User's Guide

SimpleLink CC131x and CC135x Family Hardware Migration Guide

ABSTRACT

This migration guide describes the hardware change requirements when moving between the CC131x and CC135x family of SimpleLink™ wireless MCUs. This document gives a general overview of the CC131x and CC135x device family, outlines the different device features, and includes a description of the device naming system. This guide discusses hardware specifics and device-to-device hardware migration considerations in detail. Finally, the document includes links to recommended resources and device data sheets.

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Trademarks

1 Introduction

This document details hardware change considerations when migrating between different devices within the CC131x and CC135x family of SimpleLink™ wireless MCUs. The changes are because of different physical properties of the devices, such as package sizes, and because of updated reference designs that utilize improved technologies like smaller passive component package sizes. The hardware changes can be optional or mandatory depending on the specific device-to-device migration. This document provides advice on when a change is required or recommended.

Section 2 provides a reference guide for the differences between the CC131x and CC135x family of devices and highlights other useful TI documentation when appropriate. Section 3 details the necessary changes for migrating between different members of the device family, with references to Section 2 for more specific information. Section 5 provides links to recommended TI source documentation, additional TI support resources, and the data sheets for the CC131x and CC135x devices.

2 CC131x and CC135x Device Family Comparison

2.1 Device Naming

The part number indicates the following features of a given device:

- Frequency bands of operation
- Device generation
- Major features
- Radio output power
- Memory size

Table 2-1. CC131x and CC135x Device Naming Convention

Connectivity (1)	Frequency Band	Generation	Protocols	Major Features	Radio Output Power	Memory Size
CC	A	B	C	D	E	F

(1) Details in this table come from the device data sheets. Reference the device data sheets for additional details in Section 5.2.

Note

This document is only concerned with the CC131x and CC135x family of devices, so the 2.4GHz part numbering is not detailed. Do not use this section as an explanation for the 2.4GHz part numbering.

2.1.1 Frequency Band

Table 2-2. Frequency Band Code Description

Code	Frequency Band
1	Sub-1GHz or Multi-band
2	2.4GHz-only

2.1.2 Generation, Sub-1GHz and Multi-band

Table 2-3. Device Generation Code Description

Code	Generation
0, 1, 2	Legacy and value-line
3	1st and 2nd generation

2.1.3 Protocols

Table 2-4. Supported Protocols Code Description

Code	Supported Protocols
1	Sub-1GHz
5	Sub-1GHz and 2.4GHz

2.1.4 Major Features

Table 2-5 only describes the differences in the major hardware features. Reference the device data sheets in Section 5.2 for the device feature descriptions.

Table 2-5. Major Hardware Features Code Description

Code	Features
0	ARM® Cortex®-M3 processor
	Sensor Controller Engine
1	48MHz ARM® Cortex®-M4 processor
2	48MHz ARM® Cortex®-M4F processor
	Improved Sensor Controller Engine
	Updated peripherals

Table 2-5. Major Hardware Features Code Description (continued)

Code	Features
4	48MHz ARM® Cortex®-M33 processor with TrustZone®
	FPU and DSP extensions
	Improved Sensor Controller Engine
	Updated peripherals

2.1.5 Radio Output Power

Table 2-6. Radio Output Power Code Description

Code	Supported Output Power
N/A	CC13x0 devices only, refer to device data sheets in Section 5.2
R	Up to +14dBm at Sub-1GHz (TX and RX supported)
	Up to +5dBm at 2.4GHz if a multi-band device (TX and RX supported)
P	Up to +20dBm integrated high-power amplifier (for support of the frequency bands of the device), TX-only
	Up to +14dBm at Sub-1GHz (TX and RX supported)
	Up to +5dBm at 2.4GHz if a multi-band device (TX and RX supported)

2.1.6 Memory Size

Table 2-7. Memory Size Code Description

Code	Flash Program Memory (kB)	Ultra-Low Leakage SRAM With Parity + Cache (kB)
N/A	CC13x0 devices: Refer to Section 2.6 and the device data sheet.	
1 (referred to as CC13x2R and CC13x2P)	352	80 + 8
3	352	32 + 8
7	704	144 + 8
10	1024	256 + 8 (32kB of additional SRAM is available if parity is disabled)

2.2 Available RF Outputs

As mentioned in Section 2.1.5, the CC131xRx devices contain a Sub-1GHz radio that supports up to +14dBm (TX) output power. The CC135xRx devices contain the same Sub-1GHz radio and a 2.4GHz radio that supports up to +5dBm TX output power.

