MS51 驅動 RGB 7 段 LED

NuMicro® 1T 8051 系列微控制器範例代碼介紹

文件資訊

應用簡述	使用 MS51 32K 系列驅動 RGB 彩色 7 段 LED 顯示
BSP 版本	MS51_Series_BSP_Keil_V1.00.006
開發平臺	NuMaker-MS51PC V1.1 & PWM_ARGB_Control_Board V1.0

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1. 概述

1.1 原理

傳統 7 段顯示為單一顏色，使用者只需把正極接電，不同的負極接地就能控制七段顯示不同的數字。

RGB 是色光的色彩模式。R 代表紅色，G 代表綠色，B 代表藍色，三種色彩疊加形成了其它的色彩。因為三種顏色都有 256 個亮度水準級，所以三種色彩疊加就形成 1670 萬種顏色。

所以當 RGB 應用於 7 段 LED 顯示時，不僅需要點亮，還需要控制 RGB 三色不同的色階，達成混合顏色的效果。

本範例使用 ADH-Tech 的 ACD8143 RGB LED 模塊來實現，LED 腳位定義與內部驅動線路如下：共點亮 2 個 RGB LED 分別定義為 DIG. 1、DIG.2 。

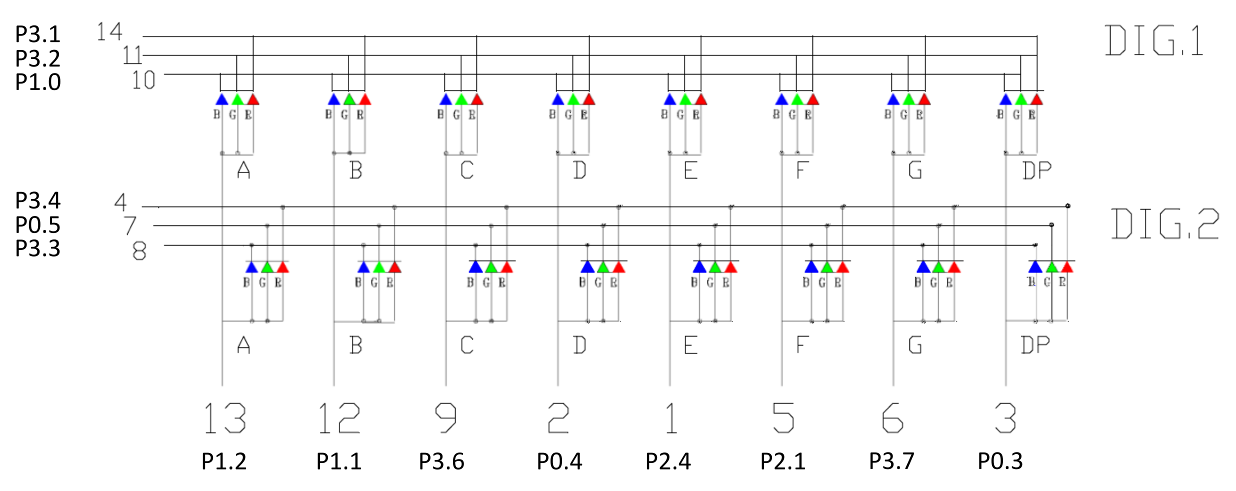


圖 1-1 ACD8143 腳位定義與內部驅動線路

腳位 10\11\14 分別代表需要點亮 DIG.1 的 PWM 色階 B\G\R 控制， 腳位 4\7\8 用於點亮 DIG.2，PWM 輸出控制 255 級色階。

其餘腳位 13\12\9\2\1\5\63 直接以 GPIO 控制點亮，程式內定義名稱為 SEG, 分別對應 SEG_A ~ SEG_G 以及 SEG_DP。

例如當需要點亮 DIG1 的 A 段綠色時，設定 LED 11 腳 PWM 輸出 Duty 定義色階，13 腳 GPIO 定為 1 來進行 Enable SEG 配置。

