

AN14546

Bidirectional USB Audio Host on MCX N23x

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Application note

Document information

Information	Content
Keywords	AN14546, Audio, USB host, USB audio host, bidirectional audio, MCX N23x, MCX N236
Abstract	This application note describes how to implement a bidirectional USB audio host on the MCX N23x and how to test this USB audio host.



1 Introduction

The MCX N23x series MCU is the second MCU of the MCX N series. Compared with the MCX Nx4x series, it has been optimized in terms of cost, memory, and power consumption. It can be regarded as a cropped version of the MCX Nx4x series, but it still supports rich peripheral interfaces. [Figure 1](#) shows the block diagram of MCX N23x.

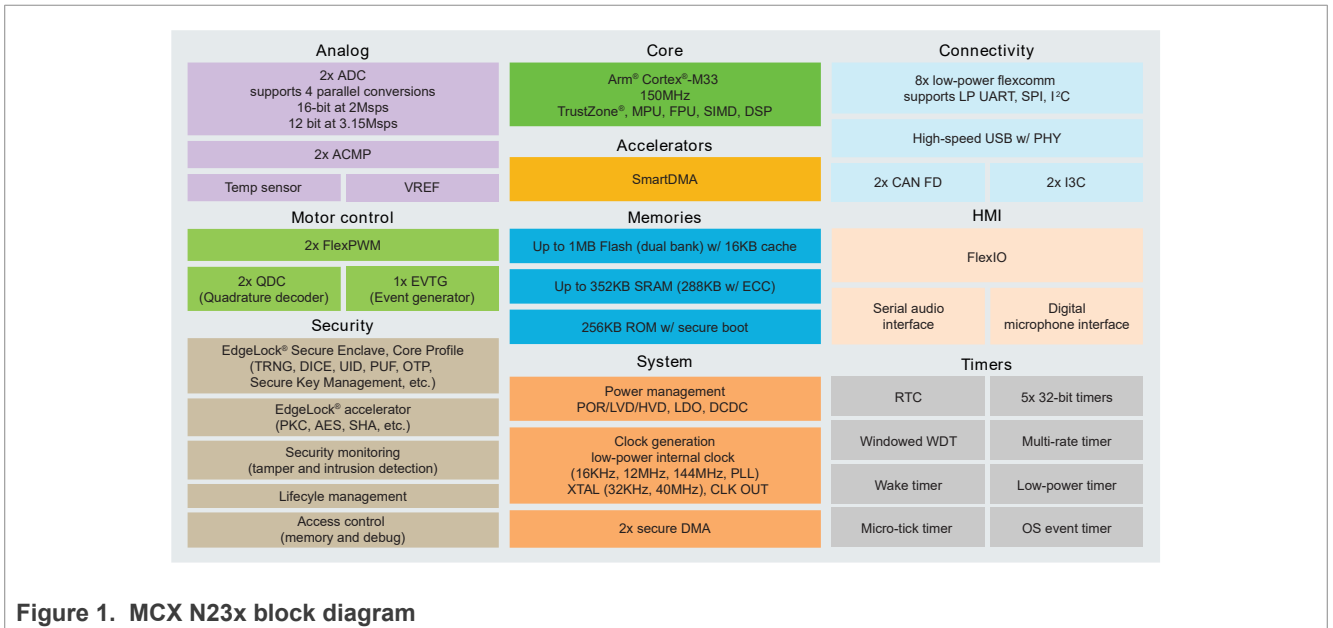


Figure 1. MCX N23x block diagram

As shown in [Figure 1](#), MCX N23x has an HS USB, which can support host and device modes, and two SAI modules, so it is suitable for USB audio applications. [Figure 2](#) shows the block diagram of the SAI module on MCX N23x.

