Bluetooth Low Energy
Hands On Training

TI CC2540DK-MINI Hardware

Debugger

- Works with keyfob and USB dongle
- Supports IAR and TI flash programmer

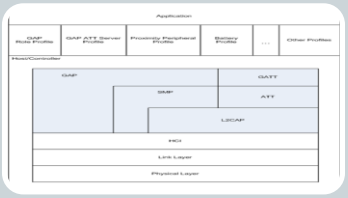
CC2540 Keyfob

- Powered by CR2032 coin cell battery
- LED, buttons, buzzer, accelerometer
- Usually acts as peripheral, application is on chip.

USB Dongle

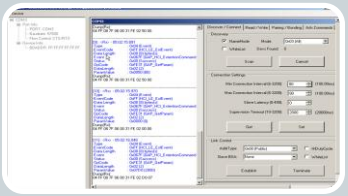
- Use Btool.exe to or custom app to send HCI commands.
- Usually acts as master (cell phone)

TI CC2540DK-MINI Software



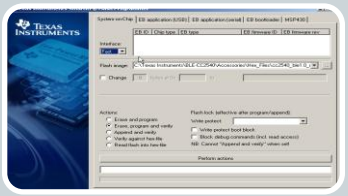
Stack Libraries

- Royalty free
- Full qualification
- Example Projects



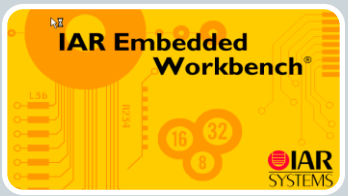
Btool Application

- Drives USB dongle with HCI commands
- Scan for devices, connect, authentication
- Log messages



SmartRF Flash Programmer

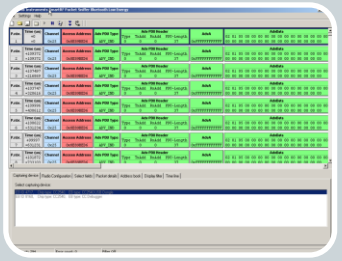
- Can flash CC2540
- Change address on device



IAR Compiler and IDE

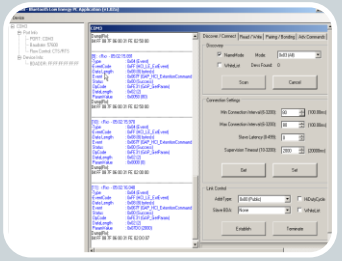
- Robust 8051 compiler with CC2540 support.
- 30 day free evaluation

TI CC2540DK-MINI Support



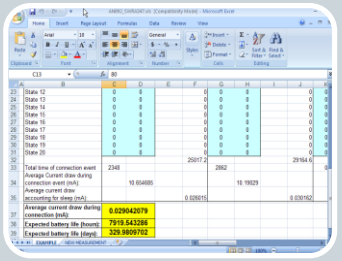
TI RF Sniffer

- Free
- Works with Mini Kit USB Dongle



Example Applications

- SimplePeripheral – keypress, strings
- KeyFobDemo – Accelerometer, buzzer, beeper, proximity, battery level.
- Other SIG profile applications under development



Power Calc Applications Note

- Excel sheet to help calculate battery life expectancy

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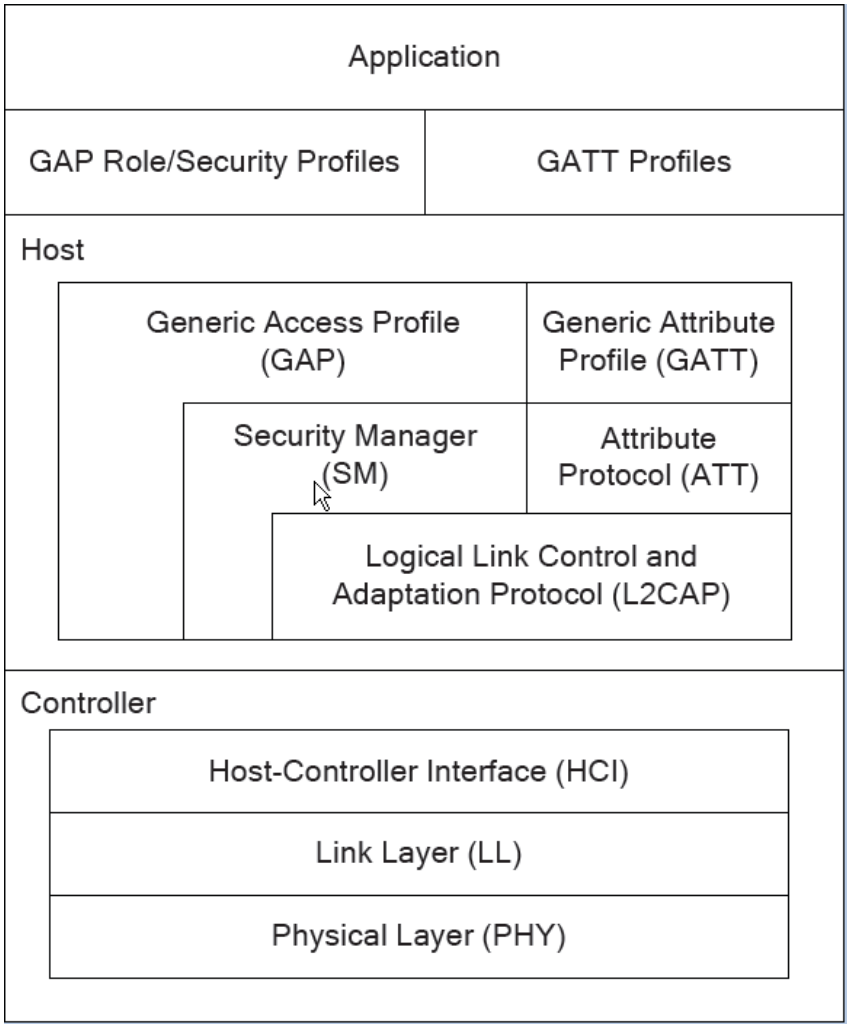
Device Configurations



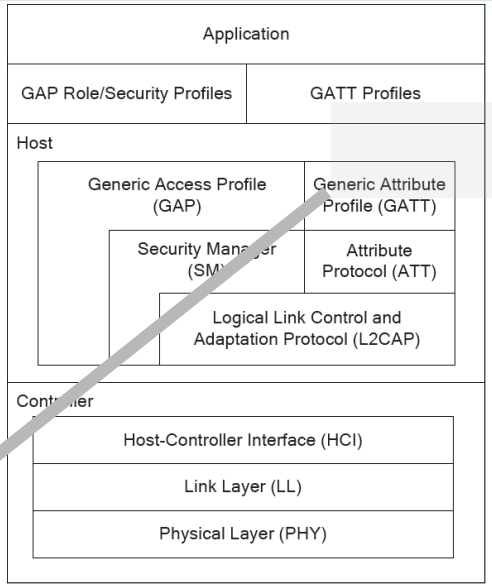
USB, Serial

Single Device (Keyfob)

Network Processor (USB Dongle)

GATT Table

- Allows master to scan for services
- Contains groups of characteristics
  - Name
  - Enable Notifications
  - Value
- SIG assigned numbers



Type (hex)	Type (#DEFINE)	Value (default)	Local Parameter Name	Application Permissions	GATT Server Permissions	Description
0x2800	GATT_PRIMARY_SERVICE_UUID	0xFFE0 (SK_SERVICE_UUID)			Read	Start of Service
0x2803	GATT_CHARACTER_UUID	10 (properties: notify only) 1F 00 (handle: 0x001F) E1 FF (UUID: 0xFFE1)			Read	Key Press State Characeristic Declaration
0xFFE1	SK_KEYPRESSED_UUID	0 (1 byte)	SK_KEY_ATTR	Read / Write	Notify	Key Press State Characteristic Value
0x2902	GATT_CLIENT_CHAR_CFG_UUID	00:00 (2 bytes)			Read	Key Press State Characteristic Value
0x2901	GATT_CHAR_USER_DESC_UUID	"Key Press State" (16 bytes)			Read	Key Press State Characteristic Configuration

Labs

KeyPress

- Use TI flash programmer to assign address and flash images.
- Enable keypress notifications from keyfob to USB dongle.
- Use Btool to see logging

Sniffer

- Load sniffer image into USB Dongle
- Enable advertisements on keyfob and watch on sniffer.

