MS51 SPI 實現 ARGB LED 彩虹燈燈效

NuMicro® 8 位系列微控制器範例代碼介紹

文件資訊

應用簡述	本範例代碼使用MS51 SPI 來模擬ARGB LED 的時序並實現彩虹燈燈效
BSP 版本	MS51 Series BSP V1.00.003
開發平台	NuMaker-MS51PC Ver1.0

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1 概述

此範例代碼使用MS51 系列的SPI 來模擬ARGB LED 的時序，演示ARGB LED 彩虹燈效果。此範例代碼使用一組timer 來定時更新ARGB LED 彩虹燈的顏色及一組SPI 來模擬ARGB LED 的時序。

1.1 原理

1.1.1 ARGB LED 資料傳輸時間(TH+TL=1.25 us ± 600 ns)

ARGB LED 時序圖如圖 1-1 邏輯'0'與圖 1-2 邏輯'1'所示。邏輯'0'定義為高準位0.4us ± 150ns 與低準位0.85us ± 150ns; 邏輯'1'定義為高準位0.8us ± 150ns 與低準位0.45us ± 150ns。

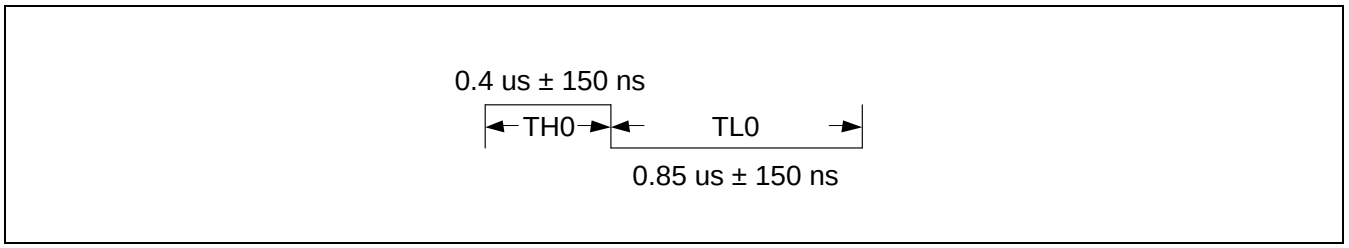

圖 1-1 邏輯'0'

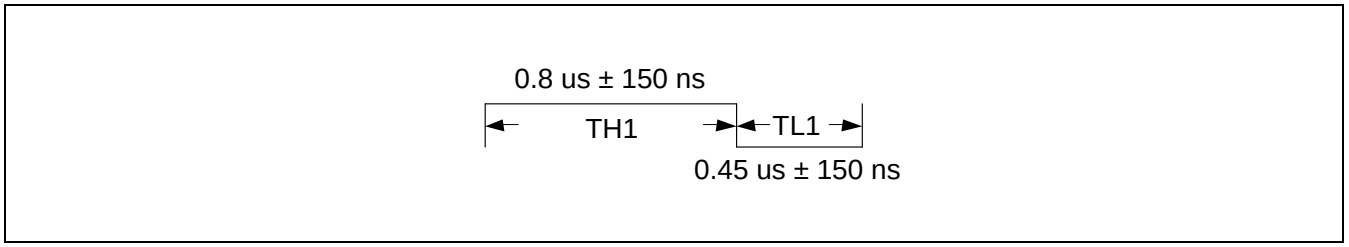

圖 1-2 邏輯'1'

圖 1-3 重置

1.1.2 SPI 時鐘頻率

程式中設定系統時鐘HIRC 為24 MHz 以及SPI 時鐘除頻值為8，由此可計算出SPI 時鐘速率為3 MHz，這代表一個SPI 時鐘為 0.333 us。換句話說，邏輯'0' 映射為SPI 位元樣式為'1000'; 邏

