

## Bluetooth Low Energy System-in-Package (SiP) Module

### GENERAL DESCRIPTION

The BCM20737S is a compact, highly integrated Bluetooth low energy (BLE) system-in-package (SiP) module. The BCM20737S SiP includes an embedded BLE antenna, 24 MHz clock, and 512 Kb EEPROM, so only a minimal set of external components is needed to create a standalone BLE device.

The BCM20737S is designed to accelerate time to market. The Bluetooth stack and several application profiles are built into the module, allowing customers to focus on their core applications. To further reduce application development time, the BCM20737S includes integrated software support, with one-click installation of the complete environment and a one-click compile/build/link/load cycle. All this, coupled with an ultrasmall form factor and support for a wide voltage range, makes the BCM20737S well suited for virtually any Bluetooth Smart application.

### FEATURES

- ARM Cortex-M3 microcontroller unit (MCU)
- Embedded 512 Kb EEPROM
- Broadcom Serial Control (BSC), SPI, and UART interfaces
- FCC and CE compliant
- RoHS compliant, certified lead- and halogen-free

### FEATURES

- Moisture Sensitivity Level (MSL) 3 compliant
- 6.5 mm × 6.5 mm × 1.2 mm Land Grid Array (LGA) 48-pin package

### APPLICATIONS

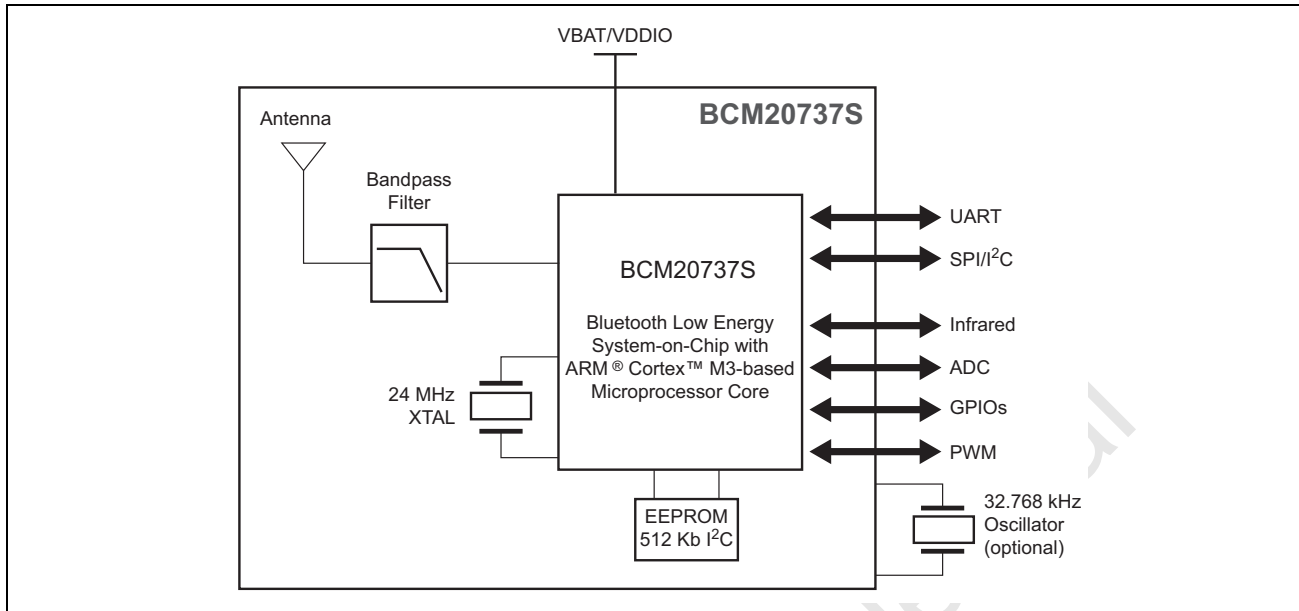
Profiles supported in ROM:

- Battery status
- Blood pressure monitor
- Find me
- Heart rate monitor
- Proximity
- Thermometer
- Weight scale
- Time
- Blood glucose monitor
- Support for RSA security library
- Support for LE Audio
- Support for pairing using NFC tags

Additional profiles supported in RAM:

- Blood glucose monitor
- Temperature alarm
- Location
- Other custom profiles

**Figure 1: BCM20737S BLE SiP Block Diagram**



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## Revision History

<i>Revision</i>	<i>Date</i>	<i>Change Description</i>
20737S-DS101-R	04/10/16	<b>Updated:</b> <ul style="list-style-type: none"><li>• <a href="#">Table 5: “Current Consumption,” on page 14</a></li></ul>
20737S-DS100-R	09/26/2014	Initial release

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## About This Document

### Purpose and Audience

This document provides descriptions of the interfaces, pin assignments, and specifications of Broadcom® BCM20737S Bluetooth Low Energy (BLE) System-in-Package (SiP) module. It is intended for designers who are responsible for adding the BCM20737S module to wireless input devices including heart-rate monitors, blood pressure monitors, proximity sensors, temperature sensors, and battery monitors.

### Acronyms and Abbreviations

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

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

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## 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.

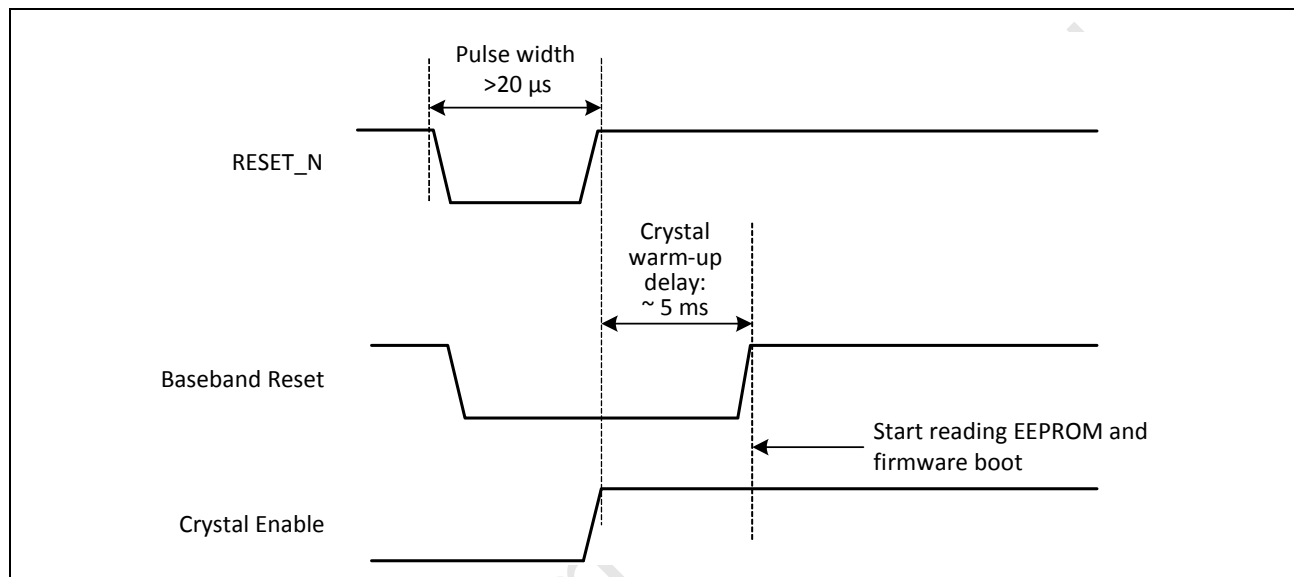
In addition, Broadcom provides other product support through its Downloads and Support site (<http://www.broadcom.com/support/>).

