



# ***CC2533 RF4CE Development Kit***

## ***Hardware User's Guide***



SWRU266A

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## 1 Introduction

The CC2533 RF4CE Development Kit allows you to evaluate RF4CE remote controls and develop applications based on the RF4CE standard. The main components of the development kit are two complete RF remote controls, one advanced with motion sensors functionality (3-axis accelerometer and 3-axis gyroscope), and another basic, a target module (receiver board) that interfaces to PC remote control emulation software via USB and two different USB dongles.

Texas Instruments also provide a complete RF4CE SW package, this software package includes software and tools required to develop your own remote controls. The CC Debugger is used for programming and debugging all Low Power RF products from Texas Instruments.

## 2 About this manual

This manual covers the hardware of the CC2533 RF4CE Development Kit. To use the development kit the RemoTI™ software must be downloaded from <http://www.ti.com/remoTI>. Separate manuals cover the RemoTI target emulator PC software and the software development suite.

The complete schematics and layout files for the remote control and the target module is available from <http://www.ti.com/RemoTI>. The CC2533EM module reference design files are available at <http://www.ti.com/tool/cc2533em-refdes>.



**Caution!** The kit contains ESD sensitive components. Handle with care to prevent permanent damage.

**Caution!** To minimize risk of injury, avoid touching components during operation if symbolized as hot.

### 3 Acronyms and Abbreviations

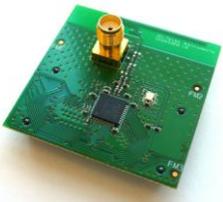
DK	Development Kit
EM	Evaluation Module
GYRO	Gyroscope
I2C	Inter-Integrated Circuit (communication bus)
IC	Integrated Circuit
IR	Infra Red
kB	Kilo Byte (1024 byte)
LED	Light Emitting Diode
LPRF	Low Power RF
MCU	Micro Controller
RF	Radio Frequency
RF4CE	Radio Frequency for Consumer Electronic
SoC	System on Chip
SPI	Serial Peripheral Interface
TI	Texas Instruments
TX	Transmit
UART	Universal Asynchronous Receive Transmit
USB	Universal Serial Bus
ZID	ZigBee Interface Devices
ZRC	ZigBee Remote Control

## 4 Getting started

### 4.1 Development Kit Content

The development kit includes the following main components:

<p><b>Advanced RF remote control</b></p> <p>A complete RF4CE remote control reference design with gyro and accelerometer enabling air mouse functionality and with an integrated PCB antenna. The remote control can be programmed using the debug interface.</p>	
<p><b>Basic RF remote control</b></p> <p>A simple RF remote control optimized for ZigBee Remote Control (ZRC). Enables all the basic remote control functions, the remote control can be programmed using the debug interface.</p>	
<p><b>Target Module</b></p> <p>Interface board for connecting I/O signals to typical remote applications. The following interfaces are accessible:</p> <ul style="list-style-type: none"> <li>• UART over USB virtual serial port</li> <li>• UART, CMOS signal level</li> <li>• SPI</li> <li>• I<sup>2</sup>C</li> <li>• IR receiver/transmitter</li> </ul>	
<p><b>CC Debugger</b></p> <p>USB Debug Interface for programming and debugging applications running on the remote control and target board.</p> <p>For programming the CC Debugger is used with the SmartRF Flash Programmer SW</p> <p>For In-Circuit debugging the CC Debugger is used with the IAR Embedded Workbench.</p>	
<p><b>CC2531 USB dongle</b></p> <p>The USB dongle can be programmed to replace the functions of the Target Module. It supports virtual serial port interface and HID (Human Interface Device) USB profiles. It can also be programmed to be used as packet sniffer of RF activity.</p>	
<p><b>CC2531 Nano USB stick</b></p> <p>The CC2531 Nano USB stick is a miniaturized version of the USB dongle and has all the functionality of the USB stick except from the peripherals, i.e. buttons and LEDs. The Nano USB stick is pre-programmed with a bootloader for easy FW upgrades.</p>	

<p><b>CC2533EM</b></p> <p><i>This is the CC2533 Evaluation Module (EM) with the RF IC reference design. Use the EM as reference design for antenna and RF layout. To be plugged into the Receiver module. The CC2533EM module includes both a no-cost PCB antenna and an SMA connector with external antenna. The antenna can be selected with a 0-ohm resistor. <b>The PCB antenna is used by default.</b></i></p>	
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**Table 4-1 RF4CE Development Kit content**

In addition the kit includes the following accessories:

- Batteries
- 2 Mini-USB cables, one for the target module and one for the CC Debugger
- 1 USB extension cable for the USB dongle
- 1 10-pin flat cable with 2x5 2.54mm connector
- 1 10-pin flat cable with 2x5 1.27mm connector
- 1 Converter board 2.54mm-1.27mm connector

To fully utilize the CC2533 RF4CE Development Kit the following SW may be downloaded from [www.ti.com](http://www.ti.com):

Application	Description	Download link and reference
<b>RemoTI stack library and sample applications</b>	The embedded software included with the advanced remote control and target board. Allows the development kit to be used out-of-the-box as an RF remote control.	SWRC131 <a href="http://www.ti.com/RemoTI">http://www.ti.com/RemoTI</a>
<b>RemoTI emulator PC tool</b>	A PC tool that can be connected to the USB interface of the target module to test the remote controls.	Included in the RemoTI SW package
<b>SmartRF Packet Sniffer</b>	A PC tools that can be used to display all RF4CE packets on the network. Requires a packet sniffer hardware adapter to be used with RF4CE.	<a href="http://focus.ti.com/docs/toolsw/folders/print/packet-sniffer.html">http://focus.ti.com/docs/toolsw/folders/print/packet-sniffer.html</a> <a href="http://www.ti.com/lit/zip/swrc045">www.ti.com/lit/zip/swrc045</a>
<b>SmartRF Flash Programmer</b>	Programming tool for programming hex files.	<a href="http://focus.ti.com/docs/toolsw/folders/print/flash-programmer.html">http://focus.ti.com/docs/toolsw/folders/print/flash-programmer.html</a> <a href="http://www.ti.com/lit/zip/swrc044">www.ti.com/lit/zip/swrc044</a>
<b>IAR EW8051 C-compiler</b>		<a href="http://www.iar.com/ew8051">www.iar.com/ew8051</a>