輯’1’ 映射為SPI 位元樣式為‘1110’，亦即3 個位元組的RGB 資料格式可轉化成12 個位元組的SPI 資料格式。

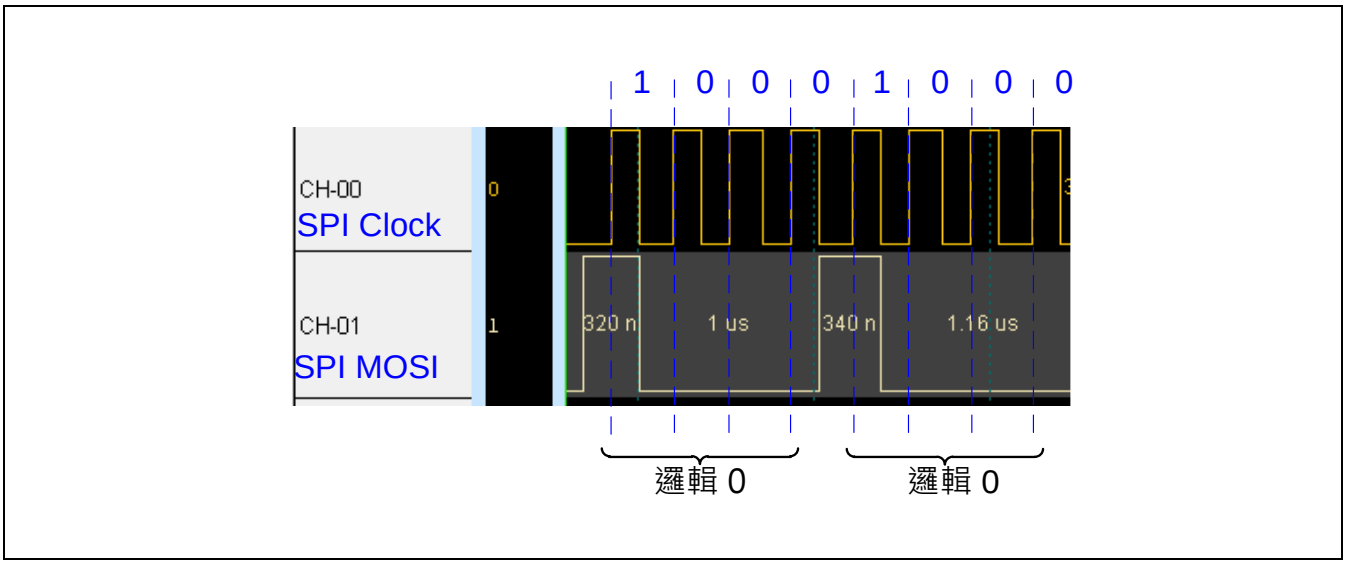

圖 1-4 邏輯’0’ 映射為 SPI 位元樣式

1.2 執行結果

執行結果。

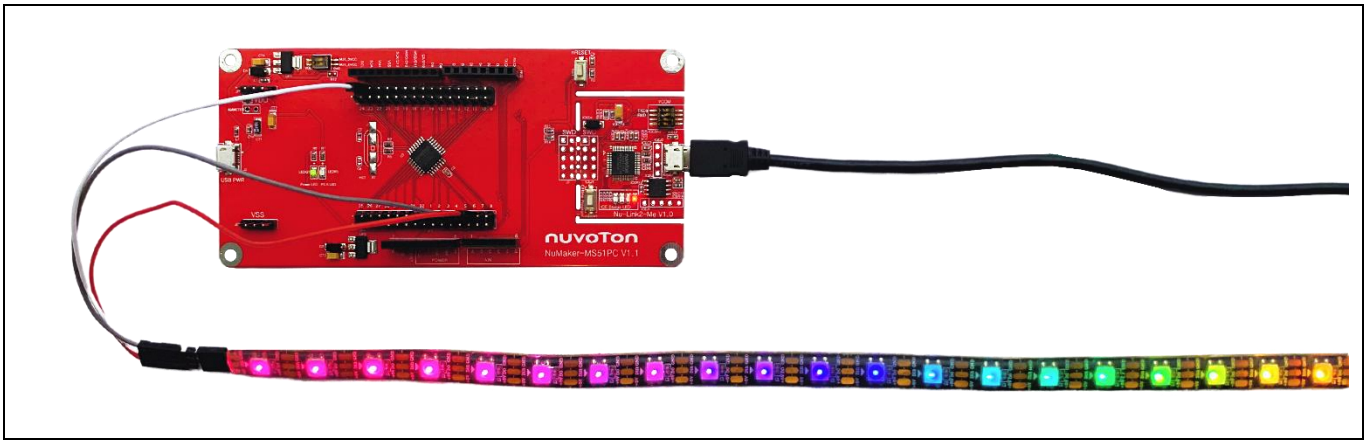

圖 1-5 執行結果

2 代碼介紹

代碼工作流程如下：

1. main.c 中初始化 MS51 相關外設，包含 HIRC、SPI、與 Timer 3

2. 在 while 迴圈中呼叫 RainbowWave_TOPDOWN()來計算出相對應的 ARGB LED 顏色

3. 使用 SPI_Send() 來模擬 ARGB LED 時序

```
void main (void)
{
    MODIFY_HIRC(HIRC_24);

    /* Set LED output */
    P00 = 1;
    P00_INPUT_MODE;
    ENABLE_P00_PULLDOWN;

    SPI_Init();

    /* Enable Timer3 to add time counter */
    Timer3_1ms_initial();


    /* Init LED to all disable */
    Disable_TOPDOWN();
    SPI_Send();

    while(1)
    {

    /* Control LED */
        {
            RainbowWave_TOPDOWN();
            SPI_Send();
        }
    }
}
```

當 RainbowWave_TOPDOWN()被呼叫時，在函數內部使用它來計算週期內的 ARGB LED 顏色。

```
void RainbowWave_TOPDOWN(void)
{
    unsigned char i, j;
    /* Velocity = LEDs / Second */
    unsigned char Velocity[3] = {5, 9, 13};
    unsigned long deltaT, TotalDuration, CurrentTime, NextTime;
    unsigned char ColorCursor1, ColorCursor2;

    /* Duration for one time effect */
    TotalDuration = HDIV_Div(30 * 1000, Velocity[TOPDOWNSpeed]);
```

```
    /* Next LED time */
    NextTime = HDIV_Div(TotalDuration, 30);
