AN14546

基于MCX N23x的双向USB音频主机

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文档信息

信息	内容
关键词	AN14546、音频、USB主机、USB音频主机、双向音频、MCX N23x、MCX N236
摘要	本应用笔记介绍了如何在MCX N23x上实现双向USB音频主机，以及如何对其进行测试。

1 介绍

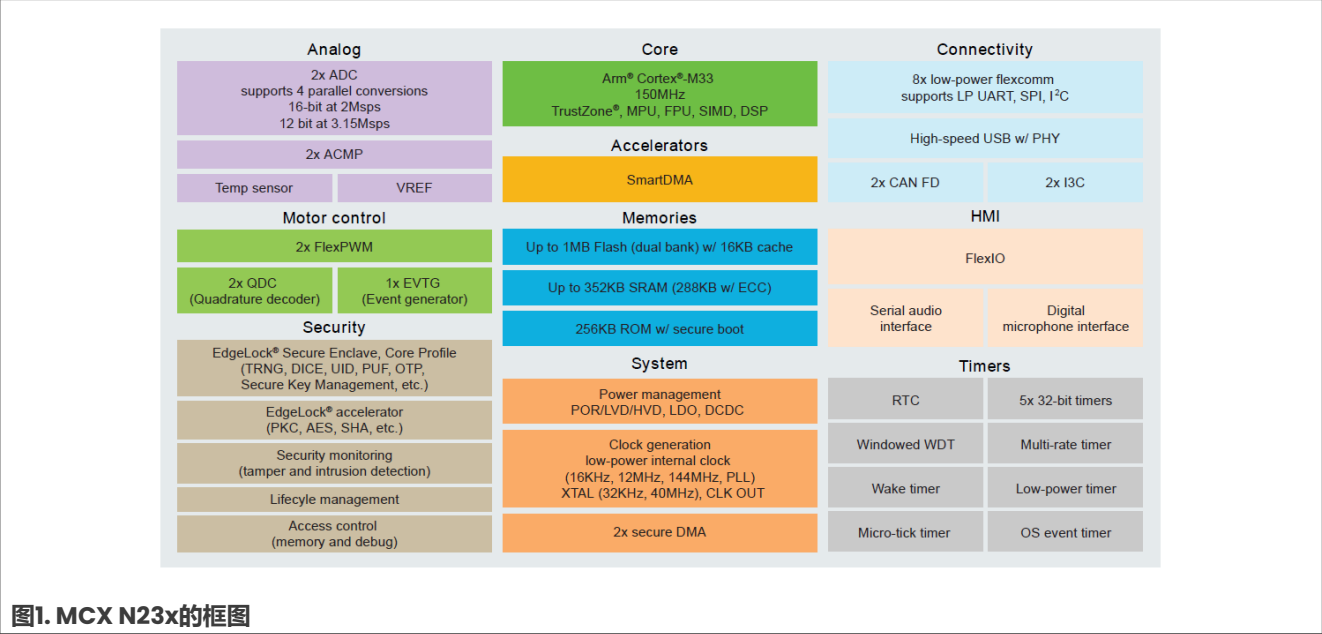MCX N23x系列MCU是MCX N系列的第二款MCU。与MCX Nx4x系列相比，该系列在成本、内存和功耗方面进行了优化。它可以被视为MCX Nx4x系列的一个精简版本，但仍然支持丰富的外设接口。图1所示为MCX N23x的框图。

