Bluetooth® low energy CC2541 Advanced Remote Control Kit

User's Guide

TEXAS INSTRUMENTS

Contents

List of Figures

List of Tables

References

The following references provide additional information on the CC2540, CC2541, the TI *Bluetooth®* low energy stack (BLE-Stack™), the BLE HID over GATT profile, the HID Service, and the *Bluetooth* Core Specification. Path and file references in this document assume you have installed the BLE-Stack development kit software to the default path C:\Texas Instruments\BLE-CC254x-1.4.x\. See the release notes in the installed BLE-Stack version for the latest updates.

1.1 Printed Copy Included in the Box with CC2541-ARC

- *CC2541 Advanced Remote Control Kit Quick Start Guide* (SWRU341)

1.2 Included with TI BLE-Stack Software Installer

The software installer is available for download at www.ti.com/ble-stack

- *TI Bluetooth low energy Software Developer's Guide* (SWRU271)
  C:\Texas Instruments\BLE-CC254x-1.4.x\Documents\TI_BLE_Software_Developer's_Guide.pdf
- *TI BLE Vendor Specific HCI Reference Guide*
  C:\Texas Instruments\BLE-CC254x-1.4.x\Documents\TI_BLE_Vendor_Specific_HCI_Guide.pdf
- *TI BLE Sample Applications Guide* (SWRU297)
  C:\Texas Instruments\BLE-CC254x-1.4.x\Documents\TI_BLE_Sample_Applications_Guide.pdf

1.3 Available from *Bluetooth* Special Interest Group (SIG)

- HID over GATT profile, Version 1.0 (27-Dec-2011)
  https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=245141
- HID Service, Version 1.0 (27-Dec-2011)
  https://www.bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=245140
- Specification of the *Bluetooth* System, Covered Core Package version: 4.0 (30-June-2010)
  https://www.bluetooth.org/technical/specifications/adopted.htm

Introduction

Thank you for purchasing a TI *Bluetooth* low energy (BLE) Advanced Remote Control Kit. The purpose of this document is to provide you an overview of the hardware and software included in the CC2541 Advanced Remote Control Kit (CC2541ARC).

Use the information in this guide begin with the kit. For more detailed information on BLE technology and the TI BLE protocol stack, consult the *TI Bluetooth low energy Software Developer's Guide* (SWRU271).

For more information on the HID over GATT profile (Human Interface Device over Generic Attribute Profile), or HOGP, which is the BLE profile used to transfer HID Reports such as keyboard and mouse keys, see the HID over GATT profile and HID Service specifications available from the *Bluetooth* SIG website and listed in *Section 1.3*.

2.1 Kit Contents Overview

The kit contains the following hardware components, including cables:

	Advanced Remote Control	CC2540 USB Dongle	CC Debugger
CC2541DK-RC	•	•	•

The **CC2541 Advanced Remote Control** is designed to act as an HID peripheral device (BLE slave), operating according to the specifications laid out in the HID over GATT profile. The remote comes pre-assembled in plastic casing with rubber buttons, battery enclosure, and a hole to access the programming header.

The advanced remote control operates on three 1.5-V alkaline AAA (LR03) batteries. Available peripheral hardware on the board includes a buzzer, gyroscope, accelerometer, and shift registers for key scanning. The PCB design also includes a 3.3-V LDO (TPS78330) to lower the voltage from a maximum 4.5 V to 3.3 V for use by the integrated circuits.

The **CC2540 USB Dongle** can emulate any *Bluetooth* low energy behavior, but usually acts as a central device (BLE master) and HID host. In this kit, the dongle comes pre-loaded with firmware that acts in a central role and as a HID service client towards the advanced remote control, and sends received input data to emulated human interface devices (USB HID) on a connected Windows®, Linux®, or OSX ®computer.

The **CC Debugger** flashes the software onto both the USB dongle and the advanced remote control. The debugger can also debug software using IAR embedded workbench.

Figure 2-1. Hardware Included with the CC2541ARC

The RF boards in this kit are FCC- and IC-certified, and tested to comply with ETSI/R&TTE over temperature from 0 to 35°C.

CAUTION
The kits include a non-rechargeable lithium battery. Always make sure the battery is removed from the CC2540/41 keyfob when it is connected to an external power source. Do not apply voltage less than 3.6 V. Dispose of the battery properly, and keep out of the reach of children. If swallowed, contact a physician immediately.

CAUTION
The kits contain ESD sensitive components. Handle with care to prevent permanent damage.

2.2 System Requirements

2.2.1 Dongle

To use the CC2540 USB dongle as a bridge between the advanced remote control and a host computer, you only need USB HID support in the operating system.

For computers without *Bluetooth* low energy-capable hardware and native support for the HID over GATT profile in the operating system, use the dongle because it hides the wireless aspect from the operating system.

Ensure the PC has a free USB port. An additional free USB port is required to use the CC debugger and the USB dongle simultaneously.