# Section 1: Functional Description

## External Reset

External reset timing for the BCM20737S is illustrated in [Figure 2](#).

**Figure 2: External Reset Timing**



## 32.768 kHz Oscillator

The BCM20737S includes a standard Pierce oscillator. The oscillator circuit includes a comparator with hysteresis on the output to create a single-ended digital output. The hysteresis eliminates chatter when the input is near the comparator threshold (~100 mV). The oscillator circuit can be designed for a 32 kHz or 32.768 kHz crystal oscillator, and can also be driven by an external clock input with a similar frequency. Characteristics for a 32 kHz oscillator are defined in [Table 1](#).

**Table 1: 32 kHz Crystal Oscillator Characteristics**

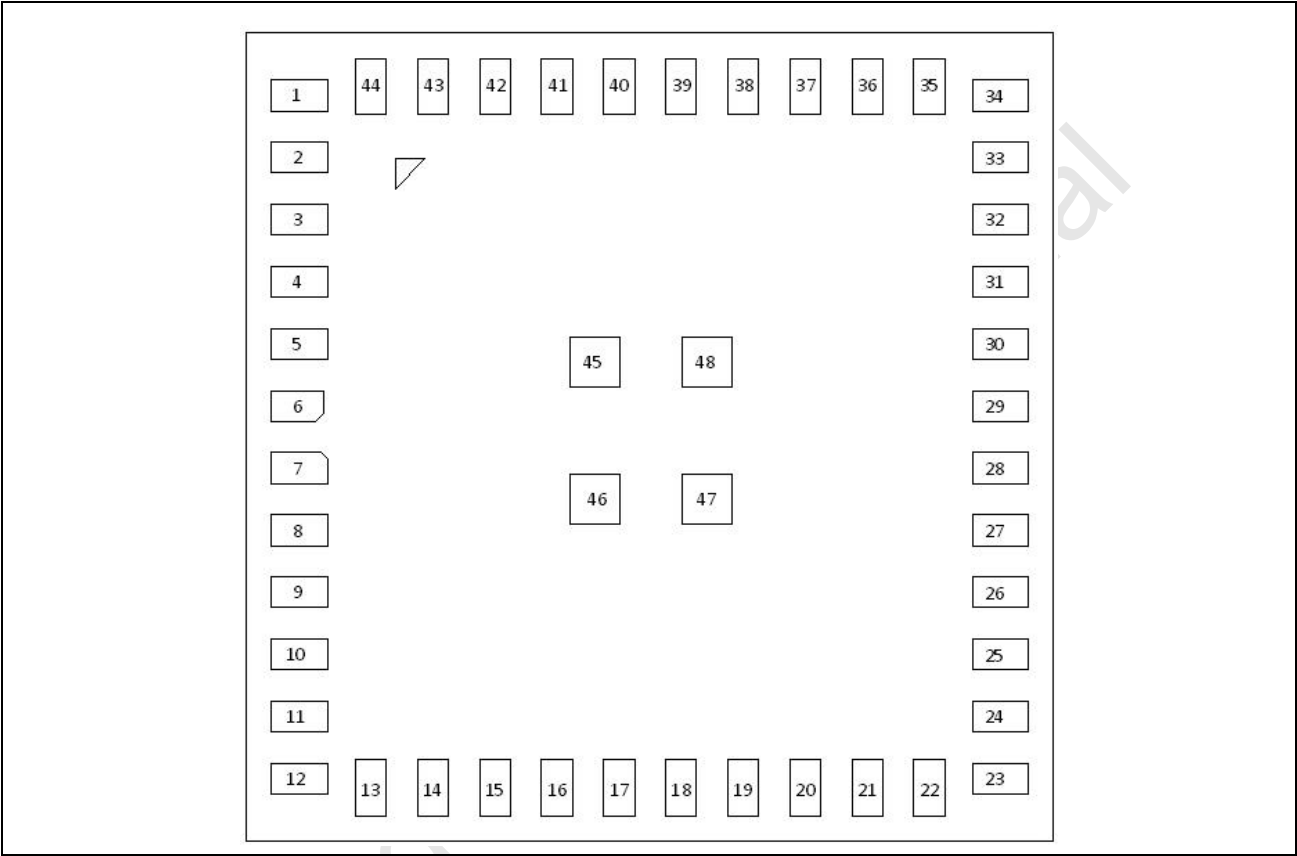
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output frequency	$F_{\text{oscout}}$	—	—	32.768	—	kHz
Frequency tolerance	$F_{\text{tol}}$	Crystal-dependent	—	100	—	ppm
Start-up time	$T_{\text{startup}}$	—	—	—	500	$\mu$ s
Crystal drive level	$P_{\text{drv}}$	For crystal selection	0.5	—	—	$\mu$ W
Crystal series resistance	$R_{\text{series}}$	For crystal selection	—	—	70	k $\Omega$
Crystal shunt capacitance	$C_{\text{shunt}}$	For crystal selection	—	—	1.3	pF



# Section 2: Pin Map and Signal Descriptions

The BCM20737S pin map is shown in [Figure 3](#).

Figure 3: BCM20737S (TOP View)



The signal name, type, and description of each pin in the BCM20737S is listed in [Table 2 on page 10](#). The symbols shown under I/O Type indicate pin directions (I/O = bidirectional, I = input, O = output) and the internal pull-up/pull-down characteristics (PU = weak internal pull-up resistor and PD = weak internal pull-down resistor), if any.