**Table 4-2 SW description**

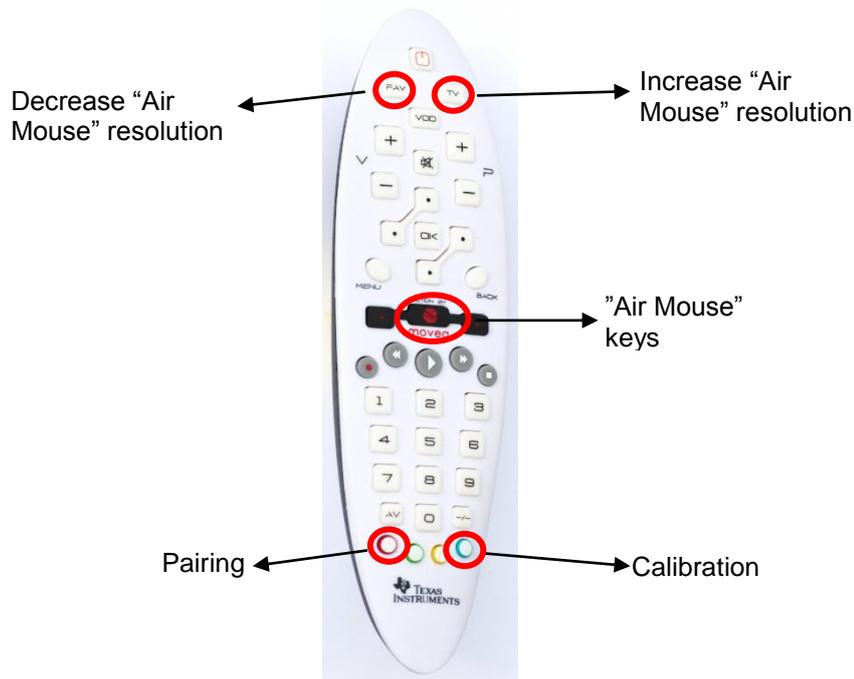
Additional CC Debugger and packet sniffer hardware adapters can be purchased from the TI eStore on [estore.ti.com](http://estore.ti.com)

## 4.2 The CC2533 Remote Control

The remote control is powered by 3xAAA batteries included with the development kit.

Figure 4-1 Figure 4-1: Remote Control Key layouts shows the key layout of the remote control with some of the important keys highlighted:

- Pairing key (“Red”) - pair the remote control with the target
- “Air Mouse” – enabling “Air Mouse” functionality
- FAV/TV - Decrease and Increase the air mouse resolution
- Calibration (“Blue”) – used to calibrate the motion sensing HW



**Figure 4-1: Remote Control Key layout**

### 4.2.1 Using the remote control

The advanced remote will transmit ZID (ZigBee Interface Device) keyboard and mouse reports to the USB dongle when certain keys are pressed. Keys that produce keyboard reports can be displayed on the PC connected to the USB dongle by opening up an application such as Notepad. The following keys will produce keyboard reports:

- Numeric keys
- “OK” key for “return”
- Navigation keys for left/right/up/down cursor movement

The advanced remote can also act as an air mouse by utilizing one of the following modes:

- **Manual mode:** hold down the “Air Mouse” key and move the remote. The cursor on the screen will move according to the movement of the remote. Release the “Air Mouse” key, and the cursor will freeze.
- **Free running mode:** double click the “Air Mouse” key, and move the mouse as in manual mode. The difference is that the mouse movements will not stop until the “Air Mouse” key is pressed again.
- In either mode, the buttons to the left and right of the “Air Mouse” key act as left and right mouse buttons

Before using the air mouse capabilities for the first time, you need to calibrate the motion sensor hardware inside the remote. The sensors are calibrated as follows:

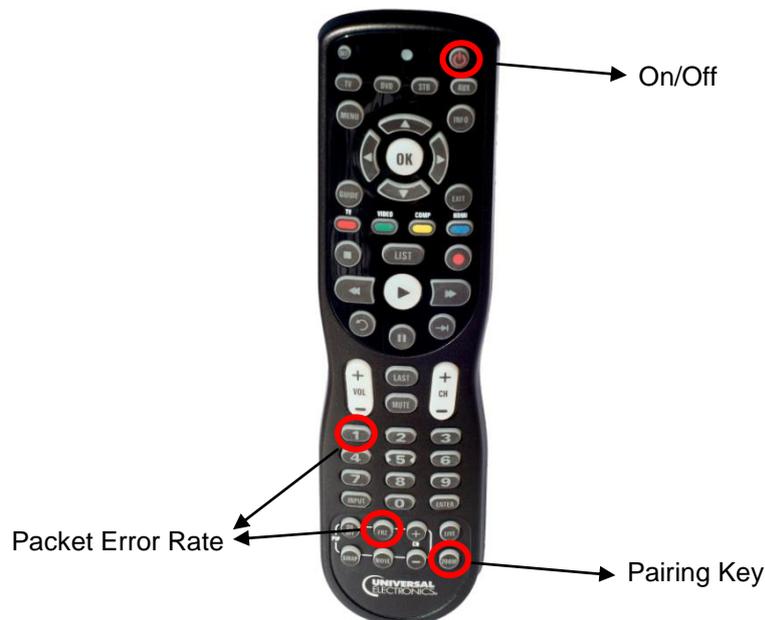
- Press the blue button on the remote
- Place the remote face down (buttons down) on a flat surface
- When the remote emits a short beep after about 5 seconds, the calibration is complete

The advanced remote will also transmit ZRC (ZigBee Remote Control) commands like volume up/down, play/stop etc. which can be used in combination with a Media Player running on the host.

