# General Description


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

BDE-MP2652R7 is a high-performance multiprotocol 2.4-GHz wireless module series based on Texas Instruments (TI)'s multiprotocol wireless microcontroller (MCU) CC2652R74T0RGZR. In order to fulfil different integration scenarios, BDE provides different variants for this module series. They are listed and described in Table 1.

BDE-MP2652R7 module series integrates a powerful 48-MHz Arm® Cortex®-M4F processor, which supports Thread, Zigbee®, Matter, Bluetooth® 5.2 Low Energy, IEEE 802.15.4g, IPv6-enabled smart objects (6LoWPAN), proprietary systems including TI 15.4-Stack (2.4-GHz), and concurrent multiprotocol through a Dynamic Multiprotocol Manager (DMM) driver. The device is optimized for low-power wireless communication and advanced sensing in building security systems, HVAC, medical, wired networking, portable electronics, and home theater & entertainment markets.

BDE-MP2652R7 module series can support +5 dBm output power setting and a receive sensitivity of -102 dBm for 125-kbps Bluetooth® Low Energy Coded PHY. It has a low sleep current of 0.9 µA with RTC and 144KB RAM retention that enables longer battery life wireless applications. The module series supports Low SER (Soft Error Rate) FIT (Failure-in-time) for long operational lifetime with no disruption for industrial markets with always-on SRAM parity against corruption due to potential radiation events. The device also has an autonomous ultra-low power Sensor Controller CPU with fast wake-up capability. As an example, the sensor controller is capable of 1-Hz ADC sampling at 1-µA system current.

BDE-MP2652R7 module series 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. It is for easy assembly and low-cost PCB design. It can work standalone without using an external MCU. With its best-in-class radio performance, ultra-low power, small form factor and low cost, the BDE-MP2652R7 module series is the best choice for the applications that are sensitive to power consumption, size and cost.

**Table 1. Module Variants**

| Part Number | Antenna Type | Integrated On-board SPI Flash (Mbit) | Operating Temperature |
|---|---|---|---|
| BDE-MP2652R7A32 | PCB trace antenna | 32 | -40℃ to +85℃ |
| BDE-MP2652R7U32 | U.FL connector | | |
| BDE-MP2652R7N32 | ANT pin | | |
| BDE-MP2652R7A0 | PCB trace antenna | 0 | |
| BDE-MP2652R7U0 | U.FL connector | | |
| BDE-MP2652R7N0 | ANT pin | | |
| BDE-MP2652R7A32-IN | PCB trace antenna | 32 | -40℃ to +105℃ |
| BDE-MP2652R7U32-IN | U.FL connector | | |
| BDE-MP2652R7N32-IN | ANT pin | | |

| Part Number | Antenna Type | Integrated On-board SPI Flash (Mbit) | Operating Temperature |
|---|---|---|---|
| BDE-MP2652R7A0-IN | PCB trace antenna | 0 | |
| BDE-MP2652R7U0-IN | U.FL connector | | |
| BDE-MP2652R7N0-IN | 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
  - Dynamic multiprotocol manager (DMM) driver
  - Programmable radio includes support for 2-(G)FSK, 4-(G)FSK, MSK, Bluetooth® 5.2 Low Energy, IEEE 802.15.4 PHY and MAC
  - Supports over-the-air (OTA) update
- **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:
    - 3.10 mA active mode, CoreMark
    - 65 µA/MHz running CoreMark
    - 0.9 µA standby mode, RTC, 144KB RAM
    - 0.1 µA shutdown mode, wake-up on pin
  - Ultra-low power sensor controller consumption:
    - 29.2 µA in 2 MHz mode
    - 799 µA in 24 MHz mode
  - Radio Consumption:
    - 6.4 mA RX
    - 7.3 mA TX at 0 dBm
    - 9.7 mA TX at +5 dBm
- **Wireless protocol support**
  - Thread, Zigbee®, Matter
  - Bluetooth® 5.2 Low Energy
  - SimpleLink™ TI 15.4-stack
  - 6LoWPAN
  - Proprietary systems
- **High performance radio**
  - -102 dBm for Bluetooth® Low Energy 125-kbps
  - Output power up to +3 dBm (+5 dBm setting)
- **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
  - 33 GPIOs – none SPI flash versions
  - 29 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 / -40 to +105°C
- **Package**
  - Dimension: 21.5 mm x 15 mm x 2.15 mm
  - LCC-36 – BDE-MP2652R7A variants
  - LCC-39 – BDE-MP2652R7U and BDE MP2652R10N variants

- RoHS-compliant package

- **Antenna options**
  - Integrated PCB trace antenna
  - U.FL connector for external antenna
  - ANT pin out for external antenna
- **On-board SPI flash**
  - 32-Mbit, only available in SPI flash versions
- **Package**
  - Dimension: 21.5 mm x 15 mm x 2.15 mm
  - LCC-36 – A variants
  - LCC-39 – U and N variants
- **Certification**
  - FCC ID: 2ABRU-MP26R
  - IC: 25657-MP26R
  - CE-RED
  - Bluetooth SIG

# Applications

- 2400 to 2480 MHz ISM and SRD systems with down to 4 kHz of receive bandwidth
- 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)
  - Video surveillance – IP network camera
  - Elevators and escalators – elevator main control panel for elevators and escalators
- Industrial transport – asset tracking
- Factory automation and control
- Medical
  - Personal care & fitness
  - Patient monitoring & diagnostics – medical sensor patches, multiparameter patient monitor
  - Medical equipment
  - Home healthcare – blood glucose monitor, pulse oximeter
- Electronic point of sale (EPOS) – Electronic Shelf Label (ESL)
- Communication equipment
- Wired networking – wireless LAN or Wi-Fi access points, edge router
- Personal electronics
  - Portable electronics – RF smart remote control
  - Home theater & entertainment – smart speakers, smart display, set-top box
  - Connected peripherals – consumer wireless keypads
  - Gaming – electronic and robotic toys
  - Wearables (non-medical) – smart trackers, smart clothing

# 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 Options | On-board SPI Flash (Mbit) | Operating Temp. (°C) | Size (mm) |
|---|---|---|---|---|---|---|---|---|---|
| Module BDE-MP26R | BDE-MP2674R10A32 | CC2674R10 Cortex-M33 | 1024 | 296 | 2.4GHz BLE 5.2 & ZigBee & Thread | PCB trace antenna | 32 | -40 to +85 | 21.5 × 15 × 2.15 |
| | BDE-MP2674R10U32 | | | | | U.FL connector | | | |
| | BDE-MP2674R10N32 | | | | | ANT pin | | | |
| | BDE-MP2674R10A0 | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2674R10U0 | | | | | U.FL connector | | | |
| | BDE-MP2674R10N0 | | | | | ANT pin | | | |
| | BDE-MP2674R10A32-IN | | | | | PCB trace antenna | 32 | -40 to +105 | |
| | BDE-MP2674R10U32-IN | | | | | U.FL connector | | | |
| | BDE-MP2674R10N32-IN | | | | | ANT pin | | | |
| | BDE-MP2674R10A0-IN | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2674R10U0-IN | | | | | U.FL connector | | | |
| | BDE-MP2674R10N0-IN | | | | | ANT pin | | | |
| | BDE-MP2652R7A32 | CC2652R7 Coretex-M4F | 704 | 152 | 2.4GHz BLE 5.2 & ZigBee & Thread | PCB trace antenna | 32 | -40 to +85 | 21.5 × 15 × 2.15 |
| | BDE-MP2652R7U32 | | | | | U.FL connector | | | |
| | BDE-MP2652R7N32 | | | | | ANT pin | | | |
| | BDE-MP2652R7A0 | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2652R7U0 | | | | | U.FL connector | | | |
| | BDE-MP2652R7N0 | | | | | ANT pin | | | |
| | BDE-MP2652R7A32-IN | | | | | PCB trace antenna | 32 | -40 to +105 | |
| | BDE-MP2652R7U32-IN | | | | | U.FL connector | | | |
| | BDE-MP2652R7N32-IN | | | | | ANT pin | | | |
| | BDE-MP2652R7A0-IN | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2652R7U0-IN | | | | | U.FL connector | | | |
| | BDE-MP2652R7N0-IN | | | | | ANT pin | | | |
| | BDE-MP2652RA32 | CC2652R Coretex-M4F | 352 | 88 | 2.4GHz BLE 5.2 & ZigBee & Thread | PCB trace antenna | 32 | -40 to +85 | 21.5 × 15 × 2.15 |
| | BDE-MP2652RU32 | | | | | U.FL connector | | | |
| | BDE-MP2652RN32 | | | | | ANT pin | | | |
| | BDE-MP2652RA0 | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2652RU0 | | | | | U.FL connector | | | |
| | BDE-MP2652RN0 | | | | | ANT pin | | | |
| | BDE-MP2652RA32-IN | | | | | PCB trace antenna | 32 | -40 to +105 | |
| | BDE-MP2652RU32-IN | | | | | U.FL connector | | | |
| | BDE-MP2652RN32-IN | | | | | ANT pin | | | |
| | BDE-MP2652RA0-IN | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2652RU0-IN | | | | | U.FL connector | | | |

| Product Type & Series Name | Orderable Part Number | Chipset & Core | On-chip Flash Size (KB) | On-chip SRAM Size (KB) | Connectivity | Antenna Options | On-board SPI Flash (Mbit) | Operating Temp. (°C) | Size (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | BDE-MP2652RN0-IN | | | | | ANT pin | | | |
| | BDE-MP2651R3A32 | CC2651R3 Cortex-M4 | 352 | 40 | 2.4GHz BLE 5.2 & ZigBee & Thread | PCB trace antenna | 32 | -40 to +85 | 21.5 × 15 × 2.15 |
| | BDE-MP2651R3U32 | | | | | U.FL connector | | | |
| | BDE-MP2651R3N32 | | | | | ANT pin | | | |
| | BDE-MP2651R3A0 | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2651R3U0 | | | | | U.FL connector | | | |
| | BDE-MP2651R3N0 | | | | | ANT pin | | | |
| | BDE-MP2651R3A32-IN | | | | | PCB trace antenna | 32 | -40 to +105 | |
| | BDE-MP2651R3U32-IN | | | | | U.FL connector | | | |
| | BDE-MP2651R3N32-IN | | | | | ANT pin | | | |
| | BDE-MP2651R3A0-IN | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2651R3U0-IN | | | | | U.FL connector | | | |
| | BDE-MP2651R3N0-IN | | | | | ANT pin | | | |
| | BDE-MP2642RA32 | CC2642R Coretex-M4F | 352 | 88 | 2.4GHz BLE 5.2 | PCB trace antenna | 32 | -40 to +85 | 21.5 × 15 × 2.15 |
| | BDE-MP2642RU32 | | | | | U.FL connector | | | |
| | BDE-MP2642RN32 | | | | | ANT pin | | | |
| | BDE-MP2642RA0 | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2642RU0 | | | | | U.FL connector | | | |
| | BDE-MP2642RN0 | | | | | ANT pin | | | |
| | BDE-MP2642RA32-IN | | | | | PCB trace antenna | 32 | -40 to +105 | |
| | BDE-MP2642RU32-IN | | | | | U.FL connector | | | |
| | BDE-MP2642RN32-IN | | | | | ANT pin | | | |
| | BDE-MP2642RA0-IN | | | | | PCB trace antenna | 0 | | |
| | BDE-MP2642RU0-IN | | | | | U.FL connector | | | |
| | BDE-MP2642RN0-IN | | | | | ANT pin | | | |