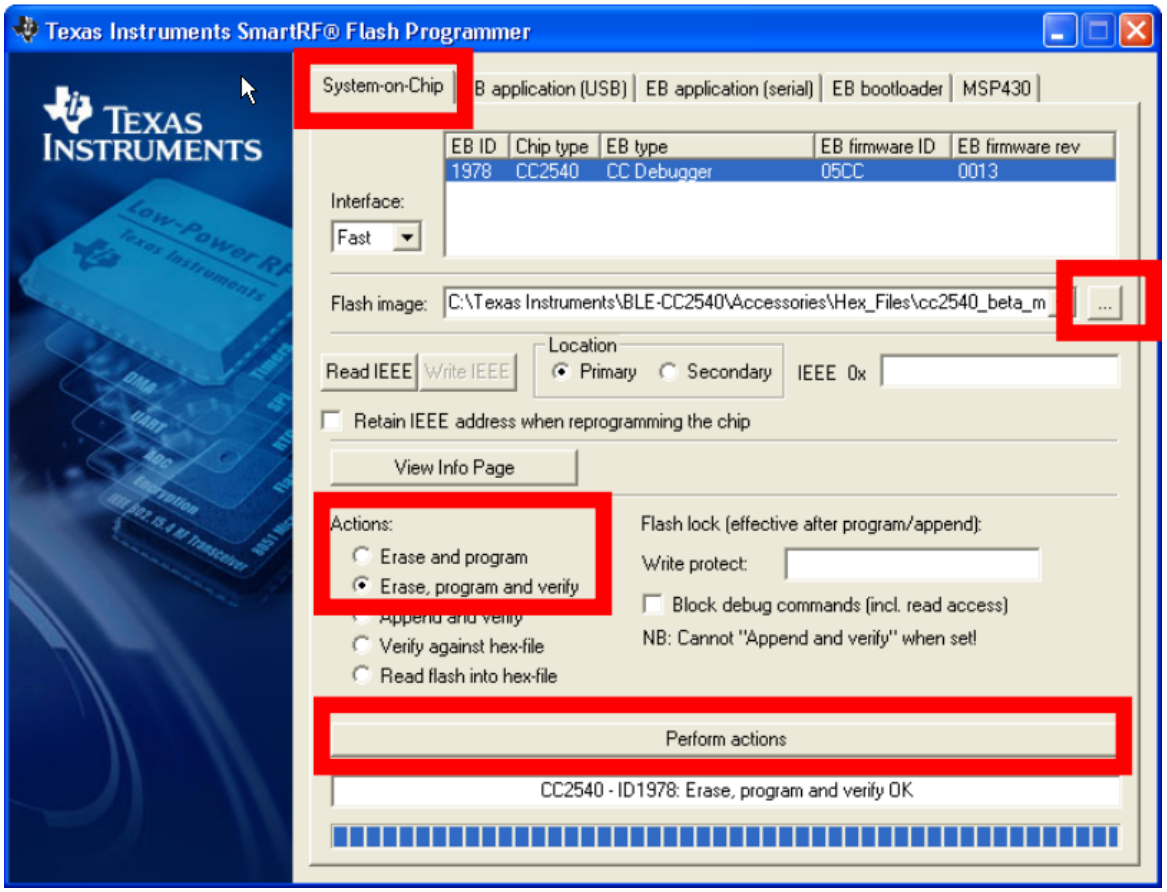
Accelerometer (optional)

- Load keyfobdemo application
- Enable accelerometer notifications

Lab #1.1

1. Connect USB Dongle and CC Debugger as shown
2. CC debugger light should be green and USB dongle LED should be green.

Lab #1.2

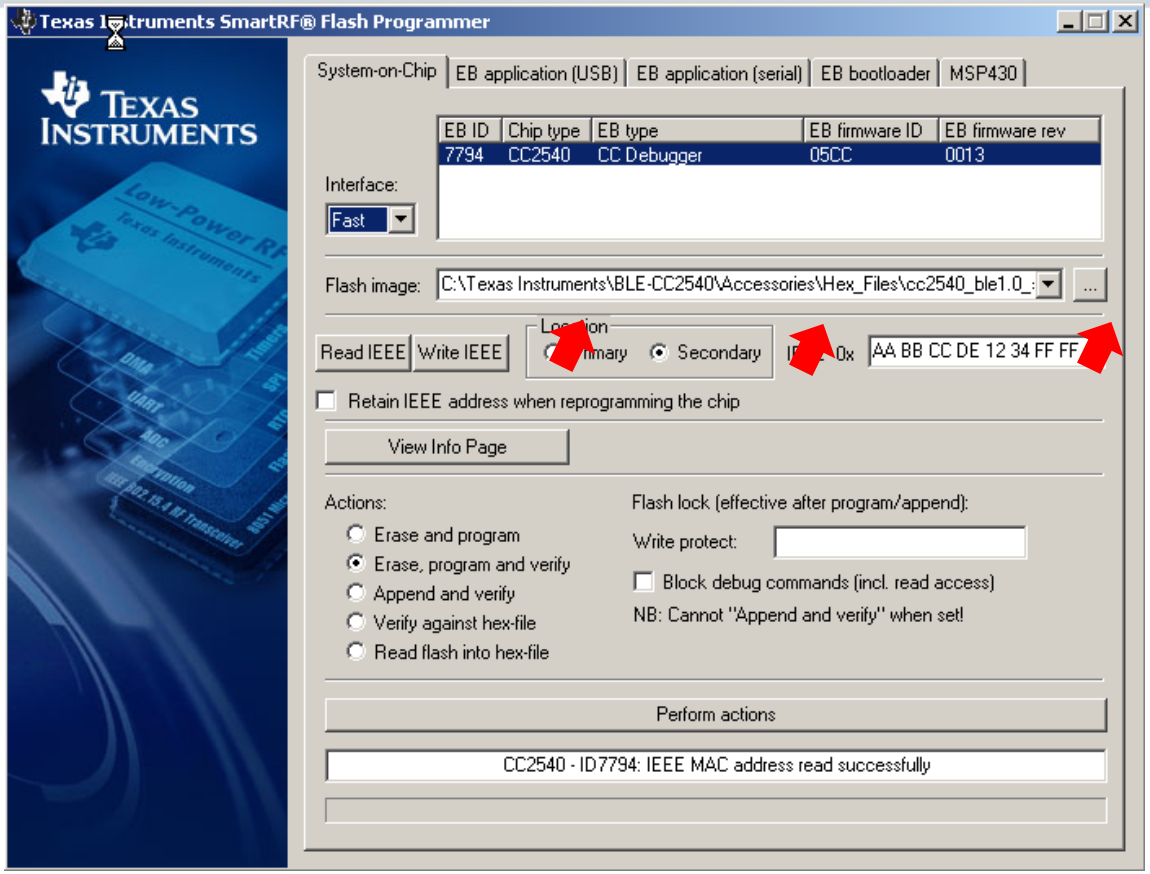


1. Use SmartRF flash programmer to download .hex file

C:\Texas Instruments\BLE-CC2540\Accessories\Hex_Files\cc2540_ble1.0_master_usb_dongle.hex

* USB Dongle LED should turn red

Lab #1.2b



1. Use SmartRF flash programmer change address

Click secondary radio button
Enter in new address – left six bytes
Click Write IEEE
Read back to verify

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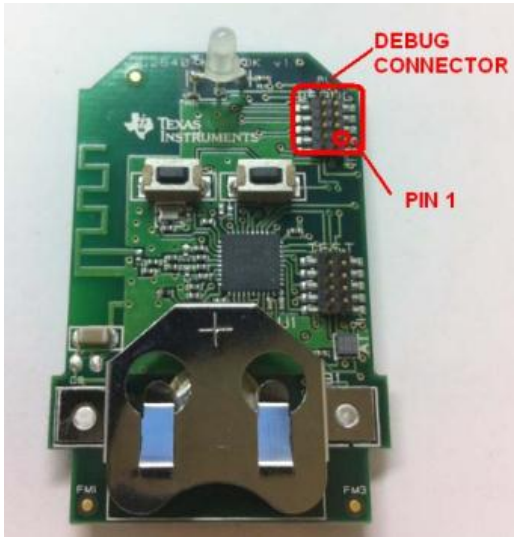
Lab #1.3

