Features

- 3.3V operating voltage
- Integrated high performance RF and MODEM for enhanced BLE.
- Few external components required as well as on-chip 32 MHz crystal capacitors to reduce the BOM cost.
- Integrated DC/DC converter and LDOs allowing a wider supply range with a single power supply
- Over 75dB RX of gain in programmable gain steps
- Integrated SPI and UART for ACI interfaces
- Includes Sleep and Power Down modes for low power consumption
- Embedded patch memory to reduce system development effort and cost – BC7602 only
- Package types:
  - BC7601: 32-pin QFN – 4mmx4mm
  - BC7602: 46-pin QFN – 6.5mmx4.5mm

Applications

- Health care products
- Smart home appliances
- Beacons

General Description

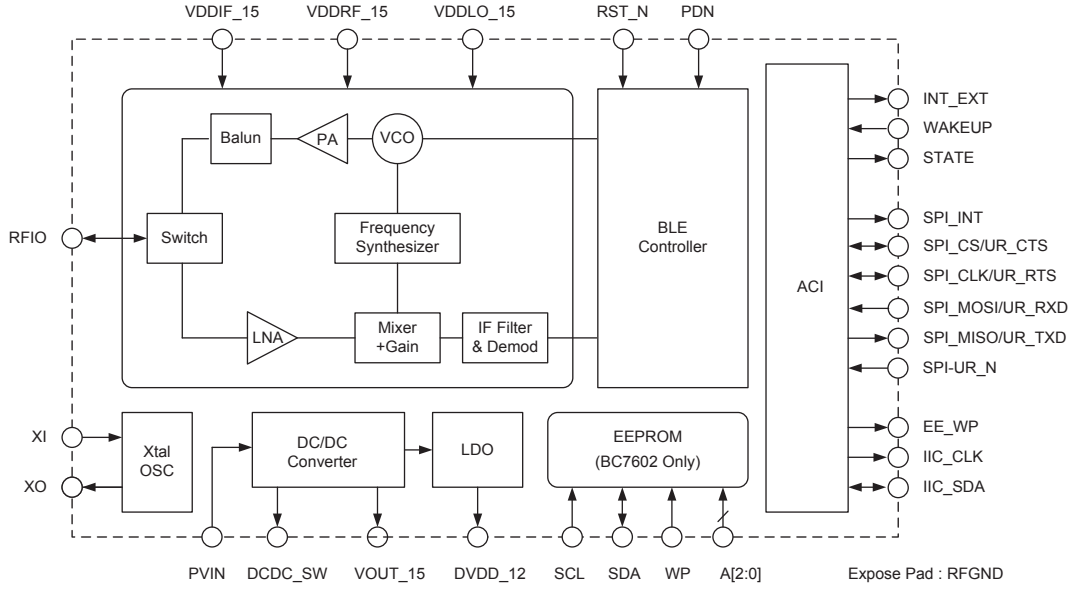
The BC7601/BC7602 devices are fully-integrated, single-chip Bluetooth Low Energy, BLE, controllers. The devices are specially designed to act as BLE slave controllers in accordance with the Bluetooth specification v4.1.

The devices can be controlled by any external microcontroller through the Application Controller Interface, ACI, which is designed to allow the devices to easily communicate with external circuitry. The UART and SPI interfaces are available as the ACI transport layers.

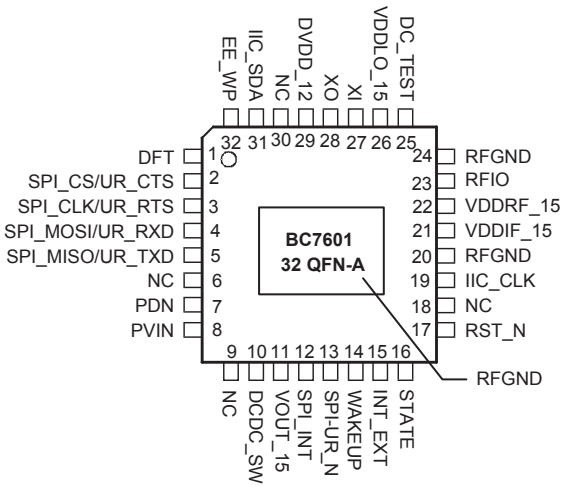
Additionally, during intervals where there is no active BLE RF connection, the devices will enter a Sleep Mode thus further reducing power consumption.