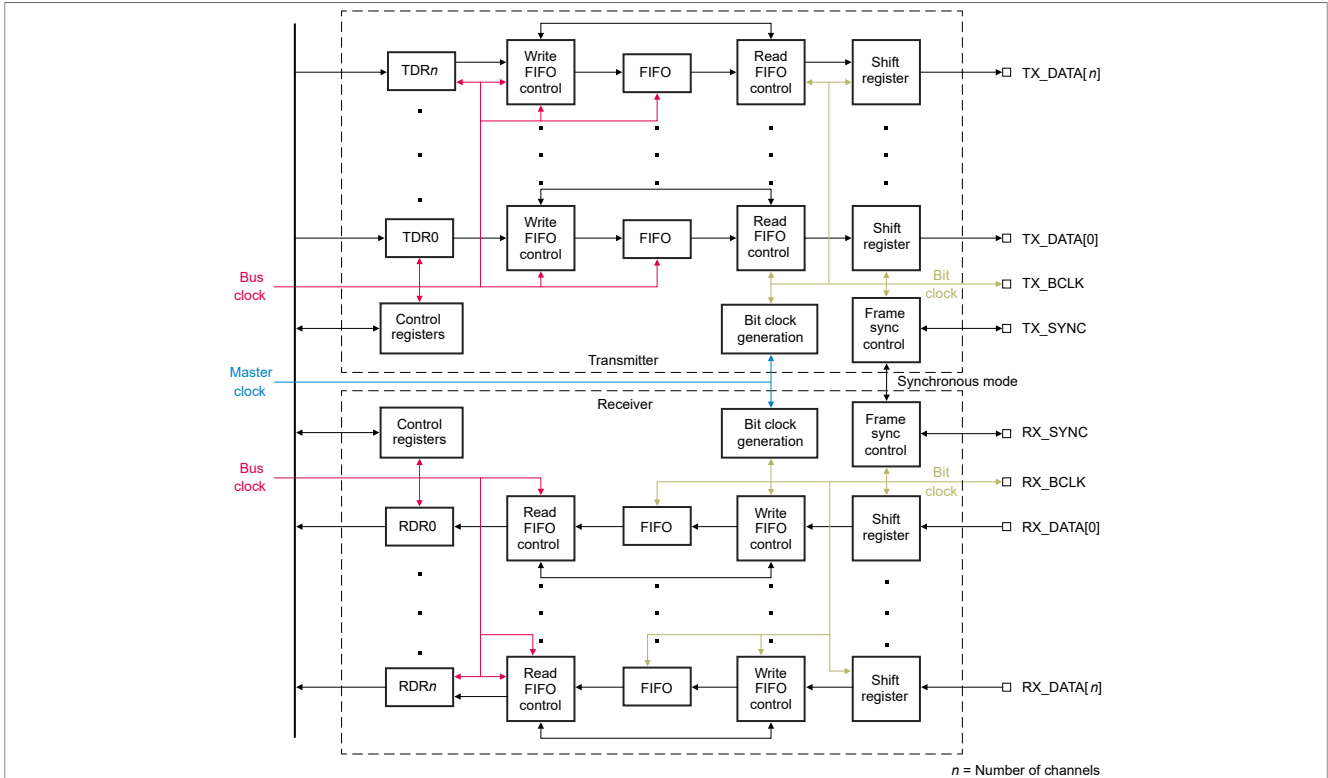


Figure 2. SAI block diagram on MCX N23x

The SAI module of MCX N23x can support the following functions:

- Transmitter with independent bit clock and frame synchronization supporting two data lines
- Receiver with independent bit clock and frame synchronization supporting two data lines
- Maximum frame size of 32 words per data line
- Word length configured separately for the first word and remaining words in a frame
- Asynchronous 8 × 32-bit FIFO for each transmit and receive data line supports:
 - Graceful restart after FIFO error.
 - Automatic restart after FIFO error without software intervention.
 - 8-bit and 16-bit data packing into each 32-bit FIFO word.
 - Multiple-data-line FIFOs combining into single-data-line FIFO.

The FRDM-MCXN236 board can be used to evaluate the various peripherals of the MCX N23x, but the audio codec DA7212 and audio jacks are not soldered on this board by default. Solder them on this board to support the evaluation of audio functions. In addition, FRDM-MCXN236 SDK v2.16 also provides a wealth of SAI examples, as shown in [Table 1](#).

