Objective

This example demonstrates the use of PRoC BLE as a Time Multiplexed GAP Central.

Overview

This example configures the PRoC BLE as a Time Multiplexed GAP Central device. A Time Multiplexed GAP Central device connects to more than one GAP Peripheral device in a round-robin manner. This functionality can be used to implement a star connection with multiple GAP Peripheral devices communicating to a single GAP Central device.

The GAP Central device connects to each GAP Peripheral device in its bonded device list one-by-one. Each GAP Peripheral device is allotted one second, including both its advertisement and connection time. This means that if a GAP Peripheral device is not found in its allotted slot, it is skipped for that round. The time slot allotted to a GAP Peripheral device is not shifted if the previous device is not found, as long as both the GAP Peripheral devices are part of the GAP Central's bonded device list.

New GAP Peripheral devices (up to a maximum of four) can be added to the Time Multiplexed GAP Central by sending 'a' or 'A from a UART terminal and then connecting to that GAP Peripheral. Existing devices can be removed from the bonded device list by sending 'r' or 'R from a UART terminal and then select the device to be removed from bonded list.

Requirements

Tool: PSoC Creator 3.1 SP1

Programming Language: C (GCC 4.8.4)

Associated Parts: All PSoC 4 BLE, PRoC BLE parts

Related Hardware: CY8CKIT-042-BLE Bluetooth® Low Energy (BLE) Pioneer Kit

Hardware Setup

The BLE Pioneer Kit has the necessary hardware connections required for this lab. If you are using your own hardware for the GAP Central, then connect the BLUE LED to P3.3, UART RX to P1[4] and UART TX to P1[5] of the PRoC BLE device. If you are using your own hardware for the GAP Peripheral, connect the GREEN LED to P3[6] and the BLUE LED to P3[7]. You need at least two PSoC 4 BLE / PRoC BLE modules and one CySmart USB Dongle to test this example.

