# Text LCD Control

## MIAT STM32 Development Kit

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# Declared Version

| Training Only | |
|---|---|
| **Declare** | |
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| Platform | ■ MIAT STM32F10x EVB<br>■ MIAT IOB |
| Peripheral | ■ Text LCD |
| Author | ■Wu-Yang |
| Key Word | STM32F10x, Text LCD |

# 實驗目的

嵌入式系統中，文字形顯示器是相當常見的外接裝置，本章將針對ARM Cortex-M3如何控制文字形顯示器做介紹，並使讀者瞭解：

- 標準文字形顯示器控制方式

實做重點

- 顯示固定字元
- 字元跑馬燈
- 顯示自訂特殊字元

# 實驗原理

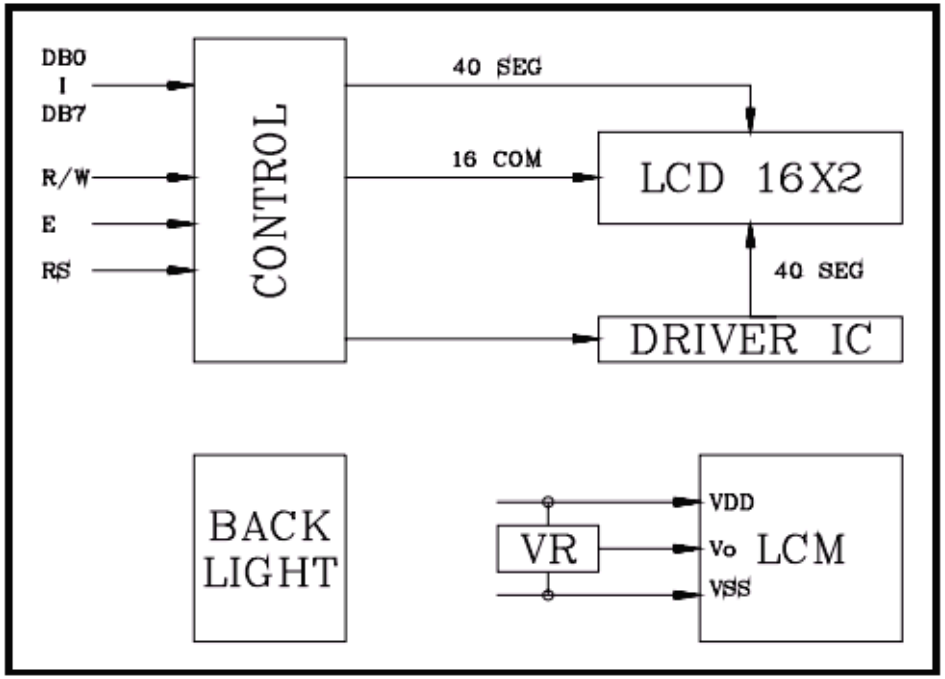
- Text LCD Control
- Text LCD Function List
- Development Flow
- ARM Configure

# Text LCD Control(1)

## Text LCD Pin Define

| NO | SYMBOL | LEVEL | FUNCTION |
|---|---|---|---|
| 1 | VSS | -- | GND ( 0V) |
| 2 | VDD | H/L | DC +5V |
| 3 | VO | H/L | Contrast Adjust |
| 4 | RS | H/L | Register select |
| 5 | R/W | H/L | Read/Write |
| 6 | E | H,H→L | Enable signal |
| 7 | DB0 | H/L | Data Bit 0 |
| 8 | DB1 | H/L | Data Bit 1 |
| 9 | DB2 | H/L | Data Bit 2 |
| 10 | DB3 | H/L | Data Bit 3 |
| 11 | DB4 | H/L | Data Bit 4 |
| 12 | DB5 | H/L | Data Bit 5 |
| 13 | DB6 | H/L | Data Bit 6 |
| 14 | DB7 | H/L | Data Bit 7 |
| 15 | A+ (EL1) | -- | A (EL Backlight 1) |
| 16 | K- (EL2) | -- | K (EL Backlight 2) |

## Text LCD Block Diagram



# Text LCD Control(2)

- 1.固定字型ROM，稱為CG（Character Generator）ROM。

  CG ROM內儲存著192個5x7點矩陣的字型，這些字型均已固定，例如我們將"A"寫入LCD中，就是將 "A" 的ASCII碼41H寫至DDRAM中，同時至CG ROM中將 "A"的字型點矩陣資料找出來而顯示在LCD上。