Table 1. SAI examples in FRDM-MCXN236 SDK v2.16

1	sai_edma_record_playback
2	sai_edma_transfer
3	sai_interrupt
4	sai_interrupt_record_playback
5	sai_interrupt_transfer

In addition, the SDK also provides some USB audio-related examples, which are all in the `usb_examples` directory, as shown in [Table 2](#).

Table 2. USB audio examples in FRDM-MCXN236 SDK v2.16

1	<code>usb_device_audio_generator</code>
2	<code>usb_device_audio_generator_lite</code>
3	<code>usb_device_audio_speaker</code>
4	<code>usb_device_audio_speaker_lite</code>
5	<code>usb_device_composite_hid_audio_unified</code>
6	<code>usb_device_composite_hid_audio_unified_lite</code>
7	<code>usb_host_audio_speaker</code>

For the USB audio host, the FRDM-MCXN236 SDK v2.16 only provide a separate USB host audio speaker example, which only supports USB speaker devices. This application note serves as a supplement to the SDK examples to introduce how to implement a bidirectional USB audio host on MCX N23x so that it can simultaneously support composite devices that integrate USB audio speaker and USB audio recorder.

2 Implementation of bidirectional USB audio host

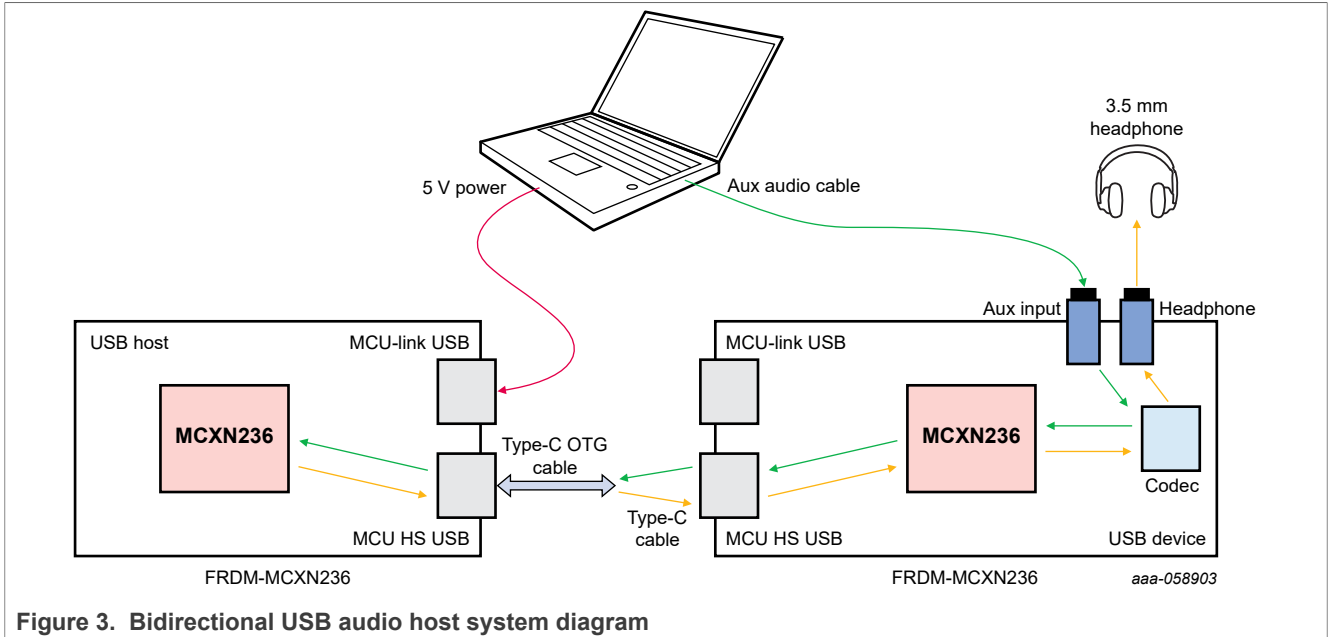
This section describes how to implement a bidirectional USB audio host and the hardware required to test the host.