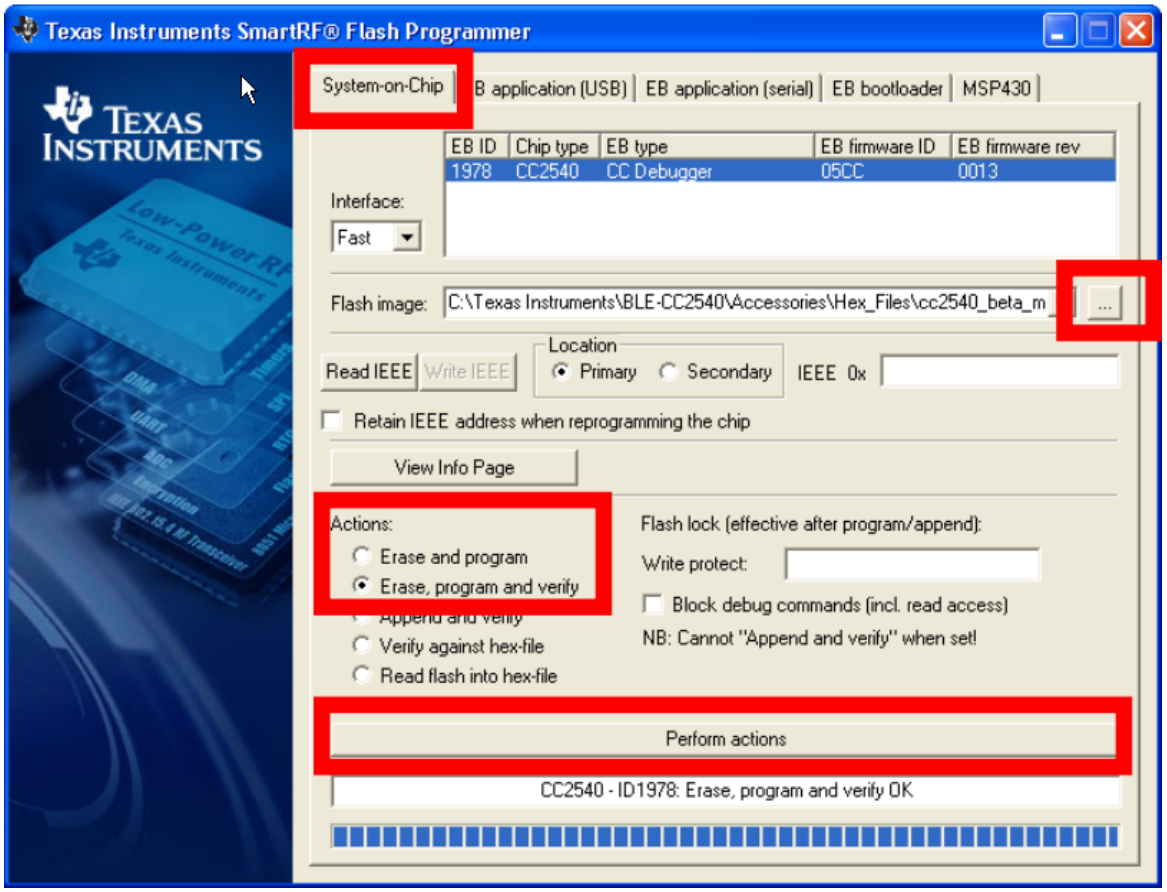
1. Connect keyfob and CC Debugger as shown
2. Insert battery
3. Press button to stop buzzer
4. CC debugger light should be green. (may need to detach and attach USB cable)



1. Use SmartRF flash programmer to download .hex file

C:\Texas Instruments\BLE-CC2540\Accessories\Hex_Files\cc2540_ble1.0_slave_keyfob.hex

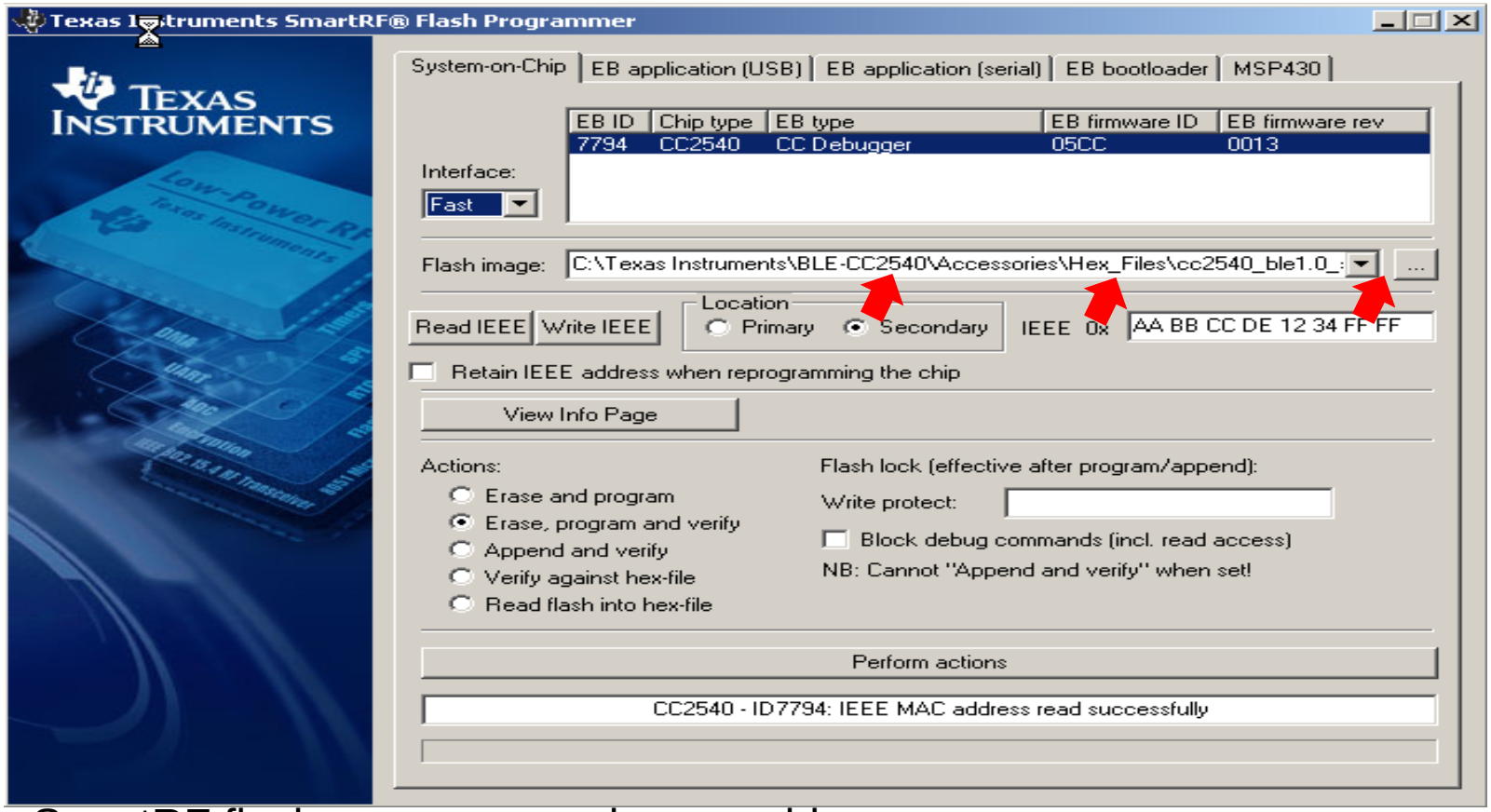
Lab #1.4



1. Use SmartRF flash programmer to download .hex file

C:\Texas Instruments\BLE-CC2540\Accessories\Hex_Files\cc2540_ble1.0_slave_keyfob.hex

Lab #1.4b



1. Use SmartRF flash programmer change address

Click secondary radio button
Enter in new address – left six bytes
Click Write IEEE
Read back to verify