2.2.2 Windows 8

Computers running Windows 8® require a *Bluetooth* 4.0 dual mode dongle or internal hardware, with hardware drivers that support *Bluetooth* low energy. You can verify that these are supported in the Windows device manager by checking that for a reference to *Bluetooth* LE Enumerator.
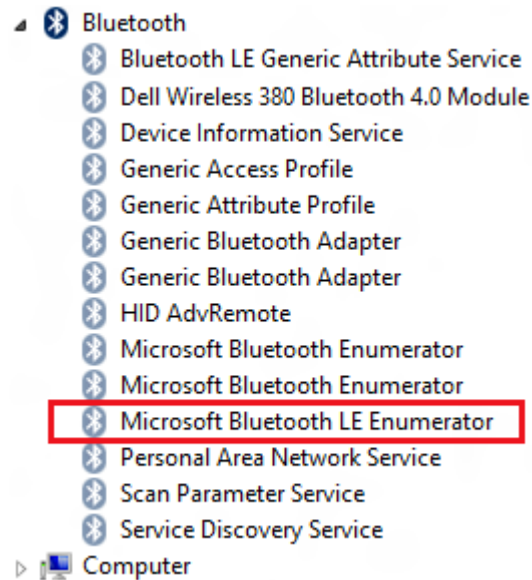

Figure 2-2. *Bluetooth* **Devices as seen in Windows Device Manager**

2.2.3 Debugging

You must have the IAR Embedded Workbench for 8051 development environment to make changes to the keyfob software. You can find more information on IAR in the TI *Bluetooth* low energy Software Developer's Guide (SWRU271) .

Using the CC2540 USB Dongle

This section describes how the USB dongle appears to a computer running Windows 7®, how it operates, and how to use the buttons on the dongle.

3.1 Plugging the Dongle into a Computer

As the CC2540 USB dongle comes pre-programmed with emulated HID USB endpoints. The dongle works out of the box free of extra drivers. After the USB dongle has been discovered and configured by Windows, several USB HID devices appear in the device manager.
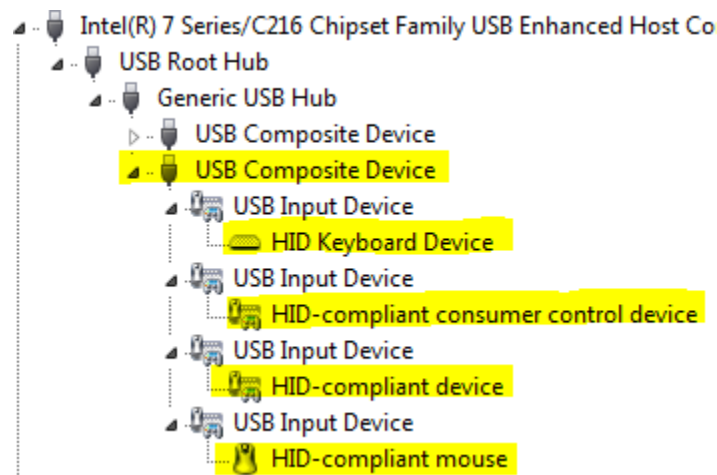
Figure 3-1. CC2540 USB Dongle Viewed in the Device Manager

Figure 3-1 shows the USB dongle enumerated as a USB composite device, with four interfaces representing the different capabilities of the advanced remote control and USB dongle:

- HID Keyboard Device
  Number keys, arrow keys, OK, and Back on the advanced remote
- HID-compliant consumer control device
  Volume buttons, play, pause, rewind, and similar consumer device control buttons
- HID-compliant mouse
  Movement data sent from the Advanced Remote when the mouse is activated
- HID-compliant device
  Control point for communication between the USB dongle firmware and applications running on the computer. Can be used for pairing, pin codes, feedback, resetting, and so forth. Not in use by the pre-programmed USB dongle firmware.

3.2 Connecting to the Advanced Remote Control

3.2.1 Pairing for the First Time

When the devices are programmed, they lose stored pairing information. The dongle powers up and shows a solid red LED.

1. To initiate a connection to an ARC, press the SW2 button on the HID dongle.

> **NOTE:** This action causes the HID dongle to scan for an ARC for 5 seconds. While scanning, the red LED will blink once a second.