**Table 2: Pin Descriptions**

<b>Pin</b>	<b>Name</b>	<b>I/O Type</b>	<b>Description</b>
1	GPIO: P27 PWM1	I	Default direction: Input. After POR state: Input floating. Drain current: 16 mA Alternate function: MOSI (master and slave) for SPI_2
2	GND	GND	GND
3	VBAT	I	Battery supply input.
4	GND	GND	GND
5	GND	GND	GND
6	GND	GND	GND
7	GND	GND	GND
8	GND	GND	GND
9	GND	GND	GND
10	Reserved	–	Leave floating
11	GND	GND	GND
12	GND	GND	GND
13	GND	GND	GND
14	GND	GND	GND
15	GND	GND	GND
16	GND	GND	GND
17	GND	GND	GND
18	UART_RX	I	UART_RX. This pin is pulled low through an internal 10 kΩ resistor.
19	UART_TX	O, PU	UART_TX
20	GND	GND	GND
21	SCL	I/O, PU	SCL I/O, PU clock signal for an external I <sup>2</sup> C device
22	SDA	I/O, PU	SDA I/O, PU data signal for an external I <sup>2</sup> C device
23	GND	GND	GND
24	GND	GND	GND
25	GPIO: P1	I	Default direction: Input. After POR state: Input floating. This pin is tied to the WP pin of the embedded EEPROM. Requires an external 10K pull-up
26	TMC	I	Test mode control. Pull this pin high to invoke test mode; leave it floating if not used. This pin is connected to GND through an internal 10 kΩ resistor.
27	RESET_N	I/O PU	Active-low system reset with open-drain output

**Table 2: Pin Descriptions (Cont.)**

<b>Pin</b>	<b>Name</b>	<b>I/O Type</b>	<b>Description</b>
28	GPIO: P0	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• Peripheral UART TX (PUART_TX)</li> <li>• MOSI (master and slave) for SPI_2</li> <li>• IR_RX</li> <li>• 60Hz_main</li> </ul>
29	GND	GND	GND
30	GPIO: P3	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• Peripheral UART CTS (PUART_CTS)</li> <li>• SPI_CLK (master and slave) for SPI_2</li> </ul>
31	GPIO: P2	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• Peripheral UART RX (PUART_RX)</li> <li>• SPI_CS (slave only) for SPI_2</li> <li>• SPI_MOSI (master only) for SPI_2</li> </ul>
32	GPIO: P4	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• Peripheral UART RX (PUART_RX)</li> <li>• MOSI (master and slave) for SPI_2.</li> <li>• IR_TX</li> </ul>
33	GPIO: P8	I	Default direction: Input. After POR state: Input floating. Alternate functions: A/D converter input.
34	GPIO: P33	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• MOSI (slave only) for SPI_2</li> <li>• Auxiliary clock output (ACLK1)</li> <li>• Peripheral UART RX (PUART_RX)</li> </ul>

**Table 2: Pin Descriptions (Cont.)**

<b>Pin</b>	<b>Name</b>	<b>I/O Type</b>	<b>Description</b>
35	GPIO: P32	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• SPI_CS (slave only) for SPI_2.</li> <li>• Auxiliary clock output (ACLK0)</li> <li>• Peripheral UART TX (PUART_TX)</li> </ul>
36	GPIO: P25	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• MISO (master and slave) for SPI_2</li> <li>• Peripheral UART RX (PUART_RX)</li> </ul>
37	GPIO: P24	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• SPI_CLK (master and slave) for SPI_2</li> <li>• Peripheral UART TX (PUART_TX)</li> </ul>
38	NC	NC	No Connection (N/C).
39	GPIO: P13 PWM3	I	Default Direction: Input After POR State: Input Floating Drain current: 16 mA Alternate function: A/D converter input
	GPIO: P28 PWM2	I	Default direction: Input. After POR state: Input floating. Drain current: 16 mA Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• LED1</li> <li>• IR_TX</li> </ul>
40	GPIO: P14 PWM2	I	Default direction: Input. After POR state: Input floating. Alternate function: A/D converter input
	GPIO: P38	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• MOSI (master and slave) for SPI_2</li> <li>• IR_TX</li> </ul>

**Table 2: Pin Descriptions (Cont.)**

<b>Pin</b>	<b>Name</b>	<b>I/O Type</b>	<b>Description</b>
41	GPIO: P15	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• IR_RX</li> <li>• 60 Hz_main</li> </ul>
42	GPIO: P26 PWM0	I	Default direction: Input. After POR state: Input floating. Drain current: 16 mA Alternate function: SPI_CS (slave only) for SPI_2
43	GPIO: P12	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• XTALO32K</li> </ul>
	XTALO32K	O	Low-power oscillator (LPO) output. Alternate functions: <ul style="list-style-type: none"> <li>P12</li> <li>P26</li> </ul>
44	GPIO: P11	I	Default direction: Input. After POR state: Input floating. Alternate functions: <ul style="list-style-type: none"> <li>• A/D converter input</li> <li>• XTALI32K</li> </ul>
	XTALI32K	I	Low-power oscillator (LPO) input. Alternate functions: <ul style="list-style-type: none"> <li>• P11</li> <li>• P27</li> </ul>
45	GND	GND	GND
46	GND	GND	GND
47	GND	GND	GND
48	GND	GND	GND

## Section 3: Electrical Specifications

Absolute maximum ratings are defined in [Table 3](#).

**Table 3: Absolute Maximum Ratings**

<b>Parameter</b>	<b>Min.</b>	<b>Max.</b>	<b>Unit</b>
Supply power	NA	3.63	V
Storage temperature	–40	125	°C
Voltage ripple	0	±2	%
Power supply (VBAT absolute maximum rating)	1.62	3.63	V

Power for the BCM20737S module is provided by the host through the power pins.

**Table 4: Voltage**

<b>Symbol</b>	<b>Parameter</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>
VBAT	Battery voltage	1.62	–	3.63	V

**Table 5: Current Consumption**

<b>Operating Mode</b>	<b>Condition</b>	<b>Nominal</b>	<b>Maximum</b>	<b>Unit</b>
Receive	Receiver and baseband are both operating, 100%	24.0	28.0	mA
Transmit	Transmitter and baseband are both operating, 100%	24.0	28.0	mA
Sleep	Wake in < 5 ms	55.0	60.0	μA
Deep Sleep	Wake on interrupt	2.0	2.5	μA

**Note:** All measurements taken at 25°C

Based on the current measurements in [Table 5 on page 14](#), BCM20737S peak power values are:

- RX: 101.6 mW
- TX: 101.6 mW
- Sleep mode: 217.8 μW
- Deep Sleep mode: 9.1 μW

## Section 4: RF Specifications

BCM20737S receiver specifications are defined in [Table 6](#).

**Table 6: Receiver Specifications**

<b>Parameter</b>	<b>Mode and Conditions</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>
Frequency range	–	2402	–	2480	MHz
RX sensitivity (standard)	Packets: 200 Payload: PRBS 9 Length: 37 Bytes Dirty Transmitter: off. PER: 30.8%	–	–94	–	dBm
Maximum input	–	–10	–	–	dBm

**Note:** All measurements taken at 3.0V (default voltage)

RF transmitter specifications are defined in [Table 7](#).

