –       | –147                 | –       | dBm/Hz |
| 1930–1990 MHz  | PCS          | –       | –147                 | –       | dBm/Hz |
| 2110–2170 MHz  | WCDMA        | –       | –147                 | –       | dBm/Hz |

a. Typical operating conditions are 1.22V operating voltage and 25°C ambient temperature.

b. The receiver sensitivity is measured at BER of 0.1% on the device interface.

c. Meets this specification using front-end band pass filter.

d.  $f_0 = -64$  dBm Bluetooth-modulated signal,  $f_1 = -39$  dBm sine wave,  $f_0 = 2f_1 - f_2$ , and  $|f_2 - f_1| = n \times 1$  MHz, where n is 3, 4, or 5. For the typical case, n = 4.

e. Includes baseband radiated emissions.



**Table 22. Transmitter RF Specifications (TBD)**

| Parameter                      | Conditions | Minimum | Typical | Maximum               | Unit |
|--------------------------------|------------|---------|---------|-----------------------|------|
| General                        |            |         |         |                       |      |
| Frequency range                | –          | 2402    | –       | 2480                  | MHz  |
| Class 1: GFSK TX power         | –          | –       | 10      | –                     | dBm  |
| Power control step             | –          | 2       | 4       | 8                     | dB   |
| Out-of-Band Spurious Emissions |            |         |         |                       |      |
| 30 MHz to 1 GHz                | –          | –       | –       | –36.0 <sup>a</sup>    | dBm  |
| 1 GHz to 12.75 GHz             | –          | –       | –       | –30.0 <sup>a, b</sup> | dBm  |
| 1.8 GHz to 1.9 GHz             | –          | –       | –       | –47.0                 | dBm  |
| 5.15 GHz to 5.3 GHz            | –          | –       | –       | –47.0                 | dBm  |

- a. Maximum value is the value required for Bluetooth qualification.
- b. Meets this spec using a front-end band-pass filter.

**Table 23. BLE RF Specifications**

| Parameter                           | Conditions             | Minimum | Typical | Maximum | Unit |
|-------------------------------------|------------------------|---------|---------|---------|------|
| Frequency range                     | N/A                    | 2402    | –       | 2480    | MHz  |
| RX sense <sup>a</sup>               | GFSK, 0.1% BER, 1 Mbps | –       | –94.5   | –       | dBm  |
| TX power                            | N/A                    | –       | 12      | –       | dBm  |
| Mod Char: Delta F1 average          | N/A                    | 225     | 255     | 275     | kHz  |
| Mod Char: Delta F2 max <sup>b</sup> | N/A                    | 99.9    | –       | –       | %    |
| Mod Char: Ratio                     | N/A                    | 0.8     | 0.95    | –       | %    |

- a. Dirty TX is OFF.
- b. At least 99.9% of all delta F2 max frequency values recorded over 10 packets must be greater than 185 kHz.

### 3.4 Timing and AC Characteristics

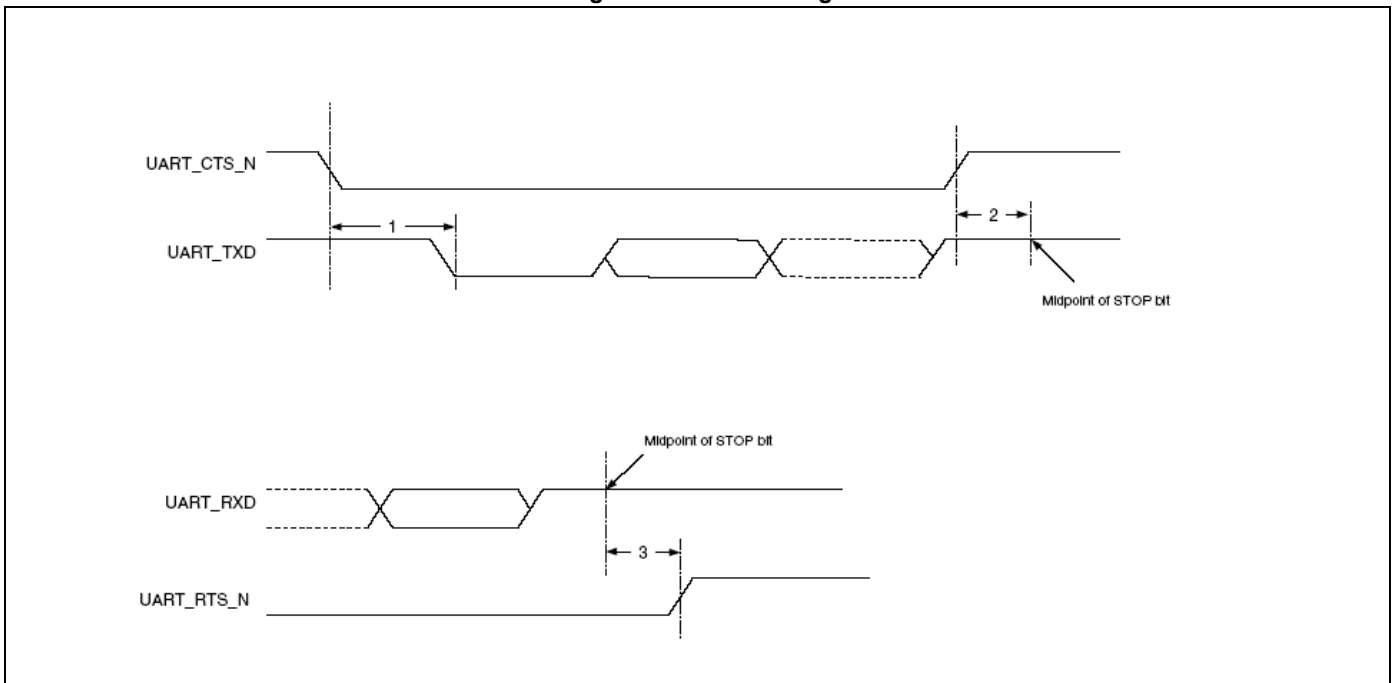
In this section, use the numbers listed in the Reference column of each table to interpret the following timing diagrams.