### 4.3 The Basic Remote Control

The basic remote control is powered by 2xAA batteries included with the development kit. Figure 4-2 shows the key layout of the basic remote control with some of the important keys:

- Pairing key, pair the remote control with the target
- Packet Error Rate (PER) keys, the 'FRZ' key is used to start the packet error rate mode, and the '1' button is then used to start the PER test. Use this mode to test range and RF quality.
- On/Off, switches power on the target. Note that most applications can still receive remote control commands when powered off, but the latency is longer



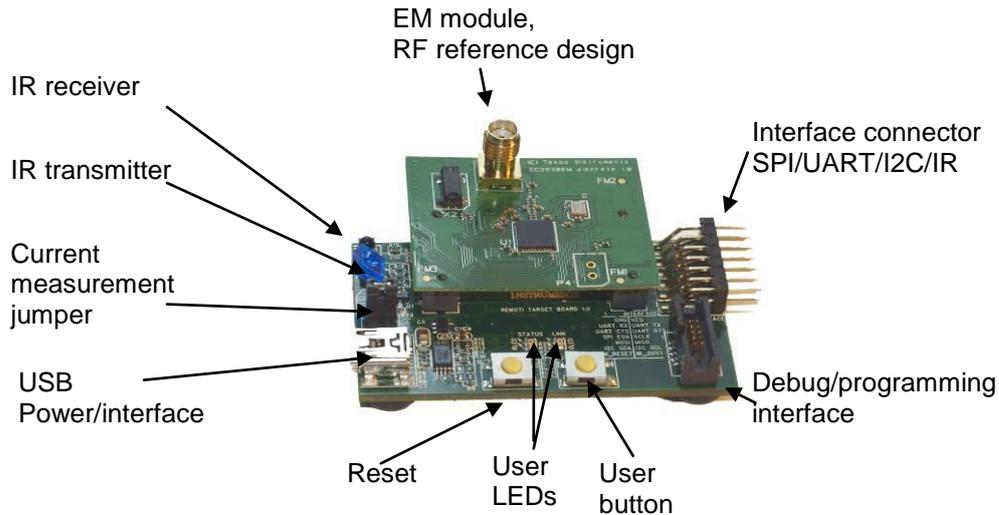
**Figure 4-2 Basic Remote Control Key layout**

### 4.4 The Target Module

The target module includes the following features and interfaces:

- Virtual serial port USB interface to allow using a COM port on a PC
- I2C/SPI/UART interface for connection to A/V equipment
- Flash memory for storage of Over the air (OAD) images and IR codes
- 1 channel IR drivers and LED for IR repeater function
- IR sensor input
  - o Learning IR code functionality
  - o Direct translation of IR codes to RF commands
- Buttons for reset and pairing
- Status LEDs

The target module is powered from the USB interface connected to a PC or a power adapter with USB interface.



**Figure 4-3 Target module layout**

Figure 4-3 shows the key layout of the target module with some of the peripheral interfaces highlighted. For details of the target module features, please see chapter 6.

#### **4.5 Installing RemoTI software and Windows drivers**

Before connecting the RemoTI target Module to a PC the required drivers for the tool must be installed. The latest version of the driver is included with the RemoTI software package. It can be downloaded from <http://www.ti.com/remoTI>.

After the software is installed, the driver files are located at this default location:  
C:\Texas Instruments\RemoTI\Tools\Driver

For instructions how to install the CC Debugger , please follow the quick start guide included with the CC Debugger .

The RemoTI software includes drivers for the target module. It is highly recommended to install this software before you connect the target module to the PC.

#### **4.6 RemoTI Software**

Included with the RemoTI software package is the Target Emulator application. This application is located at the C:\Texas Instruments\RemoTI\bin folder. The target module is programmed to be a RF4CE network processor that receives commands from the Target emulator software and handles the RF4CE protocol.

The Target Emulator lets you emulate a remote control on the PC. It displays all messages sent between the target module and the PC and works in many ways as a system that would interface to a real life remote control receiver.

The target emulator can be used to initiate the bootloader mode on the CC2531 nano USB stick. Click on the **'options'** tab and select **'bootloader'**, this will erase the application on the USB stick and the next time the CC2531 USB Nano stick is powered it will be in bootloader mode.

The RemoTI software includes RF4CE example software for remote controls and for target interface. The software is designed to easily allow customized versions of remote controls and to support a variety of interfaces on the target side.

The latest version of RemoTI software can be downloaded from the Texas Instruments website, <http://www.ti.com/remoti>, where you will also find a complete user manual

#### **4.7 Installing the target module Windows drivers**

Before your PC can communicate with the target modules over USB, you will need to install the driver files for the target module. Drivers for Windows are included with the installer<sup>1</sup> and a brief set of installation instructions for Microsoft Windows XP will be given here, but Microsoft 7 (32 and 64 bit) are also supported.

After you have downloaded RemoTI software from the web, run the installer file and follow the instructions.

Before connecting the target module to the USB port of the PC, plug the CC2533EM module onto the target module. The PCB antenna is used by default, hence it is not required to connect the external antenna. Figure 4-3 shows a complete assembled target module.



**Figure 4-4: Assembled target module**

You can now connect your target module to the computer with a mini-USB cable. A "Found New Hardware" dialog box will prompt you to locate the missing driver.

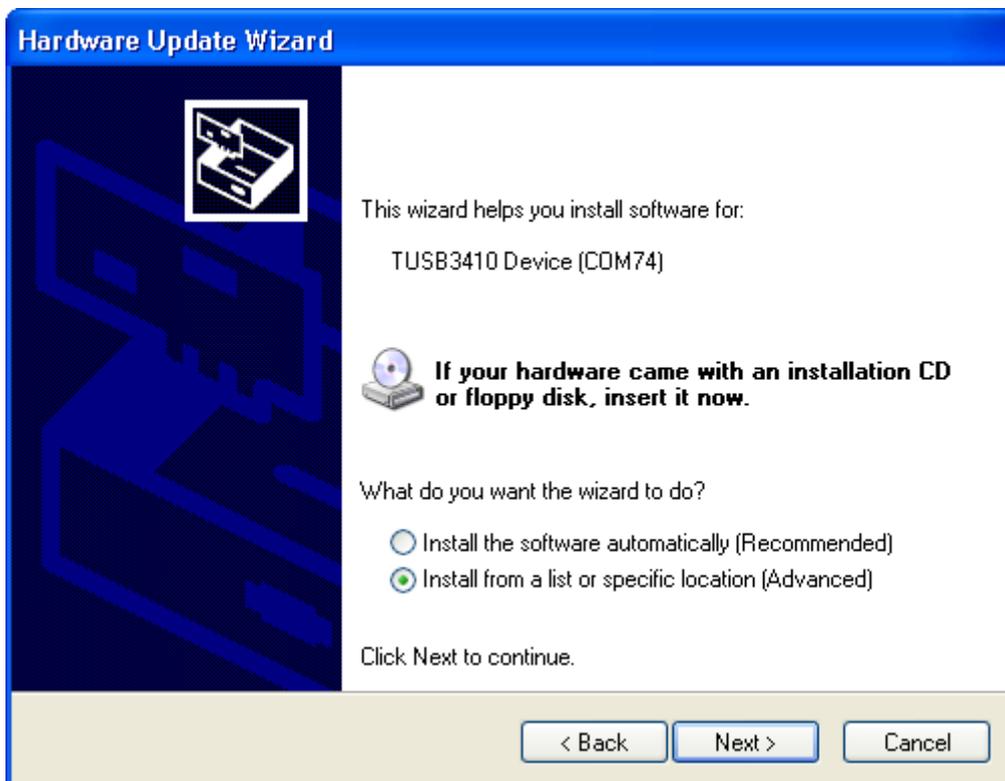
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<sup>1</sup> For RemoTI 1.3 the driver for the TUSB3410 needs to be downloaded separately from TI's web page: <http://www.ti.com/tool/tusbwinvcv>



