



Single-Chip Bluetooth Low Energy-Only System-On-Chip with Support for Wireless Charging

GENERAL DESCRIPTION

The Broadcom® BCM20737 is an advanced Bluetooth low energy (aka Bluetooth Smart) SoC that supports wireless charging, includes advanced security features and introduces new software support for NFC pairing. The BCM20737 is designed to support the entire spectrum of Bluetooth Smart use cases for the medical, home automation, accessory, sensor, Internet Of Things, and wearable market segments.

The BCM20737 radio has been designed to provide low power, low cost, and robust communications for applications operating in the globally available 2.4 GHz unlicensed Industrial, Scientific, and Medical (ISM) band.

The single-chip Bluetooth low energy SoC is a monolithic component implemented in a standard digital CMOS process and requires minimal external components to make a fully compliant Bluetooth device. The BCM20737 is available in a 32-pin, 5 mm × 5 mm 32-QFN package as well as WLPGA SIP and die packages.

APPLICATIONS

The following profiles are supported^a in ROM:

- Battery status
- Blood pressure monitor
- Find me
- Heart rate monitor
- Proximity
- Thermometer
- Weight scale
- Time

Additional profiles that can be supported^a from RAM include:

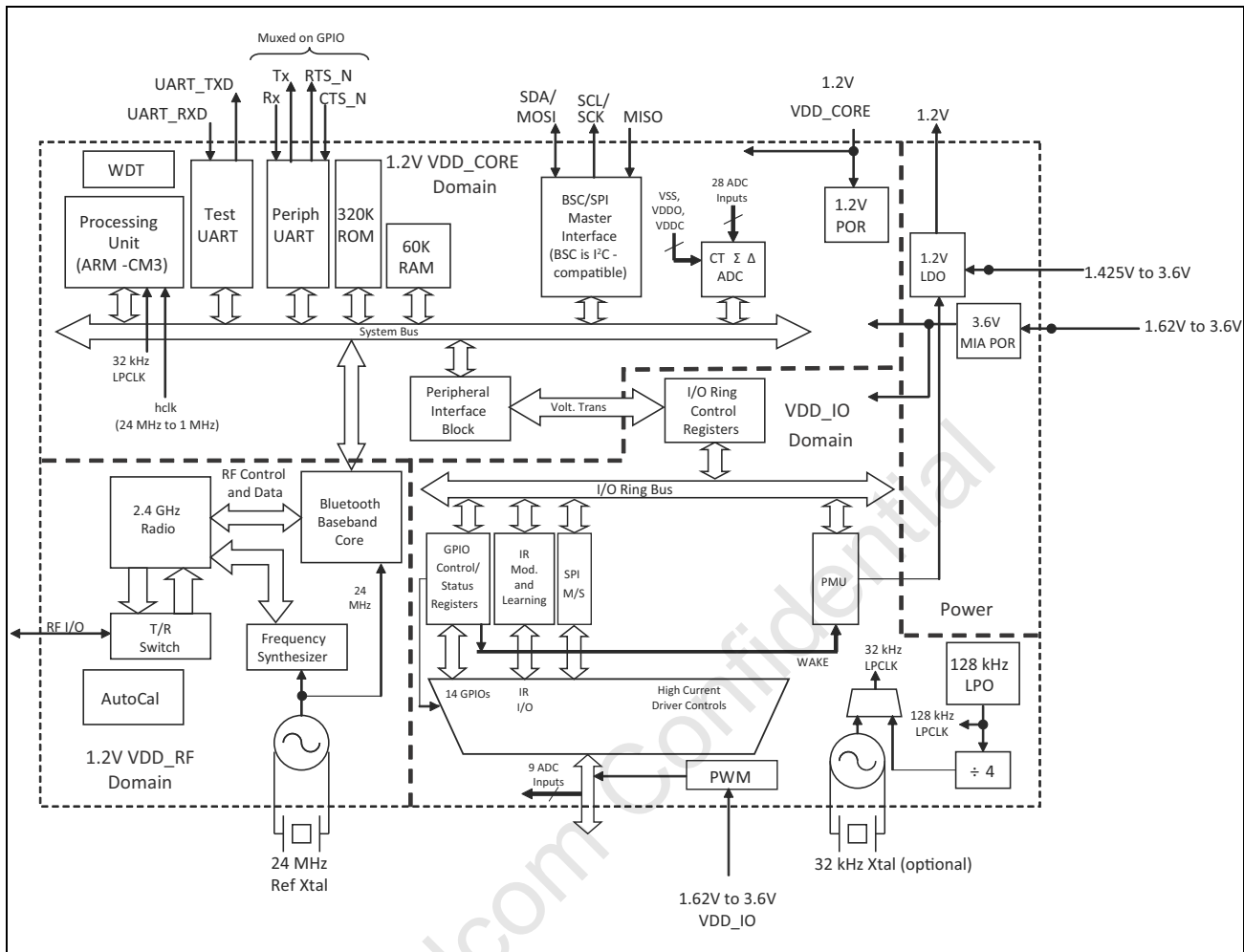
- Blood glucose monitor
- Temperature alarm
- Location

a. Full qualification and use of these profiles may require FW updates from Broadcom. Some of these profiles are under development/approval at the Bluetooth SIG and conformity with the final approved version is pending. Contact your supplier for updates and the latest list of profiles.

FEATURES

- Alliance for Wireless Power (A4WP) wireless charging
- Support for RSA encryption/decryption and key exchange mechanisms (up to 4 kbit)
- Support for X.509 certificate exchange
- Support for NFC tag-based "tap-to-pair"
- Support for Bluetooth Smart Based Audio
- Bluetooth low energy (BLE)-compliant
- Infrared modulator
- IR learning
- Supports Adaptive Frequency Hopping
- Excellent receiver sensitivity
- 10-bit auxiliary ADC with nine analog channels
- On-chip support for serial peripheral interface (master and slave modes)
- Broadcom Serial Communications interface (compatible with Philips® I²C slaves)
- Programmable output power control
- Integrated ARM® Cortex™-M3 based microprocessor core
- Automation Profile
- Support for secure OTA
- On-chip power-on reset (POR)
- Support for EEPROM and serial flash interfaces
- Integrated low-dropout regulator (LDO)
- On-chip software controlled power management unit
- Package type:
 - 32-pin 32-QFN package (5 mm × 5 mm)
- RoHS compliant

Figure 1: Functional Block Diagram



Revision History

| <i>Revision</i> | <i>Date</i> | <i>Change Description</i> |
|-----------------|-------------|---------------------------|
| 20737-DS100-R | 05/30/14 | Initial release. |

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About This Document

Purpose and Audience

This data sheet provides a description of the major blocks, interfaces, pin assignments, and specifications of the BCM20736 single-chip Bluetooth low energy (BLE) SoC. This is a required document for designers responsible for adding the BCM20736 BLE SoC to wireless input device applications including heart-rate monitors, blood-pressure monitors, proximity sensors, temperature sensors, wireless chargers, and battery monitors. Acronyms and Abbreviations

In most cases, acronyms and abbreviations are defined on first use.

Acronyms and abbreviations in this document are also defined in Appendix A: “Acronyms and Abbreviations,” on page 44.

For a comprehensive list of acronyms and other terms used in Broadcom documents, go to: <http://www.broadcom.com/press/glossary.php>.

Document Conventions

The following conventions may be used in this document:

| Convention | Description |
|-------------------|---|
| Bold | User input and actions: for example, type exit , click OK , press Alt+C |
| Monospace | Code: <code>#include <iostream></code> HTML: <code><td rowspan = 3></code> Command line commands and parameters: <code>w1 [-1] <command></code> |
| < > | Placeholders for <i>required</i> elements: enter your <code><username></code> or <code>w1 <command></code> |
| [] | Indicates <i>optional</i> command-line parameters: <code>w1 [-1]</code> Indicates bit and byte ranges (inclusive): <code>[0:3]</code> or <code>[7:0]</code> |

Technical Support

Broadcom provides customer access to a wide range of information, including technical documentation, schematic diagrams, product bill of materials, PCB layout information, and software updates through its customer support portal (<https://support.broadcom.com>). For a CSP account, contact your Sales or Engineering support representative.

In addition, Broadcom provides other product support through its Downloads and Support site (<http://www.broadcom.com/support/>).

Section 1: Functional Description

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 data routing for all connections. It also buffers data that passes through it, handles data flow control, schedules ACL 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.

The following transmit and receive functions are also implemented in the BBC hardware to increase TX/RX data reliability and security before sending over the air:

- Receive Functions: symbol timing recovery, data deframing, forward error correction (FEC), header error control (HEC), cyclic redundancy check (CRC), data decryption, and data dewatering.
- Transmit Functions: data framing, FEC generation, HEC generation, CRC generation, link key generation, data encryption, and data whitening.

Frequency Hopping Generator

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

E0 Encryption

The encryption key and the encryption engine are implemented using dedicated hardware to reduce software complexity and provide minimal processor intervention.

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, which takes software commands, and other controllers that are activated or configured by the Command Controller to perform the link control tasks. Each task performs a different Bluetooth link controller state. STANDBY and CONNECTION are the two major states. In addition, there are five substates: page, page scan, inquiry, and inquiry scan.

Adaptive Frequency Hopping

The BCM20737 gathers link quality statistics on a channel-by-channel basis to facilitate channel assessment and channel map selection. The link quality is determined by using both RF and baseband signal processing to provide a more accurate frequency hop map.

Bluetooth Low Energy Profiles

The BCM20737 supports Bluetooth low energy, including the following profiles that are supported¹ in ROM:

- Battery status
- Blood pressure monitor
- Find me
- Heart rate monitor
- Proximity
- Thermometer
- Weight scale
- Time
- Alliance for Wireless Power (A4WP) wireless charging
- Automation profile
- Support for secure OTA

The following additional profiles can be supported¹ from RAM:

- Blood glucose monitor
- Temperature alarm
- Location
- Custom profile

Test Mode Support

The BCM20737 fully supports Bluetooth Test mode, as described in the Bluetooth low energy specification.