依據上述定義，配合 NuMaker-MS51PC，設計控制板線路如下：

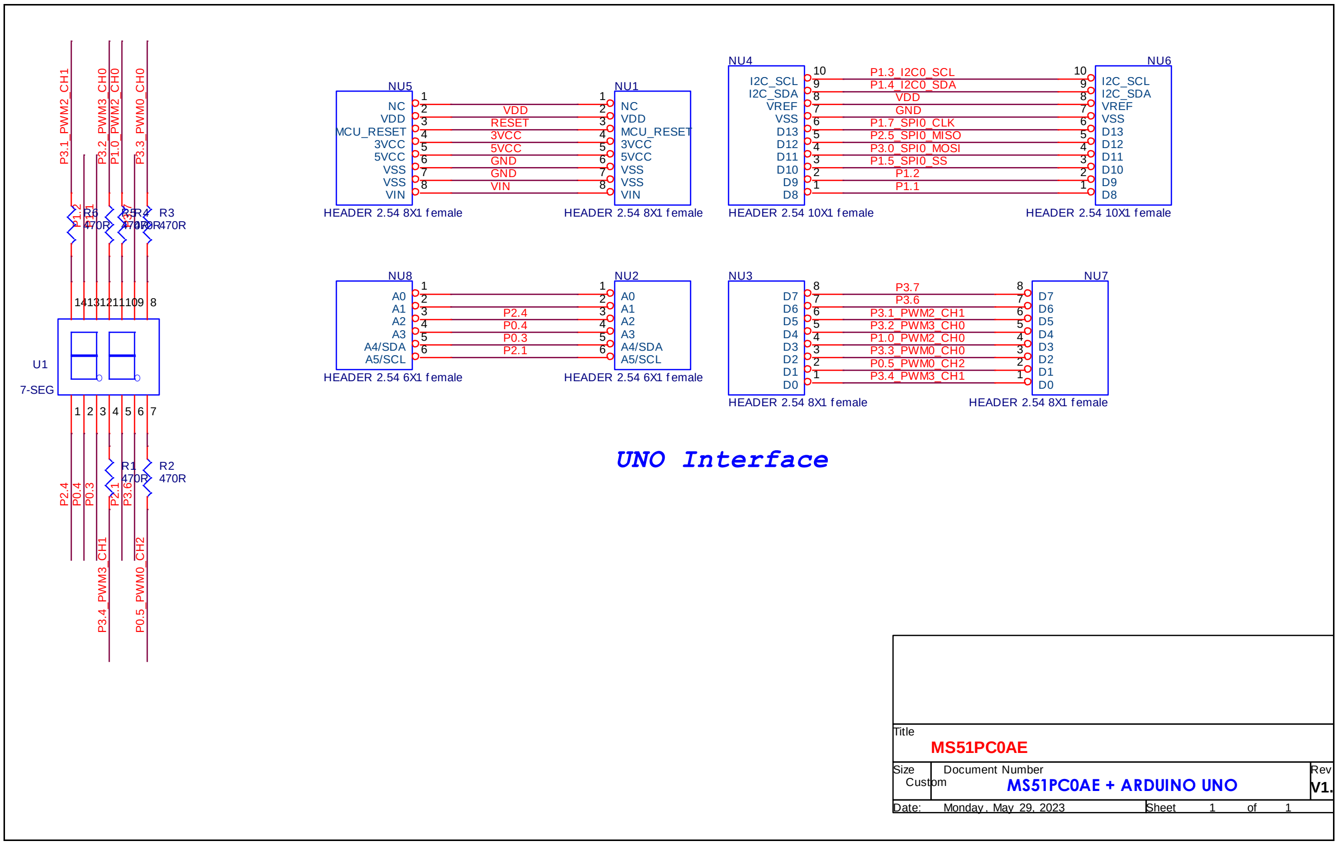


圖 1-1 ACD8143 控制板線路圖

1.2 執行結果

通過 Access Port UART 傳輸固定格式 RGB LED 顯示對應顯示的數字與顏色

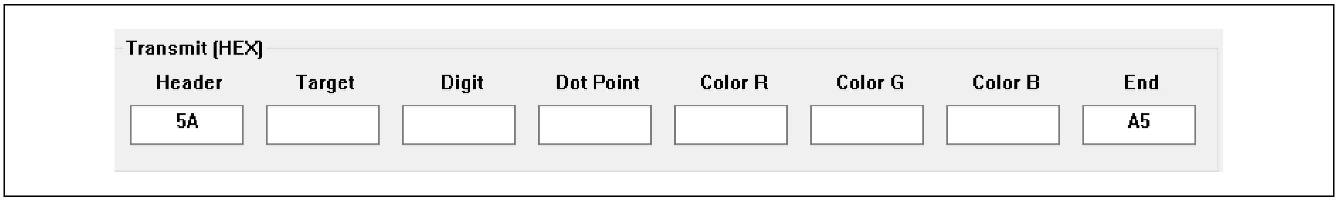
UART 傳輸格式如下，每次傳輸定義一個 7seg

Target: 0 = DIG.1, 1 = DIG.2;