#### 3.4.1 UART Timing

**Table 24. UART Timing Specifications**

| Reference | Characteristics   | Min. | Max. | Unit         |
|-----------|---|------|------|--------------|
| 1         | Delay time, UART_CTS_N low to UART_TXD valid            | –    | 1.50 | Baud periods |
| 2         | Setup time, UART_CTS_N high before midpoint of stop bit | –    | 0.67 | Baud periods |
| 3         | Delay time, midpoint of stop bit to UART_RTS_N high     | –    | 1.33 | Baud periods |

**Figure 9. UART Timing**



3.4.2 SPI Timing

The SPI interface can be clocked up to 12 MHz.

Table 25 and Figure 10 show the timing requirements when operating in SPI Mode 0 and 2.

Table 25. SPI Mode 0 and 2

| Reference | Characteristics  | Min.  | Max.    | Unit |
|-----------|--|-------|---------|------|
| 1         | Time from master assert SPI_CSN to first clock edge          | 45    | –       | ns   |
| 2         | Hold time for MOSI data lines                                | 12    | 1/2 SCK | ns   |
| 3         | Time from last sample on MOSI/MISO to slave deassert SPI_INT | 0     | 100     | ns   |
| 4         | Time from slave deassert SPI_INT to master deassert SPI_CSN  | 0     | –       | ns   |
| 5         | Idle time between subsequent SPI transactions                | 1 SCK | –       | ns   |

Figure 10. SPI Timing, Mode 0 and 2

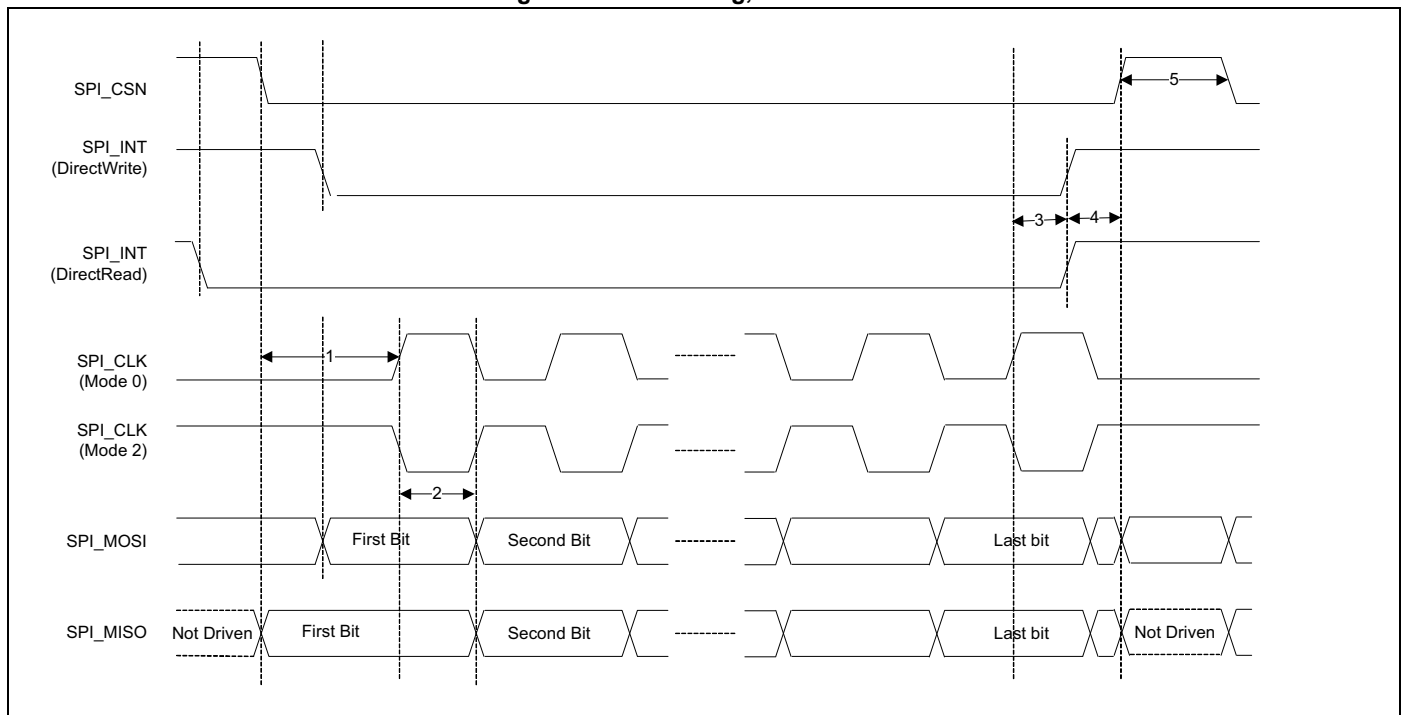
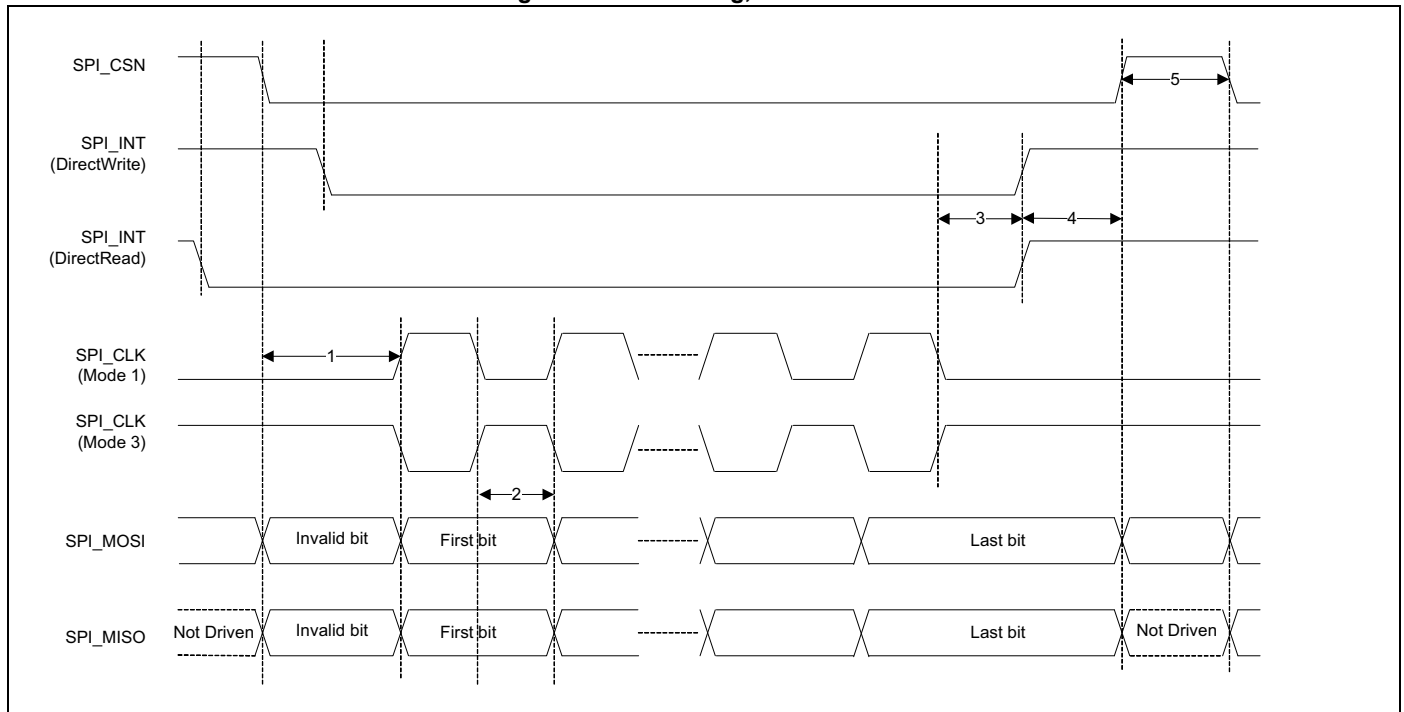