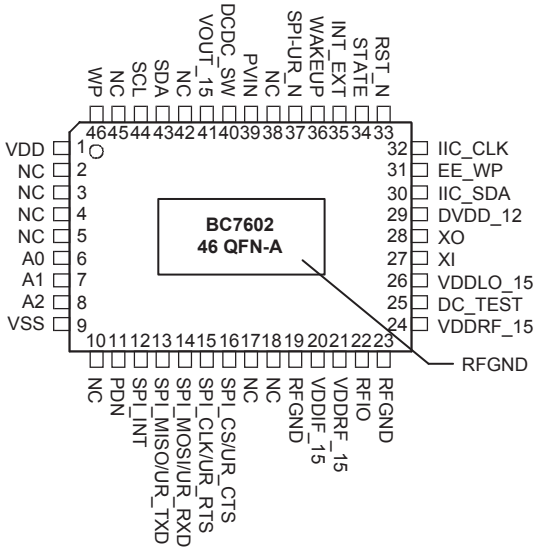
In general practice, the BC7601/BC7602 devices will be required to download a patch code for full BLE optimisation. For convenience and system cost reduction, the BC7602 device already supports an internal patch code and so does not need to patch from the external microcontroller.

Block Diagram



Pin Assignment





Pin Description

BC7601

Name	No	Type	Description
DFT	1	DI	For normal operation connect to RFGND.
SPI_CS/UR_CTS	2	DI	SPI CS or UART CTS; selected by SPI-UR_N during the power-on period
SPI_CLK/UR_RTS	3	DI	SPI CLK or UART RTS; selected by SPI-UR_N during the power-on period
SPI_MOSI/UR_RXD	4	DI	SPI MOSI or UART RXD; selected by SPI-UR_N during the power-on period
SPI_MISO/UR_TXD	5	DO	SPI MISO or UART TXD; selected by SPI-UR_N during the power-on period
NC	6	—	No Connection – connect to RFGND
PDN	7	DI	Power down control pin When low the device enters the Power down mode
PVIN	8	P	Power-supply; 2.2V~3.6V
NC	9	—	No Connection – connect to RFGND
DCDC_SW	10	P	Switching Output – connect to the switching end of the inductor
VOUT_15	11	P	1.5V power output
SPI_INT	12	DO	SPI interrupt request when SPI mode is selected
SPI-UR_N	13	DI	SPI/UART mode select pin during the power-on period 1: SPI pins selected 0: UART pins selected
WAKEUP	14	DI	Wake-up pin Enters the Sleep Mode when low
INT_EXT	15	DO	External Interrupt
STATE	16	DO	IC state pin indicator 1: Operating mode 0: Sleep mode
RST_N	17	DI	Hardware reset, active low
NC	18	—	No Connection – connect to RFGND
IIC_CLK	19	DIO	Connect to external host or EEPROM SCL pin. IIC_CLK pin is baud rate selection when UART mode is selected. Where 0: 9600bps, 1: 115200bps.
RFGND	20	P	RF Power Ground
VDDIF_15	21	P	Analog power for IF section – connect to VOUT_15
VDDRF_15	22	P	Analog power for RF section – connect to VOUT_15
RFIO	23	AIO	RF input or output
RFGND	24	P	RF Power Ground
DC_TEST	25	AO	RF function test pin
VDDLO_15	26	P	Analog power for RF section, connect to VOUT_15
XI	27	AI	Crystal oscillator input
XO	28	AO	Crystal oscillator output
DVDD_12	29	P	1.2V internal digital power – connect 0.1μF capacitor to RFGND
NC	30	—	No Connection – connect to RFGND
IIC_SDA	31	DIO	Connect to external host or EEPROM SDA pin
EE_WP	32	DO	Connect to external host or EEPROM WP pin
RFGND	EP	P	Exposed Pad on package lower side. Internally connected to RFGND. Solder this exposed pad to a PCB pad that uses multiple ground vias to provide heat transfer out of the device into the PCB ground planes. These multiple ground vias are also required to achieve the noted RF performance.

Legend: AI=Analog Input; AO=Analog Output; AIO=Analog In/out;
DI=Digital Input; DO=Digital Output; DIO=Digital In/Out; P=Power

