使用PWM捕獲功能偵測UART鮑率

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	使用 NUC123 的 PWMA 通道 0 (PA.12) 的捕獲功能偵測 UART1 鮑率
BSP 版本	NUC123 Series BSP CMSIS v3.01.001
開發平台	NuTiny-SDK-NUC123AE V1.0 Nu-Link2-Me

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1 功能介紹

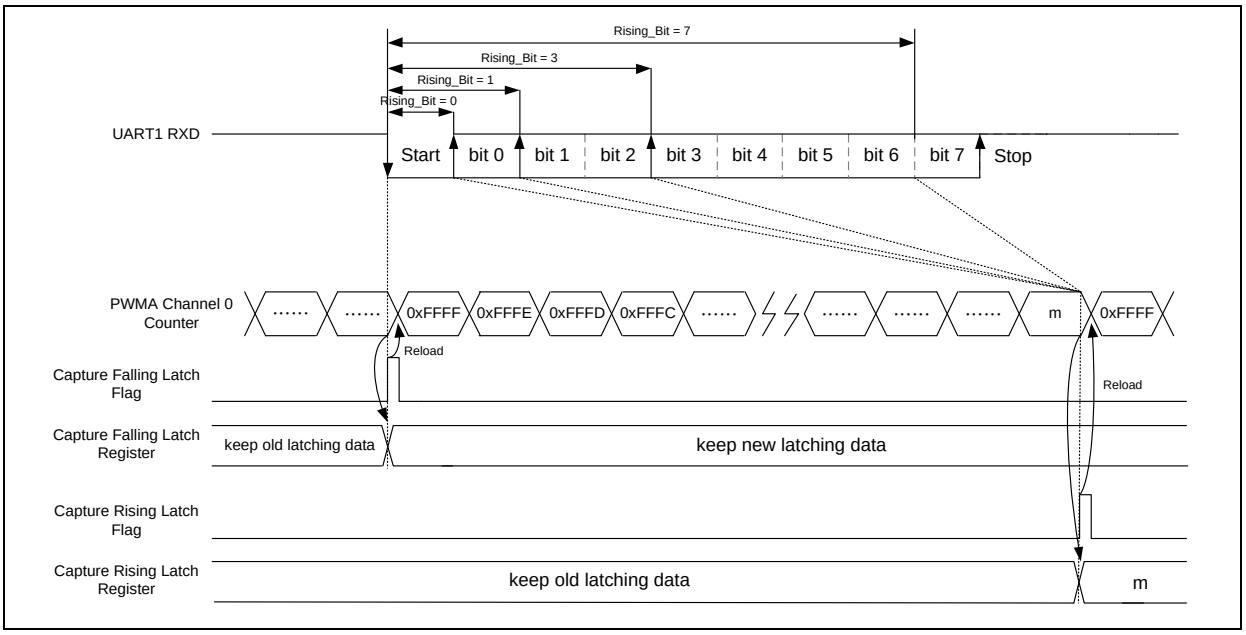
1.1 簡介

使用PWMA通道0 (PA.12) 的捕獲功能偵測UART1報率。PWM捕獲功能可以在偵測到下降沿的時候，重置計數器的值，並且在偵測到上升沿的時候，鎖存計數器的值。使用者可以在RXD腳位傳輸特定的資料，利用上述方法計算低電平的時間，以偵測UART鮑率。

在使用這個範例程式前，使用者需要將PWMA通道0 (PA.12) 接到 UART1的RXD (PB.4) 腳位。同時將Nu-Link2-Me的ICE_TX腳位和GND，分別接到NUC123的UART1的RXD腳位和GND，以傳送測試資料。

1.2 原理

當接收到傳輸資料的Start位元時，如果使用者使能中斷，PWM捕獲功能將重置計數器的值。其值為CNR可設定的最大值0xFFFF。一旦PWM捕獲功能偵測到上升沿的時候，PWM捕獲功能將鎖存當下計數器的值到暫存器。操作流程如下圖所示：



使用者可以傳輸不同的資料，使上升沿發生在不同的位元，以變更低電平的時間。使用越長的低電平時間，可以得到越精準的結果。根據程式中定義的Rising_Bit，對應的傳送資料如下表所示：

Rising_Bit	UART Data	Rising_Bit	UART Data
0	0xFF	4	0xF0
1	0xFE	5	0xE0
2	0xFC	6	0xC0
3	0xF8	7	0x80

UART鮑率的計算公式如下所示：

$$UART\,鮑率 = \frac{(Rising_Bit\ +\ 1)}{\left(0xFFFF - 上升沿鎖存值\right) * (計數器的單位時間)}$$

計數器的單位時間計算公式如下所示：

$$計數器的單位時間 = \frac{PWM\,預除頻\,(Prescaler)}{PWM\,時鐘源頻率}$$

1.3 執行結果

每當Nu-Link2-Me傳送資料時，範例程式將偵測鮑率，並且使用計算結果設定UART1。結果如下圖所示：

```
CPU @ 71884800 Hz
+------------------------------------------------------------+
|    Detect UART Baud Rate by PWM Capture Sample Code        |
|    Use PWMA Channel 0 to detect UART1 RXD                  |
|    Please connect PWMA Channel 0 (PA.12) to UART1 RXD (PB.4)    |
+------------------------------------------------------------+
Rising_Bit is 4.

PWM Capture counter value is 104.
Set UART1 baud rate to 192307.

PWM Capture counter value is 524.
Set UART1 baud rate to 38167.

PWM Capture counter value is 2092.
Set UART1 baud rate to 9560.

PWM Capture counter value is 16743.
Set UART1 baud rate to 1194.
```

Nu-Link2-Me依序使用UART鮑率194000、38400、9600以及1200，傳送資料0xF0。計算誤差分別為-0.873%、-0.607%、-0.417% 以及-0.500%。

