1 Introduction

1.1 Overview

The Headset contains a speaker, a microphone and some User Interface (UI) components, such as, buttons, sliders, rotary switches and LED. The main functions are summarized as below,

- **Send**: To transmit recorded audio or control signal to Dongle.
- **Receive**: To receive audio stream sent from Dongle and playback using CODEC.
- **OTA**: To receive OTA_Headset firmware sent from Dongle and write it to host controller’s Flash.

To give the audience a systematic view of Headset in **LPC54114 BLE Audio System**, this document describes the hardware design and software architecture (top level design).

1.2 Reference documents

Table 1. References

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<td>[LPC OTA]</td>
<td>LPC54114 BLE Audio System OTA operation steps</td>
</tr>
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2 System overview

2.1 Block diagram

The block diagram of LPC54114_Headset is as shown in Figure 1.
As we can see in Figure 1,

- The host controller (LPC54114) is used to run Headset and OTA_Headset demos.
- The NXH3670 communicates with the LPC54114 through the SPI interface.
- CODEC (WM8904) is programed to encode or decode a digital data stream or signal, use I^2C interface to configure the CODEC in software design.
- The NXH3670 (I^2S slave) communicates with CODEC (I^2S master) directly through the I^2S interface and no MCU processing is required. The NXH3670 receives the audio stream sent from Dongle and transmits to CODEC through the I^2S interface.

### 2.2 USB Headset software architecture

The software architecture of USB Headset is as shown in Figure 2.
As seen in Figure 2, the Headset contains **NVM service**, **CODEC service**, **NXH service** and **UI service**. This document lists the following functions.

1. **Nvm service**: to read **Partition Table**.
2. **NxH Control**: to boot, start and transfer data with LPC54114 through the SPI interface.
3. **UI service**: to use buttons to control the volume, start and pause.
4. **CODEC service**: to configure CODEC via the I²C interface.

In hardware design, NXH3670 and CODEC are connected through the I²S interface. Audio data is transmitted directly from NXH3670 to CODEC through the I²S interface, so users need to initialize the I²C peripheral instead of the I²S peripheral.

The audio transfer process is as shown in Figure 3.
Playback (forward channel): the audio path from the PC to the Headset.

Record (backward channel): The audio path from the Headset to the PC.

NOTE
As shown in Figure 3, the Headset software does not handle audio stream, so only NXH3670 and CODEC are required to be configured. For more information about audio transfer process, refer to LPC54114 USB Dongle with NxH3670 (document AN12568).

Users can download the demo for 48 KHz 16-bit downstream to test playback function and 16 KHz 16-bit upstream to test record function.

This document introduces the audio transfer process of the Headset section. For more information of Dongle section, refer to LPC54114 USB Dongle with NxH3670 (document AN12568).

3 Components of USB headset

3.1 LPC54114

3.1.1 Host controller

The following describes the features used in LPC54114 USB Headset with NXH3670. The LPC5411x are Arm® Cortex®-M4 based microcontrollers for embedded applications. These devices include:
• an optional Arm Cortex-M0+ coprocessor
• up to 192 KB of on-chip SRAM
• up to 256 KB on-chip flash
• full-speed USB device interface
• a DMIC subsystem with dual-channel PDM microphone interface and I²S
• one 24-bit Multi-Rate Timer (MRT)
• eight flexible serial communication peripherals (each of which can be a USART, SPIs, or I²C interface)

3.1.2 Clocks

The following two crystals are used on the board.

• 32 MHz crystal connected with the NxH3670
• 12.288 MHz TCXO for the CODEC’s MCLK (currently, it is an external master clock and possible to be used to output of PLL as MCLK later)

Users can select their clock source via J10, as shown in Figure 5.

![Figure 5. Selection of MCLK (CLK_SELECT)](image)

3.1.3 Pin connections

Table 2 lists the connection information between LPC54114 and other components.

<table>
<thead>
<tr>
<th>Function</th>
<th>Jumper (LPC54114 Headset)</th>
<th>Name</th>
<th>Jumper (NXH3670)</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>I²S (no need to connect MCU)</td>
<td>—</td>
<td>CODEC_SDI</td>
<td>J12_1/9 (I2S_CONFIG)</td>
<td>BLE_SDO</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>CODEC_SDO</td>
<td>J12_3/11 (I2S_CONFIG)</td>
<td>BLE_SDI</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>CODEC_WS</td>
<td>J12_5/13 (I2S_CONFIG)</td>
<td>BLE_WS</td>
</tr>
<tr>
<td></td>
<td>—</td>
<td>CODEC_SCK</td>
<td>J12_7/15 (I2S_CONFIG)</td>
<td>BLE_SCK</td>
</tr>
</tbody>
</table>

Table continues on the next page...
Table 2. Pin connections (continued)