BC7602

Name	Pin	Type	Description
VDD	1	P	EEPROM power supply; 1.8V~3.6V
NC	2	—	No Connection – connect to RFGND
NC	3	—	No Connection – connect to RFGND
NC	4	—	No Connection – connect to RFGND
NC	5	—	No Connection – connect to RFGND
A0	6	DI	EEPROM address A0 input
A1	7	DI	EEPROM address A1 input
A2	8	DI	EEPROM address A2 input
VSS	9	P	EEPROM Digital ground - connect to RFGND
NC	10	—	No Connection - connect to RFGND
PDN	11	DI	Power down control pin When low the device enters the Power down mode
SPI_INT	12	DO	SPI interrupt request when SPI mode is selected
SPI_MISO/UR_TXD	13	DO	SPI MISO or UART TXD; selected by SPI-UR_N during the power-on period
SPI_MOSI/UR_RXD	14	DI	SPI MOSI or UART RXD; selected by SPI-UR_N during the power-on period
SPI_CLK/UR_RTS	15	DI	SPI CLK or UART RTS; selected by SPI-UR_N during the power-on period
SPI_CS/UR_CTS	16	DI	SPI CS or UART CTS; selected by SPI-UR_N during the power-on period
NC	17	—	No Connection – connect to RFGND
NC	18	—	No Connection – connect to RFGND
RFGND	19	P	RF Power Ground
VDDIF_15	20	P	Analog power for IF section – connect to VOUT_15
VDDRF_15	21	P	Analog power for RF section – connect to VOUT_15
RFIO	22	AIO	RF input or output
RFGND	23	P	RF Power Ground
VDDRF_15	24	P	Analog power for RF section – connect to VOUT_15
DC_TEST	25	AO	RF function test pin
VDDLO_15	26	P	Analog power for RF section – connect to VOUT_15
XI	27	AI	Crystal oscillator input
XO	28	AO	Crystal oscillator output
DVDD_12	29	P	1.2V internal digital power – connect 0.1μF capacitor to RFGND
IIC_SDA	30	DIO	Externally connected to SDA pin
EE_WP	31	DIO	Externally connected to WP pin
IIC_CLK	32	DO	Externally connected to SCL pin
RST_N	33	DI	Hardware reset input, active low
STATE	34	DO	IC state pin indicator 1: Operating mode 0: Sleep mode
INT_EXT	35	DO	External Interrupt
WAKEUP	36	DI	Wake-up pin Enters the Sleep Mode when low
SPI-UR_N	37	DI	SPI/UART mode select pin during the power-on period 1: SPI pins selected 0: UART pins selected
NC	38	—	No Connection – connect to RFGND
PVIN	39	P	Power-supply; 2.2V~3.6V
DCDC_SW	40	P	Switching Output - connect to the switching end of the inductor
VOUT_15	41	P	1.5V power output
NC	42	—	No Connection – connect to RFGND
SDA	43	DIO	EEPROM SDA

Name	Pin	Type	Description
SCL	44	DI	EEPROM SCL
NC	45	—	No Connection – connect to RFGND
WP	46	DI	EEPROM WP
RFGND	EP	P	Exposed Pad on the lower side of the package. Internally connected to RFGND. Solder this exposed pad to a PCB pad that uses multiple ground vias to provide heat transfer out of the device into the PCB ground planes. These multiple ground vias are also required to achieve the noted RF performance.

Legend: AI=Analog Input; AO=Analog Output; AIO=Analog In/out;
DI=Digital Input; DO=Digital Output; DIO=Digital In/Out; P=Power

Absolute Maximum Ratings

Supply Voltage ..... V_{IN}-0.3V to V_{IN}+4.3V
Input Voltage ..... V_{IN}-0.3V to V_{IN}+0.3V
Storage Temperature ..... -50°C to 125°C
Operating Temperature .....0°C to 70°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

D.C. Characteristics

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Power supply voltage(*)	—	2.2(*)	3.3	3.6	V
Digital Inputs						
V_{IH}	High level input voltage	—	0.7 × V_{IN}	—	—	V
V_{IL}	Low level input voltage	—	—	—	0.2 × V_{IN}	V
I_{IH}	High level input current	—	—	10	—	μA
I_{IL}	Low level input current	—	—	10	—	μA
C_I	Input capacitance	—	—	5	—	pF
Digital Outputs						
V_{OH}	High level output voltage	I_{OH} = 1mA	V_{IN} -0.5	—	—	V
V_{OL}	Low level output voltage	I_{OL} = 1mA	—	—	0.5	V
I_{OZ}	High impedance output current	—	—	—	1	μA
Supply current (Ta=25°C, V_{IN}=3.3V, unless otherwise specified)						
I_{RX}	Rx mode	—	—	14.5	—	mA
I_{TX}	TX mode, 0 dBm output power	—	—	9	—	mA
I_{SLEEP}	Idle mode when MCU sleep	—	—	13	20	uA
I_{ACT}	Idle mode when MCU active	—	—	2	—	mA
I_{PDN}	Power down	—	—	280	360	nA

Note: If the BC760x device is operating under the condition where V_{IN}<2.2V, the LDO mode must be selected. However this will consume more power.