图1. MCX N23x的框图

如图1所示，MCX N23x具有一个高速（HS）USB，可支持主机和设备模式，并配备两个SAI模块，因此适用于USB音频应用。图2所示为MCX N23x上的SAI模块的框图。
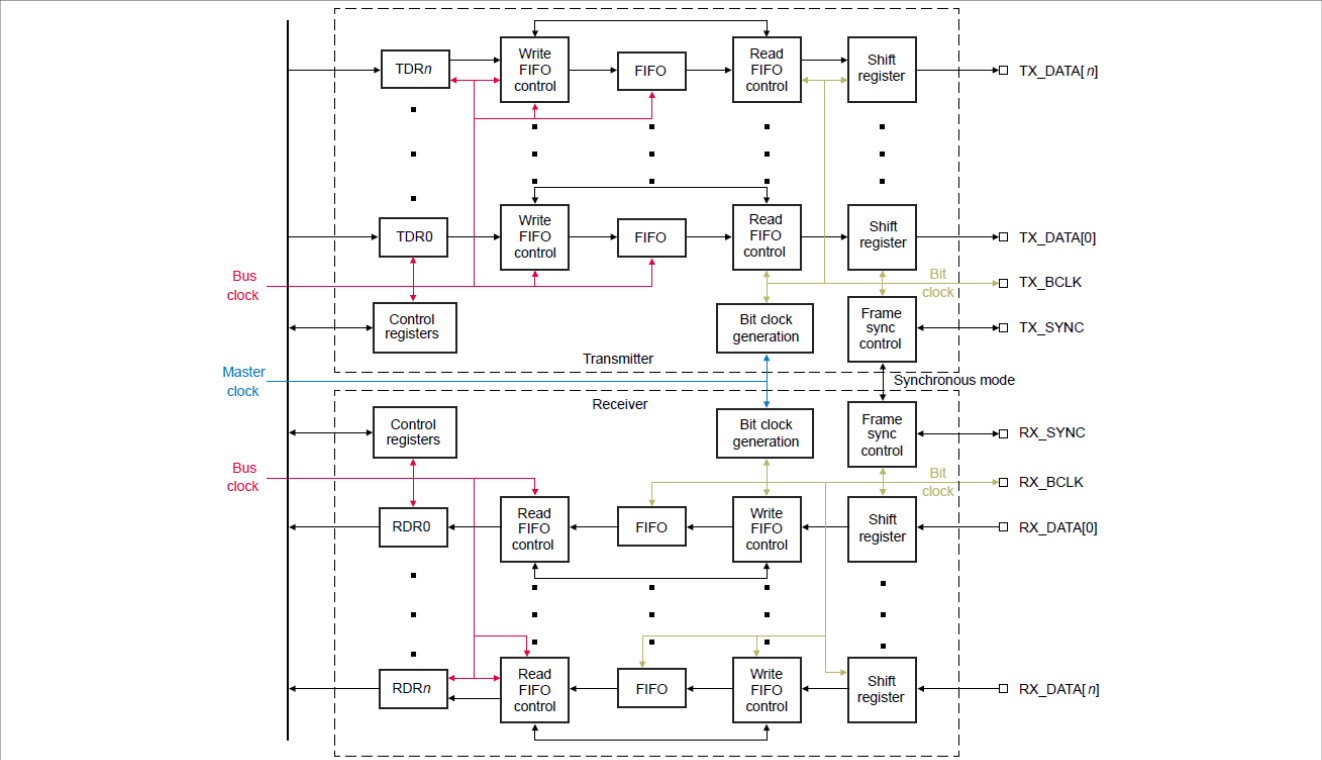
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图2. MCX N23x上的SAI的框图

MCX N23x的SAI模块能够支持以下功能：

- 带有独立位时钟和帧同步的发送器，支持两条数据线
- 带有独立位时钟和帧同步的接收器，支持两条数据线
- 每条数据线最大帧大小为32个字
- 可分别配置帧内第一个字和其余字的字长
- 每条发送和接收数据线配备异步8×32位FIFO，支持：
  - 发生FIFO错误后平稳重启。
  - 发生FIFO错误后自动重启，无需软件干预。
  - 将8位和16位数据打包到每个32位的FIFO字中。
  - 将多数据线的FIFO合并为单数据线的FIFO。