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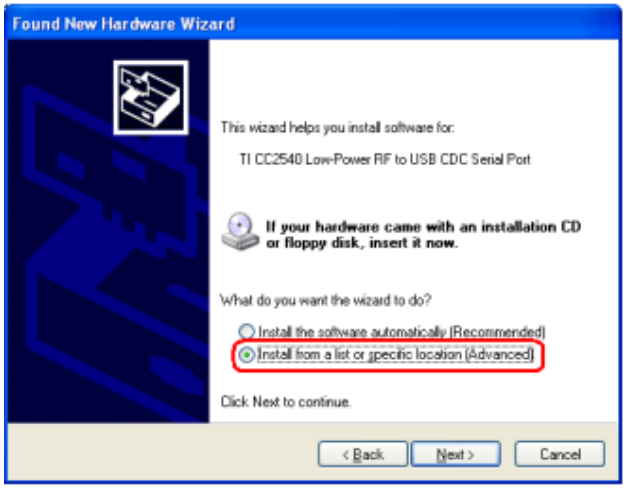
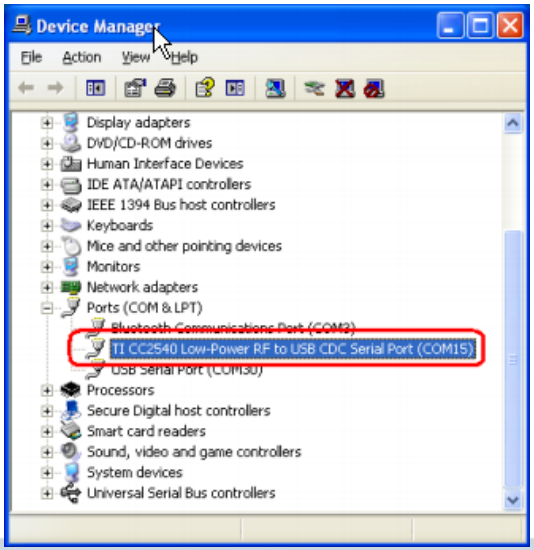
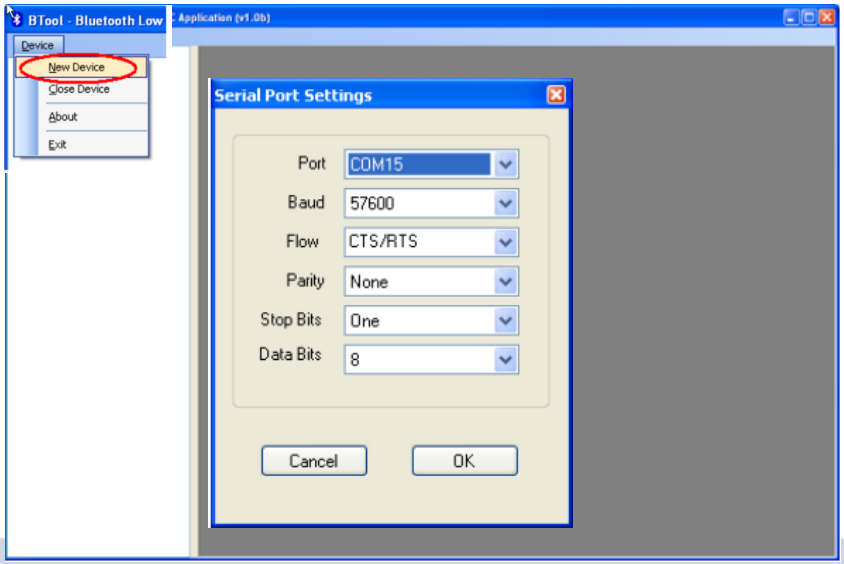
Lab #1.5

1. Plug in USB Dongle, install driver from - C:\Texas Instruments\BLE-CC2540\Accessories\Drivers
2. Use Device Manager to determine COM used for USB Dongle.
3. Start Btool.exe (C:\Texas Instruments\BLE-CC2540\Projects\Btool)
4. Open Device (this is COM port which USB Dongle shows up as)







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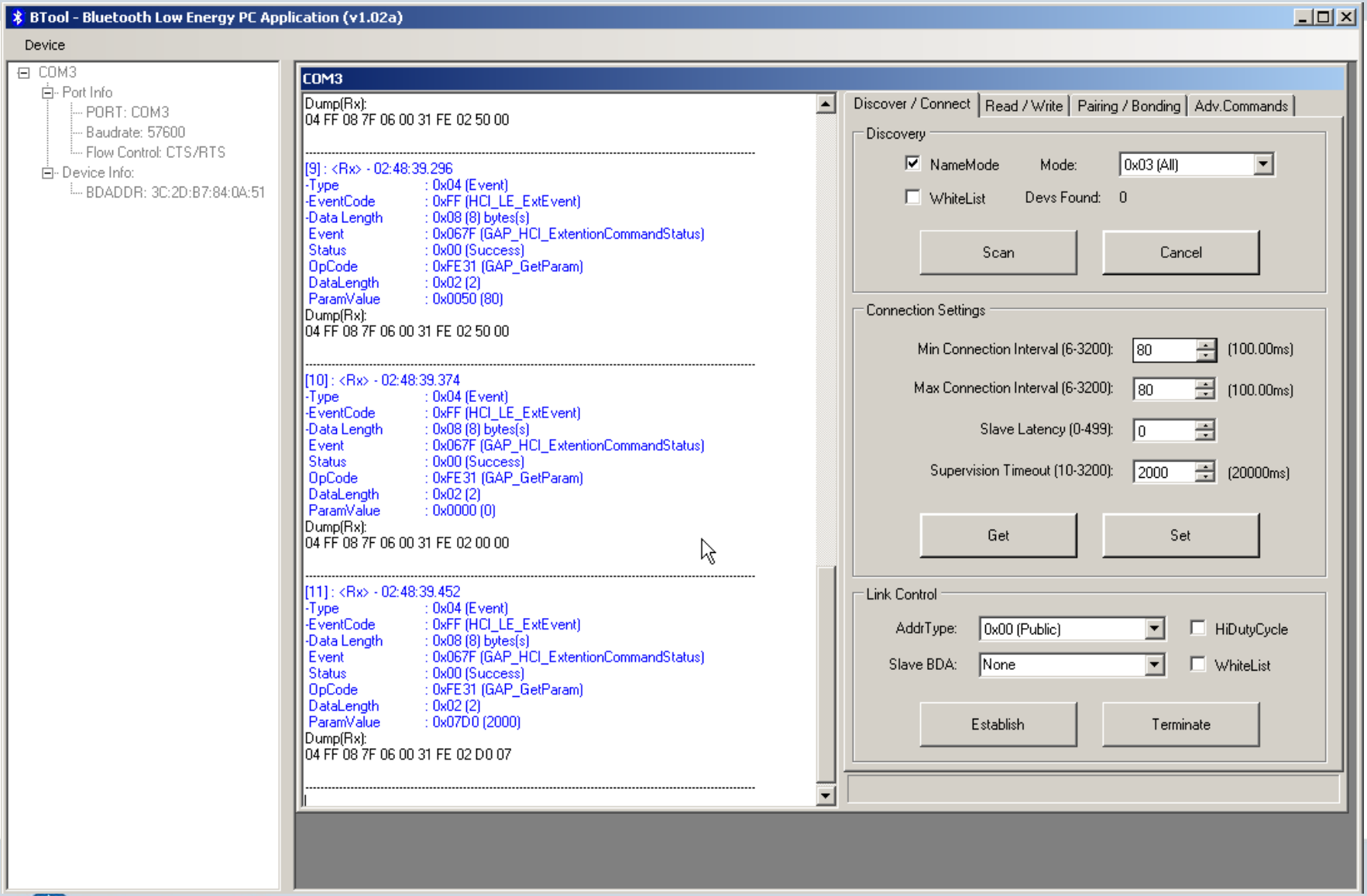
Lab #1.6



