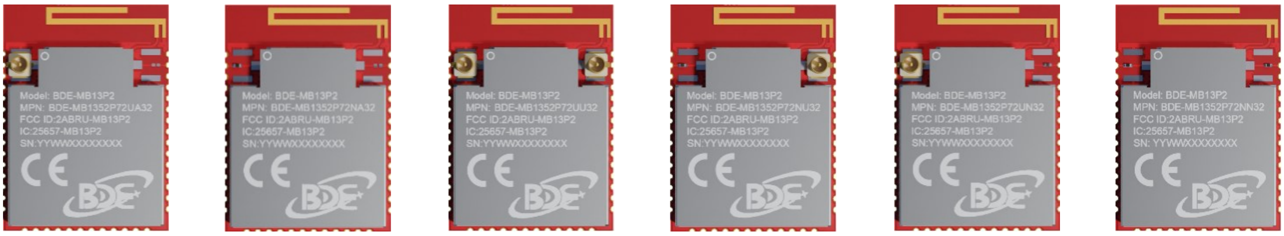
General Description



Note: Images are for illustrative purposes only; actual products may differ.

The BDE-MB1352P72 is a multi-band (Sub-1 GHz and 2.4 GHz), multi-protocol wireless module series with an integrated PA in the 2.4 GHz band, based on Texas Instruments' (TI) single-chip wireless microcontroller (MCU) CC1352P74T0RGZR. To meet different integration requirements, BDE offers multiple variants of this module series, as listed and described in Table 1.

The BDE-MB1352P72 integrates an Arm® Cortex®-M4F MCU and a dedicated software-controlled radio controller (Arm® Cortex®-M0). This architecture supports multiple physical layers and RF standards, including Thread, Zigbee®, Bluetooth® 5.2 Low Energy, IEEE 802.15.4g, IPv6-enabled smart objects (6LoWPAN), mioty, Wi-SUN, Amazon Sidewalk, proprietary systems, and TI 15.4-Stack for both Sub-1 GHz and 2.4 GHz bands. Concurrent multiprotocol operation is enabled through TI's Dynamic Multiprotocol Manager (DMM) driver. The module features 704 KB flash, 144 KB SRAM, and 8 KB cache SRAM.

The module supports operation in the 861 – 1054 MHz and 2360 – 2500 MHz frequency bands, with up to +14 dBm TX power in the Sub-1 GHz band and +20 dBm TX power in the 2.4 GHz band.

The BDE-MB1352P72 has an ultra-low sleep current of 0.9 µA with RTC and 144 KB RAM retention, enabling long battery life for wireless applications. In addition to the main Cortex®-M4F processor, it includes an autonomous ultra-low-power Sensor Controller CPU with fast wake-up capability. For example, the sensor controller can perform 1 Hz ADC sampling at 1 µA system current. The device offers low SER (Soft Error Rate) FIT (Failure-In-Time) for long operational lifetime, and always-on RAM parity minimizes corruption risk from potential radiation events.

Optimized for low-power wireless communication and advanced sensing, the module is well-suited for grid infrastructure, building automation, retail automation, personal electronics, and medical applications.

The series integrates all required system-level components — including clocks, balun filter, passives, and a PCB trace antenna or U.FL connector — into a compact PCB form factor, ensuring easy assembly and low-cost PCB design.

Pre-certified with FCC, ISED, CE, and Bluetooth SIG, the BDE-MB1352P72 enables quick integration and fast time-to-market for customer products.

Table 1. Module Variants

Orderable Part Number	Antenna in Sub-1G	Antenna in 2.4G	On-board SPI Flash (Mbit)	Operating Temperature
BDE-MB1352P72UA32	U.FL Connector	PCB Trace Antenna	32	-40°C to +85°C
BDE-MB1352P72NA32	ANT Pin	PCB Trace Antenna		
BDE-MB1352P72UU32	U.FL Connector	U.FL Connector		
BDE-MB1352P72NU32	ANT Pin	U.FL Connector		
BDE-MB1352P72UN32	U.FL Connector	ANT Pin		
BDE-MB1352P72NN32	ANT Pin	ANT Pin		
BDE-MB1352P72UA0	U.FL Connector	PCB Trace Antenna	0	
BDE-MB1352P72NA0	ANT Pin	PCB Trace Antenna		
BDE-MB1352P72UU0	U.FL Connector	U.FL Connector		
BDE-MB1352P72NU0	ANT Pin	U.FL Connector		
BDE-MB1352P72UN0	U.FL Connector	ANT Pin		
BDE-MB1352P72NN0	ANT Pin	ANT Pin		
BDE-MB1352P72UA32-IN	U.FL Connector	PCB Trace Antenna	32	-40°C to +105°C
BDE-MB1352P72NA32-IN	ANT Pin	PCB Trace Antenna		
BDE-MB1352P72UU32-IN	U.FL Connector	U.FL Connector		
BDE-MB1352P72NU32-IN	ANT Pin	U.FL Connector		
BDE-MB1352P72UN32-IN	U.FL Connector	ANT Pin		
BDE-MB1352P72NN32-IN	ANT Pin	ANT Pin		
BDE-MB1352P72UA0-IN	U.FL Connector	PCB Trace Antenna	0	
BDE-MB1352P72NA0-IN	ANT Pin	PCB Trace Antenna		
BDE-MB1352P72UU0-IN	U.FL Connector	U.FL Connector		
BDE-MB1352P72NU0-IN	ANT Pin	U.FL Connector		
BDE-MB1352P72UN0-IN	U.FL Connector	ANT Pin		
BDE-MB1352P72NN0-IN	ANT Pin	ANT Pin		

Key Features

- **Wireless microcontroller**
  - Powerful 48-MHz Arm® Cortex®-M4F processor
  - 704KB flash program memory
  - 256KB of ROM for protocols and library functions
  - 8KB of cache SRAM
  - 144KB of ultra-low leakage SRAM with parity for high-reliability operation
  - Dual-band Sub-1 GHz and 2.4 GHz operation
  - Dynamic multiprotocol manager (DMM) driver
  - Programmable radio includes support for 2-(G)FSK, 4-(G)FSK, MSK, OOK, Bluetooth®5.2 Low Energy, IEEE 802.15.4 PHY and MAC
  - Supports over-the-air upgrade(OTA)
- **Ultra-low power sensor controller**
  - Autonomous MCU with 4KB of SRAM
  - Sample, store, and process sensor data
  - Fast wake-up for low-power operation
  - Software defined peripherals; capacitive touch, flow meter, LCD
- **Low power consumption**
  - MCU consumption:
    - 2.63 mA active mode, CoreMark
    - 55 µA/MHz running CoreMark
    - 0.8 µA standby mode, RTC, 144KB RAM
    - 0.1 µA shutdown mode, wake-up on pin
  - Ultra low-power sensor controller consumption:
    - 25.2 µA in 2 MHz mode
    - 701 µA in 24 MHz mode
  - Radio Consumption:
    - 5.4 mA RX at 868 MHz
    - 6.4 mA RX at 2.4 GHz
    - 9.8 mA TX at +5 dBm at 2.4 GHz
    - 24.9 mA TX at +14 dBm at 868 MHz
    - 101 mA TX at +20 dBm at 2.4 GHz
- **Wireless protocol support**
  - Thread, Zigbee®, Matter
  - Bluetooth® 5.2 Low Energy
  - Wi-SUN
  - Mioty
  - Amazon Sidewalk
  - Wireless M-Bus
  - SimpleLink™ TI 15.4-stack
  - 6LoWPAN
  - Proprietary systems
- **High performance radio**
  - -121 dBm for 2.5-kbps long-range mode
  - -110 dBm at 50 kbps, 802.15.4, 868 MHz
  - -104 dBm for Bluetooth® Low Energy 125-kbps
- **MCU peripherals**
  - Digital peripherals can be routed to any GPIO
  - Four 32-bit or eight 16-bit general-purpose timers
  - 12-bit ADC, 200 kSamples/s, 8 channels
  - 8-bit DAC
  - Two comparators
  - Programmable current source
  - Two UART, two SSI, I2C, I2S
  - Real-time clock (RTC)
  - Integrated temperature and battery monitor
  - 26 GPIOs – none SPI flash versions
  - 22 GPIOs – SPI flash versions
- **Security enablers**
  - AES 128- and 256-bit cryptographic accelerator
  - ECC and RSA public key hardware accelerator
  - SHA2 Accelerator (full suite up to SHA-512)
  - True random number generator (TRNG)
- **Operating range**
  - On-chip buck DC/DC converter
  - 1.8-V to 3.8-V single supply voltage
  - 2.3-V to 3.6-V single supply voltage (SPI flash variants)
  - -40 to +85°C or -40 to +105°C
- **Antenna options**
  - ANT pin for external antenna (Sub-1GHz & 2.4GHz)
  - U.FL connector for external antenna (Sub-1GHz & 2.4GHz)
  - Integrated PCB trace antenna (2.4GHz)
- **On-board SPI Flash**
  - 32-Mbit, only available in SPI flash versions
- **Package**
  - LCC-42, 26 mm x 19 mm x 2.15 mm
  - RoHS-compliant package
- **Certification**
  - FCC ID: 2ABRU-MB13P2
  - IC: 25657-MB13P2
  - CE-RED
  - Bluetooth SIG

Applications

- Grid infrastructure
  - Smart Meters – electricity meter, water meter, gas meter and heat cost allocator
  - Grid communications – wireless communications
  - EV charging infrastructure – AC charging (pile) station
  - Other alternative energy – energy harvesting
- Building automation
  - Building security systems – motion detector, electronic smart lock, door and window sensor, garage door system, gateway
  - HVAC – thermostat, wireless environmental sensor, HVAC system controller, gateway
  - Fire safety system – smoke and heat detector, fire alarm control panel (FACP)
- Retail Automation
  - Retail automation & payment applications
  - electronic shelf labels and portable POS terminal
- Personal Electronics
  - RF remote controls– Smart Speakers, Smart Displays and Set-top box
  - Gaming and electronic and robotic toys
  - Wearables (non-medical), smart trackers, smart clothing and smartwatch

Module Family

Table 2. Module Family

Product Type & Series Name	Orderable Part Number	Chipset & Core	On-chip Flash Size (KB)	On-chip SRAM Size (KB)	Connectivity	Antenna in Sub-1G	Antenna in 2.4G	On-board SPI Flash (Mbit)	Operating Temp (°C)	Size (mm)
Module BDE-MB13P2	BDE-MB1354P102UA32	CC1354P10 Coretex-M33	1024	296	Sub-1GHz: Wireless M-Bus & mioty & Wi-SUN & Sidewalk 2.4GHz: BLE & Zigbee & Thread	U.FL Connector	PCB Trace Antenna	32	-40 to +85	26 X 19 X 2.15
	BDE-MB1354P102NA32					ANT Pin	PCB Trace Antenna			
	BDE-MB1354P102UU32					U.FL Connector	U.FL Connector			
	BDE-MB1354P102NU32					ANT Pin	U.FL Connector			
	BDE-MB1354P102UN32					U.FL Connector	ANT Pin			
	BDE-MB1354P102NN32					ANT Pin	ANT Pin			
	BDE-MB1354P102UA0					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1354P102NA0					ANT Pin	PCB Trace Antenna			
	BDE-MB1354P102UU0					U.FL Connector	U.FL Connector			
	BDE-MB1354P102NU0					ANT Pin	U.FL Connector			
	BDE-MB1354P102UN0					U.FL Connector	ANT Pin			
	BDE-MB1354P102NN0					ANT Pin	ANT Pin			
	BDE-MB1354P102UA32-IN					U.FL Connector	PCB Trace Antenna	32	-40 to +105	
	BDE-MB1354P102NA32-IN					ANT Pin	PCB Trace Antenna			
	BDE-MB1354P102UU32-IN					U.FL Connector	U.FL Connector			
	BDE-MB1354P102NU32-IN					ANT Pin	U.FL Connector			
	BDE-MB1354P102UN32-IN					U.FL Connector	ANT Pin			
	BDE-MB1354P102NN32-IN					ANT Pin	ANT Pin			
	BDE-MB1354P102UA0-IN					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1354P102NA0-IN					ANT Pin	PCB Trace Antenna			
	BDE-MB1354P102UU0-IN					U.FL Connector	U.FL Connector			
	BDE-MB1354P102NU0-IN					ANT Pin	U.FL Connector			
	BDE-MB1354P102UN0-IN					U.FL Connector	ANT Pin			
	BDE-MB1354P102NN0-IN					ANT Pin	ANT Pin			
	BDE-MB1352P72UA32	CC1352P7 Coretex-M4F	704	152	Sub-1GHz: Wireless M-Bus & mioty & Wi-SUN & Sidewalk 2.4GHz: BLE & Zigbee & Thread	U.FL Connector	PCB Trace Antenna	32	-40 to +85	
	BDE-MB1352P72NA32					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P72UU32					U.FL Connector	U.FL Connector			
	BDE-MB1352P72NU32					ANT Pin	U.FL Connector			
	BDE-MB1352P72UN32					U.FL Connector	ANT Pin			
	BDE-MB1352P72NN32					ANT Pin	ANT Pin			
	BDE-MB1352P72UA0					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1352P72NA0					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P72UU0					U.FL Connector	U.FL Connector			
	BDE-MB1352P72NU0					ANT Pin	U.FL Connector			
	BDE-MB1352P72UN0					U.FL Connector	ANT Pin			
	BDE-MB1352P72NN0					ANT Pin	ANT Pin			
	BDE-MB1352P72UA32-IN					U.FL Connector	PCB Trace Antenna	32	-40 to +105	
	BDE-MB1352P72NA32-IN					ANT Pin	PCB Trace			

Product Type & Series Name	Orderable Part Number	Chipset & Core	On-chip Flash Size (KB)	On-chip SRAM Size (KB)	Connectivity	Antenna in Sub-1G	Antenna in 2.4G	On-board SPI Flash (Mbit)	Operating Temp (°C)	Size (mm)
							Antenna			
	BDE-MB1352P72UU32-IN					U.FL Connector	U.FL Connector			
	BDE-MB1352P72NU32-IN					ANT Pin	U.FL Connector			
	BDE-MB1352P72UN32-IN					U.FL Connector	ANT Pin			
	BDE-MB1352P72NN32-IN					ANT Pin	ANT Pin			
	BDE-MB1352P72UA0-IN					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1352P72NA0-IN					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P72UU0-IN					U.FL Connector	U.FL Connector			
	BDE-MB1352P72NU0-IN					ANT Pin	U.FL Connector			
	BDE-MB1352P72UN0-IN					U.FL Connector	ANT Pin			
	BDE-MB1352P72NN0-IN					ANT Pin	ANT Pin			
	BDE-MB1352P2UA32	CC1352P Coretex-M4F	352	88	Sub-1GHz: Wireless M-Bus & mioty & Wi-SUN 2.4GHz: BLE & Zigbee & Thread	U.FL Connector	PCB Trace Antenna	32	-40 to +85	
	BDE-MB1352P2NA32					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P2UU32					U.FL Connector	U.FL Connector			
	BDE-MB1352P2NU32					ANT Pin	U.FL Connector			
	BDE-MB1352P2UN32					U.FL Connector	ANT Pin			
	BDE-MB1352P2NN32					ANT Pin	ANT Pin			
	BDE-MB1352P2UA0					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1352P2NA0					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P2UU0					U.FL Connector	U.FL Connector			
	BDE-MB1352P2NU0					ANT Pin	U.FL Connector			
	BDE-MB1352P2UN0					U.FL Connector	ANT Pin			
	BDE-MB1352P2NN0					ANT Pin	ANT Pin			
	BDE-MB1352P2UA32-IN					U.FL Connector	PCB Trace Antenna	32	-40 to +105	
	BDE-MB1352P2NA32-IN					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P2UU32-IN					U.FL Connector	U.FL Connector			
	BDE-MB1352P2NU32-IN					ANT Pin	U.FL Connector			
	BDE-MB1352P2UN32-IN					U.FL Connector	ANT Pin			
	BDE-MB1352P2NN32-IN					ANT Pin	ANT Pin			
	BDE-MB1352P2UA0-IN					U.FL Connector	PCB Trace Antenna	0		
	BDE-MB1352P2NA0-IN					ANT Pin	PCB Trace Antenna			
	BDE-MB1352P2UU0-IN					U.FL Connector	U.FL Connector			
	BDE-MB1352P2NU0-IN					ANT Pin	U.FL Connector			
	BDE-MB1352P2UN0-IN					U.FL Connector	ANT Pin			
	BDE-MB1352P2NN0-IN					ANT Pin	ANT Pin			