PSoC Creator Schematic

Figure 1. PSoC Creator Schematic of the GAP Central

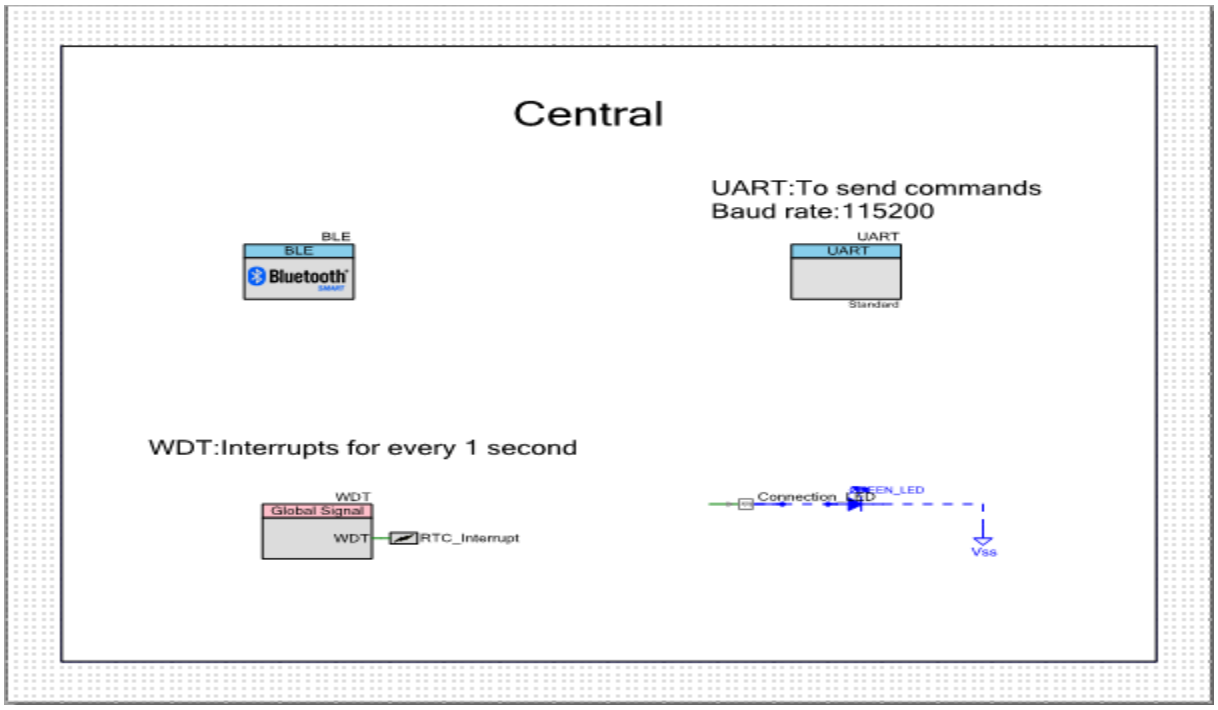
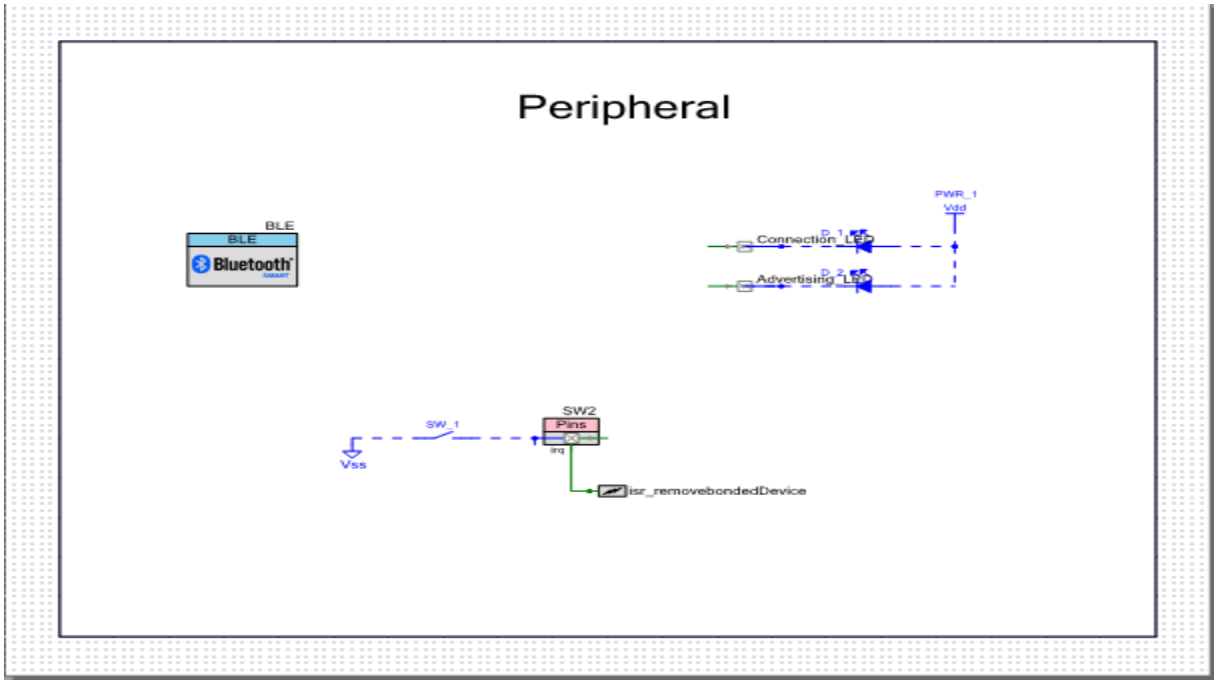


Figure 2. PSoC Creator Schematic of the GAP Peripheral



GAP Central Project Description:

On the first instance, the GAP Central scans with the whitelist disabled and shows the list of available GAP Peripheral devices. It also mentions whether the particular device is in its whitelist or not You can connect to one of the devices by sending a command 'c' or 'C' from the UART terminal of the GAP Central followed by the device number. Once the device is connected, it stores the bonding information and shows the bonded device list. The Blue LED turns ON when it is connected. If you want to add a new device, then send the command 'a' or 'A' from the UART terminal and select the device number from the list of addresses to connect with.