2.1 Hardware

Testing of the bidirectional USB audio host requires the following hardware:

- Two FRDM-MCXN236 Rev C
- Two Type-C USB cable
- One Type-C OTG cable
- 3.5 mm headphone
- 3.5 mm Aux audio cable

[Figure 3](#) shows the block diagram of the hardware connection.



2.2 Software

We can implement a bidirectional USB audio host based on the `usb_host_audio_speaker` example in the FRDM-MCXN236 SDK v2.16. The LPCXpresso5516 SDK v2.16 provides a `usb_host_audio_unified_bm` example that supports composite devices that integrate USB audio speaker, USB audio recorder, and HID classes. [Figure 4](#) shows the structure of the `usb_host_audio_unified_bm` example in the LPCXpresso55S16 SDK v2.16.

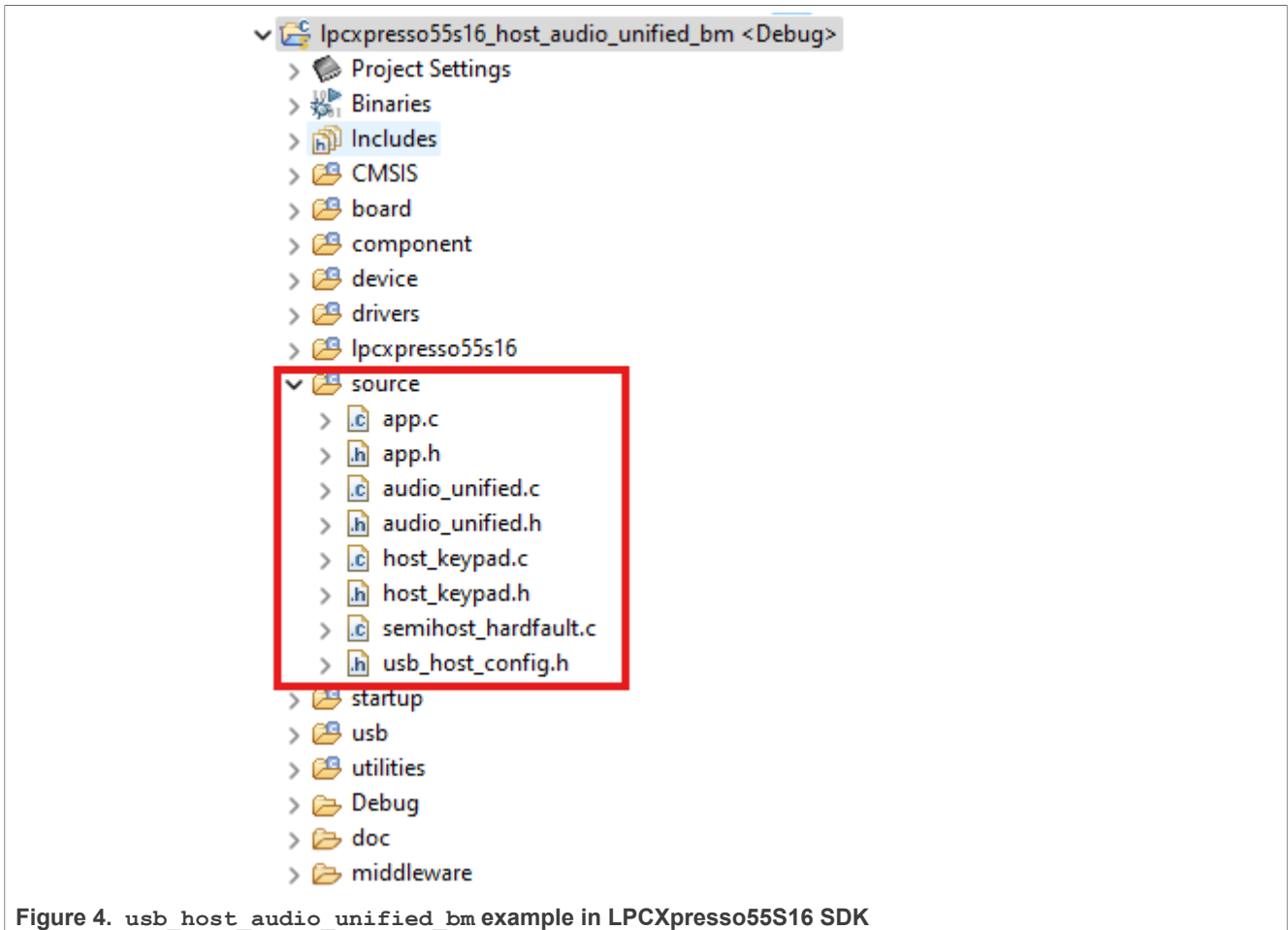