# Naming Convention

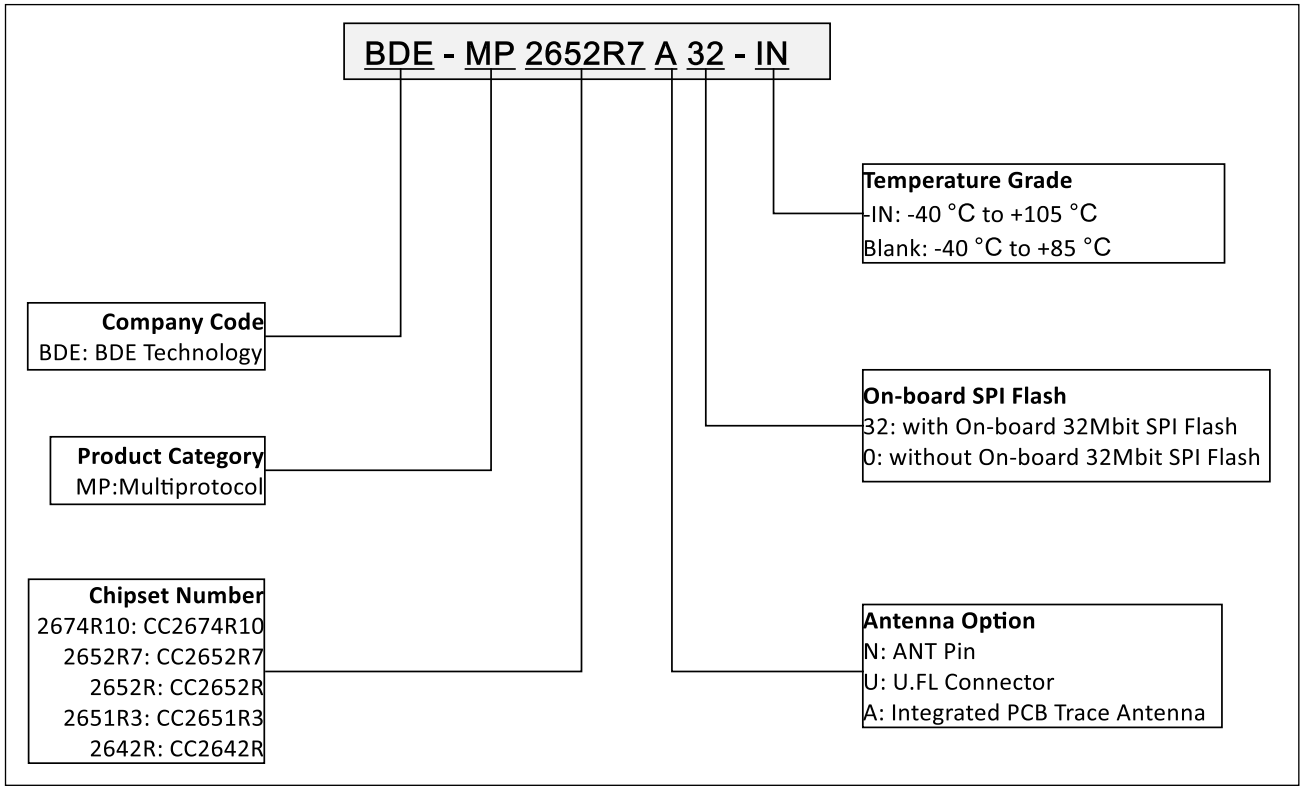


**Figure 1. Module Naming Convention**

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# Reference

[1] CC2652R7 resources: https://www.ti.com/product/CC2652R7

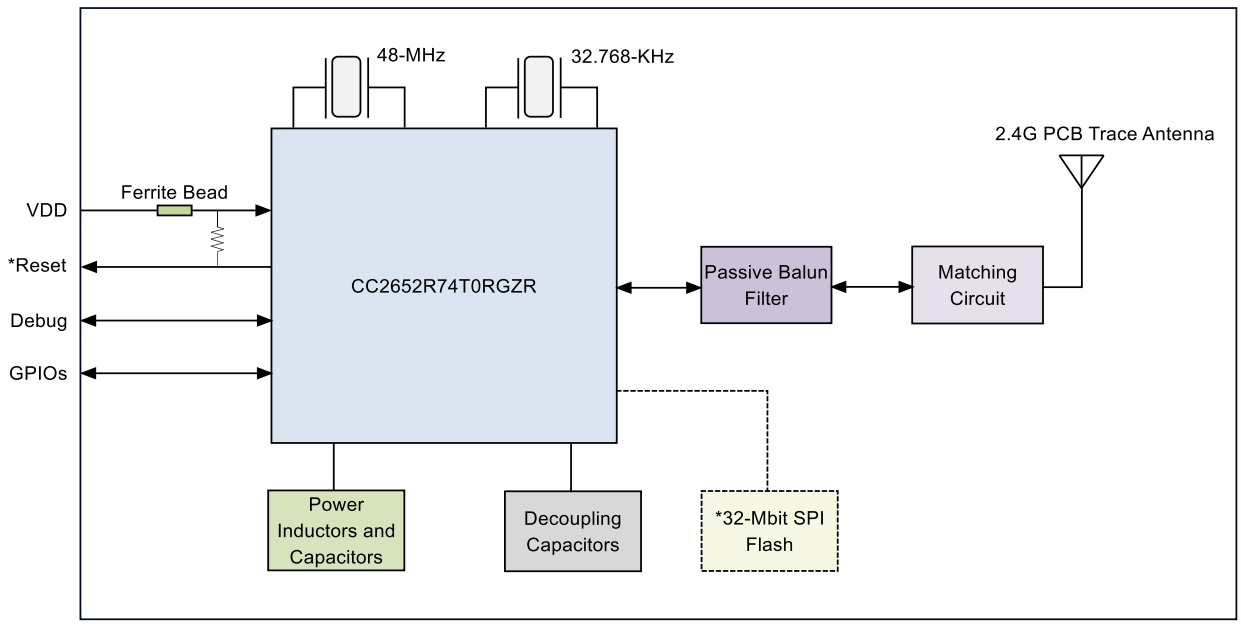
# 1. System Overview

## 1.1. Block Diagram

BDE-MP2652R7 module series is based on CC2652R7 single chip wireless MCU from Taxes Instruments. With clocks, other required passives and antenna/connector (optional) integrated, it allows faster time to market at reduced development cost.

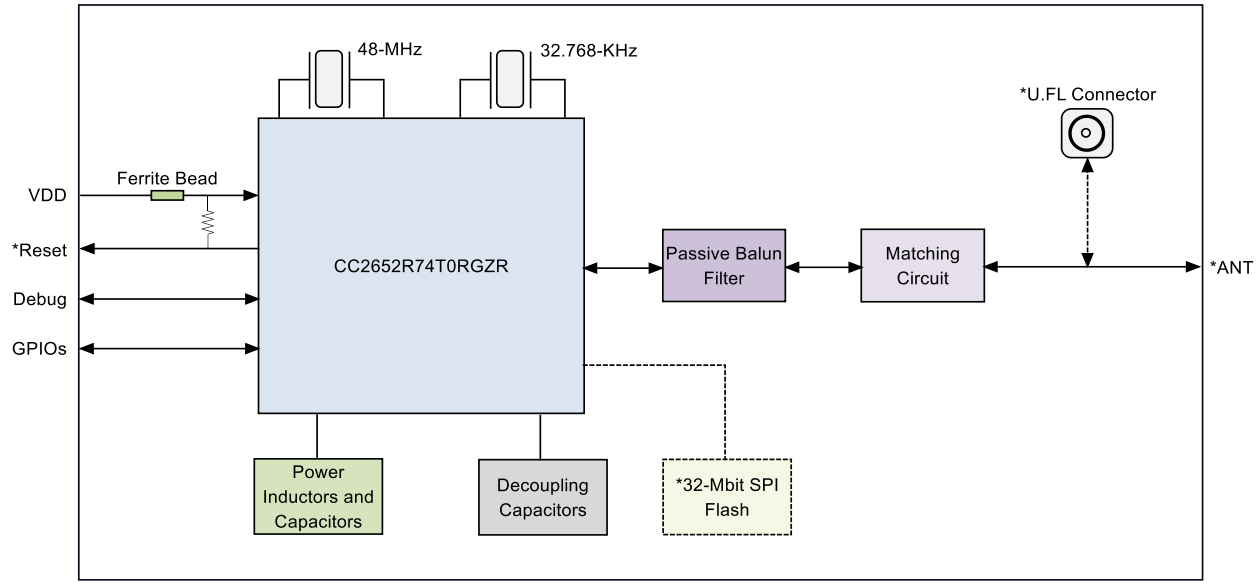
The block diagram of the series modules can be seen in Figure 2 and Figure 3, comprises of:

- 48-MHz HFXT
- 32.768-kHz LFXT
- 32-Mbit SPI flash (SPI flash variants)
- Power inductors and capacitors
- Pull-up resistor
- Passive balun filter
- Decoupling capacitors
- Matching circuit
- PCB trace antenna / U.FL connector for external antenna / ANT pin out for external antenna




(1) This block diagram is for BDE-MP2652R7A variants;
(2) The 32-Mbit SPI flash is only for SPI flash variants;
(3) Reset pin has an internal pull-up resistor and a decoupling capacitor on module.

**Figure 2. The Block Diagram of BDE-MP2652R7A**




(1) This block diagram is for BDE-MP2652R7U and BDE-MP2652R7N variants;
(2) The 32-Mbit SPI flash is only for SPI flash variants;
(3) The U.FL connector is only for BDE-MP2652R7U variants, ANT pin is only for BDE-MP2652R7N variants;
(4) Reset pin has an internal pull-up resistor and a decoupling capacitor.

**Figure 3. The Block Diagram of BDE-MP2652R7U and BDE-MP2652R7N**

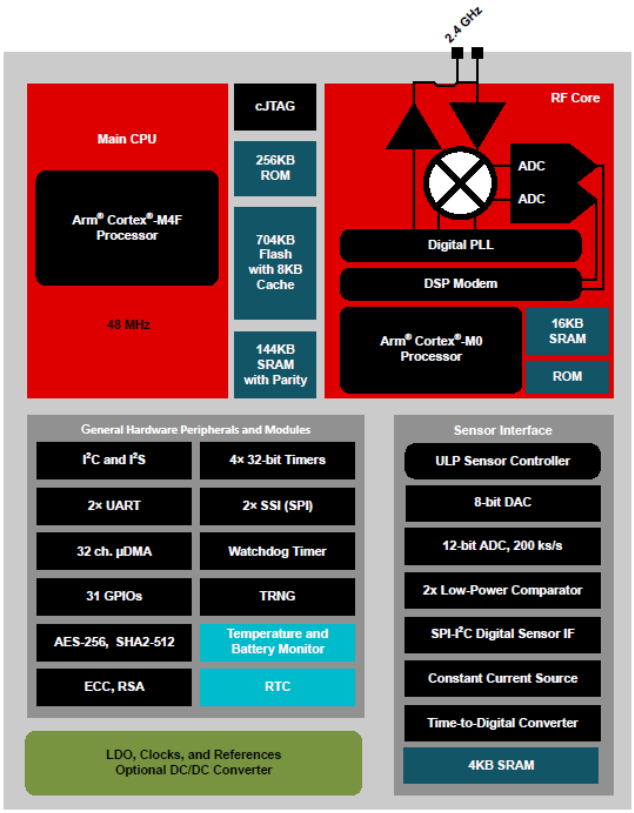



**Figure 4. The Block Diagram of CC2652R7**

## 1.2. System CPU

The BDE-MP2652R7 module series utilizes CC2652R7 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.

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. 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.

### 1.3.2. 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 eight 32 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 also provides an option with integrated an on-board 32-Mbit SPI flash for the applications that need to store big 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 ksps 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 accelerator, 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 run 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 Processing
- Curve Support
- Message Authentication Codes
- Block cipher mode of operation
- Hash Algorithm
- True random number generation

## 1.7. Timer

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
• Always On Watchdog timer (AON_WDT)

## 1.8. Serial Peripherals and I/O

The SPI interface provides a standardized synchronous serial interface to communicate with devices compatible with SPI (3 and 4 wire), MICROWIRE and TI Synchronous Serial Format. The SPIs support master/slave operation up to 12 MHz, programmable clock bit rate with prescaler, as well as configurable phase and polarity.

The UART interface implements universal asynchronous receiver and transmitter functions. The UART supports flexible baud-rate generation up to a maximum of 3 Mbps with FIFO, multiple data sizes, stop and parity bits as well as hardware handshake.

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 also 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 module 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

The module has the following 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.

## 1.13. Network Processor

Depending on the product configuration, the module 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 CC2652R7 supports a number of power modes and power management features.

**Table 3. Power Mode**

| 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 the 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.

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 control the peripherals in the Sensor Controller indepently 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 CC2652R7 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 CC2652R7 software development kit (SDK). Therefore, BDE highly recommends using this software framework for all application development on the device. The complete SDK with TI-RTOS (optional), device drivers, and examples are offered free of charge in source code.

## 1.15. Antenna

The module series provides three different types of antenna integration options, integrated PCB trace antenna, U.FL connector and ANT pin for connecting external antenna. Detail characteristics for the antennas can be found in Section 3.3.

# 2. Pinout Functions

The module series is with LCC-36 package for BDE-MP2652R7A variants and LCC-39 package for BDE-MP2652R7U and BDE-MP2652R7N variants, 36 or 39 pads are exposed for user. This section describes pinout functions of the module in details.