**Table 7: Transmitter Specifications**

<b>Parameter</b>	<b>Min.</b>	<b>Typ.</b>	<b>Max.</b>	<b>Unit</b>
<b>Transmitter</b>				
Frequency range <sup>a</sup>	2402	–	2480	MHz
Output power adjustment range	–20	–	4	dBm
Output power	–	2	–	dBm
Output power variation	–	2.5	–	dB
<b>LO Performance</b>				
Initial carrier frequency tolerance	–	–	±150	kHz
<b>Frequency Drift</b>				
Frequency drift	–	–	±50	kHz
Drift rate	–	–	20	kHz/50 $\mu$ s
<b>Frequency Deviation</b>				
Average deviation in payload (sequence: 00001111)	225	–	275	kHz
Average deviation in payload (sequence: 10101010)	185	–	–	kHz
Channel spacing	–	2	–	MHz

a. This parameter is taken from the Bluetooth 4.0 specification.

## Section 5: ADC Specifications

BCM20737S ADC specifications are defined in [Table 8](#).

**Table 8: 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	–	Charging refsel	7.5	–	–	$\mu$ s
Input resistance	$R_{inp}$	Effective, single-ended	–	500	–	k $\Omega$
Input capacitance	$C_{inp}$	–	–	–	5	pF
Conversion rate	$F_c$	–	5.859	–	187	kHz
Conversion time	$T_c$	–	5.35	–	170.7	$\mu$ s
Resolution	R	–	–	16	–	Bits
Absolute voltage measurement error	–	Using on-chip ADC firmware driver	–	$\pm 2$	–	%
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	$\mu$ s
Integral nonlinearity	$I_{NL}$	In the guaranteed performance range	–1	–	1	LSB <sup>a</sup>
Differential nonlinearity	$D_{NL}$	In the guaranteed performance range	–1	–	1	LSB <sup>a</sup>

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



# Section 6: Timing and AC Characteristics

## SPI Timing

SPI interface timing is illustrated in [Figure 4](#) and [Figure 5](#) and defined in [Table 9](#) on page 18.

Figure 4: SPI Timing—Modes 0 and 2

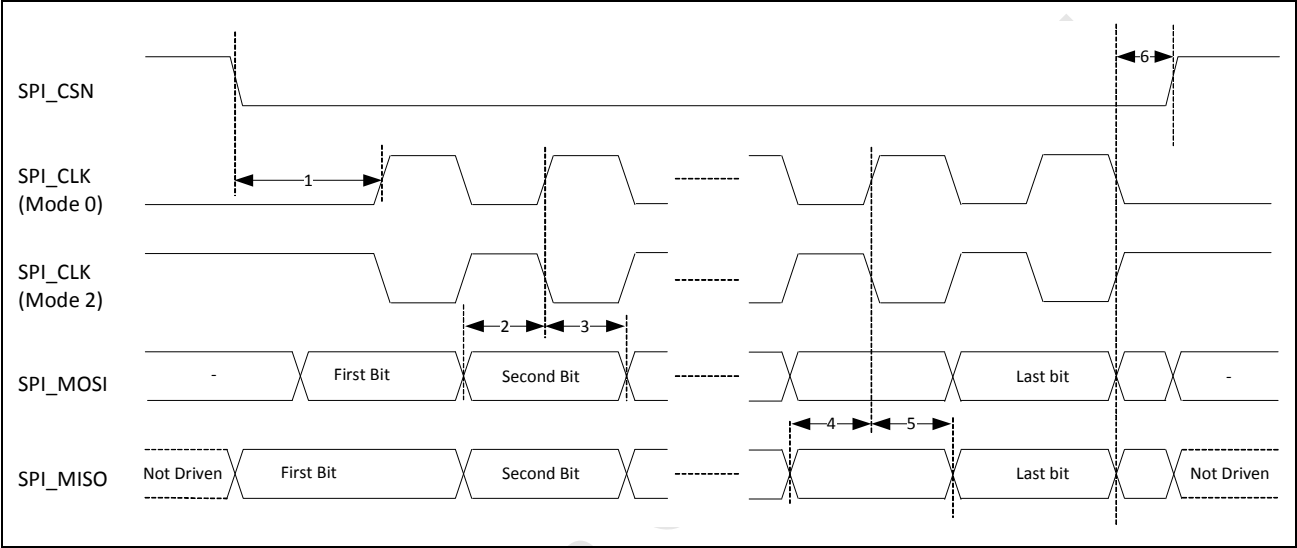
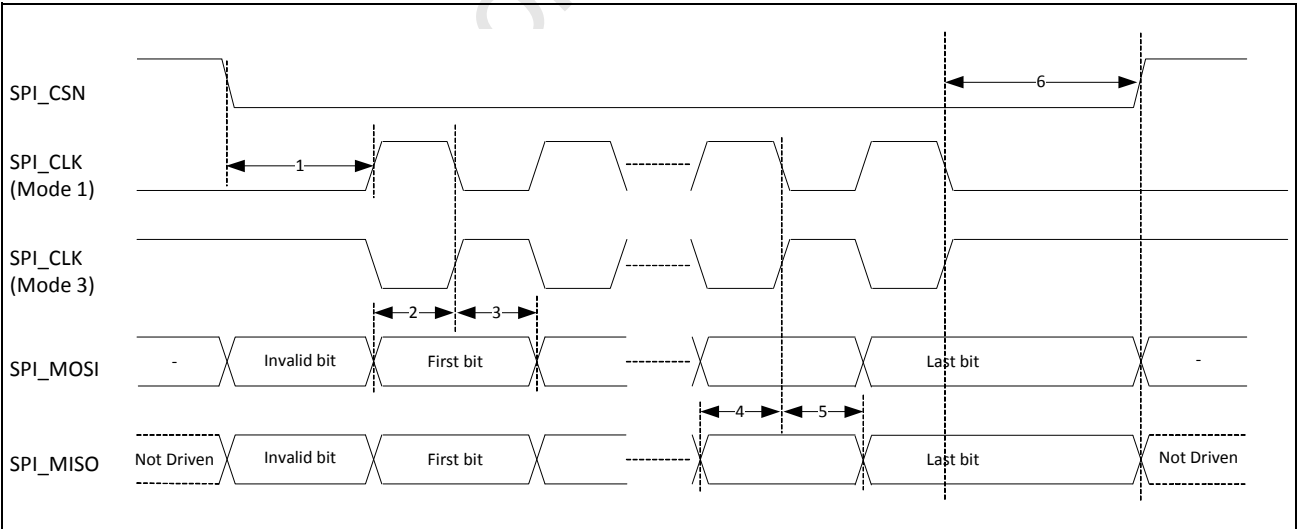