Table 26 and Figure 11 show the timing requirements when operating in SPI Mode 1 and 3.

**Table 26. SPI Mode 1 and 3**

| Reference | Characteristics  | Min.  | Max.    | Unit |
|-----------|--|-------|---------|------|
| 1         | Time from master assert SPI_CSN to first clock edge          | 45    | –       | ns   |
| 2         | Hold time for MOSI data lines                                | 12    | 1/2 SCK | ns   |
| 3         | Time from last sample on MOSI/MISO to slave deassert SPI_INT | 0     | 100     | ns   |
| 4         | Time from slave deassert SPI_INT to master deassert SPI_CSN  | 0     | –       | ns   |
| 5         | Idle time between subsequent SPI transactions                | 1 SCK | –       | ns   |

**Figure 11. SPI Timing, Mode 1 and 3**



3.4.3 I<sup>2</sup>C Interface Timing

The specifications in Table 27 references Figure 12.

Table 27. I<sup>2</sup>C Interface Timing Specifications (up to 1 MHz)

| Reference | Characteristics                   | Minimum | Maximum | Unit |
|-----------|-----------------------------------|---------|---------|------|
| 1         | Clock frequency                   | -       | 100     | kHz  |
|           |                                   |         | 400     |      |
|           |                                   |         | 800     |      |
|           |                                   |         | 1000    |      |
| 2         | START condition setup time        | 650     | -       | ns   |
| 3         | START condition hold time         | 280     | -       | ns   |
| 4         | Clock low time                    | 650     | -       | ns   |
| 5         | Clock high time                   | 280     | -       | ns   |
| 6         | Data input hold time <sup>a</sup> | 0       | -       | ns   |
| 7         | Data input setup time             | 100     | -       | ns   |
| 8         | STOP condition setup time         | 280     | -       | ns   |
| 9         | Output valid from clock           | -       | 400     | ns   |
| 10        | Bus free time <sup>b</sup>        | 650     | -       | ns   |

a. As a transmitter, 125 ns of delay is provided to bridge the undefined region of the falling edge of SCL to avoid unintended generation of START or STOP conditions.

b. Time that the CBUS must be free before a new transaction can start.