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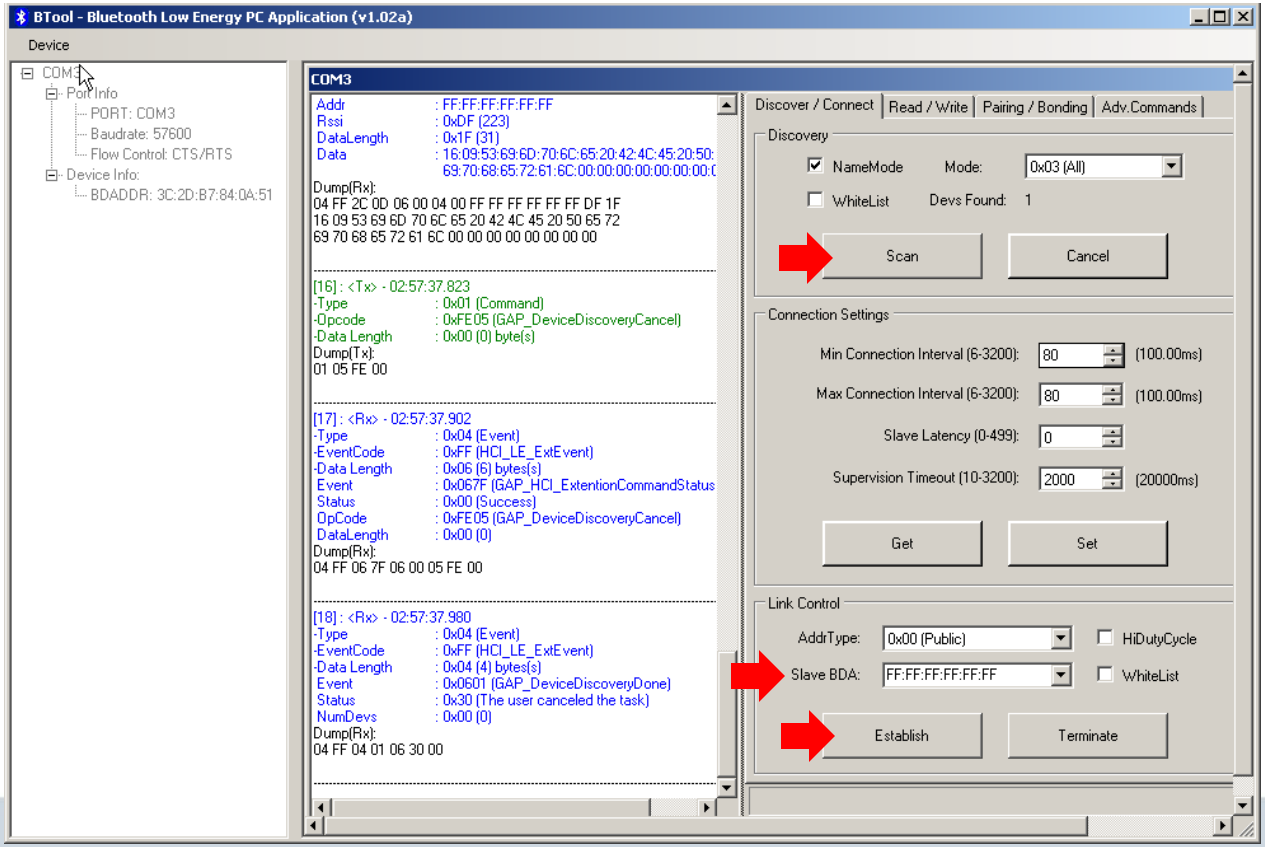
Lab #1.7

1. Press button on keyfob to begin advertising for 20 sec
2. Scan, select you keyfob address, and establish



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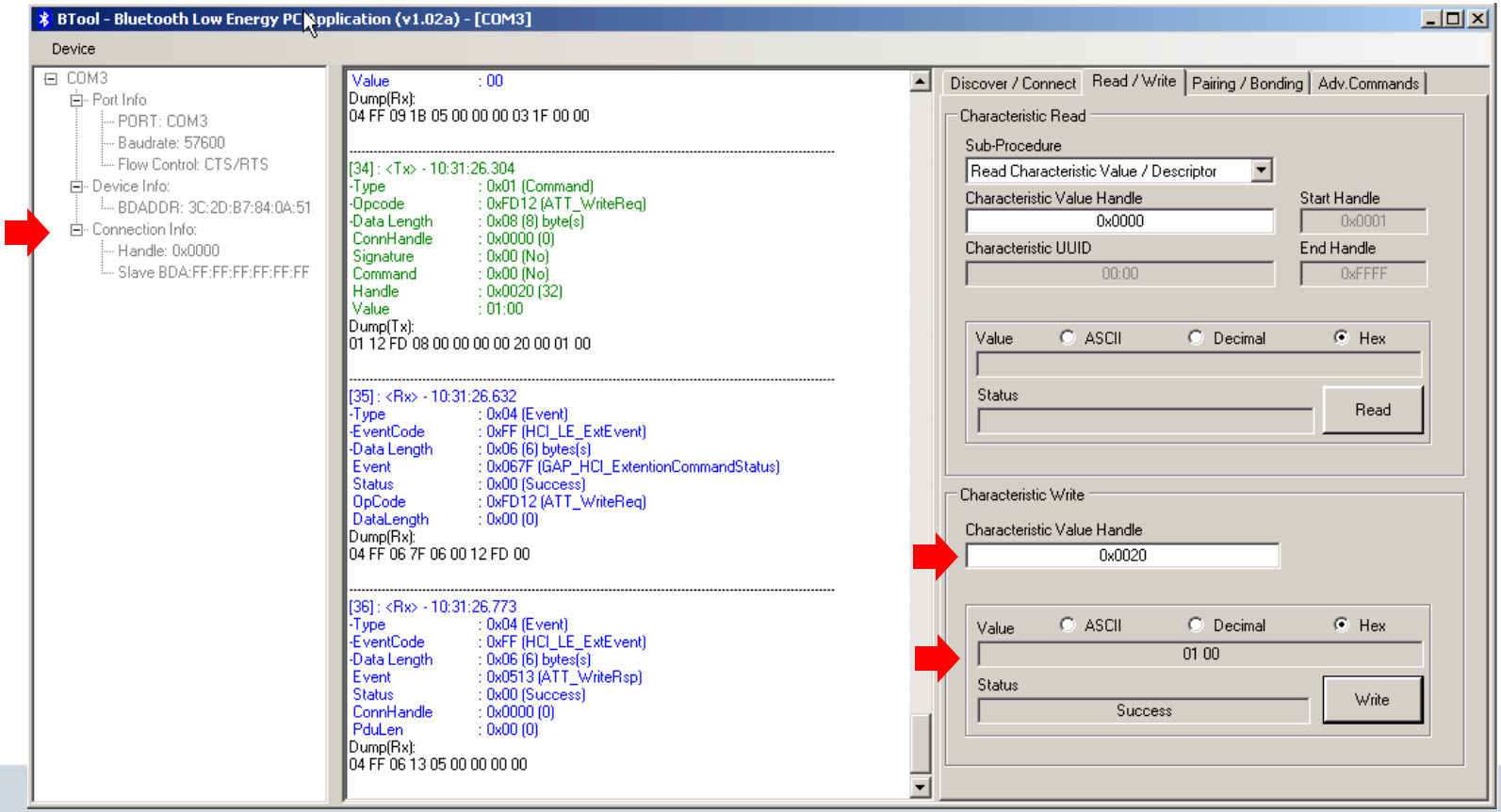
Lab #1.8

0x1D	29	0x2800	GATT_PRIMARY_SERVICE_UUID	0xFFE0 (SK_SERVICE_UUID)	GATT_PERMIT_READ	Start of Simple Keys Service
0x1E	30	0x2803	GATT_CHARACTER_UUID	10 (properties: notify only) 1F 00 (handle: 0x001F) E1 FF (UUID: 0xFFE1)	GATT_PERMIT_READ	Key Press State characteristic declaration
0x1F	31	0xFFE1	SK_KEYPRESSED_UUID	0 (1 byte)	(none)	Key Press State characteristic value
0x20	32	0x2902	GATT_CLIENT_CHAR_CFG_UUID	00:00 (2 bytes)	GATT_PERMIT_READ | GATT_PERMIT_WRITE	Key Press State characteristic configuration
0x21	33	0x2901	GATT_CHAR_USER_DESC_UUID	"Key Press State" (16 bytes)	GATT_PERMIT_READ	Key Press State characteristic user description

