Application Report
SWRA649–February 2019

Getting started with CC2652RB for Crystal-less BAW operation

ABSTRACT

The SimpleLink™ CC2652RB device has a high frequency internal oscillator allowing you to design any 2.4 GHz wireless-stack based product for Zigbee®, Thread, *Bluetooth*® Low Energy or 802.15.4 without the need for external crystals. This simplifies design, testing and integration as wells as reducing the total required footprint.

This document helps you get started using the SimpleLink crystal-less BAW CC2652RB multiprotocol 2.4-GHz wireless MCU. If you are currently using a SimpleLink product such as the CC2642R or CC2652R in your design, leveraging the CC2652RB device and porting your application code to this device is explained in the application report.

Contents

Trademarks

1 Differences Between CC26x2R and CC2652RB

SimpleLink CC2652RB is a multi-standard ultra-low power wireless MCU for 2.4 GHz operations that comes with the same features as CC2652R, but additionally includes an internal high precision (HP) bulk acoustic wave (BAW) resonator that enables wireless communication and operation without the need for any external crystals. The internal BAW resonator is the source for the high frequency (HF) clock and eliminates the need for a 48 MHz crystal, which is required for the other CC13x2/CC26x2 device family members. For applications that require a low frequency (LF) clock source, a total crystal-less design can be obtained by using either the internal LF RC oscillator, or deriving the LF clock from the HF clock.

CC2652RB shares the same pin-out and package (RGZ) as CC2652R and can replace CC2652R in existing designs without any required changes to the PCB or the bill of materials (BOM). The pinout is also compatible with CC2642R and the previous generation of CC26xx wireless MCUs; CC2640, CC2650 and CC2640R2F.

The integrated high precision resonator is being compensated in the Cortex®-M0 radio core for temperature and voltage variations to ensure ±40 ppm accuracy. Using the high precision resonator as a clock source marginally increases the current consumption compared to using an external crystal.

2 Hardware Design

When designing a new PCB for CC2652RB, it is highly recommended to follow the reference design: LP-CC2652RB. For more detailed information about PCB design considerations, see *CC13x2, CC26x2 SimpleLink™ wireless MCU technical reference manual*.

2.1 Hardware Migration From the CC26xx Device Family

To enable crystal-less operation of an existing design based on CC26x2R, no changes are required, but it is recommended to remove the 48 MHz crystal from the BOM, or mark it as “DNP” as this component is no longer needed. This can also be done for the 32.768 kHz crystal. If a new PCB spin is planned one can also leverage any potential footprint savings.

For designs based on the CC26x0 family of products, see *Hardware Migration From CC26x0 to CC26x2R*.

While the CC2652RB is very similar to CC26xx from an RF perspective, there are several updates to the device (for example clock frequencies), which typically triggers the need for new regulatory compliance certification.

3 Low Frequency Clock Source

Most low power applications need a LF clock to keep track of time when entering Standby mode to save power. For synchronous RF stacks such as BLE, an LF clock is required to synchronize RF transmission and there are also requirements for the clock accuracy to be compliant with specific stacks. For example, BLE requires a real time clock (RTC) accuracy of ±500 ppm. CC2652RB has multiple options for the LF clock with different benefits and drawbacks as listed in Table 1.

Table 1. LF Clock Sources

LF Clock Source	Cost	Power	Accuracy
Internal LF RC oscillator	Low	Low	±500 ppm (1)
Derived from the HF clock	Low	High	±40 ppm
External LF crystal	Med	Low	Crystal dependent

(1) Only when running the supported BLE roles and using the recommended calibration as described in *Running Bluetooth® Low Energy on CC2640 without 32 kHz crystal*.

3.1 Internal LF RC oscillator

The internal LF RC oscillator enables a crystal-less design with no added cost. This alternative is only available for certain Bluetooth Low Energy roles. For more information, see *Running Bluetooth® low energy on CC2640 Without 32 kHz Crystal*.

3.2 Derive LF Clock From the HF Clock

Another option for a crystal-less design is to use the BAW resonator with a divider as LF clock source. This will give a clock with ±40 ppm accuracy. The only downside to this solution is that the high precision resonator must be active at all time, which will increase the average current consumption.

3.3 External LF Crystal

To achieve low power consumption as well as high RTC accuracy, an external crystal should be used. On the reference design, LP-CC2652RB, a footprint for a LF crystal is available and a 32.768 kHz crystal can be mounted to evaluate this type of configuration.

3.4 External LF Clock Source

A fourth option is to connect an external LF clock source to one of CC2652RB pins and use this signal to increment the RTC.

4 Software Changes

The CC2652RB device is supported by SimpleLink CC2652RB BLE SDK 3.10 and SimpleLink CC13x2 and CC26x2 SDK 3.20 or newer. If you already have a CC26x2R project, you can follow the SDK migration guide in the SDK documentation. In the CC2652RB project files, the BAW resonator is enabled and selected as HF clock source. By default, the BAW resonator will also be the source for the LF clock. This can be changed by using the RCOSC build configuration that uses the LF RC oscillator as LF clock source. If you want to use an external LF crystal oscillator, or an external LF clock you have to do the following changes:

1. Make sure to use the non RCOSC build configuration where USE_RCOSC is not defined.
2. Make sure that the HF oscillator is disabled when entering standby mode. This requires a change in the RF Driver settings in CC2652RB_LAUNCHXL.c which is linked to from the board.c-file:

```
const RFCC26XX_HWAttrsV2 RFCC26XX_hwAttrs = {
    .hwiPriority        = ~0,       /* Lowest HWI priority */
    .swiPriority        = 0,        /* Lowest SWI priority */
#ifdef USE_RCOSC
    .xoscHfAlwaysNeeded = false,    /* Keep XOSC dependency while in standby */
#else
    .xoscHfAlwaysNeeded = false,    /* <-- Set to false */
#endif
    .globalCallback     = NULL,     /* No board specific callback */
    .globalEventMask    = 0         /* No events subscribed to */
};
```

3. Add this line to the project's CCFG-file to use the LF crystal oscillator: (1)

```
#define SET_CCFG_MODE_CONF_SCLK_LF_OPTION 0x2 // LF XOSC
```

4. Or to use an external LF clock source, add the following lines:

```
#define SET_CCFG_MODE_CONF_SCLK_LF_OPTION 0x1 // External LF clock
#define SET_CCFG_EXT_LF_CLK_DIO 0x01 // DIO number if useing external LF clock
```

(1) Note that you'll have to solder on an external 32.768 kHz crystal oscillator and load capacitors to use this option.

5 References

- CC2652RB Data Sheet
- CC2652RB LaunchPad
- Texas Instruments: *CC13x2, CC26x2 SimpleLink™ wireless MCU technical reference manual*
- Texas Instruments: *Running Bluetooth® low energy on CC2640 Without 32 kHz Crystal*
- Texas Instruments: *Hardware migration from CC26x0 to CC26x2R*
- Texas Instruments: *CC13xx/CC26xx hardware configuration and PCB design considerations*
- Texas Instruments: *SimpleLink crystal-less BAW CC2652RB multiprotocol 2.4GHz wireless MCU devopment kit*

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