2. Press any key on the ARC to start advertising.

> **NOTE:** When a suitable advertisement is found, the CC2540 USB dongle connects, pairs, and exchanges long-term bonding information with the remote, performs discovery of the services and characteristics used by the HID over GATT profile, and enables GATT notifications to be sent for button presses and mouse movements from the advanced remote.
>
> The green LED lights up when the connection is alive, and the red LED blinks when data is received. The connection is terminated to save power after the advanced remote has been idle for 60 s.
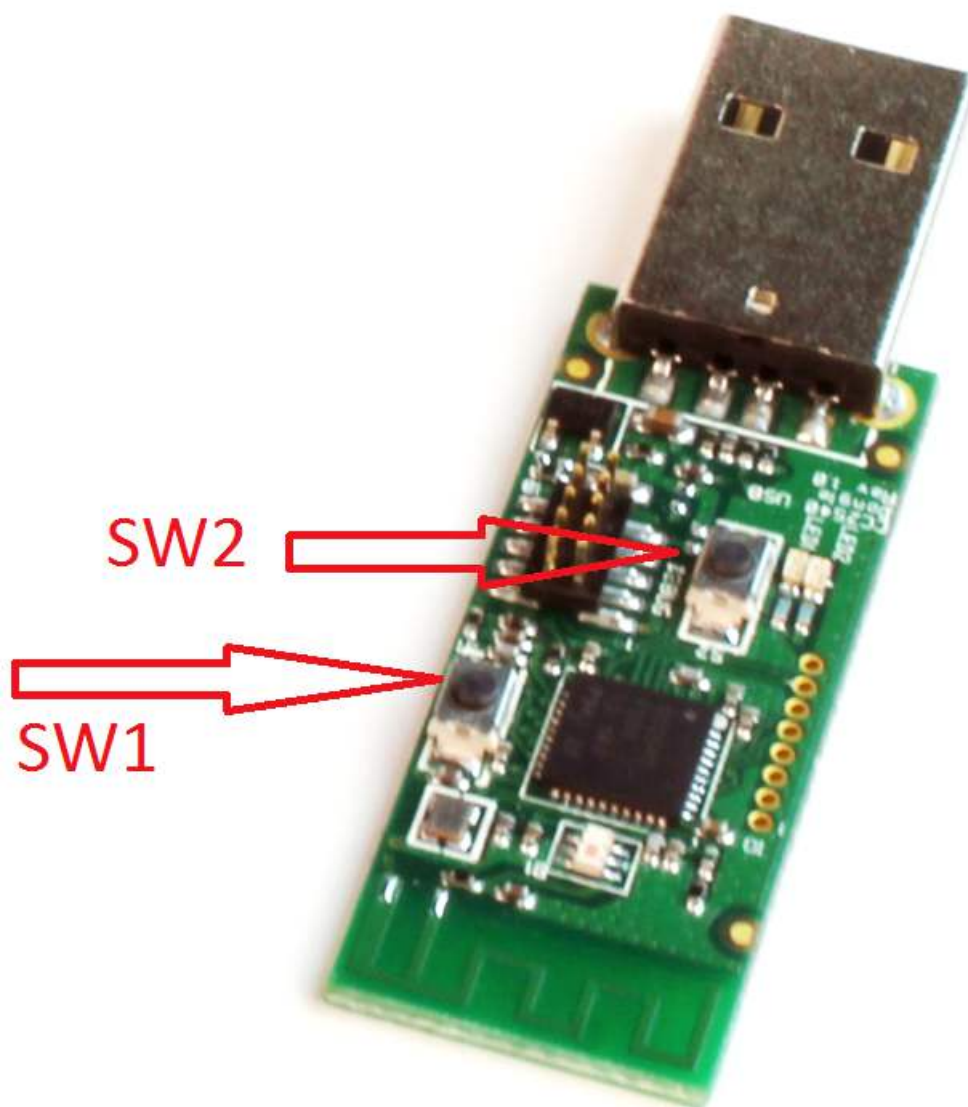
**Figure 3-2. SW1 - Clear Bonding Information
SW2 - Scan and Pair With Advanced Remote Control**

Sequence:

1. Press **SW2** to start scanning for the remote. (A blinking red LED indicates scanning.)
2. Press any key on remote to start advertising.
3. Verify a green LED, which indicates a successful connection.

3.2.2 Connecting Devices Already Bonded

If an HID dongle and an advanced remote previously paired and stored bonding data, then the HID dongle will continuously scan for this specific advanced remote. When in this continuous scanning mode, the HID dongle will blink the green LED once per second.

An HID dongle only stores pairing information for one remote, so other remotes will be unable to connect to the HID dongle until the bonding info is cleared.

3.2.3 Disconnecting

Pressing **SW2** on the dongle disconnects it from the advanced remote control and returns to scanning, while retaining long-term bonding information.

Because the advanced remote and the USB dongle are bonded and notifications are enabled on the remote, activating the advanced remote control causes it to start advertising, reconnect, and immediately transmit the button presses recorded while disconnected.

3.2.4 Removing Long Term Bond-Data

Pressing **SW1** (see Figure 3-2) while not connected erases the USB dongle's record of the long-term bonding data stored for the advanced remote in the flash memory of the USB dongle.

This action does not affect the data stored on the advanced remote. See Chapter 5 for information on erasing this data.

3.2.5 LED States

Table 3-1. LED States

LED Action	HID Dongle State
Solid Red	Idle
Blinking Red	Scanning for any BLE advanced remote
Solid Green	Connected
Blinking Green	Scanning for previously bonded remote

3.2.6 Button Actions

Table 3-2. Button Actions

Button	State	Action
SW1	Idle	Erase bonding info
SW2	Idle	Start scanning
SW2	Connected	Disconnect

Connecting the Advanced Remote Control to Windows 8

When the *Bluetooth* low energy-capable hardware is installed in a Windows 8 computer and updated drivers are installed (refer to *Section 2.2.2*), discover and use the advanced remote control by following the steps below.

4.1 Adding the Advanced Remote Control

1. Click Settings.
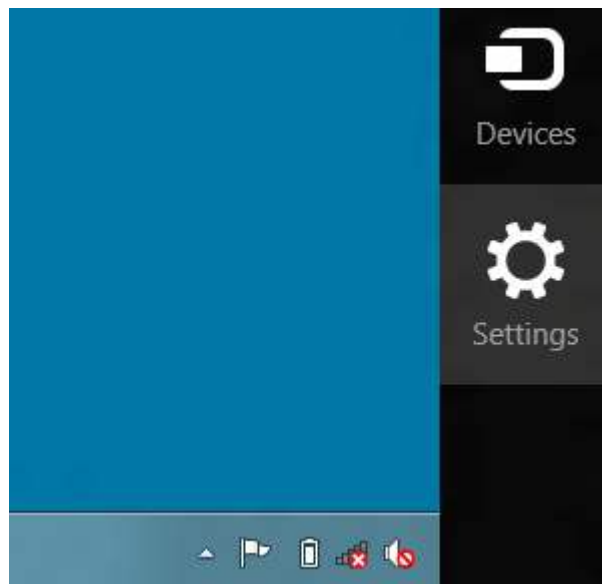
> **NOTE:** A new widget appears, allowing you to click on Change PC Settings.