Digit = 0~9, A~F;

Dot Point: 0 = Disable, 1 = Enable;

Color R/G/B = 0x00 ~ 0xFF



Transmit (HEX)

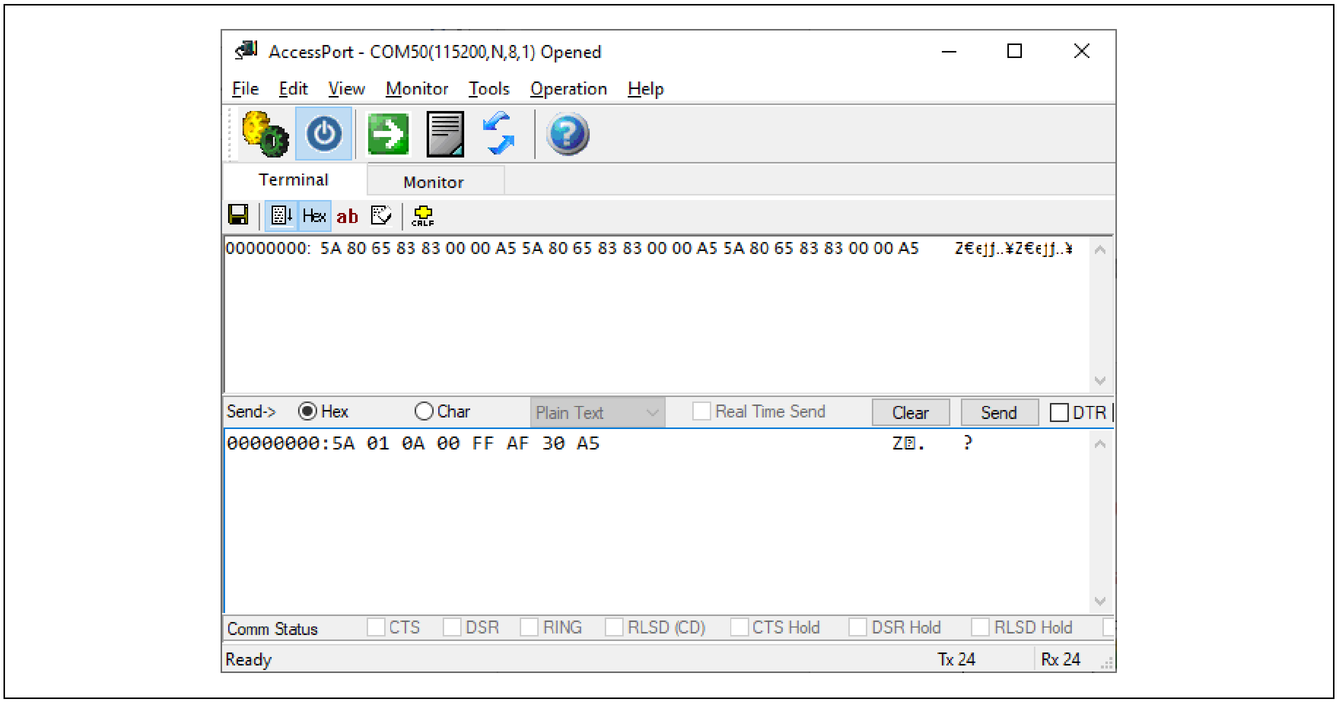
Header	Target	Digit	Dot Point	Color R	Color G	Color B	End
5A							A5

圖 1-2 UART 傳輸格式定義

輸入範例，

第一組輸入 5A 00 03 00 69 AA 00 A5 控制 DIG.1 顯示數字 [3] ，顏色為嫩綠色

第二組輸入 5A 01 0A 00 FF AF 30 A5 控制 DIG.1 顯示字元 [A] ，顏色為嫩黃色



AccessPort - COM50(115200,N,8,1) Opened

```
00000000:  5A 80 65 83 83 00 00 A5 5A 80 65 83 83 00 00 A5 5A 80 65 83 83 00 00 A5      Z€eƒƒ..¥Z€eƒƒ..¥
```

