計時器/計數器
Timer/Counter

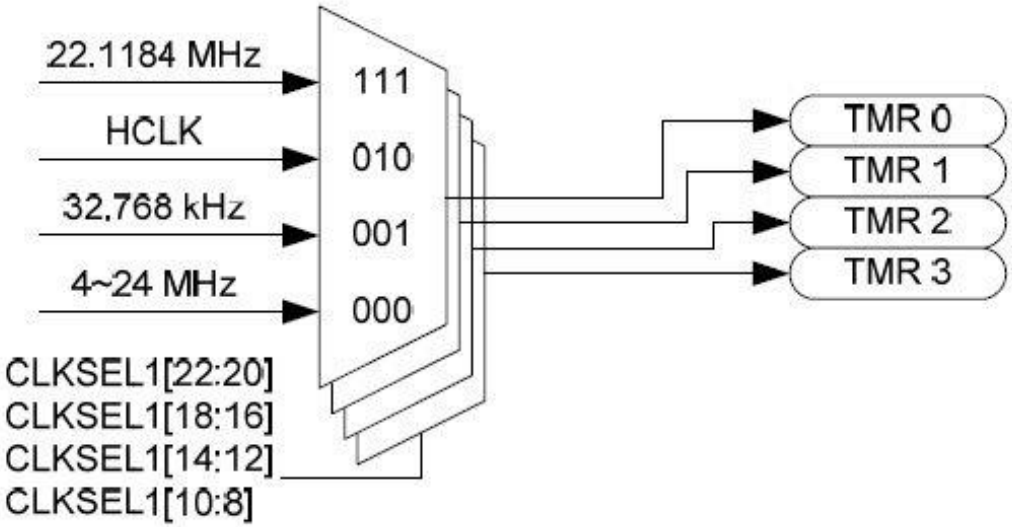
- 2013/4/3

課程大綱 (Lesson Outline)

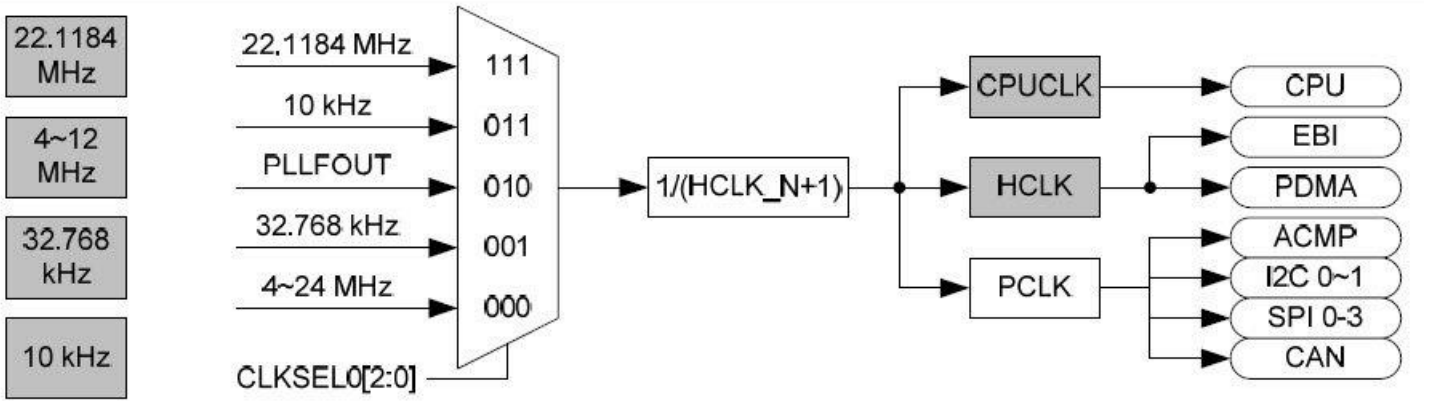
- **Cortex-M0 MCU 計數器/看門狗計數/計時時序 設計原理**
  - 計數器(Timer)
  - 看門狗(WatchDog)
  - 時序(RTC)
- **實習範例 : Smpl_Timer_WDT_RTC**
- **實習範例 : Timer計數器 – 單次模式、週期模式、循環模式**
  - 程式修改為使用三個Timer 把Timer0,1,2 以不同速度計時及顯示至LCD
- **範例練習: WDT看門狗計數器**
  - 利用範例修改出只使用WDT 看門狗之程式
- **範例練習: RTC計時時序**
  - 利用範例修改出只使用RTC時序計時之應用

時序控制器和計時器

- 參閱
- 技術手冊 5.3 時序控制器
- 技術手冊 5.10 計時器
- 計時器的時序源有22MHz,外部32K,外部4-24M,HCLK
- HCLK的時序源有22MHz,10KHz,外部32K,外部4-24M, PLLFOUT