2. Click Change PC settings.
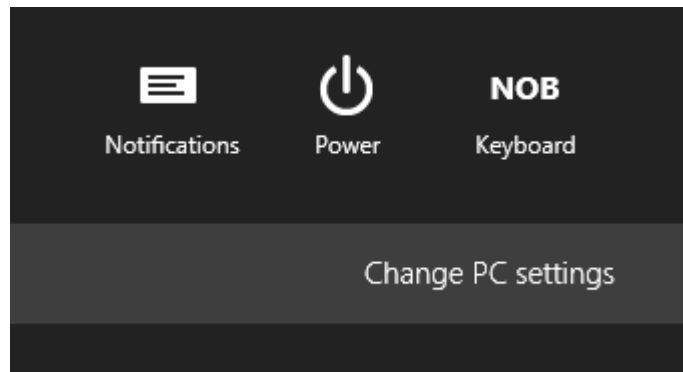
3.   In the PC Settings window, choose PC and devices.
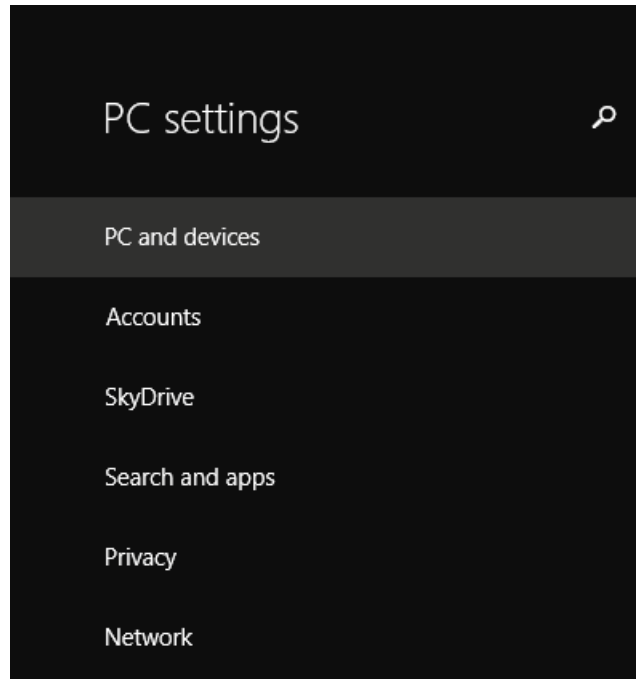
4.   In PC and devices, select *Bluetooth*.
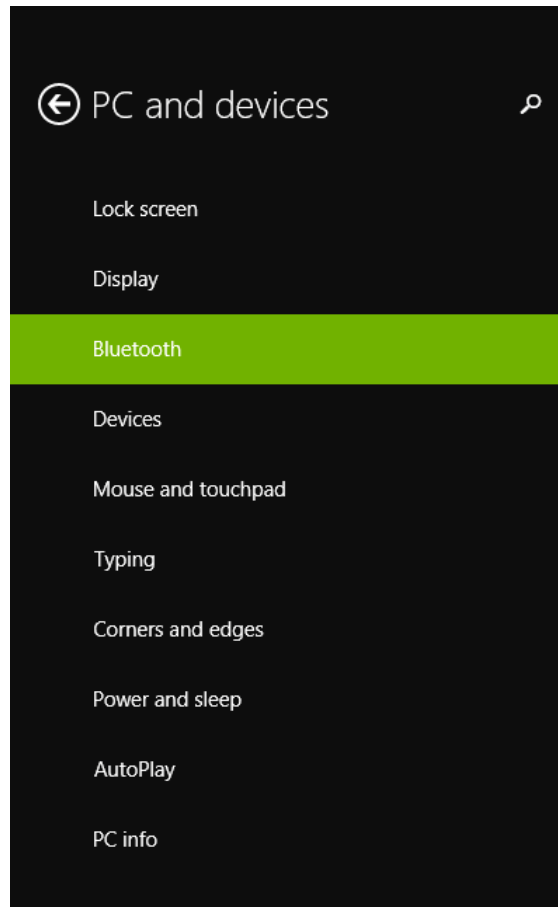
5. Ensure that the *Bluetooth* is set to ON.

NOTE: The PC will search for *Bluetooth* devices.

---
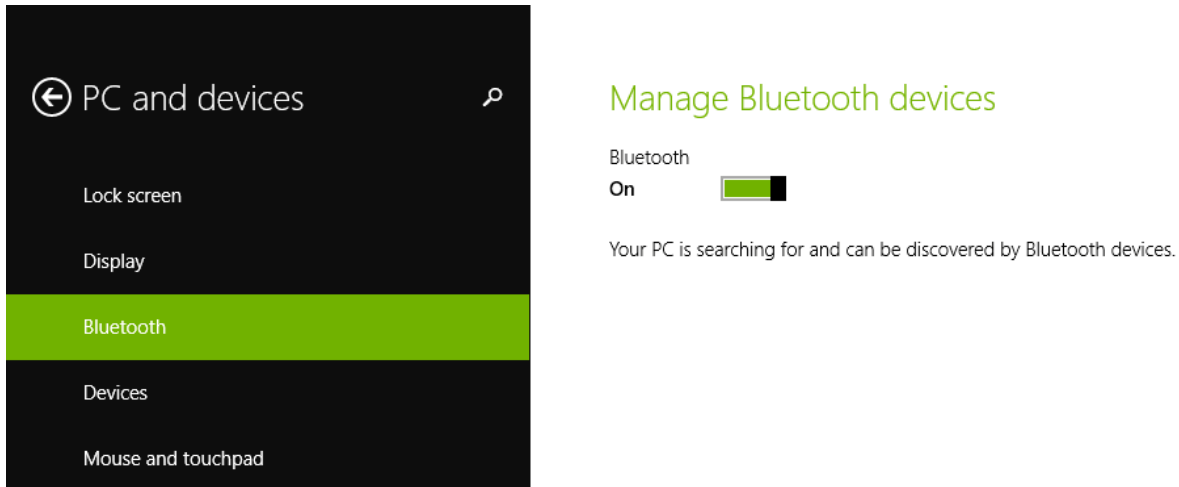
6. Press any button on the remote to start advertising.

