LMU Bluetooth Chipset Application Note

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1   Introduction

This application note documents the use of Bluetooth chipset device based on TI MSP430F5438A microcontroller and CC2564 RF processor. The BTCS device has Bluetooth LE4.0 dual mode capabilities. The firmware is based on Stonestreet One Bluetopia protocol stack. The document uses as an example the Texas Instruments CC 2541 Sensor Tag with the purpose of reading the temperature from TI TMP006 temperature sensor. A "KeyFob" device which broadcasts "Button xx press" events together with "battery charge state as percentage" information is used as another example.

2   Description

The BTCS device is connected to a LMU serial port**.** The BTCS unit supports Bluetooth SPP mode of operation. BTCS plays a server slave device which upon connection with a Remote Bluetooth client master device can exchange data**.** There are two Bluetooth low energy (BLE) modes of operation: "Connection" based and an "Advert Broadcast Scanning" mode. In "Connection" mode, the LMU firmware starts the discovery process of all BLE remote devices. If a match is found based on the remote address stored as an "APP PARAM 2082", the discovery sequence is ended and the connection process starts. Upon the reception of "CONNECTED_OK" event, the user will be able to send setup commands to the remote device, and consequently receive the sensor data.

In "Advert Broadcast scanning" mode BT driver simply receives the broadcast advertisements from all remote BLE devices.

The block diagram is presented in Figure 1 below.
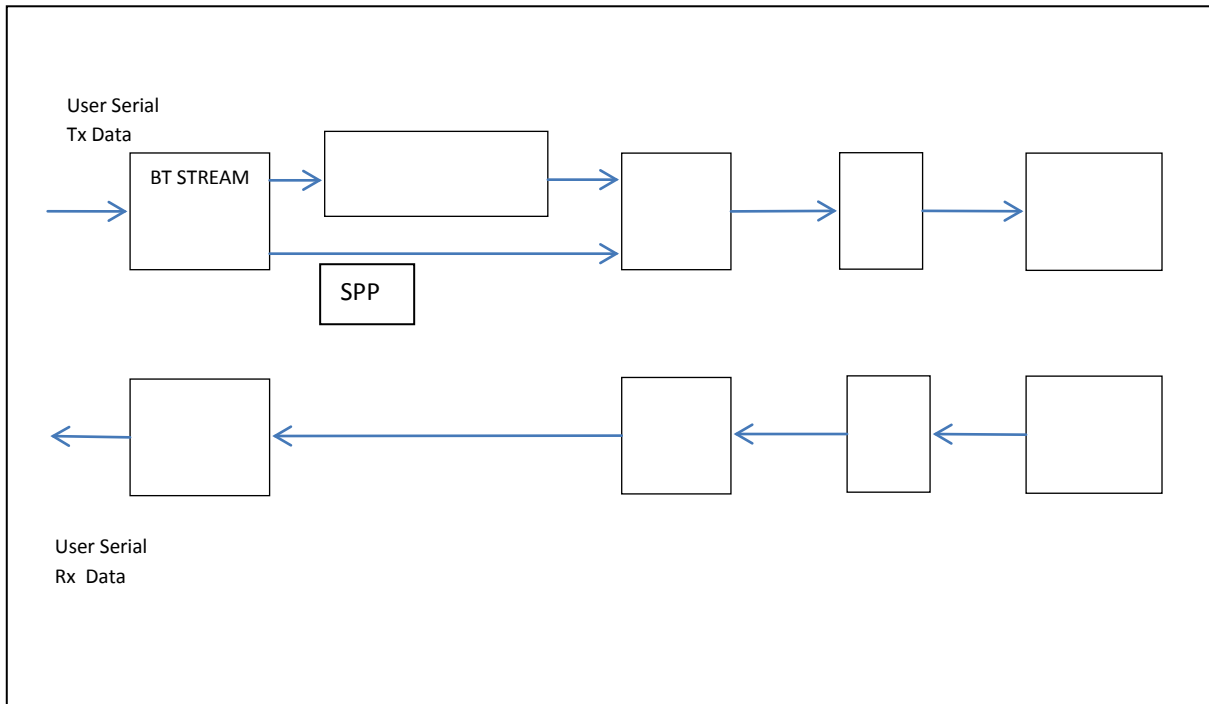
Figure 1

3   Setup

3.1   LMU BT LE driver streams and serial port configuration parameters setup example.

- Map debug stream to Aux1 port.
  AT$APP PARAM 3072,3,0
- Bluetooth stream to AUX 2.
  AT$APP PARAM 3072,14,1
- A Bluetooth stream baud rate set to 115200
  AT$APP PARAM 3073,14,12
- A Bluetooth stream set to 8, n, 1
  AT$APP PARAM 3074,14,3
- User0 Stream to Bluetooth Port
  AT$APP PARAM 3072,0,8

3.2   LMU BTST SPP driver streams and serial port configuration parameters setup example.

- LMU BT driver SPP mode setup:
  at$app param 2083,0,0

- Turn off stream for User 0:
  at$app param 3072,0,255
- Map Debug stream to BT_port:
  at$app param 3072,3,8
- Reset LMU :
  ATRESET
  LMU debug log will be visible on BT remote Android device console upon connection.
  The connection process is initiated by Android master device.

