

## **Bluetooth Sample Application for RF3**

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Texas Instruments  
Stonestreet One

HFK DP Software Applications

### **ABSTRACT**

The application on the Texas Instruments TMS320C5407™ DSP board and Stonestreet One's (SS1) Bluetooth™ daughtercard hardware is intended to show the operation of a Bluetooth Protocol Stack and the Hands-Free and Headset Profiles within the bounds of the eXpressDSP Software Reference Framework level 3 (RF3). The application incorporates several drivers and SS1's existing Bluetopia® core stack, Hands-Free profile, and Headset profile IP with the framework defined by RF3. There are two main differences from the base RF3 application. The first is the lack of any synchronous data processing. All of the SWIs and modules in the base application to process audio have been removed to allow the user to focus on the Bluetooth functionality. Second, there is a large addition to the control thread which is where the Bluetooth sample application resides.

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### **Contents**

<b>1</b>	<b>Introduction</b> .....	<b>1</b>
<b>2</b>	<b>Application</b> .....	<b>2</b>
	2.1 Bluetopia Callbacks .....	3
	2.2 Button Event Handler .....	3
<b>3</b>	<b>Bluetooth Hardware Interface</b> .....	<b>3</b>
<b>4</b>	<b>Running the Sample Application</b> .....	<b>4</b>
<b>5</b>	<b>References</b> .....	<b>4</b>
	<b>Appendix A Sample Application Software Layer Diagram</b> .....	<b>5</b>
	<b>Appendix B User Interface Flow Diagram</b> .....	<b>6</b>

### **List of Figures**

Figure A–1	Sample Application Software Layer Diagram .....	5
Figure B–1	Hands-Free Kit Reference Platform: User Interface .....	6

## **1 Introduction**

With the aid of this document, those familiar with TI's Reference Framework 3 (RF3) and the Code Composer Studio development environment should be able to have the Hands-Free/Headset sample application up and running quickly. For those interested in how to add Bluetopia® for RF3 to their own application, please see application report, *Bluetopia for RF3 Integration* (SPRA944).

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## 1.1 Definitions, Acronyms, and Abbreviations

The following list of terms will be used in this application report and other Bluetopia documentation:

- ACL – asynchronous connectionless link
- AG – audio gateway (ex. mobile phone)
- API – application programmer's Interface
- Bluetopia – Stonestreet One's Bluetooth Protocol Stack
- CSL – chip support library
- DSP – digital signal processor
- GAP – generic access profile
- HCI – host controller interface
- HFK – Hands-Free Kit
- IP – intellectual property
- L2CAP – logical link control and adaptation protocol
- LED – light emitting diode
- McBSP – multichannel buffered serial port
- PCM – pulse code modulation
- RF – radio frequency
- RF3 – Texas Instrument's Flexible Framework: Reference Framework Level 3
- RFCOMM – RFCOMM layer of the Bluetooth Protocol Stack
- SCO – synchronous connection-oriented link
- SDP – service discovery protocol
- SPP – serial port profile
- SS1 – Stonestreet One
- TI – Texas Instruments
- UART – universal asynchronous receiver transmitter

## 2 Application

The first responsibility of the application is to initialize the Bluetooth protocol stack. This is performed through the function call `InitializeBluetooth()`. `InitializeBluetooth` first calls the initialization routines for the stack and then places the Bluetooth module into the appropriate mode, as well as setting the device name. For this application, the device is set to both discoverable and connectable modes using GAP, so that mobile phones can find and pair with the kit. `InitializeBluetooth` next opens both a Headset and a Hands-Free server. Along with opening the servers, the SDP database is populated with the appropriate record so that a mobile phone can query the services of the kit. Once all of the initialization has been performed, the application is driven by two major components: the Bluetopia callback routines and the button event handler. A simple block diagram of the program layers is shown in Appendix A.

## 2.1 Bluetopia Callbacks

The three separate callbacks from the Bluetooth protocol stack, GAP, Headset, and Hands-Free, are each responsible for decoding and handling events for their respective layers of the stack.

The GAP callback is mainly responsible for handling authentication with the phone.

The Headset profile callback is responsible for handling events such as connection and disconnection indications, phone call or ring indications, as well as any remote messages to control speaker and microphone gain.

The Hands-Free is the most complicated of the three. Similar to the Headset callback, the Hands-Free callback handles connection and disconnection indications. It also has the ability to handle more advanced mobile phone features such as call waiting, caller ID, and voice recognition activation, among others.