NOTE: The HID AdvRemote will appear in the device list.

---

7. Press the icon.
8. Press the Pair to pair the remote to the PC.
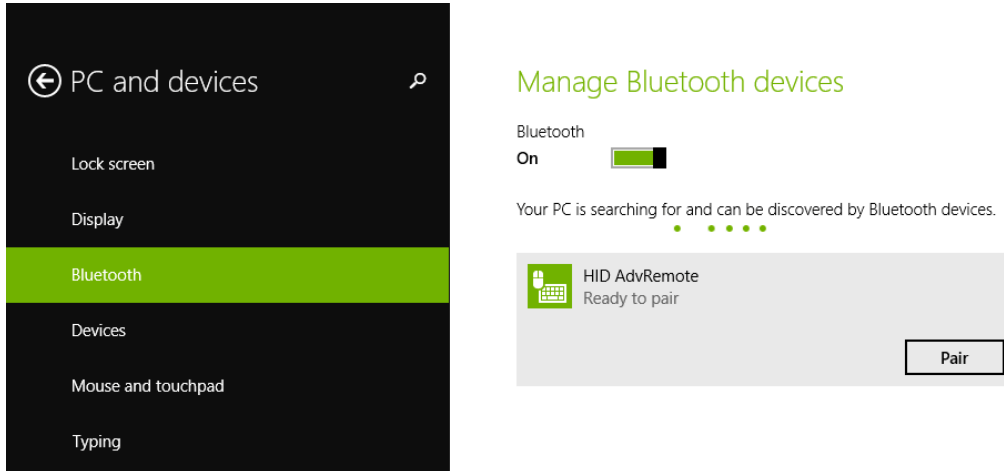
NOTE: A window opens with a passcode.

---

9. Input the passcode using the numeric buttons on the remote.
10. Press OK .
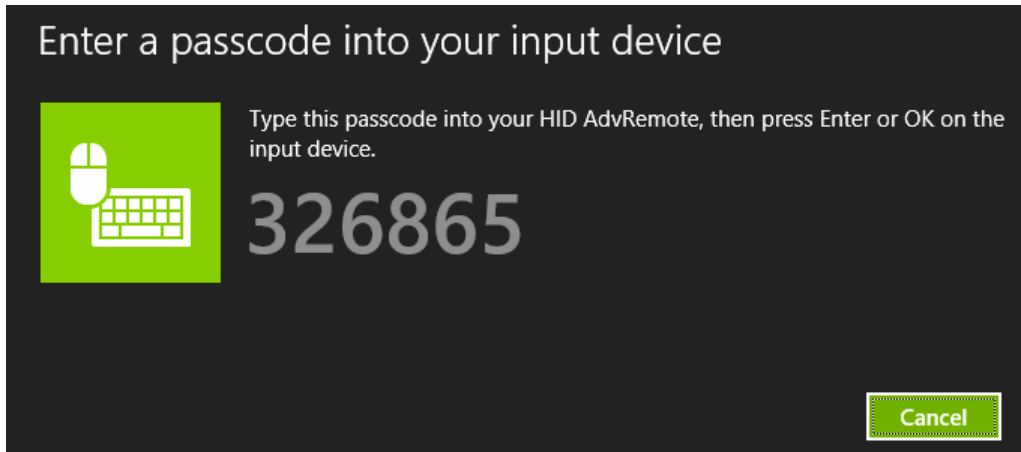
NOTE: The PC and remote will start the pairing process. When finished, the remote appears as a connected device in the device list.
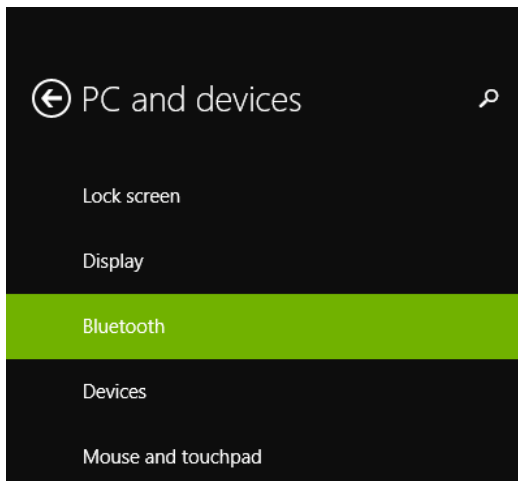
NOTE: The remote stops advertising after 30 seconds. If the remote does not show up in the list, press any button to begin advertising again.