3.3 LMU Bluetooth driver configuration parameters setup.

- PID 2082 holds up to 8 remote device addresses 6 Bytes long.
  at$app param 2082,0,144,89,175,10,169,169 corresponding to remote device MAC
  address: 0x9059AF0AA9A9
  The first location in the array of addresses above is used to establish a BLE
  connection to a remote BLE device in BLE" Connected" mode.
  All unused addresses must contain 255,255,255,255,255,255.
- PID 2083 holds the mode of operation and it is 2 Bytes long. Bit 0 is used for mode
  selection 0- standard-SPP, and 1- Low Energy.
  For instance to configure BT driver in SPP mode use the following:
  at$app param 2083,0,0
  For example in order to configure BT driver in BLE "Connection" mode use:
  at$app param 2083,0,1
  Bit 1 defines if broadcast scanning is enabled 0 – disabled , 1 – enabled.
  Bit 2: 0- whitelist should be used to filter out the remote devices with MAC
  addresses which are not found in the list of the remote addresses. BTCS ignores the
  whitelist functionality at present.
  1: scan all advert broadcasts, no whitelist.
  For instance in order to configure BT driver in "LE advert broadcast scan all" mode
  use:
  at$app param 2083,0,7
- To disable Bluetooth driver use:
  at$app param 2083,0,65535
- The above commands allow the LMU to switch from one mode to another without
  the necessity of AT reset command, given that the data stream configuration is not
  changed. It could take up to 40s to complete the switch.

3.4 LMU user serial message configuration parameters setup example.

- If user data packets from the remote device are required to be transmitted to the backend server at a rate above one per five seconds, the User Message Disposition S-Register must be set to unacknowledged Message:

  S-137< VALUE = 5>

  ats137=5

- Configure serial message filters:

  at$app param 2178,0,""
  at$app param 2178,1,""
  at$app param 2178,2,""
  at$app param 2178,3,""
  at$app param 2178,4,""
  at$app param 2178,5,""
  at$app param 2178,6,""
  at$app param 2178,7,""

  Use the same as above for 2176 app param:

  at$app param 2176,0,""
  at$app param 2176,1,""
  at$app param 2176,2,""
  at$app param 2176,3,""
  at$app param 2176,4,""
  at$app param 2176,5,""
  at$app param 2176,6,""
  at$app param 2176,7,""

- Ensure that these new configurations do not cause any stream conflicts. Send the query:

  at$app stream?

  Below is an example of a stream conflict:

  ```
   at$app stream?
  Stream      Port      Rate   Word
  ------      ----      ----   ----
   0:User0    8:BTPort   9600   8/N/1
   1:Modem    4:Radio    115200 8/N/1
   2:User1    --
   3:Debug    0:Aux1     115200 8/N/1 PREEMPT
   4:NMEA Out --
   5:DUN      --
  ```

```
6:PEG Serial  --
7:VBUS        --
8:GPS Rcvr   5:GPS      115200  8/N/1
9:AltMdm     1:Aux2     115200  8/N/1
10:HostApp0   --
11:HostApp1   --
12:HostApp2   --
13:Undef.     --
14:BlueTooth 1:Aux2     115200  8/N/1
15:Undef.     --
16:Undef.     --
17:Undef.     --
18:Undef.     --
19:Undef.     --

OK
```

AUX2 must only have one stream assigned to it, so the AltMdm stream must be moved:

at$app param 3072,9,3

This command will move the AltMdm stream to the daughterboard port.

at$app param 3072,9,255 will disable it.

- Finally reset the LMU by executing: at$app reboot

3.5 BTCS version format.

Upon RESET BTCS firmware reports its version as follows:

BT: Rcv: VERSION,4.1.1.1CBA8C2A9539 with format: dcs.bts.ver.macaddr , where dcs is Device chipset version, bts is the bluetopia stack id, ver is BTCS firmware vesrion and macaddr is the local device MAC address.

3.6 BTCS default Pass key.

The default Pass Key is "0000".