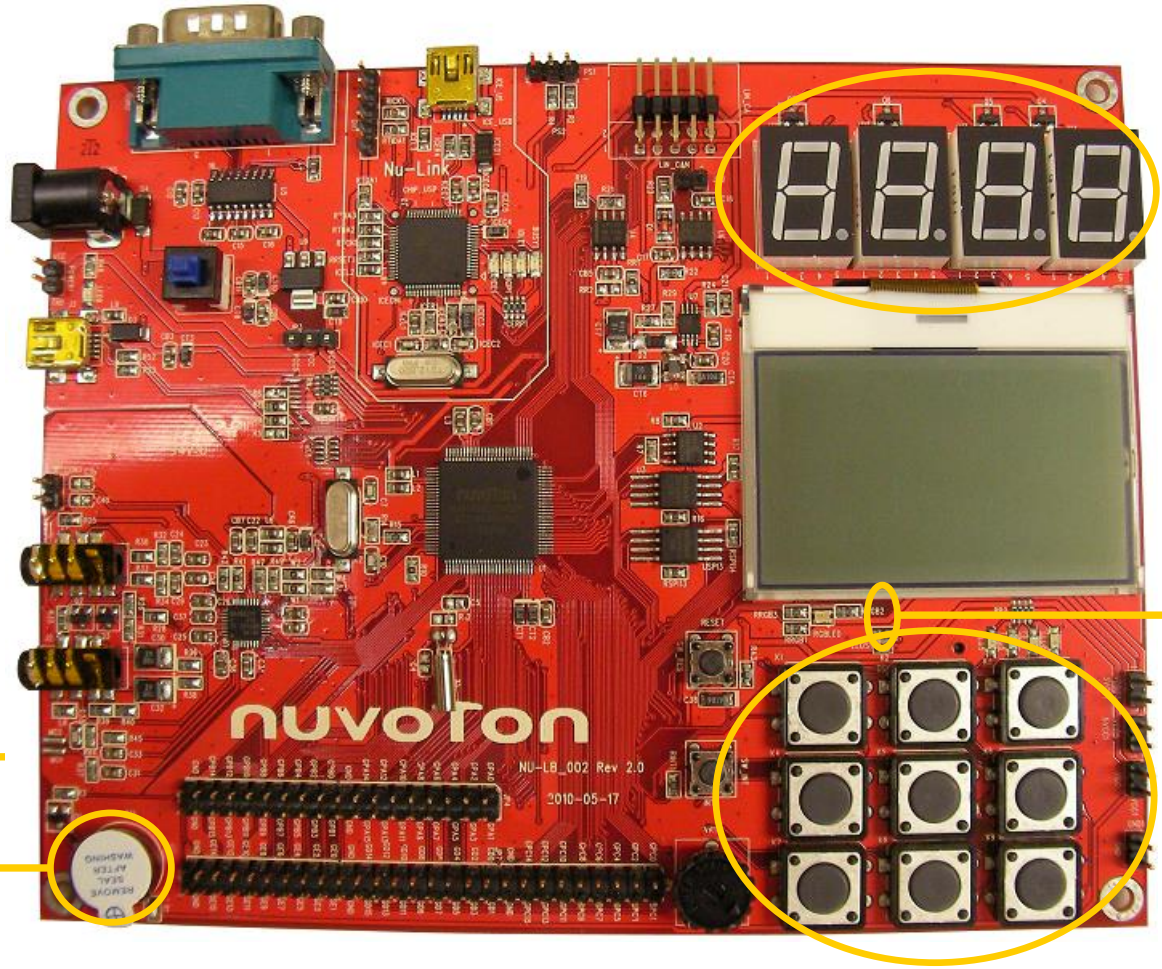


時序控制器和計時器



- HCLK的時序源有22MHz,10KHz,外部32K,外部4-24M, PLLFOUT
- PLLFOUT可使用PLLCON設定各種頻率(max 50MHz)。

NU-LB-NUC140 開發板



7 segment LEDs

RGB LED
GPA12,13,14

Keypad

SW Int
GPB15

Buzzer
GPB11

Unlockreg() & lockreg()

Unlockreg()

Unlock the locked registers before access

暫存器鎖定鍵地址暫存器(RegLockAddr) :

有些系統控制暫存器需要被保護起來，以防止誤操作而影響芯片運行，這些暫存器在reset後是鎖定的。用戶可以連續依次寫入“59h”, “16h” “88h”到0x5000_0100解鎖

LOCKREG();

//向 “0x5000_0100”寫入任何值，就可以重新上鎖保護暫存器

PWRCON: Power Down Control Register

- 功能：System Power Down Control Register (1: enable)
- 設定時序來源，10K,22M,32K預設為開啟。外部4-24M必須啟動後，才能使用。

Bits	function	Descriptions
3	OSC10K_EN	Internal 10 kHz Low Speed Oscillator Enable
2	OSC22M_EN	Internal 22.1184 MHz High Speed Oscillator Enable
1	XTL32K_EN	External 32.768 kHz Low Speed Crystal Enable
0	XTL12M_EN	External 4~24 MHz High Speed Crystal Enable

Function: DrvSYS_SetOscCtrl

- 功能：enable/disable internal oscillator or external crystal.
- 函數：int32_t DrvSYS_SetOscCtrl (E_SYS_CHIP_CLKSRC eClkSrc, int32_t i32Enable)
- 參數：eClkSrc: 暫存器PWRCON
  E_SYS_XTL12M:[0]外部4-24M振盪器
  E_SYS_XTL32K:[1]外部32.768K振盪器
  E_SYS_OSC22M:[2]內部22.1184M振盪器
  E_SYS_OSC10K:[3]內部10K振盪器
- 參數： i32Enable:1: Enable / 0: Disable.
- 範例：DrvSYS_SetOscCtrl(E_SYS_XTL12M, 1);
- 與下列指令的作用相同
- SYSCLK->PWRCON.XTL12M_EN = 1;

CLKSTATUS: Clock status Register

- 功能：Clock status monitor Register (1:stable)

Bits	function	Descriptions
4	OSC22M_STB	Internal 22.1184 MHz High Speed Oscillator Clock Source Stable Flag
3	OSC10K_STB	Internal 10 kHz Low Speed Oscillator Clock Source Stable Flag
2	PLL_STB	Internal PLL Clock Source Stable Flag
1	XTL32K_STB	External 32.768 kHz Low Speed Crystal Clock Source Stable Flag
0	XTL12M_STB	External 4~24 MHz High Speed Crystal Clock Source Stable Flag