4.2 Remove Device

To remove the remote from Windows and to delete the bond data, do the following:

1. Click the device.
2. Click Remove device
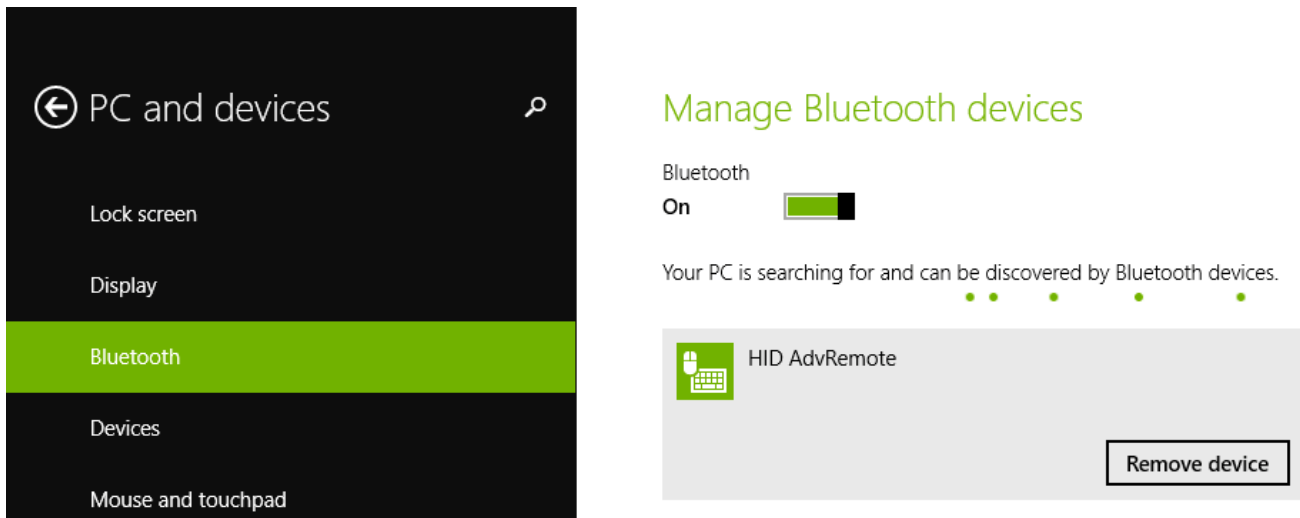
Figure 4-1. Remove *Bluetooth* **Device**

![Texas Instruments logo]

Using the Advanced Remote Control

![Figure 5-1 Advanced Remote Control showing Mouse keys, Mouse speed, and Action keys]

Figure 5-1. Advanced Remote Control

5.1 Advertising and Connecting

All keys, except the mouse speed and action keys, make the advanced remote advertise and become discoverable by hosts scanning for HID-capable BLE devices.

5.2 Using the Keyboard

Pressing any number acts as a keyboard input of that number. OK acts as Enter. Back is Backspace.

The four keys surrounding OK act as directional keys.

5.3 Controlling the Media Settings with Consumer Control Buttons

Volume, Mute, Play/Pause, and so forth are consumer control keys that control the media settings on the computer.

5.4 Using the Mouse

Holding down the middle mouse button prompts the advanced remote to interpret the movement of the remote as mouse input, and send this input to the computer.

Double-clicking the middle button locks the mouse function. The left and right buttons act as left and right mouse buttons.

Pressing AV and –/– decreases and increases mouse speed.

5.5 Removing Bond Information

Pressing the Red action key removes the bonding information stored on the advanced remote. Pairing can be redone using a passkey entry if applicable. If the remote is in a connection, the connection is dropped, and the bonding information is erased.

5.6 Calibrating

1. Ensure the mouse function is off and the device is laying on a flat surface.
2. Press the Blue action key to recalibrate the onboard motion sensors.

   NOTE: If the advanced remote is not ready for calibration, a high-pitched note sounds.

3. Press the blue key again

   NOTE: During calibration, a low-pitched tick sounds for 12 seconds. A high-pitched note indicates success.

Programming and Debugging the CC2541 Advanced Remote

The CC debugger lets you debug using the IAR Embedded Workbench for 8051. The debugger also lets you read and write hex files to the CC2540/41 flash memory using the SmartRF™ Flash Programmer software. The hex files are included with the installer. SmartRF Flash Programmer can also change the IEEE address of the CC2540/41 device. This section details the hardware setup using the CC debugger and includes information on using SmartRF Flash Programmer. You can find information on using IAR Embedded Workbench for debugging in the *TI Bluetooth low energy Software Developer's Guide* (SWRU271).

6.1 Hardware Setup for Advanced Remote

The debug port is on the back of the remote.

• Connect the debugger as shown in Figure 6-1.

Figure 6-1. Advanced Remote Programming Setup

> **NOTE:** The red stripe (pin 1) should be on the same side as the blue and 3 keys. When connected
> properly, the debugger LED shows green after pressing the CC debugger reset button.

Power Savings Tip: Leaving the remote in debug mode causes extra power drain on the battery.

To exit debug mode, do the following:

1. Remove the debugger cable.
2. Power cycle the remote.

6.2 Hardware Setup for USB Dongle

The setup process for flashing the USB dongle is similar to the process of flashing the remote.

1. Connect the CC debugger to the USB dongle as shown in Figure 6-2.

Figure 6-2. CC2540 USB Dongle Connected to CC Debugger

NOTE: The ribbon cable must be oriented properly, with the red stripe connected to pin 1 as shown
        in Figure 6-2. The USB dongle also must be powered to program, and should be placed in a
        USB port before programming with CC debugger.

2. Connect the CC debugger to the PC USB port.

> **NOTE:** The status indicator LED on the CC debugger should turn on. If the LED is red, no CC2540 device is detected. If the LED is green, a CC2540 device has been detected.
>
> If the USB dongle is connected and the LED is red, pressing reset on the CC debugger. This resets the debugger and re-checks for a CC2540 device. If the LED still does not turn green, re-check that all cables are securely connected.