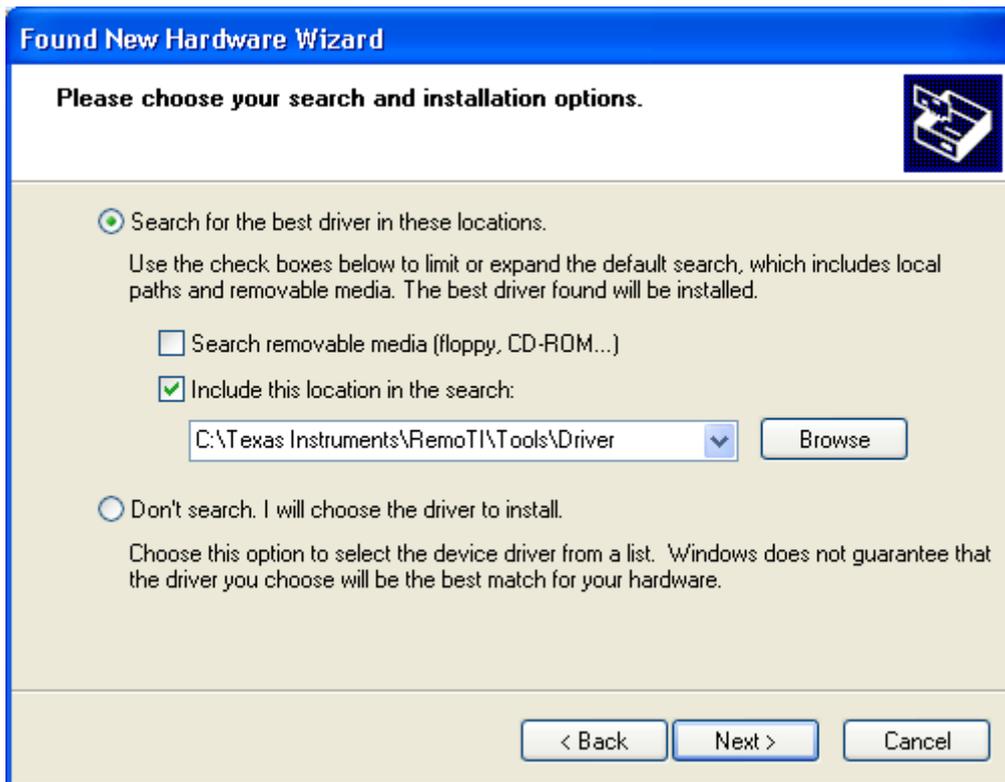
**Figure 4-5: Connecting the target module for the first time (Windows XP)**

Select “No, not this time” and continue with “Next”.



**Figure 4-6: Select automatic installation of software (Windows XP)**

Select “Install from a list or specific location (Advanced)” to install the driver.



**Figure 4-7: The driver installation is completed (Windows XP)**

Select the following directory <Installation Path>\Tools\Driver for the needed \*.inf and \*.sys driver files.

The driver is now installed and the PC is can communicate with target module using a virtual COM port. Unfortunately Windows does not confirm what COM port the device is assigned to.

To see the COM port number, open the Windows Control panel – System – Hardware – Device Manager and check the COM port number under Ports (COM and LPT).

The driver is properly installed if the target module is listed under the “Ports(COM & LPT)” contains “TUSB3410 Device(COM xx)” and that it is not labelled with an exclamation mark. If there is an exclamation mark, right click with the mouse on the line and choose “update driver” and follow the instructions above.



**Figure 4-8: Correct target module setup (Windows XP)**

#### **4.8 Testing the Remote Control application**

You are now ready to use the development kit to test remote control. The RemoTI software package includes a remote control target emulator. This is an application that is running on a PC and emulates as for instance a TV or Blu-ray player. It controls the RemoTI receiver using a serial port interface. For real applications the target emulator SW will be running on the host processor of the equipment.

The target emulator can be found in the <Installation Path>\RemoTI\bin folder. For instructions on how to set up and use the target emulator please see the RemoTI Target Emulator Users Guide (SWRU202) in the <Installation Path>\Documents\User Guide folder.

## 5 Programming and Debugging

### 5.1 Using the SmartRF Flash Programmer PC software

The SmartRF Flash programmer PC software is used for programming the software on the remote control and the target module. The RemoTI installation package includes several hex files in the <Installation Path>\RemoTI\bin folder:

<b>Remote control:</b>	AdvancedRemote-CC2533F96.hex	Advanced Remote (ZID) Sample Application
	BasicRemote-CC2533F96.hex	Basic Remote (ZRC) Sample Application
<b>CC2531 Nano USB:</b>	ZID_Nano_Dongle-CC2531F256.hex	ZID image for Nano USB
<b>CC2531 USB dongle:</b>	ZID_Dongle-CC2531F256.hex	ZID image for USB dongle
<b>Target module:</b>	RNP-CC2533F96.hex	Remote Network Processor