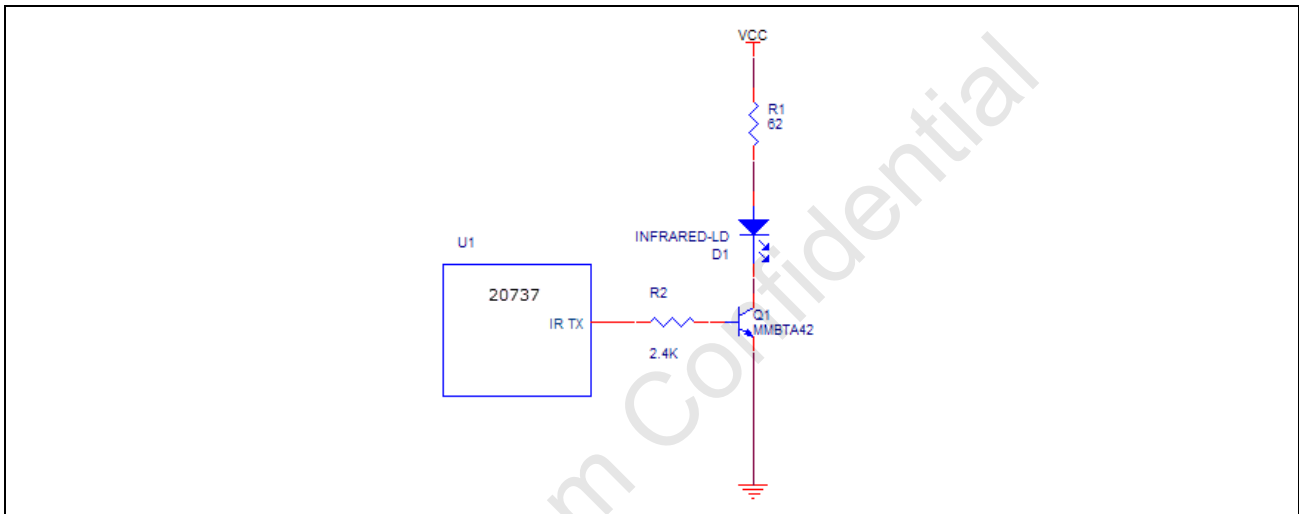
1. Full qualification and use of these profiles may require FW updates from Broadcom. Some of these profiles are under development/approval at the Bluetooth SIG and conformity with the final approved version is pending. Contact your supplier for updates and the latest list of profiles.

Infrared Modulator

The BCM20737 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 μ sec. The BCM20737 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 2](#)).

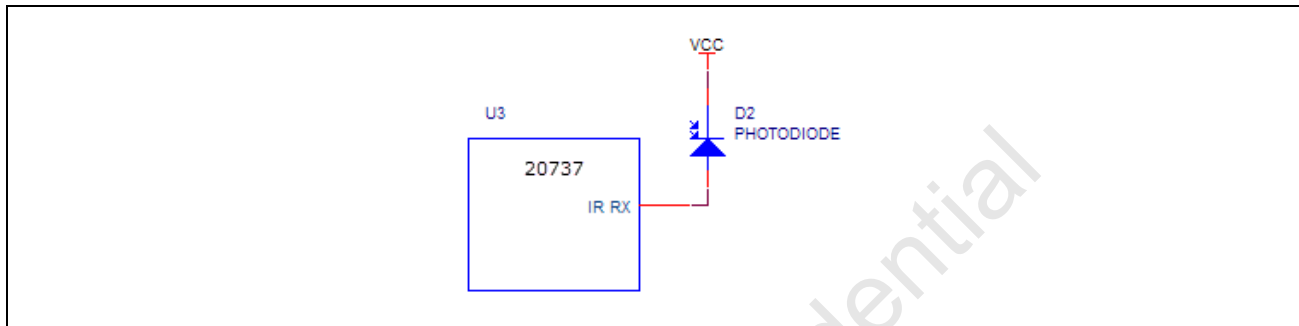
Figure 2: Infrared TX



Infrared Learning

The BCM20737 includes hardware support for infrared learning. The hardware can detect both modulated and unmodulated signals. For modulated signals, the BCM20737 can detect carrier frequencies between 10 kHz–500 kHz and the duration that the signal is present or absent. The BCM20737 firmware driver supports further analysis and compression of learned signal. The learned signal can then be played back through the BCM20737 IR TX subsystem (see [Figure 3](#)).

Figure 3: Infrared RX



Wireless Charging

The BCM20737 includes support for wireless charging in hardware, software, and firmware. It supports the protocol for implementing wireless charging solutions based on the specifications written by the Alliance for Wireless Power (A4WP).

The A4WP protocol is embedded in the BCM20737. Hardware and firmware elements required for wireless charging are either implemented in the BCM20737 or can be obtained through a Broadcom technical support representative (see [page 8](#)).

An end-to-end charging solution comprises of the following:

- **Power Transmitting Unit (PTU):** The PTU transfers the power to the receiving unit. The receiving unit is any device (phone, wearable, or other embedded device) that needs to be charged. The PTU is typically plugged into a power source such as a wall outlet. The BCM20737 includes the peripherals needed to implement and drive a reference charging circuit and otherwise requires only a few external components. PTU reference designs based on the BCM20737, including bills of material (BOMs), are available through Broadcom technical support. Depending on charging power requirements, a Power Management Unit (PMU) such as the BCM8935X may be included in the design. However, most PTUs requiring < 5W will not need a PMU. The references designs leverage ADCs, PWMs, and other internal peripherals to help drive the charging circuitry for energy transfer as well as provide feedback for charging control. The application and algorithm that drive the reference designs are available on request.
- **Power Receive Unit (PRU):** The PRU receives energy from the PTU to charge the local device, and is typically embedded in the local device. Like the PTU, a separate PMU may or may not be needed depending on power requirements. PRU reference designs based on the BCM20736, both with and without a PMU, are also available through Broadcom technical support.

Security

BCM20737 provides elaborate mechanisms for implementing security and authentication schemes using:

- RSA (Public Key Cryptography)
- X.509 (excluding parsing)
- Hash functions: MD5, SHA-1, SHA-224, SHA-256, SHA-384, SHA-512
- Message authentication code: HMAC MD5, HMAC SHA-1



Note: Details on how to use this functionality via SDK are available in application notes on this topic.

Support for NFC Tag Based Pairing

BCM20737 provides support for "ease of pairing" and "secure key exchange" use cases using passive tags. Active tags can be used with the chip for OOB pairing. In a typical use case, the BCM20203 (NFC tag) can be used to provide "tap to pair" functionality for easy pairing.



Note: Details on how to use this functionality via SDK are available in application notes on this topic.

Bluetooth Smart Audio

BCM20737 supports using the BLE link for audio streaming. This functionality can be used for audio applications in toys, wearable, and HID devices, as well as in hearing aids.



Note: Details on how to use this functionality via SDK are available in application notes on this topic.

ADC Port

The BCM20737 contains a 16-bit ADC (effective number of bits is 10).

Additionally:

- There are 9 analog input channels in the 32-pin package
- The following GPIOs can be used as ADC inputs:
 - P0
 - P1
 - P8/P33 (select only one)
 - P11
 - P12
 - P13/P28 (select only one)
 - P14/P38 (select only one)
 - P15
 - P32
- The conversion time is 10 μ s.
- There is a built-in reference with supply- or bandgap-based reference modes.
- The maximum conversion rate is 187 kHz.
- There is a rail-to-rail input swing.

The ADC consists of an analog ADC core that performs the actual analog-to-digital conversion and digital hardware that processes the output of the ADC core into valid ADC output samples. Directed by the firmware, the digital hardware also controls the input multiplexers that select the ADC input signal V_{inp} and the ADC reference signals V_{ref} .

The ADC input range is selectable by firmware control:

- When an input range of 0–3.6V is used, the input impedance is 3 M Ω .
- When an input range of 0–2.4V is used, the input impedance is 1.84 M Ω .
- When an input range of 0–1.2V is used, the input impedance is 680 k Ω .

ADC modes are defined in [Table 1](#).

Table 1: ADC Modes

| <i>Mode</i> | <i>ENOB (Typical)</i> | <i>Maximum Sampling Rate (kHz)</i> | <i>Latency^a (μs)</i> |
|-------------|-----------------------|------------------------------------|--|
| 0 | 13 | 5.859 | 171 |
| 1 | 12.6 | 11.7 | 85 |
| 2 | 12 | 46.875 | 21 |
| 3 | 11.5 | 93.75 | 11 |
| 4 | 10 | 187 | 5 |

a. Settling time after switching channels.

Serial Peripheral Interface

The BCM20737 has two independent SPI interfaces. One is a master-only interface and the other can be either a master or a slave. Each interface has a 16-byte transmit buffer and a 16-byte receive buffer. To support more flexibility for user applications, the BCM20737 has optional I/O ports that can be configured individually and separately for each functional pin as shown in [Table 2](#), [Table 3](#), and [Table 4](#). The BCM20737 acts as an SPI master device that supports 1.8V or 3.3V SPI slaves. The BCM20737 can also act as an SPI slave device that supports a 1.8V or 3.3V SPI master.

Table 2: BCM20737 First SPI Set (Master Mode)

| Pin Name | SPI_CLK | SPI_MOSI | SPI_MISO^a | SPI_CS^b |
|---------------------|----------------|-----------------|-----------------------------|---------------------------|
| Configured Pin Name | SCL | SDA | – | – |
| | – | – | – | – |
| | – | – | P32 | P33 ^c |

- SPIFFY1 MISO should always be P32. Boot ROM does not configure any others.
- Any GPIO can be used as SPI_CS when SPI 1 is in master mode, and when the SPI slave is not a serial flash.
- P33 is always SPI_CS when a serial flash is used for non-volatile storage.