## 2.1. Pinout Diagram

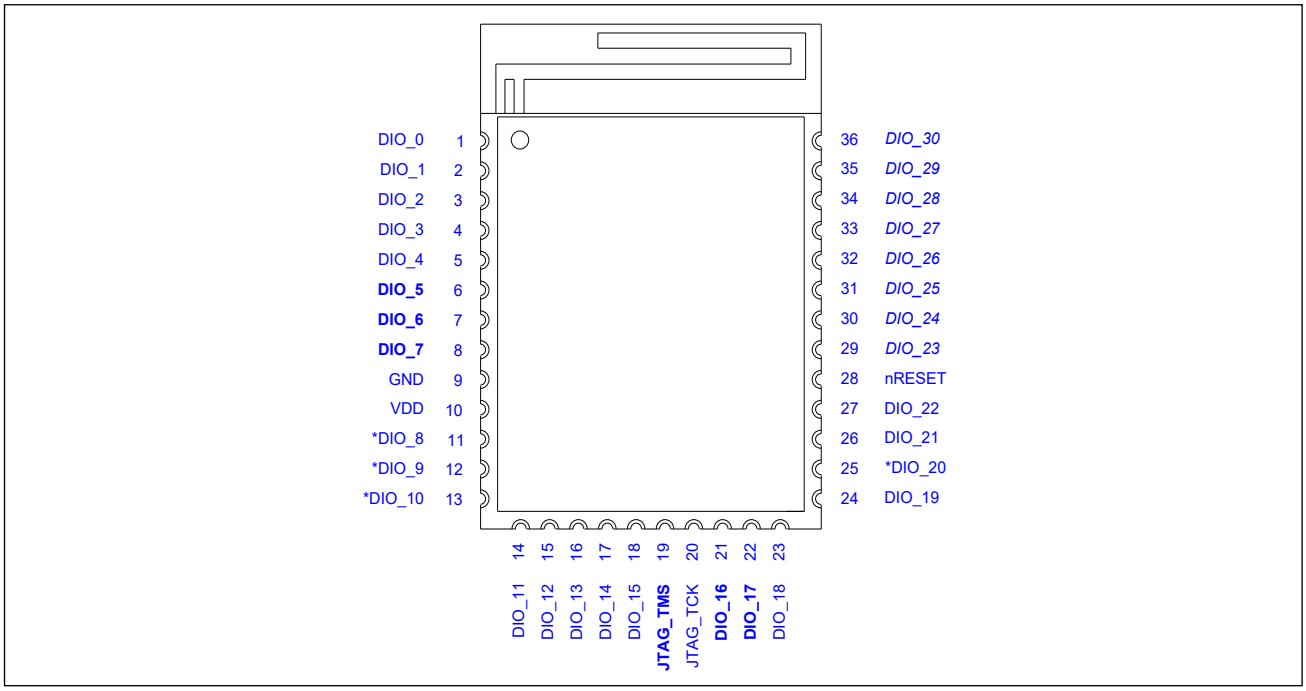



**Figure 5. Pinout Diagram of BDE-MP2652R7A Top View**

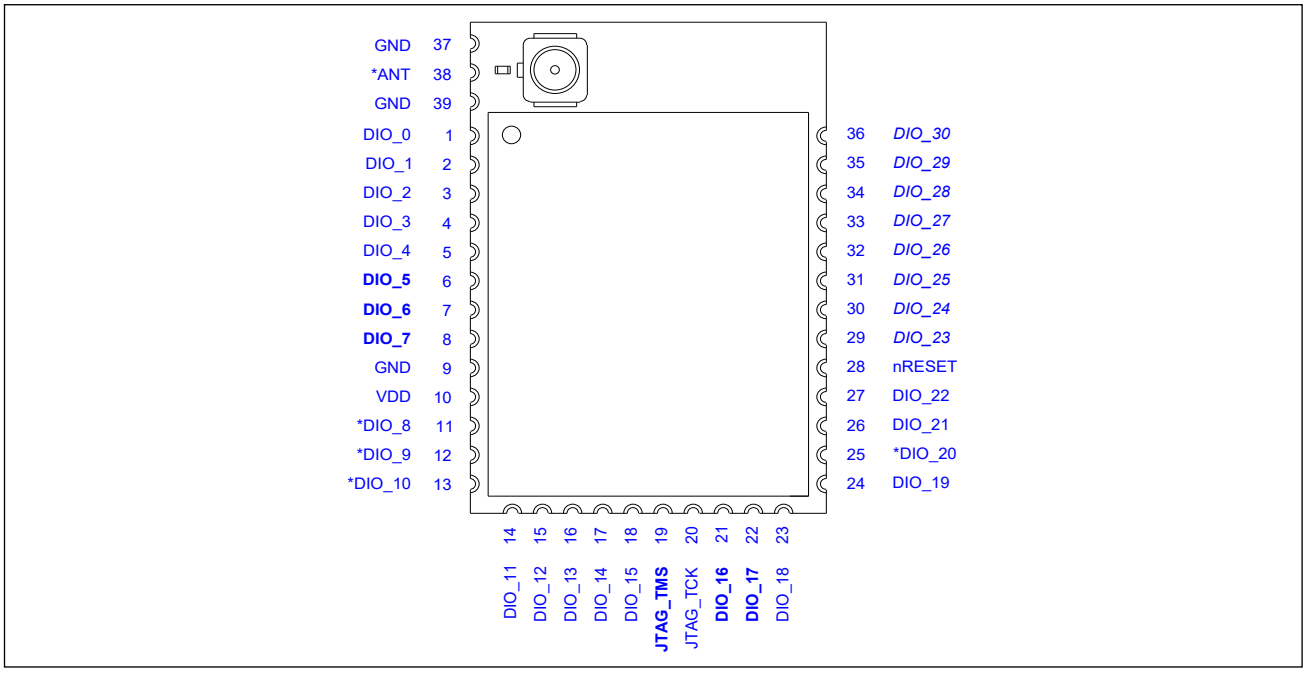



**Figure 6. Pinout Diagram of BDE-MP2652R7U and BDE-MP2652R7N Top View**

The following I/O pins marked in Figure 5 and Figure 6 in **bold** have high-drive capabilities:

- Pin 6, DIO5
- Pin 7, DIO6
- Pin 8, DIO7
- Pin 19, JTAG_TMS
- Pin 21, DIO16
- Pin 22, DIO17

The following I/O pins marked in Figure 5 and Figure 6 in *italics* have analog capabilities:

- Pin 29, DIO23
- Pin 30, DIO24
- Pin 31, DIO25
- Pin 32, DIO26
- Pin 33, DIO27
- Pin 34, DIO28
- Pin 35, DIO29
- Pin 36, DIO30

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

- Pin 11, SFL_MISO_DIO8
- Pin 12, SFL_MOSI_DIO9
- Pin 13, SFL_CLK_DIO10
- Pin 25, SFL_CS_DIO20

Pin 38 is for connecting external antenna for BDE-MP2652R7N variants, if U.FL variants are used, leave this pin NC.

## 2.2. Pinout Descriptions

Table 4 describes the definitions of the pins of the module. Pin number of CC2652R7 chip is also stated here, because the chip pin is referred to in the software design kit (SDK).

**Table 4. Pin Description**(1)

| Module Pin # | Pin Name | Type | CC2652R74T0RGZR Pin # | Description |
|---|---|---|---|---|
| 1 | DIO_0 | I/O | 5 | GPIO |
| 2 | DIO_1 | I/O | 6 | GPIO |
| 3 | DIO_2 | I/O | 7 | GPIO |
| 4 | DIO_3 | I/O | 8 | GPIO |
| 5 | DIO_4 | I/O | 9 | GPIO |
| 6 | DIO_5 | I/O | 10 | GPIO, high-drive capability |
| 7 | DIO_6 | I/O | 11 | GPIO, high-drive capability |
| 8 | DIO_7 | I/O | 12 | GPIO, high-drive capability |
| 9 | GND | Ground | - | Power ground |
| 10 | VDD | Power | - | Power supply |
| 11 | DIO_8 | I/O | 14 | SFL_MISO(2), GPIO |
| 12 | DIO_9 | I/O | 15 | SFL_MOSI(2), GPIO |
| 13 | DIO_10 | I/O | 16 | SFL_SCLK(2), GPIO |

| Module Pin # | Pin Name | Type | CC2652R74T0RGZR Pin # | Description |
|---|---|---|---|---|
| 14 | DIO_11 | I/O | 17 | GPIO |
| 15 | DIO_12 | I/O | 18 | GPIO |
| 16 | DIO_13 | I/O | 19 | GPIO |
| 17 | DIO_14 | I/O | 20 | GPIO |
| 18 | DIO_15 | I/O | 21 | GPIO |
| 19 | JTAG_TMS | I/O | 24 | JTAG TMSC, high-drive capability |
| 20 | JTAG_TCK | I | 25 | JTAG TCKC |
| 21 | DIO_16 | I/O | 26 | GPIO, JTAG_TDO, high-drive capability |
| 22 | DIO_17 | I/O | 27 | GPIO, JTAG_TDI, high-drive capability |
| 23 | DIO_18 | I/O | 28 | GPIO |
| 24 | DIO_19 | I/O | 29 | GPIO |
| 25 | DIO_20 | I/O | 30 | SFL_CS(2), GPIO |
| 26 | DIO_21 | I/O | 31 | GPIO |
| 27 | DIO_22 | I/O | 32 | GPIO |
| 28 | nRESET | I | 35 | Reset, active-low, 100K ohm internal pull-up resistor |
| 29 | DIO_23 | I/O | 36 | GPIO, analog capability |
| 30 | DIO_24 | I/O | 37 | GPIO, analog capability |
| 31 | DIO_25 | I/O | 38 | GPIO, analog capability |
| 32 | DIO_26 | I/O | 39 | GPIO, analog capability |
| 33 | DIO_27 | I/O | 40 | GPIO, analog capability |
| 34 | DIO_28 | I/O | 41 | GPIO, analog capability |
| 35 | DIO_29 | I/O | 42 | GPIO, analog capability |
| 36 | DIO_30 | I/O | 43 | GPIO, analog capability |
| 37(3) | GND | Ground | - | Power ground |
| 38(3) | ANT | RF | - | Antenna port |
| 39(3) | GND | Ground | - | Power ground |

(1) For pin multiplexing details, refer to CC2652R7 SimpleLink™ Multiprotocol 2.4 GHz Wireless MCU;
(2) These four pins are used as SPI for on-board 32-Mbit flash in SPI flash module variants. They can be used as GPIOs in none SPI flash module variants;
(3) Pin 37, Pin 38 and Pin 39 are only included in BDE-MP2652R7U and BDE-MP2652R7N variants.

## 2.3. Connections for Unused Pins

**Table 5. 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 6. Absolute Maximum Ratings**

| Parameter | MIN | MAX | Unit | Note |
|---|---|---|---|---|
| VDD, Supply voltage | -0.3 | 4.1 | V | |
| Voltage on any digital pins | -0.3 | VDD+0.3≤4.1 | V | Including DIOs with analog capability |
| Voltage on ADC input | -0.3 | VDD | 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 |
| Input level, for ANT pin (Pin38) | | 5 | dBm | For –N variants |
| TSTG, Storage temperature | -40 | 125 | °C | |

### 3.1.2. ESD Ratings

**Table 7. 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 8. Recommended Operating Conditions**

| Parameter | MIN | TYP | MAX | Unit | Note |
|---|---|---|---|---|---|
| VDD, Supply voltage | 1.8 | 3.3 | 3.8 | V | |
| | 2.3 | 3.3 | 3.8 | V | For SPI flash variants |
| TA, Operating Temperature | -40 | 25 | 85 | °C | |
| | -40 | 25 | 105 | °C | For -IN variants |
| Rising supply voltage slew rate | 0 | | 100 | mV/µs | |
| Falling supply voltage slew rate | 0 | | 20 | mV/µs | |

## 3.1.4. Power Consumption

The measurement is made with $T_A$ = 25 °C, VDD = 3.0 V, DCDC enabled, GLDO disabled, none SPI flash variants unless otherwise noted.