1. Verify connection in left pane
2. Write “01 00” to address 0x0020
3. Press button on keyfob to see notifications



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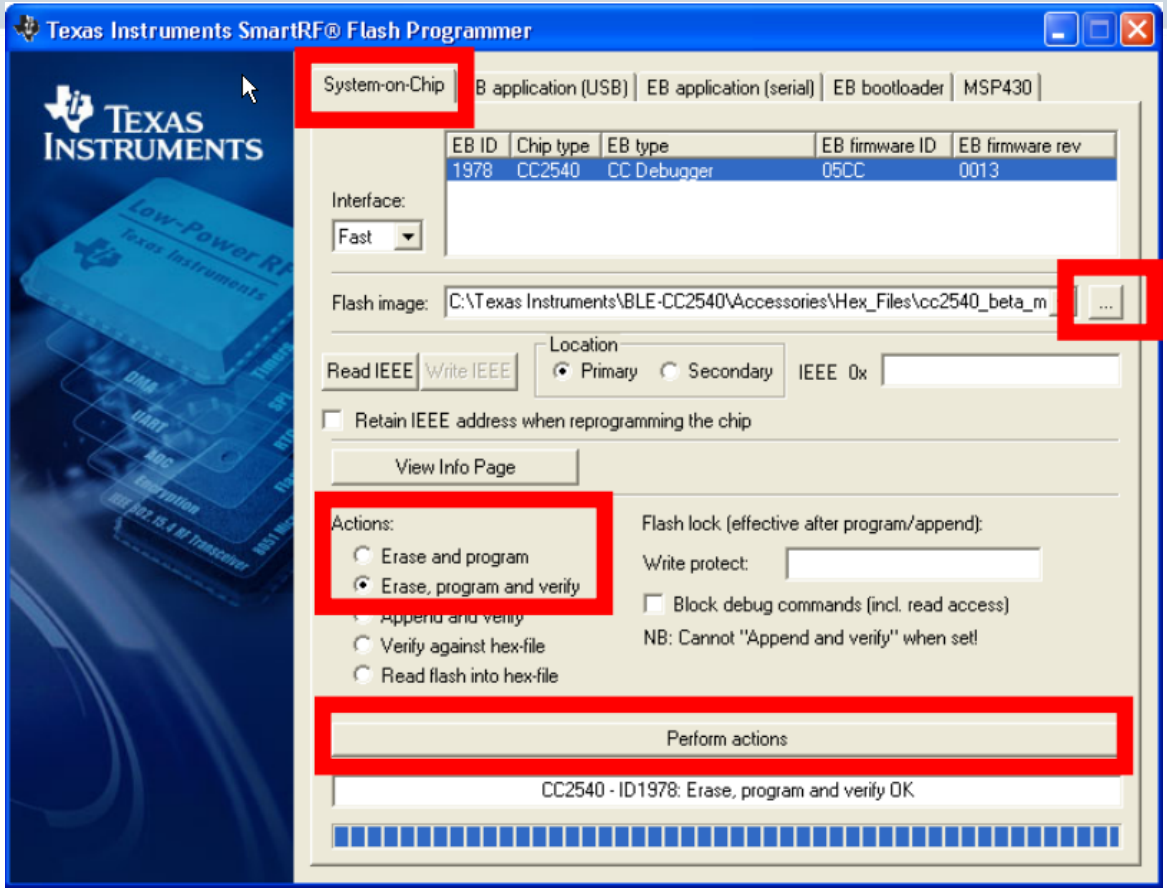
Lab #2.1

1. Connect USB Dongle and CC Debugger as shown
2. CC debugger light should be green.

Lab #2.2



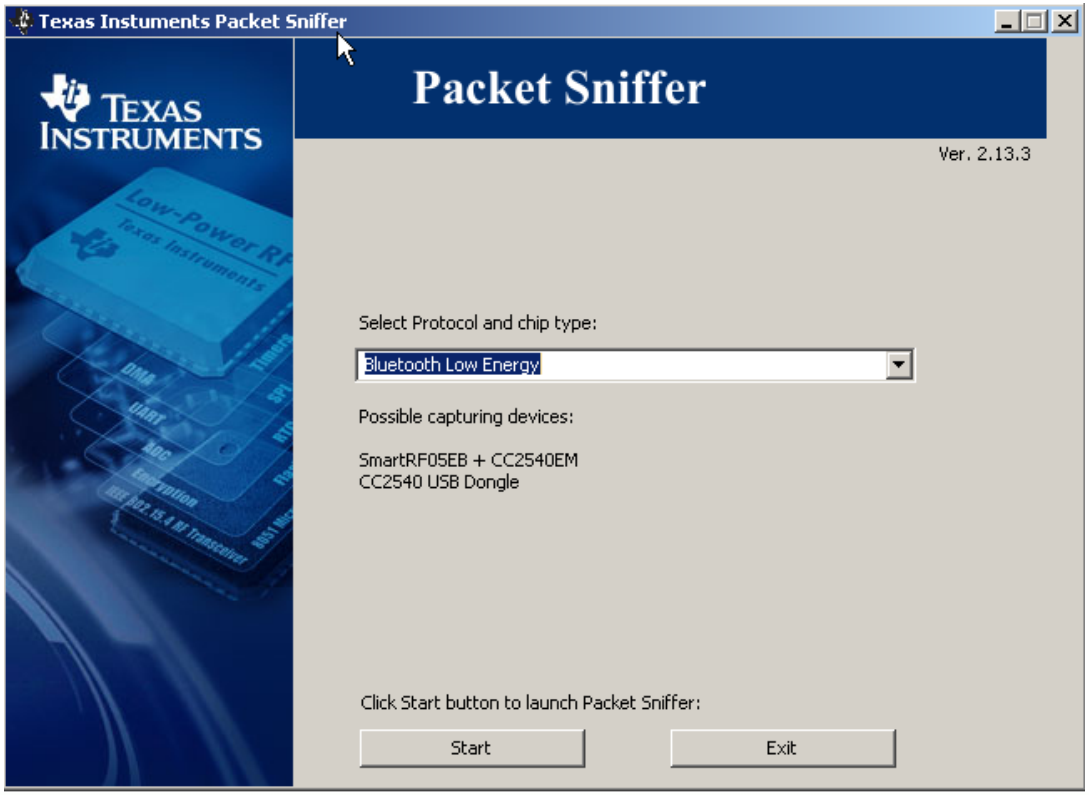
1. Use SmartRF flash programmer to download .hex file

C:\Program Files\Texas Instruments\Packet Sniffer\General\Firmware\sniffer_fw_cc2540_usb.hex