Figure 12. I<sup>2</sup>C Interface Timing Diagram

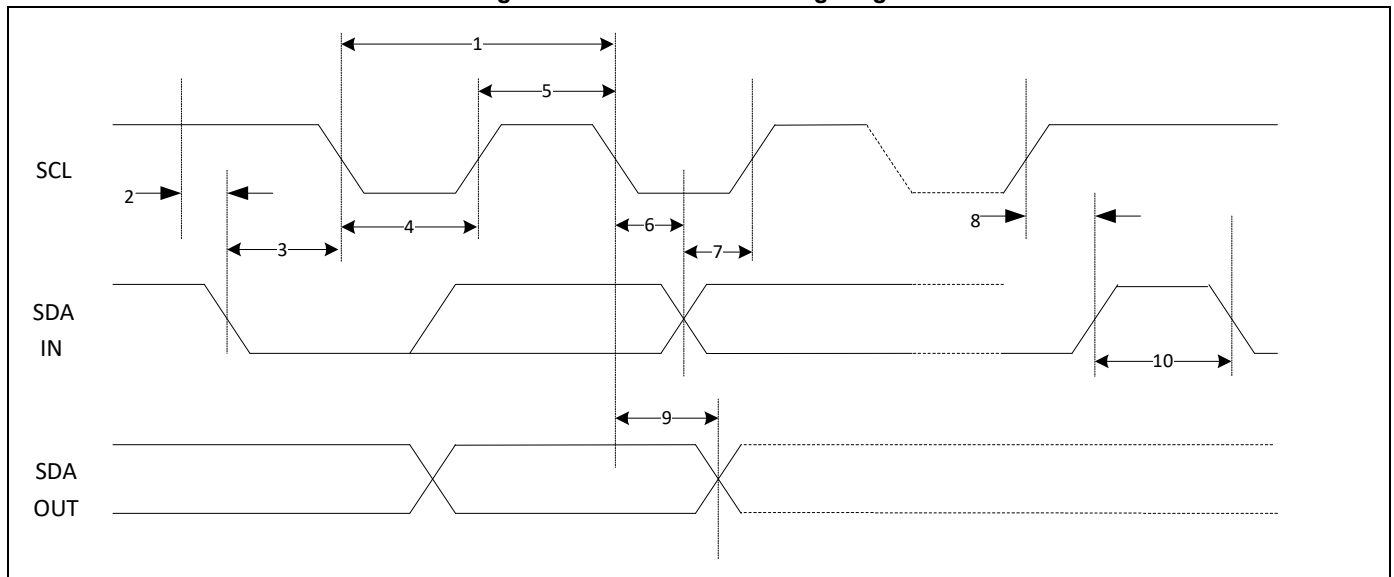
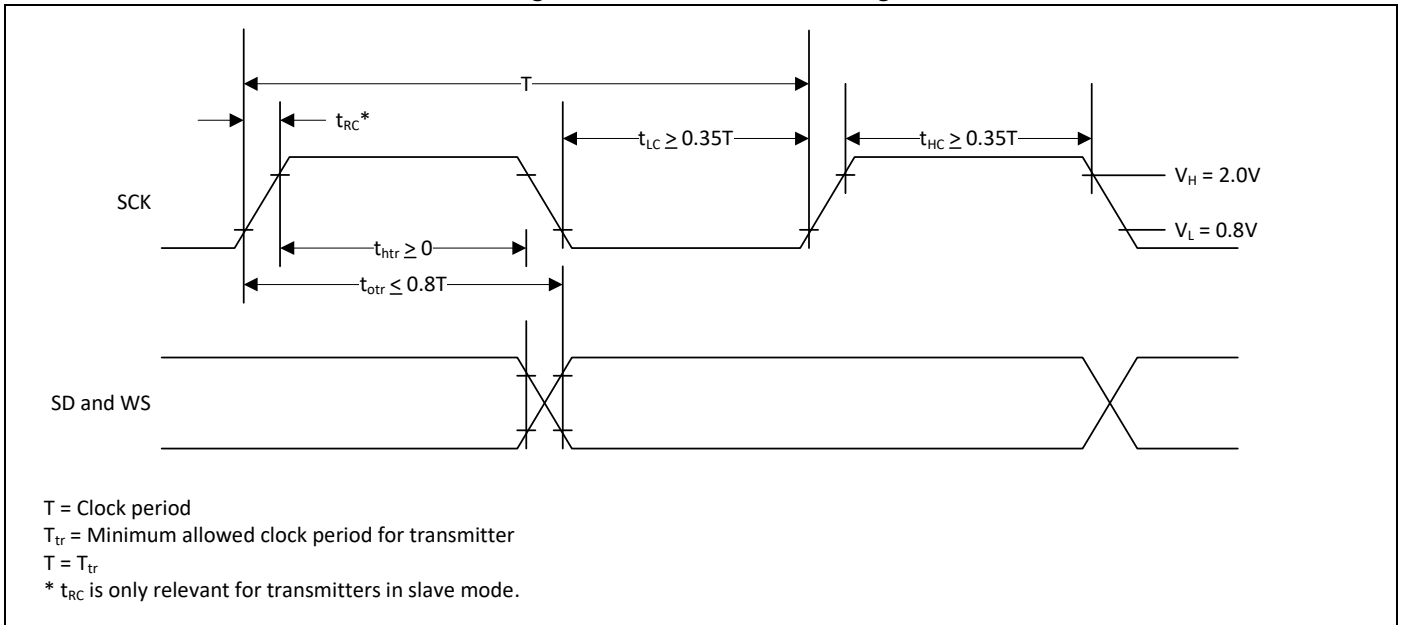
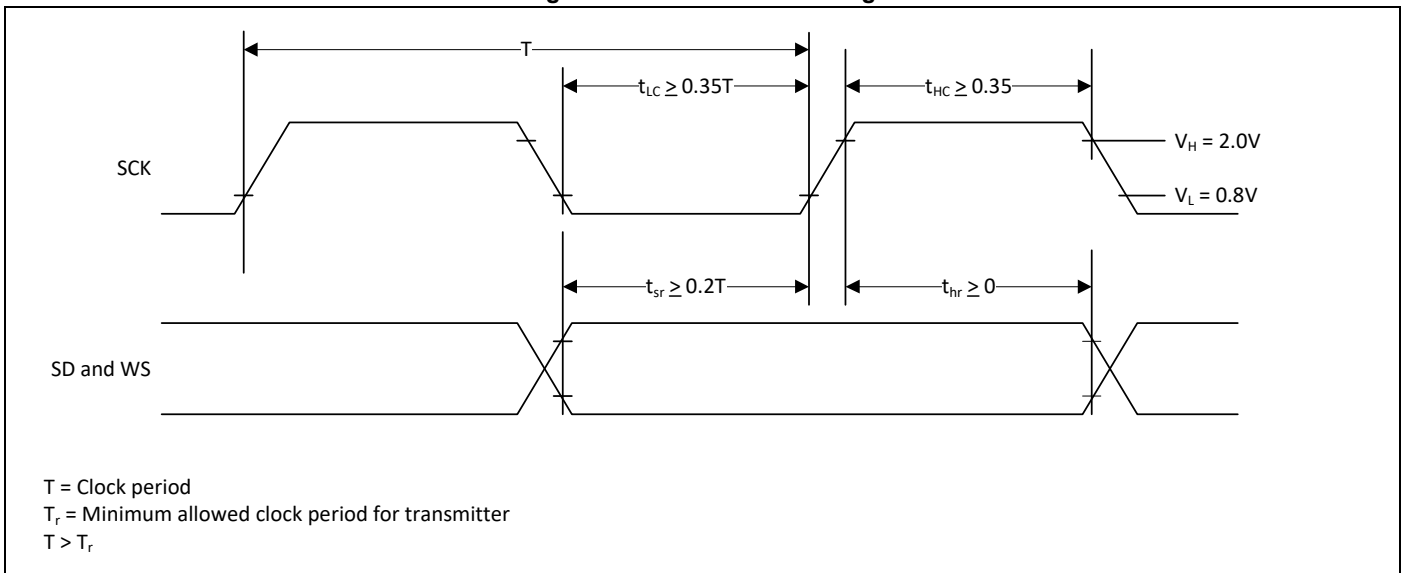