When the GAP Central is bonded with more than one device, it allots one second for each device. A counter (based on the Watchdog timer) is used to generate an interrupt every second. Whenever the interrupt is triggered, the GAP Central tries to connect to next device in the bonded device list, in a round-robin manner. This is done by disconnecting from the current connection and scanning for the next device in the bonded list. If the GAP Central can't find the next GAP Peripheral in the scheduled time slot (one second), it then mentions that the "Device is missing" and starts scanning for the next available device.

The GAP Central device also checks for the commands from the UART terminal and process these commands:

I. 'A' or 'a': To add new GAP Peripheral to the GAP Central. If there is at least one bonded device, the multiplexing process is stopped and a new scan is started with whitelist disabled. This command works only when there is at least one bonded device is the list.

II. 'C' or 'c': To connect to one of the devices listed in a scan.

III. 'R' or 'r": To remove a device from the bonded device list. If there is at least one bonded device, then the multiplexing process is stopped and the list of bonded devices is shown. On entering a valid device number, that device is removed from the list, and multiplexing with the remaining devices in the list is started again. If the bonded device list turns empty after removal of the last device, the GAP Central starts a fresh scan with whitelist disabled. This command works only when there is at least one bonded device present.

GAP Peripheral Project Description:

On the first instance, the GAP Peripheral starts *connectable undirected advertising*. On connection with a peer device, the peer's information is stored to flash (called bonding). Upon disconnection or a power cycle event, the bonded device list is checked to see if it is non-empty, and if so, *directed advertising* is performed. Else, *connectable undirected advertising* is performed. Press switch SW2 to remove the bonded device information. The GAP Peripheral then starts *connectable undirected advertising*. The advertising Green LED turns ON and when connected, the Blue LED turns ON.

Programming the devices:

I. Program CySmart USB dongle (included with the BLE Pioneer Kit) with the example project called **Central.**

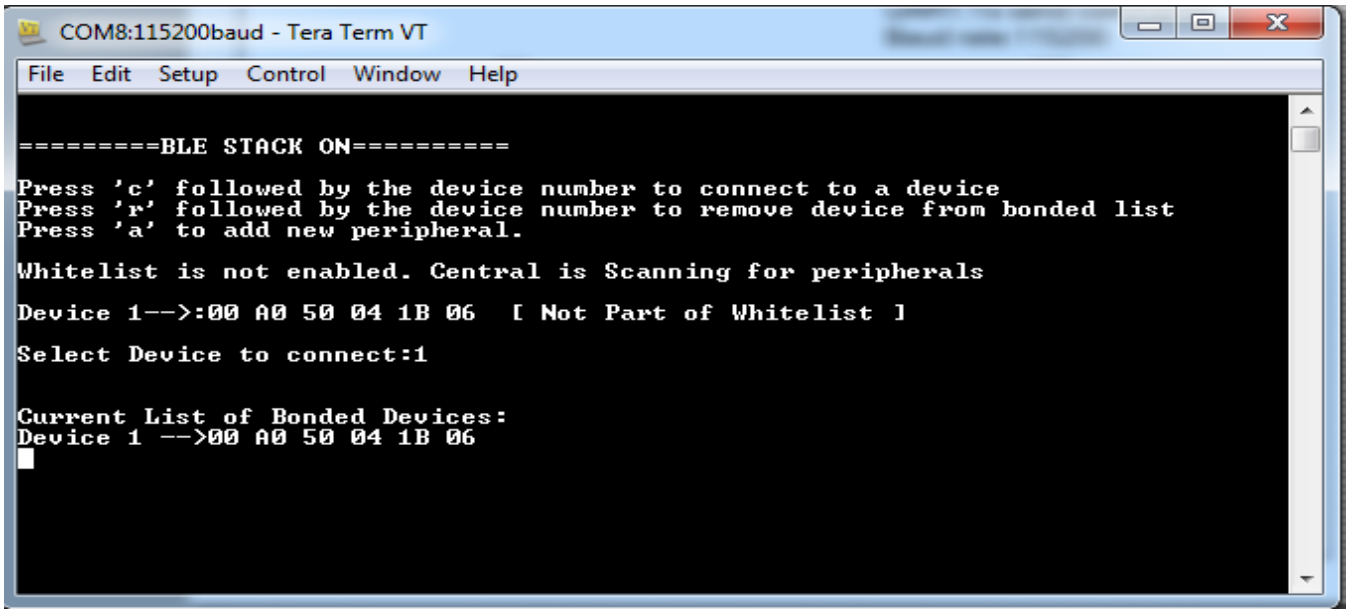
II. Program the PSoC 4 BLE module on the BLE Pioneer Kit with the example project called **Peripheral.**