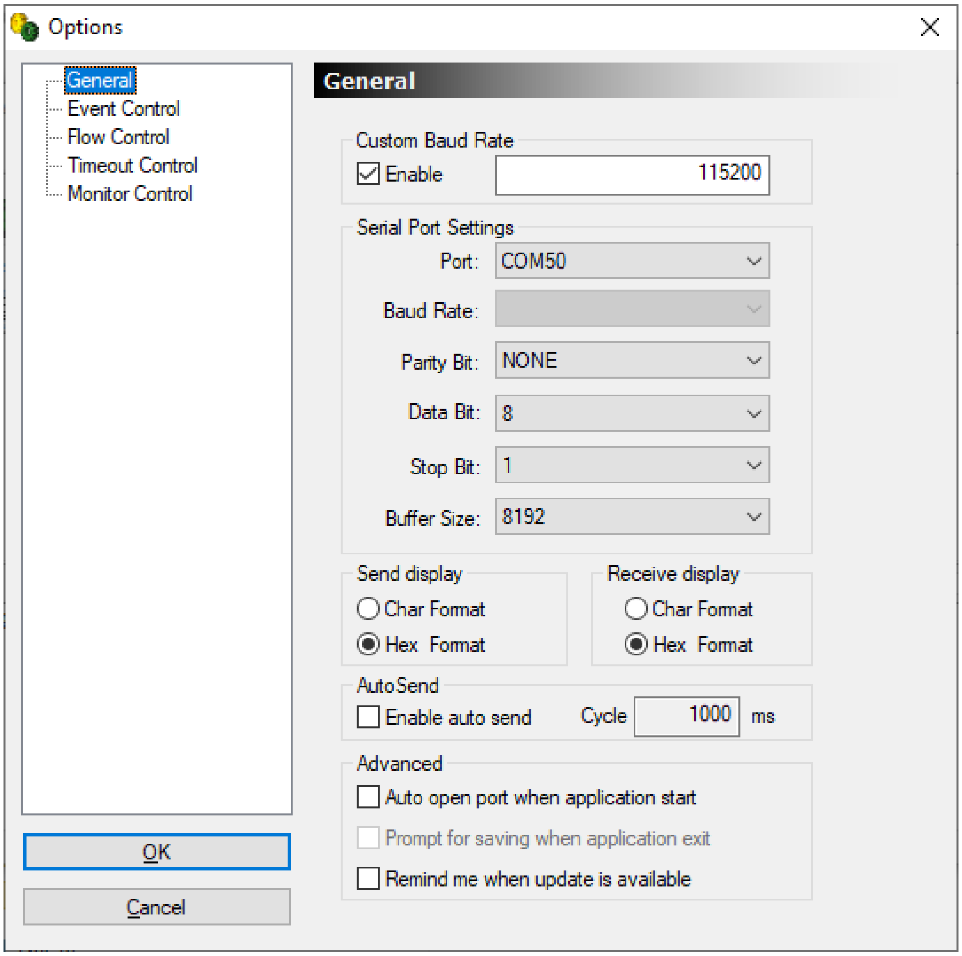
Send-> ● Hex ○ Char

```
00000000:5A 01 0A 00 FF AF 30 A5                    Z□.    ?
```

Comm Status ☐ CTS ☐ DSR ☐ RING ☐ RLSD (CD) ☐ CTS Hold ☐ DSR Hold ☐ RLSD Hold

Ready Tx 24 Rx 24

圖 1-3 UART 輸入與返回值



Options

General

Custom Baud Rate

☑ Enable 115200

Serial Port Settings

Port: COM50

Baud Rate:

Parity Bit: NONE

Data Bit: 8

Stop Bit: 1

Buffer Size: 8192

Send display

○ Char Format

● Hex Format

Receive display

○ Char Format

● Hex Format

AutoSend

☐ Enable auto send Cycle 1000 ms

Advanced

☐ Auto open port when application start

☐ Prompt for saving when application exit

☐ Remind me when update is available

圖 1-4 Access Port 配置示意圖

2. 代碼介紹

計算原代碼位元組數的函式，代碼位於 *main.c*。

定義 7 段顯示器不同顯示字元的 SEG。SEG_DP 在每個 PWM 更新的週期判斷是否需要點亮。

```
uint8_t Show_Char[16][8] =
{
    /* SEG_A, SEG_B, SEG_C, SEG_D, SEG_E, SEG_F, SEG_G */
    {      1,      1,      1,      1,      1,      1,      0},    // 0
    {      0,      1,      1,      0,      0,      0,      0},    // 1
    {      1,      1,      0,      1,      1,      0,      1},    // 2
    {      1,      1,      1,      1,      0,      0,      1},    // 3
    {      0,      1,      1,      0,      0,      1,      1},    // 4
    {      1,      0,      1,      1,      0,      1,      1},    // 5
    {      1,      0,      1,      1,      1,      1,      1},    // 6
    {      1,      1,      1,      0,      0,      0,      0},    // 7
    {      1,      1,      1,      1,      1,      1,      1},    // 8
    {      1,      1,      1,      1,      0,      1,      1},    // 9
    {      1,      1,      1,      0,      1,      1,      1},    // A
    {      0,      0,      1,      1,      1,      1,      1},    // B
    {      1,      0,      0,      1,      1,      1,      0},    // C
    {      0,      1,      1,      1,      1,      0,      1},    // D
    {      1,      0,      0,      1,      1,      1,      1},    // E
    {      1,      0,      0,      0,      1,      1,      1},    // F
};
```

SEG 所用到的 GPIO 初始配置。

```
    ……
void Segment_Initial(void)
{
    /* Set all segment pins to output low */
    SEG_A = SEG_B = SEG_C = SEG_D = \
    SEG_E = SEG_F = SEG_G = SEG_DP = 0;
    /* Set all segment pins to output mode */
    P12_PUSHPULL_MODE;    // SEG_A
    P11_PUSHPULL_MODE;    // SEG_B
    P36_PUSHPULL_MODE;    // SEG_C
    P04_PUSHPULL_MODE;    // SEG_D
    P24_PUSHPULL_MODE;    // SEG_E
    P21_PUSHPULL_MODE;    // SEG_F
    P37_PUSHPULL_MODE;    // SEG_G
    P03_PUSHPULL_MODE;    // SEG_DP

    /* Initial value */
    *(uint8_t *)&Scan_Pos = 0x01;
}
```

色階所用到的PWM初始配置。

```
void PWM_Initial(void)
{
    /* Set all PWM pins to output mode */
    P31_PUSHPULL_MODE;    // Dig1_R
    P32_PUSHPULL_MODE;    // Dig1_G
    P10_PUSHPULL_MODE;    // Dig1_B
    P34_PUSHPULL_MODE;    // Dig2_R
    P05_PUSHPULL_MODE;    // Dig2_G
    P33_PUSHPULL_MODE;    // Dig2_B

    /* Set PWM clock source */
    PWM0_ClockSource(PWM_FSYS, 1);
    PWM123_ClockSource(PWM2, 1);
    PWM123_ClockSource(PWM3, 1);

    /* Set PWM period value */
    /* PWM0 for Dig2_G, Dig2_B */
    SFRS = 0;
    PWM0PH = PWM_FEQ_H;
    PWM0PL = PWM_FEQ_L;
    /* PWM2 for Dig1_R, Dig1_B */
    SFRS = 2;
    PWM2PH = PWM_FEQ_H;
    PWM2PL = PWM_FEQ_L;
    /* PWM3 for Dig1_G, Dig1_G */
    PWM3PH = PWM_FEQ_H;
    PWM3PL = PWM_FEQ_L;

    /* Reset SFRS */
    SFRS = 0;

    /* Enable PWM output */
    ENABLE_PWM2_CH1_P31_OUTPUT;    // Dig1_R
    ENABLE_PWM3_CH0_P32_OUTPUT;    // Dig1_G
    ENABLE_PWM2_CH0_P10_OUTPUT;    // Dig1_B
    ENABLE_PWM3_CH1_P34_OUTPUT;    // Dig2_R
    ENABLE_PWM0_CH2_P05_OUTPUT;    // Dig2_G
    ENABLE_PWM0_CH0_P33_OUTPUT;    // Dig2_B
};
```