Table 28. Timing for I<sup>2</sup>S Transmitters and Receivers

|  | Transmitter  |              |              |        | Receiver     |              |             |     | Notes |
|--|--------------|--------------|--------------|--------|--------------|--------------|-------------|-----|-------|
|  | Lower Limit  |              | Upper Limit  |        | Lower Limit  |              | Upper Limit |     |       |
|  | Min          | Max          | Min          | Max    | Min          | Max          | Min         | Max |       |
| Clock Period T   | $T_{tr}$     | –            | –            | –      | $T_r$        | –            | –           | –   | a     |
| <b>Master Mode: Clock generated by transmitter or receiver</b> |              |              |              |        |              |              |             |     |       |
| HIGH $t_{HC}$  | $0.35T_{tr}$ | –            | –            | –      | $0.35T_{tr}$ | –            | –           | –   | b     |
| LOW $t_{LC}$   | $0.35T_{tr}$ | –            | –            | –      | $0.35T_{tr}$ | –            | –           | –   | b     |
| <b>Slave Mode: Clock accepted by transmitter or receiver</b>   |              |              |              |        |              |              |             |     |       |
| HIGH $t_{HC}$  | –            | $0.35T_{tr}$ | –            | –      | –            | $0.35T_{tr}$ | –           | –   | c     |
| LOW $t_{LC}$   | –            | $0.35T_{tr}$ | –            | –      | –            | $0.35T_{tr}$ | –           | –   | c     |
| Rise time $t_{RC}$   | –            | –            | $0.15T_{tr}$ | –      | –            | –            | –           | –   | d     |
| <b>Transmitter</b>   |              |              |              |        |              |              |             |     |       |
| Delay $t_{dtr}$  | –            | –            | –            | $0.8T$ | –            | –            | –           | –   | e     |
| Hold time $t_{htr}$  | 0            | –            | –            | –      | –            | –            | –           | –   | d     |
| <b>Receiver</b>  |              |              |              |        |              |              |             |     |       |
| Setup time $t_{sr}$  | –            | –            | –            | –      | –            | $0.2T_r$     | –           | –   | f     |
| Hold time $t_{hr}$   | –            | –            | –            | –      | –            | 0            | –           | –   | f     |

- a. The system clock period T must be greater than  $T_{tr}$  and  $T_r$  because both the transmitter and receiver have to be able to handle the data transfer rate.
- b. At all data rates in master mode, the transmitter or receiver generates a clock signal with a fixed mark/space ratio. For this reason,  $t_{HC}$  and  $t_{LC}$  are specified with respect to T.
- c. In slave mode, the transmitter and receiver need a clock signal with minimum HIGH and LOW periods so that they can detect the signal. So long as the minimum periods are greater than  $0.35T_r$ , any clock that meets the requirements can be used.
- d. Because the delay ( $t_{dtr}$ ) and the maximum transmitter speed (defined by  $T_{tr}$ ) are related, a fast transmitter driven by a slow clock edge can result in  $t_{dtr}$  not exceeding  $t_{RC}$  which means  $t_{htr}$  becomes zero or negative. Therefore, the transmitter has to guarantee that  $t_{htr}$  is greater than or equal to zero, so long as the clock rise-time  $t_{RC}$  is not more than  $t_{RCmax}$ , where  $t_{RCmax}$  is not less than  $0.15T_{tr}$ .
- e. To allow data to be clocked out on a falling edge, the delay is specified with respect to the rising edge of the clock signal and T, always giving the receiver sufficient setup time.
- f. The data setup and hold time must not be less than the specified receiver setup and hold time.