Table 3: BCM20737 Second SPI Set (Master Mode)

| Pin Name | SPI_CLK | SPI_MOSI | SPI_MISO | SPI_CS^a |
|---------------------|----------------|-----------------|-----------------|---------------------------|
| Configured Pin Name | P3 | P0 | P1 | – |
| | – | P4 | P25 | – |
| | P24 | P27 | – | – |

- Any GPIO can be used as SPI_CS when SPI is in master mode.

Table 4: BCM20737 Second SPI Set (Slave Mode)

| Pin Name | SPI_CLK | SPI_MOSI | SPI_MISO | SPI_CS |
|---------------------|----------------|-----------------|-----------------|---------------|
| Configured Pin Name | P3 | P0 | P1 | P2 |
| | – | P27 | – | – |
| | P24 | P33 | P25 | P26 |
| | – | – | – | P32 |

Microprocessor Unit

The BCM20737 microprocessor unit (μ PU) executes software from the link control (LC) layer up to the application layer components. The microprocessor is based on an ARM® Cortex™ M3, 32-bit RISC processor with embedded ICE-RT debug and JTAG interface units. The μ PU has 320 KB of ROM for program storage and boot-up, 60 KB of RAM for scratch-pad data, and patch RAM code. The SoC has a total storage of 380 KB, including RAM and ROM.

The internal boot ROM provides power-on reset flexibility, which enables the same device to be used in different HID applications with an external serial EEPROM or with an external serial flash memory. At power-up, the lowest layer of the protocol stack is executed from the internal ROM memory.

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

EEPROM Interface

The BCM20737 provides a Broadcom Serial Control (BSC) master interface. BSC is programmed by the CPU to generate four types of bus transfers: read-only, write-only, combined read/write, and combined write/read. BSC supports both low-speed and fast mode devices. BSC is compatible with an NXP® I²C slave device, except that master arbitration (multiple I²C masters contending for the bus) is not supported.

The EEPROM can contain customer application configuration information including application code, configuration data, patches, pairing information, BD_ADDR, baud rate, SDP service record, and file system information used for code.

Native support for the Microchip® 24LC128, Microchip 24AA128, and ST Micro® M24128-BR is included.

Serial Flash Interface

The BCM20737 includes an SPI master controller that can be used to access serial flash memory. The SPI master contains an AHB slave interface, transmit and receive FIFOs, and the SPI core PHY logic.

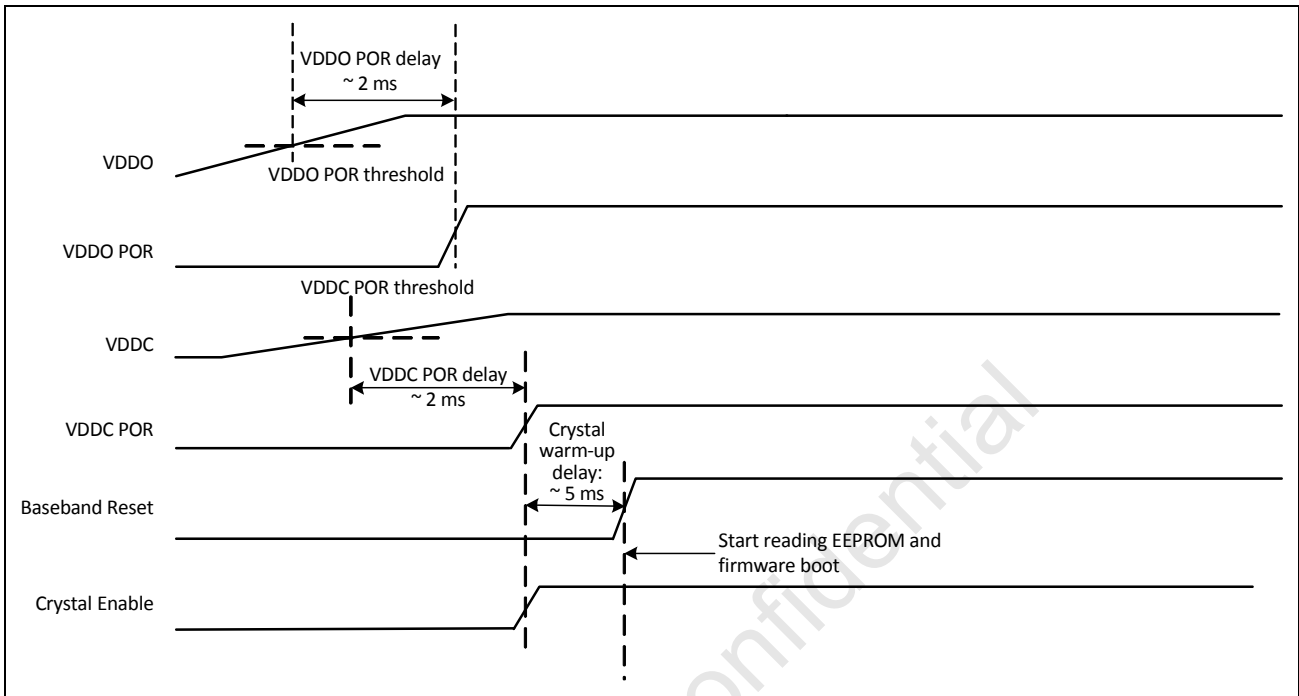
Devices natively supported include the following:

- Atmel® AT25BCM512B
- MXIC® MX25V512ZUI-20G

Other (larger) serial flash parts from MXIC, Numonyx, and Adesto with commands identical to these parts here are also supported.

Internal Reset

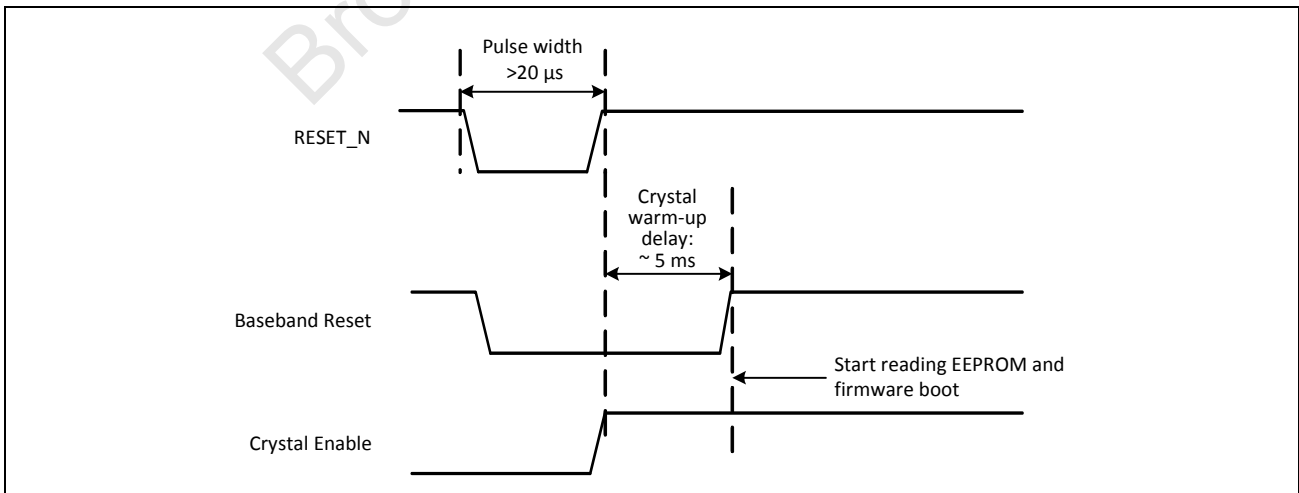
Figure 4: Internal Reset Timing



External Reset

The BCM20737 has an integrated power-on reset circuit that completely resets all circuits to a known power-on state. An external active low reset signal, **RESET_N**, can be used to put the BCM20737 in the reset state. The **RESET_N** pin has an internal pull-up resistor and, in most applications, it does not require that anything be connected to it. **RESET_N** should only be released after the VDDO supply voltage level has been stabilized.

Figure 5: External Reset Timing



Integrated Radio Transceiver

The BCM20737 has an integrated radio transceiver that is optimized for 2.4 GHz Bluetooth wireless systems. It has been designed to provide low power, low cost, and robust communications for applications operating in the globally available 2.4 GHz unlicensed ISM band. It is fully compliant with Bluetooth Radio Specification 4.0 and meets or exceeds the requirements to provide the highest communication link quality of service.

Transmitter Path

The BCM20737 features a fully integrated transmitter. The baseband transmit data is GFSK modulated in the 2.4 GHz ISM band.

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.

Power Amplifier

The BCM20737 has an integrated power amplifier (PA) that can transmit up to +4 dBm for class 2 operation.

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, and high-order, on-chip channel filtering to ensure reliable operation in the noisy 2.4 GHz ISM band. The front-end topology, which has built-in out-of-band attenuation, enables the BCM20737 to be used in most applications without off-chip filtering.

Digital Demodulator and Bit Synchronizer

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

Receiver Signal Strength Indicator

The radio portion of the BCM20737 provides a receiver signal strength indicator (RSSI) to the baseband. This enables the controller to 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.

Local Oscillator

The local oscillator (LO) provides fast frequency hopping (1600 hops/second) across the 79 maximum available channels. The BCM20737 uses an internal loop filter.

Calibration

The BCM20737 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 takes place transparently during normal operation and hop setting times.

Internal LDO Regulator

The BCM20737 has an integrated 1.2V LDO regulator that provides power to the digital and RF circuits. The 1.2V LDO regulator operates from a 1.425V to 3.63V input supply with a 30 mA maximum load current.



Note: Always place the decoupling capacitors near the pins as closely together as possible.

Peripheral Transport Unit

Broadcom Serial Communications Interface

The BCM20737 provides a 2-pin master BSC interface, which can be used to retrieve configuration information from an external EEPROM or to communicate with peripherals such as track-ball or touch-pad modules, and motion tracking ICs used in mouse devices. The BSC interface is compatible with I²C slave devices. The BSC does not support multimaster capability or flexible wait-state insertion by either master or slave devices.