A.C. Characteristics

Symbol	Parameter		Min.	Typ.	Max.	Unit
Crystal Oscillator						
f	Frequency		—	32	—	MHz
	Frequency accuracy requirement		-40	—	40	ppm
ESR	Equivalent series resistance		—	—	100	Ω
C0	Crystal shunt capacitance		1.5	7	—	pF
CL	Crystal load capacitance		8	12	16	pF
RX Characteristics						
P_{SENS}	Sensitivity		—	-90	—	dBm
	Sensitivity (dirty on)		—	-88	—	dBm
P_{IN}	Maximum input power		—	-5	—	dBm
CI0	In-band blocking	Co-channel interference	—	12	—	dB
CI1		Interferer at f_{OFFS} = +/- 1MHz	—	-2/4	—	dB
CI2		Interferer at f_{OFFS} = +/- 2MHz	—	-25/-35	—	dB
CI3		Interferer at f_{OFFS} = +/- 3MHz	—	-40/-40	—	dB
CI4		Interferer at f_{IMAGE}	—	-35	—	dB
CI5		Interferer at f_{IMAGE} +/- 1MHz	—	4/-38	—	dB
	Out-of-band blocking	f = 30~2000MHz	—	-20	—	dBm
		f = 2000~2399MHz	—	-25	—	dBm
		f = 2484~3000MHz	—	-25	—	dBm
		f = 3000~12750MHz	—	-30	—	dBm
	Intermodulation performance for desired signal at -64dBm and 1 Mbps BLE, 3rd, 4th and 5th offset channel		—	-40	—	dBm
TX Characteristic						
P_{TX}	Output power		-18	—	+3	dBm
	TX RF output steps		—	6	—	dB
ΔF2AVG	Average frequency deviation for 10101010 pattern		—	230	—	KHz
ΔF1AVG	Average frequency deviation for 11110000 pattern		—	260	—	KHz
EO	Eye opening = ΔF2AVG/ΔF1AVG		—	0.88	—	
	Frequency accuracy		-50	—	+50	KHz
	Maximum frequency drift		—	30	—	KHz
	Initial frequency drift		—	10	—	KHz
FDR	Drift rate		—	0.2	—	KHz/50us
	Spurious emissions	Frequency < 2.4GHz	—	-50	—	dBm
		Frequency in 2.4-12 GHz	—	-40	—	dBm
	In-band emissions	< f ± 2MHz (f=2400~2483.5MHz, P_{TX}=0dBm)	—	-51	—	dBm
		> f ± 3MHz (f=2400~2483.5MHz, P_{TX}=0dBm)	—	-55	—	dBm

Functional Description

Introduction

These devices are fully-integrated, single-chip Bluetooth Low Energy, BLE, controllers. The devices are specially designed to act as BLE slave devices in accordance with the Bluetooth specification v4.1. The devices can be controlled by any external microcontroller through the Application Controller Interface, ACI, which is specially designed to allow easy communication with external circuitry. The UART and SPI interfaces are available as the ACI transport layers. Additionally, during any time intervals where there is no active BLE RF connection, the devices will enter the Sleep Mode which can further reduce the power consumption. As the complexity of BLE RF controllers does not permit comprehensive RF operation information to be provided in this datasheet, the reader should therefore refer to the corresponding user manuals for a detailed understanding of the BLE RF.

Controller Interface

Application Controller Interface

The BC760x device includes an Application Controller Interface which supports two different transport layers selected according to the logic level of the STATE and SPI-UR_N pins during power-on.

- STATE/SPI-UR_N with pull-high resistor – selects the SPI interface
- STATE/SPI-UR_N with pull-down resistor – selects the UART interface

For the SPI interface, the Write FIFO command must be sent first for each CMD from the host to the devices while the read FIFO command must be sent first for each Return operation. For the UART interface the write FIFO and read FIFO commands are not required. Data follows the little-endian format whose commands are shown in Figure 1.

	Packet Type	Payload			
Ctrl CMD	0x25 8 bits	CtrlCode 8 bits	CtrlDataLength 8 bits	CtrlDataLength *8 bits	
Read Ctrl Info CMD	0x20 8 bits	CtrlCode 8 bits			
Ctrl Info Return	0x21 8 bits	CtrlCode 8 bits	DataLength 8 bit	DataLength *8 bits	
Data Packet CMD	0x22 8 bits	DataLength 8 bits	DataLength *8 bits		
Return Packet	0x26 8bit	CtrlCode 8 bits	DataReturn 8 bits		
Write Phy CMD	0x55 8 bits	DataLength 8bit(<62)	Reserved 16bit	Address 32bit	DataLength *32bit
Read Phy CMD	0x56 8 bits	DataLength 8 bits(<62)	Address 32 bits		
Read Phy Return	0x57 8 bits	DataLength 8 bits	Reserved 16 bit	Address 32 bits	DataLength *32 bits

Figure 1. BC7601/BC7602 ACI Protocol

SPI Interface

The BC760x devices include a 5-wire, 8-bit, MSB-first, Motorola-compatible with CPOL=0 and CPHA=0 slave SPI interface. The slave SPI interface has the following characteristics.

- SPI clock speed up to 10 MHz
- Supports mode 0 only
- Integrated 32 byte RX/TX FIFOs for continuous SPI bursts.

Pin Name	In/Out	SPI Description
SPI_CLK	In	SPI clock
SPI_MOSI	In	SPI master output slave input
SPI_MISO	Out	SPI master input slave output
SPI_CS	In	SPI CS, active low.
SPI_INT	Out	SPI interrupt request
Note: The SPI-UR_N pin is pulled high during power-on period.		

Table 1. SPI Pin Function

- **Protocol and Timing**

  The SPI timing diagram is shown in Figure 2.