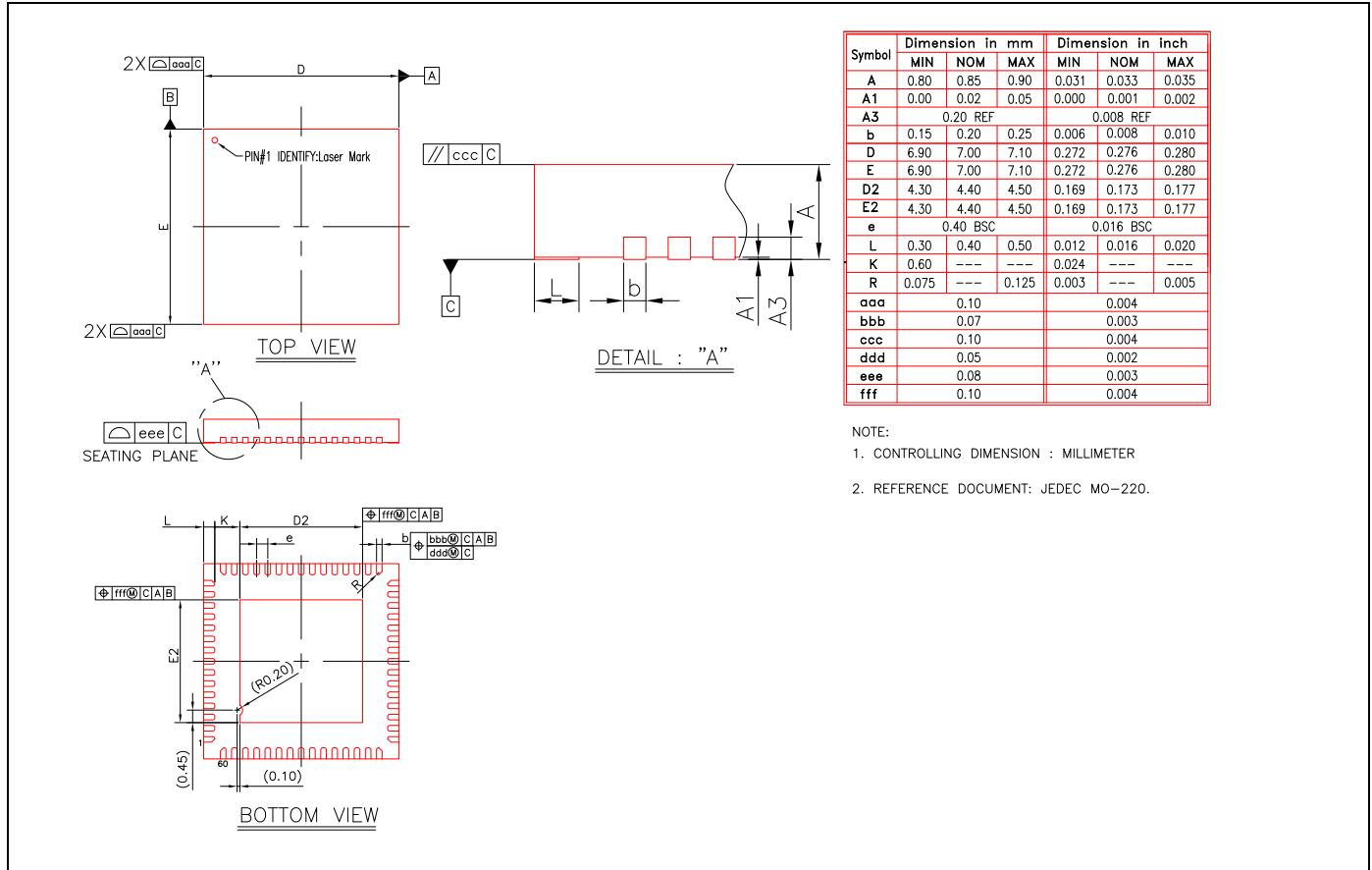
**Figure 13. I<sup>2</sup>S Transmitter Timing**

**Figure 14. I<sup>2</sup>S Receiver Timing**


## 4. Mechanical Information

### 4.1 Package Diagrams

#### 4.1.1 60-Pin QFN Package

Figure 15. CYW20735B1 7 mm × 7 mm 60-Pin QFN Package





## 4.2 Tray Packaging Specifications

### 4.2.1 QFN

The CYW20735B1 QFN package and tray dimensions are annotated in Figure 16 and defined in Table 29 and Table 30 on page 41.