The CC131xPx and CC135xPx devices contain the Sub-1GHz and 2.4GHz radios described above (Sub-1GHz and Multi-band respectively) and an additional +20dBm power amplifier (PA). This PA can be configured for Sub-1GHz or 2.4GHz operation depending on the BOM and RF settings used.

For clarity, since the additional port on *P devices* solely contains a PA, that additional port is TX-only. This configuration utilizes the PA to achieve a higher TX output power at Sub-1GHz or 2.4GHz. The other relevant radio output can then be used for RX operation only.

The standard RF output for the desired frequency band can be used with the standard configuration (for RX), together with the PA (for TX), if a CC135xPx device is used. For example, the LP-CC1352P7-1 reference design uses the PA for +20dBm output power in the 868-915MHz bands so that the Sub-1GHz and PA networks form the Sub-1GHz design. The 2.4GHz path is then used for up to +5dBm TX output power and for RX.

2.3 Device Package Size

The CC131x and CC135x family of wireless MCUs have a variety of package sizes available. The number of available GPIOs is dependent on the package size.

Table 2-8 provides a summary of the different package sizes available for the different devices.

Table 2-8. Available Device Package Sizes

Device(1) (2)	Package Size (pin count)				
	RSM 4mm × 4mm VQFN (32)	RHB 5mm × 5mm VQFN (32)	RKP 5mm × 5mm VQFN (40)	RGZ 7mm × 7mm VQFN (48)	RSK 8mm × 8mm VQFN (64)
CC1310	√	√		√	
CC1311R3			√	√	
CC1311P3				√	
CC1312R				√	
CC1312R7				√	
CC1314R10				√	√
CC1350	√	√		√	
CC1352R				√	
CC1354R10				√	√
CC1352P				√	
CC1352P7				√	
CC1354P10				√	√

(1) All devices are available in an RGZ 7mm × 7mm VQFN package.
(2) Additional package size information for each device can be found in the device data sheets.

2.3.1 Pin-to-Pin Compatibility

Many RGZ (7mm × 7mm) devices are pin-to-pin compatible depending on if the devices are Sub-1GHz or Multi-band and if the device includes an integrated PA, which allows scalability depending on design requirements. The compatible devices are shown in Table 2-9.

Table 2-9. RGZ (7mm × 7mm) Pin-to-Pin Compatibility Matrix

Device	CC1310	CC1311R3	CC1312R	CC1312R7	CC1314R10	CC1311P3	CC1352P	CC1352P7	CC1354P10	CC1352R	CC1354R10
CC1310 (1)		√	√	√	√						
CC1311R3	√		√	√	√						
CC1312R	√	√		√	√						
CC1312R7	√	√	√		√						
CC1314R10	√	√	√	√							
CC1311P3							√	√	√		
CC1352P						√		√	√		
CC1352P7						√	√		√		
CC1354P10						√	√	√			
CC1352R (2)											√
CC1354R10										√	

(1) The different CC1310 RGZ (7mm × 7mm) variants have the same pin-to-pin compatibility as outlined above.
(2) The CC1350 is not pin-to-pin compatible with other CC135x devices.

2.3.2 Package Size and Reference Design

Using the correct reference design for the selected device package size is important. Using a reference design that is not designed for the package size can affect the RF impedance matching and filtering stage (the RF path) and consequentially degrade the RF performance.

For example, using a reference design that was designed for the Sub-1GHz RF path (like the 868-915MHz bands) of an RGZ 7mm × 7mm VQFN package with an RSK 8mm × 8mm VQFN package has sub-optimal RF performance. However, using a reference design for the Sub-1GHz RF path (like the 868-915MHz bands) of an RGZ 7mm × 7mm VQFN package with an RGZ 7mm × 7mm VQFN package has comparable RF performance, and can be reused.

Note

Up-to-date reference designs for the CC131x and CC135x family are maintained in *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations* application note.

2.3.3 Available GPIO Count

The number of available GPIOs depends on the package size and if the device is Sub-1GHz or Multi-band. A summary of the available GPIO count is given in Table 2-10, with individual colors indicating the same GPIO count.

Table 2-10. Device GPIO Count

Device	GPIO Count				
	RSM (4mm × 4mm)	RHB (5mm × 5mm)	RKP (5mm × 5mm)	RGZ (7mm × 7mm)	RSK (8mm × 8mm)
CC1310	10	15		30	
CC1311R3			22	30	
CC1311P3				26	
CC1312R				30	
CC1312R7				30	
CC1314R10				30	46
CC1350	10	15		30	
CC1352R				28	
CC1354R10				28	42
CC1352P				26	
CC1352P7				26	
CC1354P10				26	42

2.4 SMD Component Package Size

The selected SMD component package size is an important factor for the RF path and checking the component size in the reference design is vital. This information is typically found in the Bill of Materials (BOM) included with the reference design.