Steps to Test the project:

1. Open a UART Terminal (TeraTerm or Putty) and the select the COM port (of the GAP Central device) and use the following settings:
    I. Baud rate:115200
    II. Data rate: 8 bit
    III. Parity: none
    IV. Stop: 1 bit
    V. Flow control : none

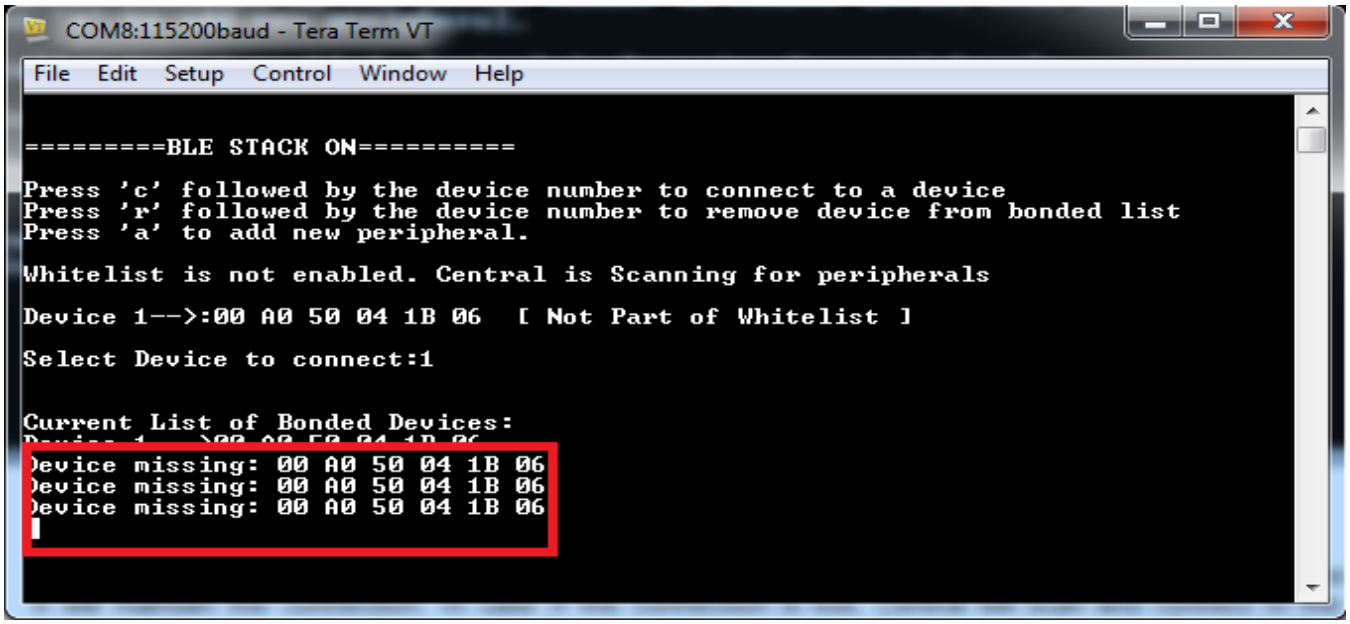
2. Power on at least one of the PSoC 4 BLE modules which is programmed with the project called **Peripheral**.
3. On the UART terminal you can see the list of peer devices which are advertising. Select one of the peer devices (programmed with project Peripheral) by sending command ‘c’ or ‘C’ from the UART terminal. After the device is connected, it stores the bonding information and displays the list of bonded devices.