Function: DrvSYS_GetChipClockSourceStatus

- 功能：monitor if the chip clock source stable or not.
- 函數：int32_t DrvSYS_GetChipClockSourceStatus (E_SYS_CHIP_CLKSRC eClkSrc)
- 參數：eClkSrc: 暫存器CLKSTATUS
  - E_SYS_XTL12M:[0]外部4-24M振盪器
  - E_SYS_XTL32K :[1]外部32.768K振盪器
  - E_SYS_OSC22M :[4]內部22.1184M振盪器
  - E_SYS_OSC10K :[3]內部10K振盪器
  - E_SYS_PLL:[2]內部PLL時序源
- 範例： DrvSYS_GetChipClockSourceStatus(E_SYS_XTL12M)
- 與下列指令的作用相同
- SYSCLK->CLKSTATUS.XTL12M_STB

CLKSEL0: Clock Source Select Control Register 0

Bits	function	Descriptions
5:3	STCLK_S	**Cortex_M0 SysTick clock source select** 000 = external 4~24 MHz high speed crystal clock 001 = external 32.768 kHz low speed crystal clock 010 = external 4~24 MHz high speed crystal clock/2 011 = Clock source from HCLK/2 111 = internal 22.1184 MHz high speed oscillator clock/2
2:0	HCLK_S	**HCLK clock source select** 000 = external 4~24 MHz high speed crystal clock 001 = external 32.768 kHz low speed crystal clock 010 = Clock source from PLL clock 011 = internal 10 kHz low speed oscillator clock 111 = internal 22.1184 MHz high speed oscillator clock

Function: DrvSYS_SelectHCLKSources

- 功能：select HCLK clock source.
- 函數：int32_t DrvSYS_SelectHCLKSource(uint8_t u8ClkSrcSel)
- 參數：u8ClkSrcSel: 暫存器CLKSEL0

  0: External 12M clock

  1: External 32K clock

  2: PLL clock

  3: Internal 10K clock

  7: Internal 22M clock
- 範例： DrvSYS_SelectHCLKSource(0);
- 與下列指令的作用相同
- SYSCLK->CLKSEL0.HCLK_S = 0;
- SystemCoreClockUpdate();

CLKSEL1: Clock Source Select Control Register 1

Bits	function	Descriptions
[10:8]	**TMR0_S**	**TIMER0** 時序源選擇 000 = 時序源為外部 4~24 MHz 晶振時序 001 = 時序源為外部 32.768 kHz 晶振時序 010 = 時序源為 HCLK 111 = 時序源為內部 22.1184 MHz 振盪器時序
[7:4]	**Reserved**	保留
[3:2]	**ADC_S**	**ADC** 時序源選擇 00 = 時序源為外部 4~24 MHz 晶振時序 01 = 時序源來自 PLL 時序 10 = 時序源為 HCLK 11 = 時序源為內部 22.1184 MHz 振盪器時序

APB 設備時序使能控制寄存器 (APBCLK)

- 功能：該寄存器各位用於使能/禁用外設控制器時序。

Bits		描述
[4]	TMR2_EN	Timer2 時序使能控制 1 = 使能 Timer2 時序 0 = 禁用 Timer2 時序
[3]	TMR1_EN	Timer1 時序使能控制 1 = 使能 Timer1 時序 0 = 禁用 Timer1 時序
[2]	TMR0_EN	Timer0 時序使能控制 1 = 使能 Timer0 時序 0 = 禁用 Timer0 時序

定時器控制寄存器 (TCSR)

Bits	symbol	描述
[31]	**DBGACK_TMR**	**ICE debug mode acknowledge Disable**（寫保護位） 0 = ICE除錯模式回應影響定時器計數。 當ICE除錯模式回應時，定時器計數將被鎖定。 1 = ICE除錯模式回應禁用。 無論ICE除錯模式回應與否，定時器計數將持續下去。
[30]	**CEN**	**Timer Enable Bit** 1 = 開始計數 0 = 停止/暫停計數 注1：在停止狀態，設置 CEN = 1 將致能 24-位向上計數器從上次停止的計數值繼續計數。 注2：在 one-shot 模式下 (MODE [28:27] =00)，當相應的定時中斷產生時 (IE [29] =1)，該位元由硬體自動清零。

定時器控制寄存器 (TCSR)

Bits	symbol	描述
[29]	**IE**	**Interrupt Enable Bit** 1 = 致能定時器中斷 0 = 禁用定時器中斷 當定時器中斷致能，當計數值與TCMPR寄存器內數值相同是，觸發中斷。
[28:27]	**MODE**	00:當定時器定義為單觸發模式 (one-shot) 時，定時器溢出僅觸發中斷一次（如果 IE 致能），進入中斷後 CEN 由硬件自動清除為 0。
		01:當定時器定義為週期模式 (period) 時，定時器每次溢出都觸發相應中斷（如果 IE 致能）。
		10:當定時器工作在 toggle 模式，中斷信號週期性產生（如果 IE 致能）。且相應的信號 (tout) 以占空比為 50% 週期改變。
		11:定時器工作在連續計數 (continuous counting) 模式。相應的中斷在 TDR = TCMPR 時產生（如果 IE 致能）。 然而，24位的向上定時器繼續計數而不會復位。

定時器控制寄存器 (TCSR)

Bits	symbol	描述
[26]	**CRST**	**Timer Reset Bit** 0 = 該位寫 0 無效。 1 = 重置定時器的 8-位預分頻計數器，內部 24-位向上計數器和 CEN 位。
[25]	**CACT**	**Timer Active Status Bit**（只讀） 該位表示當前定時器計數器的狀態。 0 = 定時器未激活 1 = 定時器激活
[24]	**CTB**	**Counter Mode Enable Bit** 該位是計數模式致能位元。當定時器用作事件計數器時，該位需要設置成 1 且定時器作為事件計數器外部觸發引腳。計數器根據 TX_PHASE 定義的相位在外部管腳的上升沿/下降沿檢測相位。 1 = 致能計數器模式 0 = 禁用計數器模式