    /* Current Time */
    CurrentTime = HDIV_Mod(TOPDOWNTimeCounter, TotalDuration);
    /* Unit time for each color */
    deltaT = HDIV_Div(TotalDuration, 7);

    /* Reset CountingTime */
    if(TOPDOWNTimeCounter >= TotalDuration)
    {
        TOPDOWNTimeCounter -= TotalDuration;
    }

    /* Mix Color */
    for(j = 0; j < TOP_DOWN_LED_Num; j++, CurrentTime += NextTime)
    {
        if(CurrentTime >= TotalDuration)
            CurrentTime -= TotalDuration;

        if(CurrentTime >= (deltaT * 7))
        {
            /* Color Cursor */
            ColorCursor1 = 0;
            ColorCursor2 = 1;

            for(i = 0; i < 3; i++)
            {
                TOPDOWNRGBArray[(TOP_DOWN_LED_Num-j-1)][i]=RainbowColor[ColorCursor1][i];
            }
        }
        else
        {
            /* Color Cursor */
            ColorCursor1 = HDIV_Mod(HDIV_Div(CurrentTime, deltaT), 7);
            ColorCursor2 = HDIV_Mod((ColorCursor1 + 1), 7);

            for(i = 0; i < 3; i++)
            {
                TOPDOWNRGBArray[(TOP_DOWN_LED_Num-j-1)][i] =
HDIV_Div(((RainbowColor[ColorCursor1][i] * ((ColorCursor1 + 1) * deltaT - CurrentTime)) +\

(RainbowColor[ColorCursor2][i] * (CurrentTime - ColorCursor1 * deltaT))), deltaT);
            }
        }
    }
}
```