2 代碼介紹

初始化 PWMA 通道 0 捕獲功能。設定計數器的單位時間為 250 us。

```
void PWMA_Init(void)
{
    /* Set PWMA Channel 0 input clock divider */
    PWM_SET_DIVIDER(PWMA, 0, PWM_CLK_DIV_1);

    /* Set PWMA Channel 0 auto-reload mode */
    PWMA->PCR |= PWM_PCR_CH0MOD_Msk;

    /* Set PWMA Channel 0 prescaler value to make unit count time is 250 ns */
    /* PWMA clock input is HCLK = 72 MHz, prescaler value is HCLK*250/(10^9) - 1 = 17 */
    PWM_SET_PRESCALER(PWMA, 0, 17);

    /* Set PWMA Channel 0 CNR to max value */
    PWM_SET_CNR(PWMA, 0, 0xFFFF);

    /* Enable capture rising and falling edge interrupt for PWMA channel 0 */
    PWM_EnableCaptureInt(PWMA, PWM_CH0, PWM_CAPTURE_INT_RISING_LATCH |
PWM_CAPTURE_INT_FALLING_LATCH);

    /* Enable PWMA NVIC interrupt */
    NVIC_EnableIRQ(PWMA_IRQn);

    /* Enable Timer for PWMA channel 0  */
    PWM_Start(PWMA, BIT0);

    /* Enable Capture Function for PWMA channel 0 */
    PWM_EnableCapture(PWMA, BIT0);

    /* Clear detect flag */
    g_u8DetectFlag = 0;
}
```

在 PWM 中斷處理中，在偵測到下降沿時，重置 g_u32CaptureCounter 的值，並且在偵測到上升沿時，取得計數器的值。

```
void PWMA_IRQHandler(void)
{
    uint32_t u32CaptureFlag = PWM_GetCaptureIntFlag(PWMA, 0);
```

```
    /* Detect rising edge */
    if (u32CaptureFlag == 1)
    {
        /* Clear rising edge flag */
        PWM_ClearCaptureIntFlag(PWMA, 0, PWM_CAPTURE_INT_RISING_LATCH);

        /* Detect rising bit, get counter value */
        g_u32CaptureCounter = 0xFFFF - PWM_GET_CAPTURE_RISING_DATA(PWMA, 0);

        /* Set detect flag */
        g_u8DetectFlag = 1;
    }
    /* Detect falling edge */
    else if (u32CaptureFlag == 2)
    {
        /* Clear falling edge flag */
        PWM_ClearCaptureIntFlag(PWMA, 0, PWM_CAPTURE_INT_FALLING_LATCH);

        /* Detect start bit, clear g_u32CaptureCounter to get counter value */
        g_u32CaptureCounter = 0;
    }
    /* Detect both rising and falling edge */
    else if (u32CaptureFlag == 3)
    {
        /* Clear rising edge flag */
        PWM_ClearCaptureIntFlag(PWMA, 0, PWM_CAPTURE_INT_RISING_LATCH);

        /* Clear falling edge flag */
        PWM_ClearCaptureIntFlag(PWMA, 0, PWM_CAPTURE_INT_FALLING_LATCH);
    }
}
```

計算 UART1 的新鮑率，並且設定到 UART1。

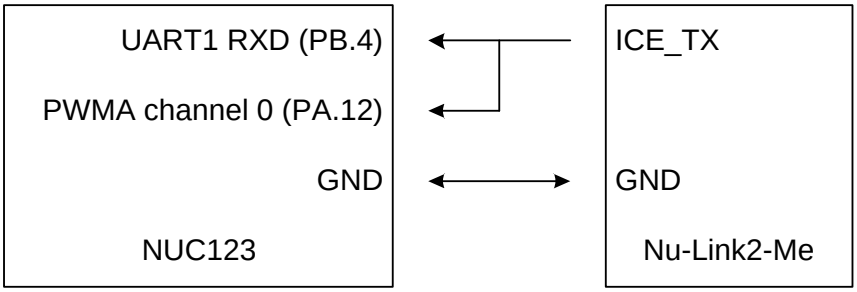
```
    while (1)
    {
        /* Wait until detection finish */
        while (!g_u8DetectFlag);

        /* Print PWM Capture result */
        printf("PWM Capture counter value is %d.\n", g_u32CaptureCounter);
```

```
        /* Set UART1 baud rate */
        u32Baudrate = (uint32_t)((Rising_Bit + 1) * 100000000) / (g_u32CaptureCounter *
25);
        printf("Set UART1 baud rate to %d.\n\n", u32Baudrate);

        /* Init UART1 */
        UART1_Init(u32Baudrate);

        /* Clear detect flag */
        g_u8DetectFlag = 0;
    }
```

3 軟體與硬體環境

- **軟體環境**
  - BSP 版本
    - NUC123Series BSP CMSIS v3.01.001
  - IDE 版本
    - Keil uVersion 5.26
- **硬體環境**
  - 電路元件
    - NuTiny-SDK-NUC123AE V1.0
    - Nu-Link2-Me
  - 示意圖

NUC123 將 UART1 RXD (PB.4) 腳位連接到 Nu-Link2-Me 的 ICE_TX 腳位，以接收資料。同時將 NUC123 的 PWMA 通道 0 (PA.12) 連接到 UART1 RXD。



4 目錄資訊

- EC_NUC123_Detect_Baudrate_by_PWM_Capture_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 NUC123_Detect_Baudrate_by_PWM_Capture.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
4. 使用終端機軟體，從 Nu-Link2-Me 傳送資料給 NUC123 UART1 RXD。

6 修訂紀錄

Date	Revision	Description
July 1, 2019	1.00	1. 初始發布.

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