定時器控制寄存器 (TCSR)

Bits	symbol	描述
[16]	TDR_EN	**Data Load Enable** TDR_EN 被設定後，當計數器計數時，TDR（Timer 數據寄存器）將被 24-位元向上計數器的值不斷更新。 1 = Timer 數據寄存器更新致能。 0 = Timer 數據寄存器禁用更新。
[7:0]	PRESCALE	**Pre-scale Counter** 時序輸入根據 PRESCALE +1 進行預分頻。如果 PRESCALE=0，不進行預分頻。

定時器比較寄存器 (TCMPR)

Bits	symbol	描述
[23:0]	**TCMP**	定時器比較值 TCMP 是24-位元比較寄存器。當內部 24-位元向上計數器的值與 TCMP 的值相等時，如果TCSR.IE[29]=1，產生中斷請求。 TCMP 的值定義定時器計數的週期時間。 週期時間 =（定時器時序輸入的週期）* (8-bit PRESCALE + 1) * (24-bit TCMP) 注1：不能向 TCMP 裡寫 0x0 或 0x1，否則內核將運行到未知狀態。 注2：當定時器工作在 continuous counting 模式時，如果軟體寫一個新的值到 TCMP，24-位元向上計數定時器將繼續計數。 如果定時器工作在其他模式，如果軟件寫一個新的值到 TCMP，定時器將使用新比較值並退出當前計數，開始重新計數。

定時器中斷狀態寄存器 (TISR)

Bits	symbol	描述
[0]	**TIF**	定時器中斷旗標 此位元顯示定時器中斷狀態。 當內部 24-位元向上計數定時器符合定時器比較值 (TCMP)，硬體設定TIF=1。 用軟體寫入1，將該位元清除為0。

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Bits	符號	描述
[31:0]	**SETPEND**	寫 1，由軟件控制掛起相應中斷。每位元代表 IRQ0 ~ IRQ31 的中斷號（向量號：從16到47）。 寫 0 無效 讀取該寄存器返回當前等待處理的中斷狀態。

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvTIMER_Init	User must to call this function before any timer operations after system boot up.
DrvTIMER_Open	Open the specified timer channel with specified operation mode.
DrvTIMER_Close	close the timer channel.
DrvTIMER_SetTimerEvent	Install the interrupt callback function of the specified timer channel.
DrvTIMER_ClearTimerEvent	Clear the timer event of the specified timer channel.
DrvTIMER_EnableInt	enable the specified timer interrupt.
DrvTIMER_DisableInt	disable the specified timer interrupt

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvTIMER_GetIntFlag	Get the interrupt flag status from the specified timer channel.
DrvTIMER_ClearIntFlag	Clear the interrupt flag of the specified timer channel.
DrvTIMER_Start	Start to count the specified timer channel
DrvTIMER_GetIntTicks	get the number of interrupt occurred after the timer interrupt function is enabled.
DrvTIMER_ResetIntTicks	clear interrupt ticks to 0.
DrvTIMER_Delay	add a delay loop by specified interrupt ticks of the timer channel.
DrvTIMER_OpenCounter	open the timer channel with the specified operation mode.

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvTIMER_StartCounter	Start counting of the specified timer channel
DrvTIMER_GetCounters	get the current counters of the specified timer channel.
DrvTIMER_OpenCapture	initial the external timer capture source and set to start catpure or reset specified timer counter.
DrvTIMER_CloseCapture	close the external timer capture source.
DrvTIMER_SelectExternalMode	select to run capture function or reset the timer counter.
DrvTIMER_SelectCaptureEdge	configure the detect edge of timer capture mode.

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvTIMER_EnableCaptureInt	enable the timer external interrupt function.
DrvTIMER_DisableCaptureInt	disable the timer external interrupt function
DrvTIMER_EnableCapture	enable the specified capture function.
DrvTIMER_DisableCapture	disable the specified capture function
DrvTIMER_GetCaptureData	get the capture value of the specified timer channel.
DrvTIMER_GetCaptureIntFlag	Get the external interrupt flag status from the specified timer channel.
DrvTIMER_ClearCaptureIntFlag	Clear the external interrupt flag of the specified timer channel

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvTIMER_EnableCaptureDebounce	Enable the debounce function of specified external capture input source
DrvTIMER_DisableCaptureDebounce	Disable the debounce function of specified external capture input source.
DrvTIMER_EnableCounterDebounce	Enable the debounce function of specified external counter input source.
DrvTIMER_DisableCounterDebounce	Disable the debounce function of specified external counter input source.
DrvTIMER_SelectCounterDetectPhase	configure the counter detect phase of specified source.
DrvTIMER_GetVersion	Get the version number of Timer/WDT driver.

IRQ0 ~ IRQ31 Set-Pending Control Register (NVIC_ISPR)

Function	Description
DrvWDT_Open	Enable WDT engine clock and set WDT time-out interval.
DrvWDT_Close	stop/disable WDT relative functions.
DrvWDT_InstallISR	install WDT interrupt service routine.
DrvWDT_Ioctl	start/stop the WDT, enable/disable WDT interrupt function, enable/disable WDT time-out wake up function, enable/disable system reset