Figure 16. QFN Package and Tray Dimensions

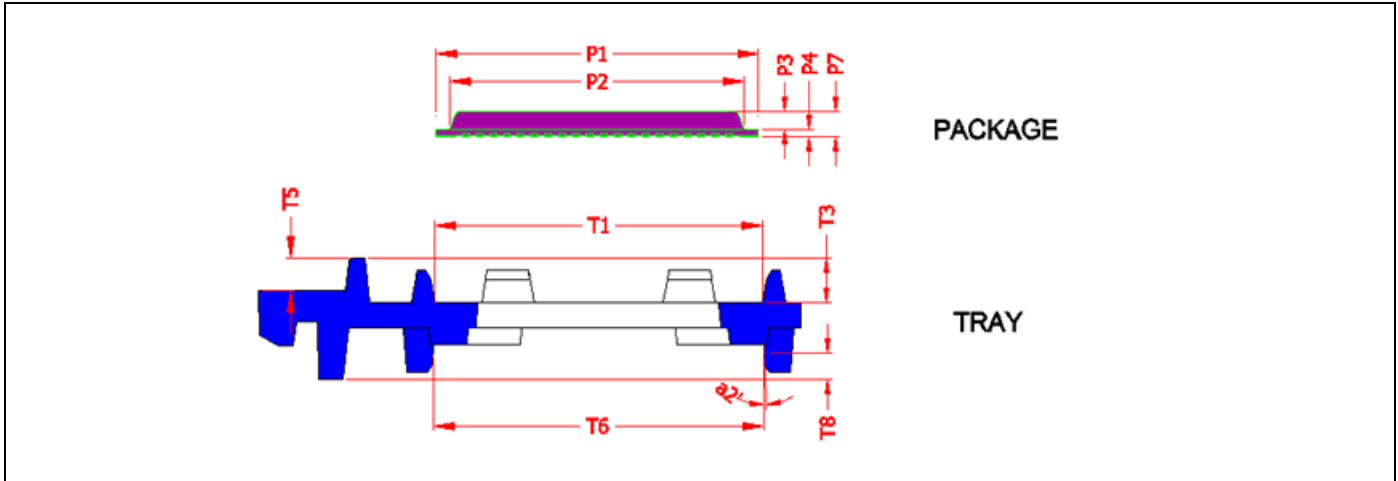


Table 29. QFN Package Dimensions and Tolerances

| Parameter | Description               | Nom. | Min. | Max. | ± Tol. | Unit |
|-----------|---------------------------|------|------|------|--------|------|
| P1        | Package size              | 7    | 6.9  | 7.1  | 0.1    | mm   |
| P2        | Top hat width             | 0    | 0    | 0    | –      | mm   |
| P3        | Top hat height            | 0    | 0    | 0    | –      | mm   |
| P4        | Substrate thickness       | 0.85 | 0.8  | 0.9  | 0.05   | mm   |
| P7        | Total thickness (P3 + P4) | 0.85 | 0.8  | 0.9  | 0.05   | mm   |

Table 30. QFN Tray Dimensions and Tolerances

| Parameter | Description                              | Nom.  | Min. | Max. | ± Tol. | Unit    |
|-----------|--|-------|------|------|--------|---------|
| T1        | Top pocket size                          | 7.25  | 7.17 | 7.33 | 0.08   | mm      |
| T3        | Top pocket depth                         | 1.75  | 1.5  | 2    | 0.25   | mm      |
| T5        | Stacking height                          | 2     | 1.87 | 2.13 | 0.13   | mm      |
| T6        | Bottom pocket size                       | 7.25  | 7.17 | 7.33 | 0.08   | mm      |
| T8        | Bottom pocket depth                      | 1.650 | 1.52 | 1.78 | 0.13   | mm      |
| a2        | Bottom pocket relief wall draft angle    | 5     | 5    | 5    | 0      | Degrees |
| T10       | Packing value between two stacking trays | 0.2   | 0.07 | 0.33 | 0.13   | mm      |

## 5. Ordering Information

Table 31. Ordering Information

| Part Number      | Package    | Ambient Operating Temperature |
|------------------|------------|-------------------------------|
| CYW20735B1PKML1G | 60-pin QFN | 0°C to 70°C                   |

## 6. Additional Information

### 6.1 IoT Resources

Cypress provides a wealth of data at <http://www.cypress.com/internet-things-iot> to help you to select the right IoT device for your design, and quickly and effectively integrate the device into your design. Cypress provides customer access to a wide range of information, including technical documentation, schematic diagrams, product bill of materials, PCB layout information, and software updates. Customers can acquire technical documentation and software from the Cypress Support Community website (<https://community.cypress.com/>)

### 6.2 Acronyms and Abbreviations

In most cases, acronyms and abbreviations are defined upon first use. For a more complete list of acronyms and other terms used in Cypress documents, go to: <http://www.cypress.com/glossary>.

The following list of acronyms and abbreviations may appear in this document.