FRDM-MCXN236开发板可用于评估MCX N23x的各种外设，但默认情况下，该开发板上并未焊接音频编解码器DA7212和音频插座。需要将这些组件焊接到开发板上，以支持音频功能的评估。此外，FRDM-MCXN236 SDK v2.16还提供了丰富的SAI示例，如表1所示。

表1. FRDM-MCXN236 SDK v2.16中的SAI示例

1	`sai_edma_record_playback`
2	`sai_edma_transfer`
3	`sai_interrupt`
4	`sai_interrupt_record_playback`
5	`sai_interrupt_transfer`

此外，该SDK还提供了一些与USB音频相关的示例，这些示例都位于`usb_examples`目录中，如表2所示。

表2. FRDM-MCXN236 SDK v2.16中的USB音频示例

1	`usb_device_audio_generator`
2	`usb_device_audio_generator_lite`
3	`usb_device_audio_speaker`
4	`usb_device_audio_speaker_lite`
5	`usb_device_composite_hid_audio_unified`
6	`usb_device_composite_hid_audio_unified_lite`
7	`usb_host_audio_speaker`

对于USB音频主机，FRDM-MCXN236 SDK v2.16仅提供了一个单独的USB主机音频扬声器示例，该示例仅支持USB扬声器设备。本应用笔记作为对SDK示例的补充，介绍了如何在MCX N23x上实现双向USB音频主机，使其能够同时支持集成了USB音频扬声器和USB音频录音机的复合设备。
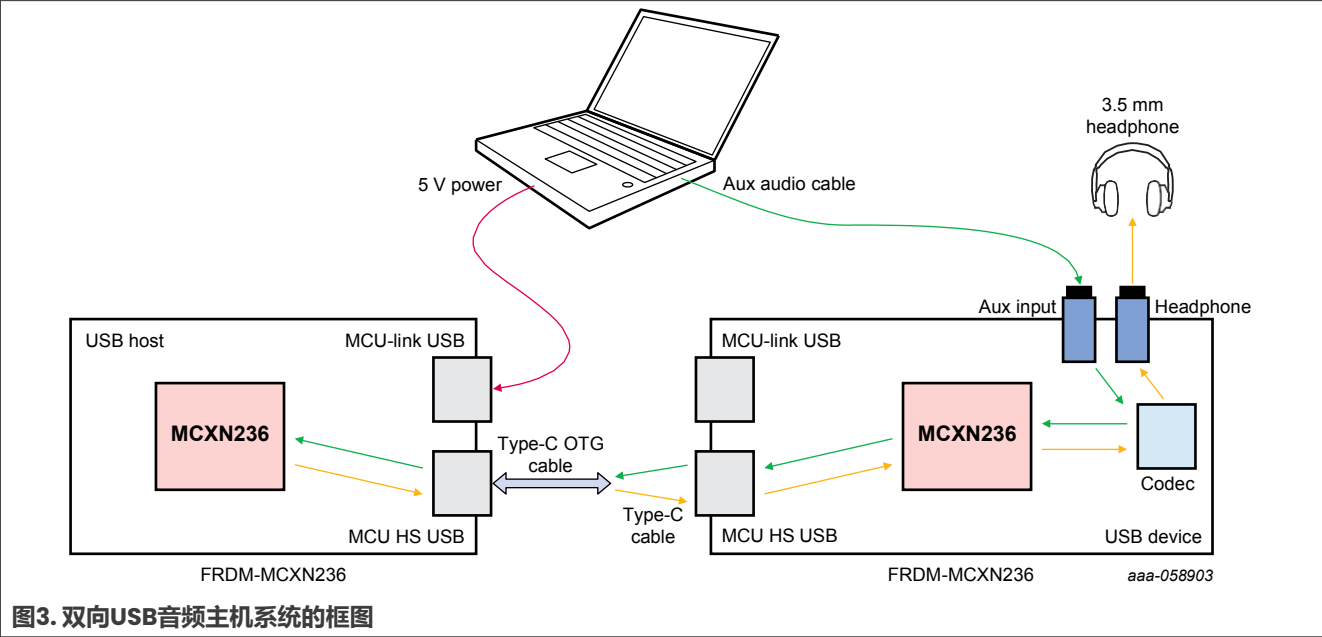
2 双向USB音频主机的实现