# Text LCD Control(3)

| Lower 4 bit \ Higher 4 bit | CHARACTER PATTERN CHART(5×7DOTS+CURSOR) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0000 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 | | |
| Lower 4-bit (D0-D3) of Character Code (Hexadecimal) | xxxx0000 | CG RAM (1) | | 0 | @ | P | ` | p | | ー | タ | ミ | α | p |
| | xxxx0001 | (2) | ! | 1 | A | Q | a | q | 。 | ア | チ | ム | ä | q |
| | xxxx0010 | (3) | " | 2 | B | R | b | r | 「 | イ | ツ | メ | ß | θ |
| | xxxx0011 | (4) | # | 3 | C | S | c | s | 」 | ウ | テ | モ | ε | ∞ |
| | xxxx0100 | (5) | $ | 4 | D | T | d | t | 、 | エ | ト | ヤ | μ | Ω |
| | xxxx0101 | (6) | % | 5 | E | U | e | u | ・ | オ | ナ | ユ | σ | ü |
| | xxxx0110 | (7) | & | 6 | F | V | f | v | ヲ | カ | ニ | ヨ | ρ | Σ |
| | xxxx0111 | (8) | ' | 7 | G | W | g | w | ァ | キ | ヌ | ラ | g | π |
| | xxxx1000 | (1) | ( | 8 | H | X | h | x | ィ | ク | ネ | リ | ｊ | x̄ |
| | xxxx1001 | (2) | ) | 9 | I | Y | i | y | ゥ | ケ | ノ | ル | -' | y |
| | xxxx1010 | (3) | * | : | J | Z | j | z | ェ | コ | ハ | レ | j | 千 |
| | xxxx1011 | (4) | + | ; | K | [ | k | { | ォ | サ | ヒ | ロ | × | 万 |
| | xxxx1100 | (5) | , | < | L | ¥ | l | \| | ャ | シ | フ | ワ | ¢ | 円 |
| | xxxx1101 | (6) | - | = | M | ] | m | } | ュ | ス | ヘ | ン | ŧ | ÷ |
| | xxxx1110 | (7) | . | > | N | ^ | n | → | ョ | セ | ホ | ゛ | ñ | |
| | xxxx1111 | (8) | / | ? | O | _ | o | ← | ッ | ソ | マ | ゜ | ö | ■ |

# Text LCD Control(2)

- 2.資料顯示RAM，稱為DD（Data Display）RAM。

DD RAM內用來儲存寫至LCD內部的字元，DD RAM的位址分佈從00H到67H，分別代表LCD的各行位置，如下表所示，例如我們要將 "A"寫入第2行的第1個位置，就先設定DD RAM位址為40H，而後寫入41H至LCD即可。

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Line 1 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 8A | 8B | 8C | 8D | 8E | 8F | | | | |
| Line 2 | C0 | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | CA | CB | CC | CD | CE | CF | | | | |
| Line 3 | | | | | | | | | | | | | | | | | | | | |
| Line 4 | | | | | | | | | | | | | | | | | | | | |

# Text LCD Control(2)

- 3.使用者自訂字型RAM，稱為CG RAM。

  此區域只有64位元組，可由使用者將自行設計的字型寫入LCD中，一個字的大小為5x8點矩陣，共可以儲存8個字型，其顯示碼為00H到07H。

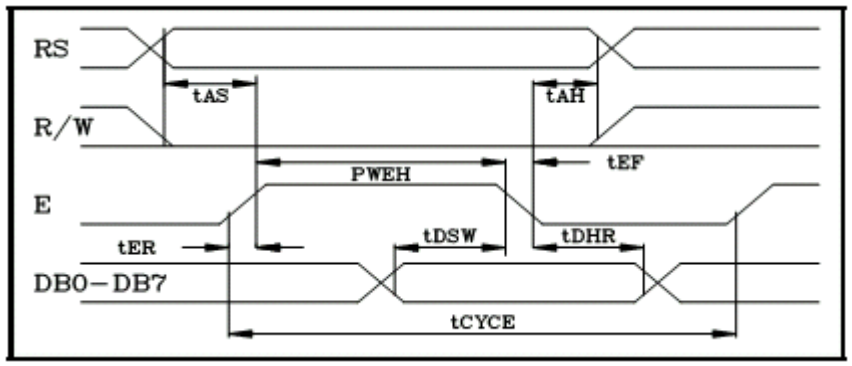
# Text LCD Control(3)