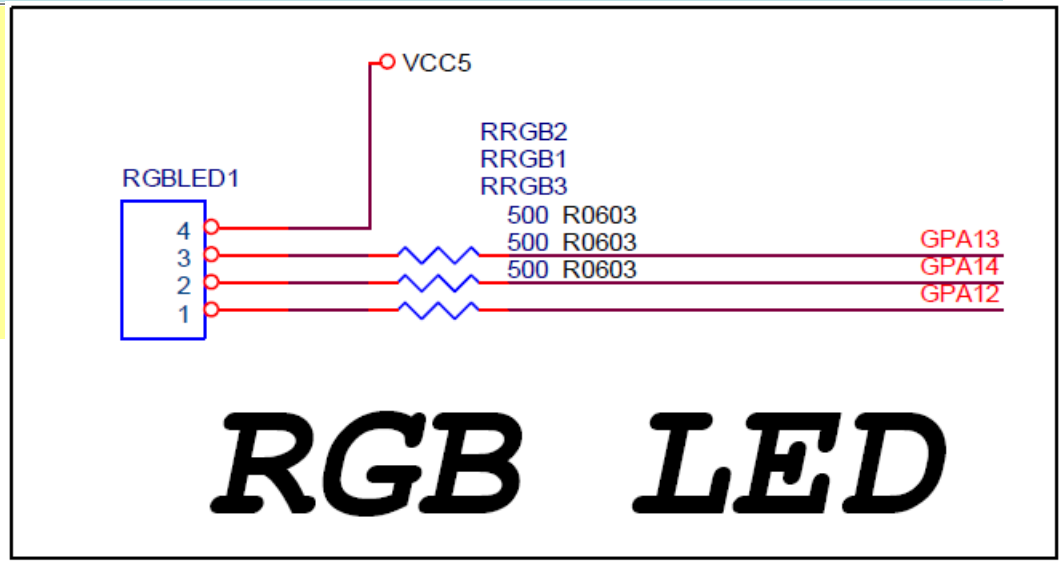
7.1Test_RGBled 學習板電路圖

- RGB LED : GPA12,13,14

GPA12 : Blue　0 = on, 1 = off

GPA13 : Green　0 = on, 1 = off

GPA14 : Red　0 = on, 1 = off



寫一程式輪流顯示藍色，綠色，紅色LED，每個LED亮一秒。

1. 使用Timer 0控制時間，每秒產生一次中斷。
2. 在Timer 0中斷時，切換顯示的LED。
3. 藍色LED :GPA[12]，綠色LED :GPA[13]，紅色LED :GPA[14]

7.1Test_RGBled (1/x)

```
int main (void)
{
        uint32_t freq;

        // Initial LED: set GPIO GPA12,13,14 to output mode
        // initial GPIO GPA pin  12 to output mode
        DrvGPIO_Open(E_GPA, 12, E_IO_OUTPUT);
        // initial GPIO GPA pin  13 to output mode
        DrvGPIO_Open(E_GPA, 13, E_IO_OUTPUT);
        // initial GPIO GPA pin  14 to output mode
        DrvGPIO_Open(E_GPA, 14, E_IO_OUTPUT);
```

7.1Test_RGBled (2/x)

```
// Initial 12M and TIMER0
        Init12M();  //initial external 12M
        freq=1;
        InitTIMER0(freq);
// Main loop
        while (1)
        {

        }
}
```

7.1Test_RGBled (3/x)

```
void InitTimer0(uint32_t freq)
{
        // Select TIMER0 clock source
        // 0=extgernal, 1=32k,2=hclk,7=22M
        DrvSYS_SelectIPClockSource (E_SYS_TMR0_CLKSRC, 0);

        // Enable TIMER0 engine clock
        DrvSYS_SetIPClock (E_SYS_TMR0_CLK, 1);

        // User must to call this function before any timer operations.
        DrvTIMER_Init ();
```

7.1Test_RGBled (4/x)

```
        // Open the specified timer channel with specified operation mode.
        DrvTIMER_Open (E_TMR0, freq, E_PERIODIC_MODE);
        // enable the specified timer interrupt.
        DrvTIMER_EnableInt (E_TMR0);
        // Install the interrupt callback function
        //1= Number of timer interrupt occurred
        //0= A parameter of the callback function
        DrvTIMER_SetTimerEvent (E_TMR0, 1,
(TIMER_CALLBACK) TMR_Callback, 0);
        // Start to count the specified timer channel.
        DrvTIMER_Start (E_TMR0);
}
```

7.1Test_RGBled (5/x)

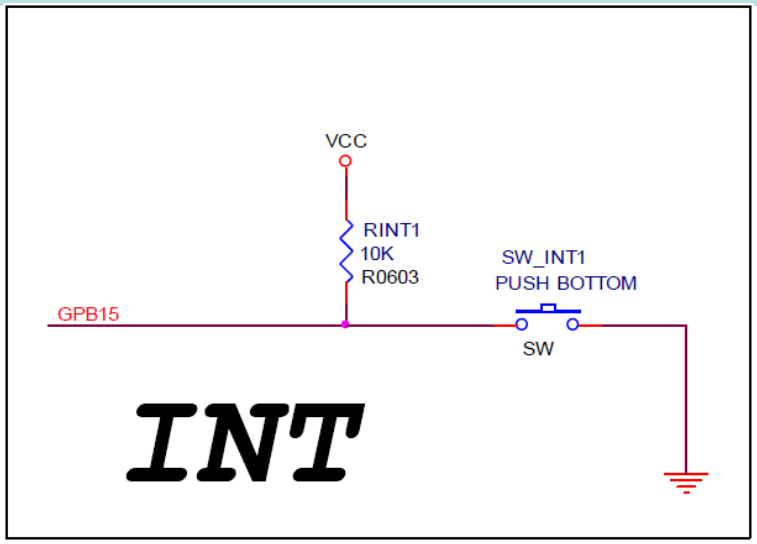
```
void TMR_Callback(void) // Timer0 interrupt subroutine
{
        //set GPIOA[LedLighted]=1, LED off
        DrvGPIO_SetBit(E_GPA,LedLighted);
        //next LED
        LedLighted++;
        if(LedLighted == 15)LedLighted=12;
        //set GPIOA[LedLighted]=0, LED on
        DrvGPIO_ClrBit(E_GPA,LedLighted);
}
```