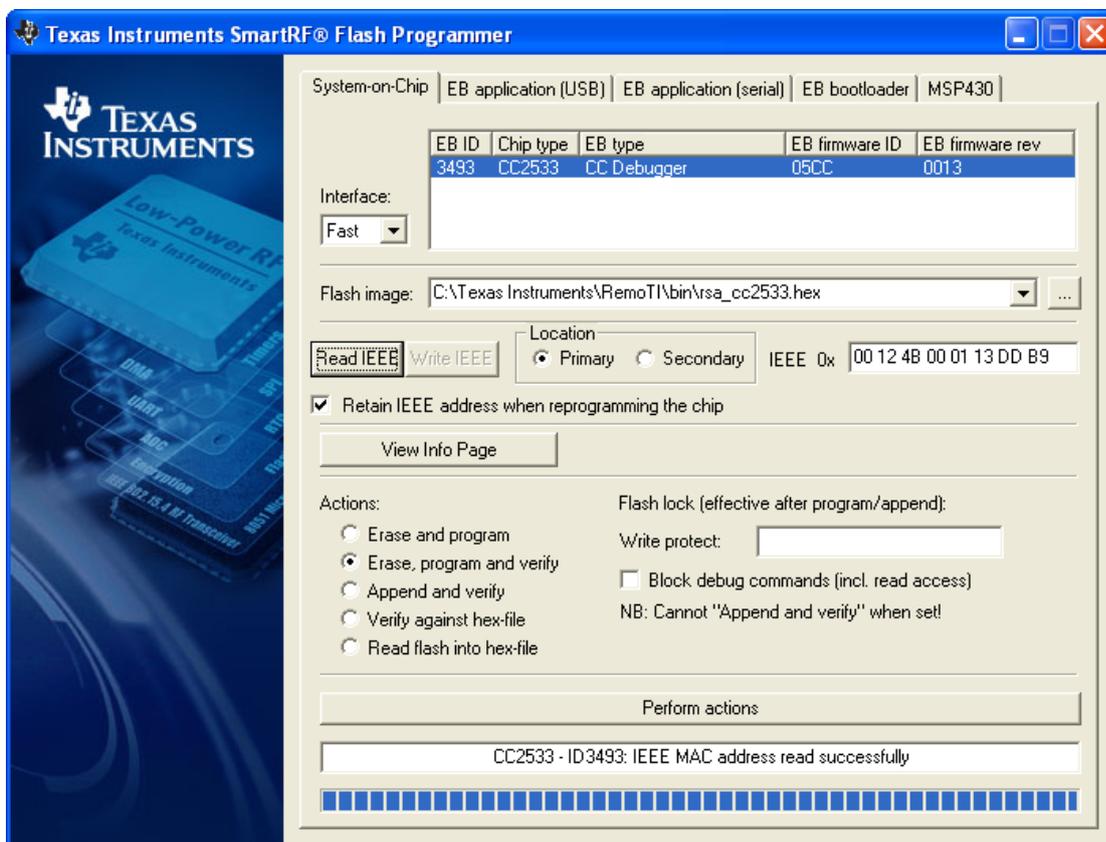
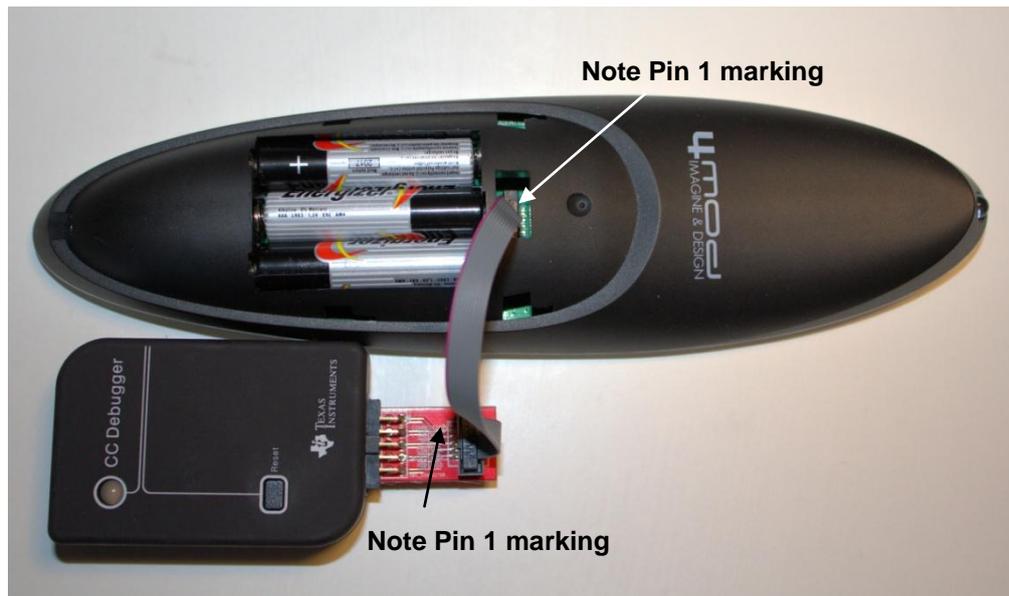


Figure 5-1: SmartRF flash programmer interface

### 5.2 Programming and debugging the remote control

The CC2533 can be programmed and used as an in-circuit emulator using the debugging interface on the rear under the battery compartment cover. The CC Debugger is used to program and debug remote control applications.



**Figure 5-2: Connecting the remote control to the CC Debugger**

Care should be taken when connecting the CC Debugger cable to the remote control. There is no protection from connecting the cable with wrong orientation. The pin 1 marking on the CC Debugger adapter board must match the pin 1 marking on the remote control.

On the CC Debugger adapter board pin 1 is marked with a **triangle** and **1** close to the connector. On the remote control pin 1 is marked with a **1** on the PCB close to the connector.

The batteries must be inserted in the remote control to provide power to the target module before programming.

Press the Reset button on the CC Debugger after the USB is connected, the LED on the CC Debugger should now turn green

### **5.3 Programming and debugging the target module**

The CC Debugger can be used to program and debug applications on the target module. See Figure 5-3 for instruction how to connect the CC Debugger. The connectors on both the CC Debugger and the target module are fitted with a sleeve to make sure the cable can only be fitted with correct orientation.

The USB cable must be connected to provide power to the target module before programming.