## Instruction Set

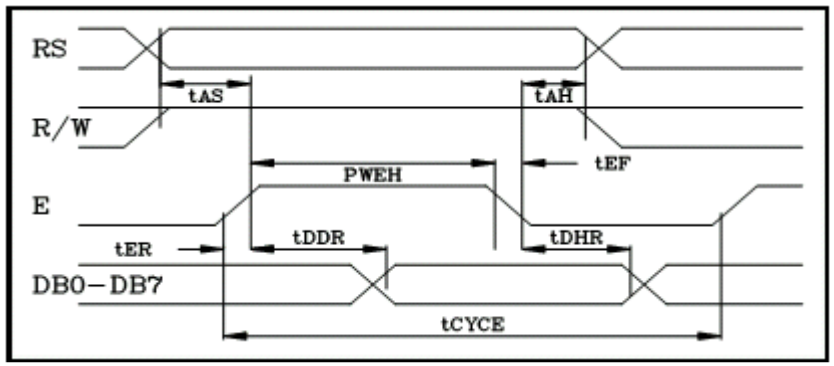
| FUNCTION | RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | DESCRIPTION | EXECU. TIME* (MAX.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clear Display | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Clears entire display and returns the cursor to home position ( address 0 ). | 1.64ms |
| Return Home | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | x | Return the cursor to the home position. Also returns the display being shifted to the original position. DD RAM contents remain unchanged. | 1.64ms |
| Entry mode set | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | I/D | S | Set cursor move direct and specifies display shift.These operations are performed during data rite/read. For normal operation, set S to zero. I/D=1 : increment ; 0 :decrement ;S=1 : accompanies display shift when data is written, for normal operation, set to zero. | 40 $\mu$ s |
| Display ON/OFF control | 0 | 0 | 0 | 0 | 0 | 0 | 1 | D | C | B | Set ON/OFF all display(D),cursor ON/OFF(C), and blink of cursor position character(B). D=1: ON display; 0:OFF display. C=1: ON cursor;0: OFF cursor. B=1: ON blink cursor; 0: OFF blink cursor. | 40 $\mu$ s |
| Cursor or Display shift | 0 | 0 | 0 | 0 | 0 | 1 | S/C | R/L | x | x | Move the cursor and shift the display without changing DD RAM contents. S/C=1: Display shift; 0:Cursor move. R/L=1: shift to right; 0: shift to left. | 40 $\mu$ s |
| Function Set | 0 | 0 | 0 | 0 | 1 | DL | N | F | x | x | Set the interface data length (DL). Number of display lines (N) and character font (F). DL=1: 8 bits; 0:4 bits. N=1: 2 lines; 0: 1 lines. F=1: 5x10 dots; 0: 5x7 dots. | 40 $\mu$ s |
| Set CG RAM address | 0 | 0 | 0 | 1 | ACG | | | | | | Set CG RAM address. CG RAM data is sent and received after this setting. | 40 $\mu$ s |
| Set DD RAM address | 0 | 0 | 1 | ADD | | | | | | | Set DD RAM address. DD RAM data is sent and received after this setting | 40 $\mu$ s |
| Read busy flag & address | 0 | 1 | BF | AC | | | | | | | Reads Busy Flag (BF) indicating internal operation is being performed and reads address counter contents. BF=1: internally operating. 0: can accept instruction | 1 $\mu$ s |
| Write Data to CG/DDRAM | 1 | 0 | WRITE DATA | | | | | | | | Write data into DD RAM or CG RAM. | 40 $\mu$ s |
| Read Data for CG/DDRAM | 1 | 1 | READ DATA | | | | | | | | Read data from DD RAM or CG RAM | 40 $\mu$ s |