每次更新色階，需要重新定義PWM的duty。

```
void Set_PWM_Duty(void)
{
    /* Digi_1 */
    if(((g_u8Scan_Pos == 0x07) && g_Dig_Setting[0].DP) || \
       ((g_u8Scan_Pos < 0x07) && (*(Show_Char[g_Dig_Setting[0].Char] + g_u8Scan_Pos))))
    {
        /* Enable segment */
        SFRS = 2;
        /* Dig1_R */
        PWM2C1H = ((255 - g_Dig_Setting[0].R) >> 4);
        PWM2C1L = ((255 - g_Dig_Setting[0].R) << 4);
        /* Dig1_G */
        PWM3C0H = ((255 - g_Dig_Setting[0].G) >> 4);
        PWM3C0L = ((255 - g_Dig_Setting[0].G) << 4);
        /* Dig1_B */
        PWM2C0H = ((255 - g_Dig_Setting[0].B) >> 4);
        PWM2C0L = ((255 - g_Dig_Setting[0].B) << 4);
    }
    else
    {
        /* Disable segment */
        SFRS = 2;
        /* Dig1_R */
        PWM2C1H = PWM_FEQ_H;
        PWM2C1L = PWM_FEQ_L;
        /* Dig1_G */
        PWM3C0H = PWM_FEQ_H;
        PWM3C0L = PWM_FEQ_L;
        /* Dig1_B */
        PWM2C0H = PWM_FEQ_H;
        PWM2C0L = PWM_FEQ_L;
    }

    /* Digi_2 */
   if(((g_u8Scan_Pos == 0x07) && g_Dig_Setting[1].DP) || \
       ((g_u8Scan_Pos < 0x07) && (*(Show_Char[g_Dig_Setting[1].Char] + g_u8Scan_Pos))))
    {
        /* Enable segment */
        SFRS = 2;
        /* Dig2_R */
        PWM3C1H = ((255 - g_Dig_Setting[1].R) >> 4);
        PWM3C1L = ((255 - g_Dig_Setting[1].R) << 4);
        SFRS = 0;
        /* Dig2_G */
        PWM0C2H = ((255 - g_Dig_Setting[1].G) >> 4);
        PWM0C2L = ((255 - g_Dig_Setting[1].G) << 4);
        /* Dig2_B */
        PWM0C0H = ((255 - g_Dig_Setting[1].B) >> 4);
        PWM0C0L = ((255 - g_Dig_Setting[1].B) << 4);
    }
    else
    {
        /* Disable segment */
        SFRS = 2;
        /* Dig2_R */
        PWM3C1H = PWM_FEQ_H;
        PWM3C1L = PWM_FEQ_L;
        SFRS = 0;
        /* Dig2_B */
        PWM0C0H = PWM_FEQ_H;
        PWM0C0L = PWM_FEQ_L;
        /* Dig2_G */
        PWM0C2H = PWM_FEQ_H;
        PWM0C2L = PWM_FEQ_L;
    }

    /* Reload new setting */
    set_PWM0CON0_LOAD;
    set_PWM2CON0_LOAD;
    set_PWM3CON0_LOAD;

    /* Wait new setting reload */
    while(PWM3CON0 & BIT6);

    /* Reset SFR */
    SFRS = 0;
}
```

主程式設定每 1ms 更新一次所有 GPIO 的狀態，達成循環點亮所有 LED。

完成 LED 輪詢點亮後，重置 Timer 0 定時並等候下一次定時中斷。

```
    while(1)
    {
        if(TF0 == 1)
        {
            /* Stop Timer0 */
            clr_TCON_TR0;

            /* Set all segment pins to output low */
            SEG_A = SEG_B = SEG_C = SEG_D = \
            SEG_E = SEG_F = SEG_G = SEG_DP = 0;

            /* Set PWM duty */
            Set_PWM_Duty();

            /* Scan segment pins */
            SEG_A  = Scan_Pos.A;
            SEG_B  = Scan_Pos.B;
            SEG_C  = Scan_Pos.C;
            SEG_D  = Scan_Pos.D;
            SEG_E  = Scan_Pos.E;
            SEG_F  = Scan_Pos.F;
            SEG_G  = Scan_Pos.G;
            SEG_DP = Scan_Pos.DP;
            (Scan_Pos.DP == 0x01)?(*(uint8_t *)&Scan_Pos = 0x01):(*(uint8_t *)&Scan_Pos
             <<= 1);
            (g_u8Scan_Pos == 0x07)?(g_u8Scan_Pos = 0):(g_u8Scan_Pos++);

            /* Set next time-out */
            TH0 = TH0_INIT;
            TL0 = TL0_INIT;

            /* Clear Timer0 overflow flag */
            TF0 = 0 ;

           /* Start Timer0 */
           set_TCON_TR0;
        }
```