Naming Convention

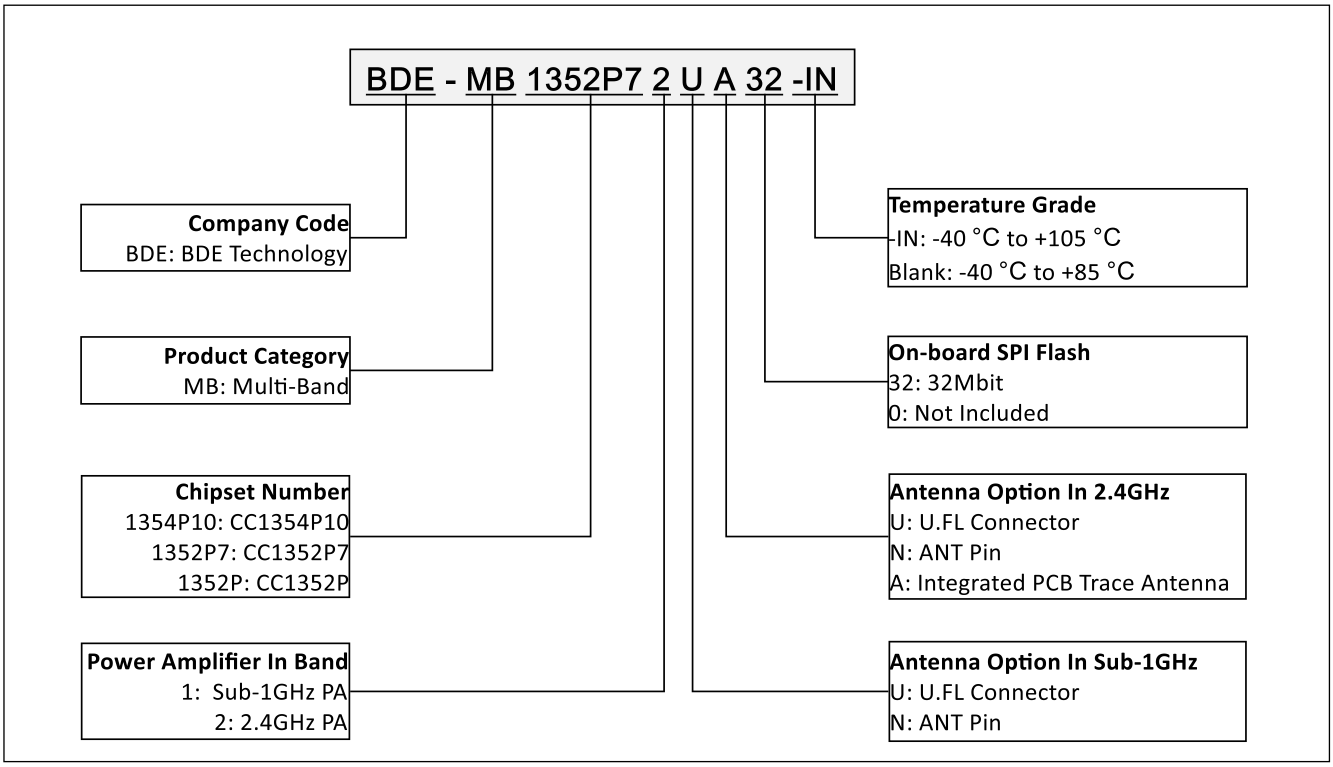


Figure 1. Module Naming Convention

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References

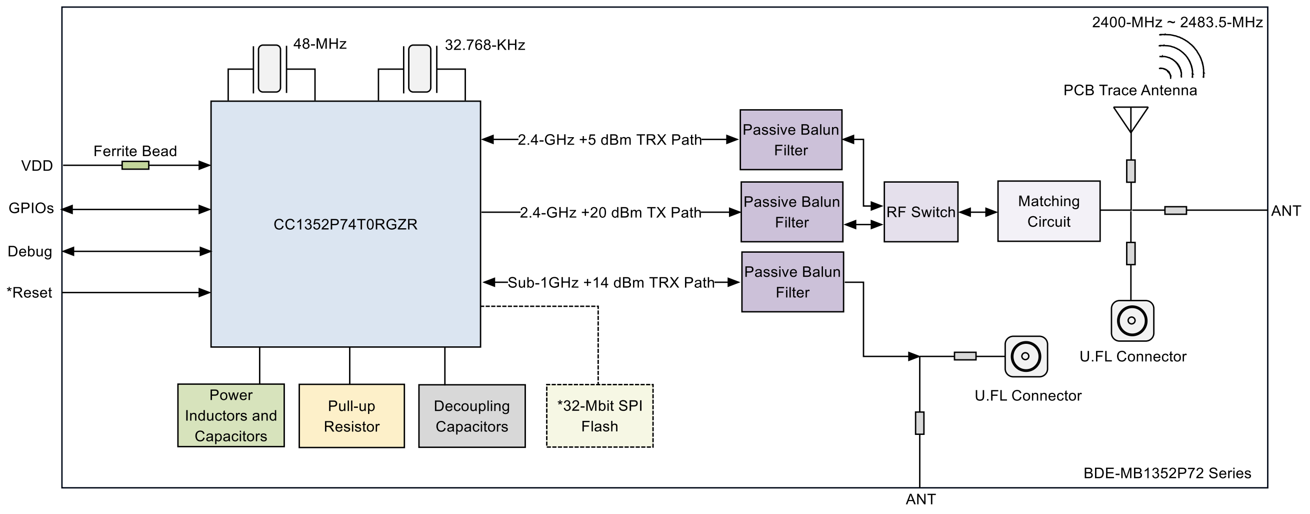
[1] CC1352P7 resources: https://www.ti.com/product/CC1352P7

1. System Overview

1.1. Block Diagram

BDE-MB1352P72 module series is based on the Texas Instruments' CC1352P7single chip wireless MCU. The module integrates all required system-level hardware components including clocks, balun filter, other passives, and PCB trace antenna or U.FL connector into a small PCB form factor.

The module series, as seen in Figure 2, comprises of:
- 48-MHz XTAL
- 32.768-kHz XTAL
- Power inductors and capacitors
- Pull-up resistor
- Passive balun filter
- Decoupling capacitors
- Matching circuit
- PCB trace antenna (BDE-MB1352P72xA)
- U.FL connector (BDE-MB1352P72xU/BDE-MB1352P72Ux)



(1) The 32-Mbit SPI flash is only included in SPI flash variants;
(2) Reset pin has an internal pull-up resistor and a decoupling capacitor.

Figure 2. BDE-MB1352P72 Module Block Diagram

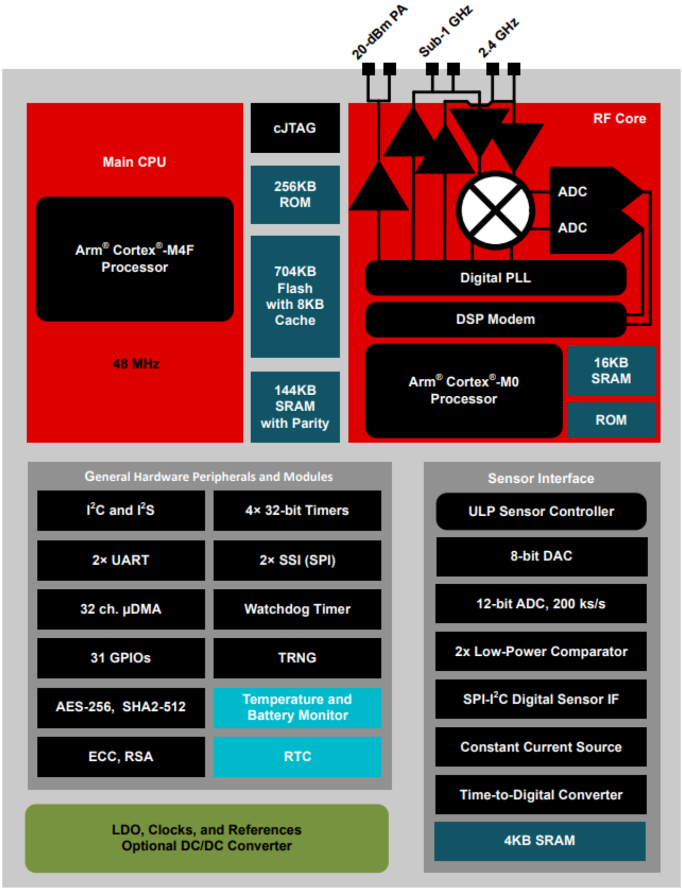


Figure 3. The block diagram of CC1352P7 (Adopted form CC1352P7 Datasheet)

1.2. System CPU

The BDE-MB1352P72 module series utilizes CC1352P7 SimpleLink™ Wireless MCU. The MCU contains an Arm® Cortex®-M4F system CPU, which runs the application and the higher layers of radio protocol stacks.

The system CPU is the foundation of a high-performance, low-cost platform that meets the system requirements of minimal memory implementation, and low-power consumption, while delivering outstanding computational performance and exceptional system response to interrupts.

1.3. Radio (RF Core)

The RF Core is a highly flexible and future proof radio module which contains an Arm Cortex-M0 processor that interfaces the analog RF and base-band circuitry, handles data to and from the system CPU side, and assembles the information bits in a given packet structure. The RF core offers a high level, command-based API to the main CPU that configurations and data are passed through. The Arm Cortex-M0 processor is not programmable by customers and is interfaced through the TI-provided RF driver that is included with the SimpleLink Software Development Kit (SDK).

The RF core can autonomously handle the time-critical aspects of the radio protocols, thus offloading the main CPU, which reduces power and leaves more resources for the user application. Several signals are also available to control external circuitry such as RF switches or range extenders autonomously.

Dual-band and multiprotocol solutions are enabled through time-sliced access of the radio, handled transparently for the application through the TI-provided RF driver and dual-mode manager.

The various physical layer radio formats are partly built as a software defined radio where the radio behavior is either defined by radio ROM contents or by non-ROM radio formats delivered in form of firmware patches with the SimpleLink SDKs. This allows the radio platform to be updated for support of future versions of standards even with over-the-air (OTA) updates while still using the same silicon.

1.3.1. Proprietary Radio Formats

The BDE-MB1352P72 radio can support a wide range of physical radio formats through a set of hardware peripherals combined with firmware available in the device ROM, covering various customer needs for optimizing towards parameters such as speed or sensitivity. This allows great flexibility in tuning the radio both to work with legacy protocols as well as customizing the behavior for specific application needs.

Table 3 gives a simplified overview of features of the various radio formats available in ROM. Other radio formats may be available in the form of radio firmware patches or programs through the Software Development Kit (SDK) and may combine features in a different manner, as well as add other features.

Table 3. Feature Support

Feature	Main 2-(G)FSK Mode	High Data Rates	Low Data Rates	SimpleLink™ Long Range
Programmable preamble, sync word and CRC	Yes	Yes	Yes	No
Programmable receive bandwidth	Yes	Yes	Yes (down to 4 kHz)	Yes
Data / Symbol rate (3)	20 to 1000 kbps	≤ 2 Msps	≤ 100 ksps	≤ 20 ksps
Modulation format	2- (G)FSK	2-(G)FSK 4-(G)FSK	2-(G)FSK 4-(G)FSK	2- (G)FSK
Dual Sync Word	Yes	Yes	No	No
Carrier Sense (1) (2)	Yes	No	No	No
Preamble Detection (2)	Yes	Yes	Yes	No
Data Whitening	Yes	Yes	Yes	Yes
Digital RSSI	Yes	Yes	Yes	Yes
CRC filtering	Yes	Yes	Yes	Yes
Direct-sequence spread spectrum (DSSS)	No	No	No	1:2 1:4 1:8
Forward error correction (FEC)	No	No	No	Yes
Link Quality Indicator (LQI)	Yes	Yes	Yes	Yes

---

(1) Carrier Sense can be used to implement HW-controlled listen-before-talk (LBT) and Clear Channel Assessment (CCA) for compliance with such requirements in regulatory standards. This is available through the CMD_PROP_CS radio API.

(2) Carrier Sense and Preamble Detection can be used to implement sniff modes where the radio is duty cycled to save power.

(3) Data rates are only indicative. Data rates outside this range may also be supported. For some specific combinations of settings, a smaller range might be supported.

1.3.2. Bluetooth 5.2 Low Energy

The RF Core offers full support for Bluetooth 5.2 Low Energy, including the high speed 2 Mbps physical layer and the 500 kbps and 125 kbps long range PHYs (Coded PHY) through the TI provided Bluetooth 5.2 stack or through a high-level Bluetooth API. The Bluetooth 5.2 PHY and part of the controller are in radio and system ROM, providing significant savings in memory usage and more space available for applications.

The new high-speed mode allows data transfers up to 2 Mbps, twice the speed of Bluetooth 4.2 and five times the speed of Bluetooth 4.0, without increasing power consumption. In addition to faster speeds, this mode offers significant improvements for energy efficiency and wireless coexistence with reduced radio communication time.

Bluetooth 5.2 also enables unparalleled flexibility for adjustment of speed and range based on application needs, which capitalizes on the high-speed or long-range modes respectively. Data transfers are now possible at 2 Mbps, enabling development of applications using voice, audio, imaging, and data logging that were not previously an option using Bluetooth low energy. With high-speed mode, existing applications deliver faster responses, richer engagement, and longer battery life. Bluetooth 5.2 enables fast, reliable firmware updates.

1.3.3. 802.15.4 Thread, Zigbee, and 6LoWPAN

Through a dedicated IEEE radio API, the RF Core supports the 2.4 GHz IEEE 802.15.4-2011 physical layer (2 Mchips per second Offset-QPSK with DSSS 1:8), used in Thread, Zigbee, and 6LoWPAN protocols. The 802.15.4 PHY and MAC are in radio and system ROM. TI also provides royalty-free protocol stacks for Thread and Zigbee as part of the SimpleLink SDK, enabling a robust end-to-end solution.

1.4. Memory

The up to 704 KB nonvolatile (Flash) memory provides storage for code and data. The flash memory is in-system programmable and erasable. The last flash memory sector must contain a Customer Configuration section (CCFG) that is used by boot ROM and TI provided drivers to configure the device. This configuration is done through the ccfg.c source file that is included in all TI provided examples.

The ultra-low leakage system static RAM (SRAM) is split into up to four 32 kB and one 16 kB blocks and can be used for both storage of data and execution of code. Retention of SRAM contents in Standby power mode is enabled by default and included in Standby mode power consumption numbers. Parity checking for detection of bit errors in memory is built-in, which reduces chip-level soft errors and thereby increases reliability. Parity can be disabled for an additional 32 kB which can be allocated for general purpose SRAM. System SRAM is always initialized to zeroes upon code execution from boot.

To improve code execution speed and lower power when executing code from nonvolatile memory, a 4-way nonassociative 8 kB cache is enabled by default to cache and prefetch instructions read by the system CPU. The cache can be used as a general-purpose RAM by enabling this feature in the Customer Configuration Area (CCFG).

There is a 4 kB ultra-low leakage SRAM available for use with the Sensor Controller Engine which is typically used for storing Sensor Controller programs, data and configuration parameters. This RAM is also accessible by the system CPU. The Sensor Controller RAM is not cleared to zeroes between system resets.

The ROM includes a TI-RTOS kernel and low-level drivers, as well as significant parts of selected radio stacks, which frees up flash memory for the application. The ROM also contains a serial (SPI and UART) bootloader that can be used for initial programming of the device.

The module series also provides an option with integrated an on-board 32-Mbit SPI flash for the applications that need to store large application data.

1.5. Sensor Controller

The Sensor Controller contains circuitry that can be selectively enabled in both Standby and Active power modes. The peripherals in this domain can be controlled by the Sensor Controller Engine, which is a proprietary power-optimized CPU. This CPU can read and monitor sensors or perform other tasks autonomously; thereby significantly reducing power consumption and offloading the system CPU.

The Sensor Controller Engine is user programmable with a simple programming language that has syntax similar to C. This programmability allows for sensor polling and other tasks to be specified as sequential algorithms rather than static configuration of complex peripheral modules, timers, DMA, register programmable state machines, or event routing.

The peripherals in the Sensor Controller include the following:

- The low-power clocked comparator can be used to wake the system CPU from any state in which the comparator is active. A configurable internal reference DAC can be used in conjunction with the comparator. The output of the comparator can also be used to trigger an interrupt or the ADC.
- Capacitive sensing functionality is implemented through the use of a constant current source, a time-to-digital converter, and a comparator. The continuous time comparator in this block can also be used as a higher-accuracy alternative to the low-power clocked comparator. The Sensor Controller takes care of baseline tracking, hysteresis, filtering, and other related functions when these modules are used for capacitive sensing.
- The ADC is a 12-bit 200 ksamples/s ADC with eight inputs and a built-in voltage reference. The ADC can be triggered by many different sources including timers, I/O pins, software, and comparators.
- The analog modules can connect to up to eight different GPIOs.
- Dedicated SPI master with up to 6 MHz clock speed.

The peripherals in the Sensor Controller can also be controlled from the main application processor.

1.6. Cryptography

The device comes with a wide set of modern cryptography-related hardware accelerators, drastically reducing code footprint and execution time for cryptographic operations. It also has the benefit of being lower power and improves availability and responsiveness of the system because the cryptography operations runs in a background hardware thread.

Together with a large selection of open-source cryptography libraries provided with the Software Development Kit (SDK), this allows for secure and future proof IoT applications to be easily built on top of the platform. The hardware accelerator modules are:

- True Random Number Generator (TRNG) module provides a true, nondeterministic noise source for the purpose of generating keys, initialization vectors (IVs), and other random number requirements. The TRNG is built on 24 ring oscillators that create unpredictable output to feed a complex nonlinear-combinatorial circuit.

- Secure Hash Algorithm 2 (SHA-2) with support for SHA224, SHA256, SHA384, and SHA512.
- Advanced Encryption Standard (AES) with 128, 192 and 256 bit key lengths.
- Public Key Accelerator - Hardware accelerator supporting mathematical operations needed for elliptic curves up to 512 bits.

Through use of these modules and the TI provided cryptography drivers, the following capabilities are available for application or stack:

- Key Agreement Schemes
- Signature Generation
- Curve Support
- SHA2 based MACs
- True random number generation

Other capabilities, such as RSA encryption and signatures as well as Edwards type of elliptic curves such as Curve1174 or Ed25519, can also be implemented using the provided hardware accelerators but are not part of the TI SimpleLink SDK for the CC1352P7 device.