# Text LCD Timer

Write Operation

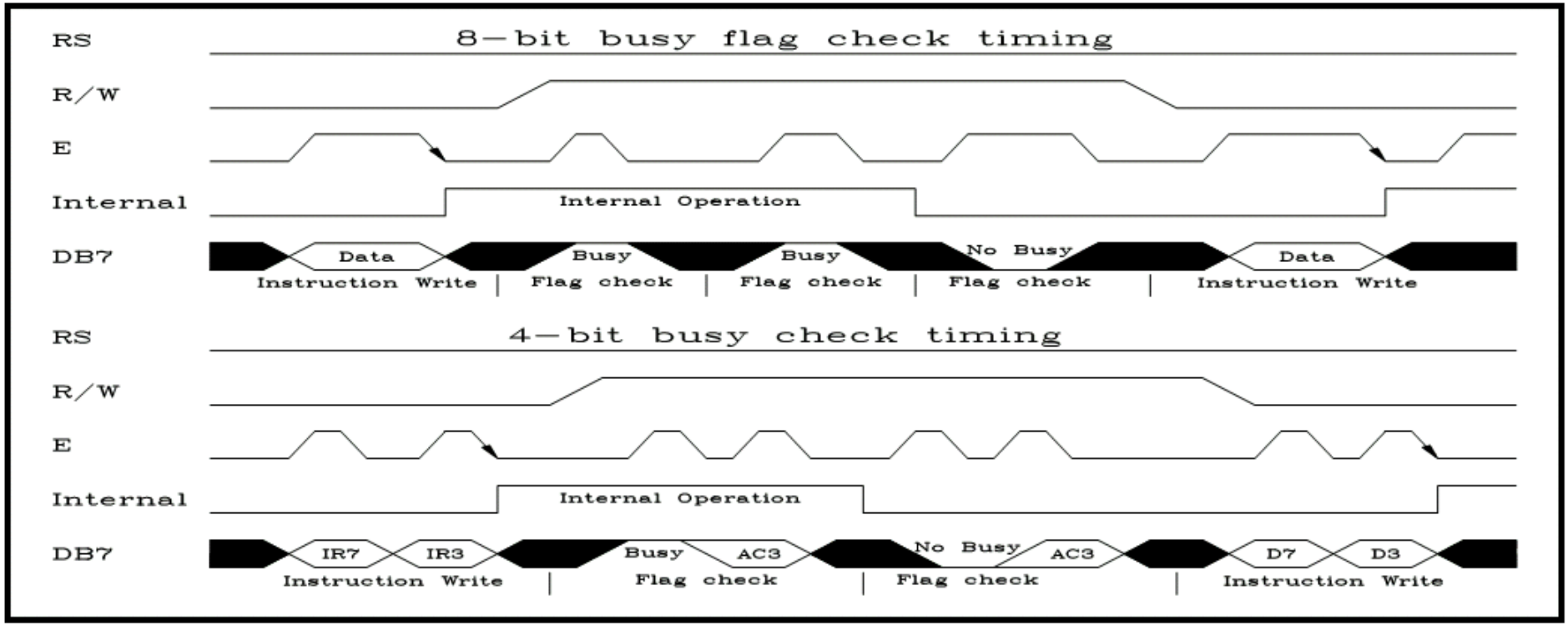



Read Operation




| Item | Symbol | Limit (Min.) | Limit (Max.) | Unit |
|---|---|---|---|---|
| Enable Cycle Time | tCYCE | 1000 | -- | ns |
| Enable Pules Width ( High level ) | PWEH | 450 | -- | ns |
| Enable Rise/Fall Time | tER,tEF | -- | 25 | ns |
| Address Set-Up Time ( RS,R/W,E ) | tAS | 100 | -- | ns |
| Address Hole Time | tAH | 10 | -- | ns |
| Data Set-Up Time | tDSW | 100 | -- | ns |
| Data Delay Time | tDDR | -- | 190 | ns |
| Data Hold Time | tDHR | 20 | -- | ns |

# Busy check


8—bit busy flag check timing
RS
R/W
E
Internal
Internal Operation
DB7
Data
Busy
Busy
No Busy
Data
Instruction Write
Flag check
Flag check
Flag check
Instruction Write
4—bit busy check timing
RS
R/W
E
Internal
Internal Operation
DB7
IR7
IR3
Busy
AC3
No Busy
AC3
D7
D3
Instruction Write
Flag check
Flag check
Instruction Write

# Text LCD Function List(1)

- init_lcd()
  LCD初始化，設定LCD游標是否出現、資料傳送方式等
- write_com(unsigned char c)
  將參數C寫入指令暫存器
- write_data(unsigned char c)
  將參數C寫入資料暫存器
- print(char line, char *str)
  將LCD清空並把*str印在LCD上，line是決定要印在哪一行
- prline1(char x, char w)
  LCD不清空，將字元w印在第一行的x位置
- prline2(char x, char w)
  LCD不清空，將字元w印在第二行的x位置