* USB Dongle LED should turn green

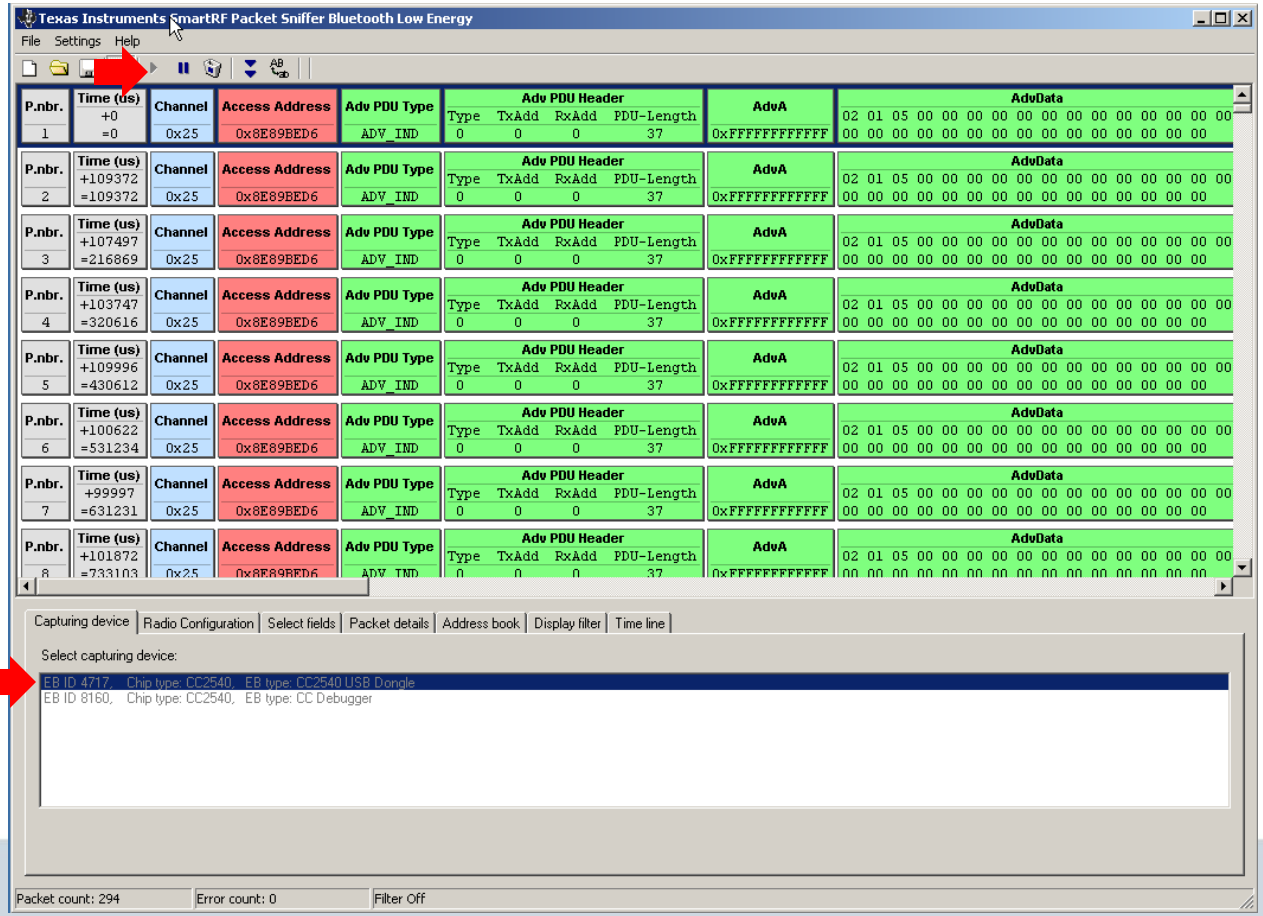
Lab #2.3

1. Start Packet Sniffer application
2. Select Bluetooth Low Energy



Lab #2.4

1. Select CC2540USB Dongle
2. Press play
3. Press button on keyfob to start advertising



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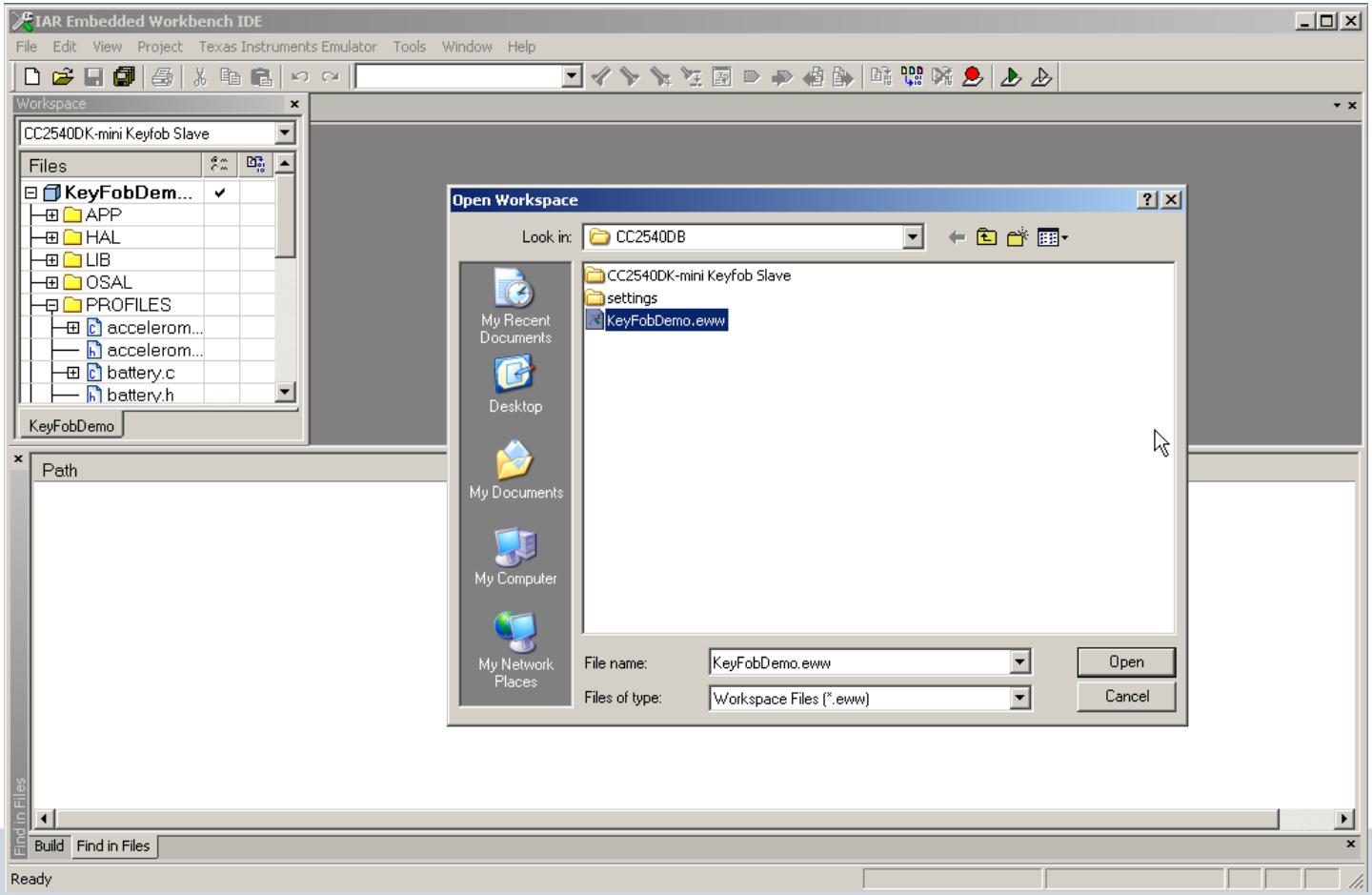
Lab #3.1 – Accelerometer and IAR

1. Download and unzip project from - http://processors.wiki.ti.com/images/e/ec/Keyfobdemo.zip
2. Extract to C:\Texas Instruments\BLE-CC2540
3. Open workspace C:\Texas Instruments\BLE-CC2540\Projects\ble\KeyFob\CC2540DB\KeyFobDemo.eww
4. Press play button to download and debug
5. Press Go button



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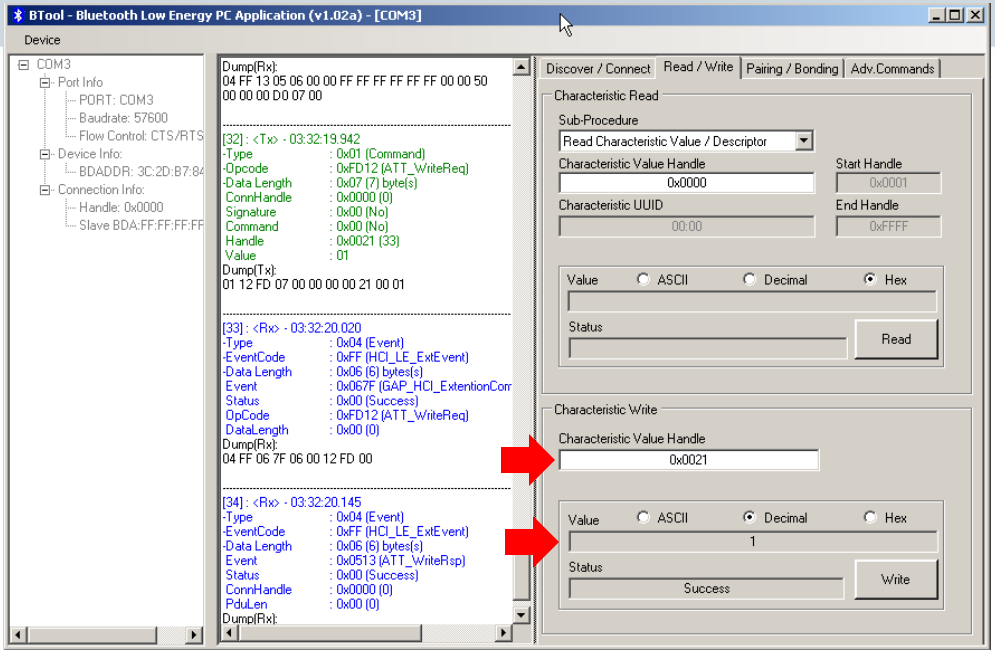
Lab #3.2 – Accelerometer and IAR

1. Start Btool
2. Scan and Connect
3. Write a “1” to 0x0021 to enable the accelerometer
4. Write a “01 00”to 0x0028 to enable the X axis notifications
5. Move the keyfob to generate notifications.