3 顏色計算公式

以所在區域的比例，計算前後顏色的混合比例

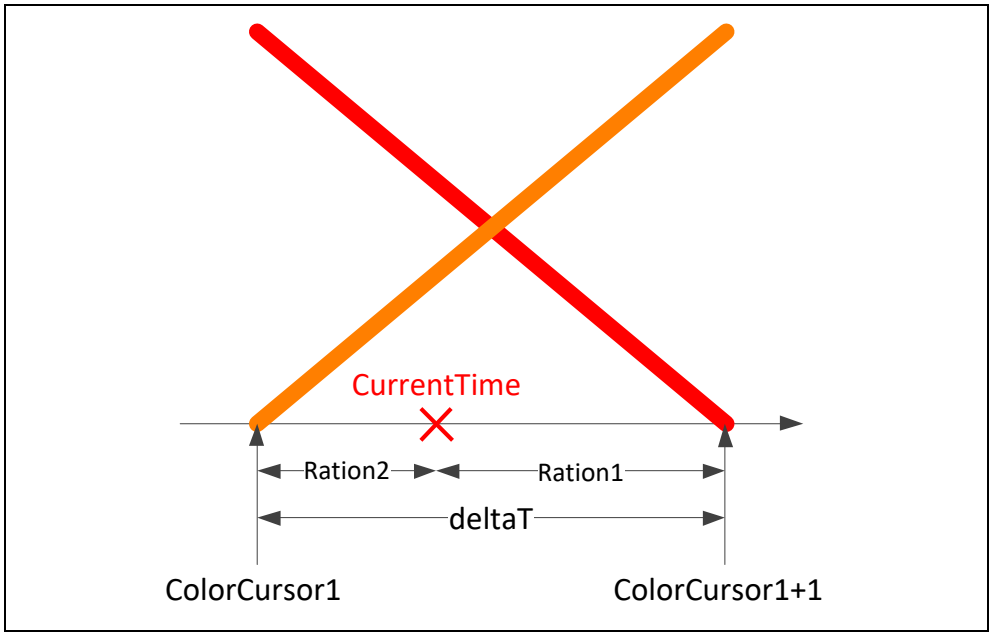

圖 3-1 計算 RGB 混合比例示意圖

Ration1 = (ColorCursor1 + 1) * deltaT - CurrentTime
Ration2 = CurrentTime - ColorCursor1 * deltaT

顏色計算公式:

$$Color = \frac{Color1 \times Ration1}{deltaT} + \frac{Color2 \times Ration2}{deltaT} =$$

$$\frac{Color1 \times \left((ColorCursor1+1) \times deltaT - CurrentTime\right) + Color2 \times (CurrentTime - Cursor1 \times deltaT)}{deltaT}$$

4 軟體與硬體需求

- **軟體需求**
  - BSP 版本
    - MS51 Series BSP V1.00.003
  - IDE 版本
    - Keil uVersion 5.26
- **硬體需求**
  - 電路元件
    - NuMaker-MS51PC Ver1.0
    - ARGB LED
  - 示意圖

使用 SPI MOSI 腳位來模擬 ARGB LED 時序圖。

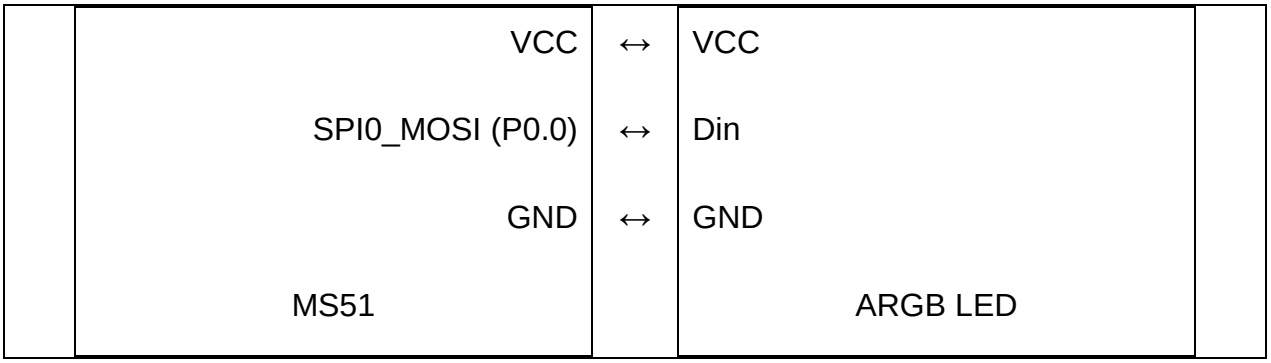

圖 4-1 接線示意圖

註：ARGB LED 工作電壓為 5V，故 NuMaker-MS51PC 開發板為 ARGB LED 供電電壓必須更換為 5V。可以改變 Nu-Link2-Me 上的 ICEJPR1(MCUVCC)電阻使其輸出 5V 電壓。