若有 UART 傳輸要求更改顯示內容，判定 UART 接受字串是否完整。接受完成後重新定義 PWM 色階並 UART 回傳更改結果。

```
            /* Check UART0 RX */
            if(UART0_RX_Flag)
            {
                /* Start UART RX */
                if(UART0_RX_TempCount == 0)
```

```
                    UART0_RX_TempCount = UART0_RX_Count;
                else
                {
                    /* UART stops */
                    if(UART0_RX_TempCount == UART0_RX_Count)
                    {
                        UART0_Timeout_Count++;
                        if(UART0_Timeout_Count == 5)
                        {
                            UART0_RX_Flag = 0;
                            UART0_TX_Flag = 1;
                            UART0_Timeout_Count = 0;
                        }
                    }
                    else
                    {
                        UART0_RX_TempCount = UART0_RX_Count;
                        UART0_Timeout_Count = 0;
                    }
                }
            }

        /* Set/Get command */
        if(UART0_TX_Flag)
        {
            /* Check valid data */
            if((UART0_RX_Data[0] == 0x5A) && (UART0_RX_Data[UART0_RX_Ptr-1] == 0xA5))
            {
                /* Set Command */
                if(UART0_RX_Data[1] < DIGI_COUNT)
                {
                    g_Dig_Setting[UART0_RX_Data[1]].Char = UART0_RX_Data[2];
                    g_Dig_Setting[UART0_RX_Data[1]].DP   = UART0_RX_Data[3];
                    g_Dig_Setting[UART0_RX_Data[1]].R    = UART0_RX_Data[4];
                    g_Dig_Setting[UART0_RX_Data[1]].G    = UART0_RX_Data[5];
                    g_Dig_Setting[UART0_RX_Data[1]].B    = UART0_RX_Data[6];

                    /* Transmit reply */
                    DISABLE_UART0_INTERRUPT;
                    for(i = 0; i < 8; i++)
                        UART_Send_Data(UART0, Set_Reply[i]);
                    ENABLE_UART0_INTERRUPT;
                }
            }
            UART0_RX_Count = UART0_RX_Ptr = UART0_RX_TempCount = UART0_TX_Flag = 0;
        }
```

3. 軟體與硬體需求

3.1 軟體需求

- BSP 版本
  - MS51_Series_BSP_Keil_V1.00.006
- IDE 版本
  - Keil uVision5 and PK51 Development Kit V9.52

3.2 硬體需求

- 電路元件
  - NuMaker-MS51PC V1.1
  - PWM_ARGB_Control_Board V1.0
- 線路示意圖
  - 通過 NuMaker-MS51PC Arduino 介面連接，以顯示範例代碼的執行結果。