Figure 5: SPI Timing—Modes 1 and 3

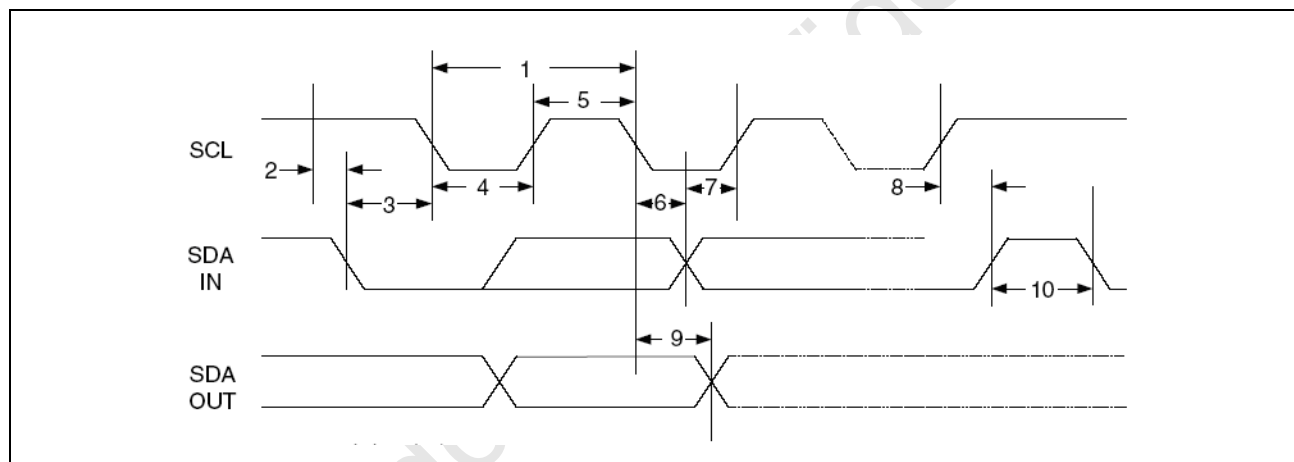


**Table 9: SPI Interface Timing Specifications**

Reference	Characteristics	Min.	Typ.	Max.
1	Time from CSN asserted to first clock edge	1 SCK	100	$\infty$
2	Master setup time	–	1/2SCK	–
3	Master hold time	1/2SCK	–	–
4	Slave setup time	–	1/2 SCK	–
5	Slave hold time	1/2 SCK	–	–
6	Time from last clock edge to CSN deasserted	SCK	10 SCK	100

## BSC Interface Timing

BSC interface timing is illustrated in [Figure 6](#) and is defined in [Table 10](#).

**Figure 6: BSC Interface Timing****Table 10: 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	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	650	–	ns

# UART Timing

UART timing is illustrated in [Figure 7](#) and defined in [Table 11](#).

Figure 7: UART Timing

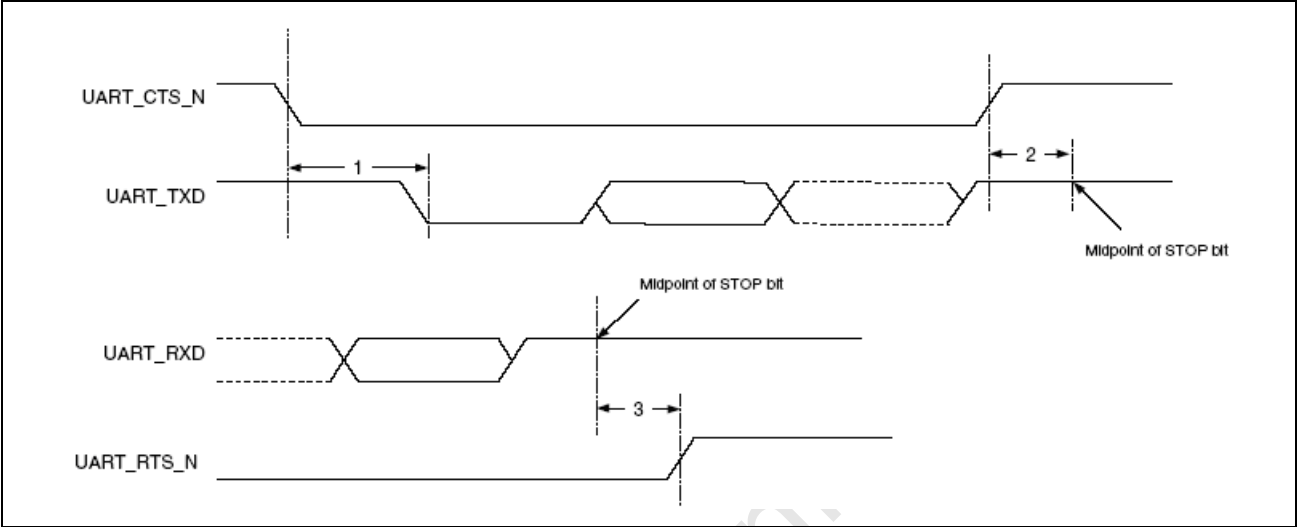


Table 11: UART Timing Specifications

Reference	Characteristics	Min.	Max.	Unit
1	Delay time, UART_CTS_N low to UART_TXD valid	–	24	Baudout 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	Baudout cycles

## Section 7: PCB Design and Manufacturing Recommendations

### Pad and Solder Mask Opening Dimensions

BCM20737S pad and solder mask opening dimensions are defined in [Table 12](#).