# Text LCD Function List(2)

- clear(void)
  清除LCD
- home(void)
  游標移至原始位置
- setCursor(char index)
  設定游標位置
- shiftDisplayLeft(void)
  左移Display
- shiftDisplayRight(void)
  右移Display
- pf4h(unsigned int value)
  將整數轉為hex並輸出於LCD上

# Development Flow

**Embedded Software Side**

**Connect the EVB and the IOB**

**Programming**

**Bootup STM32F10x**

**RCC Configure**

**GPIO Configure**

**LCD Initial**

```
int main(void)
{

  #ifdef DEBUG
    debug();
  #endif

  /* System clocks configuration ----------------------*/
  RCC_Configuration();

  /* GPIO configuration -------------------------------*/
  GPIO_Configuration();

  /* 初始化 LCD 介面  */
  init_lcd();

   clear();
   while(1)
   {
      print(1, "Hello World!!");
      delay(10000);
   }
}
```

# Configure RCC

## RCC FwLib Functions List

| Function name | Description |
|---|---|
| RCC_DeInit | Resets the RCC clock configuration to the default reset state. |
| RCC_HSEConfig | Configures the External High Speed oscillator (HSE). |
| RCC_WaitForHSEStartUp | Waits for HSE start-up. |
| RCC_HCLKConfig | Configures the AHB clock (HCLK). |
| RCC_PCLK1Config | Configures the Low Speed APB clock (PCLK1). |
| RCC_PCLK2Config | Configures the High Speed APB clock (PCLK2). |
| RCC_PLLConfig | Configures the PLL clock source and multiplication factor. |
| RCC_PLLCmd | Enables or disables the PLL. |
| RCC_SYSCLKConfig | Configures the system clock (SYSCLK). |
| RCC_APB2PeriphClockCmd | Enables or disables the High Speed APB (APB2) peripheral clock. |

```
void RCC_Configuration(void)
{
  /* RCC system reset(for debug purpose) */
  RCC_DeInit();
  /* Enable HSE */
  RCC_HSEConfig(RCC_HSE_ON);
  /* Wait till HSE is ready */
  HSEStartUpStatus = RCC_WaitForHSEStartUp();
  if(HSEStartUpStatus == SUCCESS) {
    /* Enable Prefetch Buffer */
    FLASH_PrefetchBufferCmd(FLASH_PrefetchBuffer_Enable);
    /* Flash 2 wait state */
    FLASH_SetLatency(FLASH_Latency_2);
    /* HCLK = SYSCLK */
    RCC_HCLKConfig(RCC_SYSCLK_Div1);
    /* PCLK2 = HCLK */
    RCC_PCLK2Config(RCC_HCLK_Div1);
    /* PCLK1 = HCLK/2 */
    RCC_PCLK1Config(RCC_HCLK_Div2);
    /* ADCCLK = PCLK2/4 */
    RCC_ADCCLKConfig(RCC_PCLK2_Div4);
    /* PLLCLK = 8MHz * 7 = 56 MHz */
    RCC_PLLConfig(RCC_PLLSource_HSE_Div1, RCC_PLLMul_7);
    /* Enable PLL */
    RCC_PLLCmd(ENABLE);
    /* Wait till PLL is ready */
    while(RCC_GetFlagStatus(RCC_FLAG_PLLRDY) == RESET) { }
    /* Select PLL as system clock source */
    RCC_SYSCLKConfig(RCC_SYSCLKSource_PLLCLK);
    /* Wait till PLL is used as system clock source */
    while(RCC_GetSYSCLKSource() != 0x08) {  }
  }
/* Enable peripheral clocks ------------------------------*/

/* Enable GPIOC clock */
  RCC_APB2PeriphClockCmd(RCC_APB2Periph_GPIOC, ENABLE);
}
```