Using the incorrect component package size with a chosen reference design results in degraded performance. Specific details about hardware design considerations for the RF path are found in the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*.

Currently, the TI reference designs use component package size 0402 or 0201 in the RF path. Use the imperial size code (inches) when referring to component package sizes in this document.

When a TI reference design does not exist for a given component package size, using 0201 or 0402 components in a design can produce the same RF radio performance if the RF path is re-optimized to account for the change in the impedance presented to the RF port (that results from using a different component size).

Note

A common mistake is using the values for one component package size (0201 or 0402) with a design that was designed using the other component package size. This mistake results in reduced RF performance.

Using 0201 package size components have the following advantages compared to 0402 package size components:

- More compact RF layout
- Tighter component tolerances available
- The more compact RF layout results in lower unwanted EMI emissions
- Generally cheaper than the equivalent 0402 package size components

Reference designs for devices, CC13x1, CC13x2P7, and CC13x4, use 0201 package size components, while devices CC13x0 and CC13x2 use 0402 or 0201, depending on the design and the component package size used, therefore, package size components must be checked as part of the design process.

Note

- A PCB designed for a 0402 component package size can be reused if migrating from a pin-to-pin compatible CC1310 RGZ (7mm × 7mm) VQFN variant (see Section 2.3.1), only requiring that the crystal is changed (detailed in Section 2.5).
- The RF path for the CC13x1R3, CC13x2Rx, and CC13x4Rx devices can be unchanged when migrating to another device with the same package size if the Sub-1GHz BOM uses 0402 components from an existing RGZ (7mm × 7mm) VQFN design.
- +20dBm reference designs likely use a 0201 component package size, therefore, TI recommends switching to a 0201 component package size if migrating to a *P device* to avoid two different package sizes for the Sub-1GHz and +20dBm PA RF paths.

The primary reference designs and the component package sizes used are listed in Table 2-11.

Table 2-11. Reference Design and Component Package Size Used

Component Package Size (Inches)	Reference Design
0201	LP-CC1312R7
	LP-EM-CC1314R10
	LP-CC1311P3
	LAUNCHXL-CC1352P1
	LAUNCHXL-CC1352P-2
	LAUNCHXL-CC1352P-4
	LP-CC1352P7-1
	LP-CC1352P7-4
	LP-CC1354P10-1
0402	LAUNCHXL-CC1310
	LAUNCHXL-CC13-90
	All other CC1310 designs
	LAUNCHXL-CC1312R1
	CC1312REM-XD7793
	LAUNCHXL-CC1352R1
	CC1352PEM-XD7793-XD24-PA9093
	CC1352PEM-XD7793-XD24-PA24
	CC1352-P7EM-XD7793-XD24-PA24
	CC1352-P7EM-XD7793-XD24-PA24_10dBm
	CC1352-P7EM-XD7793-XD24-PA9093

2.5 Crystal Oscillator

All devices, except CC13x0 devices, require a 48MHz high frequency (HF) crystal to generate the reference clock for the radio (XOSC-HF). The CC13x0 devices require a 24MHz HF crystal (for XOSC-HF). The radio does not operate without this external crystal.

The higher-frequency crystal makes sourcing physically small crystals within the CC131x and CC135x specification requirements easier. Application note, *Crystal Oscillator and Crystal Selection for the CC13xx, CC26xx, and CC23xx Family of Wireless MCUs*, contains detailed information about the crystal oscillators for the CC devices discussed in this document, including information about how to select an appropriate crystal for the design.

Refer to the crystal requirements outlined in the device data sheet.

2.5.1 Applications Requiring a Slow Clock Accuracy

For applications requiring a slow clock accuracy of < ±500PPM (such as, Bluetooth® Low Energy applications), an external 32kHz slow clock is required. For details, see the *Clock Accuracies and Bluetooth® LE* section of the *SimpleLink™ CC13xx CC26xx SDK BLE5-Stack User Guide*.

2.5.2 Internal Variable Load Capacitor Array

All CC131x and CC135x devices include internal variable load capacitors (in the IC) for adjusting the load capacitance of the external HF crystal without requiring external load capacitors.

For most use cases, TI recommends using an internal capacitor array, however, there are specific use cases where using external load capacitors is recommended. For more information on when TI recommends using external load capacitors, refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*.

2.6 Memory

The CC131x and CC135x devices are available in a variety of different memory sizes. The memory size is indicated in the device name for quick identification of the device memory, as discussed in Section 2.1.6.