**Table 12: Pad and Solder Mask Dimensions**

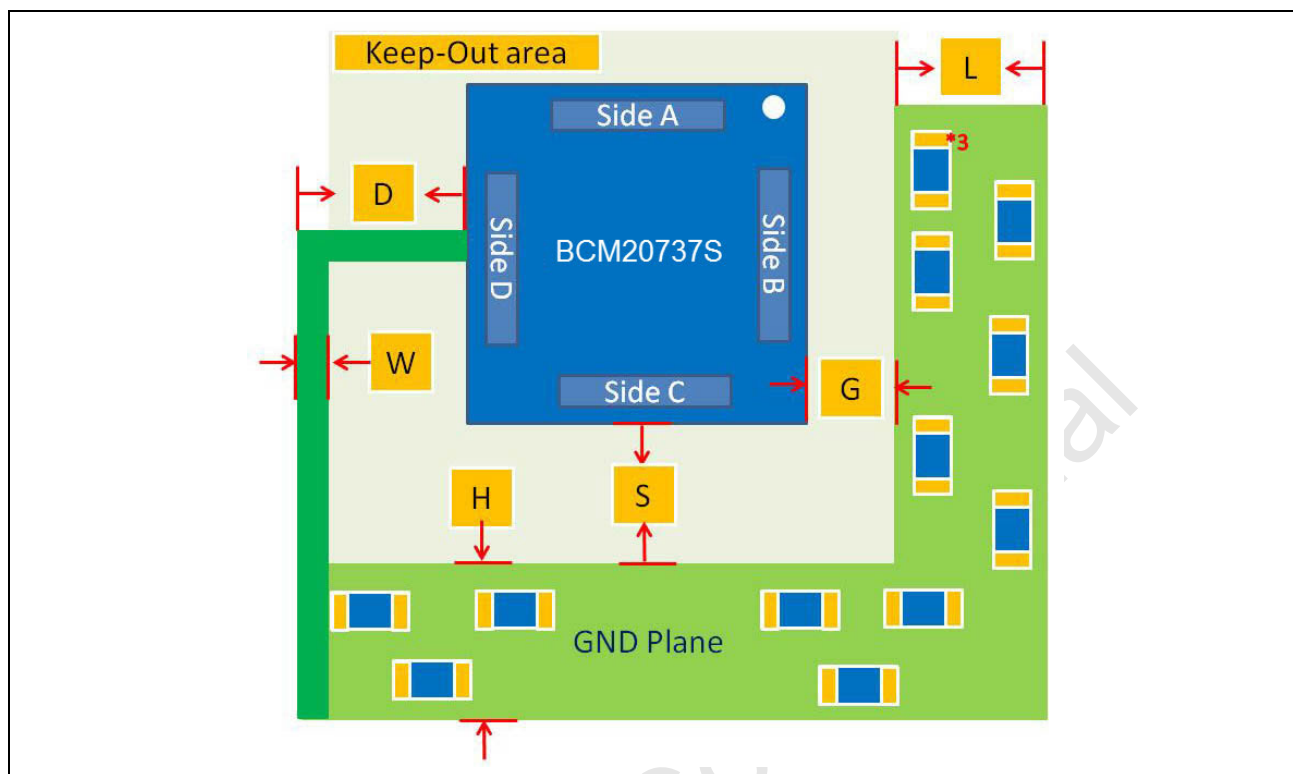
<b>Pad Type</b>	<b>Pad Dimensions</b>	<b>Solder Mask Opening Dimensions</b>	<b>Unit</b>
Type A	0.6 × 0.25	0.7 × 0.35	mm
Type B	0.55 × 0.3	0.65 × 0.4	
Type C	0.4 × 0.4	0.5 × 0.5	

### PCB Layout Recommendations

The following layout recommendations are referenced to [Figure 8 on page 21](#).

- Connect to system ground from side D of the module (pins 13–22).
- The L-shaped ground plane is required for the embedded BLE antenna. Keep the GND continuous. Do not cut off the GND shape to accommodate trace routes.
- An L-shaped ground plane is required. If the L-shaped GND plane is located on the top layer of the PCB, do not place components on the ground plane. If this cannot be avoided, move the L-shaped ground plane to another layer.
- Antenna efficiency of 31–41% can be achieved based on the layout in [Figure 8 on page 21](#) and the dimensions listed below. Following these layout recommendations is expected to yield 50+ meters of usable range; deviating from these recommendations may reduce the range of the antenna.
  - D: 4.5 mm (typical)
  - G, H, S: 3 mm (typical)
  - L: 3 mm (minimum)
  - W: 0.4 mm (typical)
- Route signal traces out of the module from side C (between pins 27 and 30) or side D (between pins 16 and 19) of the module. Traces can be overlapped to avoid routing through the keep-out area.
- Do not route traces from side A or side B.

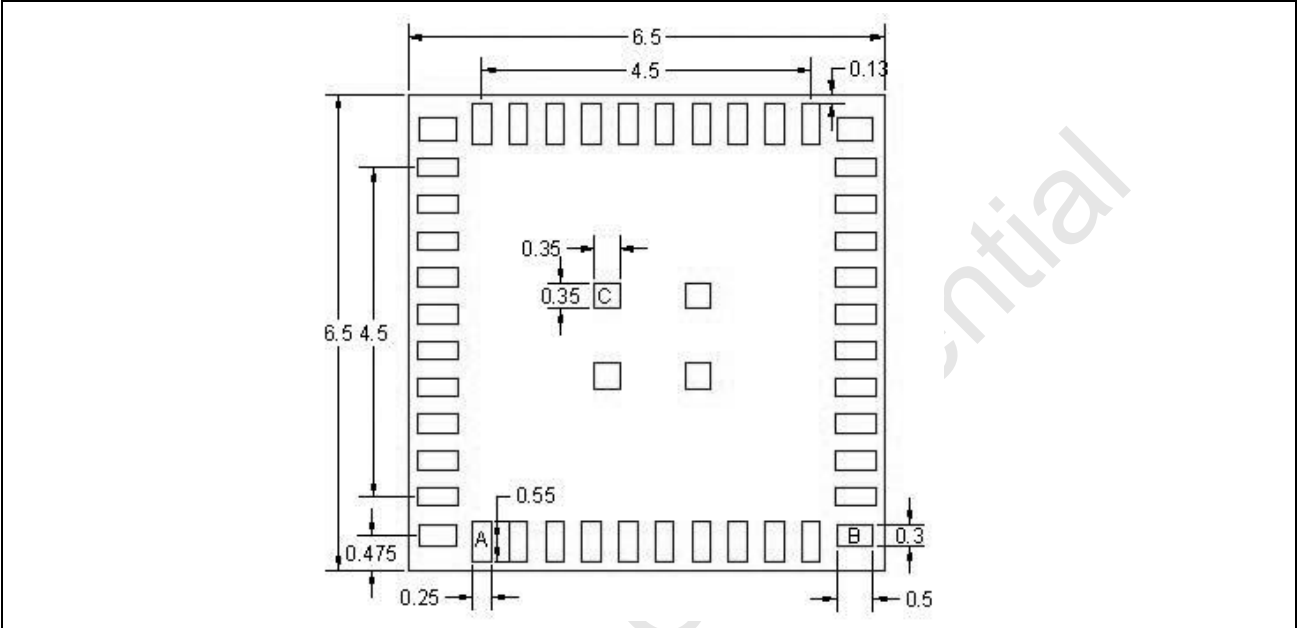
Figure 8: PCB Layout Example



# PCB Stencil

The recommended PCB stencil is shown in [Figure 9](#) (all measurements in mm). Use an unsolder mask to set the module footprint.