Figure 3. Connecting to a GAP Peripheral



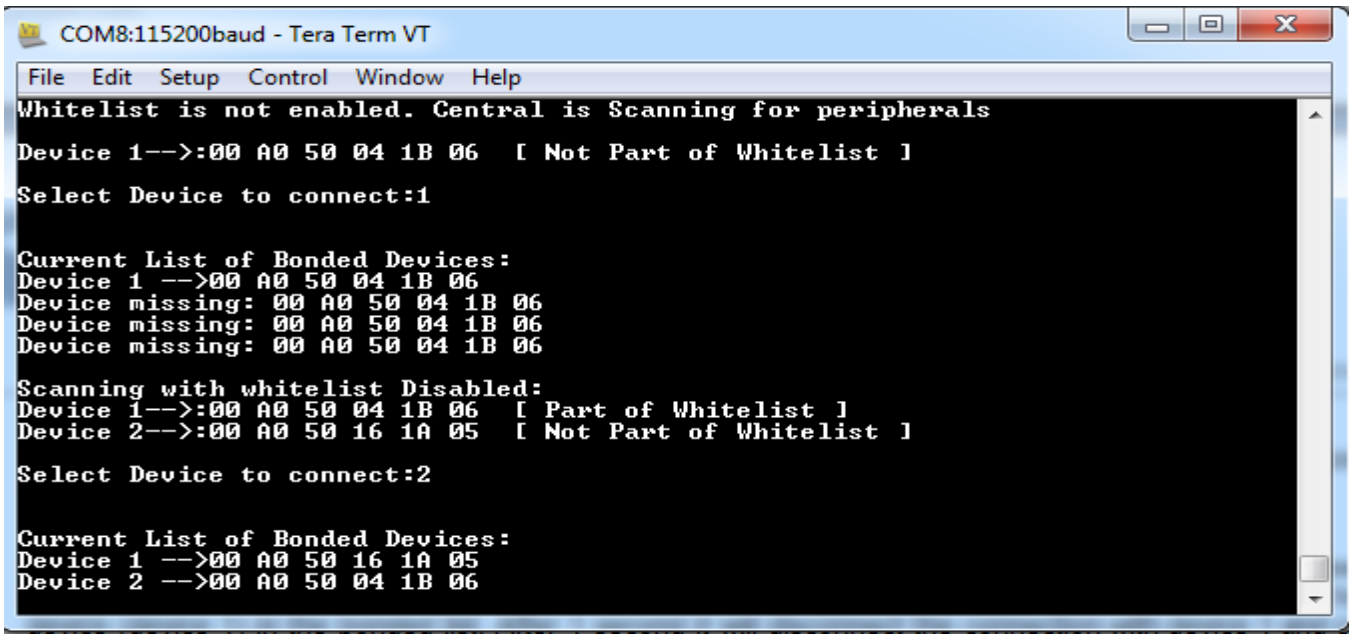
4. When only one GAP Peripheral is connected to the Time Multiplexed GAP Central, that connection is maintained until any external interaction. In case if the connection is lost due to a power cycle or interference, the GAP Central tries to connect to the same GAP Peripheral automatically. For every 1 second in the DISCONNECTED state, it displays the address of the bonded device that it is trying to connect with.