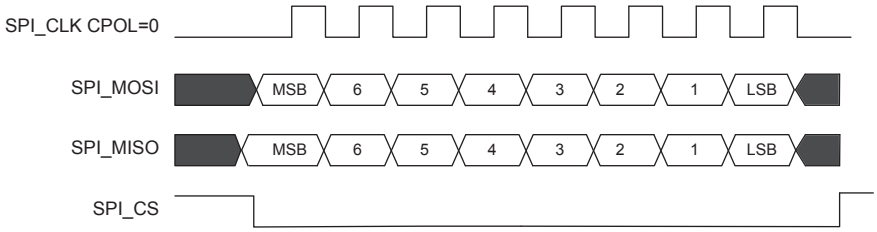


Figure 2. SPI Timing Diagram

- **SPI command format and timing**

  The SPI registers can be accessed by both the host and controller for reading or to configure the device registers

SPI Register name	SPI Register Address	Parameter Value Description
Threshold	0x0	bit[11:6]: SPI TX FIFO threshold bit[5:0]: SPI RX FIFO threshold
Int_status	0x01	Interrupt status: bit[4]: SPI RX FIFO not empty bit[3]: SPI RX FIFO overflow bit[2]: SPI RX FIFO over threshold bit[1]: SPI RX FIFO empty bit[0]: SPI RX FIFO under threshold
Int_En	0x02	Interrupt enable control: bit[4]: SPI RX FIFO not empty interrupt bit[3]: SPI RX FIFO overflow interrupt bit[2]: SPI RX FIFO over threshold interrupt bit[1]: SPI RX FIFO empty interrupt bit[0]: SPI RX FIFO under threshold interrupt * set 1 to Enable the corresponding interrupt
Int_Clr	0x03	Interrupt clear control, write only bit[4]: SPI RX FIFO not empty status clear bit[3]: SPI RX FIFO overflow status clear bit[2]: SPI RX FIFO over threshold status clear bit[1]: SPI RX FIFO empty status clear bit[0]: SPI RX FIFO under threshold status clear * set 1 to clear the corresponding status bit
fifoCount	0x04	bit [11:6]: SPI RX FIFO count bit [5:0]: SPI TX FIFO count

Table 2. SPI Interface Register Description

SPI CMD Format		
CMD Name	**Bit [7:5]**	**Bit[4:0]**
Read Register	000b	Bit [4:1] = SPI Register address, bit[0] =1
Write Register	001b	Bit [4:1] = SPI Register address, bit[0] =1
Read FIFO	011b	Bit [4:0] = n, “n” means n bytes where n=0 means 32bytes.
Write FIFO	101b	Bit [4:0] = n, “n” means n bytes where n=0 means 32bytes.