The devices, CC1311R3 and CC13x4, have the same memory for all of the available package sizes.

The CC1310 devices have three different memory options for each available package size (the package sizes are listed in Section 2.3). Later devices indicate the memory size in the part number to allow easier identification of the device features, as shown in Section 2.1.6.

Table 2-12 provides a summary of the different device memory sizes available for the CC131x and CC135x devices and Table 2-13 separately lists the memory sizes available for the different CC13x0 package sizes.

Table 2-12. CC131x and CC135x Device Memory Sizes

Device	Flash (kB)	RAM + Cache (kB)
CC1311R3	352	32 + 8
CC1311P3	352	32 + 8
CC1312R	352	80 + 8
CC1312R7	704	144 + 8
CC1314R10	1024	256 + 8
CC1352R	352	80 + 8
CC1354R10	1024	256 + 8
CC1352P	352	80 + 8
CC1352P7	704	144 + 8
CC1354P10	1024	256 + 8

Table 2-13. CC13x0 Device Memory Sizes

Device	Package Size	Flash (kB)	RAM + Cache (kB)
CC1310F128RSM	RSM (4mm × 4mm VQFN32)	128	20 + 8
CC1310F64RSM		64	16 + 8
CC1310F32RSM		32	16 + 8
CC1350F128RSM		128	20 + 8
CC1310F128RHB	RHB (5mm × 5mm VQFN32)	128	20 + 8
CC1310F64RHB		64	16 + 8
CC1310F32RHB		32	16 + 8
CC1350F128RHB		128	20 + 8
CC1310F128RGZ	RGZ (7mm × 7mm VQFN48)	128	20 + 8
CC1310F64RGZ		64	16 + 8
CC1310F32RGZ		32	16 + 8
CC1350F128RGZ		128	20 + 8

The increase in memory when migrating from a CC13x0 device to a CC13x1, CC13x2, or CC13x4 device allows for multiple stacks to run concurrently through a DMM driver.

2.7 Summary Table

A summary table outlining the different devices is given in Table 2-14.

Table 2-14. CC131x and CC135x Device Summary

Device	RF Path			Flash (kB)	RAM + Cache (kB)	GPIO	Package Size				
	Sub-1GHz	2.4GHz	+20dBm PA				RSM (4mm × 4mm)	RHB (5mm × 5mm)	RKP (5mm × 5mm)	RGZ (7mm × 7mm)	RSK (8mm × 8mm)
CC1310	√			32-128	16-20 + 8	10-30	√	√		√	
CC1311R3	√			352	32 + 8	22-30			√	√	
CC1311P3	√		√	352	32 + 8	26				√	
CC1312R	√			352	80 + 8	30				√	
CC1312R7	√			704	144 + 8	30				√	
CC1314R10	√			1024	256 + 8	30-46				√	√
CC1350	√	√		128	20 + 8	10-30	√	√		√	
CC1352R	√	√		352	80 + 8	28				√	
CC1354R10	√	√		1024	256 + 8	28-42				√	√
CC1352P	√	√	√	352	80 + 8	26				√	
CC1352P7	√	√	√	704	144 + 8	26				√	
CC1354P10	√	√	√	1024	256 + 8	26-42				√	√

Device comparisons detailing the supported radio PHYs are given in the device data sheets and are not within the scope of this document.

3 Device-to-Device Migration Considerations

The following section provides a summary of specific device-to-device hardware migration considerations, refer to the relevant sections in Section 2 for more detailed information. Major features for each device are noted by the device naming, which is described in Section 2.1.4.

TI recommends referencing the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, alongside this document. An additional design support resource is TI's E2E™ support forums. Sub-1GHz and Multi-band designs can also be reviewed by a TI engineer for feedback by using the Sub-1GHz Design Review Submission Portal before manufacture.

3.1 Sub1-GHz Devices

3.1.1 Migrating from CC1310 to CC131xRx or CC1311P3

- The CC1310 RGZ (7mm × 7mm) VQFN variants are pin-to-pin compatible with the CC131xRx RGZ (7mm × 7mm) VQFN devices. A PCB designed for this package size can be reused with only the crystal needing to be changed (detailed below): Section 2.3.
- The CC1311P3 contains an additional Sub-1GHz +20dBm PA RF path and is not pin-to-pin compatible with the CC1310 RGZ (7mm × 7mm) VQFN variants: Section 2.2.
- Change from a 24MHz to a 48MHz crystal: Section 2.5.
- The correct reference design must be chosen for the selected device package size. Refer to application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, if changing the device package size for the relevant reference design: Section 2.3.2.
- Double-check if the component package size for the new reference design used has changed from 0402 to 0201 (or reuse the existing design if the devices are pin-to-pin compatible): Section 2.4.