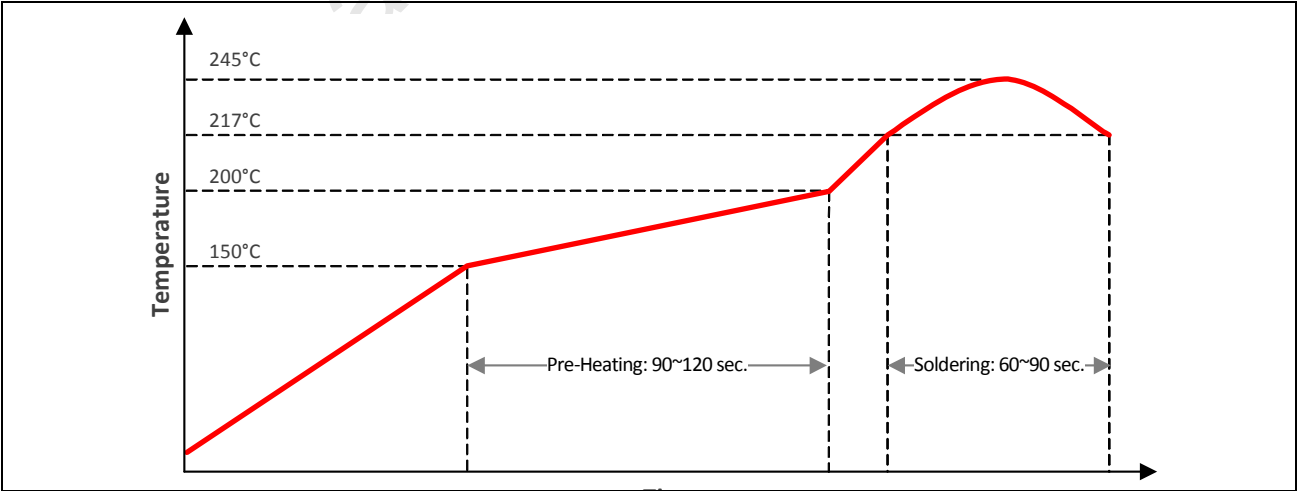
Figure 9: BCM20737S Stencil (Bottom View)



# Solder Reflow

The recommended solder reflow profile for the BCM20737S is defined in [Figure 10](#).

Figure 10: Solder Reflow Profile



## Section 8: Packaging and Storage Information

The BCM20737S is available in a tape and reel package and is shipped in an ESD-protected moisture-resistant (MSL-3) bag as shown in [Figure 11](#). The storage temperature range is  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

**Figure 11: BCM20737S ESD/Moisture Packaging**

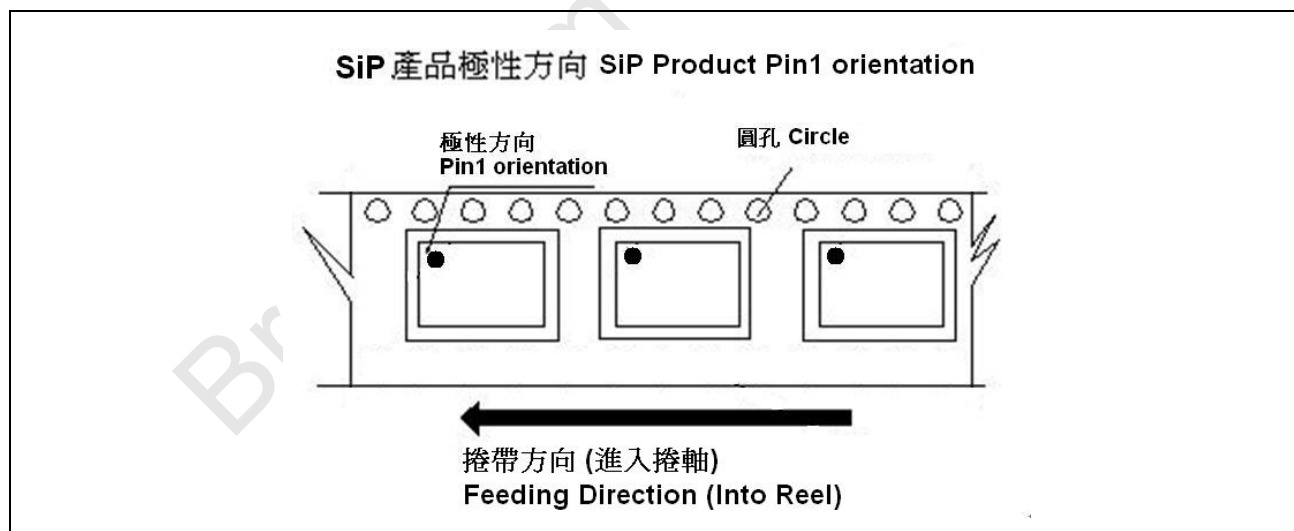


The moisture sensitivity label on the BCM20737S shipping bag is shown in [Figure 12 on page 24](#).

**Figure 12: BCM20737S Moisture Sensitivity Label**

	<b>Caution</b> This bag contains <b>MOISTURE-SENSITIVE DEVICES</b>	LEVEL <div style="border: 1px solid black; padding: 2px; display: inline-block;">3</div>
		<small>If blank, see adjacent bar code label</small>
1. Calculated shelf life in sealed bag: 12 months at $\leq 40^{\circ}\text{C}$ and $\leq 90\%$ relative humidity (RH) 2. Peak package body temperature: <u>260</u> $^{\circ}\text{C}$ <small>If blank, see adjacent bar code label</small> 3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be a) Mounted within: <u>168</u> hours of factory conditions <small>If blank, see adjacent bar code label</small> $\leq 30^{\circ}\text{C}/60\%$ RH. or b) Stored per J-STD-033 4. Devices require bake, before mounting, if: a) Humidity Indicator Card reads $>10\%$ for level 2a - 5a devices or $>60\%$ for level 2 devices when read at $23 \pm 5^{\circ}\text{C}$ b) 3a or 3b are not met 5. If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure.		
Bag Seal Date: <u>APR 26 2011</u> <small>If blank, see adjacent bar code label</small> <small>Note: Level and body temperature defined by IPC/JEDEC J-STD-020</small>		

Figure 13 shows the location of pin 1 on the BCM20737S relative to its orientation on the tape packaging.