**Table 9. Power Consumption – Power Modes**

| Parameter | | Test Condition | TYP | Unit |
|---|---|---|---|---|
| **Core Current Consumption** | | | | |
| $I_{core}$ | Reset | Reset. RESET pin asserted or VDD below power-on-reset threshold | 100 | nA |
| | Shutdown | Shutdown. No clocks running, no retention | 100 | nA |
| | Standby without cache retention | RTC running, CPU, 144 kB RAM and (partial) register retention. RCOSC_LF | 0.9 | uA |
| | | RTC running, CPU, 64 kB RAM and (partial) register retention. RCOSC_LF | 0.8 | uA |
| | | RTC running, CPU, 144 kB RAM and (partial) register retention. XOSC_LF | 1.0 | uA |
| | Standby with cache retention | RTC running, CPU, 144 kB RAM and (partial) register retention. RCOSC_LF | 2.3 | uA |
| | | RTC running, CPU, 144 kB RAM and (partial) register retention. XOSC_LF | 2.4 | uA |
| | Idle | Supply Systems and RAM powered RCOSC_HF | 699 | uA |
| | Active | MCU running CoreMark at 48 MHz with parity enabled RCOSC_HF | 3.1 | mA |
| **Peripheral Current Consumption** | | | | |
| $I_{peri}$ | RF Core | Delta current with power domain enabled, clock enabled, RF core idle | 109 | uA |
| | µDMA | Delta current with clock enabled, module is idle | 69 | |
| | Timers | Delta current with clock enabled, module is idle | 115 | |
| | I2C | Delta current with clock enabled, module is idle | 11.6 | |
| | I2S | Delta current with clock enabled, module is idle | 27.6 | |
| | SPI | Delta current with clock enabled, module is idle | 61 | |
| | UART | Delta current with clock enabled, module is idle | 131 | |
| | CRYPTO (AES) | Delta current with clock enabled, module is idle | 19.5 | |
| | PKA | Delta current with clock enabled, module is idle | 70 | |
| | TRNG | Delta current with clock enabled, module is idle | 25 | |

| Parameter | | Test Condition | TYP | Unit |
|---|---|---|---|---|
| **Sensor Controller Engine Consumption** | | | | |
| $I_{SCE}$ | Active mode | 24 MHz, infinite loop | 799 | uA |
| | Low-power mode | 2 MHz, infinite loop | 29.2 | |

**Table 10. Power Consumption – Radio Modes**

| Power Mode | Test Condition | TYP | Unit |
|---|---|---|---|
| Radio receive current | 2440 MHz, Bluetooth Low Energy | 6.4 | mA |
| Radio transmit current | 0 dBm output power setting 2440 MHz, Bluetooth Low Energy | 7.3 | mA |
| | +5 dBm output power setting 2440 MHz, Bluetooth Low Energy | 9.7 | mA |

## 3.1.5. Clock Characteristics

**Table 11. 48-MHz Crystal Oscillator (XOSC_HF) Characteristics**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Crystal frequency | | | 48 | | MHz |
| ESR, Equivalent series resistance | | | | 40 | Ω |
| Frequency tolerance | TA: 25°C | -10 | | 10 | ppm |
| Frequency stability | TA: -40°C ~ 85°C or -40°C ~ 105°C | -20 | | 20 | ppm |
| CL, Crystal load capacitance | | | 7 | | pF |

**Table 12. 32.768-KHz Crystal Oscillator (XOSC_LF) Characteristics**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Crystal frequency | | | 32.768 | | KHz |
| ESR, Equivalent series resistance | | | | 70 | kΩ |
| Frequency tolerance | TA: 25°C | -20 | | 20 | ppm |
| CL, Crystal load capacitance | | | 12.5 | | pF |

## 3.1.6. Reset Timing

**Table 13. Reset Timing**

| Parameter | MIN | TYP | MAX | Unit |
|---|---|---|---|---|
| nRESET low duration | 1 | | | us |

## 3.1.7. UART Characteristics

**Table 14. UART Characteristics**

| Parameter | MIN | TYP | MAX | Unit |
|---|---|---|---|---|
| UART baud rate | | | 3 | MBaud |

## 3.1.8. GPIO DC Characteristics

**Table 15. GPIO DC Characteristics**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| TA = 25 °C, VDD = 1.8 V | | | | | |
| GPIO VOH at 8 mA load | IOCURR = 2, high-drive GPIOs only | | 1.56 | | |
| 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 → 1 and 1 → 0 points | | 0.35 | | V |
| TA = 25 °C, VDD = 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 |
| TA = 25 °C, VDD = 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 |
| TA = 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 16. ADC Characteristics**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Resolution | | | 12 | | bit |

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Input voltage range | | 0 | | VDD | V |
| Reference voltage | Equivalent fixed internal reference (input voltage scaling 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 | | 4.3 | | V |
| 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 |
| Sampling rate | | | | 200 | ksps |

For more details on the ADC characteristic, please refer to CC2652R7 datasheet: refer to CC2652R7 SimpleLink™ Multiprotocol 2.4 GHz Wireless MCU.

## 3.1.10. DAC Characteristics

**Table 17. DAC Characteristics**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Resolution | | | 8 | | bit |
| 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 more details on the DAC characteristic, please refer to CC2652R7 datasheet: refer to CC2652R7 SimpleLink™ Multiprotocol 2.4 GHz Wireless MCU.

### 3.1.11. Comparator Characteristics

**Table 18. Low-Power Clocked Comparator**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Input voltage range | | 0 | | VDD | V |
| Clock frequency | | | 32 | | KHz |
| Internal reference voltage | Using internal DAC with VDD as reference voltage, DAC code = 0 - 255 | 0.024 | | 2.865 | V |
| Offset | Measured at VDD / 2, includes error from internal DAC | | ±5 | | mV |
| Decision time | Step from –50 mV to 50 mV | | 1 | | Clock Cycle |

**Table 19. Continuous Time Comparator**

| Parameter | Test Condition | MIN | TYP | MAX | Unit |
|---|---|---|---|---|---|
| Input voltage range | | 0 | | VDD | V |
| Offset | Measured at VDD / 2, includes error from internal DAC | | ±5 | | mV |
| Decision time | Step from –50 mV to 50 mV | | 0.78 | | µs |
| Current consumption | Internal reference | | 8.6 | | µA |

### 3.1.12. Programmable Current Source

**Table 20. Programmable Current Source**

| Parameter | MIN | TYP | MAX | Unit |
|---|---|---|---|---|
| Current source programmable output range (logarithmic range) | 0.25 | | 20 | µA |
| Resolution | | 0.25 | | µA |

## 3.2. RF Characteristics

The measurement is made with the evaluation board for BDE-MP2652R7 with TA = 25 °C, VDD = 3.3 V, DCDC enabled, GLDO disabled, unless otherwise noted.

### 3.2.1. BLE Performance: Receiver Characteristics

**Table 21. Receive (RX) Characteristics − Bluetooth**

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| **BLE 125Kbps (LE Coded) Receiver Characteristics** | | | |
| Receiver sensitivity | Differential mode, BER = $10^{-3}$ | -102 | dBm |
| Receiver saturation | Differential mode, BER = $10^{-3}$ | > 5 | dBm |
| Co-channel rejection | Wanted signal at –79 dBm, modulated interferer in channel, BER = $10^{-3}$ | -1.5 | dB |

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| Selectivity, ±1 MHz | Wanted signal at –79 dBm, modulated interferer at ±1 MHz, BER = $10^{-3}$ | 8 / 4.5 | dB |
| Selectivity, ±2 MHz | Wanted signal at –79 dBm, modulated interferer at ±2 MHz, BER = $10^{-3}$ | 44 / 37 | dB |
| Selectivity, ±3 MHz | Wanted signal at –79 dBm, modulated interferer at ±3 MHz, BER = $10^{-3}$ | 46 / 44 | dB |
| Selectivity, ±4 MHz | Wanted signal at –79 dBm, modulated interferer at ±4 MHz, BER = $10^{-3}$ | 44 / 46 | dB |
| Selectivity, ±6 MHz | Wanted signal at –79 dBm, modulated interferer at≥±6 MHz, BER = $10^{-3}$ | 48 / 44 | dB |
| Selectivity, ±7 MHz | Wanted signal at –79 dBm, modulated interferer at≥±7 MHz, BER = $10^{-3}$ | 51 / 45 | dB |
| Selectivity, image frequency | Wanted signal at –79 dBm, modulated interferer at image frequency, BER = $10^{-3}$ | 37 | dB |
| 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, BER = $10^{-3}$ | 4.5 / 44 | dB |
| **BLE 500Kbps (LE Coded) Receiver Characteristics** | | | |
| Receiver sensitivity | Differential mode, BER = $10^{-3}$ | -96.5 | dBm |
| Receiver saturation | Differential mode, BER = $10^{-3}$ | > 5 | dBm |
| Co-channel rejection | Wanted signal at –72 dBm, modulated interferer in channel, BER = $10^{-3}$ | -3.5 | dB |
| Selectivity, ±1 MHz | Wanted signal at –72 dBm, modulated interferer at ±1 MHz, BER = $10^{-3}$ | 8 / 4 | dB |
| Selectivity, ±2 MHz | Wanted signal at –72 dBm, modulated interferer at ±2 MHz, BER = $10^{-3}$ | 43 / 35 | dB |
| Selectivity, ±3 MHz | Wanted signal at –72 dBm, modulated interferer at ±3 MHz, BER = $10^{-3}$ | 46 / 46 | dB |
| Selectivity, ±4 MHz | Wanted signal at –72 dBm, modulated interferer at ±4 MHz, BER = $10^{-3}$ | 45 / 47 | dB |
| Selectivity, ±6 MHz | Wanted signal at –72 dBm, modulated interferer at≥±6MHz, BER = $10^{-3}$ | 46 / 45 | dB |
| Selectivity, ±7 MHz | Wanted signal at –72 dBm, modulated interferer at≥±6MHz, BER = $10^{-3}$ | 49 / 45 | dB |
| Selectivity, image frequency | Wanted signal at –72 dBm, modulated interferer at image frequency, BER = $10^{-3}$ | 35 | dB |
| 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, BER = $10^{-3}$ | 4 / 46 | dB |
| **BLE 1Mbps (LE 1M) Receiver Characteristics** | | | |
| Receiver sensitivity | Differential mode, BER = $10^{-3}$ | -94 | dBm |
| Receiver saturation | Differential mode, BER = $10^{-3}$ | > 5 | dBm |
| Co-channel rejection | Wanted signal at –67 dBm, modulated interferer in channel, BER = $10^{-3}$ | -6 | dB |
| Selectivity, ±1 MHz | Wanted signal at –67 dBm, modulated interferer at ±1 MHz, BER = $10^{-3}$ | 7 / 4 | dB |
| Selectivity, ±2 MHz | Wanted signal at –67 dBm, modulated interferer at ±2 MHz, BER = $10^{-3}$ | 39 /33 | dB |
| Selectivity, ±3 MHz | Wanted signal at –67 dBm, modulated interferer at ±3 MHz, BER = $10^{-3}$ | 36 / 40 | dB |
| Selectivity, ±4 MHz | Wanted signal at –67 dBm, modulated interferer at ±4 MHz, BER = $10^{-3}$ | 36 / 45 | dB |
| Selectivity, ±5 MHz or more | Wanted signal at–67 dBm, modulated interferer at≥±5 MHz, BER = $10^{-3}$ | 40 | dB |
| Selectivity, image frequency | Wanted signal at –67 dBm, modulated interferer at image frequency, BER =$10^{-3}$ | 33 | dB |
| 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, BER =$10^{-3}$ | 4 / 41 | dB |
| Out-of-band blocking | 30 MHz to 2000 MHz | -10 | dBm |

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| Out-of-band blocking | 2003 MHz to 2399 MHz | -18 | dBm |
| Out-of-band blocking | 2484 MHz to 2997 MHz | -12 | dBm |
| Out-of-band blocking | 3000 MHz to 12.75 GHz (excluding VCO frequency) | -2 | dBm |
| Intermodulation | Wanted signal at 2402 MHz, –64 dBm. Two interferers at 2405 and 2408 MHz respectively, at the given power level | -42 | dBm |
| **BLE 2Mbps (LE 2M) Receiver Characteristics** | | | |
| Receiver sensitivity | Differential mode, BER = $10^{-3}$ | -89 | dBm |
| Receiver saturation | Differential mode, BER = $10^{-3}$ | > 5 | dBm |
| Co-channel rejection | Wanted signal at –67 dBm, modulated interferer in channel, BER = $10^{-3}$ | -7 | dB |
| Selectivity, ±2 MHz | Wanted signal at –67 dBm, modulated interferer at ±2 MHz, BER = $10^{-3}$ | 8 / 4 | dB |
| Selectivity, ±4 MHz | Wanted signal at –67 dBm, modulated interferer at ±4 MHz, BER = $10^{-3}$ | 36 / 34 | dB |
| Selectivity, ±6 MHz | Wanted signal at –67 dBm, modulated interferer at ±6 MHz, BER = $10^{-3}$ | 37 / 36 | dB |
| Selectivity, image frequency | Wanted signal at –67 dBm, modulated interferer at image frequency, BER = $10^{-3}$ | 4 | dB |
| Selectivity, image frequency ±2 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, BER = $10^{-3}$ | -7 / 36 | dB |
| Out-of-band blocking | 30 MHz to 2000 MHz | -16 | dBm |
| Out-of-band blocking | 2003 MHz to 2399 MHz | -21 | dBm |
| Out-of-band blocking | 2484 MHz to 2997 MHz | -15 | dBm |
| Out-of-band blocking | 3000 MHz to 12.75 GHz (excluding VCO frequency) | -12 | dBm |
| Intermodulation | Wanted signal at 2402 MHz, –64 dBm. Two interferers at 2405 and 2408 MHz respectively, at the given power level | -38 | dBm |