# Configure GPIO

## GPIO FwLib Functions List

| Function name | Description |
|---|---|
| GPIO_DeInit | Resets the GPIOx peripheral registers to their default reset values. |
| GPIO_AFIODeInit | Resets the Alternate Functions (remap, event control and EXTI configuration) registers to their default reset values. |
| GPIO_Init | Initializes the GPIOx peripheral according to the specified parameters in the GPIO_InitStruct. |
| GPIO_StructInit | Fills each GPIO_InitStruct member with its default value. |
| GPIO_ReadInputDataBit | Reads the specified input port pin |
| GPIO_ReadInputData | Reads the specified GPIO input data port |
| GPIO_ReadOutputDataBit | Reads the specified output data port bit |
| GPIO_ReadOutputData | Reads the specified GPIO output data port |
| **GPIO_SetBits** | Sets the selected data port bits |
| **GPIO_ResetBits** | Clears the selected data port bits |
| GPIO_WriteBit | Sets or clears the selected data port bit |
| GPIO_Write | Writes data to the specified GPIO data port |
| GPIO_PinLockConfig | Locks GPIO Pins configuration registers |
| GPIO_EventOutputConfig | Selects the GPIO pin used as Event output. |
| GPIO_EventOutputCmd | Enables or disables the Event Output. |
| GPIO_PinRemapConfig | Changes the mapping of the specified pin. |
| GPIO_EXTILineConfig | Selects the GPIO pin used as EXTI Line. |

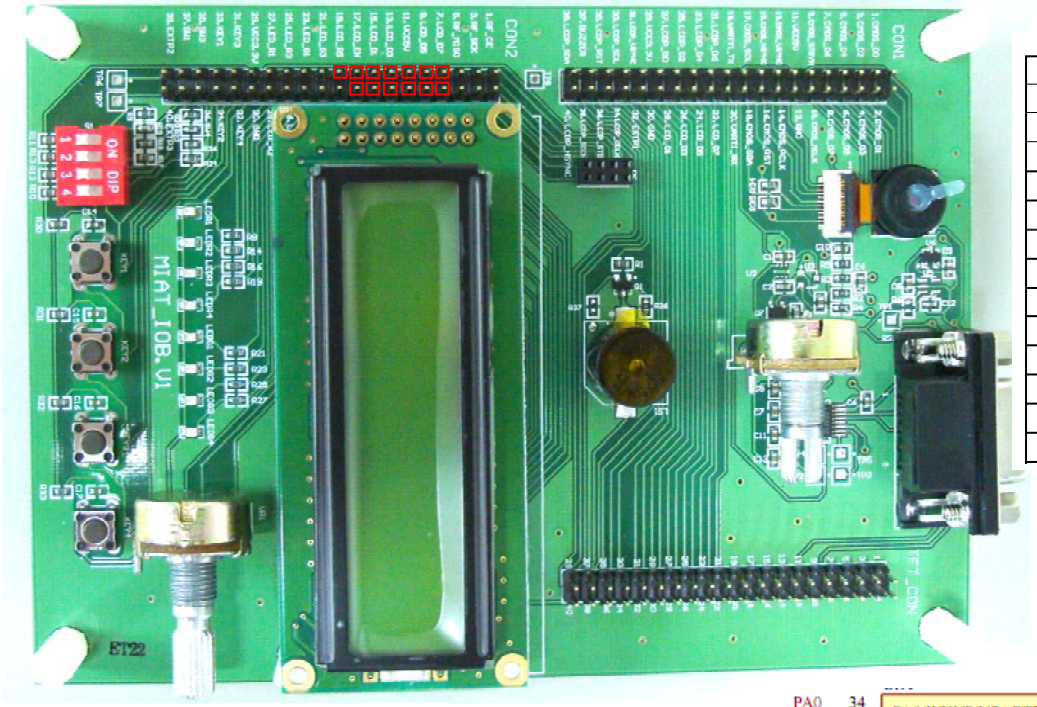
```
void GPIO_Configuration(void)
{
  GPIO_InitTypeDef GPIO_InitStructure;

  /* Configure IO connected to GPIOC *********************/
  GPIO_InitStructure.GPIO_Pin = GPIO_Pin_0 | GPIO_Pin_1 | GPIO_Pin_2
                              | GPIO_Pin_3 | GPIO_Pin_4 | GPIO_Pin_5
                              | GPIO_Pin_6 | GPIO_Pin_7 | GPIO_Pin_8
                              | GPIO_Pin_9 | GPIO_Pin_10 ;
  GPIO_InitStructure.GPIO_Mode = GPIO_Mode_Out_PP;
  GPIO_InitStructure.GPIO_Speed = GPIO_Speed_50MHz;
  GPIO_Init(GPIOC, &GPIO_InitStructure);
}
```