1.7. Timers

A large selection of timers are available as part of the device. These timers are:

- Real-Time Clock (RTC)
- General Purpose Timers (GPTIMER)
- Sensor Controller Timers
- Radio Timer
- Watchdog timer

1.8. Serial Peripherals and I/O

The SSIs are synchronous serial interfaces that are compatible with SPI, MICROWIRE, and TI's synchronous serial interfaces. The SSIs support both SPI master and slave up to 4 MHz. The SSI modules support configurable phase and polarity.

The UARTs implement universal asynchronous receiver and transmitter functions. They support flexible baud-rate generation up to a maximum of 3 Mbps.

The I2S interface is used to handle digital audio and can also be used to interface pulse-density modulation microphones (PDM).

The I2C interface is used to communicate with devices compatible with the I2C standard. The I2C interface can handle 100 kHz and 400 kHz operation, and can serve as both master and slave.

The I/O controller (IOC) controls the digital I/O pins and contains multiplexer circuitry to allow a set of peripherals to be assigned to I/O pins in a flexible manner. All digital I/Os are interrupt and wake-up capable, have a programmable pullup and pulldown function, and can generate an interrupt on a negative or positive edge (configurable). When configured as an output, pins can function as either push-pull or open-drain. Five GPIOs have high-drive capabilities, which are marked in bold in Section 2.1. All digital peripherals can be connected to any digital pin on the device.

1.9. Battery and Temperature Monitor

A combined temperature and battery voltage monitor is available in the device. The battery and temperature monitor allows an application to continuously monitor on-chip temperature and supply voltage and respond to changes in environmental conditions as needed. The module contains window comparators to interrupt the system CPU when temperature or supply voltage go outside defined windows. These events can also be used to wake up the device from Standby mode through the Always-On (AON) event fabric.

1.10. µDMA

The device includes a direct memory access (µDMA) controller. The µDMA controller provides a way to offload data-transfer tasks from the system CPU, thus allowing for more efficient use of the processor and the available bus bandwidth. The µDMA controller can perform a transfer between memory and peripherals. The µDMA controller has dedicated channels for each supported on-chip module and can be programmed to automatically perform transfers between peripherals and memory when the peripheral is ready to transfer more data.

1.11. Debug

The on-chip debug support is done through a dedicated cJTAG (IEEE 1149.7) or JTAG (IEEE 1149.1) interface. The device boots by default into cJTAG mode and must be reconfigured to use 4-pin JTAG.

1.12. Clock Systems

The module has several internal system clocks.

The 48 MHz SCLK_HF is used as the main system (MCU and peripherals) clock. This can be driven by the internal 48 MHz RC Oscillator (RCOSC_HF) or an external 48 MHz crystal (XOSC_HF). Radio operation requires an external 48 MHz crystal.

SCLK_MF is an internal 2 MHz clock that is used by the Sensor Controller in low-power mode and also for internal power management circuitry. The SCLK_MF clock is always driven by the internal 2 MHz RC Oscillator (RCOSC_MF).

SCLK_LF is the 32.768 kHz internal low-frequency system clock. It can be used by the Sensor Controller for ultra-low-power operation and is also used for the RTC and to synchronize the radio timer before or after Standby power mode. SCLK_LF can be driven by the internal 32.8 kHz RC Oscillator (RCOSC_LF), a 32.768 kHz watch-type crystal, or a clock input on any digital IO.

When using a crystal or the internal RC oscillator, the device can output the 32 kHz SCLK_LF signal to other devices, thereby reducing the overall system cost.

The module includes two crystals on board, a high frequency crystal (HFXT) with 48-MHz and a low frequency crystal (LFXT) with 32.768-KHz. The characteristics for two crystals can be found in Section 3.1.5.

1.13. Network Processor

Depending on the product configuration, the device can function as a wireless network processor (WNP - a device running the wireless protocol stack with the application running on a separate host MCU), or as a system-on-chip (SoC) with the application and protocol stack running on the system CPU inside the device.

In the first case, the external host MCU communicates with the device using SPI or UART. In the second case, the application must be written according to the application framework supplied with the wireless protocol stack.

1.14. Power Management

To minimize power consumption, the BDE-MB1352P72 series supports a number of power modes and power management features (see Table 4).

Table 4. Power Modes

Mode	Software Configurable Power Modes				Reset Pin Held
	Active	Idle	Standby	Shutdown	
CPU	Active	Off	Off	Off	Off
Flash	On	Available	Off	Off	Off
SRAM	On	On	Retention	Off	Off
Supply System	On	On	Duty Cycled	Off	Off
Register and CPU retention	Full	Full	Partial	No	No
SRAM retention	Full	Full	Full	Off	Off
48 MHz high-speed clock (SCLK_HF)	XOSC_HF or RCOSC_HF	XOSC_HF or RCOSC_HF	Off	Off	Off
2 MHz medium-speed clock (SCLK_MF)	RCOSC_MF	RCOSC_MF	Available	Off	Off
32 kHz low-speed clock (SCLK_LF)	XOSC_LF or RCOSC_LF	XOSC_LF or RCOSC_LF	XOSC_LF or RCOSC_LF	Off	Off
Peripherals	Available	Available	Off	Off	Off
Sensor Controller	Available	Available	Available	Off	Off
Wake-up on RTC	Available	Available	Available	Off	Off
Wake-up on pin edge	Available	Available	Available	Available	Off
Wake-up on reset pin	On	On	On	On	On
Brownout detector (BOD)	On	On	Duty Cycled	Off	Off
Power-on reset (POR)	On	On	On	Off	Off
Watchdog timer (WDT)	Available	Available	Paused	Off	Off

In Active mode, the application system CPU is actively executing code. Active mode provides normal operation of the processor and all of the peripherals that are currently enabled. The system clock can be any available clock source (see Table 4).

In Idle mode, all active peripherals can be clocked, but the Application CPU core and memory are not clocked and no code is executed. Any interrupt event brings the processor back into active mode.

In Standby mode, only the always-on (AON) domain is active. An external wake-up event, RTC event, or Sensor Controller event is required to bring the device back to active mode. MCU peripherals with retention do not need to be reconfigured when waking up again, and the CPU continues execution from where it went into standby mode. All GPIOs are latched in standby mode.

In Shutdown mode, the device is entirely turned off (including the AON domain and Sensor Controller), and the I/Os are latched with the value they had before entering shutdown mode. A change of state on any I/O pin defined as a wake from shutdown pin wakes up the device and functions as a reset trigger. The CPU can differentiate between reset in this way and reset-by-reset pin or power-on reset by reading the reset status register. The only state retained in this mode is the latched I/O state and the flash memory contents.

The Sensor Controller is an autonomous processor that can control the peripherals in the Sensor Controller independently of the system CPU. This means that the system CPU does not have to wake up, for example to perform an ADC sampling or poll a digital sensor over SPI, thus saving both current and wake-up time that would otherwise be wasted. The Sensor Controller Studio tool enables the user to program the Sensor Controller, control its peripherals, and wake up the system CPU as needed. All Sensor Controller peripherals can also be controlled by the system CPU.

The power, RF and clock management for the CC1352P7 device require specific configuration and handling by software for optimized performance. This configuration and handling is implemented in the TI-provided drivers that are part of the CC1352P7 software development kit (SDK). Therefore, TI highly recommends using this software framework for all application development on the device. The complete SDK with TI-RTOS (optional), device drivers, and examples is offered free of charge in source code.

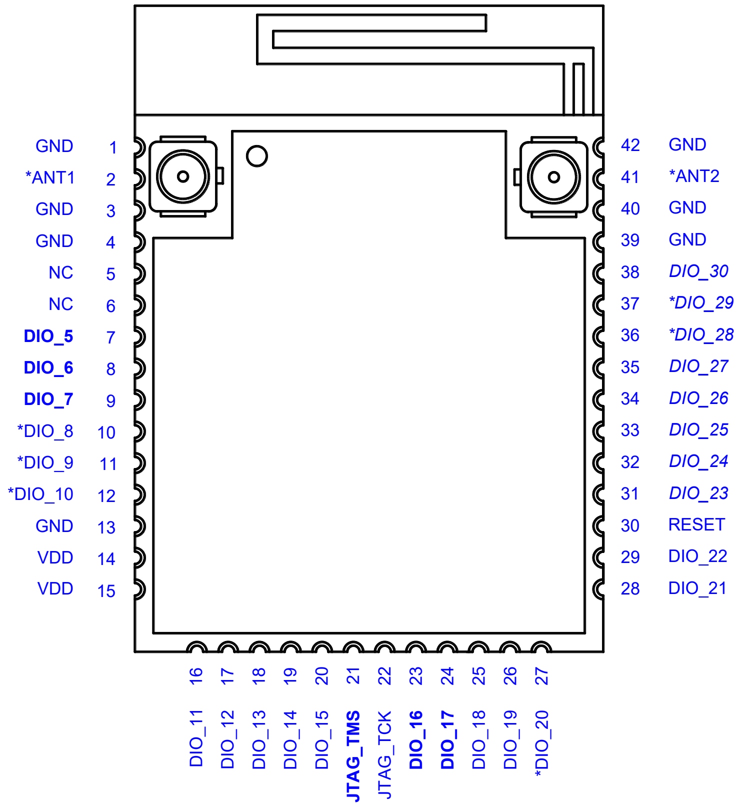
1.15. Antenna

The module series provides three different types of antenna integration, integrated PCB trace antenna, U.FL connector and ANT pin for connecting external antenna. Detail characteristics for the antennas can be found in Section 7.2.1.

2. Pinout Functions

The module series is with LCC-42 package; 42 pads are exposed for user. This section describes pinout functions of the module in details.

2.1. Pin Diagram



(1) DIO_8, DIO_9, DIO_10 and DIO_20 are assigned to the on-board SPI flash, therefore, please leave those four pins floating if the SPI flash versions are selected;

(2) DIO_28 and DIO_29 are assigned as the RF switch control pins internally. Leave those two pins floating;

(3) Pin 2 (ANT1) is the ANT pin for Sub-1G band, Pin41 (ANT2) is the ANT pin for 2.4G band. Leave floating if not used.

Figure 4. Pin Diagram of BDE-MB1352P72 (Top View)

The following I/O pins marked in **bold** in Figure 4 have high-drive capabilities:

- Pin 7, DIO_5
- Pin 8, DIO_6
- Pin 9, DIO_7
- Pin 21, JTAG_TMSC
- Pin 23, DIO_16
- Pin 24, DIO_17

The following I/O pins marked in *italics* in Figure 4 have analog capabilities:

- Pin 31, DIO_23
- Pin 32, DIO_24

- Pin 33, DIO_25
- Pin 34, DIO_26
- Pin 35, DIO_27
- Pin 36, DIO_28
- Pin 37, DIO_29
- Pin 38, DIO_30

The following four I/O pins are assigned to on-board 32-Mbit SPI flash for SPI flash variants:

- Pin 10, SFL_MISO_DIO_8
- Pin 11, SFL_MOSI_DIO_9
- Pin 12, SFL_CLK_DIO_10
- Pin 27, SFL_CS_DIO_20

2.2. Pin Attributes and Pin Multiplexing

Table 5 describes the definitions of the pins of the module.

Table 5. Pinout Description

Module Pin #	Pin Name	Type	CC1352P74T0RGZR Pin #	Description
1	GND	Ground	-	Power ground
2	ANT1	RF	-	Antenna port for Sub-1GHz
3	GND	Ground	-	Power ground
4	GND	Ground	-	Power ground
5	NC	-	-	No connect
6	NC	-	-	No connect
7	DIO_5	I/O	10	GPIO, high-drive capability
8	DIO_6	I/O	11	GPIO, high-drive capability
9	DIO_7	I/O	12	GPIO, high-drive capability
10	DIO_8 (2)	I/O	14	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
11	DIO_9 (2)	I/O	15	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
12	DIO_10 (2)	I/O	16	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
13	GND	Ground	-	Power ground
14	VDD	Power	-	Power supply
15	VDD	Power	-	Power supply
16	DIO_11	I/O	17	GPIO
17	DIO_12	I/O	18	GPIO
18	DIO_13	I/O	19	GPIO
19	DIO_14	I/O	20	GPIO
20	DIO_15	I/O	21	GPIO
21	JTAG_TMSC	I/O	24	JTAG TMSC, high-drive capability
22	JTAG_TCKC	I	25	JTAG TCKC
23	DIO_16	I/O	26	GPIO, JTAG_TDO, high-drive capability

Module Pin #	Pin Name	Type	CC1352P74T0RGZR Pin #	Description
24	DIO_17	I/O	27	GPIO, JTAG_TDI, high-drive capability
25	DIO_18	I/O	28	GPIO
26	DIO_19	I/O	29	GPIO
27	DIO_20 [(2)]	I/O	30	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
28	DIO_21	I/O	31	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
29	DIO_22	I/O	32	GPIO, assigned as SPI_MISO of on-board SPI flash in SPI flash variants
30	RESET	I	-	Reset, active low, 100K ohm internal pull-up resistor
31	DIO_23	I/O	36	GPIO, analog capability
32	DIO_24	I/O	37	GPIO, analog capability
33	DIO_25	I/O	38	GPIO, analog capability
34	DIO_26	I/O	39	GPIO, analog capability
35	DIO_27	I/O	40	GPIO, analog capability
36	DIO_28 [(4)]	I/O	41	GPIO, analog capability
37	DIO_29 [(4)]	I/O	42	GPIO, analog capability, assigned as RF switch control pin, leave NC
38	DIO_30	I/O	43	GPIO, analog capability, assigned as RF switch control pin, leave NC
39	GND	Ground	-	Power ground
40	GND	Ground	-	Power ground
41	ANT2	RF	-	Antenna port for 2.4 GHz
42	GND	Ground	-	Power ground

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(1) For pin multiplexing details, refer to CC1352P7 SimpleLink™ High-Performance Multi-Band Wireless MCU with Integrated Power Amplifier datasheet;

(2) These four pins are assigned as SPI for on-board 32-Mbit flash in SPI flash variants modules and are not exposed for user;

(3) For operating voltage, please refer to Table 9;

(4) DIO_28 and DIO_29 are assigned internally as RF switch control pins. Truth table is as follow:

	2.4G 5dBm TRX path	2.4G High power 20dBm TX path
DIO_28	1	0
DIO_29	0	1

2.3. Connections for Unused Pins

Table 6. Connections for Unused Pins

Function	Signal Name	Acceptable Practice	Proffered Practice
GPIO (Digital or analog)	DIOn	NC or GND	NC

3. Specifications

3.1. Electrical Characteristics

3.1.1. Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, so functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification are not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Over operating free-air temperature range (unless otherwise noted).

Table 7. Absolute Maximum Ratings

PARAMETER	MIN	MAX	Unit	Notes
VDD	-0.3	4.1	V	
Voltage on any digital pins	-0.3	VDD+0.3≤4.1	V	
Voltage on ADC input	-0.3	VDDS	V	Voltage scaling enabled
	-0.3	1.49	V	Voltage scaling disabled, internal reference
	-0.3	VDD/2.9	V	Voltage scaling disabled, VDD as reference
Storage temperature	-40	125	°C	

3.1.2. ESD Ratings

Table 8. ESD Ratings

Parameter	Description	Value	Unit	Note
Electrostatic discharge	Contact discharge	4000	V	As per EN 301-489
	Air discharge	8000	V	As per EN 301-489

3.1.3. Recommended Operating Conditions

Operation at or near maximum operating temperature for extended durations will result in a reduction in lifetime.

Over operating free-air temperature range (unless otherwise noted).

Table 9. Recommended Operating Conditions

PARAMETER	MIN	TYP	MAX	UNIT
VDD	1.8	3.3	3.8	V
VDD (For SPI flash variants)	2.3	3.3	3.8	V
Operating temperature	-40	-	85	°C
Operating temperature (-IN variants)	-40	-	105	°C
Rising supply voltage slew rate	0		100	mV/us
Falling supply voltage slew rate	0		20	mV/us

3.1.4. Power Consumption

The measurement is made with the evaluation module (EM board) for BDE-MB1352P72 with T_A = 25 °C, VDD = 3.0 V, DCDC enabled, GLDO disabled, unless otherwise noted.