3.7 Verification of LMU BTST SPP mode "Data" state example.

LMU debug log will contain:

BT: Rcv: SPP,0,1

BT: Connected

From this point data exchange is possible.

3.8 Verification of LMU configuration for BLE "connection" mode example.

LMU BT driver "DISCOVERED" state can be verified by observing the following debug log lines:

"BLE rx cmd:DISCOVERY,2,9059AF0AA9A9,0,-67,1,020105"

LMU BT driver "CONNECTED" state can be verified by observing the following debug log lines: "BLE rx cmd:CONNECT,1,1,0,9059AF0AA9A9" , where 1 is the connection handler index, 1-Low Energy mode, 0 – not paired, 9059AF0AA9A9 – remote device address.

The line: "BLE: Connected" indicates that the connection is achieved.

It is important to note that the connection handler index is returned by BTCS and is arbitrary number ranging from 0 to 65535. The same connection handler index must be used to send the user messages as explained in 4.1.

ATCS? Command will return the connection handler index:

SERMSG: Rcvd Msg:

41 54 43 53 2C 31 2C 31 2C 30 2C 39 30 35 39 41 46 30 41 41 39 41 39 0D

The above debug log line when converted to ASCII format is: ATCS,1,1,0,9059AF0AA9A9 where 1: connection handler index, 1: BLE mode, 0-not paired, 9059AF0AA9A9 is the BLE remote device MAC address.

3.9 Verification of LMU BLE "Advert broadcast scanning" mode configuration example.

The debug log indicates when the final LMU BLE "Scanning" state is reached by:

BLE: Scanning

The KeyFob "Button 1 Press" event user message looks like the following:

SERMSG: Rcvd Msg:
44 49 53 43 4F 56 45 52 59 2C 32 2C 30 30 30 37 38 30 36 37 41 33 35 44 2C 30 2C 2D 36 36 2C 33 2C 30 32 30 31 30 36 2D 30 32 30 41 30 33 2D 30 35 30 31 46 46 46 46 35 42 30 31 0D

The above message when converted to ASCII format looks like the following:
DISCOVERY,2,00078067A35D,0,-66,3,020106-020A03-0501FFFF5B01, where

- 2 is the GAP advertising report type: LE Connectable and undirected, Connectable and Scannable, 3 – LE Connectable Direct Advertisement, Connectable only, 4- LE Scannable Indirect Advertisement, Scannable only, 5- LE Non-connectable Indirect Advertisement, Not connectable or scannable, 6- LE Scan Response.
- 00078067CD72 is the MAC address.
- 0-public, 1- Random LE address type.
- -66 is RSSI Received Signal Strength indication value of the last packet received in dBm.

- 3 is number of advertising report data entries.
- 02 is the first advertisement report data length in Bytes.
- 01 is the first report advertisement type.
- 06 is the first report advertising data byte.
- 020A03 is the second AD report.
- 0501FFFF<mark>5B01</mark> is the third AD report.
- The user data is in the third AD report-5B: 91% battery charge remaining, 01 :Button 1 is pressed.

4   Usage

4.1   Demonstration of LMU BT SPP mode.

Follow the instructions in 3.2. Android Bluetooth SPP application starts the process of connection with BTCS and upon completion all LMU debug log data will be visible in Android device console. All Android input keyboard messages ending with 'CR' will be visible in its console.

4.2   Demonstration of BLE "connection" mode based remote temperature sensor device.

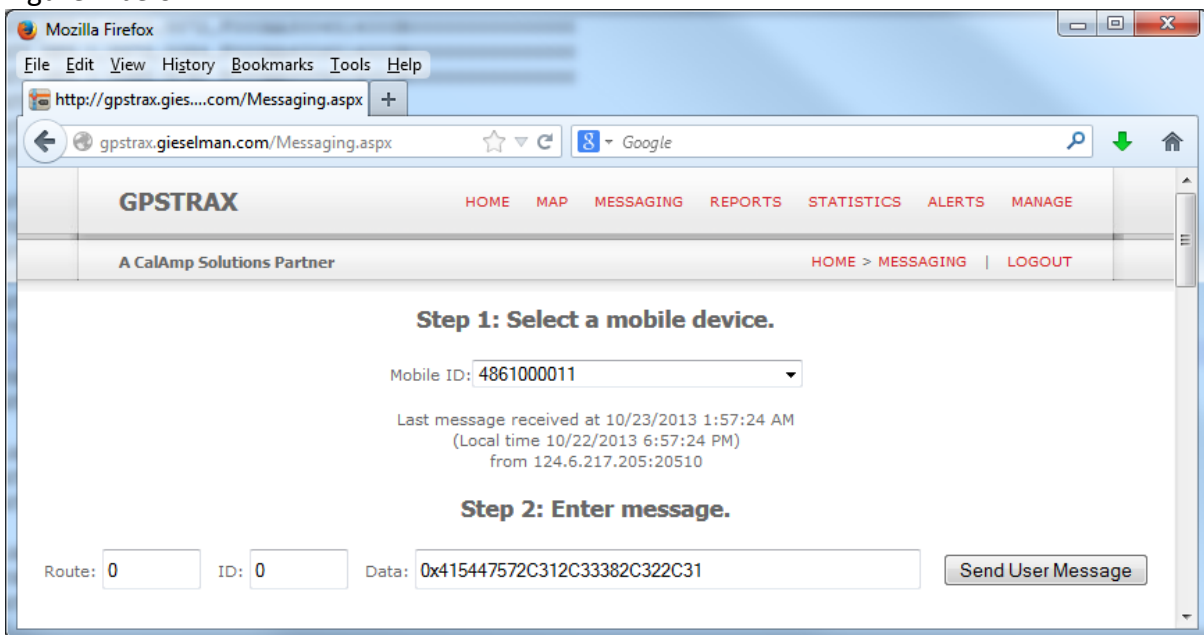"GPSTRAX" server is used to send User0 messages. Select route: 0 and ID: 0 as shown in Figure 2 below