本节介绍了如何实现双向USB音频主机及其测试所需的硬件。

2.1 硬件

测试双向USB音频主机需要以下硬件：
- 两块FRDM-MCXN236 Rev C
- 两根Type-C USB数据线
- 一根Type-C OTG数据线
- 一个3.5 mm耳机
- 一根3.5 mm辅助（Aux）音频数据线

图3所示为硬件连接的框图。

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图3. 双向USB音频主机系统的框图

2.2 软件

可以基于FRDM-MCXN236 SDK v2.16中的`usb_host_audio_speaker`示例来实现双向USB音频主机。
LPCXpresso5516 SDK v2.16提供了一个`usb_host_audio_unified_bm`示例，支持集成了USB音频扬声器、
USB音频录音机和HID类的复合设备。图4所示为LPCXpesso55S16 SDK v2.16中
`usb_host_audio_unified_bm`示例的结构。

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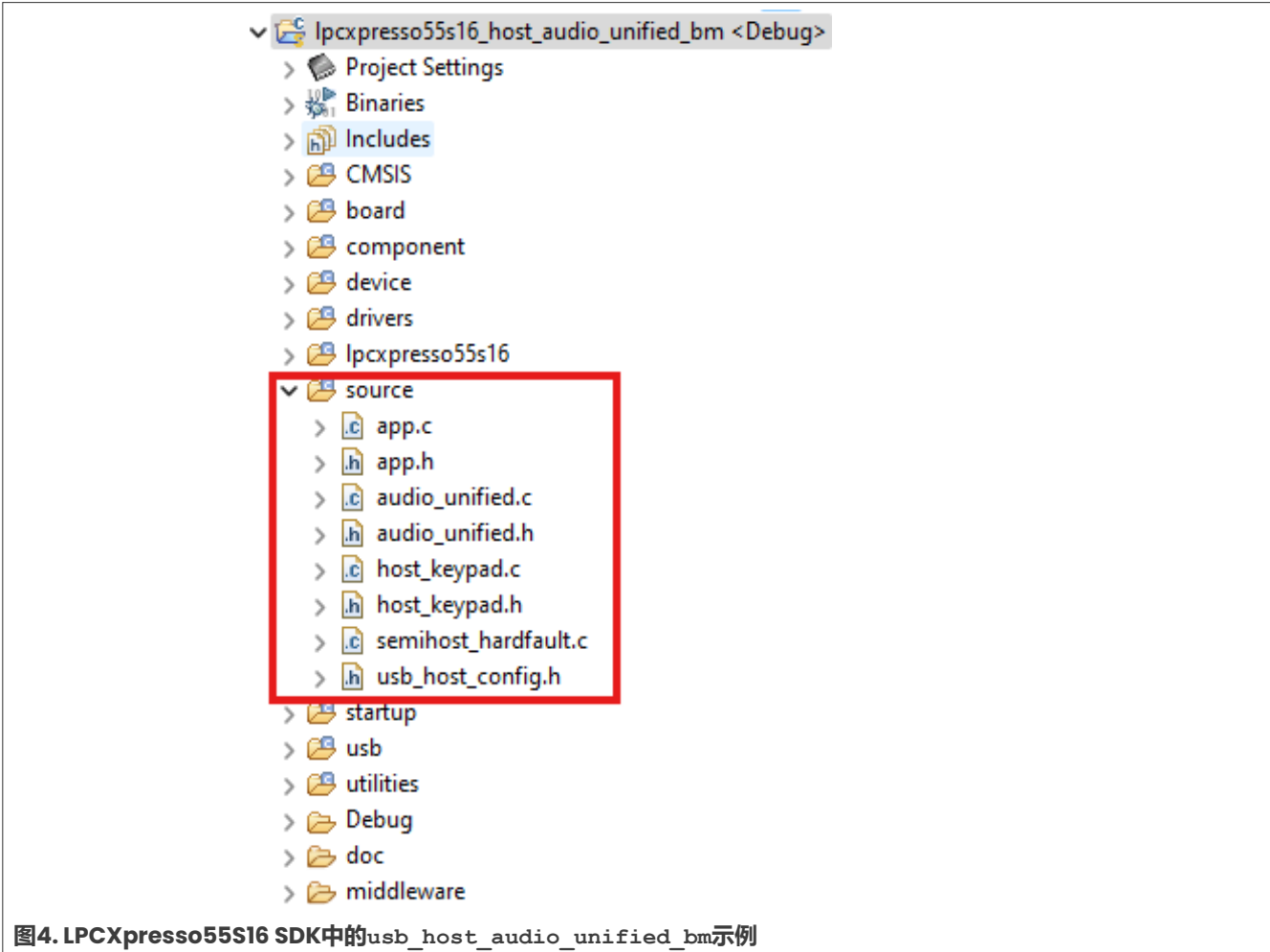© 2025NXP B.V. 版权所有。