Table 10. Power Consumption – Power Modes

Power Mode	Test Condition	TYP	Unit
Reset	Reset. RESET pin asserted or VDD below power-on-reset threshold	110	nA
Shutdown	Shutdown. No clocks running, no retention	110	nA
Standby without cache retention	RTC running, CPU, 144 kB RAM and (partial) register retention. RCOSC_LF	0.8	uA
	RTC running, CPU, 64 kB RAM and (partial) register retention. RCOSC_LF	0.7	uA
	RTC running, CPU, 144 kB RAM and (partial) register retention. XOSC_LF	0.9	uA
Standby with cache retention	RTC running, CPU, 144 kB RAM and (partial) register retention. RCOSC_LF	1.9	uA
	RTC running, CPU, 144 kB RAM and (partial) register retention. XCOSC_LF	2.0	uA
Idle	Supply Systems and RAM powered RCOSC_HF	590	uA
Active	MCU running CoreMark at 48 MHz RCOSC_HF	2.63	mA
Peripheral, power domain	Delta current with domain enabled	39	uA
Peripheral, Serial power domain	Delta current with domain enabled	2.6	uA
Peripheral, RF Core	Delta current with power domain enabled, clock enabled, RF core idle	89	uA
Peripheral, µDMA	Delta current with clock enabled, module is idle	57	uA
Peripheral, Timers	Delta current with clock enabled, module is idle	97	uA
Peripheral, I2C	Delta current with clock enabled, module is idle	9.2	uA
Peripheral, I2S	Delta current with clock enabled, module is idle	22	uA
Peripheral, SSI	Delta current with clock enabled, module is idle	50	uA
Peripheral, UART	Delta current with clock enabled, module is idle	110	uA
Peripheral, CRYPTO (AES)	Delta current with clock enabled, module is idle	16	uA
Peripheral, PKA	Delta current with clock enabled, module is idle	59	uA
Peripheral, TRNG	Delta current with clock enabled, module is idle	20	uA
Sensor Controller Engine, Active	24 MHz, infinite loop	701	uA
Sensor Controller Engine, Low-power	2 MHz, infinite loop	25.2	uA

Table 11. Power Consumption – Radio Modes

Power Mode	Test Condition	TYP	Unit
Radio receive current	868 MHz	5.4	mA
	2440 MHz, Bluetooth Low Energy	7.1	mA
Radio transmit current	0 dBm output power setting 868 MHz	8.0	mA
	+10 dBm output power setting 868 MHz	14.3	mA
	+14 dBm output power setting 868 MHz	24.9	mA
	0 dBm output power setting 2440 MHz, Bluetooth Low Energy	7.5	mA
	+5 dBm output power setting 2440 MHz, Bluetooth Low Energy	9.8	mA
	+20 dBm output power setting 2440 MHz, Bluetooth Low Energy	101	mA

3.1.5. Clock Characteristics

Table 12. 48-MHz Crystal Oscillator (XOSC_HF) Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Crystal frequency			48		MHz
ESR, Equivalent series resistance					Ω
Frequency tolerance	T_A: 25°C	-10		+10	ppm
Frequency stability	T_A: -40°C ~ 85°C	-30		+30	ppm
C_L, Crystal load capacitance			7		pF

Table 13. 32.768-KHz Crystal Oscillator (XOSC_LF) Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Crystal frequency			32.768		KHz
ESR, Equivalent series resistance					Ω
Frequency tolerance	T_A: 25°C	-20		+20	ppm
Frequency stability	T_A: -40°C ~ 85°C	-30		+30	ppm
C_L, Crystal load capacitance			12.5		pF

3.1.6. Reset Timing

Table 14. Reset Timing

Parameter	MIN	TYP	MAX	Unit
nRESET low duration	1			us

3.1.7. UART Characteristics

Measured over operating free-air temperature range (unless otherwise noted)

Table 15. UART Characteristics

Parameter	MIN	TYP	MAX	Unit
UART baud rate			2.89	MBaud

3.1.8. GPIO DC Characteristics

Table 16. GPIO DC Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
T_A = 25 °C, V_{DD} = 1.8 V					
GPIO VOH at 8 mA load	IOCURR = 2, high-drive GPIOs only		1.56		V
GPIO VOL at 8 mA load	IOCURR = 2, high-drive GPIOs only		0.24		V
GPIO VOH at 4 mA load	IOCURR = 1		1.59		V
GPIO VOL at 4 mA load	IOCURR = 1		0.21		V
GPIO pullup current	Input mode, pullup enabled, Vpad = 0 V		73		μA
GPIO pulldown current	Input mode, pulldown enabled, Vpad = VDD		19		μA
GPIO low-to-high input transition, with hysteresis	IH = 1, transition voltage for input read as 0 → 1		1.08		V
GPIO high-to-low input transition, with hysteresis	IH = 1, transition voltage for input read as 1 → 0		0.73		V
GPIO input hysteresis	IH = 1, difference between 0 → 1and 1 → 0 points		0.35		V
T_A = 25 °C, V_{DD} = 3.0 V					
GPIO VOH at 8 mA load	IOCURR = 2, high-drive GPIOs only		2.59		V
GPIO VOL at 8 mA load	IOCURR = 2, high-drive GPIOs only		0.42		V
GPIO VOH at 4 mA load	IOCURR = 1		2.63		V
GPIO VOL at 4 mA load	IOCURR = 1		0.40		V
T_A = 25 °C, V_{DD} = 3.8 V					
GPIO pullup current	Input mode, pullup enabled, Vpad = 0 V		282		μA
GPIO pulldown current	Input mode, pulldown enabled, Vpad = VDD		110		μA
GPIO low-to-high input transition, with hysteresis	IH = 1, transition voltage for input read as 0 → 1		1.97		V
GPIO high-to-low input transition, with hysteresis	IH = 1, transition voltage for input read as 1 → 0		1.55		V
GPIO input hysteresis	IH = 1, difference between 0 → 1 and 1 → 0 points		0.42		V
T_A = 25 °C					
VIH	Lowest GPIO input voltage reliably interpreted as a High	0.8*VDD			V
VIL	Highest GPIO input voltage reliably interpreted as a Low			0.2*VDD	V

3.1.9. ADC Characteristics

Table 17. ADC Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Input voltage range		0		VDD	V
Resolution			12		Bits
Sample Rate				200	ksps
Offset	Internal 4.3V equivalent reference		± 2		LSB
Gain error	Internal 4.3V equivalent reference		± 7		LSB
Differential nonlinearity			> -1		LSB
Integral nonlinearity			± 4		LSB
Reference voltage	Equivalent fixed internal reference (input voltage scaling		4.3		V

Parameter	Test Condition	MIN	TYP	MAX	Unit
	enabled). For best accuracy, the ADC conversion should be initiated through the TI-RTOS API in order to include the gain/offset compensation factors stored in FCFG1				
Reference voltage	Fixed internal reference (input voltage scaling disabled). For best accuracy, the ADC conversion should be initiated through the TI-RTOS API in order to include the gain/offset compensation factors stored in FCFG1. This value is derived from the scaled value (4.3 V) as follows: Vref = 4.3 V × 1408 / 4095		1.48		V
Reference voltage	VDD as reference, input voltage scaling enabled		VDD		V
	VDD as reference, input voltage scaling disabled		VDD/2.82		V
Input Impedance	200 kSamples/s, voltage scaling enabled. Capacitive input, Input impedance depends on sampling frequency and sampling time		> 1		MΩ

For ADC characteristics or other details, please refer to CC1352P7 datasheet: CC1352P7 SimpleLink™ High-Performance Multi-Band Wireless MCU with Integrated Power Amplifier datasheet

3.1.10. DAC Characteristics

Table 18. DAC Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Resolution			8		Bits
Supply voltage	Any load, any VREF, pre-charge OFF, DAC charge-pump ON	1.8		3.8	V
	External Load, any VREF, pre-charge OFF, DAC charge-pump OFF	2.0		3.8	V
	Any load, VREF = DCOUPL, pre-charge ON	2.6		3.8	V
Clock frequency	Buffer ON (recommended for external load)	16		250	kHz
	Buffer OFF (internal load)	16		1000	kHz

For DAC characteristics or other details, please refer to CC1352P7 datasheet: CC1352P7 SimpleLink™ High-Performance Multi-Band Wireless MCU with Integrated Power Amplifier datasheet

3.1.11. Comparator Characteristics

Tc = 25 °C, VDD = 3.0 V, unless otherwise noted.

Table 19. Low-Power Clocked Comparator Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Input voltage range		0		VDD	V
Clock frequency			32		KHz
Internal reference voltage	Using internal DAC with VDDS as reference voltage, DAC code = 0 - 255	0.024		2.865	V

Parameter	Test Condition	MIN	TYP	MAX	Unit
Offset	Measured at VDDS / 2, includes error from internal DAC		±5		mV
Decision time	Step from –50 mV to 50 mV		1		Clock Cycle

Table 20. Continuous Time Comparator Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Input voltage range		0		VDD	V
Offset	Measured at VDD/2		± 5		mV
Decision time	Step from -10 mV to 10 mV		0.70		us
Current consumption	Internal reference		8.0		uA

3.2. RF Characteristics

The measurement is made with the evaluation board for BDE-MB1352P72 with T_A = 25 °C, VDD = 3.3 V, DCDC enabled, GLDO disabled, unless otherwise noted.

3.2.1. 861 MHz to 1054 MHz Performance: Receiver Characteristics

Table 21. 861 MHz to 1054 MHz Performance: Receiver Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
802.15.4, 50 kbps, ±25 kHz deviation, 2-GFSK, 100 kHz RX Bandwidth					
Sensitivity	BER = 10^{-2}, 868 MHz		-109		dBm
Saturation limit	BER = 10^{-2}, 868 MHz		10		
Selectivity, ±200 kHz	BER = 10^{-2}, 868 MHz		44		dB
Selectivity, ±400 kHz			49		
Blocking, ±1 MHz			58		
Blocking, ±2 MHz			62		
Blocking, ±5 MHz			70		
Blocking, ±10 MHz			78		
Image rejection (image compensation enabled)	BER = 10^{-2}, 868 MHz		39		dB
RSSI dynamic range	Starting from the sensitivity limit		95		dB
RSSI accuracy	Starting from the sensitivity limit across the given dynamic range		± 3		dB
802.15.4, 100 kbps, ±25 kHz deviation, 2-GFSK, 137 kHz RX Bandwidth					
Sensitivity 100 kbps	868 MHz, 1 % PER, 127 byte payload		-102		dBm
Selectivity, ±200 kHz	868 MHz, 1 % PER, 127 byte payload. Wanted signal at -96 dBm		38		dB
Selectivity, ±400 kHz	868 MHz, 1 % PER, 127 byte payload. Wanted signal at -96 dBm		45		
Co-channel rejection	868 MHz, 1 % PER, 127 byte payload. Wanted signal at -79 dBm		-9		
802.15.4, 200 kbps, ± 50 kHz deviation, 2-GFSK, 311 kHz RX Bandwidth					
Sensitivity	BER = 10^{-2}, 868MHz		-102		dBm
Sensitivity	BER = 10^{-2}, 915MHz		-100		
Selectivity, ±400 kHz	BER = 10^{-2}, 915MHz. Wanted signal 3 dB above sensitivity limit.		44		dB

Parameter	Test Condition	MIN	TYP	MAX	Unit
Selectivity, ±800 kHz			49		
Blocking, ±2 MHz			57		
Blocking, ±10 MHz			69		
802.15.4, 500 kbps, ± 190 kHz deviation, 2-GFSK, 655 kHz RX Bandwidth					
Sensitivity 500 kbps	915 MHz, 1% PER, 127 byte payload		-95.5		dBm
Selectivity, ± 1 MHz	915 MHz, 1% PER, 127 byte payload. Wanted signal at -88 dBm		35		dB
Selectivity, ± 2 MHz	915 MHz, 1% PER, 127 byte payload. Wanted signal at -88 dBm		47		dB
Co-channel rejection	915 MHz, 1% PER, 127 byte payload. Wanted signal at -71 dBm		-9		dB
SimpleLink™ Long Range 2.5/5 kbps (20 ksps), 2-GFSK, ±5 kHz Deviation, FEC (Half Rate), DSSS = 1:2/1:4, 34 kHz RX Bandwidth					
Sensitivity	2.5 kbps, BER = 10^{-2}, 868MHz		-123		dBm
Sensitivity	5 kbps, BER = 10^{-2}, 868MHz		-120		dBm
Saturation limit	2.5 kbps, BER = 10^{-2}, 868MHz		10		dBm
Selectivity, ±100 kHz	2.5 kbps, BER = 10^{-2}, 868MHz		49		dB
Selectivity, ±200 kHz			50		
Selectivity, ±300 kHz			51		
Blocking, ±1 MHz	2.5 kbps, BER = 10^{-2}, 868MHz		63		dB
Blocking, ±2 MHz			69		
Blocking, ±5 MHz			79		
Blocking, ±10 MHz			88		
Image rejection (image compensation enabled)	2.5 kbps, BER = 10^{-2}, 868MHz		47		dB
RSSI dynamic range	Starting from the sensitivity limit		108		dB
RSSI accuracy	Starting from the sensitivity limit across the given dynamic range		± 3		dB
OOK, 4.8 kbps, 39 kHz RX Bandwidth					
Sensitivity	BER = 10^{-2}, 868 MHz		-110		dBm
Sensitivity	BER = 10^{-2}, 915 MHz		-108		
Narrowband, 9.6 kbps ± 2.4 kHz deviation, 2-GFSK, 868 MHz, 17.1 kHz RX Bandwidth					
Sensitivity	1% BER		-117		dBm
Adjacent Channel Rejection	1% BER. Wanted signal 3 dB above usable sensitivity limit (usable sensitivity -104.6dBm). Interferer ± 20 kHz		41		dB
Alternate Channel Rejection	1% BER. Wanted signal 3 dB above usable sensitivity limit (usable sensitivity -104.6dBm). Interferer ± 40 kHz		42		dB
Blocking, ± 1 MHz	1% BER. Wanted signal 3 dB above usable sensitivity limit (usable sensitivity -104.6dBm).		65		dB
Blocking, ± 2 MHz	1% BER. Wanted signal 3 dB above usable sensitivity limit (usable sensitivity -104.6dBm).		69		dB
Blocking, ± 10 MHz	1% BER. Wanted signal 3 dB above usable sensitivity limit (usable sensitivity -104.6dBm).		85		dB
1 Mbps, ± 350 kHz deviation, 2- GFSK, 2.2 MHz RX Bandwidth					
Sensitivity	BER = 10^{-2}, 868MHz		-96		dBm
Sensitivity	BER = 10^{-2}, 915MHz		-95.5		
Blocking, +2 MHz	BER = 10^{-2}, 915MHz. Wanted signal 3 dB above sensitivity limit.		44		

Parameter	Test Condition	MIN	TYP	MAX	Unit
Blocking, -2 MHz			27		
Blocking, +10 MHz			59		
Blocking, -10 MHz			54		
Wi-SUN, 2-GFSK					
Sensitivity	50 kbps, ±12.5 kHz deviation, 2-GFSK, 866.6 MHz, 68 kHz RX BW, 10% PER, 250 byte payload		-107		dBm
Selectivity, ± 100 kHz, 50 kbps, ± 12.5 kHz deviation, 2-GFSK, 866.6 MHz	50 kbps, ±12.5 kHz deviation, 2-GFSK, 68 kHz RX Bandwidth, 866.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		30		dB
Selectivity, ± 200 kHz, 50 kbps, ± 12.5 kHz deviation, 2-GFSK, 866.6 MHz	50 kbps, ±12.5 kHz deviation, 2-GFSK, 68 kHz RX Bandwidth, 866.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		36		dB
Sensitivity	50 kbps, ±25 kHz deviation, 2-GFSK, 918.2 MHz, 98 kHz RX BW, 10% PER, 250 byte payload		-105		dBm
Selectivity, ± 200 kHz, 50 kbps, ± 25 kHz deviation, 2-GFSK, 918.2 MHz	50 kbps, ±25 kHz deviation, 2-GFSK, 98 kHz RX Bandwidth, 918.2 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		34		dB
Selectivity, ± 400 kHz, 50 kbps, ± 25 kHz deviation, 2-GFSK, 918.2 MHz	50 kbps, ±25 kHz deviation, 2-GFSK, 98 kHz RX Bandwidth, 918.2 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		41		dB
Sensitivity	100 kbps, ±25 kHz deviation, 2-GFSK, 866.6 MHz, 135 kHz RX BW, 10% PER, 250 byte payload		-105		dBm
Selectivity, ± 200 kHz, 100 kbps, ± 25 kHz deviation, 2-GFSK, 866.6 MHz	100 kbps, ±25 kHz deviation, 2-GFSK, 135 kHz RX Bandwidth, 866.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		37		dB
Selectivity, ± 400 kHz, 100 kbps, ± 25 kHz deviation, 2-GFSK, 866.6 MHz	100 kbps, ±25 kHz deviation, 2-GFSK, 135 kHz RX Bandwidth, 866.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		45		dB
Sensitivity	100 kbps, ±50 kHz deviation, 2-GFSK, 920.9 MHz, 196 kHz RX BW, 10% PER, 250 byte payload		-101		dBm
Selectivity, ± 400 kHz, 100 kbps, ± 50 kHz deviation, 2-GFSK, 920.9 MHz	100 kbps, ±50 kHz deviation, 2-GFSK, 196 kHz RX Bandwidth, 920.9 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		40		dB
Selectivity, ± 800 kHz, 100 kbps, ± 50 kHz deviation, 2-GFSK, 920.9 MHz	100 kbps, ±50 kHz deviation, 2-GFSK, 196 kHz RX Bandwidth, 920.9 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		49		dB
Sensitivity	150 kbps, ±37.5 kHz deviation, 2-GFSK, 920.9 MHz, 273 kHz RX BW, 10% PER, 250 byte payload		-99		dBm
Selectivity, ± 400 kHz, 150 kbps, ± 37.5 kHz deviation, 2-GFSK, 920.9 MHz	150 kbps, ±37.5 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 920.9 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		41		dB
Selectivity, ± 800 kHz, 150 kbps, ± 37.5 kHz deviation, 2-GFSK, 920.9 MHz	150 kbps, ±37.5 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 920.9 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		47		dB