Table 3. SPI register and FIFO Operation List

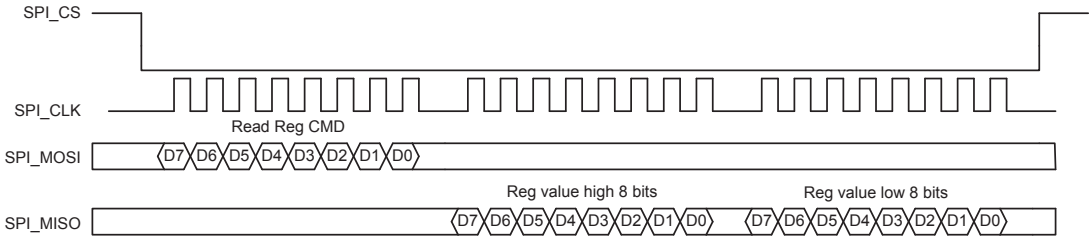


Figure 3. Read SPI Register Operation

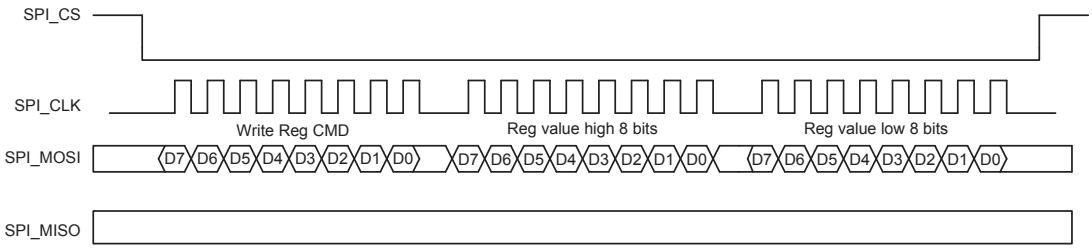


Figure 4. Write SPI Register Operation

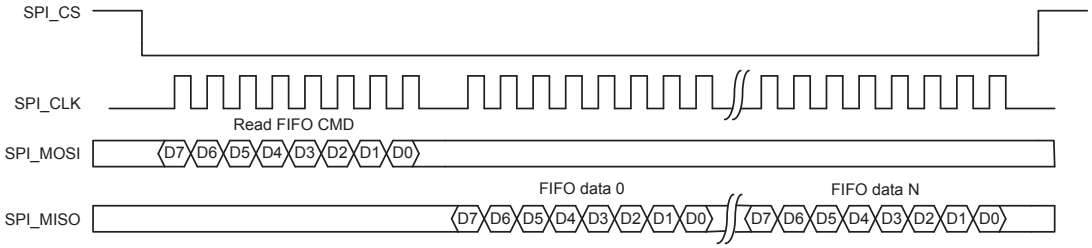


Figure 5. Read SPI FIFO Operation

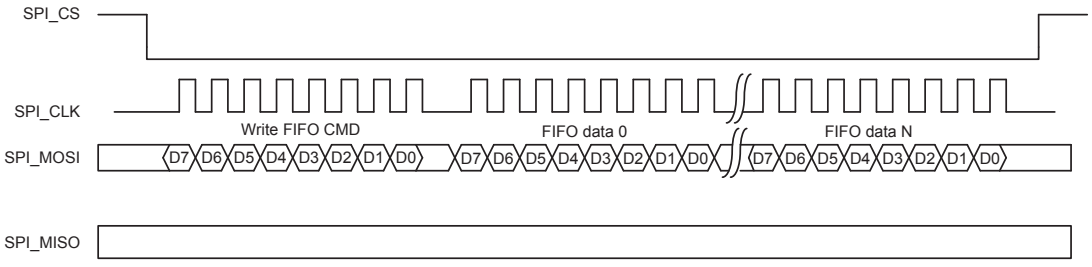


Figure 6. Write FIFO Operation

UART Interface

The UART interface supports hardware flow control signals, RTS and CTS, with the following features.

- 16 byte transmit and receive FIFOs
- Hardware flow control support (CTS/RTS)
- 8 data bits per character
- Programmable serial data baud rate from 2400 to 256000
- Connect CTS to VSS when flow control is not used

Pin Name	In/Out	UART Description
UART_RTS	Out	UART required to send
UART_RXD	In	UART RX data
UART_TXD	Out	UART TX data
UART_CTS	In	UART clear to send
Note: The SPI-UR_N pin is pulled low during power-on period.		

Table 4. UART Pin Function

I^2C Interface

The IIC_SDA, IIC_SCL pins can be used as the I^2C interface when the IIC_SDA line is pulled high.

Sleep and Wake-up

The WAKEUP pin is used to select the device operation mode while the STATE pin is used to indicate the device operation status. The external host controller can check the device operation mode by monitoring the STATE pin. When the WAKEUP pin is pulled low, the device will enter the Sleep mode and the STATE pin will go low. If the device is in the Sleep Mode, it can be woken up using the WAKEUP pin. When the WAKEUP pin is pulled high, the device will be woken up and the STATE pin will go high.

When the device enters the Sleep Mode, the external master SPI request can also wake up the device. If a high-to-low signal appears on the SPI_CS pin in the Sleep Mode, the device will be woken up and respond to the external host request. After the external master SPI access requests have been served, the device may stay in the operating mode or enter the Sleep Mode again depending upon the WAKEUP pin status.