Press the Reset button on the CC Debugger after the cables are connected, the LED on the CC Debugger should now turn green



## 6 The Target Module

The target module is designed to allow flexible interfaces for many common types of interfaces used in typical remote control applications. The target module uses a CC2533EM RF reference design

### 6.1 Target module hardware description

#### 6.1.1 CC2533EM interface

The signal names for the CC2533EM interface is detailed in Table 6-1:

EM header	RemoTI target module signal	EM header	RemoTI target module signal
P1_01	GND	P2_01	
P1_03	UART_CTS	P2_03	
P1_05	I2C_SCL	P2_05	
P1_07	UART_RX	P2_07	VCC_EM
P1_09	UART_TX	P2_09	VCC_EM
P1_11	I2C_SDA	P2_11	
P1_13	IR_OUT1	P2_13	
P1_15		P2_15	EM_RESET
P1_17	LED0	P2_17	BUTTON
P1_19	GND	P2_19	LED1
P1_02		P2_02	GND
P1_04	FLASH_CS	P2_04	
P1_06	IR_IN	P2_06	
P1_08		P2_08	
P1_10	DD	P2_10	
P1_12	DC	P2_12	USBM
P1_14	CSN	P2_14	USBP
P1_16	SCLK	P2_16	
P1_18	MOSI	P2_18	UART_RTS
P1_20	MISO	P2_20	

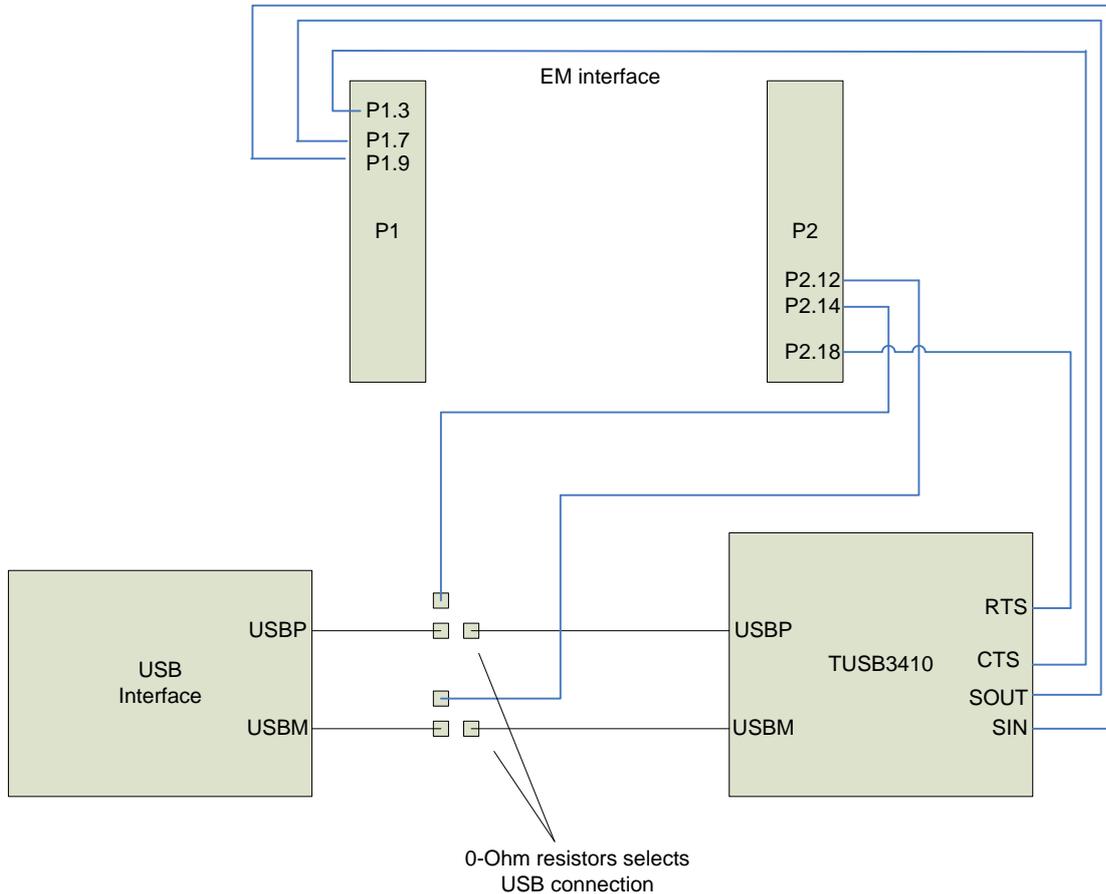
**Table 6-1: EM module interface**

Connector P1 and P2 are SMD, 2x10 pin row headers with 0.05in spacing. The part number is TFM-110-02-SM-D-A-K-TR and it is produced by Samtec, [www.samtec.com](http://www.samtec.com). The distance between P1 and P2 is 1200 mils (centre to centre).

### 6.1.2 USB

The USB port is used for powering the board and for serial interface to the CC2533. A TUSB3410 is used to translate the serial port interface to USB interface.

Future versions of the target module may use devices with integrated USB interfaces. In order to support devices with integrated USB interface 0-ohm resistors are used to select between interfacing USB directly to TUSB3410 and to the EM connector.



**Figure 6-1: USB interface selection with 0-ohm resistor**

### 6.1.3 Power supply

The board is powered from the USB connector, the voltage is 3.3V. The USB voltage is regulated using a TPS79333 voltage regulator. The power supply of the board supports current consumption up to 200mA. A jumper (J1) is mounted on the power supply line to allow easy measurement of current consumption. Note that when measuring current consumption, the TUSB3410 USB interface device may draw up to 15mA in active mode.

### 6.1.4 Interface connectors

A 2x7 pin header, 2.54 mm pitch on the edge of the board (J4) is used for connecting external equipment to the target module. The board has marking of the pin names as shown in Table 6-2.

The pinout of the connector is shown in Table 6-2. EM connector number in parentheses.

Signal name	Pin #	Pin #	Signal name
GND	1	2	VDD
UART RX(P1.7)	3	4	UART TX(P1.9)
UART CTS(P1.3)	5	6	UART RTS(P2.18)

SPI CSN(P1.14)	7	8	SCLK(P1.16)
MOSI(P1.18)	9	10	MISO(P1.20)
I2C SDA(P1.11)	11	12	I2C SCL(P1.5)
EM_RESET((P2.15)	13	14	IR_OUT1(P1.13)