Parameter	Test Condition	MIN	TYP	MAX	Unit
Sensitivity	200 kbps, ±50 kHz deviation, 2-GFSK, 918.4 MHz, 273 kHz RX BW, 10% PER, 250 byte payload		-98		dBm
Selectivity, ± 400 kHz, 200 kbps, ± 50 kHz deviation, 2-GFSK, 918.4 MHz	200 kbps, ±50 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 918.4 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		42		dB
Selectivity, ± 800 kHz, 200 kbps, ± 50 kHz deviation, 2-GFSK, 918.4 MHz	200 kbps, ±50 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 918.4 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		49		dB
Sensitivity	200 kbps, ±100 kHz deviation, 2-GFSK, 920.8 MHz, 273 kHz RX BW, 10% PER, 250 byte payload		-98		dBm
Selectivity, ± 600 kHz, 200 kbps, ± 100 kHz deviation, 2-GFSK, 920.8 MHz	200 kbps, ±100 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 920.8 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		45		dB
Selectivity, ± 1200 kHz, 200 kbps, ± 100 kHz deviation, 2-GFSK, 920.8 MHz	200 kbps, ±100 kHz deviation, 2-GFSK, 273 kHz RX Bandwidth, 920.8 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		52		dB
Sensitivity	300 kbps, ±75 kHz deviation, 2-GFSK, 917.6 MHz, 498 kHz RX BW, 10% PER, 250 byte payload		-97		dBm
Selectivity, ± 600 kHz, 300 kbps, ± 75 kHz deviation, 2-GFSK, 917.6 MHz	300 kbps, ±75 kHz deviation, 2-GFSK, 498 kHz RX Bandwidth, 917.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		42		dB
Selectivity, ± 1200 kHz, 300 kbps, ± 75 kHz deviation, 2-GFSK, 917.6 MHz	300 kbps, ±75 kHz deviation, 2-GFSK, 498 kHz RX Bandwidth, 917.6 MHz, 10% PER, 250 byte payload. Wanted signal 3 dB above sensitivity level		47		dB

3.2.2. 861 MHz to 1054 MHz Performance: Transmitter Characteristics

Table 22. 861 MHz to 1054 MHz Performance: Transmitter Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
Max output power, boost mode Sub-1 GHz PA	868 MHz and 915 MHz		14.1		dBm
12.5dBm, boost mode Sub-1 GHz PA	868 MHz and 915 MHz		12.2		dBm
12dBm setting	868 MHz and 915 MHz		11.6		dBm
11dBm setting	868 MHz and 915 MHz		9.9		dBm
10dBm setting	868 MHz and 915 MHz		8.5		dBm
9dBm setting	868 MHz and 915 MHz		7.2		dBm
8dBm setting	868 MHz and 915 MHz		6.3		dBm
7dBm setting	868 MHz and 915 MHz		4.7		dBm
6dBm setting	868 MHz and 915 MHz		3.5		dBm
5dBm setting	868 MHz and 915 MHz		2.7		dBm
4dBm setting	868 MHz and 915 MHz		2.1		dBm
3dBm setting	868 MHz and 915 MHz		0.3		dBm

Parameter	Test Condition	MIN	TYP	MAX	Unit
2dBm setting	868 MHz and 915 MHz		-0.5		dBm
1dBm setting	868 MHz and 915 MHz		-1.1		dBm
0dBm setting	868 MHz and 915 MHz		-2.1		dBm
Output power programmable range Sub-1 GHz PA	868 MHz and 915 MHz		34		dB
Output power variation over temperature Sub-1 GHz PA	+10 dBm setting Over recommended temperature operating range		± 2		dB
Output power variation over temperature Boost mode, Sub-1 GHz PA	+14 dBm setting Over recommended temperature operating range		± 1.5		dB

3.2.3. BLE Performance: Receiver Characteristics

Table 23. BLE Performance: 2.4-GHz Receiver Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
BLE 125Kbps (LE Coded)					
Receiver sensitivity	Differential mode. BER = 10^{-3}		-103.5		dBm
Receiver saturation	Differential mode. BER = 10^{-3}		> 5		
Frequency error tolerance	Difference between the incoming carrier frequency and the internally generated carrier frequency		> (-300/300)		kHz
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (37-byte packets)		> (-320/240)		ppm
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (255-byte packets)		> (-125/100)		ppm
Co-channel rejection (1)	Wanted signal at -79 dBm, modulated interferer in channel		-1.5		dB
Selectivity, ±1 MHz (1)	Wanted signal at -79 dBm, modulated interferer at ±1 MHz		8 / 4.5 (2)		
Selectivity, ±2 MHz	Wanted signal at -79 dBm, modulated interferer at ±2 MHz		44 / 37		
Selectivity, ±3 MHz	Wanted signal at -79 dBm, modulated interferer at ±3 MHz		46 / 44		
Selectivity, ±4 MHz	Wanted signal at -79 dBm, modulated interferer at ±4 MHz		44 / 46		
Selectivity, ±6 MHz	Wanted signal at -79 dBm, modulated interferer at ±6 MHz		48 / 44		
Selectivity, ±7 MHz	Wanted signal at -79 dBm, modulated interferer at ±7 MHz		51 / 45		
Selectivity, Image frequency	Wanted signal at -79 dBm, modulated interferer at image frequency		-37		
Selectivity, Image frequency ± 1 MHz	Note that Image frequency + 1 MHz is the Co- channel – 1 MHz. Wanted signal at -79 dBm, modulated interferer at ± 1 MHz from image frequency		4.5 / 44		
RSSI Range			89		
RSSI Accuracy			± 4		
BLE 500Kbps (LE Coded)					
Receiver sensitivity	Differential mode. BER = 10^{-3}		-98.5		dBm
Receiver saturation	Differential mode. BER = 10^{-3}		> 5		

Parameter	Test Condition	MIN	TYP	MAX	Unit
Frequency error tolerance	Difference between the incoming carrier frequency and the internally generated carrier frequency		> (-300/300)		kHz
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (37-byte packets)		> (-450/450)		ppm
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (255-byte packets)		> (-150/175)		ppm
Co-channel rejection	Wanted signal at -72 dBm, modulated interferer in channel		3.5		dB
Selectivity, ±1 MHz	Wanted signal at -72 dBm, modulated interferer at ±1 MHz		8 / 4		
Selectivity, ±2 MHz	Wanted signal at -72 dBm, modulated interferer at ±2 MHz		43 / 35		
Selectivity, ±3 MHz	Wanted signal at -72 dBm, modulated interferer at ±3 MHz		46 / 46		
Selectivity, ±4 MHz	Wanted signal at -72 dBm, modulated interferer at ±4 MHz		45 / 47		
Selectivity, ±6 MHz	Wanted signal at -72 dBm, modulated interferer at ±6 MHz		46 / 45		
Selectivity, ±7 MHz	Wanted signal at -72 dBm, modulated interferer at ±7 MHz		49 / 45		
Selectivity, Image frequency	Wanted signal at -72 dBm, modulated interferer at image frequency		35		
Selectivity, Image frequency ± 1 MHz	Note that Image frequency + 1 MHz is the Co- channel – 1 MHz. Wanted signal at -72 dBm, modulated interferer at ± 1 MHz from image frequency		4 / 46		
RSSI Range			90		
RSSI accuracy			± 4		
BLE 1Mbps (LE 1M)					
Receiver sensitivity	Differential mode. BER = 10^{-3}		-95.5		dBm
Receiver saturation	Differential mode. BER = 10^{-3}		> 5		
Frequency error tolerance	Difference between the incoming carrier frequency and the internally generated carrier frequency		> (-350/350)		kHz
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (37-byte packets)		> (-650/750)		ppm
Co-channel rejection	Wanted signal at -67 dBm, modulated interferer in channel		6		dB
Selectivity, ±1 MHz	Wanted signal at -67 dBm, modulated interferer at ±1 MHz		7 / 4		
Selectivity, ±2 MHz	Wanted signal at -67 dBm, modulated interferer at ±2 MHz		39 / 33		
Selectivity, ±3 MHz	Wanted signal at -67 dBm, modulated interferer at ±3 MHz		36 / 40		
Selectivity, ±4 MHz	Wanted signal at -67 dBm, modulated interferer at ±4 MHz		36 / 45		
Selectivity, ±5 MHz	Wanted signal at -67 dBm, modulated interferer at ±5 MHz		40		
Selectivity, Image frequency	Wanted signal at -67 dBm, modulated interferer at image frequency		33		
Selectivity, Image frequency ± 1 MHz	Note that Image frequency + 1 MHz is the Co- channel – 1 MHz. Wanted signal at -67 dBm, modulated interferer at ± 1 MHz from image frequency		4 / 41		
Out-of-band blocking	30 MHz to 2000 MHz		10		dBm
Out-of-band blocking	2003 MHz to 2399 MHz		18		
Out-of-band blocking	2484 MHz to 2997 MHz		12		
Out-of-band blocking	3000 MHz to 12.75 GHz		-2		
Intermodulation	Wanted signal at 2402 MHz, -64 dBm, two interferers at		-42		

Parameter	Test Condition	MIN	TYP	MAX	Unit
	2405 and 2408 MHz respectively, at the given power level				
Spurious emissions, 30 to 1000 MHz	Measurement in a 50 Ω single-ended load.		< -59		
Spurious emissions, 1 to 12.75 GHz	Measurement in a 50 Ω single-ended load.		< -47		
RSSI Range			70		dB
RSSI accuracy			± 4		
BLE 2Mbps (LE 2M)					
Receiver sensitivity	Differential mode. BER = 10^{-3}		-90.5		dBm
Receiver saturation	Differential mode. BER = 10^{-3}		> 5		
Frequency error tolerance	Difference between the incoming carrier frequency and the internally generated carrier frequency		> (-500/500)		kHz
Data rate error tolerance	Difference between incoming data rate and the internally generated data rate (37-byte packets)		> (-700/750)		ppm
Co-channel rejection	Wanted signal at -67 dBm, modulated interferer in channel		-7		dB
Selectivity, ±2 MHz	Wanted signal at -67 dBm, modulated interferer at ±2 MHz		8 / 4		
Selectivity, ±4 MHz	Wanted signal at -67 dBm, modulated interferer at ±4 MHz		36 / 34		
Selectivity, ±6 MHz	Wanted signal at -67 dBm, modulated interferer at ±6 MHz		37 / 36		
Selectivity, Image frequency	Wanted signal at -67 dBm, modulated interferer at image frequency		-4		
Selectivity, Image frequency ± 2 MHz	Note that Image frequency + 2 MHz is the Co- channel. Wanted signal at -67 dBm, modulated interferer at ± 1 MHz from image frequency		-7 / 36		
Out-of-band blocking	30 MHz to 2000 MHz		-16		dBm
Out-of-band blocking	2003 MHz to 2399 MHz		-21		
Out-of-band blocking	2484 MHz to 2997 MHz		-15		
Out-of-band blocking	3000 MHz to 12.75 GHz		-12		
Intermodulation	Wanted signal at 2402 MHz, -64 dBm, two interferers at 2408 and 2412 MHz respectively, at the given power level		-38		
RSSI Range			60		dB
RSSI accuracy			± 4		

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(1) Numbers given as C/I dB;
(2) X / Y, where X is +N MHz and Y is –N MHz;

3.2.4. BLE Performance: Transmitter Characteristics

Table 24. BLE Performance: 2.4-GHz Transmitter Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
20dBm, 2.4 GHz high power PA	2.4 GHz high power PA		18.7		dBm
19dBm, 2.4 GHz high power PA	2.4 GHz high power PA		17.3		dBm

Parameter	Test Condition	MIN	TYP	MAX	Unit
18dBm, 2.4 GHz high power PA	2.4 GHz high power PA		16.5		dBm
17dBm, 2.4 GHz high power PA	2.4 GHz high power PA		15.8		dBm
16dBm, 2.4 GHz high power PA	2.4 GHz high power PA		14.8		dBm
15dBm, 2.4 GHz high power PA	2.4 GHz high power PA		14.1		dBm
14dBm, 2.4 GHz high power PA	2.4 GHz high power PA		13.1		dBm
5dBm, 2.4 GHz PA	2.4 GHz regular power		3.8		dBm
4dBm, 2.4 GHz PA	2.4 GHz regular power		3.0		dBm
3dBm, 2.4 GHz PA	2.4 GHz regular power		2.1		dBm
2dBm, 2.4 GHz PA	2.4 GHz regular power		1.0		dBm
1dBm, 2.4 GHz PA	2.4 GHz regular power		0.1		dBm
0dBm, 2.4 GHz PA	2.4 GHz regular power		-0.5		dBm
Output power programmable range, 2.4 GHz PA	Differential mode, delivered to a single-ended 50 Ω load through a balun		26		dB

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(1) The output power is measured at frequency 2440MHz;

(2) TX power might be limited to comply with the regulatory, refer to compliance test reports for more information.

3.2.5. Zigbee and Thread Performance: Receiver Characteristics

Table 25. Zigbee and Thread Performance: 2.4-GHz Receiver Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
IEEE 802.15.4-2006 2.4 GHz (OQPSK DSSS1:8, 250 kbps)					
Receiver sensitivity	Coherent mode PER = 1%		-99		dBm
Receiver saturation	PER = 1%		> 5		
Adjacent channel rejection	Wanted signal at - 82 dBm, modulated interferer at ± 5 MHz, PER = 1%		36		dB
Adjacent channel rejection	Wanted signal at - 82 dBm, modulated interferer at ± 10 MHz, PER = 1%		57		
Channel rejection, ± 15 MHz or more	Wanted signal at - 82 dBm, undesired signal is IEEE 802.15.4 modulated channel, stepped through all channels 2405 to 2480 MHz, PER = 1%		59		
Blocking and desensitization, 5 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		57		
Blocking and desensitization, 10 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		62		
Blocking and desensitization, 20 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		62		

Parameter	Test Condition	MIN	TYP	MAX	Unit
Blocking and desensitization, 50 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		65		
Blocking and desensitization, -5 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		59		
Blocking and desensitization, -10 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		59		
Blocking and desensitization, -20 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		63		
Blocking and desensitization, -50 MHz from upper band edge	Wanted signal at -97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1%		65		
Spurious emissions, 30 to 1000 MHz	Measurement in a 50 Ω single-ended load.		-66		dBm
Spurious emissions, 1 to 12.75 GHz	Measurement in a 50 Ω single-ended load.		-53		
Frequency error tolerance	Difference between the incoming carrier frequency and the internally generated carrier frequency		> 350		kHz
Symbol rate error tolerance	Difference between incoming symbol rate and the internally generated symbol rate		> 1000		ppm
RSSI Range			95		dB
RSSI Accuracy			± 4		

3.2.6. Zigbee and Thread Performance: Transmitter Characteristics

Table 26. Zigbee and Thread Performance: 2.4-GHz Transmitter Characteristics

Parameter	Test Condition	MIN	TYP	MAX	Unit
General Parameters					
20dBm setting, 2.4 GHz high power PA	2.4 GHz high power PA		17.8		dBm
10dBm setting, 2.4 GHz high power PA	2.4 GHz high power PA		8.2		dBm
5dBm setting, 2.4 GHz PA	2.4 GHz regular power		3.9		dBm
Output power programmable range, 2.4 GHz PA	Differential mode, delivered to a single-ended 50 Ω load through a balun		26		dB
Output power programmable range, 2.4 GHz high power PA	Differential mode, delivered to a single-ended 50 Ω load through a balun		6		dB
IEEE 802.15.4-2006 2.4 GHz (OQPSK DSSS1:8, 250 kbps)					
Error vector magnitude, 2.4 GHz PA	+ 5 dBm setting		2		%
Error vector magnitude, 2.4 GHz high power PA	+ 20 dBm setting		2		%

(1) The output power is measured at frequency 2440MHz;
(2) TX power might be limited to comply with the regulatory, refer to compliance test reports for more information.

3.3. Antenna Characteristics

The module comes with an integrated PCB trace antenna for 2.4GHz band with an area of 19mm x 4.3mm. The following data was measured with the module assembled to a reference board. The module placement and the dimension of the reference board is shown in Figure 5.