Figure 4. Device is Missing



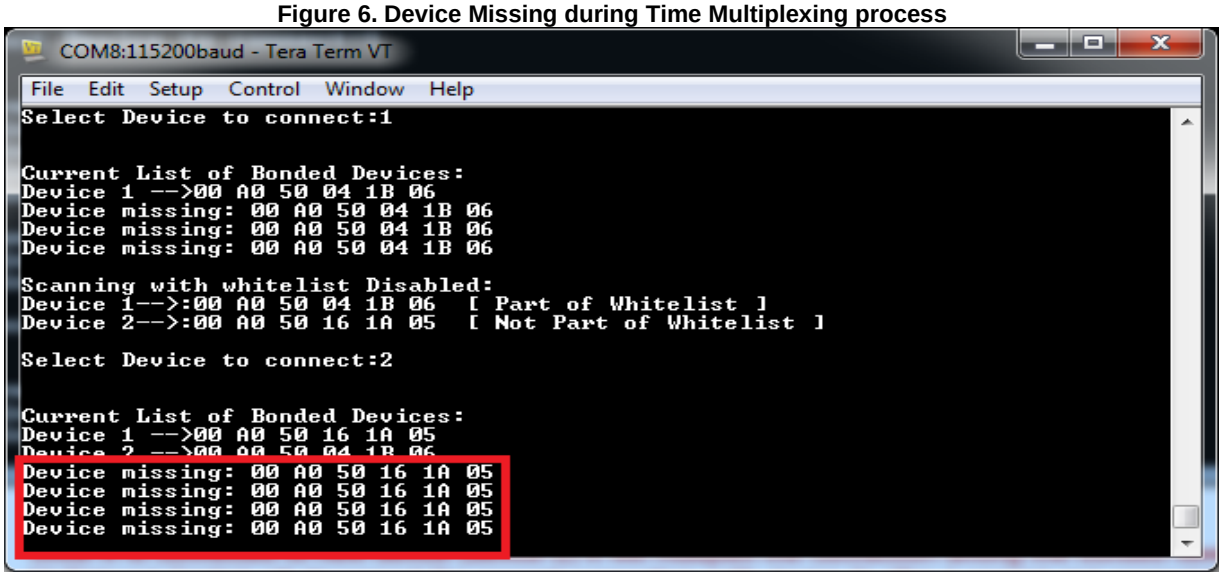
5. Send 'a' or 'A' from the UART terminal to add new GAP Peripheral. It will display the list of available GAP peripherals. Send command 'C' or 'c' followed the device number to connect to the device.

Figure 5. Adding a New GAP Peripheral



6. If one of the GAP Peripherals loses power or couldn't establish a connection to the GAP Central during its time slot, then on the UART terminal you can see the device that is missing or couldn't connect in its slot.

Figure 6. Device Missing during Time Multiplexing process



7. If you want to remove device from the bonded list, send command 'r' or 'R' from the UART terminal and select the device number from the list of devices. It will remove the bonded device and start multiplexing process if there is at least one other bonded device. If there are no bonded devices after removing the device from list, it will disable the whitelist and start scanning to allow you to add new GAP Peripherals.