Figure 4. usb_host_audio_unified_bm example in LPCXpresso55S16 SDK

Therefore, we must port the relevant source files to the `usb_host_audio_speaker` example to implement the bidirectional USB audio host on the MCX N23x. The IDE used in this application note is MCUXpresso IDE 11.9.1.

The porting steps are as follows:

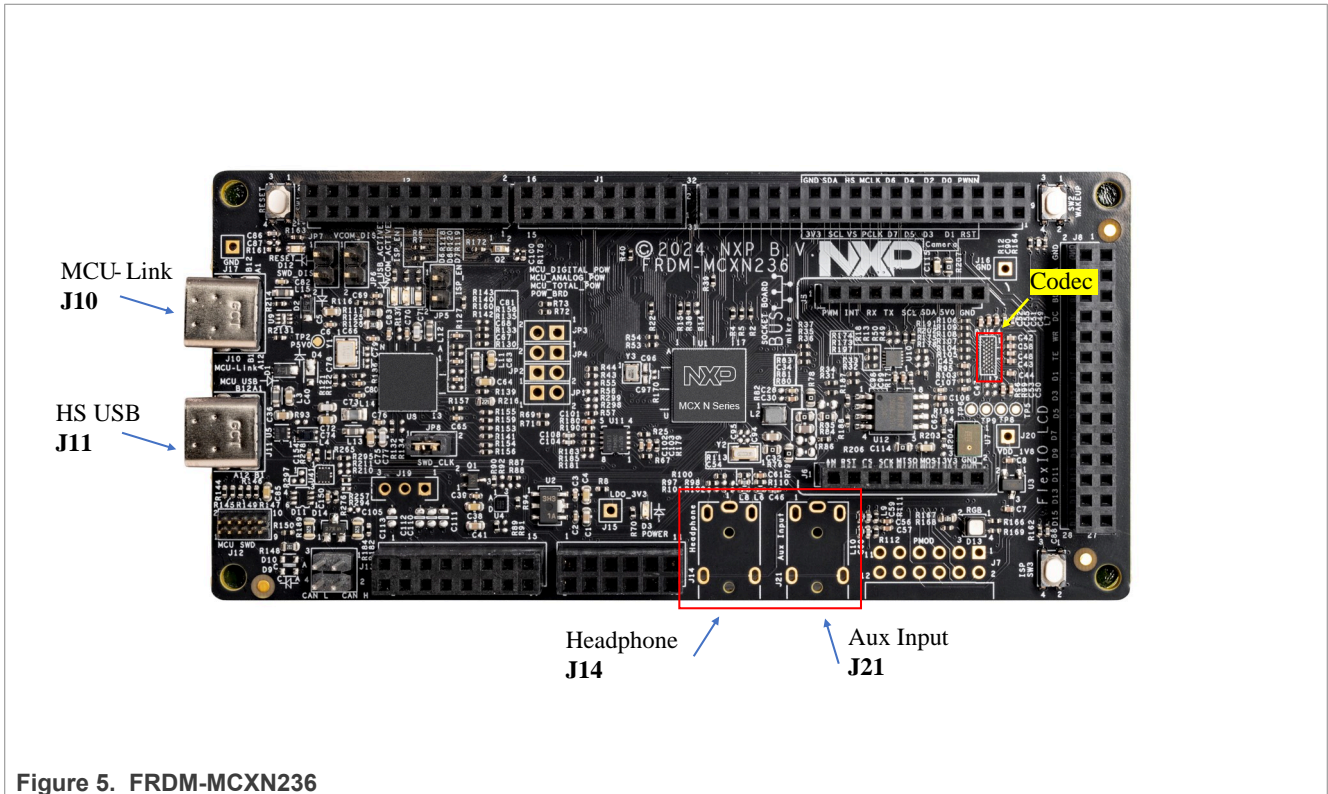
1. Copy `audio_unified.c` and `audio_unified.h` files to replace `audio_speaker.c` and `audio_speaker.h` files.
2. Modify the header file in the `app.c` file and change “`include audio_speaker.h`” to “`include audio_unified.h`”.
3. Modify the macro definition in the `usb_host_config.h` file and change the value of the `USB_HOST_CONFIG_AUDIO` macro from `1` to `2` to support two audio classes.