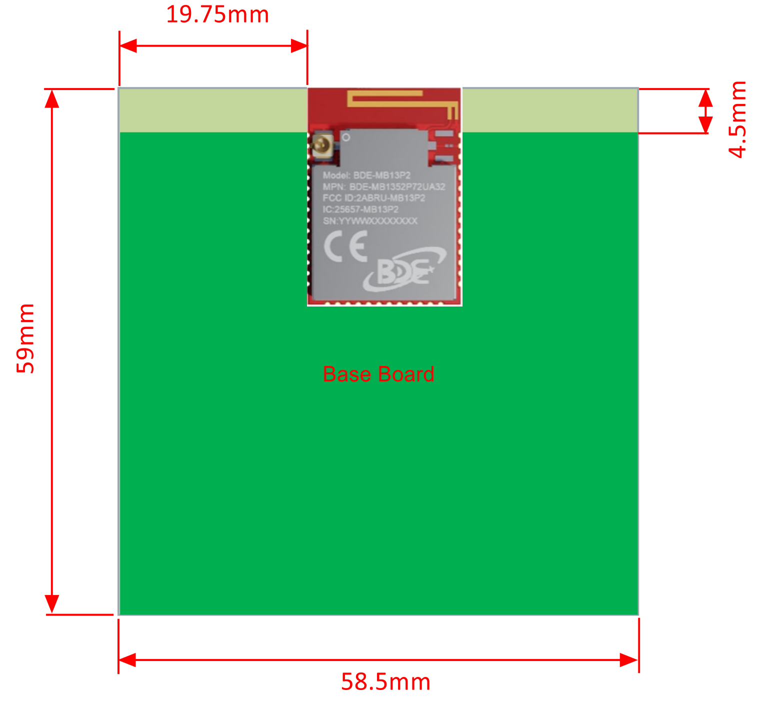


Figure 5. Antenna Placement and Reference Board

3.3.1. Antenna Gain

Table 27. Gain of Integrated PCB Trace Antenna

Frequency (MHz)	Gain (dBi)
2410	-0.3
2420	-0.1
2430	0.3
2440	0.5
2450	0.7
2460	0.8
2470	0.5
2480	0.5

3.3.2. Antenna Radiation Pattern

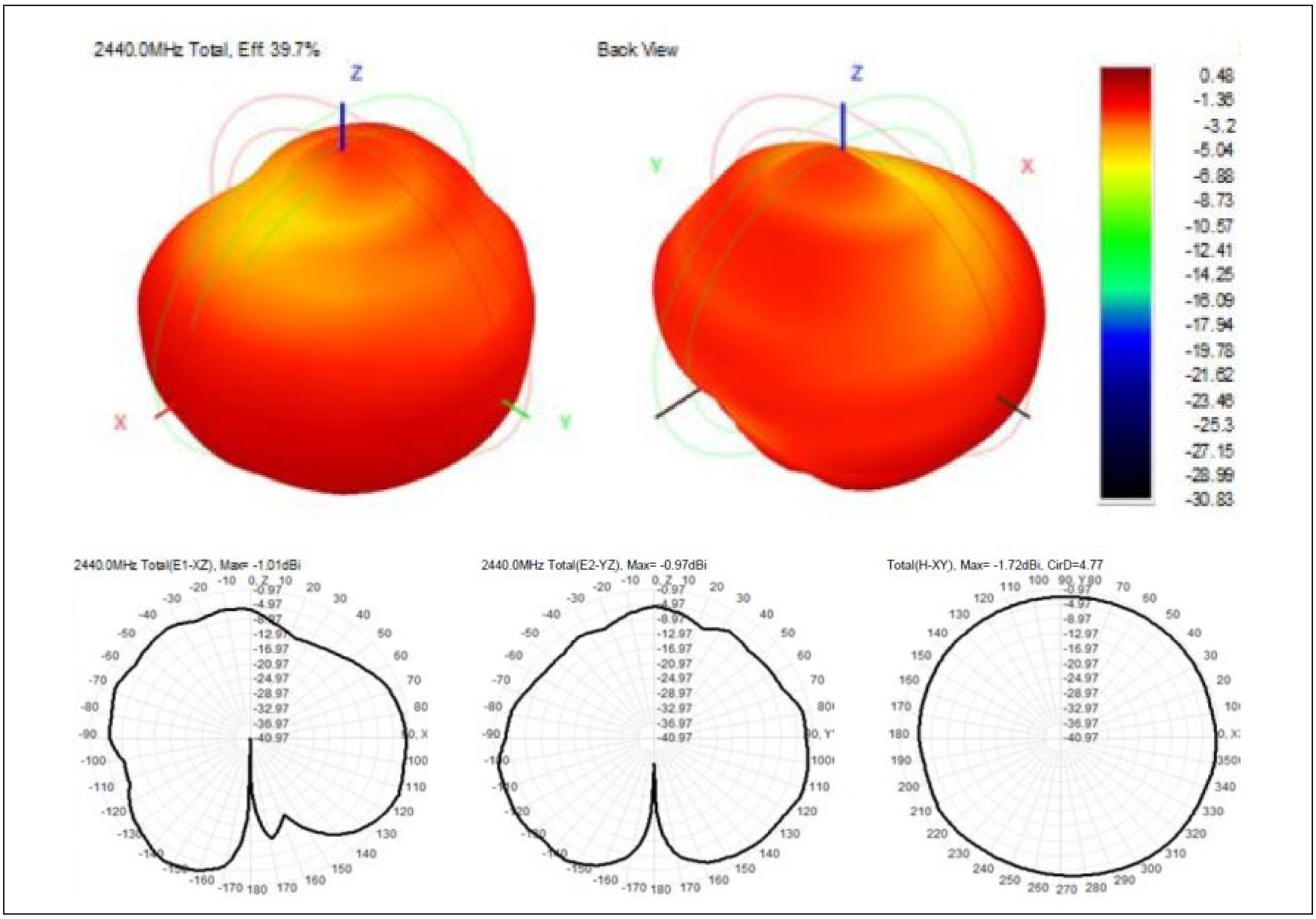


Figure 6. Radiation Pattern of the Integrated PCB Trace Antenna at 2440MHz

3.3.3. Other Certified Antennas

For other certified antennas, please refer to Table 32.

4. Mechanical Specifications

4.1. Module Dimensions

The following pages include mechanical, footprint drawings, and marking information. This information is the most current data available for the designated devices.

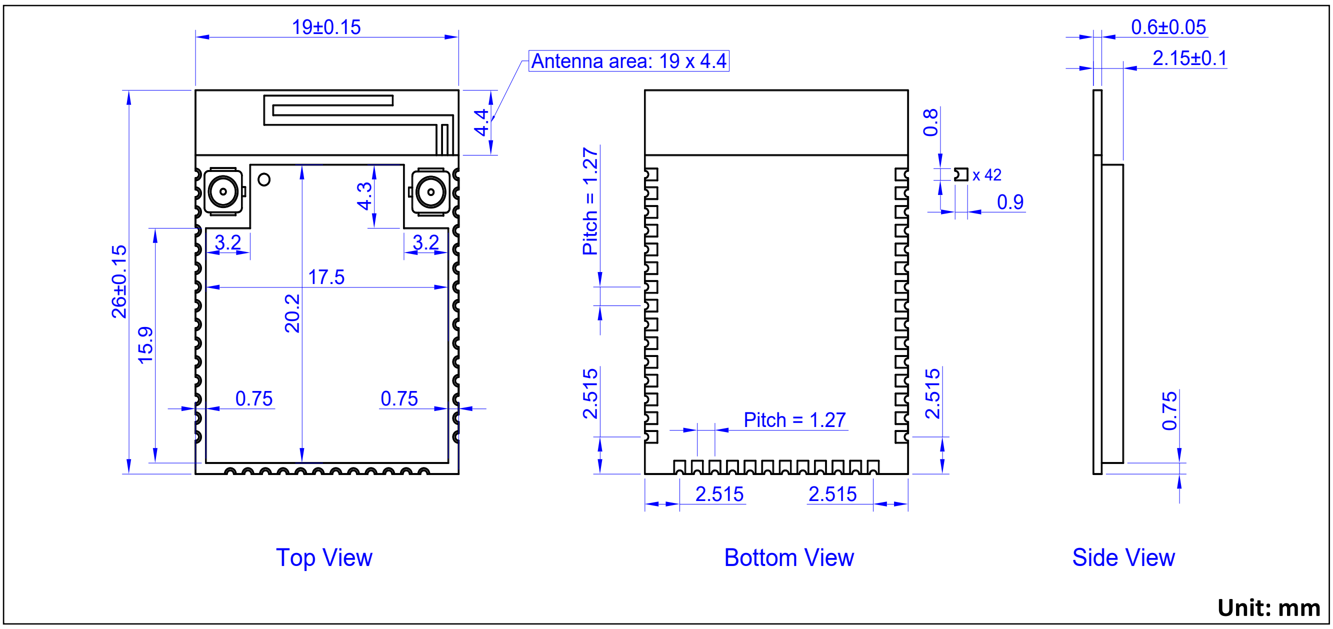
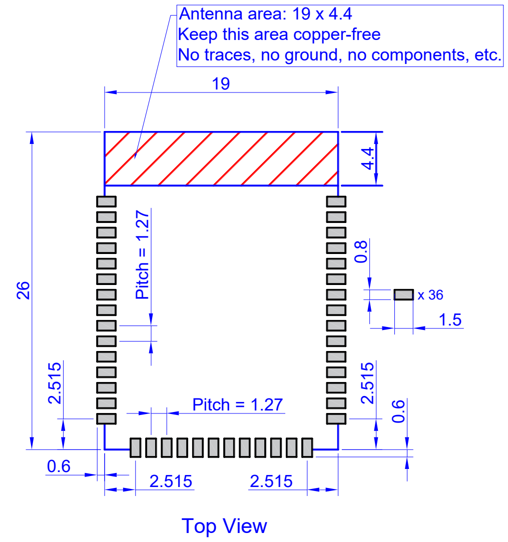


Figure 7. Mechanical Drawing of BDE-MB1352P72

4.2. PCB Footprints



(1) Solder mask should be the same or 5% larger than the dimension of the pad;

(2) Solder paste must be the same as the pin for all peripheral pads;

(3) Customers can modify the land pattern dimensions based on their manufacturing experience.

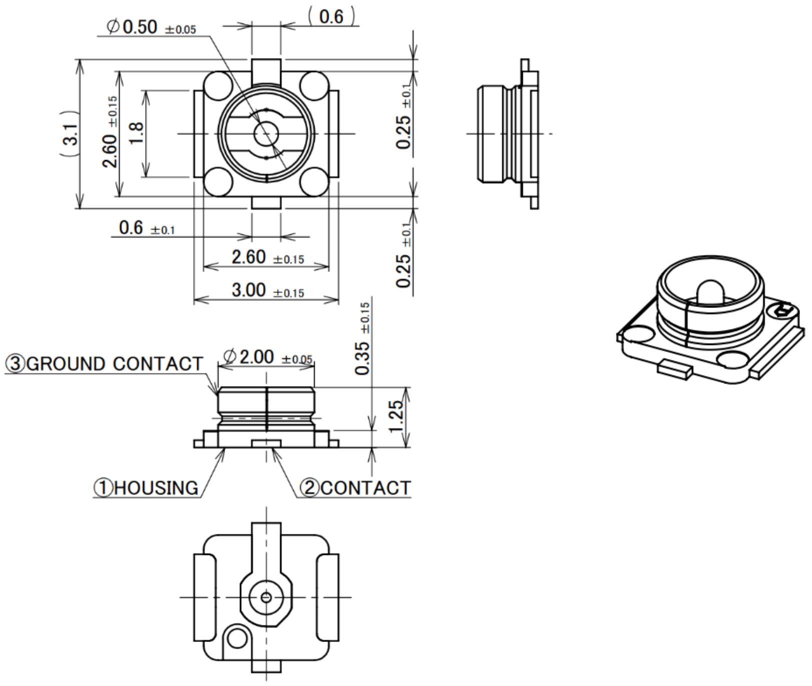
Unit: mm

Figure 8. Recommended Module Footprint of BDE-MB1352P72

4.3. U.FL Connector Specification

The drawing and specification of the U.FL connector utilized in the module is as below for reference.

The dimension unit in below drawing is millimeter.



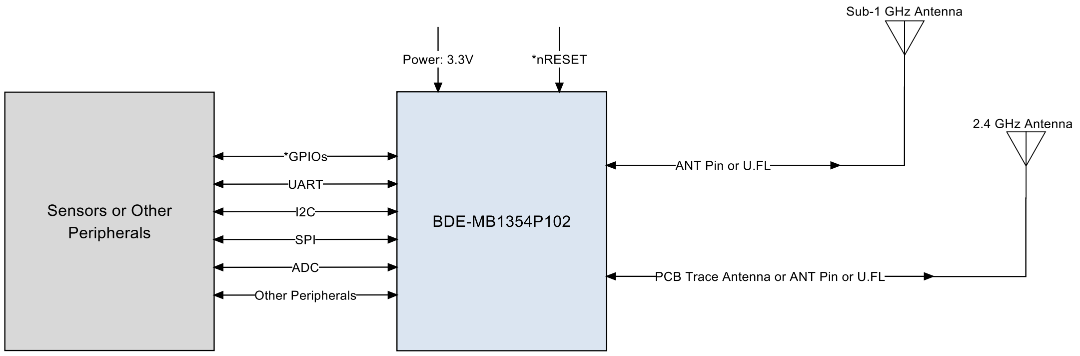
RATING VOLTAGE	60 V AC (R.M.S)	
RATING FREQUENCY	DC～9GHz	
OPERATING TEMPERATURE	233～363K (−40℃～+90℃)	
VSWR	RECEPTACLE: 1.3 MAX. AT 0.1～3 GHz, 1.4 MAX. AT 3～6 GHz, 1.8 MAX. AT 6～9 GHz	
MAIN CONTACT RESISTANCE	INITIAL: 20 mohm MAX. / AFTER TEST: ⊿R 20 mohm MAX.	
GROUND CONTACT RESISTANCE	INITIAL: 20 mohm MAX. / AFTER TEST: ⊿R 100 mohm MAX.	
INSULATION RESISTANCE	INITIAL: 500 Mohm MIN. / AFTER TEST: 100 Mohm MIN.	
DIELECTRIC WITHSTANDING VOLTAGE	200 V AC, 1 MINUTE	
DURABILITY	30 CYCLES	
UNMATING FORCE (INITIAL / AFTER TEST)	INITIAL: 5 N MIN. AFTER TEST: 3 N MIN.	INITIAL: 4 N MIN. AFTER TEST: 2 N MIN.

Figure 9. U.FL Connector Drawing and Specification

5. Integration Guideline

5.1. System Diagram

Below block diagram is applicable when the module is used as a SoC running the application and the protocol stack in the system CPU inside the module.



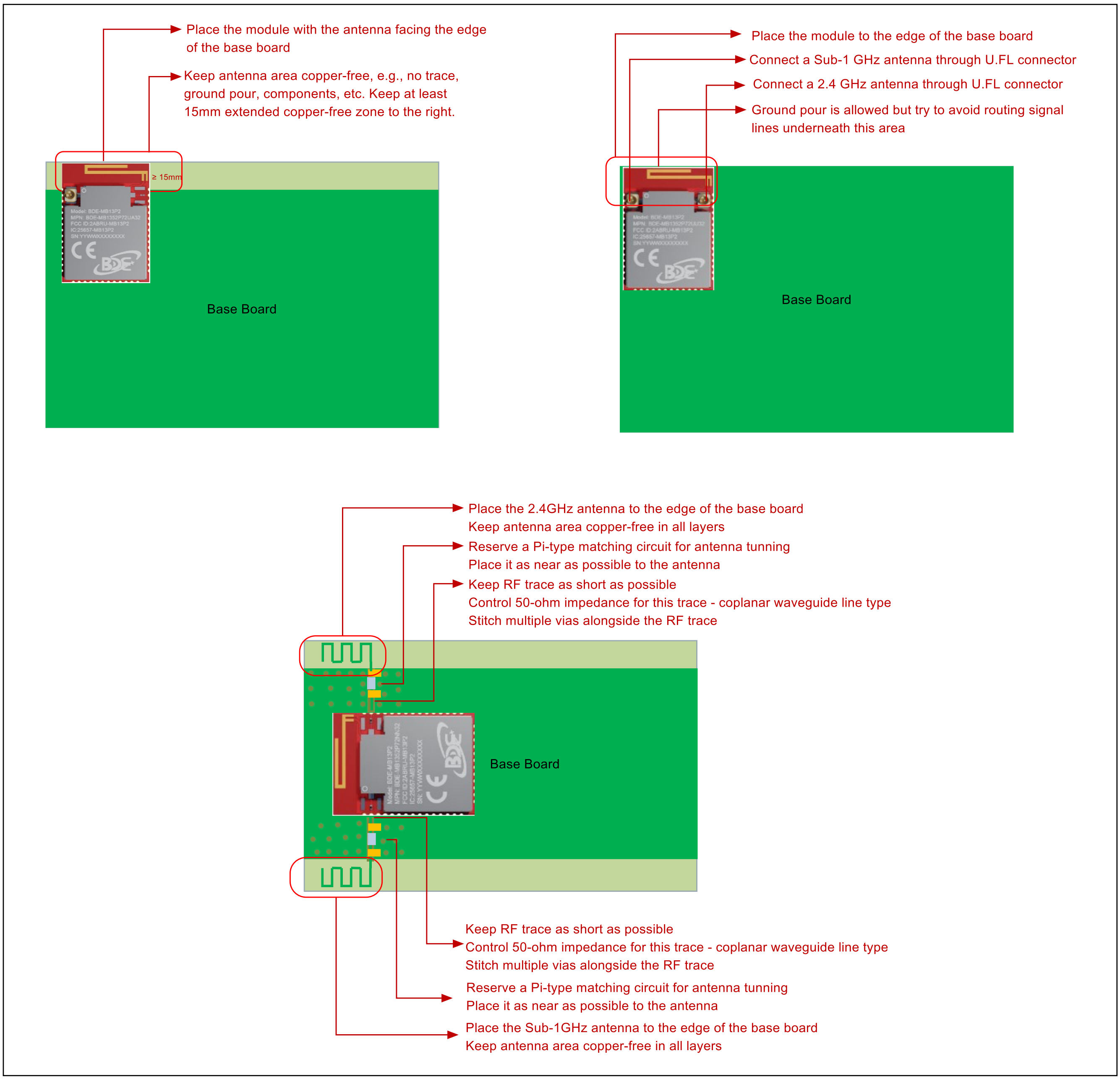
(1) The module has already been implemented with required decoupling capacitors; therefore, external decoupling capacitors are not needed. However, proper decoupling capacitors can also be added to increase module power stability depending on customer's application;
(2) The module has the internal reset circuit on board, e.g. a 100K ohm pull-up resistors and a 0.1uF decouple capacitor. Therefore, external reset circuit is not needed for the same purpose;
(3) If the SPI flash variants is chosen, please do not utilize these four GPIOs in your design, as they are already assigned to the on-board SPI flash. They are GPIO_8, GPIO_9, GPIO_10 and GPIO_20;
(4) It is recommended to reserve the matching circuit for antenna for tuning if ANT pin variant is chosen.