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图4. LPCXpresso55S16 SDK中的`usb_host_audio_unified_bm`示例

因此，必须将相关的源文件移植到`usb_host_audio_speaker`示例，以在MCX N23x上实现双向USB音频主机。本应用笔记中使用的IDE为MCUXpresso IDE 11.9.1。

移植步骤如下：

1. 复制*audio_unified.c*和*audio_unified.h*文件，以替换*audio_speaker.c*和*audio_speaker.h*文件。
2. 修改*app.c*文件中的头文件，将*#include "audio_speaker.h"*更改为*#include "audio_unifed.h"*。
3. 修改*usb_host_config.h*文件中的宏定义，将`USB_HOST_CONFIG_AUDIO`宏的值从**1**改为**2**，以支持两个音频类。

至此，已经快速实现了一个双向USB音频主机，它实现了一个功能，即从USB录音机通道接收音频数据，并通过USB扬声器通道播放接收到的音频数据。

可以使用FRDM-MCXN236 SDK中的`usb_device_composite_hid_audio_unified`示例作为USB音频设备，来测试该双向USB音频主机。下一节将介绍如何测试该双向USB音频主机。

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3 双向USB音频主机的测试

本节介绍了如何测试双向USB音频主机。首先，需要对FRDM-MCXN236 Rev C开发板进行改装，因为默认情况下，该开发板上的音频编解码器和两个音频插座并未焊接，如图5所示。需要焊接一个音频编解码器和两个3.5 mm音频插座，然后将此开发板用作USB音频设备，来测试SAI模块。音频编解码器的型号为DA7212，音频插座的型号为54-00174。