Figure 2

There is a limitation of the length of the command which has to be less than 32 BYTES.

4.2.1   Send command "Enable notifications on Temperature sensor attribute profile".
Populate the "Data" field in Figure 2 with the hexadecimal representation of ATGW,1,38,2,1 - 0x415447572C312C33382C322C31.

 Where ATGW is the BTCS API for characteristic "WRITE" (GATT WRITE). It is used to write the characteristic value or descriptor from a server when the attribute handle of the characteristic value is known. 1 is the BTCS connection handler, and can be an arbitrary number.

Use ATCS command to get the correct connection handler index as explained in 3.6. The rest of the command is "SensorTag" temperature sensor specific. 38 is the SensorTag board temperature sensor "Notification settings" handler index. 2 is the "Notifications" configuration parameter byte length. The last field is the parameter value - 1 stands for "Turn ON" operation , 0 for "Turn OFF".

4.2.2   Send command "Start temperature conversion".
Populate the "Data" field in Figure 2 with the hexadecimal representation of ATGW,1,41,1,1 - 0x415447572C312C34312C312C31

The command fields description is the same as 4.1.

4.2.3   Observe the GPSTRAX server User 0 temperature data.
474154545F56414C2C312C303033372C312C342C44394646313030430D

In LMU debug log the same message can be observed:
SERMSG: RcvMsg:
474154545F56414C2C312C303033372C312C342C44394646313030430D
Converted to ASCII format the same message is: GATT_VAL,1,37,1,4,D9FF100C0D, where
1 corresponds to the connection ID ranging from 1 to 65535,
37 corresponds to the GATT characteristic handler index specific to TI temperature sensor,
1 is GATT notification,
4 is data length in Bytes,
D9FF100C0D represents the sensor data.

The data colored in yellow represent the temperature, where 0xD9 is the lowest significant byte of the Object temperature, 0xFF- MSB of object temperature, 0x10 – LSB of the ambient temperature, 0x0C – MSB of the ambient temperature.

4.2.4   Disable BLE sensor "notifications".
Populate the data field in Figure 2 with the hexadecimal representation of ATGW,1,38,2,0 - 0x415447572C312C33382C322C30

4.2.5 Send command "Stop" temperature conversion.

Populate the data field in Figure 2 with the hexadecimal representation of ATGW,1,41,1,0 - 0x415447572C312C34312C312C30

4.2.6 "GPSTRAX" server report contains temperature sensor data.

10/22/2013 20:21:45	4861000011	36.7926	0	0	0A474154545F56414C2C312C303033372C312C342C43444646463430420D

4.3 Demonstration of BLE "broadcast scanning" mode based remote KeyFob DriverID device.

The GPSTRAX server report will contain the following User0 messages:

0A444953434F564552592C322C30303037383803637434437322C302C2D35352C332C30323
03130362D3032304130332D30353031464646463534430310D

Which converted into ASCII representing "Button1 press" event:

DISCOVERY,2,00078067CD72,0,-55,3,020106-020A03-0501FFFF5401

The user payload content description is given in 3.3.

The Raw message type 4 is presented below:

830548610000110101000415A25295086652950866EA11DA4C682ABBA70000000000000000
000AE0B020001FFCD4F09DD000000003D0A444953434F564552592C322C30303037383036
37434437322C302C2D35352C332C3032303130362D3032304130332D30353031464646463
53430310D