7.1Test_RGBled (6/x)

```
// Initial external 12M
void Init12M(void)
{
        UNLOCKREG();
        //1: enable, 0: disable
        DrvSYS_SetOscCtrl(E_SYS_XTL12M,1);
        //SYSCLK->PWRCON.XTL12M_EN = 1;
        LOCKREG();
}
```

7.2Test_Interrupt_SWInt_RGBled

- RGB LED : GPA12,13,14
  - **GPA12** : Blue 0 = on, 1 = off
  - **GPA13** : Green 0 = on, 1 = off
  - **GPA14** : Red 0 = on, 1 = off
- SW Int : GPB15
  - **GPB15**: 0=pressed, 1= not pressed



寫一程式，LED閃爍亮0.25秒，暗0.25秒。當按鍵按下時，閃爍藍色LED。按鍵再按下時，閃爍綠色LED。按鍵再按下時，閃爍紅色LED。每次按鍵按下時，LED依序循環。

GPIOB[15]作為輸入，設定為外部中斷EINT1，啟用中斷，藉由中斷程式來執行。

DrvGPIO_GetBit

- 功能：Get the pin value from the specified input GPIO pin.
- 函數：int32_t DrvGPIO_GetBit(E_DRVGPIO_PORT port, int32_t i32Bit)
- 參數：Port: E_DRVGPIO_PORT, specify GPIO port. It could be E_GPA(+0), E_GPB(+0x40), E_GPC(+0x80), E_GPD(+0xC0) and E_GPE(+0x100).
- 參數： i32Bit: Specify pin of the GPIO port. It could be 0~15.
- 範例：DrvGPIO_GetBit(E_GPB, 15)　　//get GPIOB bit15
- 　　與下列指令的作用相同
- 　　GPIOB->PIN & (1<<15) //get GPIOB bit15

DrvGPIO_EnableDebounce

- 功能：Enable the debounce function。
- 函數：int32_t DrvGPIO_EnableDebounce(E_DRVGPIO_PORT port, int32_t i32Bit)
- 參數：Port: specify GPIO port. It could be E_GPA(+0), E_GPB(+0x40), E_GPC(+0x80), E_GPD(+0xC0) and E_GPE(+0x100).
- 參數： i32Bit: Specify pin of the GPIO port. It could be 0~15.
- 範例：DrvGPIO_EnableDebounce(E_GPB, 15);
- 如同指令：
- GPIOB->DBEN |= (1<<15); //DBEN[15]=1, de-bounce enabled
- GPIO_DBNCECON->DBNCECON.ICLK_ON=1; //Interrupt clock On mode

DrvGPIO_SetDebounceTime

- 功能：Set the interrupt debounce sampling time。
- 函數：int32_t DrvGPIO_SetDebounceTime(uint32_t u32CycleSelection, E_DRVGPIO_DBCLKSRC ClockSource)
- 參數： u32CycleSelection : The number of sampling cycle selection,0-15.
- 參數： ClockSource : E_DBCLKSRC_HCLK or E_DBCLKSRC_10K.
- 範例：DrvGPIO_SetDebounceTime(4,E_DBCLKSRC_10K);
- 如同指令：
- //debounce time=16/10K=16*0.1ms=1.6ms
- GPIO_DBNCECON->DBNCECON.DBCLKSEL = 4;
- //sample once per 2^4=16 clocks
- GPIO_DBNCECON->DBNCECON.DBCLKSRC = 1; //10KHz

使用EINT1中斷的初始設定

- 1.設定中斷允許：下降邊緣,低電位或上升邊緣,高電位
- GPIOB->IEN |= (1<<15)　　//fall edge, low level
- GPIOB->IEN |= (1<<(15+16))　//rise edge, high level
- 2.設定觸發模式：
- GPIOB->IMD &= ~(1<<15);　　//=0, edge trigger
- GPIOB->IMD |= (1<<15);　　//=1, level trigger
- 3.設定EINT1優先權
- NVIC->IPR[0] = (2ul<<30);　　//11=最高, 00=最低
- 4.設定IRQ4中斷允許
- NVIC->ISER[0]=(1<<3);
- 上述步驟，可以用函數直接設定：
- DrvGPIO_EnableEINT1(E_IO_FALLING, E_MODE_EDGE, EINT1Callback); //下降邊緣，邊緣觸發，中斷處理程式 EINT1Callback

DrvGPIO_EnableEINT1()

功能： Enable the interrupt function for EINT1。
函數： void DrvGPIO_EnableEINT1(E_DRVGPIO_INT_TYPE TriggerType, E_DRVGPIO_INT_MODE Mode, GPIO_EINT1_CALLBACK pfEINT1Callback)
參數：TriggerType: interrupt trigger type(E_IO_RISING, E_IO_FALLING or E_IO_BOTH_EDGE).
參數： Mode: interrupt mode (E_MODE_EDGE or E_MODE_LEVEL).
參數： pfEINT1Callback : pfEINT1Callback (function pointer of the external INT1 callback function).
範例：DrvGPIO_EnableEINT1(E_IO_FALLING, E_MODE_EDGE, EINT1Callback);
說明：當SW INT按下時，原來程式中斷，此時GPIOB_ISRC=0x8000，IRQ3_SRC=1，MCU_IRQ=0x8，執行EINT1_IRQHandler (DRVGPIO.c)。先清除GPIOB_ISRC[15]=0，則IRQ3_SRC=0，MCU_IRQ=0x0，再呼叫函數pfEINT1Callback。

EINT1的中斷服務程式

- 在DrvGPIO.c有提供中斷服務程式
- void EINT1_IRQHandler(void)
- {
- /* EINT0 = GPB15. Clear the interrupt flag */
- GPIOB->ISRC = 1UL << 15; //清除Interrupt Source Flag
- if (_pfEINT1Callback) //如果有設定callback函數
- _pfEINT1Callback(); //呼叫callback函數
- }