Figure 10. High-Level System Block Diagram

5.2. Module Placement

The placement of the module in the base board is critical in your design. Improper placement can lead to poor antenna performance. BDE recommend following below recommended placement in your design.

Any form of proximity to the metal or other material will change/degrade the antenna performance. Keep the antenna area as far as possible to the metal material in any direction.



Place the module with the antenna facing the edge of the base board

Keep antenna area copper-free, e.g., no trace, ground pour, components, etc. Keep at least 15mm extended copper-free zone to the right.

Place the module to the edge of the base board

Connect a Sub-1 GHz antenna through U.FL connector

Connect a 2.4 GHz antenna through U.FL connector

Ground pour is allowed but try to avoid routing signal lines underneath this area

Place the 2.4GHz antenna to the edge of the base board
Keep antenna area copper-free in all layers

Reserve a Pi-type matching circuit for antenna tunning
Place it as near as possible to the antenna

Keep RF trace as short as possible
Control 50-ohm impedance for this trace - coplanar waveguide line type
Stitch multiple vias alongside the RF trace

Keep RF trace as short as possible
Control 50-ohm impedance for this trace - coplanar waveguide line type
Stitch multiple vias alongside the RF trace

Reserve a Pi-type matching circuit for antenna tunning
Place it as near as possible to the antenna

Place the Sub-1GHz antenna to the edge of the base board
Keep antenna area copper-free in all layers

Figure 11. Module Placement Recommendations

5.3. Other Design Considerations

Table 28. Other Design Considerations

Thermal	
1	The proximity of ground vias must be close to each ground pad of the module.
2	Signal traces must not be run underneath the module on the layer where the module is mounted.
3	Have a complete ground pour in layer 2 for thermal dissipation.
4	Have a solid ground plane and ground vias under the module for stable system and thermal dissipation.
5	Increase the ground pour in the first layer and have all of the traces from the first layer on the inner layers, if possible.
6	Signal traces can be run on a third layer under the solid ground layer, which is below the module mounting layer.
RF Trace and Antenna Routing	

7	The RF trace antenna feed must be as short as possible beyond the ground reference. At this point, the trace starts to radiate.
8	The RF trace bends must be gradual with an approximate maximum bend of 45° with trace mitered. RF traces must not have sharp corners.
9	RF traces must have via stitching on the ground plane beside the RF trace on both sides.
10	RF traces must have constant impedance (50-ohm Coplanar or microstrip transmission line).
11	For best results, the RF trace ground layer must be the ground layer immediately below the RF trace. The ground layer must be solid.
12	There must be no traces or ground under the antenna section.
13	RF traces must be as short as possible. The antenna, RF traces, and modules must be on the edge of the PCB product. The proximity of the antenna to the enclosure and the enclosure material must also be considered.
14	BDE recommends using double-shielded coaxial RF cable to connect with the U.FL connector with antenna if the U.FL variants are selected.
15	Do not place or run the RF cable right above or below the module.
16	If there are some other radios besides this module in the system, try to place them apart as far as possible. And ensure there is at least 25 dB isolation between the antenna port of every radio.
Supply and Interface	
17	Make VDD traces as wide as possible to ensure reduced inductance and trace resistance.
18	If possible, shield VDD traces with ground above, below, and beside the traces.

5.4. Development Resources

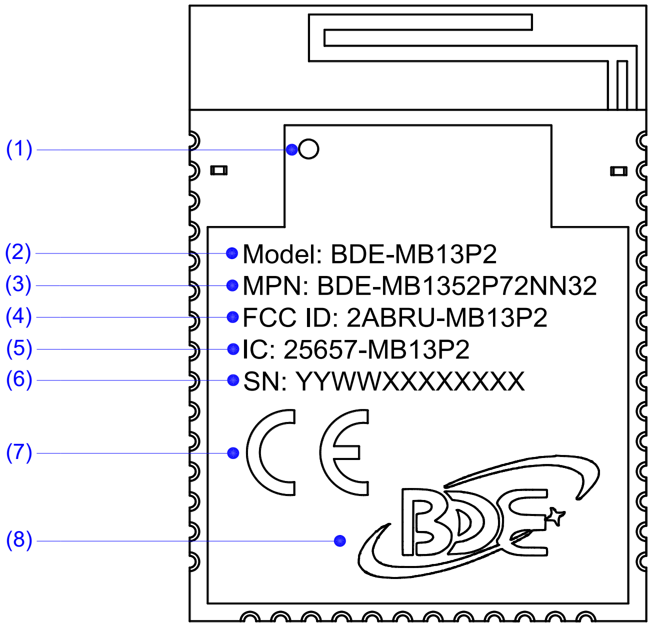
For more information on the EVK and other development resources, please visit the product page of the module on bdecomm.com.

6. Handling Instructions

The module is the surface mount module with LCC-42 footprint. It is designed to conform to the major manufacturing guidelines, including the commercial, industrial manufacturing process.

In this section, we will cover the basic shipping information, including the module markings, packaging, labeling, etc. And also, the instructions on how to handle the module in terms of storage, assembly and so on.

6.1. Module Marking

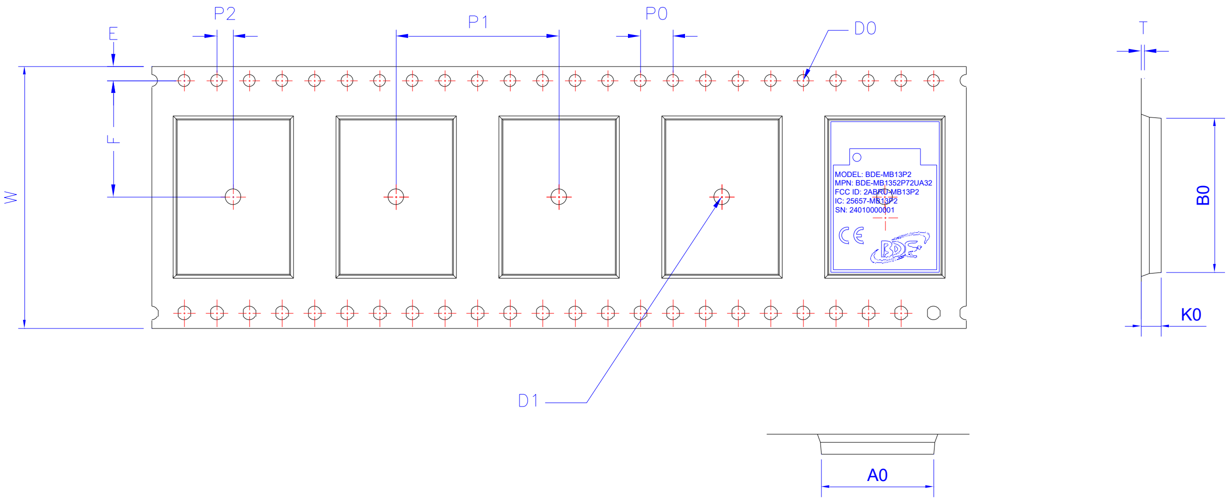


(1) Pin one index;
(2) Model series number;
(3) Orderable manufacturer part number. Refer to Table 1;
(4) FCC ID;
(5) IC ID;
(6) Serial number;
(7) CE marking;
(8) BDE logo

Figure 12. Module Marking

6.2. Packaging Information

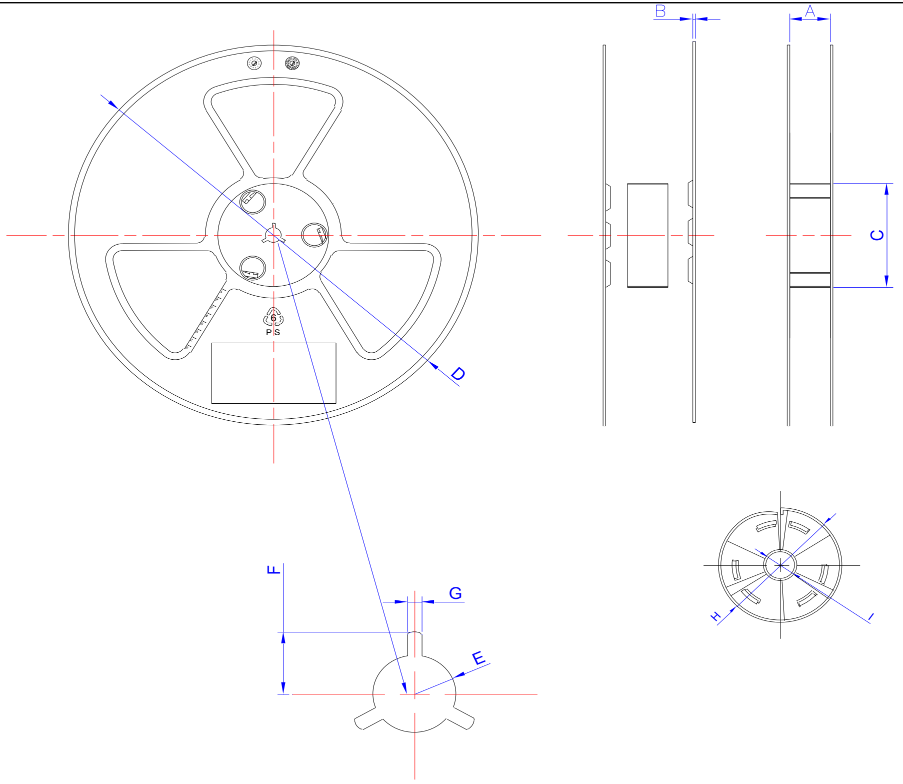
6.2.1. Tape and Reel Package Information



W	A_0	B_0	K_0	P_1	F	E	D_0	D_1	P_0	P_2	T
$44.00^{+0.30}_{-0.10}$	$19.45^{+0.10}_{-0.10}$	$26.35^{+0.10}_{-0.10}$	$2.55^{+0.10}_{-0.10}$	$24.00^{+0.10}_{-0.10}$	$20.20^{+0.10}_{-0.10}$	$1.75^{+0.10}_{-0.10}$	$1.50^{+0.10}_{-0.00}$	$2.00^{+0.10}_{-0.00}$	$4.00^{+0.10}_{-0.10}$	$2.00^{+0.10}_{-0.10}$	$0.35^{+0.05}_{-0.05}$

(1) Cumulative tolerance for every 10 sprockets pitch is ±0.2mm;
(2) Carrier camber not to exceed 1mm in every 100mm;
(3) All dimensions are in millimeter and meets EIA-481-C requirements;
(4) Material: PS Black polystyrene;
(5) Thickness: 0.35±0.05mm;
(6) Packing length per 13"reel: 20.7 meters;
(7) Component load per 13"reel: 900+24pcs (15 voids each to the head and tail);
(8) RoHS compliance;
(9) Anti-static coefficient of $10^{6\text{-}11}\Omega$.

Figure 13. Carrier Tape Drawing for BDE-MB1352P72 variants



A	B	C	D	E	F	G	H	I
44	2	100	330	6.75	10.85	2.5	100	24

(1) All dimensions are in millimeter;

(2) Material: PS blue polystyrene;

Figure 14. 13-INnch Reel Drawing

6.2.2. Carton Information and Labeling

6.2.2.1. Carton Information

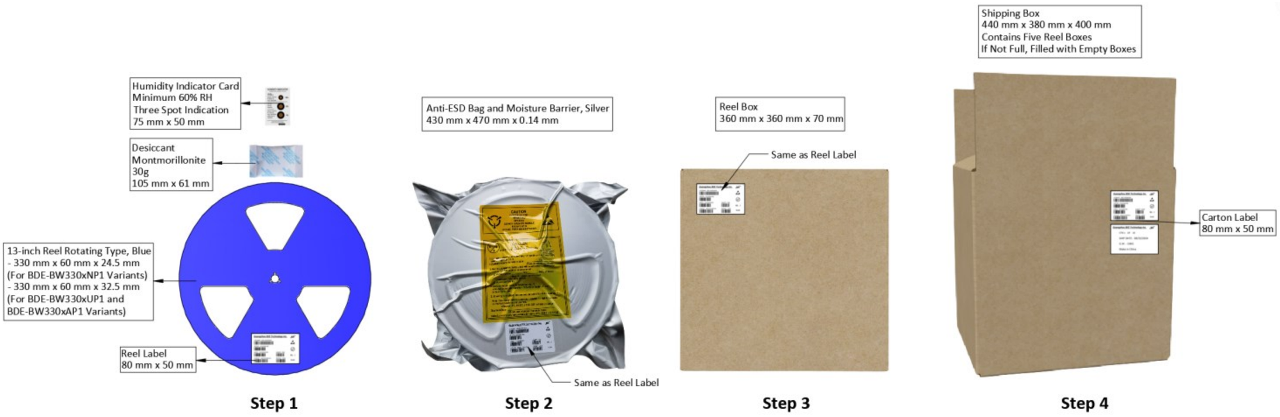
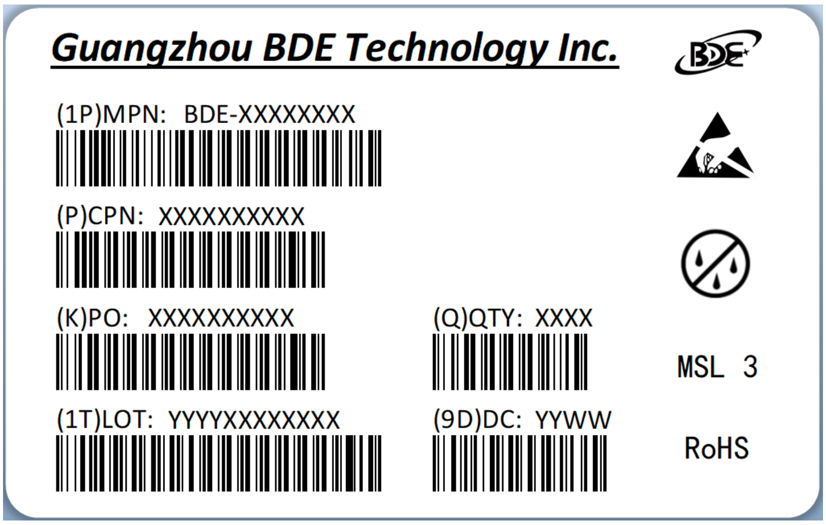


Figure 15. Carton Information

6.2.2.2. Reel Label

The reel label will be affixed onto the reel, Anti-ESD bag and reel box. It mainly shows the MPN (Manufacturer Part Number), CPN (Customer Part Number), PO (Purchase Order Number), LOT number, QTY (Quantity), DC (Date Code) and MSL (Moisture Sensitivity Level). Sometimes, it also shows other information, such as the regulatory information.



Guangzhou BDE Technology Inc.

(1P)MPN: BDE-XXXXXXXX

(P)CPN: XXXXXXXXXX

(K)PO: XXXXXXXXXX

(Q)QTY: XXXX

(1T)LOT: YYYYXXXXXXXX

(9D)DC: YYWW

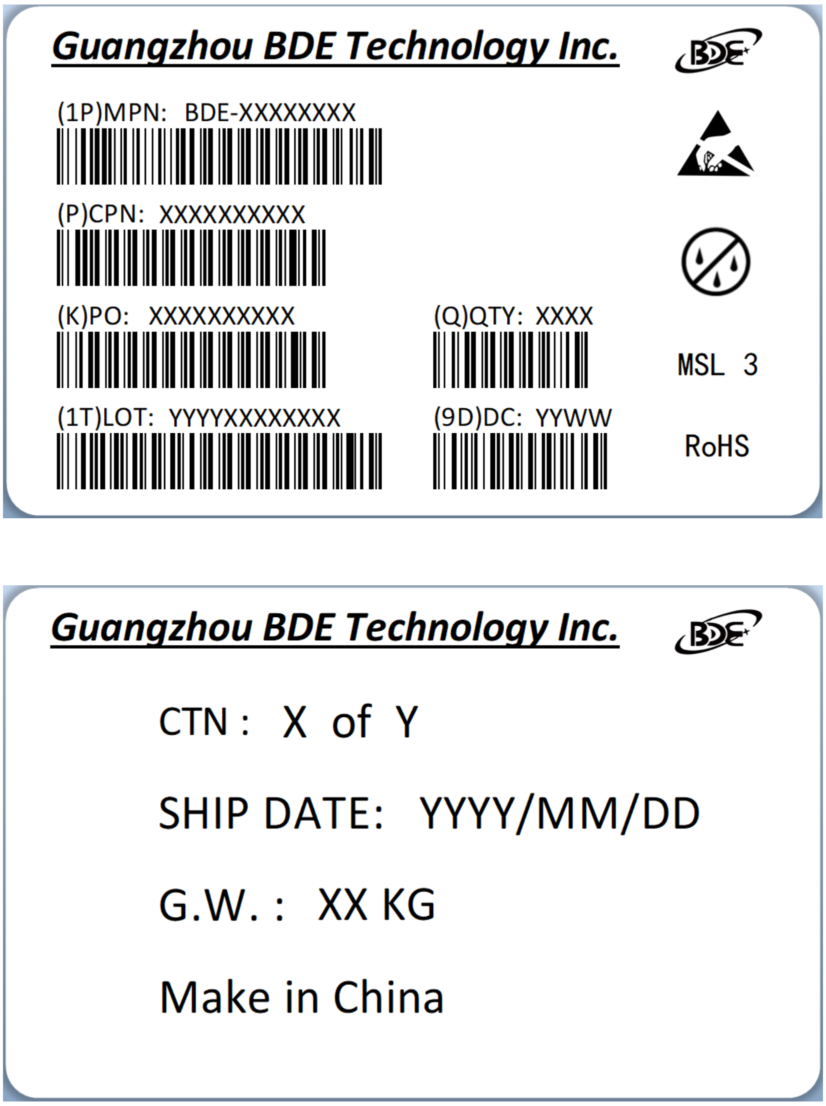
MSL 3

RoHS

Figure 16. Reel Label Information

6.2.2.3. Carton Label

The carton label will be affixed onto the surface of the carton. If the carton contains different Part Numbers or POs, there will be different labels representing different Part Numbers, different POs and Quantity.