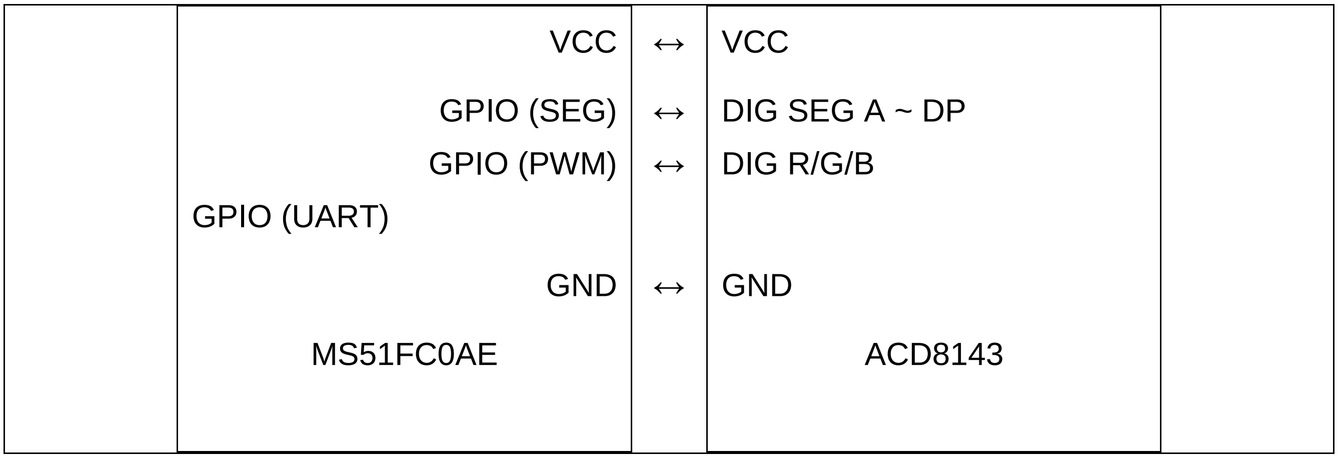


圖 3-1 線路示意圖

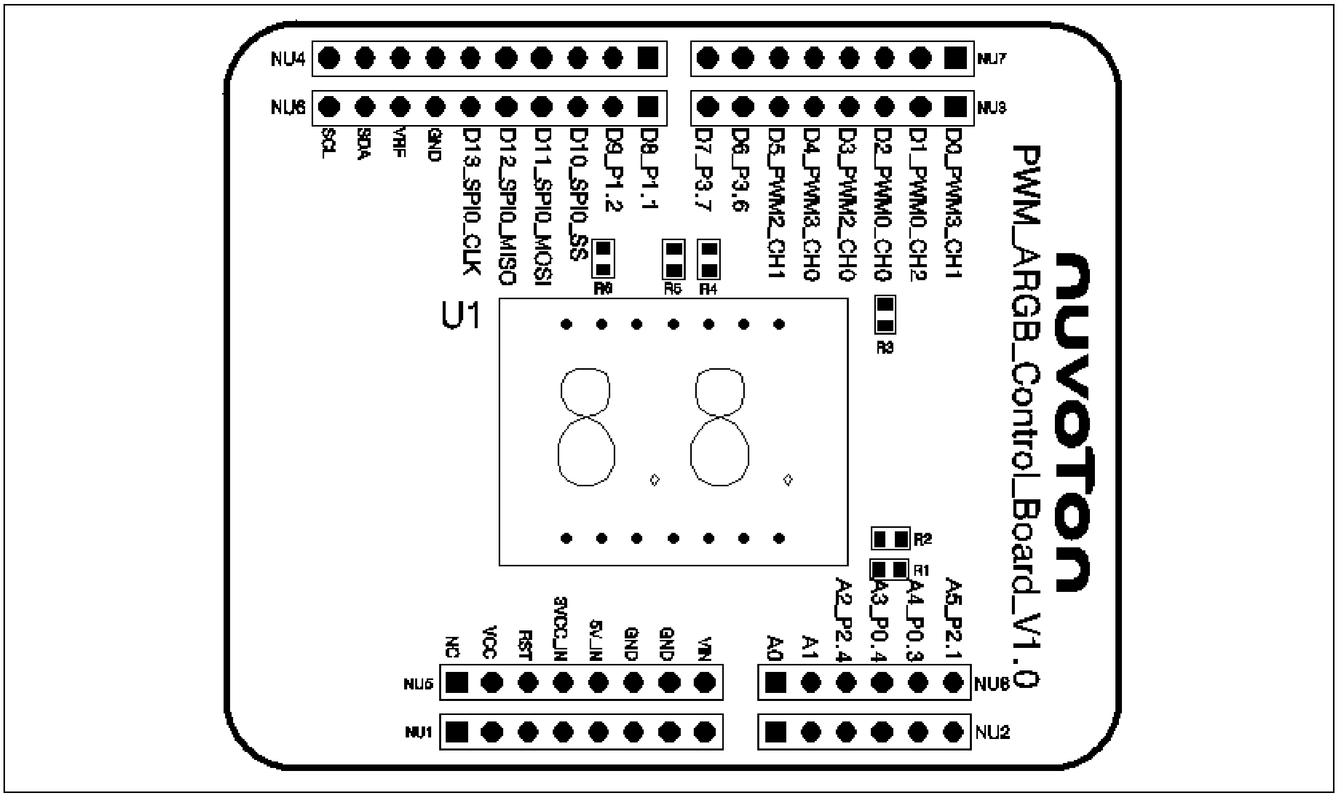


圖 3-2 PWM_ARGB_Control_Board PCB

4. 目錄資訊

🗁 EC_MS51_RGB_7Segment_UART_V1.00	
🗁 Library	Sample code header and source files
🗁 Device	MS51 compliant device header file
🗁 Startup	Startup file for MS51
🗁 StdDriver	All peripheral driver header and source files
🗁 SampleCode	
🗁 ExampleCode	Source file of example code

圖 4-1 目錄資訊

5. 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 *RGB_7Segment_UART.uvproj*。

2. 進入編譯模式介面

   - 編譯
   - 下載代碼至記憶體
   - 進入 / 離開除錯模式

3. 進入除錯模式介面

   - 執行代碼

6. 修訂紀錄

Date	Revision	Description
2023.08.11	1.00	初始發布。

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