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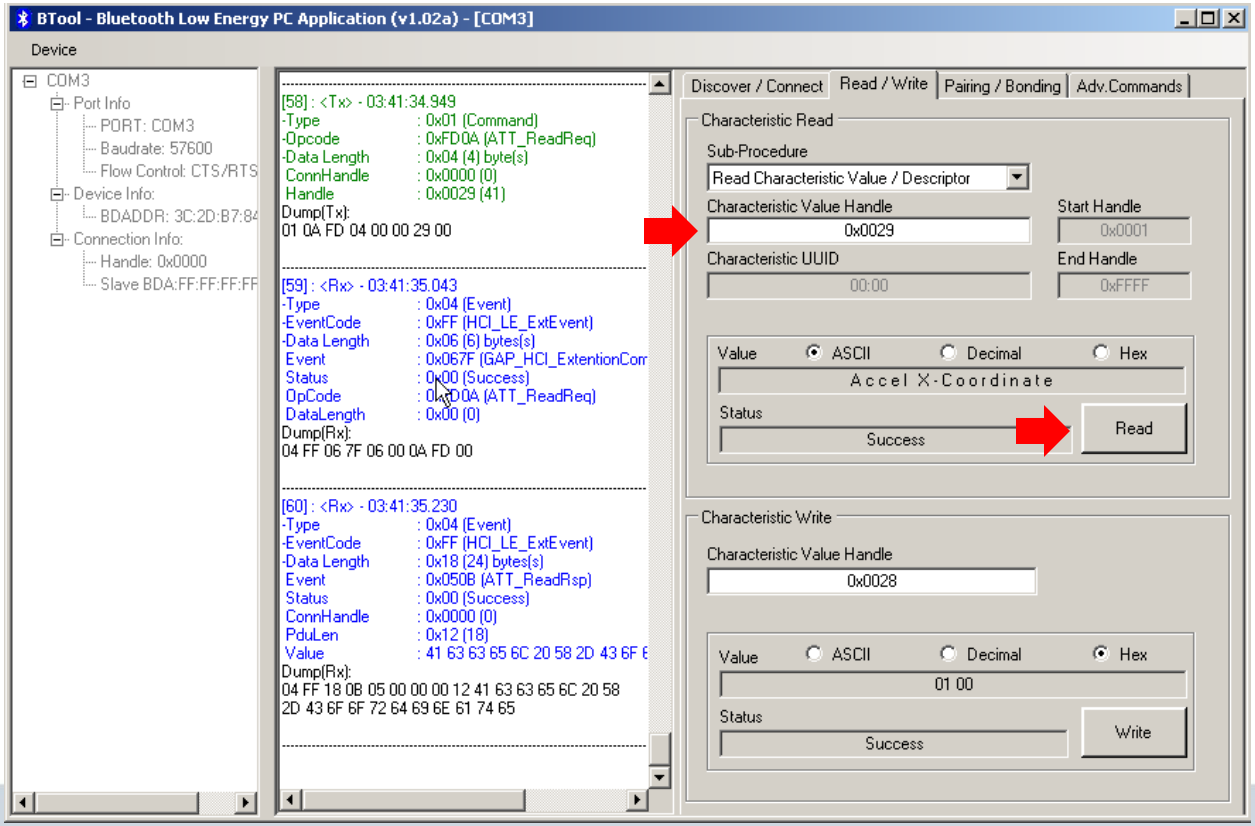
Lab #3.2 – Accelerometer and IAR

1. Enter 0X0029 in handle field
2. Click Read and change to ASCII
3. You should see Accel X-Coordinate
4. Change this in code with IAR.



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Lab #3.2 – Accelerometer and IAR

Portion of KeyFobDemo application table showing accelerometer GATT table.

handle (hex)	handle (dec)	Type (hex)	Type (#DEFINE)	Value (default)	Permissions	Notes
0x1F	31	0x2800	GATT_SERVICE_UUID	0xFFA0 (ACCEL_SERVICE_UUID)	GATT_PERMIT_READ	Start of Accelerometer Service
0x20	32	0x2803	GATT_CHARACTER_UUID	0A (read/write permissions) 21 00 (handle 0x0021) A1 FF (UUID 0xFFA1)	GATT_PERMIT_READ	Accelerometer enable characteristic declaration
0x21	33	0xFFA1	ACCEL_ENABLER_UUID	FALSE	GATT_PERMIT_READ | GATT_PERMIT_WRITE	Accelerometer enable characteristic value (TRUE or FALSE)
0x22	34	0x2901	GATT_CHAR_USER_DESC_UUID	"Accel Enable"	GATT_PERMIT_READ	Accelerometer enable characteristic user description
0x23	35	0x2803	GATT_CHARACTER_UUID	02 (read permission) 24 00 (handle 0x0024) A2 FF (UUID 0xFFA2)	GATT_PERMIT_READ	Accelerometer range characteristic declaration
0x24	36	0xFFA2	ACCEL_RANGE_UUID	20 (ACCEL_RANGE_2G)	GATT_PERMIT_READ	Accelerometer range characteristic value (can be 2G or 8G)
0x25	37	0x2901	GATT_CHAR_USER_DESC_UUID	"Accel Range"	GATT_PERMIT_READ	Accelerometer range characteristic user description
0x26	38	0x2803	GATT_CHARACTER_UUID	10 (notify permission) 27 00 (handle 0x0027) A3 FF (UUID 0xFFA3)	GATT_PERMIT_READ	Accelerometer X-coordinate characteristic declaration
0x27	39	0xFFA3	ACCEL_X_UUID		(none)	Accelerometer X-coordinate characteristic value
0x28	40	0x2902	GATT_CLIENT_CHAR_CFG_UUID	0x0000	GATT_PERMIT_READ | GATT_PERMIT_WRITE	
0x29	41	0x2901	GATT_CHAR_USER_DESC_UUID	"Accel X-Coordinate"	GATT_PERMIT_READ	Accelerometer X-coordinate characteristic user description
0x2A	42	0x2803	GATT_CHARACTER_UUID	10 (notify permission) 2B 00 (handle 0x002B) A4 FF (UUID 0xFFA4)	GATT_PERMIT_READ	Accelerometer Y-coordinate characteristic declaration
0x2B	43	0xFFA4	ACCEL_Y_UUID		(none)	Accelerometer Y-coordinate characteristic value
0x2C	44	0x2902	GATT_CLIENT_CHAR_CFG_UUID	0x0000	GATT_PERMIT_READ | GATT_PERMIT_WRITE	
0x2D	45	0x2901	GATT_CHAR_USER_DESC_UUID	"Accel Y-Coordinate"	GATT_PERMIT_READ	Accelerometer Y-coordinate characteristic user description
0x2E	46	0x2803	GATT_CHARACTER_UUID	10 (notify permission) 2F 00 (handle 0x002F) A5 FF (UUID 0xFFA5)	GATT_PERMIT_READ	Accelerometer Z-coordinate characteristic declaration
0x2F	47	0xFFA5	ACCEL_Z_UUID		(none)	Accelerometer Z-coordinate characteristic value
0x30	48	0x2902	GATT_CLIENT_CHAR_CFG_UUID	0x0000	GATT_PERMIT_READ | GATT_PERMIT_WRITE	
0x31	49	0x2901	GATT_CHAR_USER_DESC_UUID	"Accel Z-Coordinate"	GATT_PERMIT_READ	Accelerometer Z-coordinate characteristic user description

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Links

Description	Link
TI Bluetooth, overview, link to Dual mode, data sheets	www.ti.com/bluetoothlowenergy
BLE Stack and tools	www.ti.com/blestack
CC2540 Datasheets, application notes	www.ti.com/cc2540
Hardware sharepoint	http://srvoswod34.norway.design.ti.com/wiki/CC2540_Project
LPRF Wiki Page – Keyfobdemo source	http://processors.wiki.ti.com/index.php/Category:LPRF
SmartRF Flash Programmer	http://focus.ti.com/docs/toolsw/folders/print/flash-programmer.html
Bluetooth SIG	http://www.bluetooth.com/English/Products/Pages/low_energy.aspx

Documents

Description	Link
Quick Start Guide	http://focus.ti.com/lit/ml/swru272/swru272.pdf
Mini Kit User Guide	http://focus.ti.com/lit/ug/swru270a/swru270a.pdf
Software Development Guide	http://www.ti.com/litv/pdf/swru271
CC2540 User Guide	http://focus.ti.com/lit/ug/swru191b/swru191b.pdf