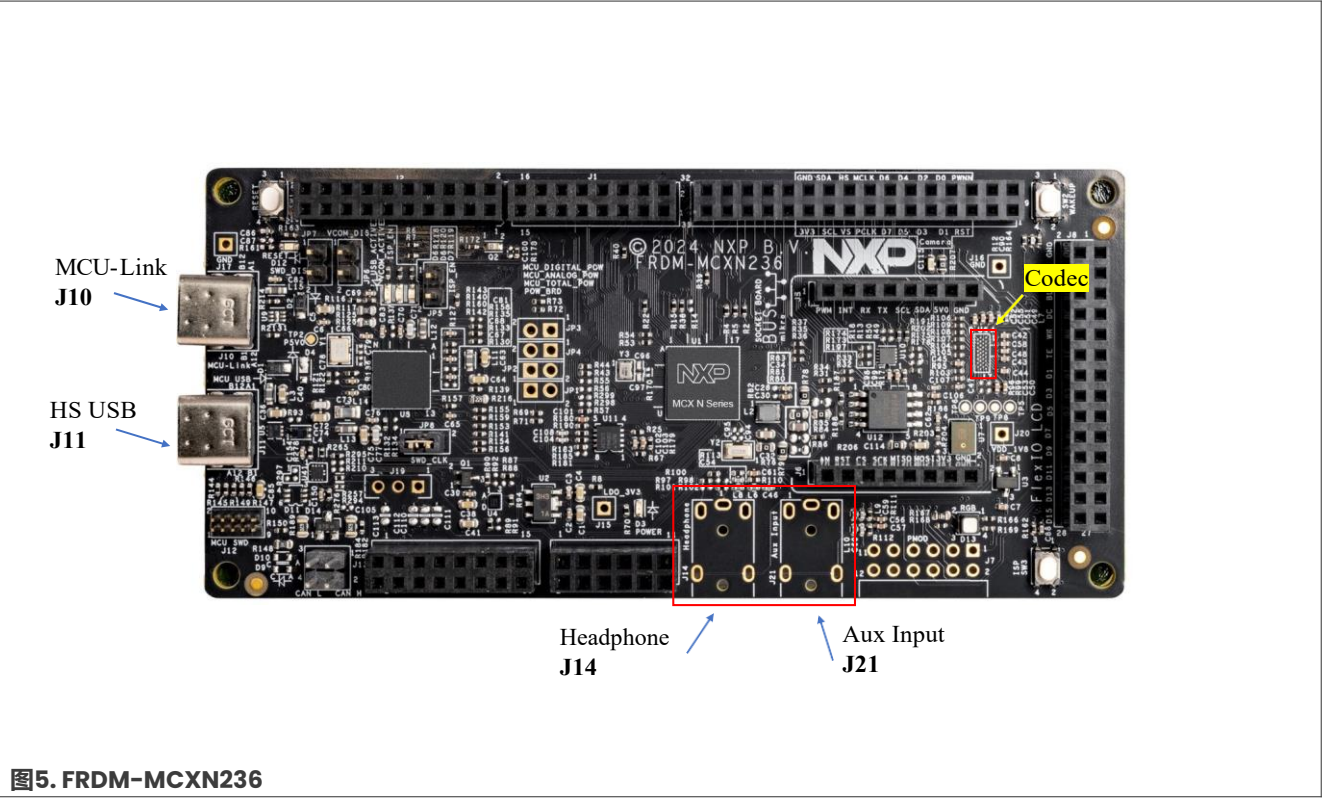
图5. FRDM-MCXN236

改装完开发板后，编译FRDM-MCXN236 SDK v2.16中的`usb_device_composite_hid_audio_unified`示例，然后通过板载调试器（MCU Link）接口J10将其下载到MCXN236。

在该示例中，USB录音机通道的音频数据来自辅助（Aux）输入接口J21，因此需要使用一根辅助（Aux）音频数据线将J21连接至计算机上的3.5 mm模拟音频输出接口，或连接至其它具有3.5 mm音频输出接口的设备，并将一个3.5 mm耳机连接至耳机接口J14。

对于USB设备，如果不希望改装FRDM-MCXN236开发板，可以选择其它带有音频编解码器的开发板，如LPCXpresso55S16和LPCXpresso55S69，并将其对应SDK中的`usb_device_composite_hid_audio_unified`示例下载到该开发板上。

对于USB音频主机：

- 编译第2.2节中修改过的USB音频主机示例，然后使用Type-C数据线将板载调试器接口J10连接至PC，并将编译好的固件下载到MCX N236。
- 将Type-C OTG数据线连接至MCXN236的HS USB接口J11，断开USB设备端MCU-Link与PC之间的连接，然后使用这条Type-C USB数据线来连接USB设备的HS USB端口J11。

- 按下USB主机开发板上的复位按钮**SW1**，以运行USB音频主机程序，即可看到以下日志信息。该USB音频主机已成功识别出一个包含USB音频扬声器、USB音频录音机和USB HID类的复合设备。


```
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.
```