At this point, we have quickly implemented a bidirectional USB audio host, which implements a function that receives audio data from the USB recorder channel and plays the received audio data through the USB speaker channel.

We can use the `usb_device_composite_hid_audio_unified` example in the FRDM-MCXN236 SDK as a USB audio device to test this bidirectional USB audio host. The next section introduces how to test this bidirectional USB audio host.

3 Testing of bidirectional usb audio host

This section introduces how to test the bidirectional USB audio host. First, rework a FRDM-MCXN236 Rev C board, because the audio codec and two audio jacks on the FRDM-MCXN236 Rev C are not soldered by default, as shown in [Figure 5](#). Solder an audio codec and two 3.5 mm audio jacks, and then use this board as a USB audio device to test the SAI module. The part number of the audio codec is DA7212, and the part number of the audio jacks is 54-00174.



After reworking the board, compile the `usb_device_composite_hid_audio_unified` example in the FRDM-MCXN236 SDK v2.16, and then download it to the MCXN236 through the onboard debugger (MCU-Link) interface J10.

In this example, the audio data of the USB recorder channel comes from the Aux input interface J21, so use an Aux audio cable to connect the J21 to the 3.5 mm analog audio output interface on the computer, or to other devices with a 3.5 mm audio output interface, and connect a 3.5 mm headphone to the headphone interface J14.

For USB device, if you don't want to rework the FRDM-MCXN236 board, choose other development boards with audio codec, such as LPCxpresso55S16, LPCxpresso55S69, and download the `usb_device_composite_hid_audio_unified` example in their corresponding SDK to the board.

For the USB audio host:

- Compile the modified USB audio host example in [Section 2.2](#), and then use the Type-C cable to connect the onboard debugger interface J10 to the PC, and download the compiled firmware to the MCX N236.
- Connect the Type-C OTG cable to the HS USB interface J11 of the MCXN236, disconnect the connection between the MCU-Link and the PC on the USB device side, and use this Type-C USB cable to connect the HS USB interface J11 of the USB device and the Type-C OTG cable.

- Press the reset button **SW1** on the USB host board to run the USB audio host program, and you can see the following log information. The USB audio host has successfully counted a composite class device with a USB audio speaker, a USB audio recorder, and a USB HID class.

```

COM10 - Tera Term VT
File Edit Setup Control Window Help
host init done
hid keypad attached:pid=0xa4vid=0x1fc9 address=1
hid audio attached:pid=0xa4vid=0x1fc9 address=1
keypad attached
USB audio unified device attached
AUDIO 2.0 device
AUDIO_GET_VOLUME_RANG
Audio recorder information:
- Frequency device support frequency rang is :MIN 48000 Hz, MAX 48000 Hz, RES attributes 0Hz,
- Bit resolution : 16 bits
- Number of channels : 2 channels
- Transfer type : Isochronous
- Sync type : Synchronous
- Usage type : Data endpoint
Audio speaker information:
- Frequency device support frequency rang is :MIN 48000 Hz, MAX 48000 Hz, RES attributes 0Hz,
- Bit resolution : 16 bits
- Number of channels : 2 channels
- Transfer type : Isochronous
- Sync type : Synchronous
- Usage type : Data endpoint
USB host unfied example is recording 48k 16bit 2ch format audio, then loop playback 48k 16bit 2ch format recorded audio.
    
```

Figure 6. Log information from the USB audio host

Finally, test the audio function. Play any audio file on the computer. The audio is received by the codec on the USB device side through the Aux input interface, and then transmitted to the USB audio host side through the USB recorder channel. The USB audio host plays the received audio data through the USB speaker channel, and you can hear the audio from the computer through the 3.5 mm headphones on the USB audio device side.