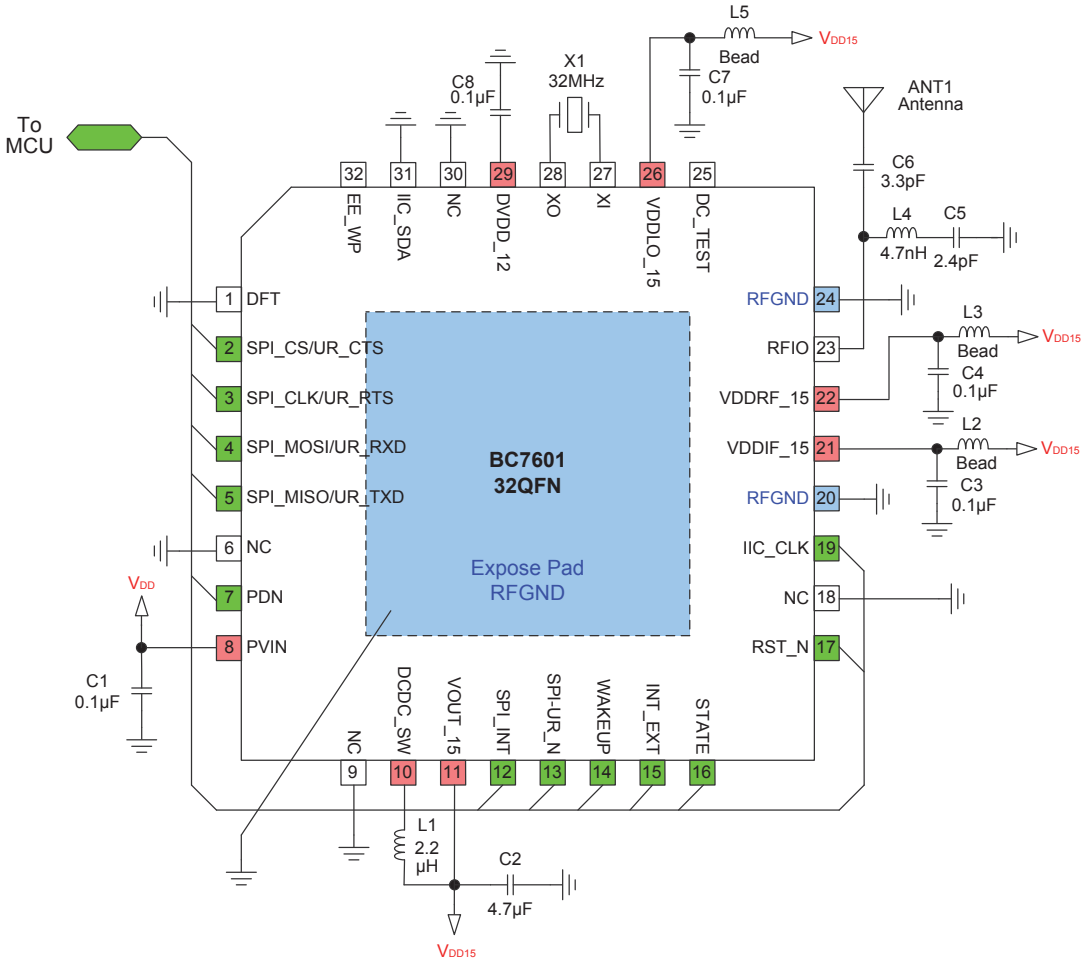
Power Down Mode

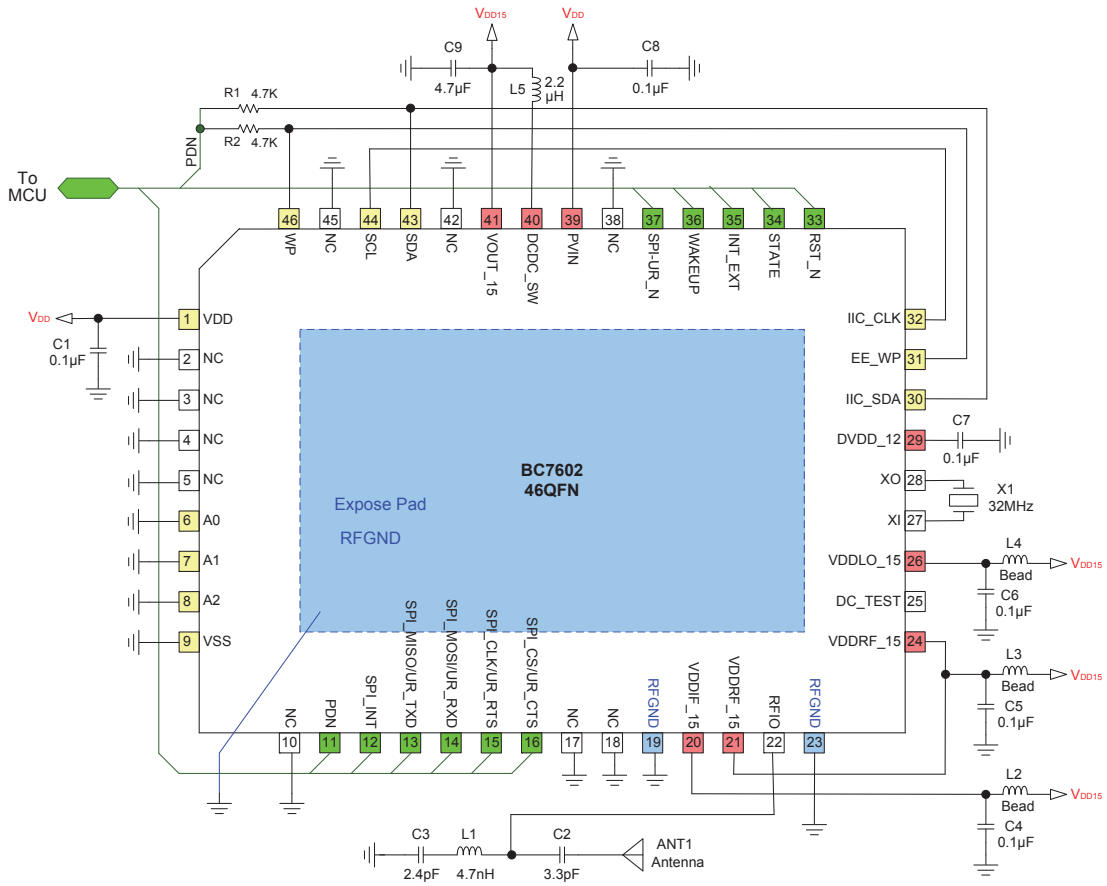
The PDN pin is used to power down the device. If the PDN pin is pulled low, the device will enter the power down mode and all internal clocks will be disabled. After the device has been powered down, there is only one way to reactivate the device which is to reset the device by pulling the RST_N pin low and then re-initialising the device.