For a complete list and more explicit details on these events, see the *TMS320C54x Bluetopia Hands-Free Profile API Reference Guide* (SPRU704) as well as the Profile specification itself.

All three of these callbacks are responsible for adjusting the HFK's internal state. For instance, after a mobile phone has connected to the Headset server, and there is an incoming call, the ring indication in the headset callback will change the state of the device to wait for a button press to determine if the call will be accepted or rejected. The buttons are described in more detail below.

## 2.2 Button Event Handler

The user interface driver is composed of several parts. The buttons are tied to external interrupts on the DSP. In the control module's clock object processing routine, the interrupt flag registers are polled. While the actual state of the button cannot be determined, the interrupt line will detect negative going edges. To accommodate debouncing, a small amount of time is delayed before the button press information is passed on to the control SWI. This allows all positive to negative transitions to settle out and avoid a false button push. The actual button press information is passed to the control thread via the SWI mailbox as bitwise flags. Reading the bitflags in `thrControlRun()` will allow for correct decoding of a button press. Each button has a specific function depending on the state of the HFK. This user interface is more clearly understood in the flowchart of Appendix B.

## 3 Bluetooth Hardware Interface

The single interface to the Bluetooth module in this sample application is the UART. All of the data passed between the DSP and the Bluetooth module is exchanged via the on-chip hardware UART of the DSP. To allow for easy porting to different platforms, the Bluetooth stack abstracts this interface through the HCI transport layer in `HCITRANS.c`. For more detailed information about this file, please see the *Bluetopia for RF3 Integration* (SPRA944) application report. This adaptation has already been completed for the sample application and the HFK platform and is ready to compile and run – as is. One item of note is that this file is a handy debugging point. If for some reason the stack will not initialize properly, breakpoints can be set in this file to verify the hardware connection to the Bluetooth module, by making sure that data is being received and applied to the protocol stack.

## 4 Running the Sample Application

The sample application can be compiled and run as is. First, compile and load the sample application. It is also advised to open the DSP/BIOS log window to receive any runtime messages that may be displayed. With the Bluetooth module UART signals properly attached, and the module powered and reset, run the application. If all of the initialization is performed successfully, the message “Bluetooth Device Initialized successfully.” will be displayed in Code Composer Studio’s log window. On failure, the cause of the error will also be displayed. Assuming this procedure completes without error, the device is now ready to be connected to by a mobile phone.

Following the instructions set forth in the mobile phone user’s guide, search for Bluetooth devices in the area. After some amount of time, a list of discovered Bluetooth devices will be displayed. The HFK device will appear listed as “HFK 5407: XX” where XX is the Bluetooth board address of the device in hexadecimal. Now that the device is discovered, the unit must first be paired with an audio gateway (i.e., the mobile phone). Due to the limited user interface of this unit, the pairing will be driven from the phone. The pin code of the device will be needed for this step. For the reference application, the pin code will be “0000”. This can be changed in `thrControl.c` via `HFK_DEFAULT_PIN_CODE`. Follow the phone’s user manual to aid in pairing with the HFK. The phone will search the HFK’s SDP database and make the determination automatically whether to use the Hands-Free or Headset interface. Once a unit is paired with a phone, the devices can freely connect back and forth to each other. The phone can now be operated normally and in conjunction with the user interface of the HFK described in Appendix B.

## 5 References

1. *TMS320C5000 DSP/BIOS Application Programming Interface (API) Reference Guide* (SPRU404)
2. *TMS320C54x Chip Support Library API Reference Guide* (SPRU420)
3. *Writing DSP/BIOS Device Drivers I/O* (SPRA802)
4. *Reference Framework 3: A Flexible, Multichannel/Algorithm, Static System* (SPRA793)
5. *Specification of the Bluetooth System, Version 1.1*, Bluetooth Special Interest Group (SIG)., 2001.
6. *Specification of the Bluetooth System Profiles, Version 1.1*, Bluetooth Special Interest Group (SIG)., 2001.
7. *Hands-Free Profile, Version 1.0*, Bluetooth Special Interest Group (SIG)., 2003.
8. *Headset Profile, Version 1.0*, Bluetooth Special Interest Group (SIG)., 2001.
9. *TMS320C54x Bluetopia Hands-Free Profile API Reference Guide* (SPRU704)
10. *Bluetopia Headset Profile API Reference Guide* (SPRU649)
11. *Bluetooth Protocol Stack API Reference Guide* (SPRU648)

