NUC505從內部SPI flash撥放WAV檔

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	本範例代碼從NUC505內部SPI flash讀取WAV檔案撥放
BSP 版本	NUC505 Series BSP CMSIS V3.02.000
開發平台	NuTiny-EVB-NUC505 V1.6

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1 功能介紹

1.1 簡介

範例程式中，NUC505使用內部音訊解碼器，讀取存在內部SPI flash的WAV檔並且撥放。使用者需先燒錄WAV檔至內部SPI flash，並從config.h檔中的WAVFile_address去指定WAV檔儲存位置。請注意WAV檔案不可超過NUC505記憶體位置。程式會先判斷WAV檔頭起始位置是否為RIFF，以及第8位元組是否為WAVE，來驗證儲存是否為WAV檔。

WAV檔案存放地址範圍	播放WAV檔案位置參數
0x2000~0x1F_FFFF	WAVFile_address

NUC505支援單/雙聲道，資料長度為16 bits格式，取樣率為8k, 11025, 12k, 16k, 22050, 24k, 32k, 44100和48k，程式碼會自動依照不同取樣率設定APLL數值。

1.2 執行結果

執行後會打印出以下資訊

```
Relocate vector table in SRAM (0x20000000) for fast interrupt handling, size = 0xbc.
+------------------------------------------------------------+
|      Play WAV file from internal Flash Sample Code         |
+------------------------------------------------------------+
  Please store WAV file first in the internal Flash.
  WAV file storage location cannot exceed flash size
  NOTE: Need head-phone.

wav.bin pre-stored in SPI Flash address from 0x00002000
wav: sampling rate = 44100
wav: Data size = 864 KB
wav: Channel Num = 2

Configure Internal CODEC ... [OK]
Start Playing ...
Play finish... enter while 1
```

2 代碼介紹

首先在main.c中對NUC505做初始化設定，並且把程式碼放入SRAM中執行以增加其執行速度，根據WAVFile_address所設定位置讀取WAV檔撥放。

```
int32_t main(void)
{
    /* Init System, IP clock and multi-function I/O */
    SYS_Init();

    /* Init UART0 to 115200-8n1 for print message */
    UART0_Init();

    /* Relocate vector table in SRAM for fast interrupt handling. */
    {
        extern uint32_t __Vectors[];
        extern uint32_t __Vectors_Size[];
        extern uint32_t Image$$ER_VECTOR2$$ZI$$Base[];

        printf("Relocate vector table in SRAM (0x%08X) for fast interrupt handling, size =
0x%x.\n", Image$$ER_VECTOR2$$ZI$$Base, (unsigned int) __Vectors_Size);
        memcpy((void *) Image$$ER_VECTOR2$$ZI$$Base, (void *) __Vectors, (unsigned int)
__Vectors_Size);
        SCB->VTOR = (uint32_t) Image$$ER_VECTOR2$$ZI$$Base;
    }
    /* Init I2S */
    I2S_Init();

    printf("+------------------------------------------------------------+\n");
    printf("|      Play WAV file from internal Flash Sample Code         |\n");
    printf("+------------------------------------------------------------+\n");
    printf("  Please store WAV file first in the internal Flash.\n");
    printf("  WAV file storage location cannot exceed flash size\n");
    printf("  NOTE: Need head-phone. \n\n");

    /* Play wav from internal flash at WAVFile_address */
    ReadFlashPlay(WAVFile_address);

    while (1);
}
```

在ReadFlashPlay(uint32_t FlashAddr)函式中，程式會先判斷WAV檔頭起始位置是否為RIFF，以及第8位元組是否為WAVE，來驗證儲存是否為WAV檔，並且讀取WAV檔相關資訊，並根據取樣率對APLL做設定。

```
    /* Parsing WAV file header */
    SPIFlash_DMARead(SPIM, FlashAddr, 0, 44, aWavHeader, SPIM_CTL0_CMDCODE_FAST_READ);

    /* Read sampling rate from WAV header */
    u32WavSamplingRate = aWavHeader[6];

    /* Check if the WAV file is correct */
    if (aWavHeader[0] != 0x46464952 | aWavHeader[2] != 0x45564157) {
        printf("WAV File ERROR, please store Wav file at 0x%08x\n", FlashAddr);
        return -1;
    }

    /* Read WAV file total size from WAV header */
    PlayFrameSize = aWavHeader[1] / (PCM_BUFFER_SIZE * 4);
    WavRealSize = aWavHeader[1] / 1024;

    /* Read Channel number from WAV header */
    ChannelNum = (aWavHeader[5] & 0x00030000) >> 16;
    AudioFormat = ChannelNum == 1 ? I2S_MONO : I2S_STEREO;
    /* Check if the MP3 SamplRate frequency is 11025 multiples */
    if (u32WavSamplingRate % 11025) {
        /* APLL is 49152031Hz for 12k, 16k, 24k, 32k, 48k, and 96k sampling rate */
        CLK_SET_APLL(CLK_APLL_49152031);

        if (u32WavSamplingRate == 8000)
            CLK_SetModuleClock(I2S_MODULE, CLK_I2S_SRC_APLL, 1);
    }
```

