M480 UAC1.0 Sample-rate 48kHz, 24-bit and 2-channel on both playback and record ways

Example Code Introduction for 32-bit NuMicro® Family

Information

Application	This example code uses M480 MCU and NAU88L25 audio codec device to implement the UAC1.0 based on sample-rate 48kHz, 24-bit data length and 2-channel on both playback and record ways.
BSP Version	M480 Series BSP CMSIS V3.03.001
Hardware	NuMaker-PFM-M487 V3.0

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1 Function Description

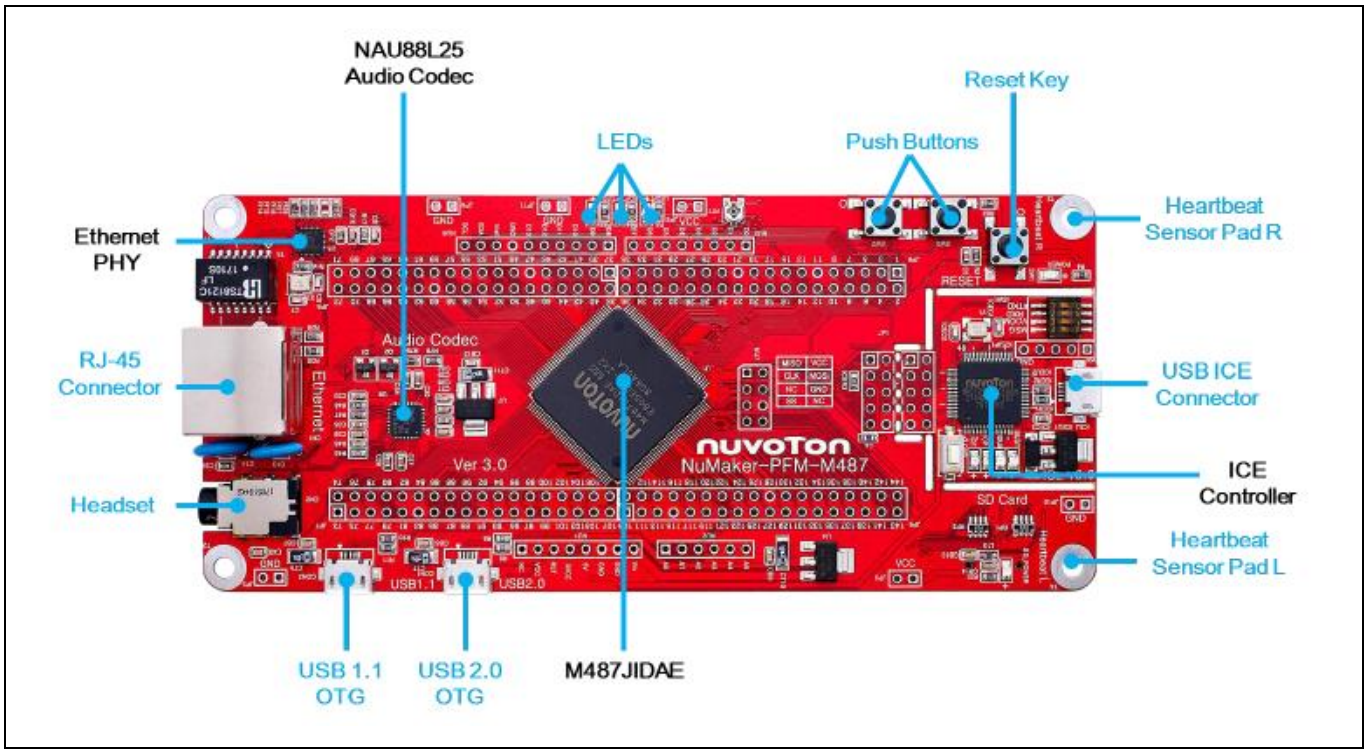
1.1 Introduction

This example code uses M480 MCU and on-board NAU88L25 audio codec device to implement the UAC1.0 (USB Audio Class 1.0) based on sample-rate 48kHz, 24-bit data length and 2-channel on both playback and record ways on the NuMaker-PFM-M487 V3.0 board.

For more information on the NuMaker-PFM-M487 board for the ARM® mbed™ Device Platform, please visit the ARM® mbed™ hardware board website or Nuvoton website to download the User Manual document UM_NuMaker-PFM_M487_User_Manual_EN:

https://developer.mbed.org/platforms/NUMAKER-PFM-M487/

https://www.nuvoton.com/hq/products/microcontrollers/arm-cortex-m4-mcus/User-Manual/?__locale=en&resourcePage=Y&category=&pageIndex=3



NuMaker-PFM-M487 V3.0 Board

1.2 Demo Result

After executed this example code, user can plug-in the USB cable that connect the USB1.1 connector (FS USB OTG) with PC Host and plug-in a headset to the CN2 connector on the NuMaker-PFM-M487 V3.0 board to listen the playing music from PC or to record the voice from the microphone of the headset to the PC recorder.