图6. 来自USB音频主机的日志信息

最后，测试音频功能。在计算机上播放任意音频文件。音频通过辅助（Aux）输入接口被USB设备端的编解码器接收，然后通过USB录音机通道传输至USB音频主机端。USB音频主机通过USB扬声器通道播放接收到的音频数据，可以通过USB音频设备端上的耳机听到计算机播放的音频。
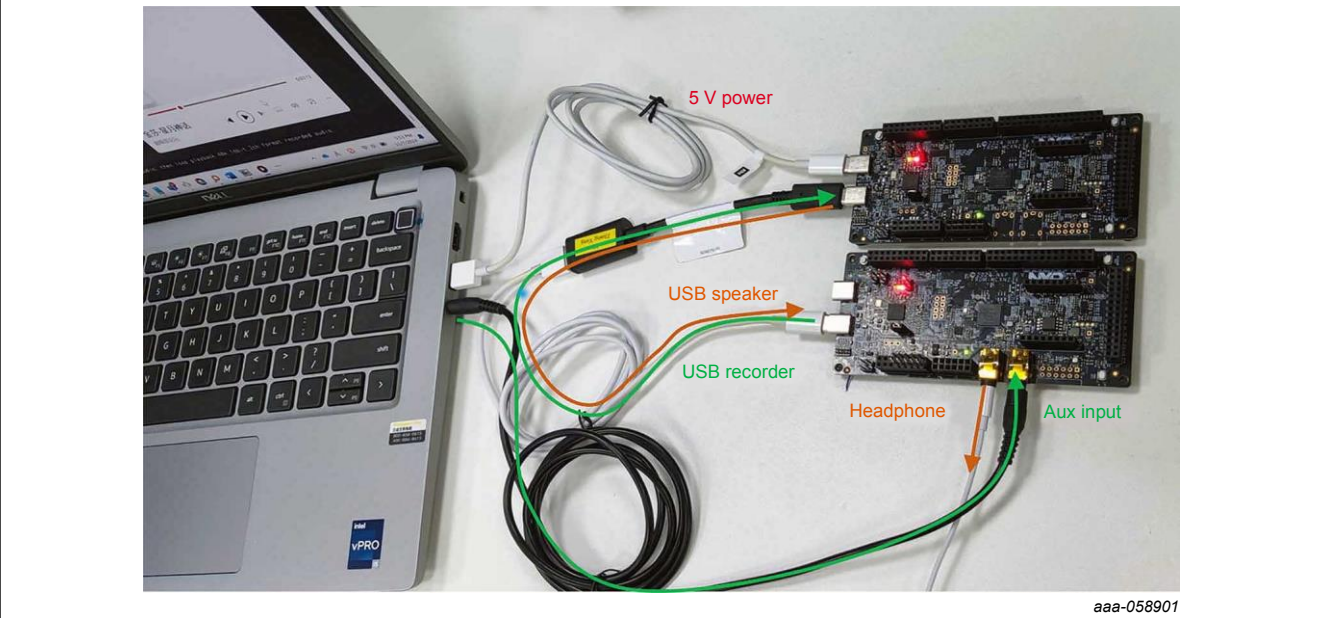

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图7. 双向USB音频主机的测试

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4 结论

本应用笔记介绍了如何在MCX N23x上实现双向USB音频主机，以及如何对其进行测试。通过本应用笔记，用户可以了解到MCX N23x适用于USB音频应用。它不仅可用作USB音频设备，还能够实现USB音频主机的功能。FRDM-MCXN236 SDK v2.16还提供了丰富的USB音频相关例程，客户可以基于这些例程快速开发自己的USB音频应用。

5 参考资料

• 《MCX N23x参考手册》（文档MCXN23XRM）

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7 修订历史

表3汇总了本文档的修订情况。

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