設定完畢之後使用Ping-pong buffer機制撥放WAV檔，其流程如下：

```
    while (1) {
        /* Set ping-pong buffer to transmit data */
        if ((aPCMBuffer_Full[0] == 1) && (aPCMBuffer_Full[1] == 1)) {
            /* In beginning, wait all buffers full and start play */
            if (!bAudioPlaying) {
                bAudioPlaying = 1;
                /* I2S DMA settings */
                I2S_SET_TX_TH_LEVEL(I2S, I2S_FIFO_TX_LEVEL_WORD_15);
```

```
                I2S_SET_RX_TH_LEVEL(I2S, I2S_FIFO_RX_LEVEL_WORD_16);
                /* Tx Start Address */
                I2S_SET_TXDMA_STADDR(I2S, (uint32_t) &aPCMBuffer[0][0]);
                /* Tx Threshold Address */
                I2S_SET_TXDMA_THADDR(I2S, (uint32_t) &aPCMBuffer[0][PCM_BUFFER_SIZE - 1]);
                /* Tx End Address */
                I2S_SET_TXDMA_EADDR(I2S, (uint32_t) &aPCMBuffer[1][PCM_BUFFER_SIZE - 1]);
                /* Enable setting -> start to play */
                I2S_ENABLE_TXDMA(I2S);
                I2S_ENABLE_TX(I2S);
                /* Enable interrupt : TX DMA Threshold and TX DMA End Interrupt */
                I2S_EnableInt(I2S, (I2S_IEN_TDMATIEN_Msk | I2S_IEN_TDMAEIEN_Msk));
                NVIC_EnableIRQ(I2S_IRQn);
                printf("Start Playing ...\n");
            }
            /* All buffers are full, wait */
            while ((aPCMBuffer_Full[0] == 1) && (aPCMBuffer_Full[1] == 1));
        }
        /* Read WAV data from internal flash */
        SPIFlash_DMARead(SPIM, FlashAddr + 44, 0, PCM_BUFFER_SIZE * 4,
_UNVMP(&aPCMBuffer[u8PCMBufferTargetIdx][0]), SPIM_CTL0_CMDCODE_FAST_READ);
        /* Move address pointer to next address */
        FlashAddr = FlashAddr + PCM_BUFFER_SIZE * 4;
        count_frame++;
        NVIC_DisableIRQ(I2S_IRQn);
        /* Set buffer full flag */
        aPCMBuffer_Full[u8PCMBufferTargetIdx] = 1;
        NVIC_EnableIRQ(I2S_IRQn);

        if (bAudioPlaying) {
            /* Make sure the current ping-pong buffer is empty */
            while (aPCMBuffer_Full[u8PCMBufferTargetIdx ^ 1]) {
                /* Break if the last audio data played */
                if (count_frame >= PlayFrameSize) {
                    goto stop;
                }
            }
        }
        /* Switch to another buffer */
        u8PCMBufferTargetIdx ^= 1;
    }
```

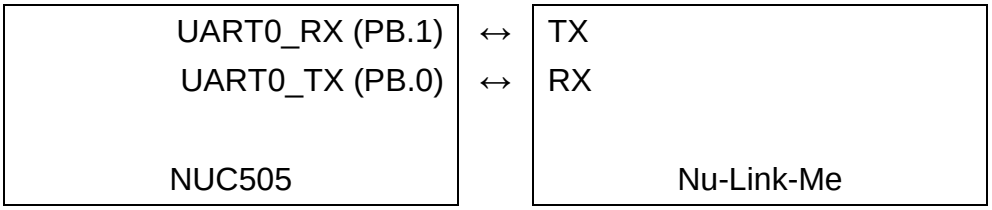
在nuc505_isr.c，當資料傳送完畢時清除緩衝區(buffer)滿溢旗標

```
void I2S_IRQHandler(void)
{
    uint32_t u32I2SIntFlag;

    /* Check interruput flag */
    u32I2SIntFlag = I2S_GET_INT_FLAG(I2S, I2S_STATUS_TDMATIF_Msk |
I2S_STATUS_TDMAEIF_Msk);

    if (u32I2SIntFlag & I2S_STATUS_TDMATIF_Msk) {
        I2S_CLR_INT_FLAG(I2S, I2S_STATUS_TDMATIF_Msk);

        /* Buffer 0 transfer completed, clear buffer full flag */
        aPCMBuffer_Full[0] = 0;
    } else if (u32I2SIntFlag & I2S_STATUS_TDMAEIF_Msk) {
        I2S_CLR_INT_FLAG(I2S, I2S_STATUS_TDMAEIF_Msk);
        /* Buffer 1 transfer completed, clear buffer full flag */
        aPCMBuffer_Full[1] = 0;
    }
}
```

3 軟體與硬體環境

- **軟體環境**
  - BSP 版本
    - NUC505 Series BSP CMSIS V3.02.000
  - IDE 版本
    - Keil uVersion 5.26
- **硬體環境**
  - 電路元件
    - NuTiny-EVB-NUC505 V1.6
    - 3.5 mm 接頭耳機
  - 示意圖

使用 3.5 mm 接頭耳機連接板上的 HP OUT 底座，並透過 NUC505 的 UART0_RX(PB.1)、UART0_TX(PB.0)連接至 Nu-Link Me，打印訊息。設置終端機的 COM Port 與 Baud，COM Port 的編號可在裝置管理員中找到「NuBridge Virtual Com Port (COMX)」，Baud 設置為 115200。



4 目錄資訊

- EC_NUC505_WavPlayerSPIFlash_V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 如何執行範例程式

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 WavPlayerSPIFlash.uvproj
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
   c. 進入 / 離開除錯模式
3. 進入除錯模式介面
   a. 執行代碼

6 修訂紀錄

Date	Revision	Description
Jul. 03, 2019	1.00	1. 初始發布.

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