2 Code Description

This EP3_Handler() function is used to transfer the 24-bit playback PCM data of Left and Right channels from PC Host and store these data to buffers (g_au32PcmPlayBuf[]) at 32-bit format for I2S0 port to transmit to the external NAU88L25 audio codec device.

```
/**
 * @brief       EP3 Handler
 *
 * @param[in]   None
 *
 * @return      None
 *
 * @details     This function is used to process EP3 event
 */
/* Play */
void EP3_Handler(void)
{
    uint32_t u32Len;
    int32_t i;
    uint8_t *pu8Src;
    uint8_t *pu8Buf;
    uint32_t u32Idx;
    uint8_t  Samples;

    /* Get the address in USB buffer */
    pu8Src = (uint8_t *)((uint32_t)USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP3));

    /* Get the byte size of play data */
    u32Len = USBD_GET_PAYLOAD_LEN(EP3);

    /* Calculate samples */
    Samples = u32Len/6;  // 48 = 288/(2ch * 3bytes)

    for(i = 0; i < Samples; i++) {
        /* Check ring buffer turn around */
        u32Idx = g_u32PlayPos_In + 1;
        if(u32Idx >= BUF_LEN)
            u32Idx = 0;

        /* Check if buffer full */
```

```
        if(u32Idx != g_u32PlayPos_Out) {
            /* Update play ring buffer only when it is not full */
            /* Each Word stores a 24-bit Left or Right PCM data */
            pu8Buf = (uint8_t *)&g_au32PcmPlayBuf[u32Idx];
            /* L-data */
            *pu8Buf++ = 0;
            *pu8Buf++ = *pu8Src++;
            *pu8Buf++ = *pu8Src++;
            *pu8Buf++ = *pu8Src++;
            /* R-data */
            *pu8Buf++ = 0;
            *pu8Buf++ = *pu8Src++;
            *pu8Buf++ = *pu8Src++;
            *pu8Buf   = *pu8Src++;

            /* Update IN index */
            u32Idx++;
            g_u32PlayPos_In = u32Idx;
        } else {
            printf("full\n");
        }
    }

    /* Prepare for next OUT packet */
    USBD_SET_PAYLOAD_LEN(EP3, EP3_MAX_PKT_SIZE);

    if(g_u8PlayEn == 0) {
        /* Start play data output through I2S only when we have enough data in buffer */
        if(GetSamplesInBuf() > BUF_LEN / 2)
            g_u8PlayEn = 1;
    }

}
```

This UAC_SendRecData() function is used to transfer the 32-bit record PCM data of Left and Right channels through the data buffers (g_au32PcmRecBuf[]) receiving from the external NAU88L25 audio codec device and store these data into the internal SRAM of Full Speed USB Device at 24-bit format for endpoint 2 (EP2).

```
/**
  * @brief  SendRecData, prepare the record data for next ISO transfer.
```

```
  * @param  None.
  * @retval None.
  */
void UAC_SendRecData(void)
{
    uint8_t *pu8Buf;
    uint8_t *pu8Src;
    int32_t i;

    /* Get the address in USB buffer */
    pu8Buf = (uint8_t *)((uint32_t)USBD_BUF_BASE + USBD_GET_EP_BUF_ADDR(EP2));

    /* Prepare the data to USB IN buffer */
    for(i = 0; i < EP2_MAX_PKT_SIZE/6; i++) {
        pu8Src = (uint8_t *)&g_au32PcmRecBuf[g_u32RecPos_Out];
        /* L-data */
        pu8Src++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;
        /* R-data */
        pu8Src++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;
        *pu8Buf = *pu8Src++;
        pu8Buf++;

        /* Update Out index */
        g_u32RecPos_Out += 2;
        if(g_u32RecPos_Out >= BUF_LEN) g_u32RecPos_Out = 0;
    }
    /* Trigger ISO IN */
    USBD_SET_PAYLOAD_LEN(EP2, EP2_MAX_PKT_SIZE);
}
```