Figure 7. Removing Bonded Device and Starting the Multiplexing Process

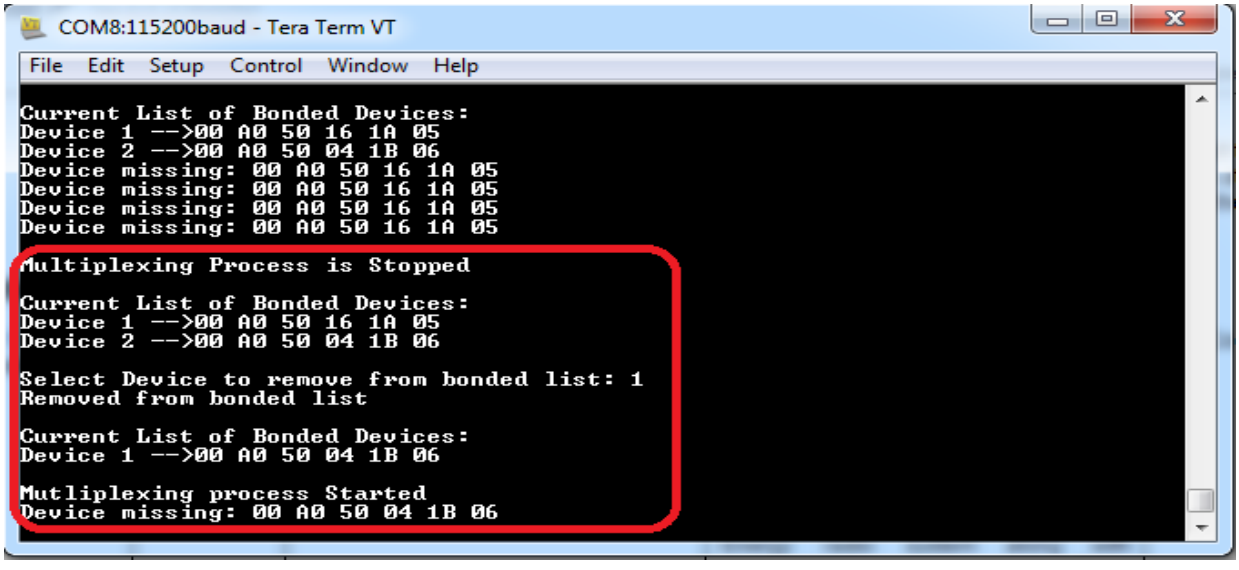
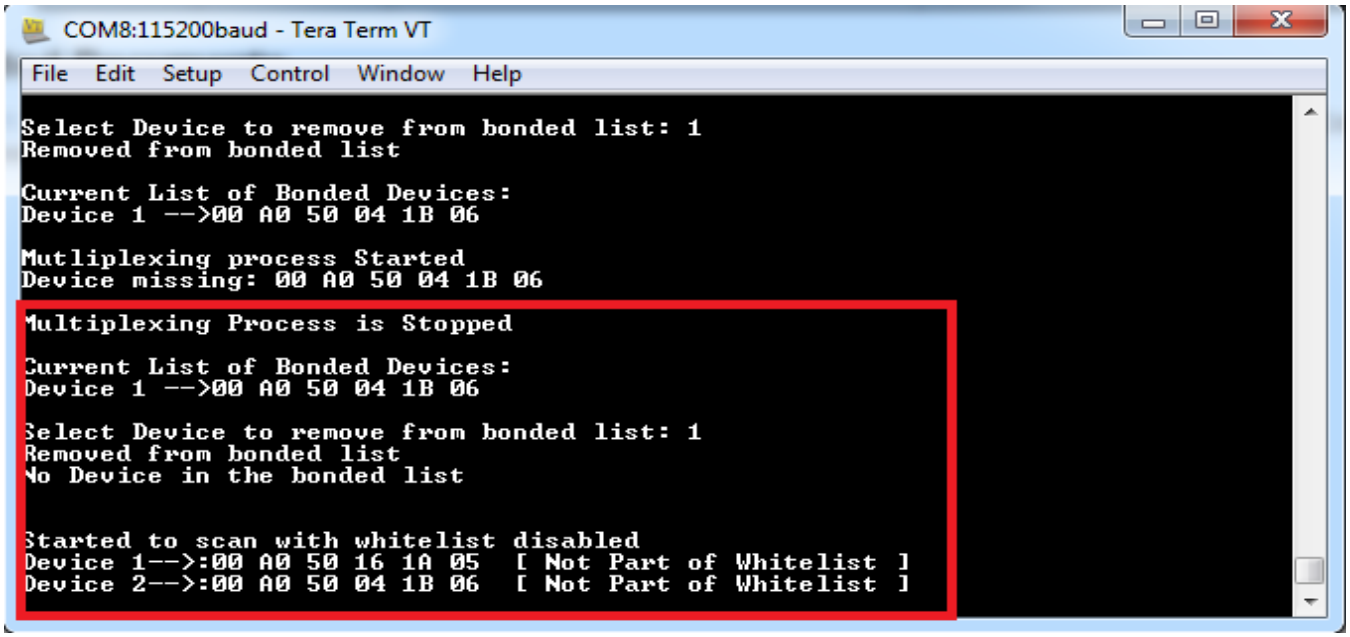
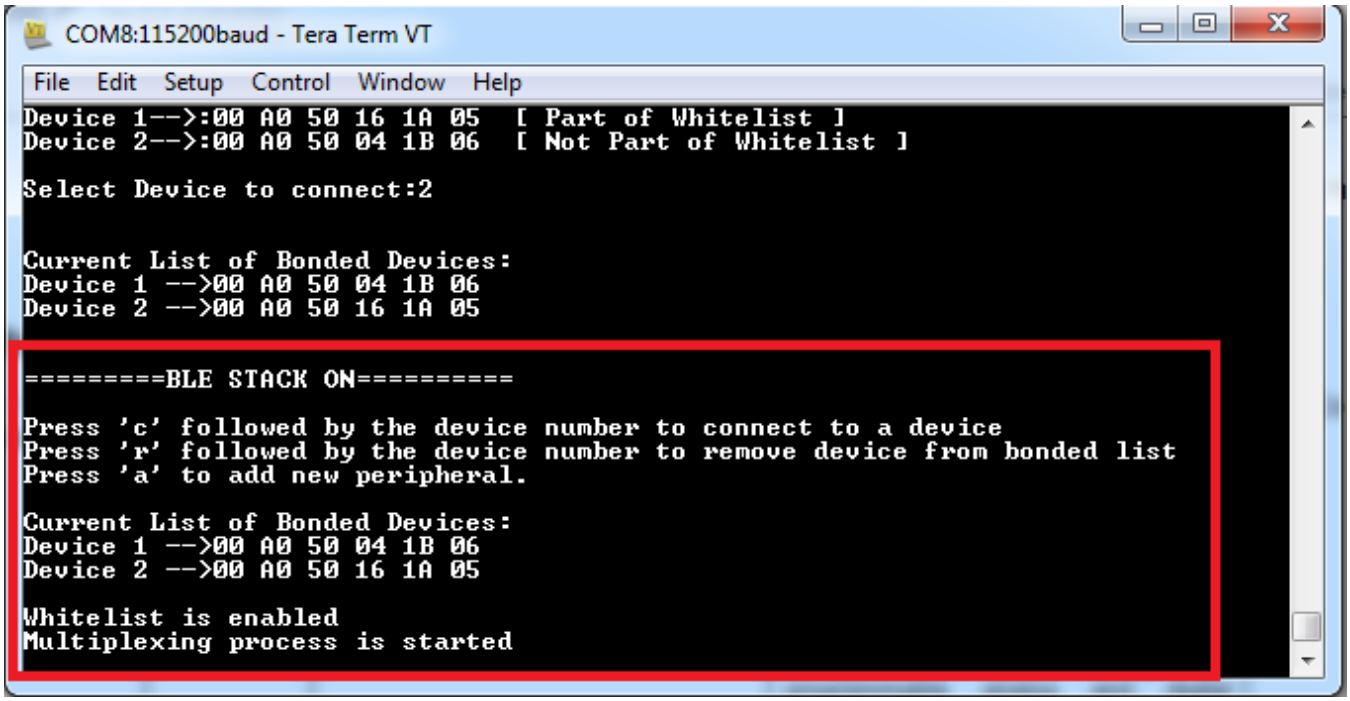


Figure 8. Removing Bonded Device and Scanning with Whitelist Disabled



8. After power cycling, the GAP Central will enable the whitelist if there is at least one bonded device and starts the time multiplexing process. If the GAP Peripherals are missing it will display the address of missing peripheral.

Figure 9. Starting Multiplexing Process after Power Cycle



Related Documents

Table 1 lists all relevant application notes, code examples, knowledge base articles, device datasheets, and Component / user module datasheets.

Table 1 Related Documents

Document	Title	Comment
AN91267	Getting Started with PSoC4 BLE	Provides an introduction to PSoC4 BLE device that integrates a Bluetooth Low Energy radio system along with programmable analog and digital resources.
AN91445	Antenna Design Guide	Provides guidelines on how to design an antenna for BLE applications.