When the CC debugger status LED is showing green, you can use IAR to debug or to read or write a hex file to and from the USB dongle.

6.3 Using SmartRF Flash Programmer Software

Use the instructions with the latest version of SmartRF Flash Programmer (version 1.12.6), available at the following URL: http://www.ti.com/tool/flash-programmer.

To start the application, do the following:

1. Navigate to Start.
2. Navigate to All Programs.
3. Navigate to Texas Instruments.
4. Navigate to SmartRF Flash Programmer.
5. Navigate to SmartRF Flash Programmer.

Figure 6-3 shows the program start-up screen.
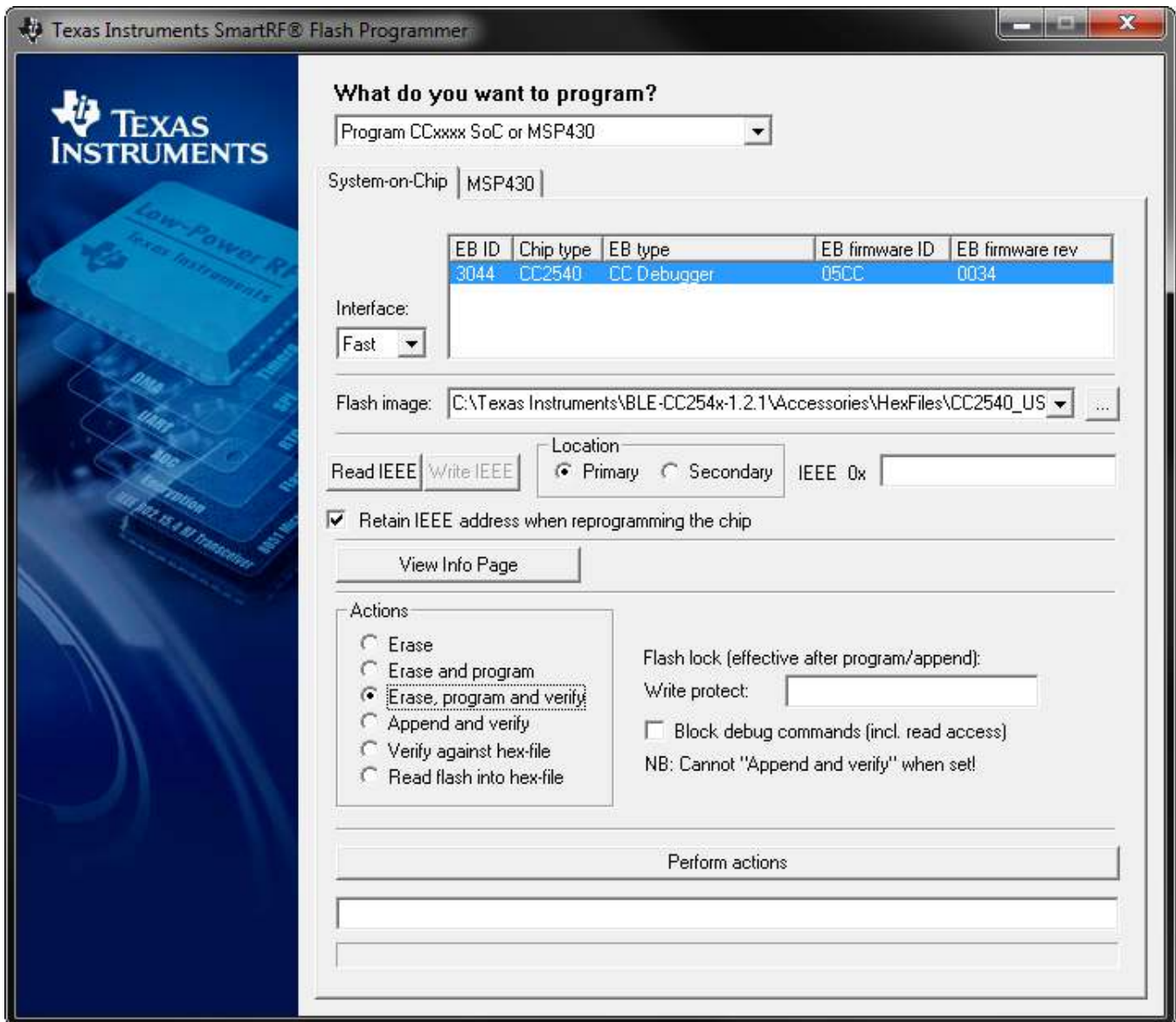
Figure 6-3. Flash Programmer

> **NOTE:** If you are prompted to update the EB firmware (CC debugger), follow the instructions to update the program.

6.3.1 Reading or Writing a Hex File to the CC2540/41

To read or write a hex file to the CC2540/41, do the following:

1. Select the System-on-Chip tab (default).

> **NOTE:** The connected CC2540/41 should be detected and show up in the list of devices.

2. Under Flash image, select a hex file to write to the device.

> **NOTE:** If reading from the CC2540/41, under Flash image enter the path and filename for the hex file.

3. To write to the CC2540/41 under Actions, select Erase, program and verify.

4. To read from the CC2540/41 under Actions, select Read flash into hex-file.

5. To begin the read or write, click Perform actions.

> **NOTE:** If the action completes successfully, the progress bar at the bottom of the window should fill up and you will see either one of the following two messages: CC254X - IDXXXX: Erase, program and verify OK or CC254X - IDXXXX: Flash read OK.