## 3.2.2. BLE Performance: Transmitter Characteristics

**Table 22. Transmit (TX) Characteristics – Bluetooth**

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| Output power | Conducted output from ANT pin of the module, 5dBm setting | 2.6 | dBm |
| | Conducted output from ANT pin of the module, 4dBm setting | 1.5 | |
| | Conducted output from ANT pin of the module, 3dBm setting | 0.6 | |
| | Conducted output from ANT pin of the module, 2dBm setting | -0.3 | |
| | Conducted output from ANT pin of the module, 1dBm setting | -1.0 | |
| | Conducted output from ANT pin of the module, 0dBm setting | -1.9 | |
| Output power programmable range | Conducted output from ANT pin of the module | 26 | dB |

## 3.2.3. Zigbee Performance: Receiver Characteristics

**Table 23. Receiver (RX) Characteristics – Zigbee Performance**

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| **General Parameters** | | | |

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| Receiver sensitivity | Coherent mode PER = 1% | -98 | dBm |
| Receiver saturation | PER = 1% | > 5 | dBm |
| 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 | dB |
| 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 | dB |
| 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 | dB |
| 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 | dB |
| 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 | dB |
| 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 | dB |
| Blocking and desensitization, –5 MHz from lower band edge | Wanted signal at –97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1% | 59 | dB |
| Blocking and desensitization, –10 MHz from lower band edge | Wanted signal at –97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1% | 59 | dB |
| Blocking and desensitization, –20 MHz from lower band edge | Wanted signal at –97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1% | 63 | dB |
| Blocking and desensitization, –50 MHz from lower band edge | Wanted signal at –97 dBm (3 dB above the sensitivity level), CW jammer, PER = 1% | 65 | dB |
| Spurious emissions, 30 MHz to 1000 MHz | Measurement in a 50 Ω single-ended load | –66 | dBm |
| Spurious emissions, 1 GHz to 12.75 GHz | Measurement in a 50 Ω single-ended load | –53 | dBm |
| Frequency error tolerance | Difference between the incoming carrier frequency and the internally generated carrier frequency | > 350 | ppm |
| Symbol rate error tolerance | Difference between incoming symbol rate and the internally generated symbol rate | > 1000 | ppm |
| RSSI dynamic range | | 95 | dB |
| RSSI accuracy | | ±4 | dB |

## 3.2.4. Zigbee Performance: Transmitter Characteristics

**Table 24. Transmit (TX) Characteristics – Zigbee Performance**

| Parameter | Test Condition | TYP | Unit |
|---|---|---|---|
| Max output power | Differential mode, delivered to a single-ended 50 Ω load through a balun | 3 | dBm |
| Output power programmable range | Conducted output from ANT pin of the module | 26 | dB |

## 3.3. Antenna Characteristics

The module series has different variants for antenna selection. BDE-MP2652R7A variant has integrated a 2.4GHz PCB trace antenna which makes it a good choice for easy integration. The antenna area is 15 mm x 3.8 mm, refer to Figure 7. 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 below figure.

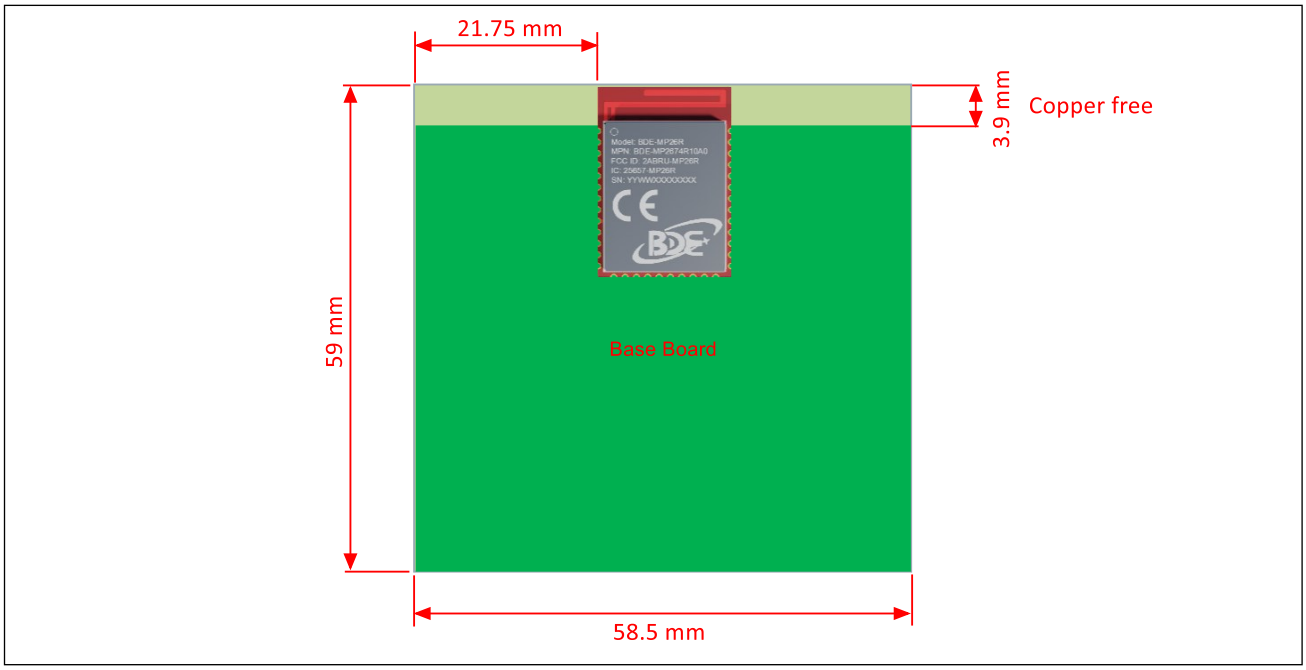



**Figure 7. Antenna Placement and Reference Board**

### 3.3.1. Antenna Gain

**Table 25. Gain of Integrated PCB Trace Antenna**

| Frequency (MHz) | Gain (dBi) |
|---|---|
| 2400 | -1.75 |
| 2410 | -1.66 |
| 2420 | -1.50 |
| 2430 | -1.32 |
| 2440 | -1.10 |
| 2450 | -0.88 |
| 2460 | -0.84 |
| 2470 | -1.13 |
| 2480 | -1.51 |

## 3.3.2. Antenna Radiation Pattern

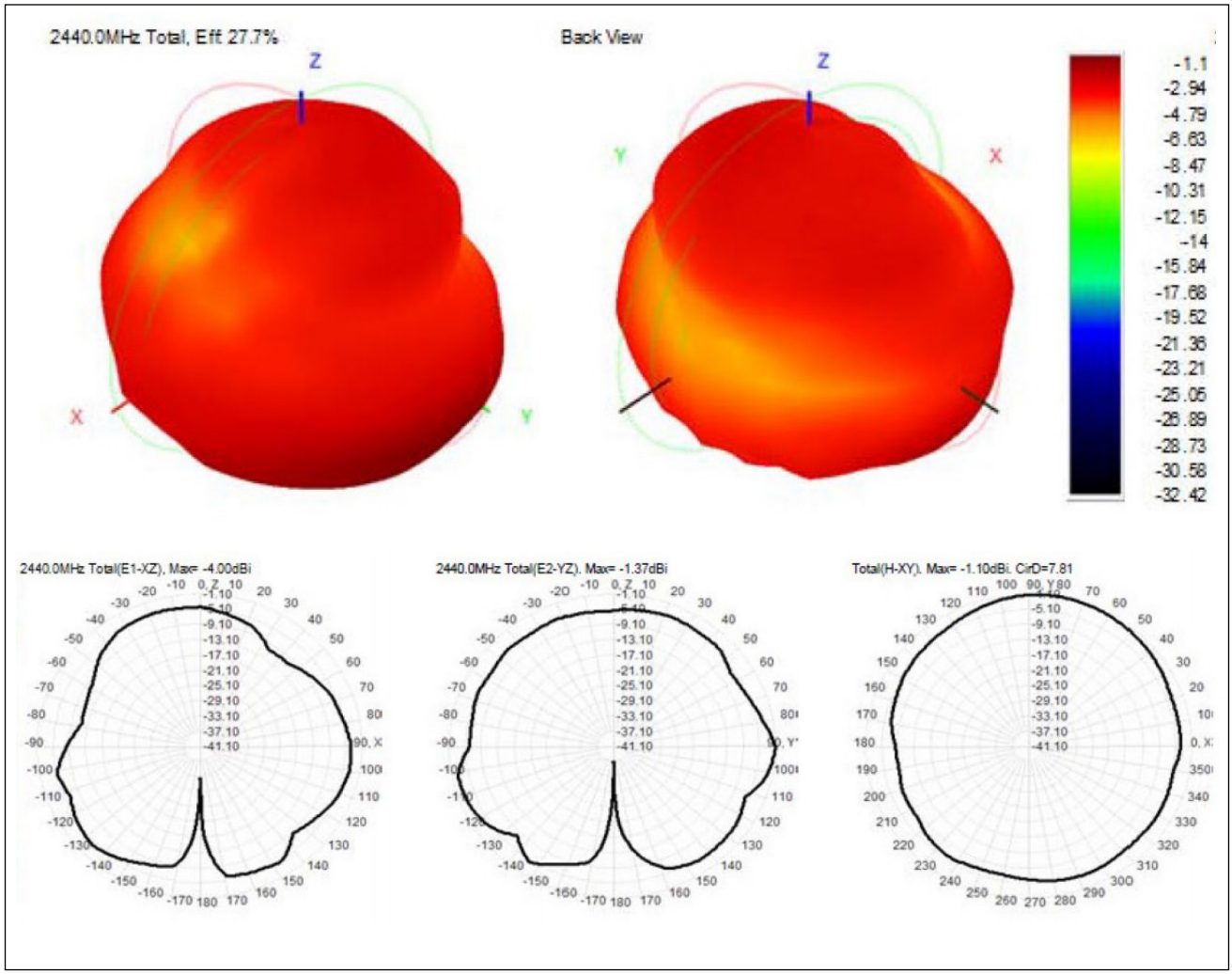



**Figure 8. Radiation Pattern of the Integrated PCB Trace Antenna at 2440MHz**

## 3.3.3. Other Certified Antennas

For other certified antennas, please refer to Table 30.

# 4. Mechanical Specifications

## 4.1. Dimensions

The following pages include mechanical, footprint drawings, and marking information.