External Interrupt

The devices provide an INT_EXT pin to output the interrupt signal to an external microcontroller. If the INT_EXT pin status is low, this means that the valid data is ready.

Application Circuits





Note: All decoupling capacitors should be located as close as possible to the device pins.

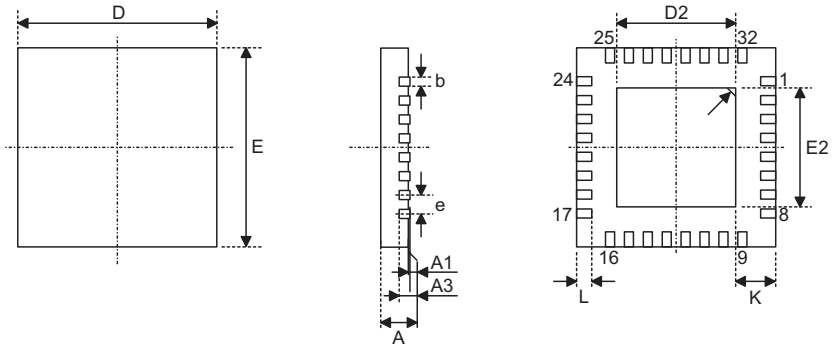
Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the Holtek website for the latest version of the Package/Carton Information.

Additional supplementary information with regard to packaging is listed below. Click on the relevant section to be transferred to the relevant website page.

- Package Information (include Outline Dimensions, Product Tape and Reel Specifications)
- The Operation Instruction of Packing Materials
- Carton information

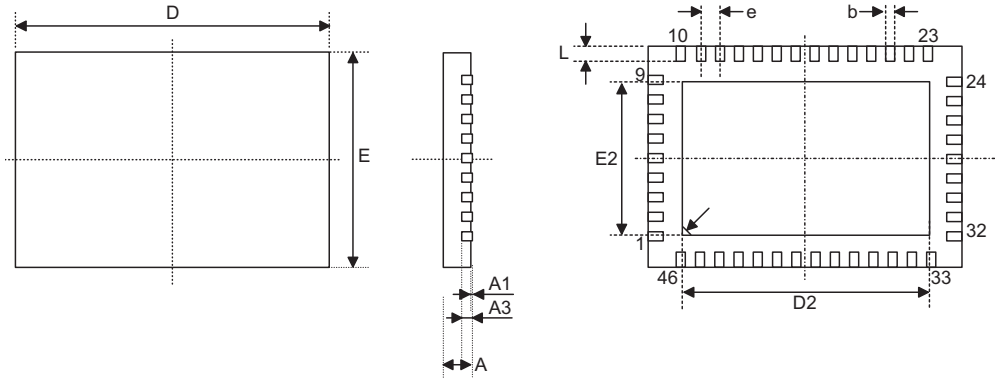
SAW Type 32-pin (4mm×4mm) QFN Outline Dimensions



Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	0.028	0.030	0.031
A1	0.000	0.001	0.002
A3	—	0.008 BSC	—
b	0.006	0.008	0.010
D	—	0.157 BSC	—
E	—	0.157 BSC	—
e	—	0.016 BSC	—
D2	0.104	0.106	0.108
E2	0.104	0.106	0.108
L	0.014	0.016	0.018
K	0.008	—	—

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	0.700	0.750	0.800
A1	0.000	0.020	0.050
A3	—	0.203 BSC	—
b	0.150	0.200	0.250
D	—	4.000 BSC	—
E	—	4.000 BSC	—
e	—	0.40 BSC	—
D2	2.65	2.70	2.75
E2	2.65	2.70	2.75
L	0.35	0.40	0.45
K	0.20	—	—

SAW Type 46-pin (6.5mm×4.5mm) QFN Outline Dimensions



Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	0.031	0.033	0.035
A1	0.000	0.001	0.002
A3	—	0.008 BSC	—
b	0.006	0.008	0.010
D	0.254	0.256	0.258
E	0.175	0.177	0.179
e	—	0.016 BSC	—
D2	0.197	0.201	0.205
E2	0.118	0.122	0.126
L	0.012	0.016	0.020
K	—	—	—

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	0.800	0.850	0.900
A1	0.000	0.020	0.040
A3	—	0.200 BSC	—
b	0.150	0.200	0.250
D	6.450	6.500	6.550
E	4.450	4.500	4.550
e	—	0.40 BSC	—
D2	5.00	5.10	5.20
E2	3.00	3.10	3.20
L	0.30	0.40	0.50
K	—	—	—