There are two pre-built hex image files for the advanced remote kit in the Accessories folder of the BLE-Stack installation path.

Table 6-1. Hex Image Files

Project	Directory
HIDAdvRemote	\Accessories\HexFiles\CC2541_ARC_HIDAdvRemote.hex
HIDAdvRemoteDongle	\Accessories\HexFiles\CC2540_USBdongle_HIDAdvRemoteDongle.hex

6.3.2 Reading or Writing the CC2540/41 Device Address

Every CC2540/41 device comes pre-programmed with a unique 48-bit IEEE address. This address is the primary address of the device and is unable be changed. You can set a secondary address on a device to override the primary address upon powerup. You can use flash programmer to read the primary address and read or write the secondary address. See the *TI Bluetooth low energy Software Developer's Guide* (SWRU271) for more information.

6.4 Using IAR for Debugging and Programming

IAR is the compiler and IDE to develop the advanced remote and HID dongle. See the *TI Bluetooth Low Energy Software Developer's Guide* (SWRU271) for more information on using IAR,. This section provides a high-level overview of advanced remote kit software projects. There are two projects for the advanced remote kit.

Table 6-2. Advanced Remote Kit Software Projects

Project	Directory
HIDAdvRemote	\Projects\ble\HIDAdvRemote
HIDAdvRemoteDongle	\Projects\ble\HIDAdvRemoteDongle

6.4.1 Advance Remote Project Files

Table 6-3 shows the important file components of the advance remote control project. After opening the project in IAR, these are visble in the left hand project explorer.

Table 6-3. File Components of the Advance Remote Control Project

File	Description
hidAdvRemote.c	Top level application. Initialization of remote hardware, connection settings, GATT, and top level task handlers. Keys and gyro/accelerometer callbacks are handled here.
battservice.c	Service for battery. Support characteristics for battery.
devinfoservice.c	Service for device information. Support characteristics such as manufacturer, serial number, and so forth.
hidDev.c	Service for HID. Support HID reads, writes, queuing reports, and state machine.
hidkbmservice.c	Service for keyboard, mouse, and consumer control reports.
hid_uuid.h	List of UUIDs for supported HID reports.
Scanparamsservice.c	Service for scan parameters.

6.4.2 HID Dongle Project Files

Table 6-4 shows the important file components of the HID dongle project.

Table 6-4. File Components of the HID Dongle Project

File	Description
hidApp.c	Top level application. Initialization of dongle hardware, service discovery, and connection state machines.
Usb_hid_reports.c	HID to USB report handling.
hid_uuid.h	List of UUIDs for supported HID reports

Software Overview

7.1 HID over GATT

The software supports the HID over GATT profile specification, which was approved by the BT SIG in December 2011. The specification is available at bluetooth.org. Microsoft Windows 8 supports HID over GATT.

7.1.1 BLE HID Terminology

Table 7-1. BLE HID Terminology

HID Host	The target machine used by the user (such as laptop, tablet, phone, and so forth).
HID Device	The device used by the user to interact with the host (such as keyboard, mouse, remote control, game controller, and so forth).
HID Report	A data message sent between the host and device. Input reports go from device-to-host, such as a mouse movement or keyboard press. Output reports go from host-to-device, such as a PC changing the caps lock LED on a keyboard.
HID Report Descriptor	A data structure that the device sends to the host which describes the capabilities of the HID device, including the types, sizes, and directions of the reports supported.

7.1.2 GATT Services

Table 7-2 shows the services defined in the HID profile specification as either mandatory or optional. The software included with the advance remote kit includes all of these services.

Table 7-2. HID Profile Services

Service	Requirement	Supported
HID Service	Mandatory	Yes
Battery Service	Mandatory	Yes
Device Information Service	Mandatory	Yes
Scan Parameter Service	Optional	Yes

7.1.3 Data Flow

Figure 7-1 shows how HID reports are sent to a central device.
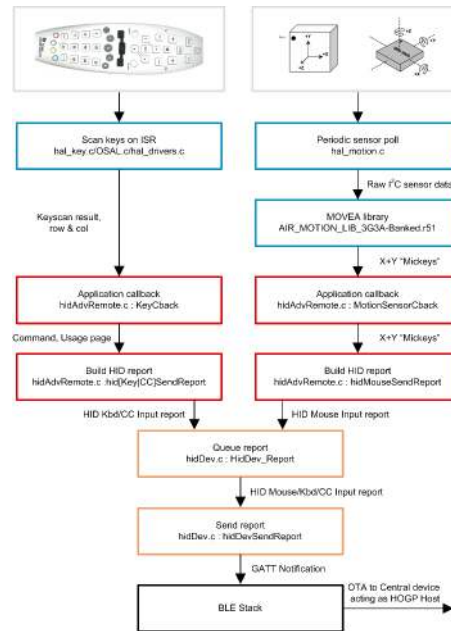
Figure 7-1. Data Flow

7.1.4 HID Report Overview

Table 7-3 shows the HID reports supported in the advanced remote control.

Table 7-3. HID Reports

Type	Bytes	Data	Function Ref.
Mouse	4	Buttons, X, Y, wheel	hidMouseSendReport
Consumer Control	2	Bitmap command	hidCCSendReport
Keyboard	8	Modifier, reserved, key code 1.6	hidKeyboardSendReport

Revision History

Changes from Original (March 2013) to A Revision **Page**

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Wireless Connectivity	www.ti.com/wirelessconnectivity		