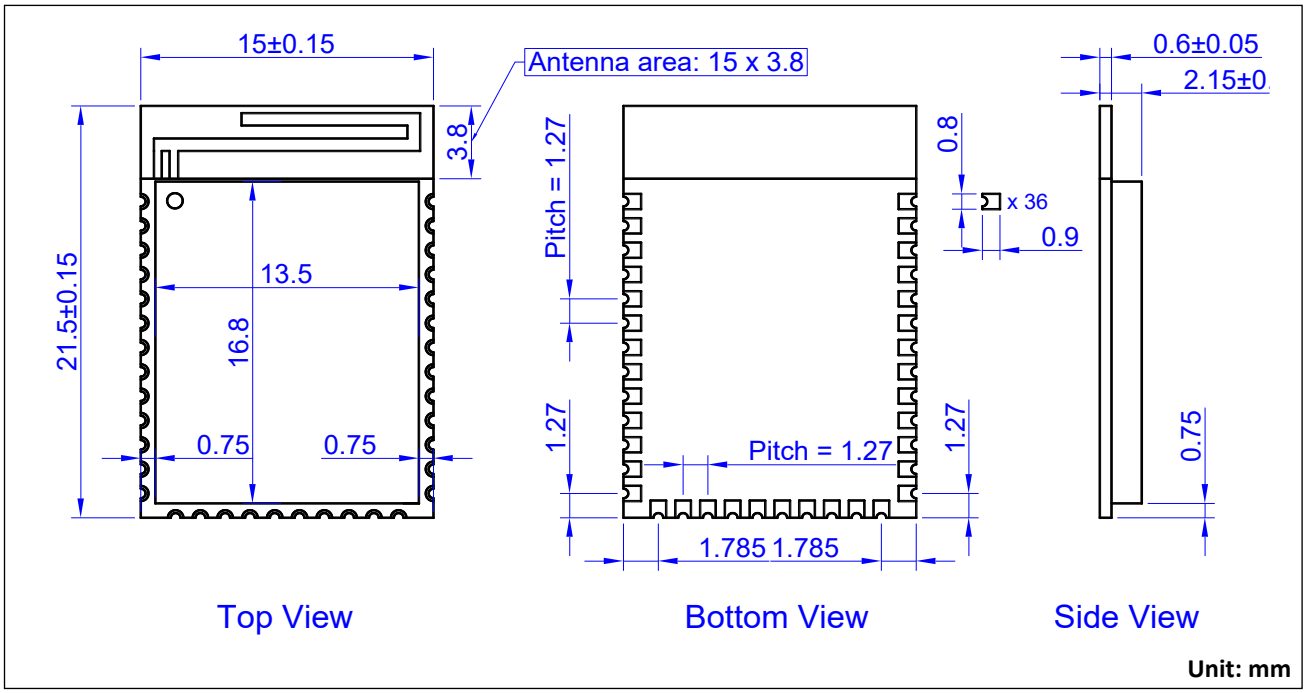



**Figure 9. Mechanical Drawing of BDE-MP2652R7A**

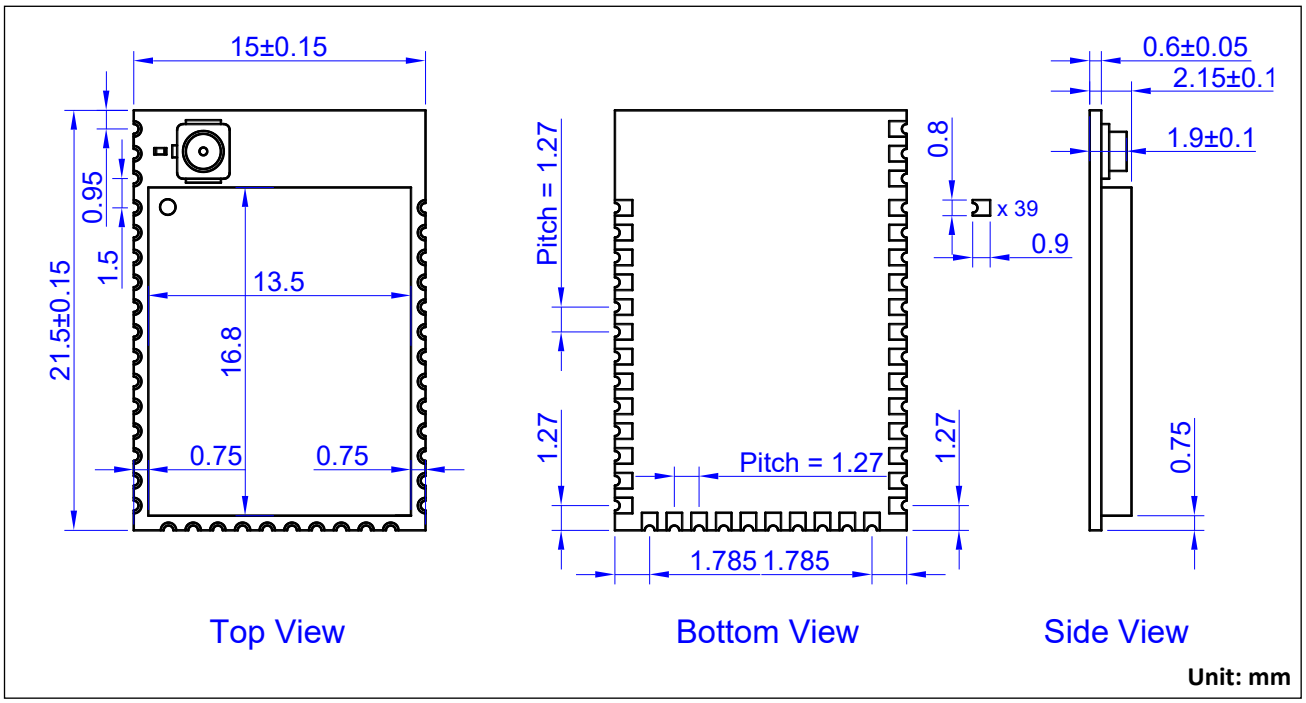
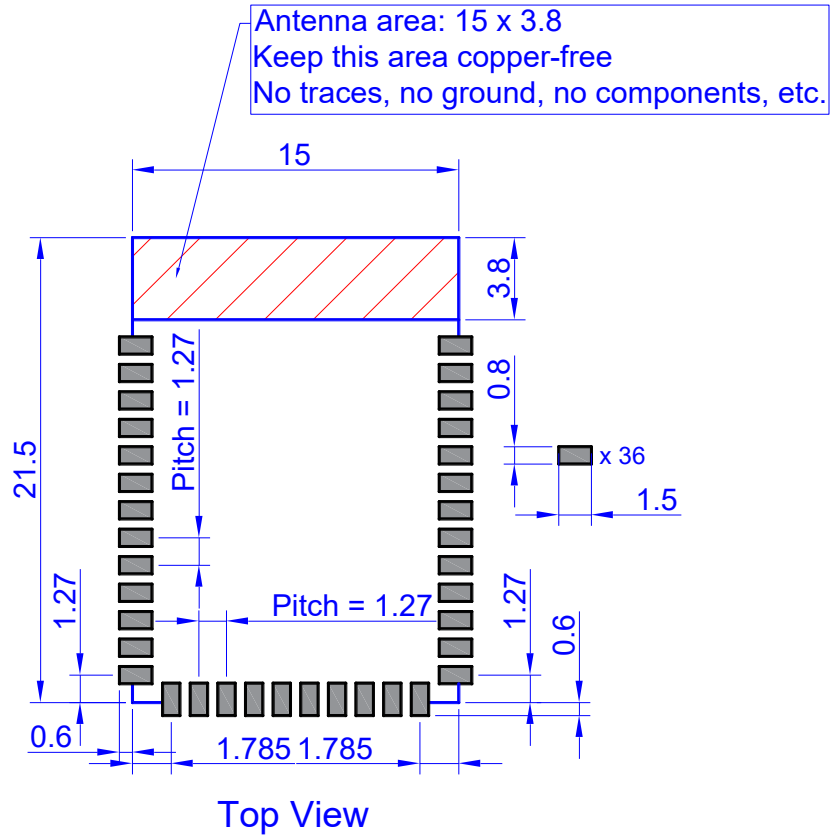



**Figure 10. Mechanical Drawing of BDE-MP2652R7U and BDE-MP2652R7N**

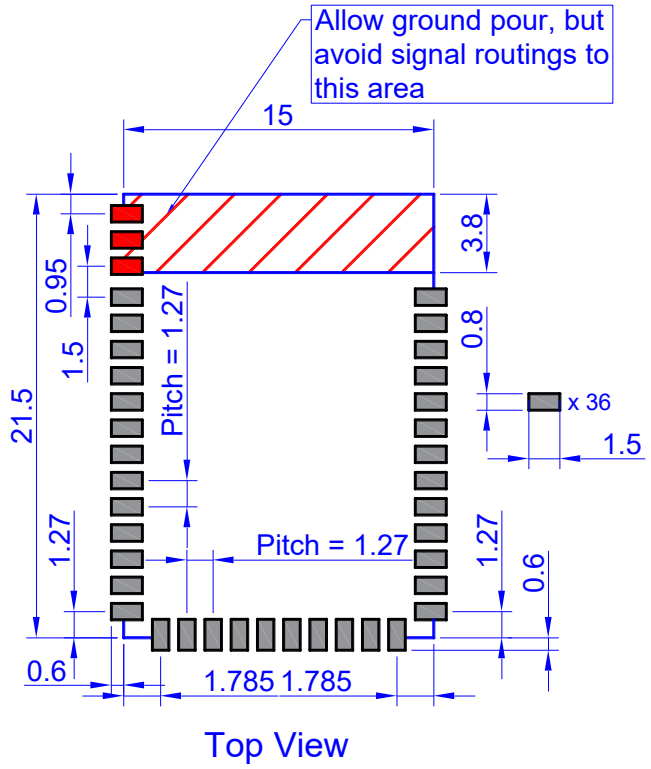
## 4.2. PCB Footprint




(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 11. Recommended Module Footprint of BDE-MP2652R7A**




(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;
(4) Three pads with red fill are only for N variants, they can be unused for U variants.

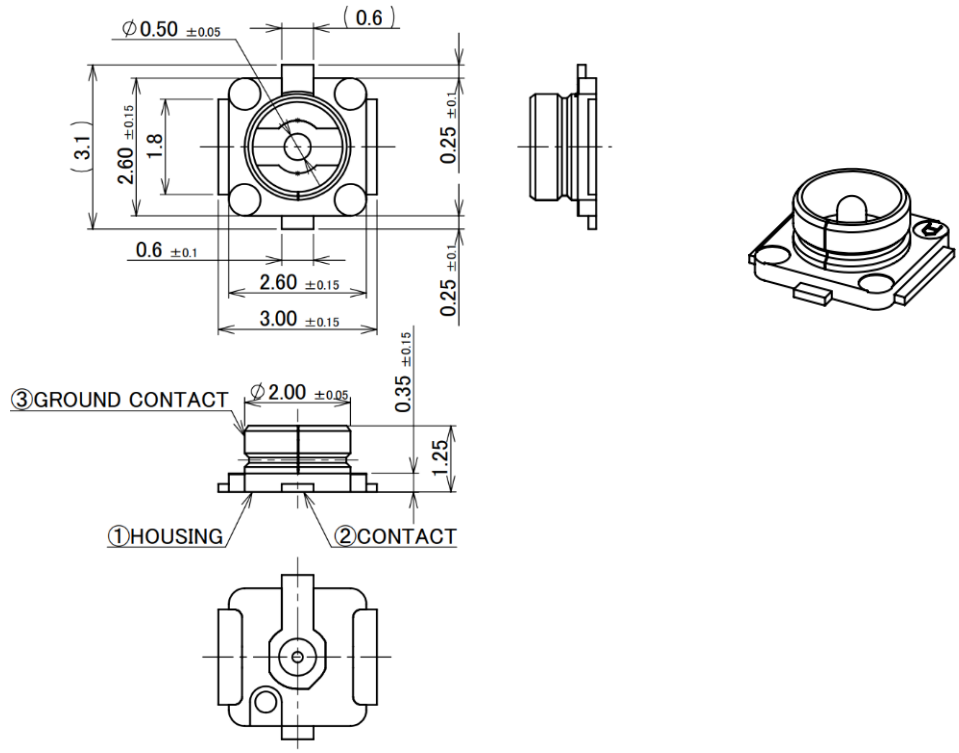
**Unit: mm**

**Figure 12. Recommended Module Footprint of BDE-MP2652R7U and BDE-MP2652R7N**

## 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.



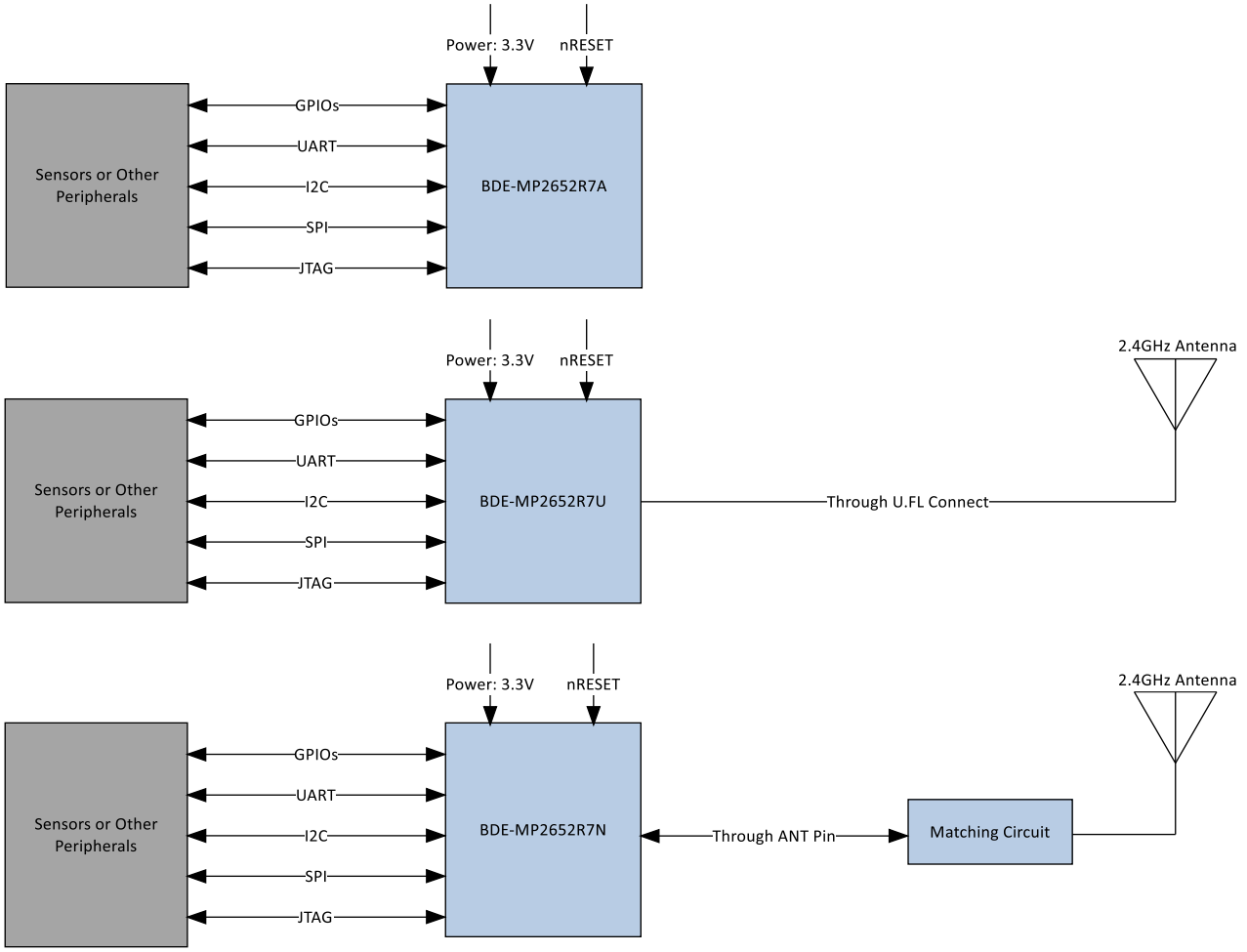

| | | |
|---|---|---|
| RATING VOLTAGE | 60 V AC (R.M.S) | |
| RATING FREQUENCY | DC～9GHz | |
| OPERATING TEMPERATURE | 233～363K (−40℃～+90℃) | |
| VSWR | RECEPTACLE: 1.3 MAX. AT 0.1～3 GHz, 1.4 MAX. AT 3～6 GHz, 1.8 MAX. AT 6～9 GHz | |
| MAIN CONTACT RESISTANCE | INITIAL: 20 mohm MAX. / AFTER TEST: ⊿R 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.<br>AFTER TEST: 3 N MIN. | INITIAL: 4 N MIN.<br>AFTER TEST: 2 N MIN. |