The following transfer clock rates are supported by the BSC:

- 100 kHz
- 400 kHz
- 800 kHz (not a standard I²C-compatible speed.)
- 1 MHz (Compatibility with high-speed I²C-compatible devices is not guaranteed.)

The following transfer types are supported by the BSC:

- Read (Up to 16 bytes can be read.)
- Write (Up to 16 bytes can be written.)
- Read-then-Write (Up to 16 bytes can be read and up to 16 bytes can be written.)
- Write-then-Read (Up to 16 bytes can be written and up to 16 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 BCM20737 are required on both the SCL and SDA pins for proper operation.

UART Interface

The UART is a standard 2-wire interface (RX and TX) and has adjustable baud rates from 9600 bps to 1.5 kbps. The baud rate can be selected via a vendor-specific UART HCI command. The interface supports the Bluetooth 3.0 UART HCI (H4) specification. The default baud rate for H4 is 115.2 kbaud.

Both high and low baud rates can be supported by running the UART clock at 24 MHz.

The BCM20737 UART operates correctly with the host UART as long as the combined baud rate error of the two devices is within $\pm 5\%$.

Clock Frequencies

The BCM20737 is set with crystal frequency of 24 MHz.

Crystal Oscillator

The crystal oscillator requires a crystal with an accuracy of ± 20 ppm as defined by the Bluetooth specification. Two external load capacitors in the range of 5 pF to 30 pF (see [Figure 6](#)) are required to work with the crystal oscillator. The selection of the load capacitors is crystal-dependent. [Table 5](#) shows the recommended crystal specifications.

Figure 6: Recommended Oscillator Configuration—12 pF Load Crystal

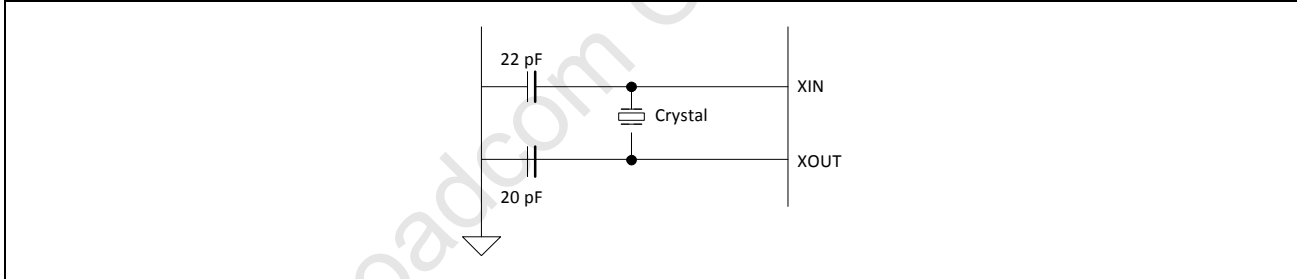


Table 5 shows the recommended crystal specifications.

Table 5: Reference Crystal Electrical Specifications

| Parameter | Conditions | Minimum | Typical | Maximum | Unit |
|-------------------------------|---------------|-------------|---------|---------|----------|
| Nominal frequency | – | – | 24.000 | – | MHz |
| Oscillation mode | – | Fundamental | | – | – |
| Frequency tolerance | @25°C | – | ±10 | – | ppm |
| Tolerance stability over temp | @0°C to +70°C | – | ±10 | – | ppm |
| Equivalent series resistance | – | – | – | 50 | Ω |
| Load capacitance | – | – | 12 | – | pF |
| Operating temperature range | – | 0 | – | +70 | °C |
| Storage temperature range | – | –40 | – | +125 | °C |
| Drive level | – | – | – | 200 | μW |
| Aging | – | – | – | ±10 | ppm/year |
| Shunt capacitance | – | – | – | 2 | pF |

Peripheral Block

The peripheral blocks of the BCM20737 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.

32 kHz Crystal Oscillator

Figure 7 shows the 32 kHz crystal (XTAL) oscillator with external components and Table 6 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 similar frequency. The default component values are: R1 = 10 MΩ, C1 = C2 = ~10 pF. The values of C1 and C2 are used to fine-tune the oscillator.

Figure 7: 32 kHz Oscillator Block Diagram

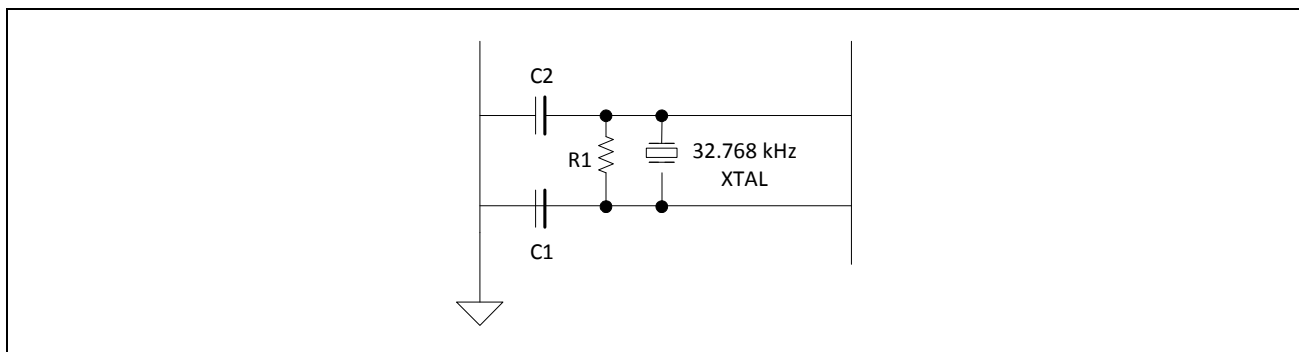


Table 6: XTAL Oscillator Characteristics

| 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 | $\text{k}\Omega$ |
| XTAL shunt capacitance | C_{shunt} | For crystal selection | – | – | 1.3 | pF |

GPIO Port

The BCM20737 has 14 general-purpose I/Os (GPIOs) in the 32-pin package. All GPIOs support programmable pull-up and pull-down resistors, and all support a 2 mA drive strength except P26, P27, and P28, which provide a 16 mA drive strength at 3.3V supply.

The following GPIOs are available:

- P0–P4
- P8/P33 (Dual bonded, only one of two is available.)
- P11/P27 (Dual bonded, only one of two is available.)
- P12/P26 (Dual bonded, only one of two is available.)
- P13/P28 (Dual bonded, only one of two is available.)
- P14/P38 (Dual bonded, only one of two is available.)
- P15
- P24
- P25
- P32

For a description of all GPIOs, see [Table 8: “GPIO Pin Descriptions,”](#) on page 27.

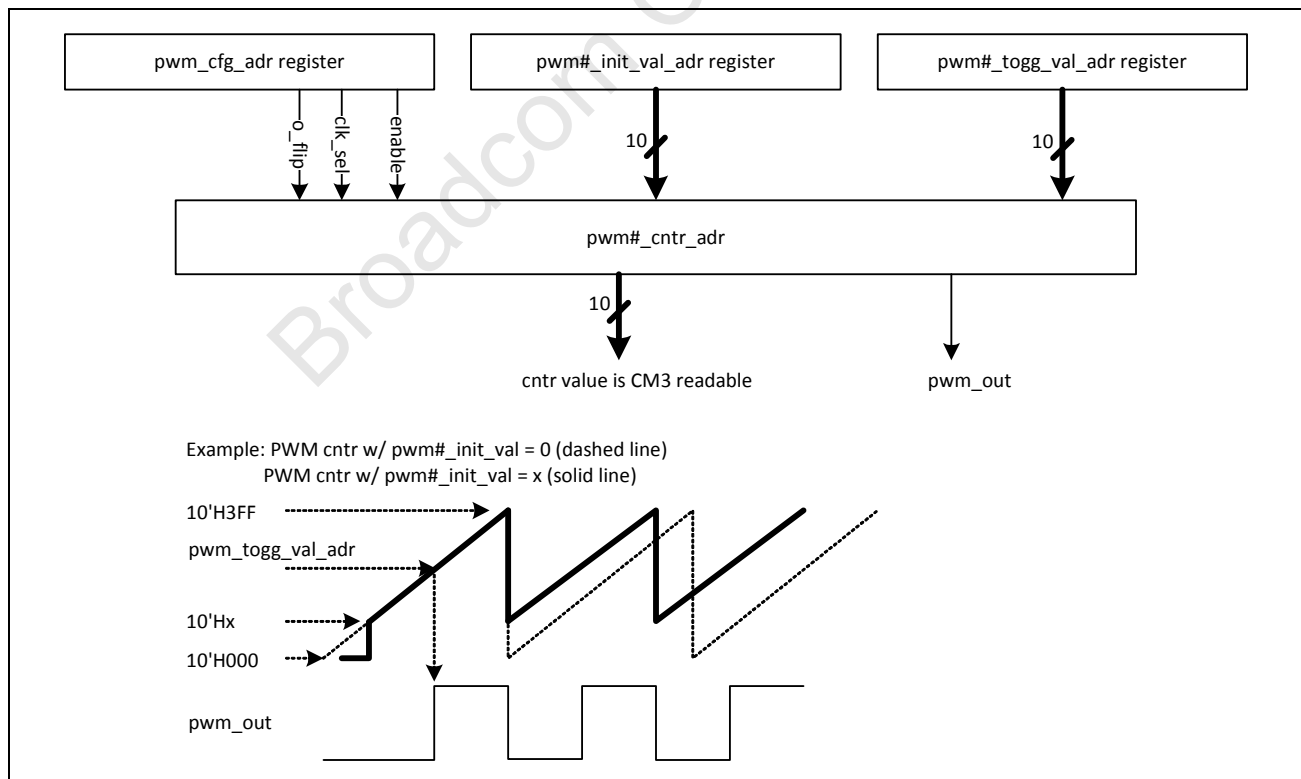
PWM

The BCM20737 has four internal PWM channels. The PWM module is described as follows:

- PWM0–3
- The following GPIOs can be mapped as PWMs:
 - P26
 - P27
 - P14/P28 (Dual bonded, only one of two is available.)
 - P13
- Each of the PWM channels, PWM0–3, contains the following registers:
 - 10-bit initial value register (read/write)
 - 10-bit toggle register (read/write)
 - 10-bit PWM counter value register (read)
- The PWM configuration register is shared among PWM0–3 (read/write). This 12-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 8 shows the structure of one PWM channel.