- callback函數必須撰寫中斷的處理程式
- void EINT1Callback(void)
- {
- ….
- }

7.2Test_SWInt_RGBled (1/x)

```
int main (void)
{       uint32_t freq;
        // Initial LED
        // Initial GPIO GPA12(blue LED) to output mode
        DrvGPIO_Open(E_GPA, 12, E_IO_OUTPUT);

        // Initial GPIO GPA13(green LED) to output mode
        DrvGPIO_Open(E_GPA, 13, E_IO_OUTPUT);

        // Initial GPIO GPA14(red LED) to output mode
        DrvGPIO_Open(E_GPA, 14, E_IO_OUTPUT);
```

7.2Test_SWInt_RGBled (2/x)

```
// Initial SW EINT1
// Initial GPIO GPB15(SW Int) to input mode
DrvGPIO_Open(E_GPB, 15, E_IO_INPUT);
//Enable the debounce function
DrvGPIO_EnableDebounce(E_GPB, 15);
//Set the interrupt debounce sampling time & clock source
//The target debounce time is (2^4)*(1/(10k)) s = 16*0.1 ms
DrvGPIO_SetDebounceTime(4,E_DBCLKSRC_10K);
// Configure external interrupt
  DrvGPIO_EnableEINT1(E_IO_FALLING,
E_MODE_EDGE, EINT1Callback);
```

7.2Test_SWInt_RGBled (3/x)

```
        // Initial 12M and Timer 0
        Init12M();
        freq=4;             //T=1/4=0.25s
        InitTIMER0(freq);
        // Main loop
        while (1)
        {
        }
}
```

7.2Test_SWInt_RGBled (4/x)

```
void EINT1Callback(void)
{
        // turn off lighted LED
         DrvGPIO_SetBit(E_GPA,led_n);

        // next LED
        led_n++;
        if(led_n > 14)led_n=12;

        // turn on next LED
        DrvGPIO_ClrBit(E_GPA,led_n);
}
```

7.2Test_SWInt_RGBled (5/x)

```
void TMR_Callback(void) // Timer0 interrupt subroutine
{
        //xor 0: unchange; xor 1: 0->1, 1->0
        GPIOA->DOUT ^= (1<<LedLighted);

}
```

7.2Test_SWInt_RGBled (6/x)

```
void InitTIMER0(uint32_t freq)
{
        // Select TIMER0 clock source
        // 0=extgernal, 1=32k,2=hclk,7=22M
        DrvSYS_SelectIPClockSource (E_SYS_TMR0_CLKSRC,0);

        // Enable TIMER0 engine clock
        DrvSYS_SetIPClock (E_SYS_TMR0_CLK, 1);

        // User must to call this function before any timer operations.
        DrvTIMER_Init ();
```

7.2Test_SWInt_RGBled (7/x)

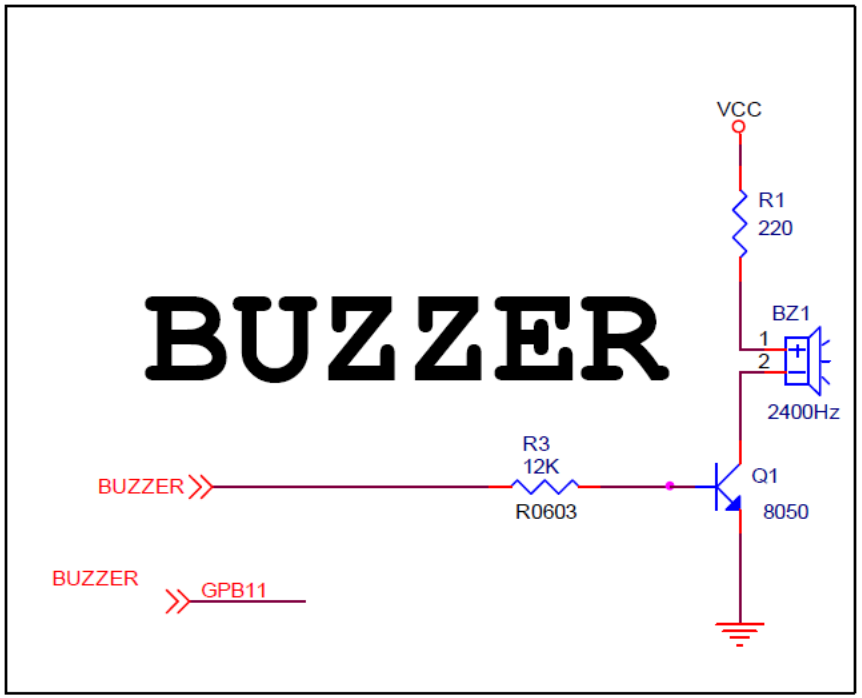
```
    // Open the specified timer channel with specified operation mode.
    DrvTIMER_Open (E_TMR0, freq, E_PERIODIC_MODE);

    // enable the specified timer interrupt.
    DrvTIMER_EnableInt (E_TMR0);

    // Install the interrupt callback function
    DrvTIMER_SetTimerEvent (E_TMR0, 1,
(TIMER_CALLBACK) TMR_Callback, 0);

    // Start to count the specified timer channel.
    DrvTIMER_Start (E_TMR0);
}
```

7.2Test_SWInt_RGBled (8/x)

```
// Initial external 12M
void Init12M(void)
{
        UNLOCKREG();
        //1: enable, 0: disable
        DrvSYS_SetOscCtrl(E_SYS_XTL12M,1);
        //SYSCLK->PWRCON.XTL12M_EN = 1;
        LOCKREG();
}
```