**Figure 13. U.FL Connector Drawing and Specification**

# 5. Integration Guidelines

## 5.1. SoC Mode

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




(1) The module has already been implemented with required decoupling capacitors; 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 variant is chosen, please do not utilize these four GPIOs in your design, because 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 the ANT pin version is chosen.

**Figure 14. High-Level System Block Diagram**

## 5.2. WNP Mode

The module can also function as the WNP (Wireless Network Processor), in this case, an external MCU will be needed to run the application and the protocol stack, and the interface between the external MCU and the module can be UART/SPI.

## 5.3. 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.

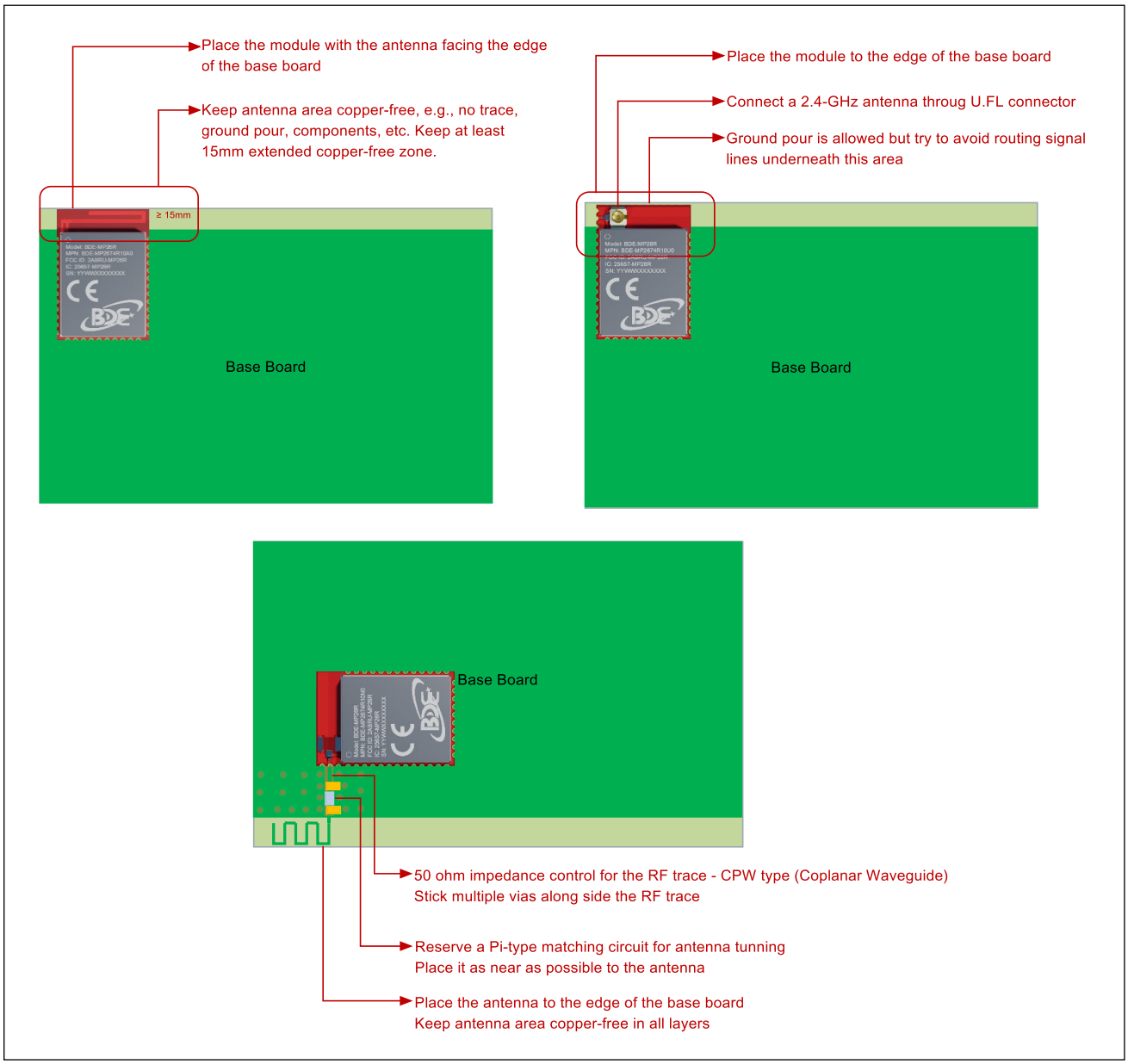



**Figure 15. Module Placement Recommendations**

## 5.4. Other Design Considerations

**Table 26. 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. |
| 19 | If possible, shield VDD traces with ground above, below, and beside the traces. |

## 5.1. Development Resources

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

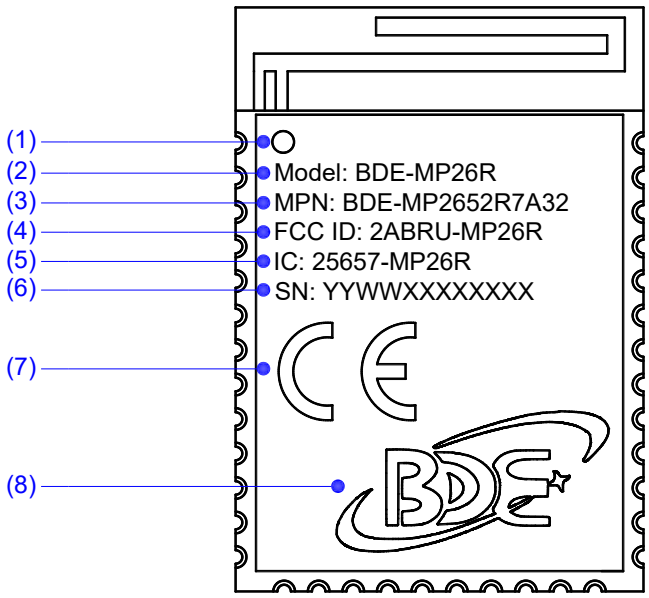
# 6. Handling Instructions

The module is the surface mount module with LCC 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 and labeling. And also, the instructions on how to handle the module in terms of storage, assembly and so on.

## 6.1. Module Marking

Below figure shows the metal shield marking for the BDE-MP2652R7 module series.

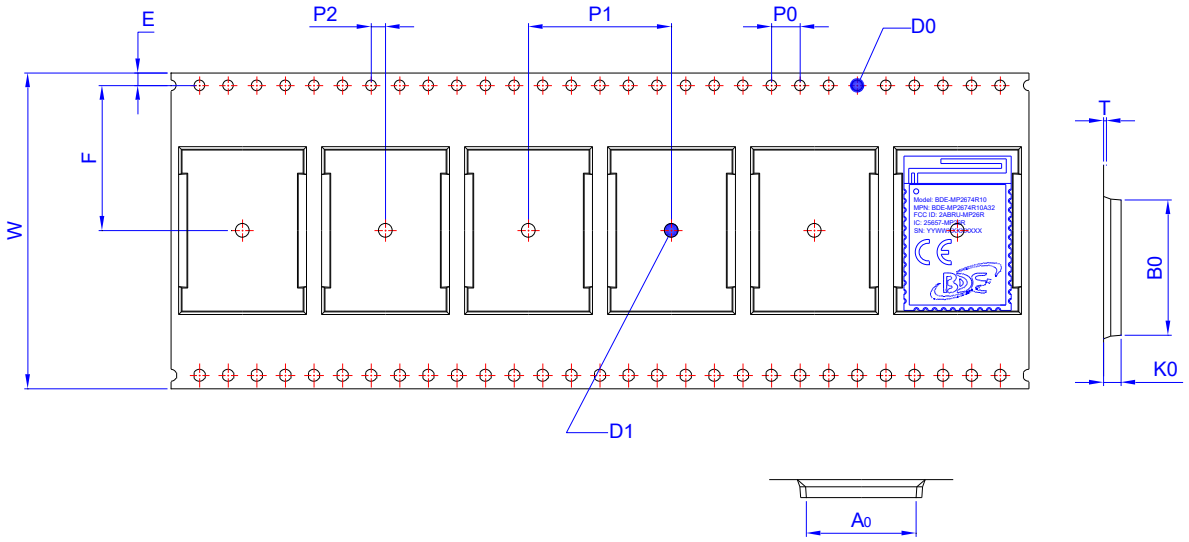



(1) Pin one index;
(2) Model series;
(3) Orderable manufacturer part number;
(4) FCC ID;
(5) IC ID;
(6) Serial number;
(7) CE marking;
(8) BDE logo

**Figure 16. Module Marking**

## 6.2. Packaging Information

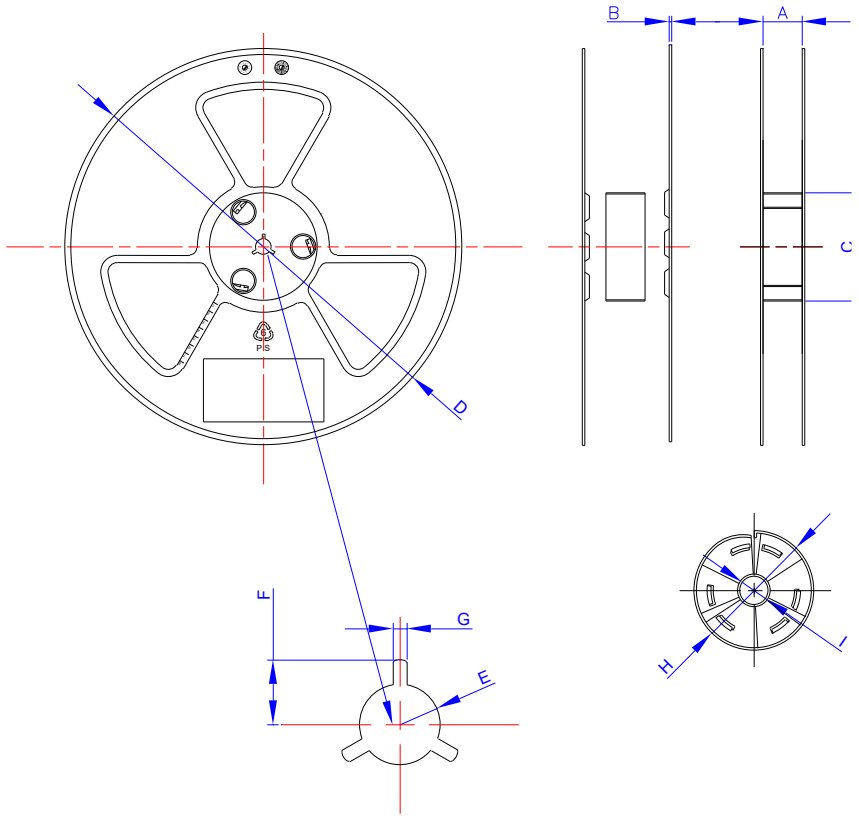
### 6.2.1. Tape and Reel Package Information




| W | $A_0$ | $B_0$ | $K_0$ | $P_1$ | F | E | $D_0$ | $D_1$ | $P_0$ | $P_2$ | T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $44.0^{+0.30}_{-0.30}$ | $15.35^{+0.10}_{-0.10}$ | $22.45^{+0.10}_{-0.10}$ | $2.50^{+0.10}_{-0.10}$ | $22.00^{+0.10}_{-0.10}$ | $14.20^{+0.10}_{-0.10}$ | $1.75^{+0.10}_{-0.10}$ | $1.50^{+0.10}_{-0.00}$ | $2.00^{+0.10}_{-0.00}$ | $4.00^{+0.10}_{-0.10}$ | $2.00^{+0.10}_{-0.10}$ | $0.35^{+0.05}_{-0.05}$ |

(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: 1000+30pcs (15 voids each to the head and tail);
(8) RoHS compliance;
(9) Anti-static coefficient of 106-11Ω.