Figure 8: PWM Channel Block Diagram



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.

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.

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 deep sleep mode.

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 BCM20737 runs on the Low Power Oscillator and wakes up after a predefined time period.

The BCM20737 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
- Timed Deep Sleep mode

The BCM20737 transitions to the next lower state after a programmable period of user inactivity. Busy mode is immediately entered when user activity resumes.

In HIDEOFF (Deep Sleep) mode, the BCM20737 baseband and core are powered off by disabling power to LDOOUT. 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 intended for long periods of inactivity.

Section 2: Pin Assignments

Pin Descriptions

Table 7: Pin Descriptions

| Pin Number | Pin Name | I/O | Power Domain | Description |
|--|----------|--------|--------------|---|
| Radio I/O | | | | |
| 6 | RF | I/O | VDD_RF | RF antenna port |
| RF Power Supplies | | | | |
| 4 | VDDIF | I | VDD_RF | IFPLL power supply |
| 5 | VDDFE | I | VDD_RF | RF front-end supply |
| 7 | VDDVCO | I | VDD_RF | VCO, LOGEN supply |
| 8 | VDDPLL | I | VDD_RF | RFPLL and crystal oscillator supply |
| Power Supplies | | | | |
| 11 | VDDC | I | VDDC | Baseband core supply |
| 28 | VDDO | I | VDDO | I/O pad and core supply |
| 14 | VDDM | I | VDDM | I/O pad supply |
| Clock Generator and Crystal Interface | | | | |
| 9 | XTALI | I | VDD_RF | Crystal oscillator input. See page 20 for options. |
| 10 | XTALO | O | VDD_RF | Crystal oscillator output. |
| 1 | XTALI32K | I | VDDO | Low-power oscillator (LPO) input is used. Alternative Function: <ul style="list-style-type: none"> • P11 • P27 |
| 32 | XTALO32K | O | VDDO | Low-power oscillator (LPO) output. Alternative Function: <ul style="list-style-type: none"> • P12 • P26 |
| Core | | | | |
| 18 | RESET_N | I/O PU | VDDO | Active-low system reset with open-drain output & internal pull-up resistor |
| 17 | TMC | I | VDDO | Test mode control High: test mode Connect to GND if not used. |
| UART | | | | |
| 12 | UART_RXD | I | VDDM | UART serial input – Serial data input for the HCI UART interface. Leave unconnected if not used. Alternative function: <ul style="list-style-type: none"> • GPIO3 |

Table 7: Pin Descriptions (Cont.)

| Pin Number | Pin Name | I/O | Power Domain | Description |
|-------------------------------------|-----------------|------------|---------------------|--|
| 13 | UART_TXD | O, PU | VDDM | UART serial output – Serial data output for the HCI UART interface. Leave unconnected if not used. Alternative Function: <ul style="list-style-type: none"> GPIO2 |
| BSC | | | | |
| 15 | SDA | I/O, PU | VDDM | Data signal for an external I ² C device. Alternative function: <ul style="list-style-type: none"> SPI_1: MOSI (master only) GPIO0 CTS |
| 16 | SCL | I/O, PU | VDDM | Clock signal for an external I ² C device. Alternative function: <ul style="list-style-type: none"> SPI_1: SPI_CLK (master only) GPIO1 RTS |
| LDO Regulator Power Supplies | | | | |
| 2 | LDOIN | I | N/A | Battery input supply for the LDO |
| 3 | LDOOUT | O | N/A | LDO output |

Table 8: GPIO Pin Descriptions^a

| Pin Number | Pin Name | Default Direction | After POR State | Power Domain | Alternate Function Description |
|-------------------|-----------------|--------------------------|------------------------|---------------------|--|
| 19 | P0 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P0 A/D converter input Peripheral UART: puart_tx SPI_2: MOSI (master and slave) IR_RX 60Hz_main Not available during TMC=1 |
| 20 | P1 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P1 A/D converter input Peripheral UART: puart_rts SPI_2: MISO (master and slave) IR_TX |
| 21 | P3 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P3 Peripheral UART: puart_cts SPI_2: SPI_CLK (master and slave) |
| 22 | P2 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P2 Peripheral UART: puart_rx SPI_2: SPI_CS (slave only) SPI_2: SPI_MOSI (master only) |
| 23 | P4 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P4 Peripheral UART: puart_rx SPI_2: MOSI (master and slave) IR_TX |
| 24 | P8 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P8 A/D converter input External T/R switch control: ~tx_pd |
| | P33 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P33 A/D converter input SPI_2: MOSI (slave only) Auxiliary clock output: ACLK1 Peripheral UART: puart_rx |
| 1 | P11 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P11 A/D converter input XTALI32K |
| | P27 PWM1 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P27 SPI_2: MOSI (master and slave) Current: 16 mA |

Table 8: GPIO Pin Descriptions^a (Cont.)

| Pin Number | Pin Name | Default Direction | After POR State | Power Domain | Alternate Function Description |
|-------------------|-----------------|--------------------------|------------------------|---------------------|--|
| 32 | P12 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P12 A/D converter input XTALO32K |
| | P26 PWM0 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P26 SPI_2: SPI_CS (slave only) SPI_1: MISO (master only) Current: 16 mA |
| 29 | P13 PWM3 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P13 A/D converter input |
| | P28 PWM2 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P28 A/D converter input LED1 IR_TX Current: 16 mA |
| 30 | P14 PWM2 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P14 A/D converter input |
| | P38 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P38 A/D converter input SPI_2: MOSI (master and slave) IR_TX |
| 31 | P15 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P15 A/D converter input IR_RX 60 Hz_main |
| 27 | P24 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P24 SPI_2: SPI_CLK (master and slave) SPI_1: MISO (master only) Peripheral UART: puart_tx |
| 26 | P25 | Input | Input floating | VDDO | <ul style="list-style-type: none"> GPIO: P25 SPI_2: MISO (master and slave) Peripheral UART: puart_rx |

Table 8: GPIO Pin Descriptions^a (Cont.)

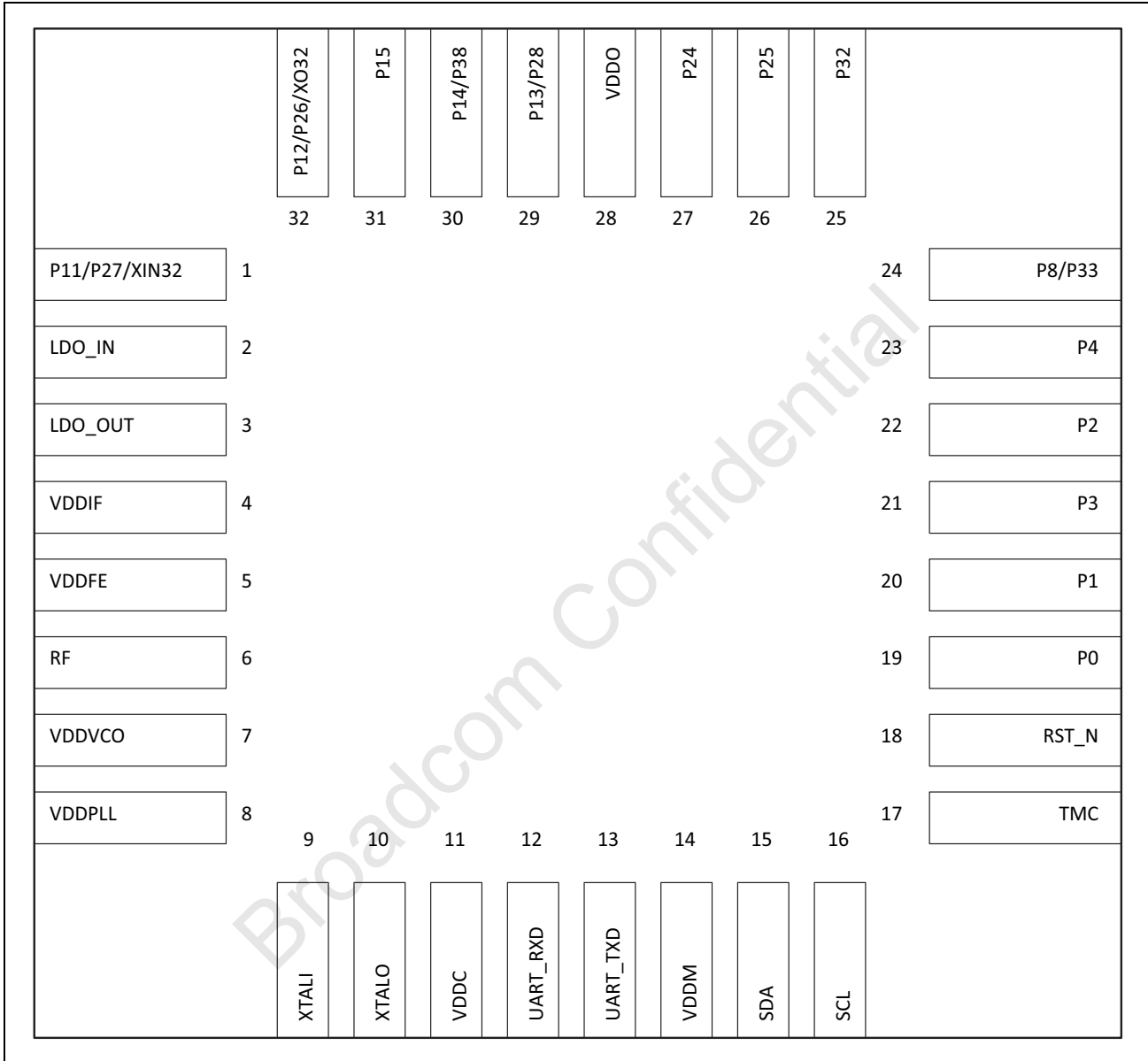
| Pin Number | Pin Name | Default Direction | After POR State | Power Domain | Alternate Function Description |
|-------------------|-----------------|--------------------------|------------------------|---------------------|---|
| 25 | P32 | Input | Input floating | VDDO | <ul style="list-style-type: none"> • GPIO: P32 • A/D converter input • SPI_2: SPI_CS (slave only) • SPI_1: MISO (master only) • Auxiliary clock output: ACLK0 • Peripheral UART: puart_tx |

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

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Ball Maps

Figure 9: 32-pin QFN Ball Map



Section 3: Specifications

Electrical Characteristics

Table 9 shows the maximum electrical rating for voltages referenced to VDD pin.