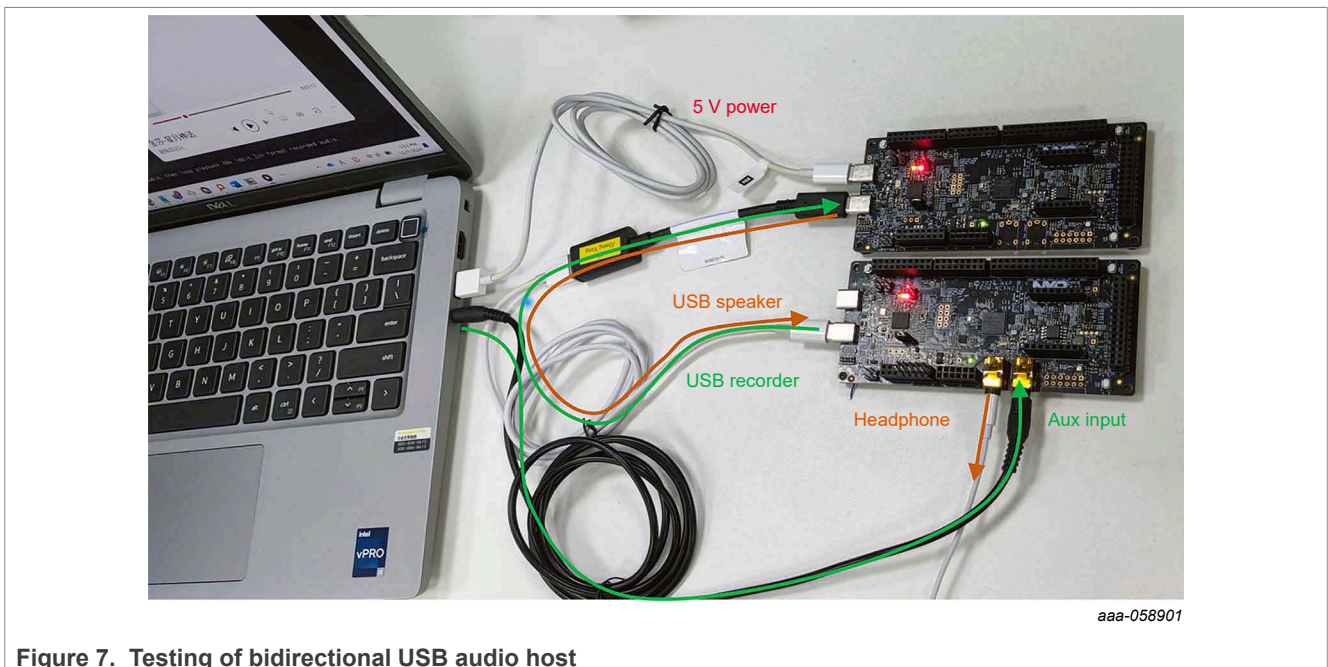


Figure 7. Testing of bidirectional USB audio host

4 Conclusion

This application note describes how to implement a bidirectional USB audio host on MCX N23x and how to test this USB audio host. In this application note, users can understand that the MCX N23x is suitable for USB audio applications. It cannot only be used as a USB audio device but also realize the function of the USB audio host. FRDM-MCXN236 SDK v2.16 also provides a wealth of USB audio-related routines, based on which customers can quickly develop their own USB audio applications.

5 Reference

- *MCX N23x Reference Manual* (document [MCXN23XRM](#))

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7 Revision history

[Table 3](#) summarizes the revisions to this document.

Table 3. Revision history

Document ID	Release date	Description
AN14546 v1.0	23 January 2025	Initial public release

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