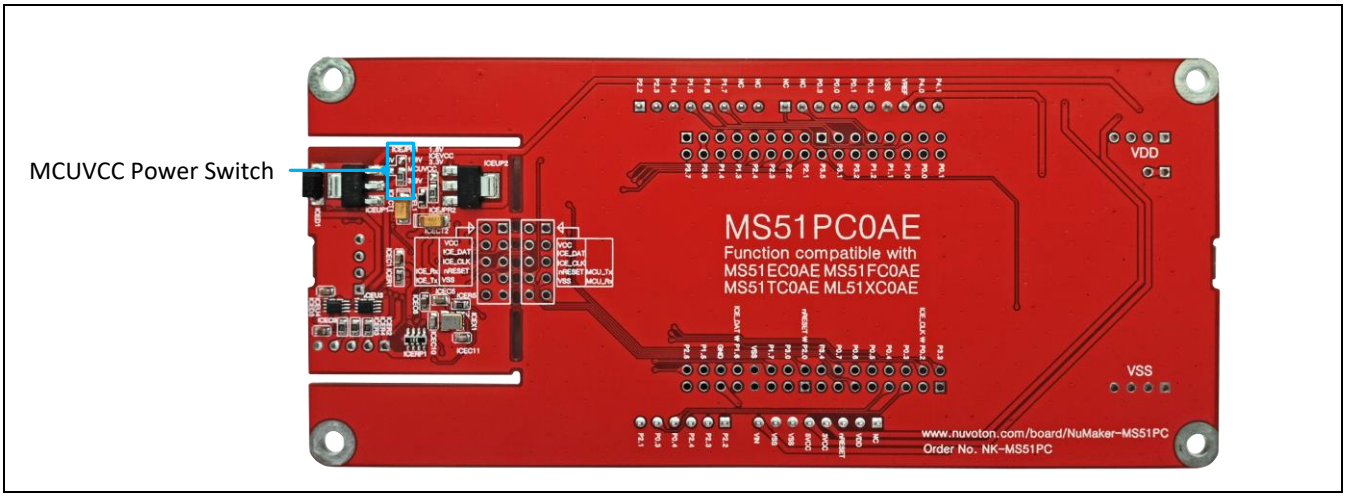

圖 4-2 MCUVCC 電源切換至 5V

5 目錄資訊

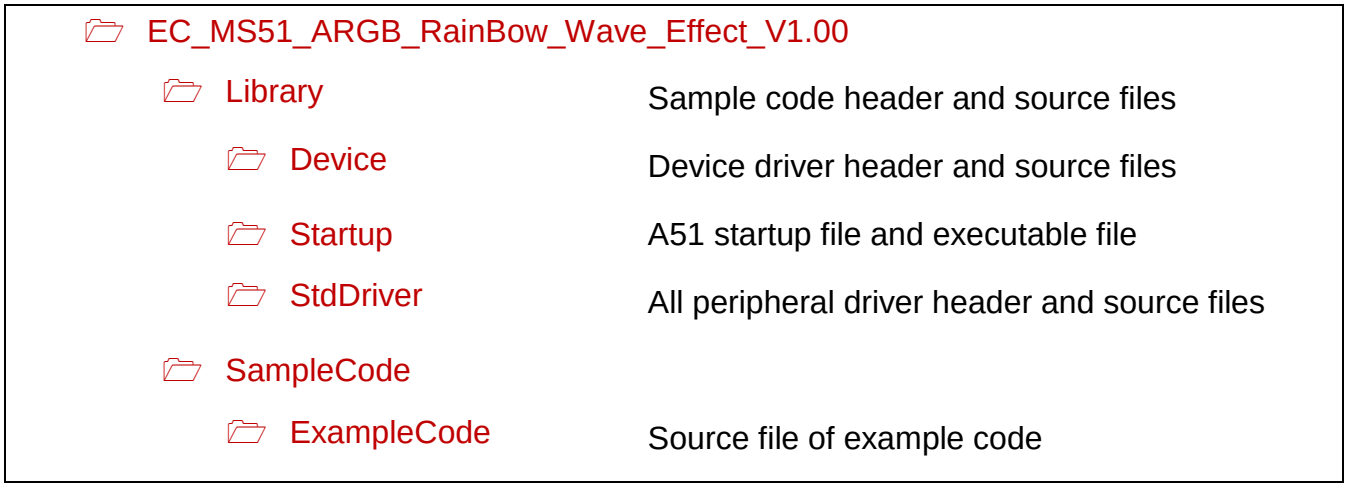

圖 5-1 目錄結構

6 範例程式執行

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 *MS51_ARGB_RainBow_Wave_Effect.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

7 修訂紀錄

Date	Revision	Description
2021.08.20	1.00	1. 初始發布.

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