Table 9: Maximum Electrical Rating

| Rating | Symbol | Value | Unit |
|---|--------|----------------------------------|------|
| DC supply voltage for RF domain | – | 1.4 | V |
| DC supply voltage for core domain | – | 1.4 | V |
| DC supply voltage for VDDM domain (UART/I ² C) | – | 3.8 | V |
| DC supply voltage for VDDO domain | – | 3.8 | V |
| DC supply voltage for VR3V | – | 3.8 | V |
| DC supply voltage for VDDFE | – | 1.4 | V |
| Voltage on input or output pin | – | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V |
| Operating ambient temperature range | Topr | –30 to +85 | °C |
| Storage temperature range | Tstg | –40 to +125 | °C |

Table 10 shows the power supply characteristics for the range $T_J = 0$ to 125°C .

Table 10: Power Supply

| Parameter | Minimum ^a | Typical | Maximum ^a | Unit |
|--|----------------------|------------------|----------------------|------|
| DC supply voltage for RF | 1.14 | 1.2 | 1.26 | V |
| DC supply voltage for Core | 1.14 | 1.2 | 1.26 | V |
| DC supply voltage for VDDM (UART/I ² C) | 1.62 | – | 3.63 | V |
| DC supply voltage for VDDO | 1.62 | – | 3.63 | V |
| DC supply voltage for LDOIN | 1.425 | – | 3.63 | V |
| DC supply voltage for VDDFE | 1.14 | 1.2 ^b | 1.26 | V |

- a. Overall performance degrades beyond minimum and maximum supply voltages.
- b. 1.2V for Class 2 output with internal VREG.

Table 11 shows the digital level characteristics for (VSS = 0V).

Table 11: LDO Regulator Electrical Specifications

| Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------|--|-------|----------|------|---------------------|
| Input voltage range | – | 1.425 | – | 3.63 | V |
| Default output voltage | – | – | 1.2 | – | V |
| Output voltage | Range | 0.8 | – | 1.4 | V |
| | Step size | – | 40 or 80 | – | mV |
| | Accuracy at any step | –5 | – | +5 | % |
| Load current | – | – | – | 30 | mA |
| Line regulation | V _{in} from 1.425 to 3.63V, I _{load} = 30 mA | –0.2 | – | 0.2 | %V _O /V |
| Load regulation | I _{load} from 1 μA to 30 mA, V _{in} = 3.3V, Bonding R = 0.3Ω | – | 0.1 | 0.2 | %V _O /mA |
| Quiescent current | No load @V _{in} = 3.3V *Current limit enabled | – | 6 | – | μA |
| Power-down current | V _{in} = 3.3V, worst@70°C | – | 5 | 200 | nA |

Table 12 shows the specifications for the ADC characteristics.

Table 12: ADC Specifications

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|------------------------------------|----------------------|---|-------|------------------------------|--------|------------------|
| Number of Input channels | – | – | – | 9 | – | – |
| Channel switching rate | f _{ch} | – | – | – | 133.33 | kch/s |
| Input signal range | V _{inp} | – | 0 | – | 3.63 | V |
| Reference settling time | – | Changing refsel | 7.5 | – | – | μs |
| Input resistance | R _{inp} | Effective, single ended | – | 500 | – | kΩ |
| Input capacitance | C _{inp} | – | – | – | 5 | pF |
| Conversion rate | f _C | – | 5.859 | – | 187 | kHz |
| Conversion time | T _C | – | 5.35 | – | 170.7 | μs |
| Resolution | R | – | – | 16 | – | bits |
| Effective number of bits | – | In specified performance range | – | See Table 1 on page 14 | – | – |
| Absolute voltage measurement error | – | Using on-chip ADC firmware driver | – | ±2 | – | % |
| Current | I | I _{avdd1p2} + I _{avdd3p3} | – | – | 1 | mA |
| Power | P | – | – | 1.5 | – | mW |
| Leakage current | I _{leakage} | T = 25°C | – | – | 100 | nA |
| Power-up time | T _{powerup} | – | – | – | 200 | μs |
| Integral nonlinearity ³ | INL | In guaranteed performance range | –1 | – | 1 | LSB ^a |

Table 12: ADC Specifications (Cont.)

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|--|--------|---------------------------------|-----|-----|-----|------------------|
| Differential nonlinearity ^a | DNL | In guaranteed performance range | -1 | - | 1 | LSB ^a |

a. LSBs are expressed at the 10-bit level.

Table 13 shows the specifications for the digital voltage levels.

Table 13: Digital Levels^a

| Characteristics | Symbol | Min | Typ | Max | Unit |
|-----------------------------------|----------|-----------------------|------|-----|------|
| Input low voltage | V_{IL} | - | - | 0.4 | V |
| Input high voltage | V_{IH} | $0.75 \times V_{DDO}$ | - | - | V |
| Input low voltage (VDDO = 1.62V) | V_{IL} | - | - | 0.4 | V |
| Input high voltage (VDDO = 1.62V) | V_{IH} | 1.2 | - | - | V |
| Output low voltage ^b | V_{OL} | - | - | 0.4 | V |
| Output high voltage ^b | V_{OH} | $V_{DDO} - 0.4$ | - | - | V |
| Input capacitance (VDDMEM domain) | C_{IN} | - | 0.12 | - | pF |

a. This table is also applicable to VDDMEM domain.

b. At the specified drive current for the pad.

Table 14 shows the specifications for current consumption.

Table 14: Current Consumption^a

| Operational Mode | Conditions | Typ | Max | Unit |
|------------------|---|------|------|---------|
| Receive | Receiver and baseband are both operating, 100% ON. | 9.8 | 10.0 | mA |
| Transmit | Transmitter and baseband are both operating, 100% ON. | 9.1 | 9.3 | mA |
| Sleep | Internal LPO is in use. | 12.0 | 13.0 | μ A |
| | | 0.65 | - | |

a. Currents measured between power terminals (Vdd) using 90% efficient DC-DC converter at 3V.

RF Specifications

Table 15: Receiver RF Specifications

| Parameter | Mode and Conditions | Min | Typ | Max | Unit |
|--|----------------------------|------------|------------|------------|-------------|
| Receiver Section^a | | | | | |
| Frequency range | – | 2402 | – | 2480 | MHz |
| RX sensitivity (standard) | 0.1%BER, 1 Mbps | – | TBD | – | dBm |
| RX sensitivity (low current) | | – | TBD | – | dBm |
| Input IP3 | – | –16 | – | – | dBm |
| Maximum input | – | –10 | – | – | dBm |
| Interference Performance^{a,b} | | | | | |
| C/I cochannel | 0.1%BER | – | – | 21 | dB |
| C/I 1 MHz adjacent channel | 0.1%BER | – | – | 15 | dB |
| C/I 2 MHz adjacent channel | 0.1%BER | – | – | –17 | dB |
| C/I \geq 3 MHz adjacent channel | 0.1%BER | – | – | –27 | dB |
| C/I image channel | 0.1%BER | – | – | –9.0 | dB |
| C/I 1 MHz adjacent to image channel | 0.1%BER | – | – | –15 | dB |
| Out-of-Band Blocking Performance (CW)^{a,b} | | | | | |
| 30 MHz to 2000 MHz | 0.1%BER ^c | – | –30.0 | – | dBm |
| 2003 MHz to 2399 MHz | 0.1%BER ^d | – | –35 | – | dBm |
| 2484 MHz to 2997 MHz | 0.1%BER ^d | – | –35 | – | dBm |
| 3000 MHz to 12.75 GHz | 0.1%BER ^e | – | –30.0 | – | dBm |
| Spurious Emissions | | | | | |
| 30 MHz to 1 GHz | – | – | – | –57.0 | dBm |
| 1 GHz to 12.75 GHz | – | – | – | –55.0 | dBm |

a. 30.8% PER.

b. Desired signal is 3 dB above the reference sensitivity level (defined as –70 dBm).

c. Measurement resolution is 10 MHz.

d. Measurement resolution is 3 MHz.

e. Measurement resolution is 25 MHz.