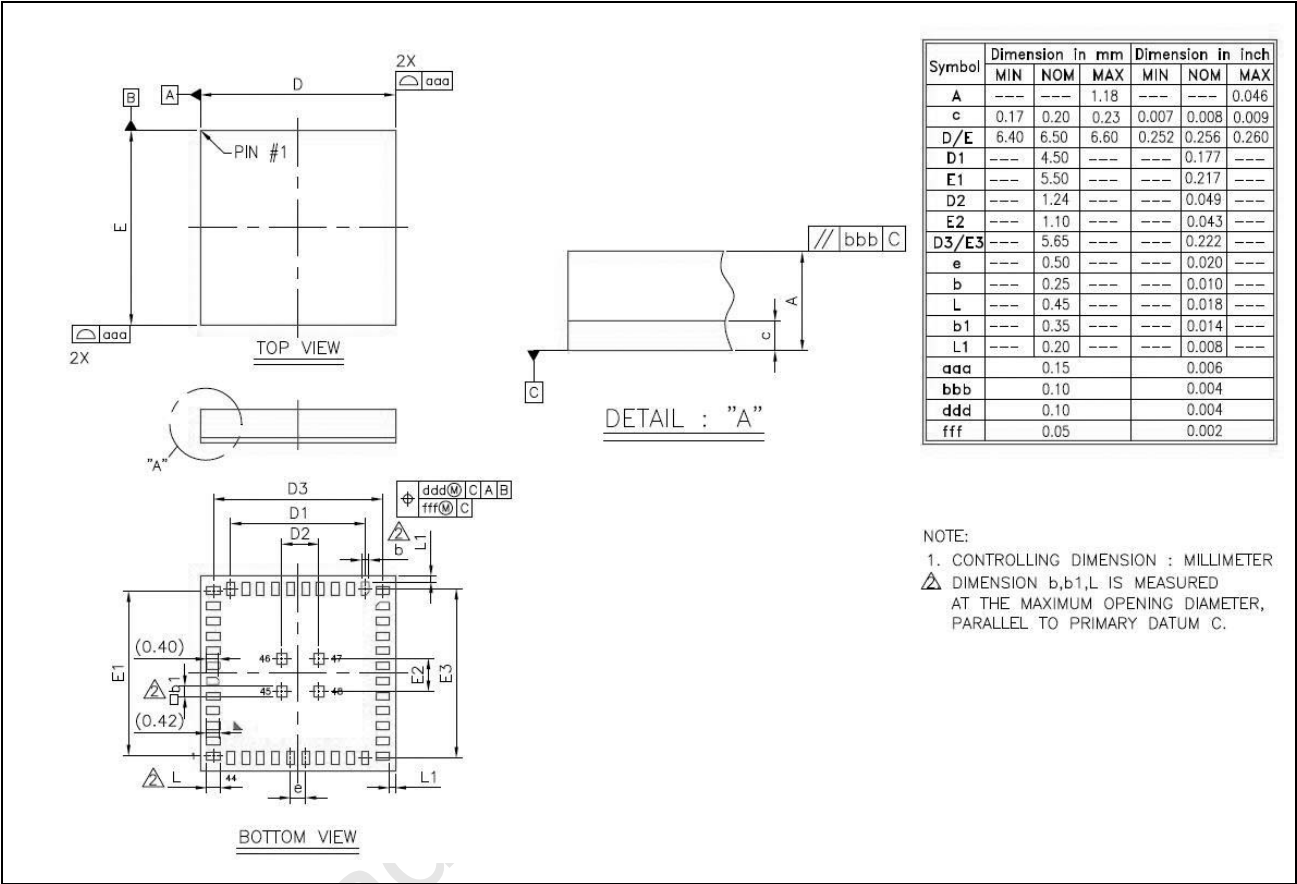
**Figure 13: BCM20737S Tape and Reel Pin 1 Location**



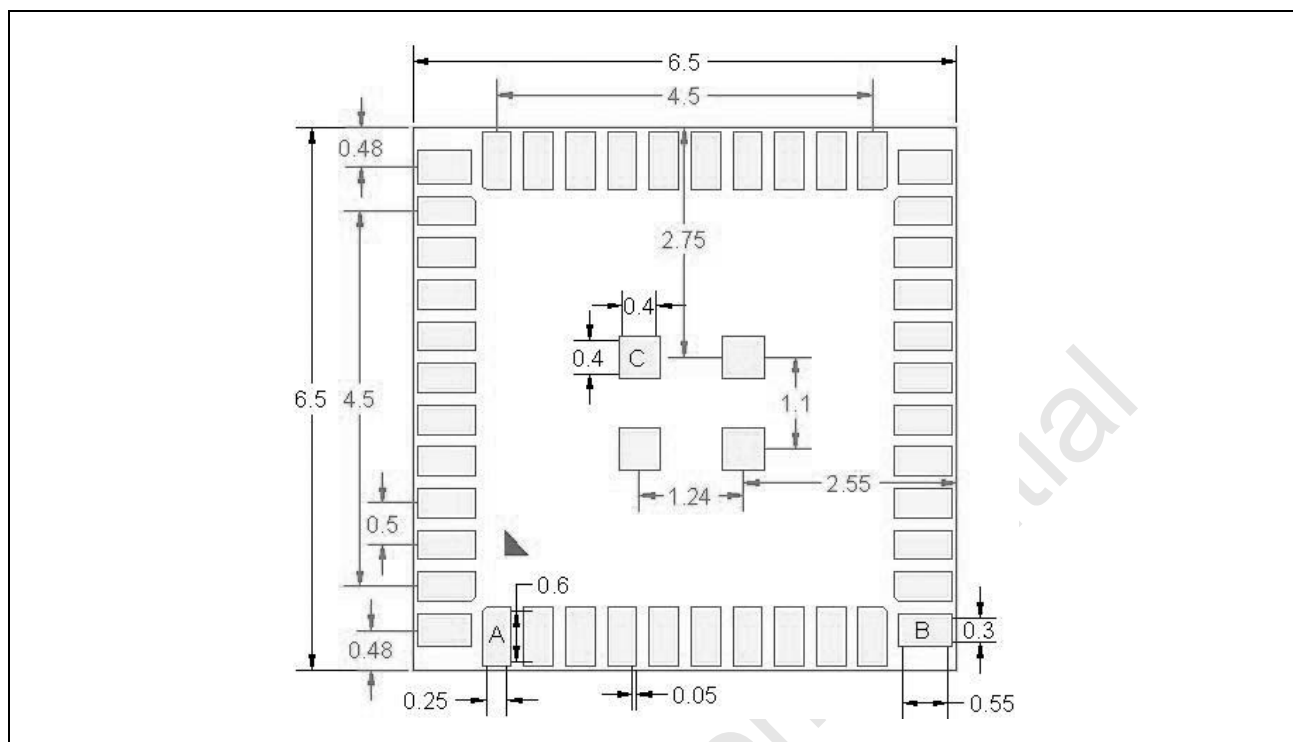
# Section 9: Mechanical Information

Package dimensions for the BCM20737S are shown in [Figure 14](#).

Figure 14: BCM20737S Package Dimensions



Additional BCM20737S package dimensions are shown in [Figure 15](#) on [page 26](#).

**Figure 15: BCM20737S Pin Dimensions (Bottom View)**

## Section 10: Ordering Information

*Table 13: Ordering Information*

<b>Part Number</b>	<b>Package</b>	<b>Operating Temperature</b>	<b>Humidity</b>
BCM20737S	48-pin LGA	–40°C to +85°C	95% max., noncondensing

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20737S-DS101-R      April 10, 2016