| Term        | Description  |
|-------------|--|
| ADC         | analog-to-digital converter  |
| AFH         | adaptive frequency hopping   |
| AHB         | advanced high-performance bus  |
| APB         | advanced peripheral bus  |
| APU         | audio processing unit  |
| ARM7TDMI-S™ | Acorn RISC Machine 7 Thumb instruction, Debugger, Multiplier, Ice, Synthesizable |
| BSC         | Broadcom Serial Control  |
| BTC         | Bluetooth controller   |
| COEX        | coexistence  |
| DFU         | device firmware update   |
| DMA         | direct memory access   |
| EBI         | external bus interface   |
| HCI         | Host Control Interface   |
| HV          | high voltage   |
| IDC         | initial digital calibration  |
| IF          | intermediate frequency   |
| IRQ         | interrupt request  |
| JTAG        | Joint Test Action Group  |
| LCU         | link control unit  |
| LDO         | low drop-out   |
| LHL         | lean high land   |
| LPO         | low power oscillator   |

| Term          | Description  |
|---------------|--|
| LV            | LogicVision™   |
| MIA           | multiple interface agent   |
| PDM           | pulse density modulation   |
| PLL           | phase locked loop  |
| PMU           | power management unit  |
| PWM           | pulse width modulation   |
| QD            | quadrature decoder   |
| RAM           | random access memory   |
| RC oscillator | A resistor-capacitor oscillator is a circuit composed of an amplifier, which provides the output signal, and a resistor-capacitor network, which controls the frequency of the signal. |
| RF            | radio frequency  |
| ROM           | read-only memory   |
| RX/TX         | receive, transmit  |
| SPI           | serial peripheral interface  |
| SW            | software   |
| SWD           | serial wire debug  |
| UART          | universal asynchronous receiver/transmitter  |
| UPI           | μ-processor interface  |
| WD            | watchdog   |

**Document History Page**

| Document Title: CYW20735B1 Single-Chip Bluetooth Transceiver for Wireless Input Devices |         |                 |                 |  |
|---|---------|-----------------|-----------------|--|
| Document Number: 002-14881  |         |                 |                 |  |
| Revision  | ECN     | Orig. of Change | Submission Date | Description of Change  |
| **  | -       | -               | 05/19/2015      | 20735-DS100-R<br>Initial release   |
| *A  | -       | -               | 10/13/2015      | 20735-DS101-R<br>See the release for the applicable change description.  |
| *B  | -       | -               | 11/09/2015      | 20735-DS102-R<br>Updated:<br>Table 3: "Reference Crystal Electrical Specifications," on page 21.<br>Section 5: "Ordering Information," on page 60: updated the part number for the QFN chip.   |
| *C  | -       | -               | 12/04/2015      | 20735-DS103-R<br><b>Updated:</b><br>Table 3: "Reference Crystal Electrical Specifications," on page 22.<br>Table 9: "Core Buck Regulator," on page 45.<br>Table 10: "Digital LDO," on page 46.<br>Table 11: "PA LDO," on page 47.<br>Table 12: "RF LDO," on page 48.<br>Table 13: "Digital I/O Characteristics," on page 49.<br>Table 14: "BLE Current Consumption," on page 49.<br>Table 19: "UART Timing Specifications," on page 54.<br><b>Added:</b> • "Tray Packaging Specifications" on page 60.<br><b>Removed</b> • Table 15: "BR Current Consumption," on page 48. • "Tape and Reel Packaging Specifications," on page 59. |
| *D  | -       | -               | 03/10/2016      | 20735-DS104-R<br><b>Updated:</b><br>Table 14: "BLE Current Consumption," on page 46  |
| *E  | -       | -               | 05/26/2016      | 20735-DS105-R<br><b>Updated:</b><br>Table 8: "Absolute Maximum Ratings," on page 42.<br>Table 13: "Core Buck Regulator," on page 44.<br>Table 14: "Digital LDO," on page 45.<br>Table 15: "PA LDO," on page 46.<br>Table 16: "RF LDO," on page 47.<br>Table 19: "ADC Microphone Specifications," on page 49.<br><b>Added:</b><br>"Table 9: "ESD/Latchup," on page 42.<br>Table 10: "Environmental Ratings," on page 43.<br>Table 11: "Recommended Operating Conditions," on page 43.<br>Table 12: "Shutdown Voltage," on page 43.<br>"Power-On Reset" on page 14<br>"Brownout Detection" on page 14                                |
| *F  | 5446946 | UTSV            | 09/29/2016      | Converted to Cypress template  |
| *G  | 5688133 | CLEU            | 05/22/2017      | Updated <a href="#">Table 24. UART Timing Specifications</a> .<br>Added <a href="#">Table 28, Figure 13</a> and <a href="#">Figure 14</a> .  |

| Document Title: CYW20735B1 Single-Chip Bluetooth Transceiver for Wireless Input Devices |         |      |            |   |
|---|---------|------|------------|---|
| Document Number: 002-14881  |         |      |            |   |
| *H  | 6123642 | MILI | 04/18/2018 | <p>Removed "CYW20735KFBG" from <a href="#">Mapping Table for Part Number between Broadcom and Cypress</a> and <a href="#">Ordering Information</a>.</p> <p>Removed "111 pin fine pitch ball grid array (FBGA)" throughout the document.</p> <p>Replaced Default Alternate Function Description for QFN Pin 12 as "Reserved for system use. Leave this GPIO unconnected".</p> <p>Removed 1.17 Infrared Learning.</p> <p>Removed FBGA Pin Number column from <a href="#">Table 6</a> and <a href="#">Table 7</a>.</p> <p>Added <a href="#">Table 1. Bluetooth Features</a>.</p> <p>Changed BSC to I<sup>2</sup>C throughout the document.</p> |
| *I  | 6284060 | SGUP | 08/17/2018 | <p>Updated the Part Number as "CYW20735B1".</p> <p>Removed "Cypress Part Numbering Scheme".</p> <p>Updated <a href="#">Features</a> section and <a href="#">Figure</a> .</p> <p>Updated <a href="#">Table 6</a>, <a href="#">Table 7</a>.</p> <p>Changed the heading "Ball Maps" to <a href="#">Pinouts</a>.</p> <p>Updated <a href="#">Ordering Information</a> table.</p>   |

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