Table 16: Transmitter RF Specifications

| Parameter | Minimum | Typical | Maximum | Unit |
|-------------------------------|----------------|----------------|----------------|-------------|
| Transmitter Section | | | | |
| Frequency range | 2402 | – | 2480 | MHz |
| Output power adjustment range | –20 | – | 4 | dBm |
| Default output power | – | 4.0 | – | dBm |
| Output power variation | – | 2.0 | – | dB |
| Adjacent Channel Power | | | | |

Table 16: Transmitter RF Specifications (Cont.)

| Parameter | Minimum | Typical | Maximum | Unit |
|---|----------------|----------------|----------------|----------------|
| $ M - N = 2$ | – | – | –20 | dBm |
| $ M - N \geq 3$ | – | – | –30 | dBm |
| Out-of-Band Spurious Emission | | | | |
| 30 MHz to 1 GHz | – | – | –36.0 | dBm |
| 1 GHz to 12.75 GHz | – | – | –30.0 | dBm |
| 1.8 GHz to 1.9 GHz | – | – | –47.0 | dBm |
| 5.15 GHz to 5.3 GHz | – | – | –47.0 | dBm |
| LO Performance | | | | |
| Initial carrier frequency tolerance | – | – | ± 150 | kHz |
| Frequency Drift | | | | |
| Frequency drift | – | – | ± 50 | kHz |
| Drift rate | – | – | 20 | kHz/50 μ s |
| Frequency Deviation | | | | |
| Average deviation in payload (sequence used is 00001111) | 225 | – | 275 | kHz |
| Maximum deviation in payload (sequence used is 10101010) | 185 | – | – | kHz |
| Channel spacing | – | 2 | – | MHz |

Timing and AC Characteristics

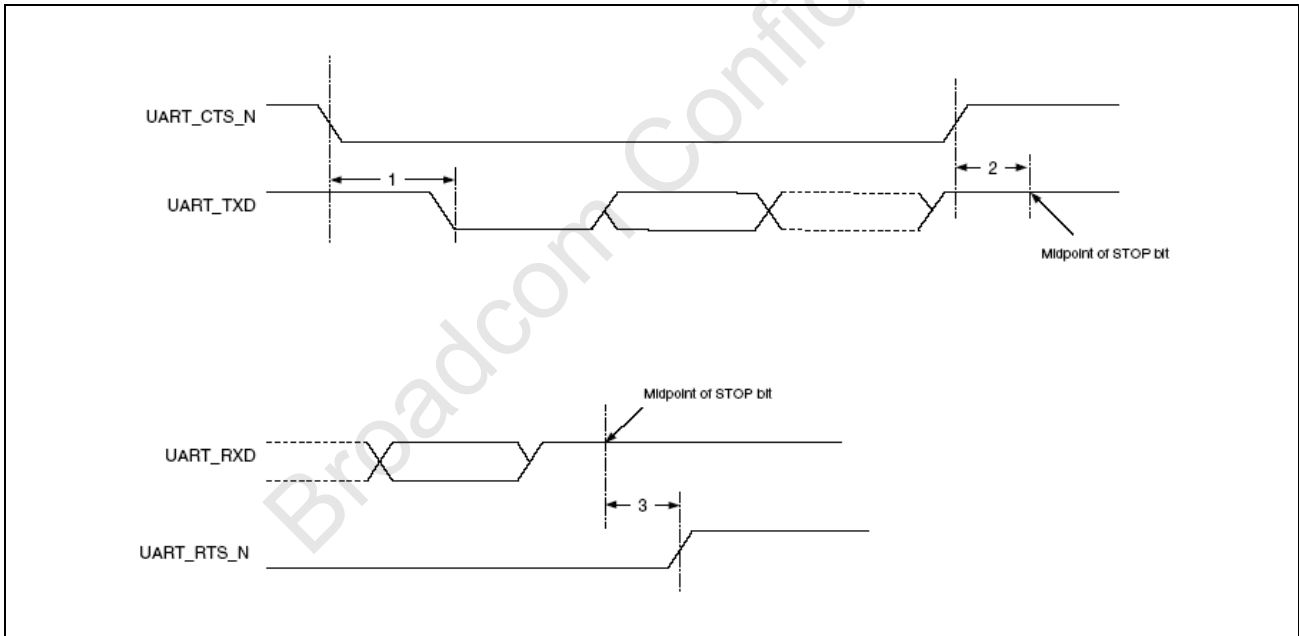
In this section, use the numbers listed in the **Reference** column of each table to interpret the following timing diagrams.

UART Timing

Table 17: UART Timing Specifications

| Reference | Characteristics | Min | Max | Unit |
|-----------|---|-----|-----|-----------------|
| 1 | Delay time, UART_CTS_N low to UART_TXD valid | – | 24 | Baud out cycles |
| 2 | Setup time, UART_CTS_N high before midpoint of stop bit | – | 10 | ns |
| 3 | Delay time, midpoint of stop bit to UART_RTS_N high | – | 2 | Baud out cycles |

Figure 10: UART Timing



SPI Timing

The SPI interface supports clock speeds up to 12 MHz with $VDDIO \geq 2.2V$. The supported clock speed is 6 MHz when $2.2V > VDDIO \geq 1.62V$.

Figure 11 and Figure 12 show the timing requirements when operating in SPI Mode 0 and 2, and SPI Mode 1 and 3, respectively.

Table 18: SPI Interface Timing Specifications

| Reference | Characteristics | Min | Typ | Max |
|-----------|---|-------------------|-------------------|----------|
| 1 | Time from CSN asserted to first clock edge | 1 SCK | 100 | ∞ |
| 2 | Master setup time | – | $\frac{1}{2}$ SCK | – |
| 3 | Master hold time | $\frac{1}{2}$ SCK | – | – |
| 4 | Slave setup time | – | $\frac{1}{2}$ SCK | – |
| 5 | Slave hold time | $\frac{1}{2}$ SCK | – | – |
| 6 | Time from last clock edge to CSN deasserted | 1 SCK | 10 SCK | 100 |

Figure 11: SPI Timing – Mode 0 and 2

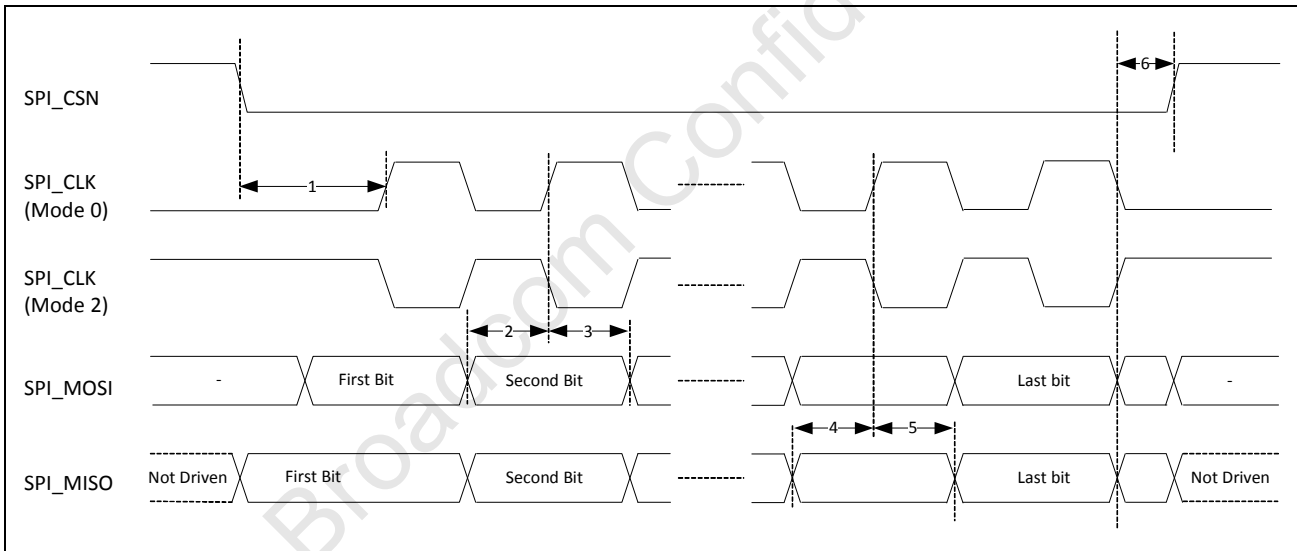
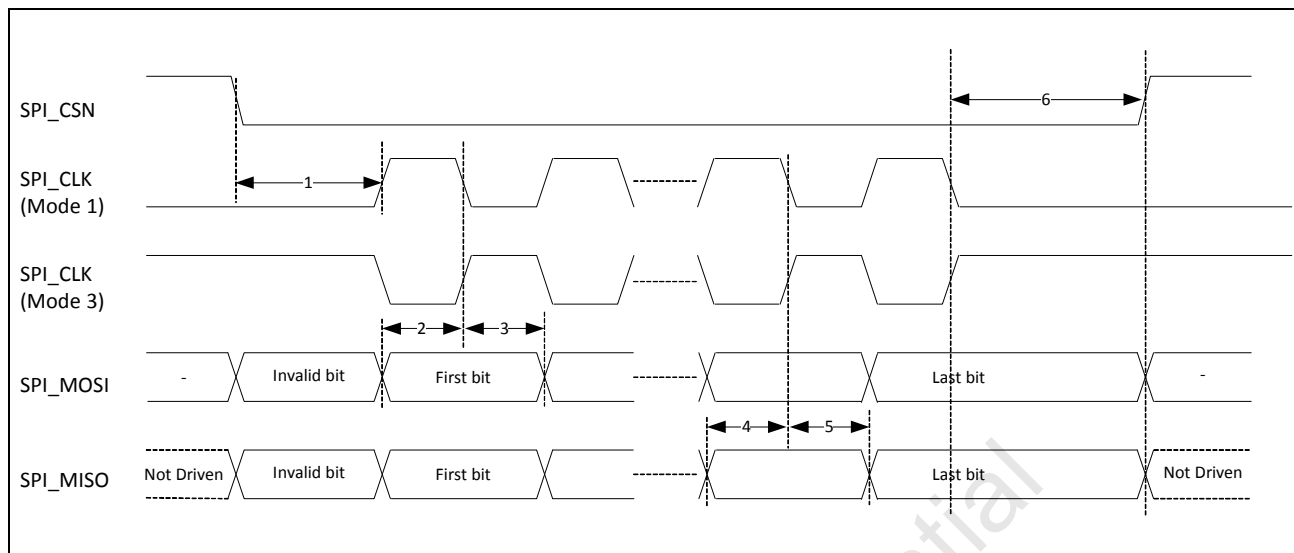