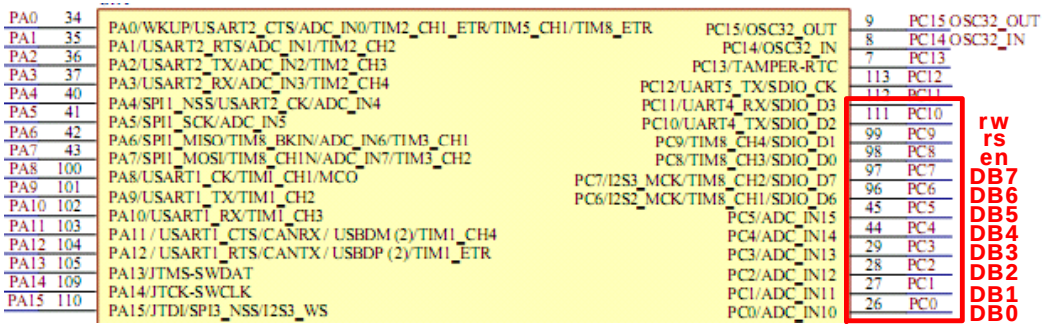
# 硬體電路配置

- Text LCD 電路配置
- 硬體接線示意圖

# Text LCD 電路配置




| 子版腳位名稱 | 子版腳位編號 | 母版腳位名稱 | 母版腳位編號 |
|---|---|---|---|
| VCC5V | CON2.11 | VCC5V | CON1.36 |
| GND | CON2.12 | GND | CON1.35 |
| LCD_D0 | CON2.16 | PC0 | CON1.24 |
| LCD_D1 | CON2.15 | PC1 | CON1.25 |
| LCD_D2 | CON2.14 | PC2 | CON1.26 |
| LCD_D3 | CON2.13 | PC3 | CON1.27 |
| LCD_D4 | CON2.10 | PC4 | CON2.8 |
| LCD_D5 | CON2.9 | PC5 | CON2.9 |
| LCD_D6 | CON2.8 | PC6 | CON3.24 |
| LCD_D7 | CON2.7 | PC7 | CON3.25 |
| LCD_EN | CON2.17 | PC8 | CON3.26 |
| LCD_RS | CON2.19 | PC9 | CON3.27 |
| LCD_R/W | CON2.18 | PC10 | CON4.3 |



# 實驗步驟

- 軟體設置
- 原始碼檔案瀏覽
- 編譯燒錄程式並觀察結果

# 檔案目錄結構

| <目錄>/檔案 | 說明 |
|---|---|
| | <..\TextLCD\E1> |
| <project> | 單元實驗Project目錄 |
| <source> | 程式碼目錄 |
| <include> | 引入檔目錄 |
| <library> | 函式庫目錄 |
| <image> | 燒錄配置檔目錄 |
| | <..\TextLCD\E1\image> |
| Lab.dfu | 燒錄配置檔 |
| | <..\TextLCD\E1\source> |
| hw_config.c | 硬體配置程式 |
| lcd_func.c | Text LCD 控制程式 |

# 編譯燒錄程式並觀察結果

- 完成系統硬體設置之工作後，依 MIAT STM32 user manual (ch3, ch4)之操作指示，將編譯後的hex檔轉換為dfu
- 透過USB 燒錄dfu檔
- 觀察Text LCD上是否有顯示文字

# 實作重點提示

- 觀察部份原始碼檔案，藉以了解程式架構
- 修改主程式，使用shiftDisplayLeft function使Text LCD左移，完成文字跑馬燈的效果。
- 修改主程式，使用setCGRAM function設定自訂字元到Text LCD的CG Ram中，並顯示結果。

# 實際操作

操作時間~***(90min)***

# 習作及參考資料

- 習作

  Exe_1：設計可顯示十進位輸出之功能。

  Exe_2：自行設定特殊字元到CGRAM中。

- 參考資料

  [1] MIAT_STM32_user_manual_V1.00.pdf

  [2] STM32F10xxx reference manual.pdf

  [3] STM32F103XX  firmware library.pdf

  [4] LMC-SSC2D16-01 Serial USER  MANUAL(Text LCD datasheet)

# *Q & A*