<table>
<thead>
<tr>
<th>Function</th>
<th>Jumper (LPC54114 Headset)</th>
<th>Name</th>
<th>Jumper (NXH3670)</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>I2C</td>
<td>J1_3 (PIN P0.26)</td>
<td>LPC54114_SDA</td>
<td>J11_2 (PERIPHERAL_I2C)</td>
<td>PH_SDA</td>
</tr>
<tr>
<td></td>
<td>J1_1 (PIN P0.25)</td>
<td>LPC54114_SCL</td>
<td>J11_4 (PERIPHERAL_I2C)</td>
<td>PH_SCL</td>
</tr>
<tr>
<td>NXH Handshake</td>
<td>J2_18 (PIN P1.4)</td>
<td>BLE_SPIS_INTN</td>
<td>J16_9 (BLE_SPI)</td>
<td>SWM4 (- INTN)</td>
</tr>
<tr>
<td></td>
<td>J2_20 (PIN P1.3)</td>
<td>BLE_SPIS_SRQ</td>
<td>J16_13 (BLE_SPI)</td>
<td>SRQ</td>
</tr>
<tr>
<td>SPI</td>
<td>J4_3 (PIN P0.13)</td>
<td>BLE_SPIS_MISO</td>
<td>J16_1 (BLE_SPI)</td>
<td>SW0</td>
</tr>
<tr>
<td></td>
<td>J4_2 (PIN P0.12)</td>
<td>BLE_SPIS_MOSI</td>
<td>J16_3 (BLE_SPI)</td>
<td>SW1</td>
</tr>
<tr>
<td></td>
<td>J4_4 (PIN P0.11)</td>
<td>BLE_SPIS_SCLK</td>
<td>J16_5 (BLE_SPI)</td>
<td>SW2</td>
</tr>
<tr>
<td></td>
<td>J4_7 (PIN P0.4)</td>
<td>BLE_SPIS_SSN</td>
<td>J16_7 (BLE_SPI)</td>
<td>SW3</td>
</tr>
<tr>
<td>NXH Reset</td>
<td>J4_8 (PIN P0.22)</td>
<td>BLE_RESETN</td>
<td>J20_5 (BLE_SWD)</td>
<td>POR_RESETN</td>
</tr>
</tbody>
</table>

As we do not make PCB for **LPC54114+NXH3670**, Figure 6 shows the demo using LPCXpresso54114 board and NXH3670 board with extra connection line.

![LPC Headset hardware design](image)

Figure 6. LPC Headset hardware design

### 3.1.4 Schematic

1. Audio transfer
   - I2C
Audio data is transmitted directly from NXH3670 to CODEC through the I2S interface. For the software, I2C peripheral is required to be initialized to configure CODEC instead of the I2S peripheral.

- I2S

The NXH3670 is connected with CODEC instead of Host Controller (LPC54114) through the I2S interface, so I2S peripheral is not required to be initialized.

2. NXH3670

- NXH Handshake

- SPI
3.1.5 Pins configurations

- SPI
  - **Interface:** SPI3
  - **Pin:** CS (P0.4), SCK (P0.11), MISO (P0.12), MOSI (P0.13)
  - **Polarity:** Active-high SPI clock (idles low)
  - **Phase:** First edge on SPSCK occurs at the middle of the first cycle of a data transfer
  - **Baud Rate:** configured to 8000000u for SPI

- I²C
  - **Interface:** I2C4.
  - **Pin:** SCL (P0.25), SDA (P0.26)
  - Configured to 0x1A for i2cAddress.

- NxH3670 relevant pins
  - **INIT (P1.4):** configured to digital input
  - **SRQ (P1.3):** configured to digital output
  - **POR (P0.22):** configured to digital output
3.2 NXH3670

For more information of NXH3670, refer to LPC54114 USB Dongle with NxH3670 (document AN12568).

4 Porting guide and demo introduction

Headset project is similar with Dongle. For example, the NXH Service part remains same. This document lists only the service configuration used in the Headset project.

4.1 I2C

No API is required to be modified in i2c_common and i2c. In SDK of KL27, APIs related to the I2C are same as of LPC54114. Figure 12 shows the configurations based on KL27 and LPC54114, which can be copied for your project.

```
services
  src
    > battery
    > codec_ctrl
    > framework
    > i2c
      > i2c_common.c
      > i2c.c
    > nvm
    > nxh_ctrl
    > ui_ctrl
```

Figure 12. I2C service porting introduction

4.2 CODEC

No API is required to be modified in codec_ctrl_power, codec_ctrl_updated, and codec_ctrl. As CODEC is connected with BLE through the jumper, so the data is transferred between CODEC and NXH3670 without other operations. Figure 13 shows the configurations based on KL27 and LPC54114, which can be copied for your project.

```
services
  src
    > battery
    > codec_ctrl
      > codec_ctrl_power.c
      > codec_ctrl_update.c
      > codec_ctrl.c
    > framework
    > i2c
    > nvm
    > nxh_ctrl
    > ui_ctrl
```

Figure 13. CODEC service porting introduction
5 Conclusions

This document describes the hardware design and software architecture (top-level design) of LPC54114_Headset in LPC54114 BLE Audio System. It can be used as a reference for your demo.
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