Figure 12: SPI Timing – Mode 1 and 3



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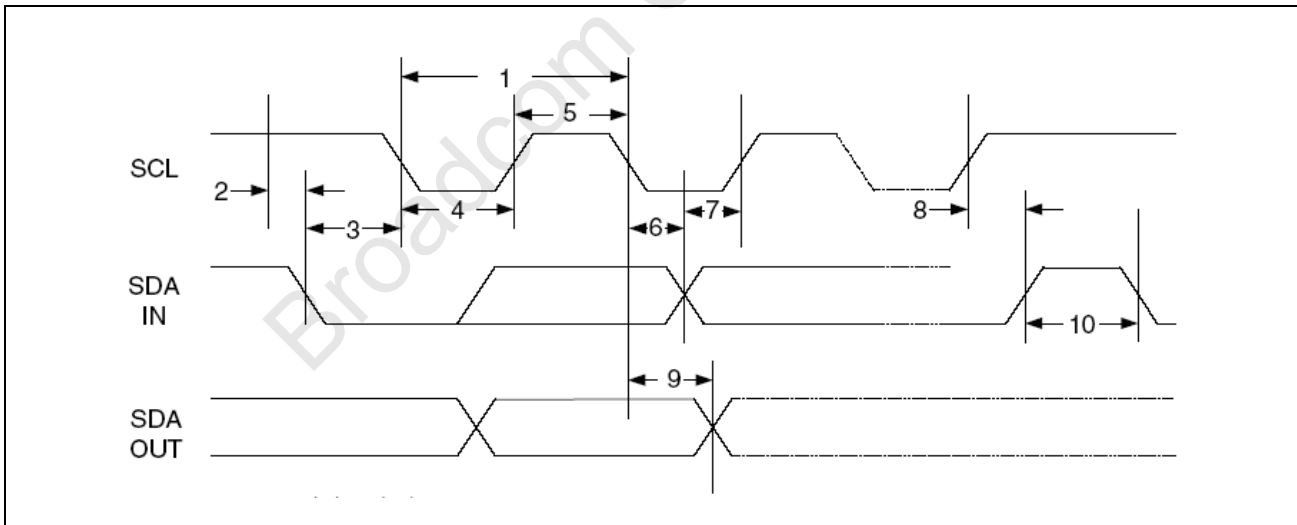
BSC Interface Timing

Table 19: BSC Interface Timing Specifications

| Reference | Characteristics | Min | Max | Unit |
|-----------|-----------------------------------|-----|---------------------------|------|
| 1 | Clock frequency | – | 100 400 800 1000 | kHz |
| 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 ^a | 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 ^b | 650 | – | ns |

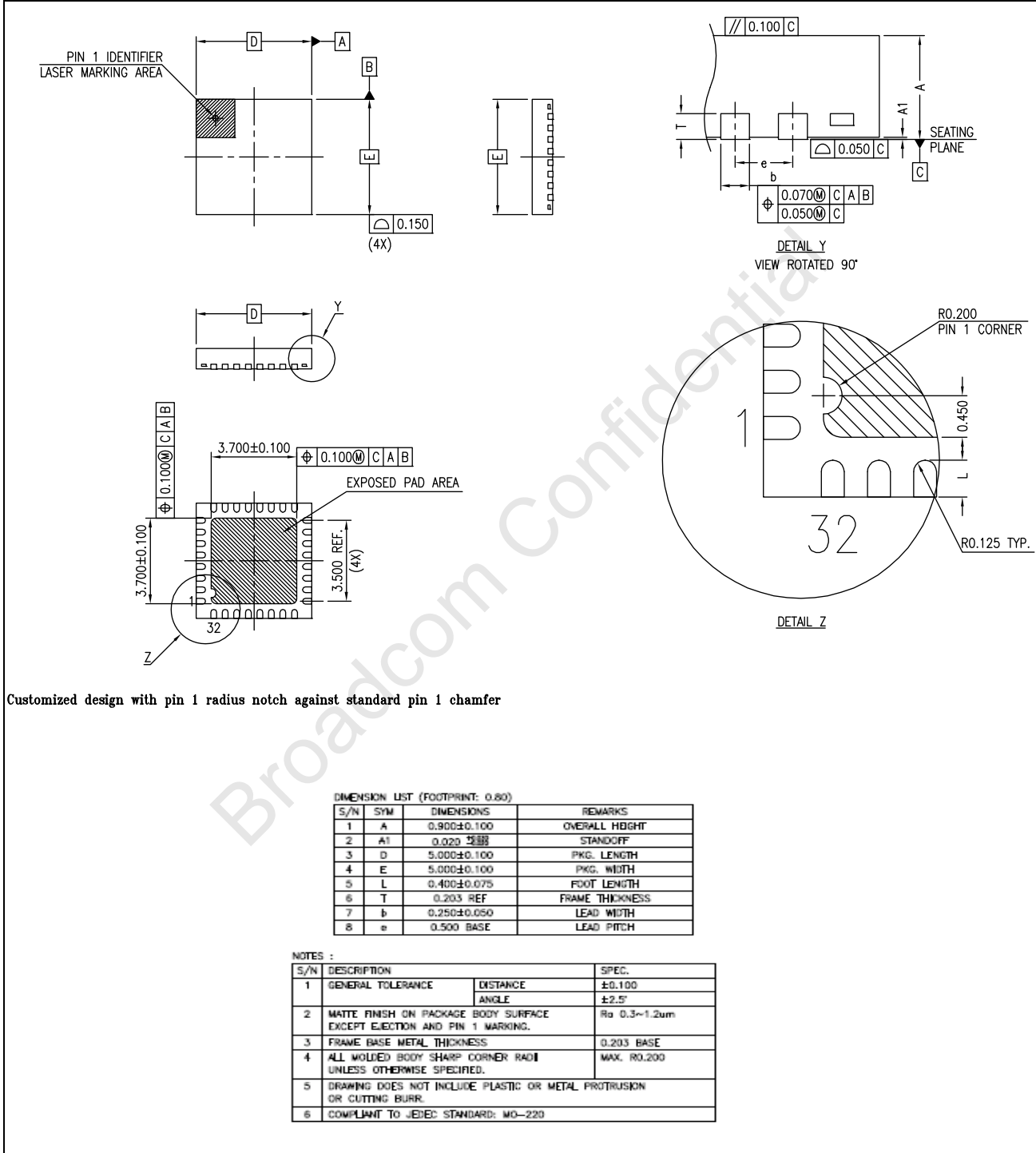
- a. As a transmitter, 300 ns of delay is provided to bridge the undefined region of the falling edge of SCL to avoid unintended generation of START or STOP conditions.
- b. Time that the cbus must be free before a new transaction can start.

Figure 13: BSC Interface Timing Diagram



Section 4: Mechanical Information

Figure 14: 32-pin QFN



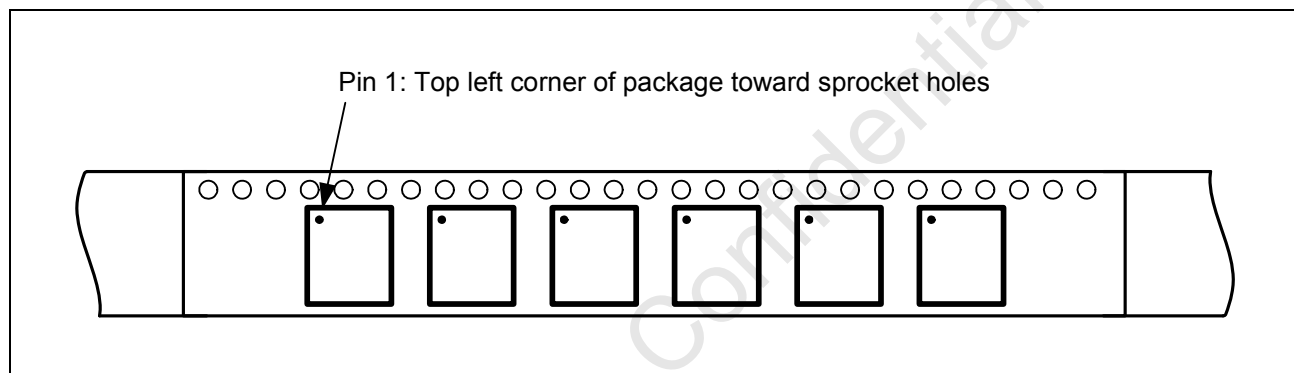
Tape Reel and Packaging Specifications

Table 20: BCM20737 5 × 5 × 1 mm QFN, 32-Pin Tape Reel Specifications

| Parameter | Value |
|-------------------|--------------|
| Quantity per reel | 2500 pieces |
| Reel diameter | 13 inches |
| Hub diameter | 7 inches |
| Tape width | 12 mm |
| Tape pitch | 8 mm |

The top left corner of the BCM20737 package is situated near the sprocket holes, as shown in [Figure 15](#).

Figure 15: Pin 1 Orientation



Section 5: Ordering Information

Table 21: Ordering Information

| <i>Part Number</i> | <i>Package</i> | <i>Ambient Operating Temperature</i> |
|--------------------|----------------|--------------------------------------|
| BCM20736A0KML2G | 32-pin QFN | -30°C to +85°C |

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Appendix A: Acronyms and Abbreviations

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 |
| LV | LogicVision™ |
| MIA | multiple interface agent |
| PCM | pulse code modulation |
| PLL | phase locked loop |
| PMU | power management unit |
| POR | power-on reset |
| PWM | pulse width modulation |
| QD | quadrature decoder |
| RAM | random access memory |
| RF | radio frequency |
| ROM | read-only memory |
| RX/TX | receive, transmit |
| SPI | serial peripheral interface |

| <i>Term</i> | <i>Description</i> |
|--------------------|---|
| SW | software |
| UART | universal asynchronous receiver/transmitter |
| UPI | μ -processor interface |
| WD | watchdog |

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