**Table 6-2: Interface header pinout**

### 6.1.5 Debug interface

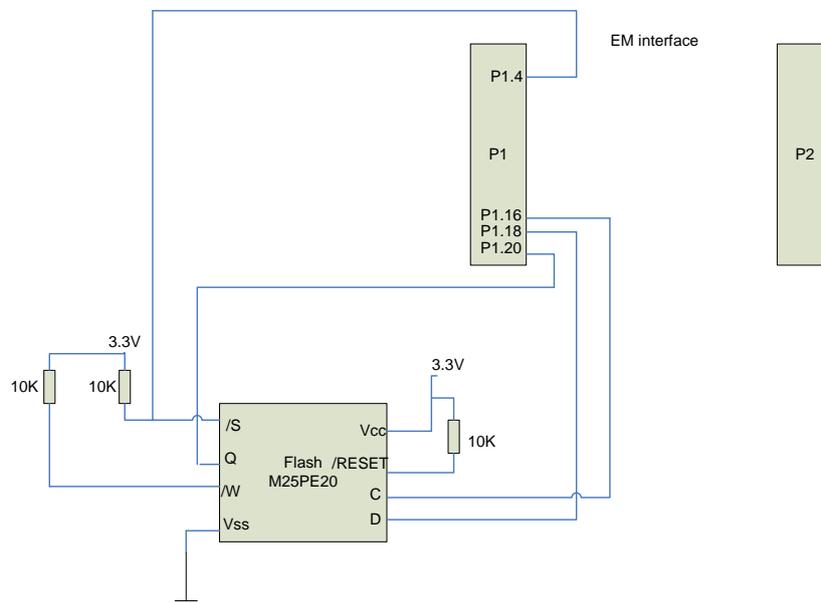
A 2x5 pin 1.27 mm pitch header (J5) is used for programming and debugging the CC2533 on the EM socket. The pinout of this connector is shown in Table 6-3 below. EM connector pin numbers in parentheses.

Signal name	Pin #	Pin #	Signal name
GND	1	2	VDD
DC(P1.12)	3	4	DD(P1.10)
CSN(P1.14)	5	6	SCLK(P1.16)
EM_RESET(P2.15)	7	8	MOSI(P1.18)
NC	9	10	MISO(P1.20)

**Table 6-3: Debug Header pinout**

### 6.1.6 Dataflash

A 2 megabit serial dataflash on the board interfaces to the SPI. The dataflash used is a Micron M25PE20. The flash SPI interface is connected to the SPI interface on the EM connector. The flash chip select signal is controlled by the FLASH\_CS signal (P1.4). The dataflash can be used for storing IR code libraries or Over the Air Download (OAD) images if the devices support downloading new program memory from the RF interface.


**Figure 6-2: Serial flash interface details**

### 6.1.7 IR Interface

The IR interface includes an IR receiver and 1 channel IR output. The IR receiver is connected to a timer input capture channel to measure IR signals. The IR output is connected to a timer output pin to generate IR waveforms.

The IR receiver is a Vishay TSOP85238. The receiver is optimized for 38 KHz input signal. The IR input is connected to the IR\_IN signal

The IR transmitter is a Vishay TSKS5400S. The diode is only used for short distance IR signals as the target module is intended to be mounted on the receiver side of the equipment. The IR diode is controlled by the IR\_OUT1 signals. The IR\_OUT1 signal is accessible on pin 12 of the interface header connector to allow driving external signals with the IR output.

#### 6.1.7.1 IR transmitter polarity

The target module shipped with this kit has changed the polarity for the I/O pin driving the IR signal from active low to active high signal. This change can easily be implemented on older target modules shipped with the CC2530EM.

In order to change the polarity of this signal, make the following changes:

- Remove Q1
- Change R18 (1kohm) with a zero ohm resistor
- Short circuit two pads (marked in red) on Q1 footprint

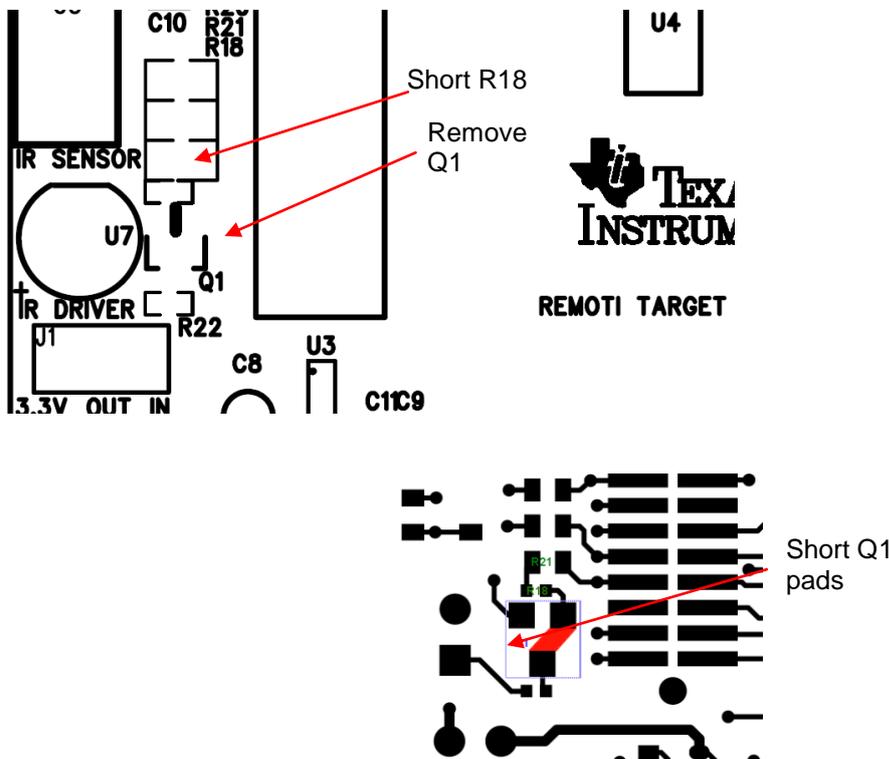


Figure 6-3: Changing polarity of IR control signal to active high

#### 6.1.8 Buttons and LEDs

The target module includes a push button which can be used to associate the target board and the remote control. In addition there is a reset button to reset the board.

The LEDs are controlled by the signals LED0 and LED1. The red LED is marked "STATUS" and the green LED is marked "LINK".

## 7 Appendix A: Opening the remote control

Yes, we know you will do it... Here are the instructions how to open the remote controls without breaking it.

### 7.1 Advanced remote control



**Figure 7-1: Tools for opening the remote**

Some versions of the remote have screws inserted in the battery area, if they are assembled remove these first. Then use a screwdriver to gently part the top and bottom plastic casing as seen in Figure 7-2.

When the first connection joints are separated, follow the edge around the sides of the remotes with a flat screwdriver and press carefully to take it apart



**Figure 7-2: Opening the remote control**

## 7.2 Basic remote control

First insert two thin flat screwdrivers on the bottom of the remote between the two slots. Press carefully to open the casing on the bottom.