This I2S0_IRQHandler() function is the interrupt service routine of IS20 port and it is used to transmit the playback PCM data to NAU88L25 codec device thru the playback buffers (g_au32PcmPlayBuf[]) by writing the internal FIFO of I2S0 port and receive the record PCM data from NAU88L25 codec device thru the record buffers (g_au32PcmRecBuf[]) by reading the internal FIFO of I2S0 port.

```
/**
  * @brief  I2S0_IRQHandler, I2S0 interrupt service routine to transmit and receive data to/from NAU88L25 codec.
  * @param  None.
  * @retval None.
  */
void I2S0_IRQHandler(void)
{
    uint32_t u32I2SIntFlag;
    uint32_t i, u32Idx;

    u32I2SIntFlag = I2S_GET_INT_FLAG(I2S0, I2S_STATUS0_TXTHIF_Msk | I2S_STATUS0_RXTHIF_Msk);

    if(u32I2SIntFlag & SPI_I2SSTS_TXTHIF_Msk) {
        /* Fill 2 word data when it is TX threshold interrupt */
        for(i = 0; i < 1; i++) {
            /* Check buffer empty */
            if(g_u8PlayEn) {
                if((g_u32PlayPos_Out != g_u32PlayPos_In)) {
                    /* Check ring buffer turn around */
                    u32Idx = g_u32PlayPos_Out + 2;
                    if(u32Idx >= BUF_LEN)
                        u32Idx = 0;

                    /* Transmit data to codec */
                    I2S_WRITE_TX_FIFO(I2S0, g_au32PcmPlayBuf[u32Idx]);
                    I2S_WRITE_TX_FIFO(I2S0, g_au32PcmPlayBuf[u32Idx+1]);

                    /* Update OUT index */
                    g_u32PlayPos_Out = u32Idx;
                } else {
                    /* Fill 0x0 when buffer is empty */
                    I2S_WRITE_TX_FIFO(I2S0, 0x00);
                    I2S_WRITE_TX_FIFO(I2S0, 0x00);

                    /* Buffer underrun. Disable play */
```

```
                    g_u8PlayEn = 0;
                    g_u32PlayPos_In = 0; //BUF_LEN / 2;
                    g_u32PlayPos_Out = 0;
                }
            } else {
                /* Fill 0x0 when buffer is empty */
                I2S_WRITE_TX_FIFO(I2S0, 0x00);
                I2S_WRITE_TX_FIFO(I2S0, 0x00);
            }
        }
    }

    if(u32I2SIntFlag & SPI_I2SSTS_RXTHIF_Msk) {
        if(g_u8RecEn == 1) {
            /* Receive data from codec */
            g_au32PcmRecBuf[g_u32RecPos_In++] = I2S_READ_RX_FIFO(I2S0);
            g_au32PcmRecBuf[g_u32RecPos_In++] = I2S_READ_RX_FIFO(I2S0);

            /* Check In index */
            if(g_u32RecPos_In >= BUF_LEN) g_u32RecPos_In = 0;
        } else {
            I2S_READ_RX_FIFO(I2S0);
            I2S_READ_RX_FIFO(I2S0);
        }
    }
}
```

3 Software and Hardware Environment

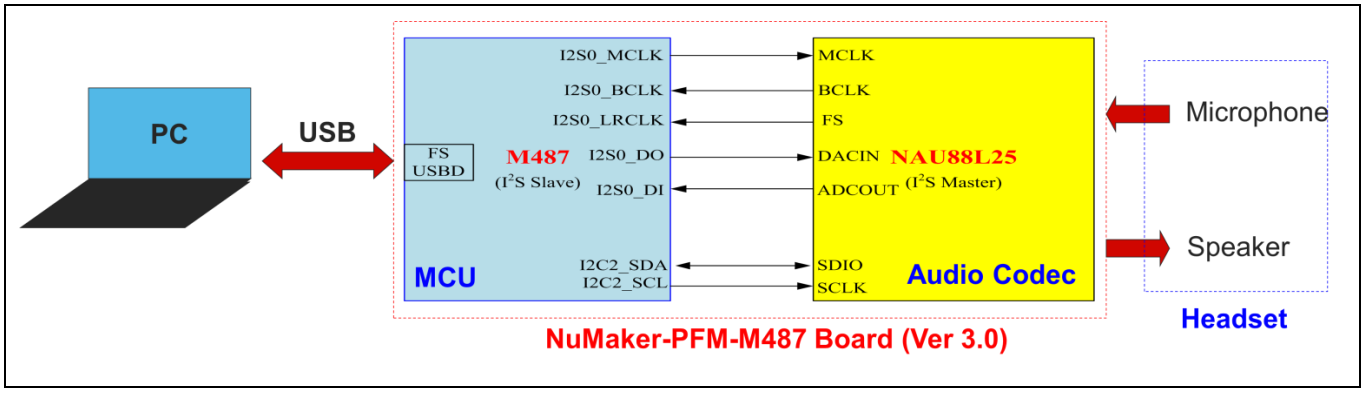
Software Environment

- BSP version
  - M480 Series BSP CMSIS V3.03.001
- IDE version
  - Keil uVersion 4.74

Hardware Environment

- Circuit components
  - NuMaker-PFM-M487 V3.0 board
- Diagram

The M480 MCU uses the I2C2 port to configure the NAU88L25 for I^2S clock settings of I^2S master, I2S0 port to transfer data with NAU88L25 audio codec device and Full Speed USB Device (FS USBD) to transfer PCM streams with PC Host.



Hardware Block Diagram

4 Directory Information

- EC_M480_UAC10_SR48kHz_24bit_2ch_Dual_V1.00
  - Library — Sample code header and source code files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header files
    - StdDriver — All peripheral driver header and source code files
  - SampleCode
    - ExampleCode — Source code files of this example code

5 How to Execute Example Code

1. Browsing into the sample code folder by Directory Information (section 4) and double click this sample code project M480_UAC10_SR48kHz_24bit_2ch_Dual.uvproj.
2. Enter Keil compile mode.
   a. Build.
   b. Download.
   c. Start/Stop debug session.
3. Enter debug mode.
   a. Run.

6 Revision History

Date	Revision	Description
June 28, 2019	1.00	1. Initially issued.

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