3.1.2 Migrating from CC1312Rx to CC1311R3 or CC1314R10

- The RGZ (7mm × 7mm) VQFN variants are pin-to-pin compatible: Section 2.3.
- The correct reference design must be chosen for the selected device package size. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, if changing the device package size for the relevant reference design: Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

3.1.3 Migrating from CC131xRx to CC1311P3

- There is an additional Sub-1GHz +20dBm PA RF path: Section 2.2.
- The devices are not pin-to-pin compatible due to the additional +20dBm PA. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, for the relevant reference design: Section 2.3 and Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

3.2 Multi-Band Devices

3.2.1 Migrating from CC1350 to CC135xRx or CC135xPx

- The CC1350 is not pin-to-pin compatible with the CC135xRx or CC135xPx devices: Section 2.3.
- Change from a 24MHz to a 48MHz crystal: Section 2.5.
- The correct reference design must be chosen for the selected device package size. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, for the relevant reference design: Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

3.2.2 Migrating from CC1352R to CC1354R10

- The RGZ (7mm × 7mm) VQFN variants are pin-to-pin compatible: Section 2.3.
- The correct reference design must be chosen for the selected device package size. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, if changing the device package size for the relevant reference design: Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

3.2.3 Migrating from CC135xRx to CC135xPx

- The CC135xPx +20dBm PA RF path uses a different BOM for either the Sub-1GHz or 2.4GHz band: Section 2.2.
- The devices are not be pin-to-pin compatible due to the additional +20dBm PA. The correct reference design must be chosen for the selected device package size. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, for the relevant reference design: Section 2.3 and Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

3.2.4 Migrating from CC1352Px to CC1354P10

- The correct reference design must be chosen for the selected device package size. Refer to the application note, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, if changing the device package size for the relevant reference design: Section 2.3 and Section 2.3.2.
- Double-check if the component package size for the new reference design has changed from 0402 to 0201: Section 2.4.

4 Summary

This document provided an overview of the hardware changes, both required and recommended, when migrating between different devices of the CC131x and CC135x SimpleLink™ wireless MCU family. The required steps for specific device-to-device hardware migration were outlined and references to helpful information were provided for each step. Explanations detailed why each change was necessary or recommended and TI support resources and reference documents were highlighted.

5 References

5.1 Recommended Resources

- Texas Instruments, *CC13xx/CC26xx Hardware Configuration and PCB Design Considerations*, application note
- Texas Instruments, *Crystal Oscillator and Crystal Selection for the CC26xx and CC13xx Family of Wireless MCUs*, application note
- Texas Instruments, *SimpleLink™ CC13xx CC26xx SDK BLE5-Stack*, user guide
- Texas Instruments, *E2E™ support forums*, website
- Texas Instruments, *Simplelink™-Sub1GHz-Design-Reviews*, website submission portal

5.2 Device Data Sheets

- Texas Instruments, *CC1311P3 SimpleLink™ High-Performance Sub-1 GHz Wireless MCU With Integrated Power Amplifier*, data sheet
- Texas Instruments, *CC1311R3 SimpleLink™ High-Performance Sub-1 GHz Wireless MCU*, data sheet
- Texas Instruments, *CC1312R7 SimpleLink™ High-Performance Sub-1 GHz Wireless MCU*, data sheet
- Texas Instruments, *CC1314R10 SimpleLink™ High-Performance Sub-1 GHz Wireless MCU*, data sheet
- Texas Instruments, *CC1312R SimpleLink™ High-Performance Sub-1 GHz Wireless MCU*, data sheet
- Texas Instruments, *CC1310 SimpleLink™ Ultra-Low-Power Sub-1 GHz Wireless MCU*, data sheet
- Texas Instruments, *CC1354P10 SimpleLink™ High-Performance Multi-band Wireless MCU With Integrated Power Amplifier*, data sheet
- Texas Instruments, *CC1354R10 SimpleLink™ High-Performance Multiband Wireless MCU*, data sheet
- Texas Instruments, *CC1352P7 SimpleLink™ High-Performance Multi-Band Wireless MCU With Integrated Power Amplifier*, data sheet
- Texas Instruments, *CC1352P SimpleLink™ High-Performance Multi-Band Wireless MCU With Integrated Power Amplifier*, data sheet
- Texas Instruments, *CC1352R SimpleLink™ High-Performance Multi-Band Wireless MCU*, data sheet
- Texas Instruments, *CC1350 SimpleLink™ Ultra-Low-Power Dual-Band Wireless MCU*, data sheet

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