**Figure 7-3: Opening the remote control, step one**

When the bottom of the remote is opened, follow the edge around the sides of the remotes with a flat screwdriver and press carefully to take it apart



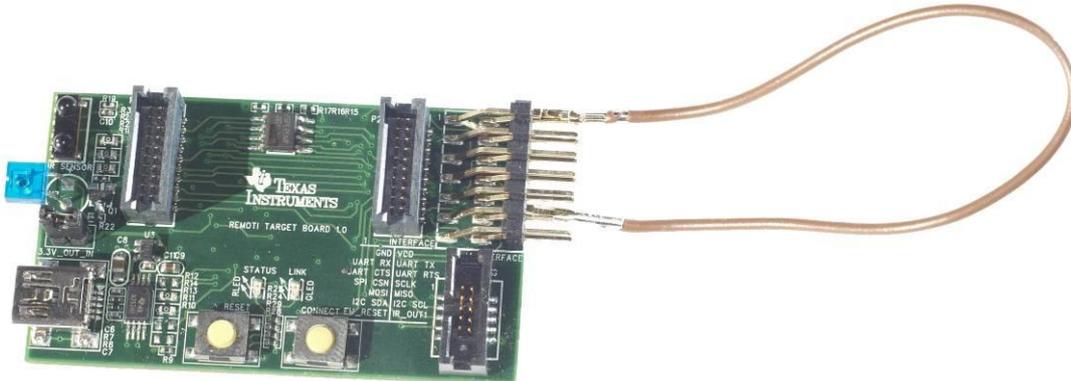
**Figure 7-4: Opening the remote control, step two**

## 8 Appendix B: How to upgrade the target module USB driver

The target module USB driver information is stored in an EEPROM for the TUSB3410 USB interface device. This EEPROM includes Vendor ID, USB ID, USB device name, and serial number. The EEPROM can be customized by programming the EEPROM via the USB interface.

To modify the EEPROM content, download the EEPROM burner SW: <http://www.ti.com/lit/zip/sllc259>. Install the program on the PC

Remove the CC2533EM from the target module and short the pins 1(GND) and pin 11(I2C SDA) on the interface header to short the EEPROM data signal to GND. Plug in the mini-USB connector.



**Figure 8-1: Short pin 1(GND) and pin11 (SDA)**

The device should now identify as a TUSB3410 device on the PC, and the new hardware wizard will be displayed. If the wizard is not displayed, go to “Control Panel -> System -> Device Manager -> Port (COM & LPT) right click on the TUSB3410 Device driver and select “Update Driver”.

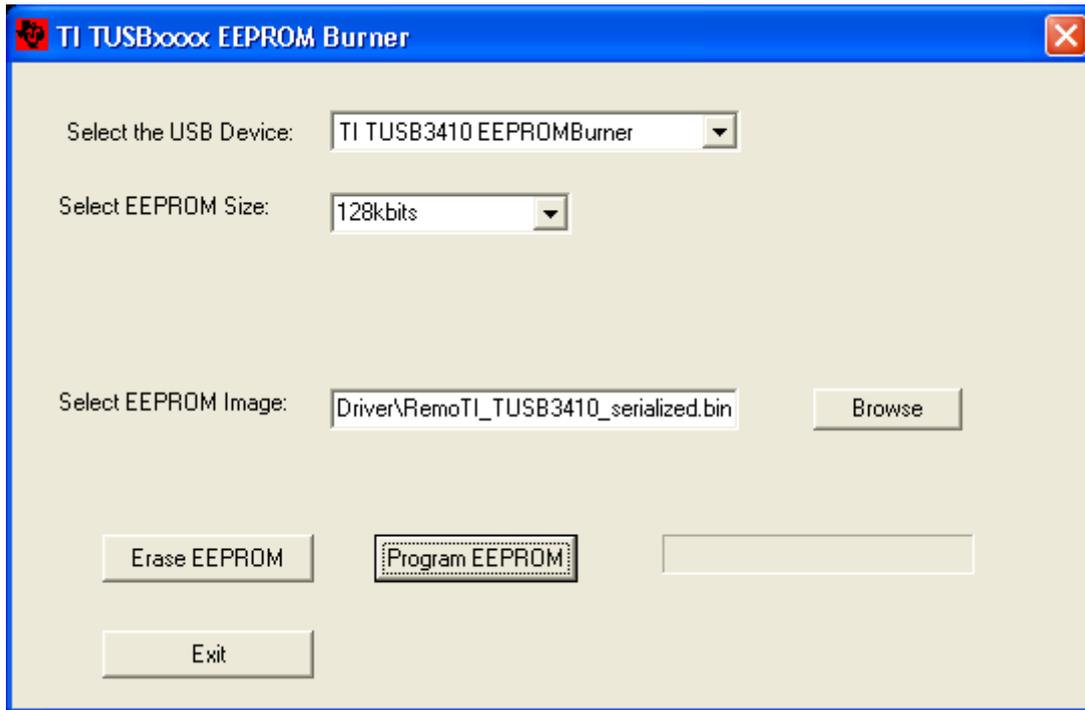


**Figure 8-2: Installing the EEPROM burner driver**

The device should now be appearing as an EEPROM burner device in the USB devices device list. Start the EEPROM burner software, select the TUSB3410 EEPROM Burner devices from the device list, 128Kb EEPROM size and load the file

<Installation path>\Tools\Driver\ RemoTI\_TUSB3410\_serialized.bin

Remove the short on the pins 1(GND) and pin 11(I2C SDA) on the interface header before clicking “Program EEPROM”



**Figure 8-3: Using the EEPROM burner software**

After successful programming, unplug the mini-USB cable, mount the CC2533EM on the target module and plug in the mini-USB cable again. The target module will now appear as a COM port in the device manager.

## 9 Schematic and Layout

The complete design files including schematic and layout for the remote control, target module, and EM module can be downloaded from <http://www.ti.com/remoTI>

### 9.1 *Layout considerations for the advanced remote*

The current design has 3x1.5V AAA batteries, the radio has a minimum operational voltage level of 2V so it is possible to make the remote with 2x1.5V batteries. This prototype design was made with a buzzer which operation level higher than 3V in addition the initial gyro needed higher operation voltage level then the gyro currently used. Since the remote control casing was designed based on the previous design the input voltage level is 4.5V.

The LDOs used for the gyro is most likely not needed and were designed in for a previous version of the gyro with the same footprint.

The number of shift registers is selected so that the design should be able to support a large number of buttons, if this is not applicable for your design these can be removed accordingly.

## 10 Document History

Revision	Date	Description/Changes
-	2010-08-16	First revision.
Swru266A	2012-01-10	Updated with Advanced remote content

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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

---

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~

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