## Appendix A Sample Application Software Layer Diagram

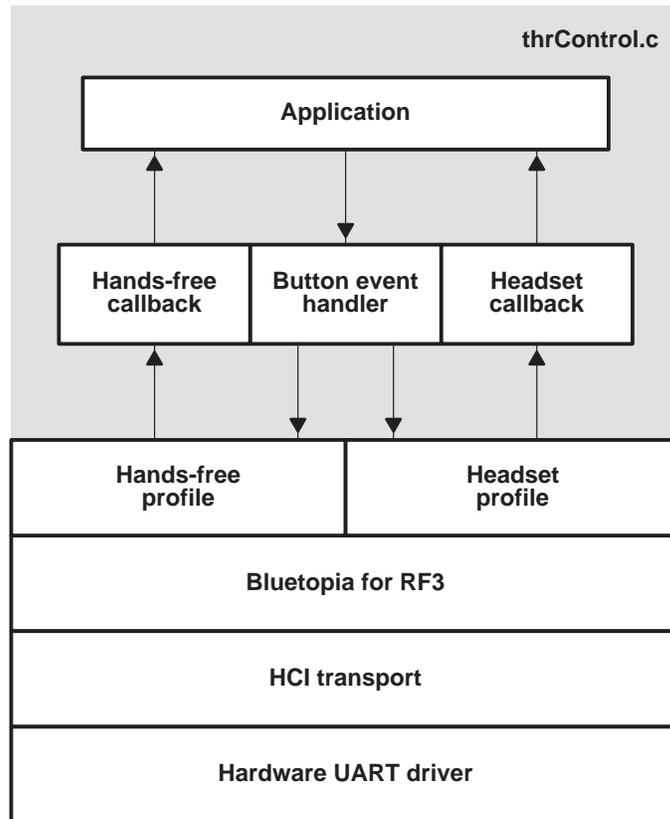
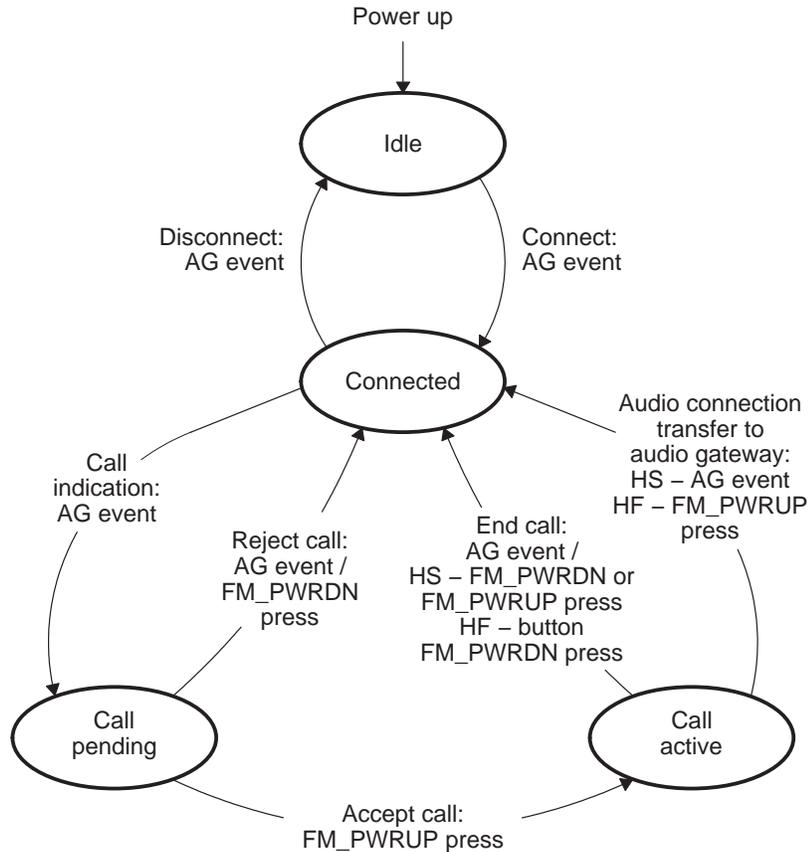


Figure A-1. Sample Application Software Layer Diagram

## Appendix B User Interface Flow Diagram



After a connection has been established, pressing BT\_CTL will disable noise reduction and echo cancellation on the audio gateway. This action needs to be performed before a call is made to the BT phone.

AG Event = Event received from the audio gateway that changes the current state of the unit.

HS = HeadSet functionality

HF = Hands-free functionality

**Figure B-1. Hands-Free Kit Reference Platform: User Interface**

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