**Figure 17. Carrier Tape Drawing for BDE-MP2652R7 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 18. 13-INnch Reel Drawing**

## 6.2.2. Carton Information and Labeling

### 6.2.2.1. Carton Information


**Figure 19. 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.

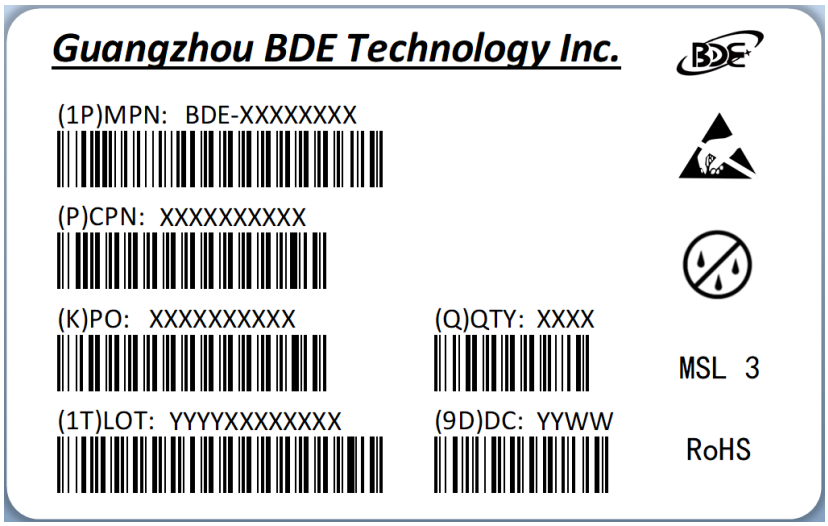



**Figure 20. Reel Label Information**

### 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.

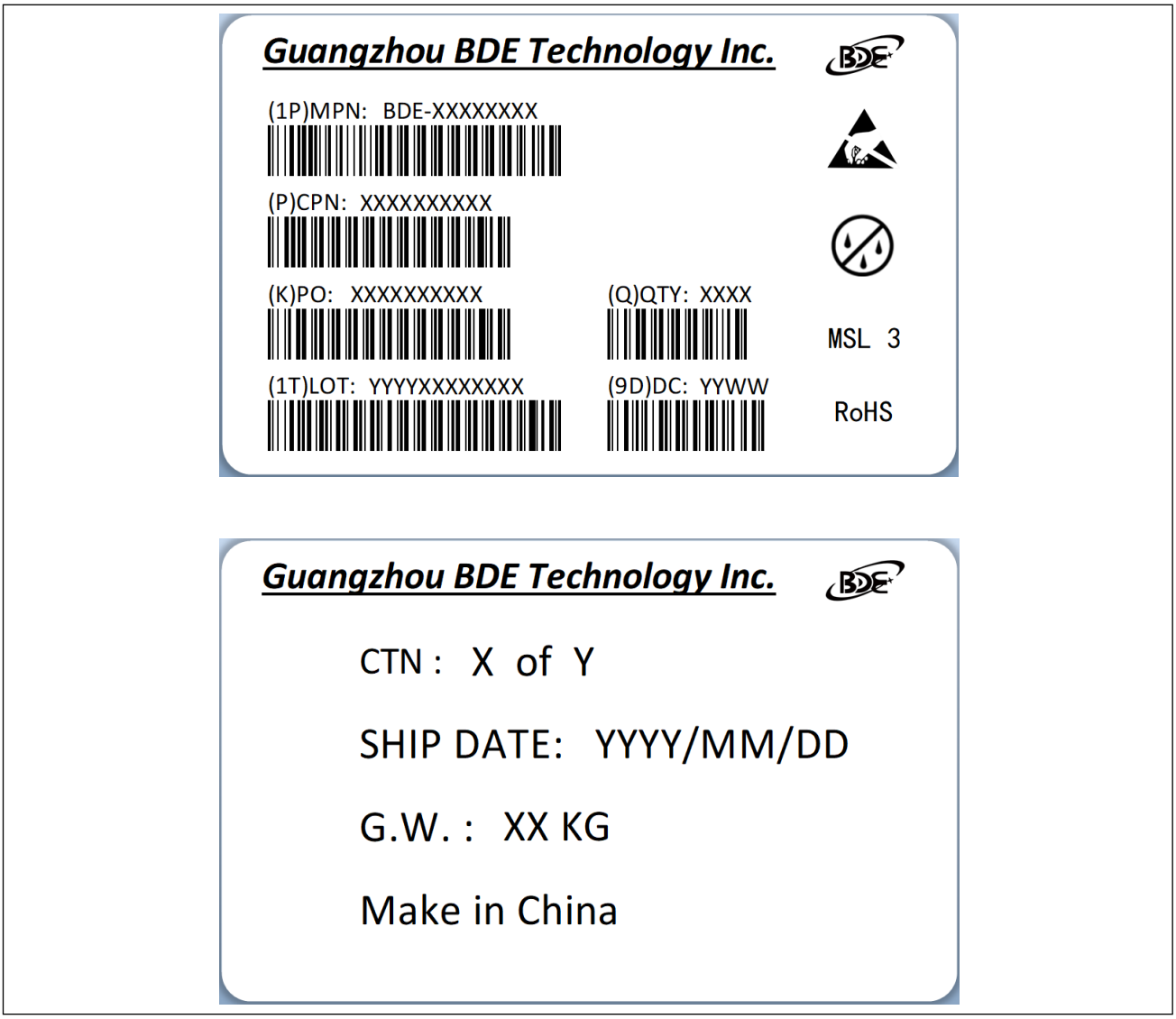


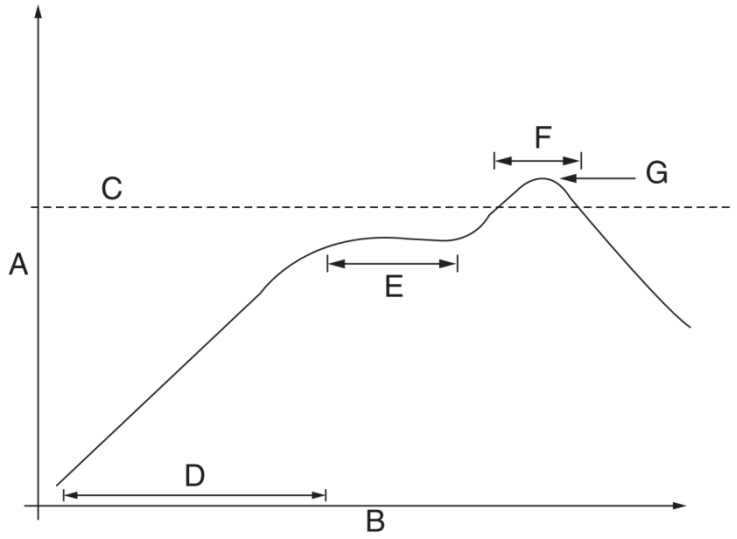

**Figure 21. Carton Label Information**

## 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:
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;
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;
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 22. Thermal Profile Schematic**

**Table 27. 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 recommend that the modules do not go through the reflow process more than one time.

## 6.3.3. Other Consideration

(1) Ultrasonic cleaning process is discouraged for the modules as the process might damage the module permanently, especially for the crystal oscillator in the module;
(2) Conformal coating is not allowed to this module. It will impact the reliability of the module once the coating flooded into the shield. Avoid the module while applying the conformal coating to the host board.

# 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 with below information in the table.

**Table 28. Bluetooth Qualification Information**

| DID/DN | QDID and Included DN |
|---|---|
| D058375 | 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 29. Certification Information**

| Regulatory Body / Region | Standard | ID | MPN |
|---|---|---|---|
| FCC (USA) | FCC CFR 47 PART 15 C (15.247) | 2ABUR-MP26R | BDE-MP2652R7A0 |
| IC/ISED (Canada) | RSS-247 Issue 3<br>RSS-Gen Issue 5<br>ANSI C63.10: 2013 | 25657-MP26R | BDE-MP2652R7A32<br>BDE-MP2652R7U0<br>BDE-MP2652R7U32 |
| ETSI/CE-RED (Europe) | ETSI EN 301 489-1 V2.2.3 (2019-11)<br>ETSI EN 301 489-17 V3.3.1 (2024-09)<br>EN 55032:2015/A11:2020<br>EN 55035:2017/A11:2020<br>ETSI EN 300 328 V2.2.2 (2019-07)<br>EN 62479:2010<br>EN 50663:2017<br>EN IEC 62368-1:2020+A11:2020 | NA | BDE-MP2652R7N0<br>BDE-MP2652R7N32<br>BDE-MP2652R7A0-IN<br>BDE-MP2652R7A32-IN<br>BDE-MP2652R7U0-IN<br>BDE-MP2652R7U32-IN<br>BDE-MP2652R7N0-IN<br>BDE-MP2652R7N32-IN |

### 7.2.1. Certified Antennas

The module series has been tested and certified with three antennas, where BDE-MP2652R7A variants utilize an integrated PCB trace antenna, BDE-MP2652R7U variants utilize an external 2.4GHz whip antenna through U.FL connector, BDE-MP2652R7N utilize an external 2.4GHz whip antenna utilized in the evluation board through the dedicated ANT pin of the module.

The characteristic of the antennas is listed in below. The PCB trace antenna is only present in the BDE-MP2652R7A.

**Table 30. Certified Antenna List**

| Antenna Type | Manufacturer | MPN | Frequency Range (MHz) | Peak Gain (dBi) | Note |
|---|---|---|---|---|---|
| PCB trace antenna | BDE | BDE-ANT-MB26RA | 2400 – 2500 | -0.84 | Internal |
| Whip antenna | BDE | BDE-W25-19513-HRP | 2400 – 2500 | 3.0 | 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 30

**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-MP26R"

**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 BDE-MP2652R7 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-MP26R".

**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-MP26R".

**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-MP26R] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed in Table 30, 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-MP26R] 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.

### 7.2.4. ETSI/CE Compliance

The BDE-MP2652R7 module is certified with required EU radio and EMC directives. See

Table 29 for detailed standards the module complies with, or refer to UK Declaration of Conformity.

# 8. Ordering Information

**Table 31. Ordering Information**

| Orderable Part Number | Description | Size (mm) | Shipping Form | MOQ |
|---|---|---|---|---|
| BDE-MP2652R7A32 | BDE 2.4GHz multiprotocol wireless module, with PCB trace antenna, with on-board 32Mbit SPI flash, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7U32 | BDE 2.4GHz multiprotocol wireless module, with U.FL connector, with on-board 32Mbit SPI flash, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7N32 | BDE 2.4GHz multiprotocol wireless module, with ANT pin, with on-board 32Mbit SPI flash, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7A0 | BDE 2.4GHz multiprotocol wireless module, with PCB trace antenna, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7U0 | BDE 2.4GHz multiprotocol wireless module, with U.FL connector, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7N0 | BDE 2.4GHz multiprotocol wireless module, with ANT pin, -40℃ to +85℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7A32-IN | BDE 2.4GHz multiprotocol wireless module, with PCB trace antenna, with on-board 32Mbit SPI Flash, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7U32-IN | BDE 2.4GHz multiprotocol wireless module, with U.FL connector, with on-board 32Mbit SPI Flash, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7N32-IN | BDE 2.4GHz multiprotocol wireless module, with ANT pin, with on-board 32Mbit SPI Flash, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7A0-IN | BDE 2.4GHz multiprotocol wireless module, with PCB trace antenna, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7U0-IN | BDE 2.4GHz multiprotocol wireless module, with U.FL connector, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |
| BDE-MP2652R7N0-IN | BDE 2.4GHz multiprotocol wireless module, with ANT pin, -40℃ to +105℃ | 21.5 × 15 × 2.15 | Tape & Reel | 1K |

# 9. Revision History

**Table 32. Revision History**

| Revision | Date | Description |
|---|---|---|
| V0.1 | 12-Octorber-2024 | Preliminary, draft |
| V1.0 | 21-January-2025 | Production release |

# Important Notice and Disclaimer

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