Guangzhou BDE Technology Inc.

(1P)MPN: BDE-XXXXXXXX

(P)CPN: XXXXXXXXXX

(K)PO: XXXXXXXXXX

(Q)QTY: XXXX

(1T)LOT: YYYYXXXXXXXX

(9D)DC: YYWW

MSL 3

RoHS

Guangzhou BDE Technology Inc.

CTN : X of Y

SHIP DATE: YYYY/MM/DD

G.W. : XX KG

Make in China

Figure 17. Carton Label Information

6.3. Assembly Instruction

6.3.1. Moisture Sensitive Level

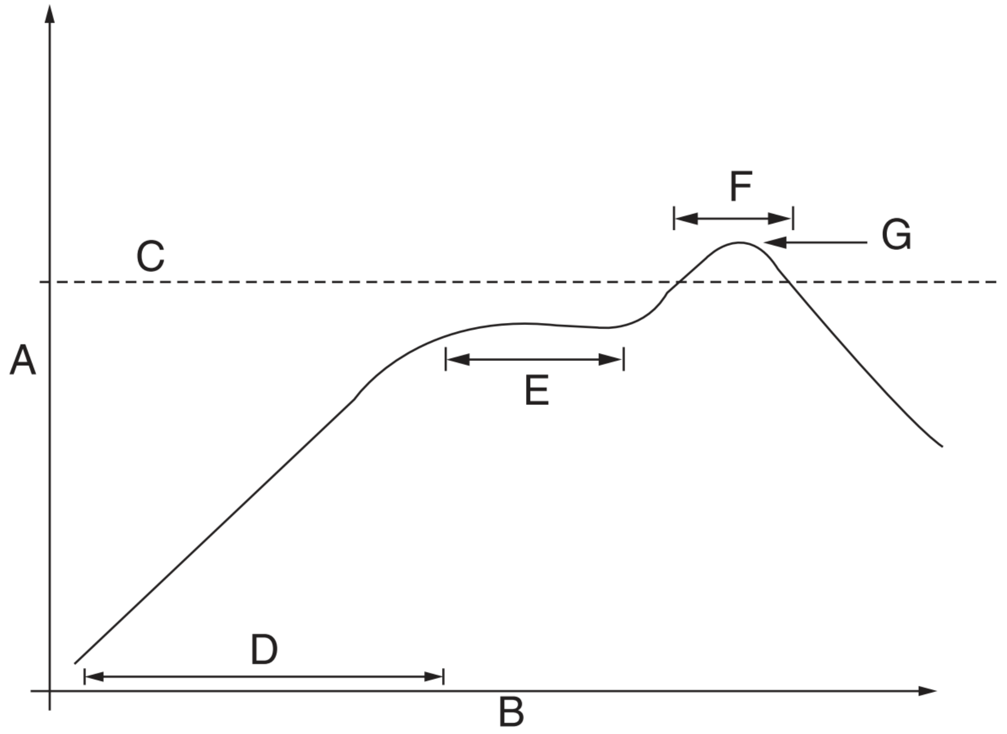
The MSL (Moisture Sensitive Level) of the module is MSL-3. Handling guidelines are listed as below:

(1) The floor life for MSL-3 device is 168 hours in ambient environment 30°C/60%RH. Before assembly, make sure to check if the modules are packaged with desiccate and humidity indicator card;

(2) After the bag is opened, make sure to mount the modules within 168 hours at factory conditions (< 30°C/60% RH) or stored at <10% RH. Repackage is needed with new desiccate and humidity indicator card if the modules are not mounted before exceeding floor life;

(3) If the card reads >10%, or the modules have been exposed for over 168 hours, the modules need to be baked before mounted. Recommended baking condition is 125℃ for 8 hours.

6.3.2. Reflow Profile



A – Temperature
B – Time
C – Alloy liquidus temperature
D – Preheat slope = temperature ramp rate
E – Preheat dwell = soak time
F – Time above liquidus
G – Peak temperature = maximum assembly temperature

Figure 18. Thermal Profile Schematic

Table 29. Reflow Profile Parameters (1) (3)

Item	Temperature Range	Ramp Rate / Time
D, preheat zone	30°C ~ 175°C	2°C ~ 4°C per second
E, soak zone	150°C ~ 200°C	60 ~ 120 seconds
C, Alloy liquidus temperature	217°C ~ 220°C	-
F, reflow zone	230°C ~ 245°C	60 ~ 90 seconds
G, target maximum reflow temperature	250°C	-
Absolute peak temperature (2)	260°C	-

---

(1) This is for Pb-free (SAC 305) paste. Different pastes require different profiles for optimum performance, so it is important to consult the paste manufacturer before developing the solder profile;
(2) Exceed the absolute peak temperature for certain period, e.g. 20s might damage the device or affect the reliability;
(3) It is recommended that the modules do not go through the reflow process more than one time.

6.3.3. Other Consideration

(3) Ultrasonic cleaning process is discouraged for the modules as the process might damage the module permanently, especially for the crystal oscillator in the module.

(4) Conformal coating is not allowed to this module. It will impact the reliability of the module once the coating flooded into the shield.

7. Certification

7.1. Bluetooth Qualification

7.1.1. Bluetooth Qualification Information

The module series is listed on the Bluetooth SIG website as a qualified End Product, referencing a RFPHY & Host combination. The detail information can be found in below table.

Table 30. Bluetooth Qualification Information

Declaration ID	Reference QDID	
D058375	RFPHY & Host	199566

7.1.2. Bluetooth Qualification Process

Below Bluetooth qualification process is provided for customers when they are listing their end product referencing BDE module.

(1) Go to https://launchstudio.bluetooth.com/ and log in;

(2) Select **Start the Bluetooth Qualification Process with No Required Testing**;

(3) Project Basics:
  (a) Enter your project name, it can be the product name or the product series name;
  (b) Enter QDID that the product reference, in this case the QDID is 199566.

(4) Product Declaration:
  (a) Select the listing date. You can select a date that you want your product listed and go public, although the qualification will complete immediately after your submission.
  (b) Add every product that integrated with this module. You can add a series of individual product models that use the same design/module without any modification.

(5) Declaration ID:
  (a) Select a DID. If you don't have one, you need to purchase a DID for your product by clicking Pay Declaration Fee.

(6) Review and Submit:
  (a) Review all information that you have entered and make sure no mistakes;
  (b) Tick all check boxes if you confirmed above information and add your name to the signature page;
  (c) Click **Signature Confirmed – Complete Project & Submit Product(s) for Qualification**.

(7) The qualification will be done immediately and your product will be listed to the Bluetooth SIG website as per your required listed date in step (4).

For more information about listing your product to Bluetooth SIG, please visit below webpage:
https://www.bluetooth.com/develop-with-bluetooth/qualification-listing/

7.2. Regulatory Compliance

The module is certified for FCC, IC/ISED and ETSI/CE as listed in below table. More regions can be cover by request.

Table 31. Certification Information

Regulatory Body / Region	Standard	ID	MPN
FCC (USA)	FCC CFR 47 PART 15 C (15.247)	2ABRU-MB13P2	BDE-MB1352P72UA32 BDE-MB1352P72NA32 BDE-MB1352P72UU32 BDE-MB1352P72NU32 BDE-MB1352P72UN32 BDE-MB1352P72NN32 BDE-MB1352P72UA0 BDE-MB1352P72NA0 BDE-MB1352P72UU0 BDE-MB1352P72NU0 BDE-MB1352P72UN0 BDE-MB1352P72NN0 BDE-MB1352P72UA32-IN BDE-MB1352P72NA32-IN BDE-MB1352P72UU32-IN BDE-MB1352P72NU32-IN BDE-MB1352P72UN32-IN BDE-MB1352P72NN32-IN BDE-MB1352P72UA0-IN BDE-MB1352P72NA0-IN BDE-MB1352P72UU0-IN BDE-MB1352P72NU0-IN BDE-MB1352P72UN0-IN BDE-MB1352P72NN0-IN
IC/ISED (Canada)	RSS-247 Issue 3 RSS-Gen Issue 5 ANSI C63.10: 2013	25657-MB13P2	
ETSI/CE (Europe)	ETSI EN 301 489-1 V2.2.3 (2019-11) ETSI EN 301 489-3 V2.3.2 (2023-01) ETSI EN 301 489-17 V3.3.1 (2024-09) EN 55032:2015/A11:2020 EN 55035:2017/A11:2020 ETSI EN 300 328 V2.2.2 (2019-07) ETSI EN 300 220-1 V3.1.1(2017-02) ETSI EN 300 220-2 V3.2.1 (2018-06) EN IEC 62311: 2020 EN IEC 62368-1:2020+A11:2020	NA	

7.2.1. Certified Antennas

The module series has been tested and certified with three antennas, where BDE-MB1352P72xA variants utilize an integrated PCB trace antenna, BDE-MB1352P72xU variants utilize an external 2.4GHz whip antenna through U.FL connector, BDE-MB1352P72Ux variants utilize an external Sub-1GHz whip antenna through U.FL connector, BDE- MB1352P72xN utilize an external 2.4GHz whip antenna utilized in the EM board through the dedicated ANT pin of the module and BDE-MB1352P72Nx utilize an external Sub-1GHz whip antenna utilized in the EM board through the dedicated ANT pin of the module.

The characteristic of the three antennas is listed in below. The PCB trace antenna is only present in the BDE-MB1352P72xA.

Table 32. Certified Antenna List

Antenna Type	Manufacturer	MPN	Peak Gain (dBi)	Note
PCB trace antenna	BDE	BDE-ANT-MB13	0.8	Internal
Whip antenna	BDE	BDE-W25-19513-HRP	3.0	External
Whip antenna	BDE	BDE-W89-20713-HRP	3.8	External

Customers are encouraged to use the certified antennas in the case of external antenna options to reduce certification testing effort and risk of failing. If customer want to choose another antenna that fits their product, there are some scenarios that need to be considered.

If the external antenna is of the same antenna type and of equal or less gain compared to the ones listed in above table, and with similar in-band and out-of-band characteristic, then the antenna can be used with the module in USA and Canada where modular approval is applicable, as long as the spot-check testing of the new antenna with host is performed to verified that it will not change the performance. However, in countries such as EU countries applying the ETSI standards where the modular approval is not applicable, the radiated emissions are always tested with the end product with any antennas.

If the external antenna is of a different type or with non-similar in-band and out-of-band characteristic, but still has equal gain or less gain compared to the above listed antennas. The new antenna can be added to the existing modular grant/certificate by filing a permissive change, C2PC (Class II Permissive Change) in case of FCC and ISED. The radiated emission testing is needed, but re-certification is not required.

In the case of the external antenna with higher gain than the peak gain listed in above table are very likely to require a full new end product certification. However, we recommended that you consult with your certification house to understand the correct approaches for your product case by case.

7.2.2. FCC Compliance

7.2.2.1. FCC Statement

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and,

(2) This device must accept any interference received, including interference that may cause undesired operation.

7.2.2.2. FCC Caution

Any changes or modifications to this unit not expressly approved by BDE for compliance could void the user's authority to operate the equipment. The integrator will be responsible to satisfy SAR/RF Exposure requirements, when the module integrated into the host device.

7.2.2.3. Integration Instructions

List of applicable FCC rules

FCC Part 15.247

Specific operational use conditions

This transmitter/module and its antenna(s) must not be co-located or operating in conjunction with any transmitter. This information also extends to the host manufacturer’s instruction manual.

Limited module procedures

Not applicable

Trace antenna designs

Not applicable

RF exposure considerations

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This compliance to FCC radiation exposure limits for an uncontrolled environment, and minimum of 20cm separation between antenna and body. The host product manufacturer would provide the above information to end users in their end-product manuals.

Antennas

Refer to Table 32

Label and compliance information

The end product must carry a physical label or shall use e-labeling followed KDB784748D01 and KDB784748 stating “Contains Transmitter Module FCC ID: 2ABRU-MB13P2”.

Information on test modes and additional testing requirements

Contact BDE for more information.

Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only FCC authorized for the specific rule parts (FCC Part 15.247) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed when contains digital circuity.

(OEM) Integrator has to assure compliance of the entire end-product that includes the module. For 15 B (§15.107 and if applicable §15.109) compliance, the host manufacturer is required to show compliance with 15 while the module is installed and operating.

Furthermore, the module should be transmitting and the evaluation should confirm that the module's intentional emissions (15C) are compliant (fundamental / out-of-band). Finally, the integrator has to apply the appropriate equipment authorization (e.g. Verification) for the new host device per definition in §15.101. Integrator is reminded to assure that these installation instructions will not be made available to the end-user of the final host device.

7.2.3. IC/ISED Compliance

7.2.3.1. IC Statement

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s license-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference, and,

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

L’émetteur/récepteur exempt de licencecontenudans le présentappareilestconforme aux CNR d’Innovation, Sciences et Développementéconomique Canada applicables aux appareils radio exempts de licence. L’exploitationestautorisée aux deux conditions suivantes :

(1) L' appareil ne doit pas produire de brouillage;
(2) L' appareildoit accepter tout brouillageradioélectriquesubi, mêmesi le brouillageest susceptible d' encompromettre le fonctionnement.

7.2.3.2. IC Caution

Any changes or modifications to this unit not expressly approved by BDE for compliance could void the user’s authority to operate the equipment. The integrator will be responsible to satisfy SAR/RF Exposure requirements, when the module integrated into the host device.

7.2.3.3. Integration Instructions

Label and compliance information

The final host device, into which this RF module is integrated has to be labeled with an auxiliary label stating the IC of the RF module, such as "Contains transmitter module IC: 25657-MB13P2”.

Informations sur l'étiquette et la conformité

Le périphériquehôte final, danslequelce module RF estintégré "doitêtreétiqueté avec uneétiquetteauxiliaireindiquant le CI du module RF, tel que "Contient le module émetteur IC: 25657-MB13P2”.

Radio Frequency Exposure Statement for IC

The device has been evaluated to meet general RF exposure requirements. The device can be used in mobile exposure conditions. The min separation distance is 20cm.

Déclaration d'exposition aux radiofréquences pour IC

L'appareil a été évalué pour répondre aux exigences générales en matière d'exposition aux RF. L'appareil peut être utilisé dans des conditions d'exposition mobiles. La distance de séparation minimale est de 20 cm.

This radio transmitter [IC: 25657-MB13P2] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed Table 32 with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Cet émetteur radio [IC: 25657-MB13P2] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous, avec le gain maximal admissible indiqué. Les types d'antenne non inclus dans cette liste qui ont un gain supérieur au gain maximum indiqué pour tout type répertorié sont strictement interdits pour une utilisation avec cet appareil.

7.2.3.4. ETSI/CE Compliance

The module is certified with required EU radio and EMC directives. See Table 31 for detailed standards the module complies with, or refer to UK Declaration of Conformity.

8. Ordering Information

Table 33. Ordering Information

Part Number	Description	Size (mm)	Shipping Form	MOQ
BDE-MB1352P72UA32	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and PCB trace antenna in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NA32	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and PCB trace antenna in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UU32	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and U.FL connector in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NU32	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and U.FL connector in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UN32	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and ANT pin in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NN32	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and ANT pin in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UA0	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and PCB trace antenna in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NA0	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and PCB trace antenna in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UU0	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and U.FL connector in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NU0	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and U.FL connector in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UN0	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and ANT pin in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NN0	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and ANT pin in 2.4GHz, -40℃ to +85℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UA32-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and PCB trace antenna in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NA32-IN	BDE multi-band & multi-protocol wireless module, with	26 × 19 × 2.15	Tape & Reel	0.9K

Part Number	Description	Size (mm)	Shipping Form	MOQ
	ANT pin in Sub-1GHz and PCB trace antenna in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃			
BDE-MB1352P72UU32-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and U.FL connector in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NU32-IN	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and U.FL connector in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UN32-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and ANT pin in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NN32-IN	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and ANT pin in 2.4GHz, with on-board 32Mbit SPI flash, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UA0-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and PCB trace antenna in 2.4GHz-40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NA0-IN	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and PCB trace antenna in 2.4GHz, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UU0-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and U.FL connector in 2.4GHz, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NU0-IN	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and U.FL connector in 2.4GHz, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72UN0-IN	BDE multi-band & multi-protocol wireless module, with U.FL connector in Sub-1GHz and ANT pin in 2.4GHz, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K
BDE-MB1352P72NN0-IN	BDE multi-band & multi-protocol wireless module, with ANT pin in Sub-1GHz and ANT pin in 2.4GHz, -40℃ to +105℃	26 × 19 × 2.15	Tape & Reel	0.9K

9. Revision History

Table 34. Ordering Information

Revision	Date	Description
V0.1	22-October-2024	Preliminary, draft
V1.0	12-August-2025	Production version

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