7.3Test_SWInt_Buzzer–

- BUZZER : GPB11
  - **GPB11** : 0 = on, 1 = off
- R1電阻太大，聲音太小聽不到。將R1短路，可聽到聲音。
- SW Int : GPB15
  - **GPB15**: 0=pressed, 1= not pressed



寫一程式，當按鍵按下時，蜂鳴器發出間斷(0.25秒on，0.25秒off)聲音。鬆開則沒有聲音。

GPIO pin GPB11=0 turn on BUZZER

GPIO pin GPB11=1 turn off BUZZER

7.3Test_TIMER_SWInt_Buzzer (1/x)

```
int main (void)
{
        uint32_t freq;
        // Initial SW EINT1
        // initial GPIO pin GPB15 (SW int ) to input mode
        DrvGPIO_Open(E_GPB, 15, E_IO_INPUT);
        // Initial buzzer
        // initial GPIO pin GPB11 for controlling Buzzer to output mode
        DrvGPIO_Open(E_GPB, 11, E_IO_OUTPUT);
        // Initial Timer
        Init12M();
        freq=4;
        InitTimer0(freq);
```

7.3Test_TIMER_SWInt_Buzzer (2/x)

```
// Main loop
while (1)
{

}
```

7.3Test_TIMER_SWInt_Buzzer (3/x)

```
void InitTimer0(uint32_t freq)
{
        // Select TIMER0 clock source
        // 0=extgernal, 1=32k,2=hclk,7=22M
        DrvSYS_SelectIPClockSource (E_SYS_TMR0_CLKSRC, 0);

        // Enable TIMER0 engine clock
        DrvSYS_SetIPClock (E_SYS_TMR0_CLK, 1);

        // User must to call this function before any timer operations.
        DrvTIMER_Init ();
```

7.3Test_TIMER_SWInt_Buzzer (4/x)

```
    // Open the specified timer channel with operation mode.
    DrvTIMER_Open (E_TMR0, freq, E_PERIODIC_MODE);

    // enable the specified timer interrupt.
    DrvTIMER_EnableInt (E_TMR0);

    // Install the interrupt callback function
    DrvTIMER_SetTimerEvent (E_TMR0, 1,
(TIMER_CALLBACK) TMR_Callback, 0);

    // Start to count the specified timer channel.
    DrvTIMER_Start (E_TMR0);
}
```

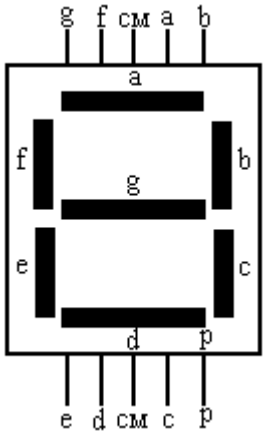
7.3Test_TIMER_SWInt_Buzzer (5/x)

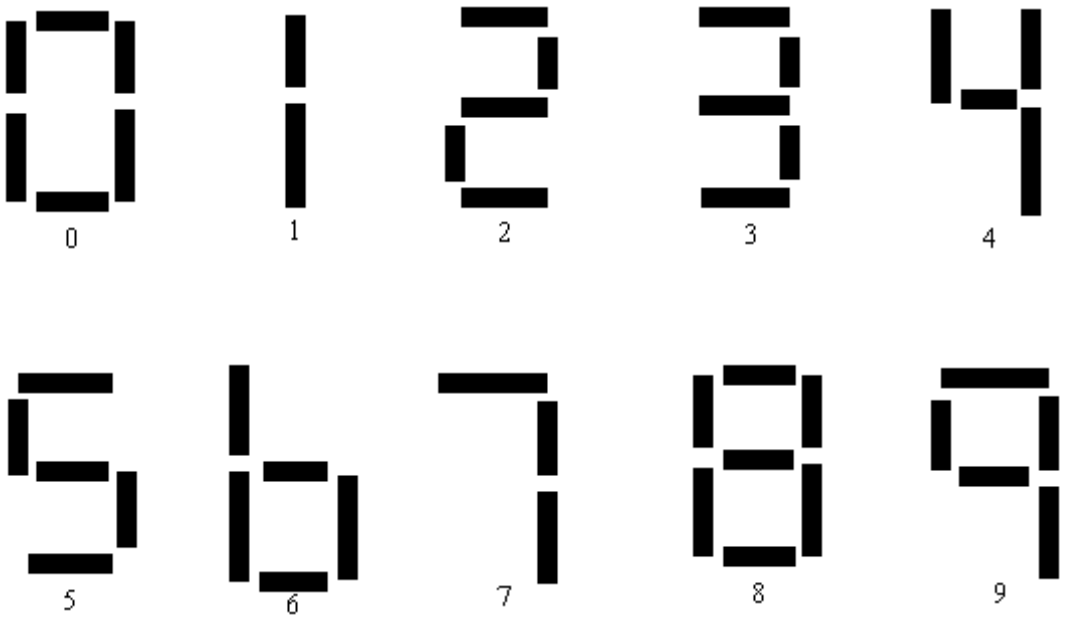
```
void TMR_Callback(void) // Timer0 interrupt subroutine
{
    //change GPIOB[11] output state
    //xor 0: unchange; xor 1: 0->1, 1->0
     if(DrvGPIO_GetBit(E_GPB,15))
        DrvGPIO_SetBit(E_GPB,15); //buzzer off
    else
        GPIOB->DOUT ^= (0x1<<11); //buzzer change state (on/off)
}
```

7.3Test_TIMER_SWInt_Buzzer (6/x)

```
// Initial external 12M
void Init12M(void)
{
        UNLOCKREG();
        //1: enable, 0: disable
        DrvSYS_SetOscCtrl(E_SYS_XTL12M,1);
        //SYSCLK->PWRCON.XTL12M_EN = 1;
        LOCKREG();
}
```

7.4Test_7seg–七段顯示器





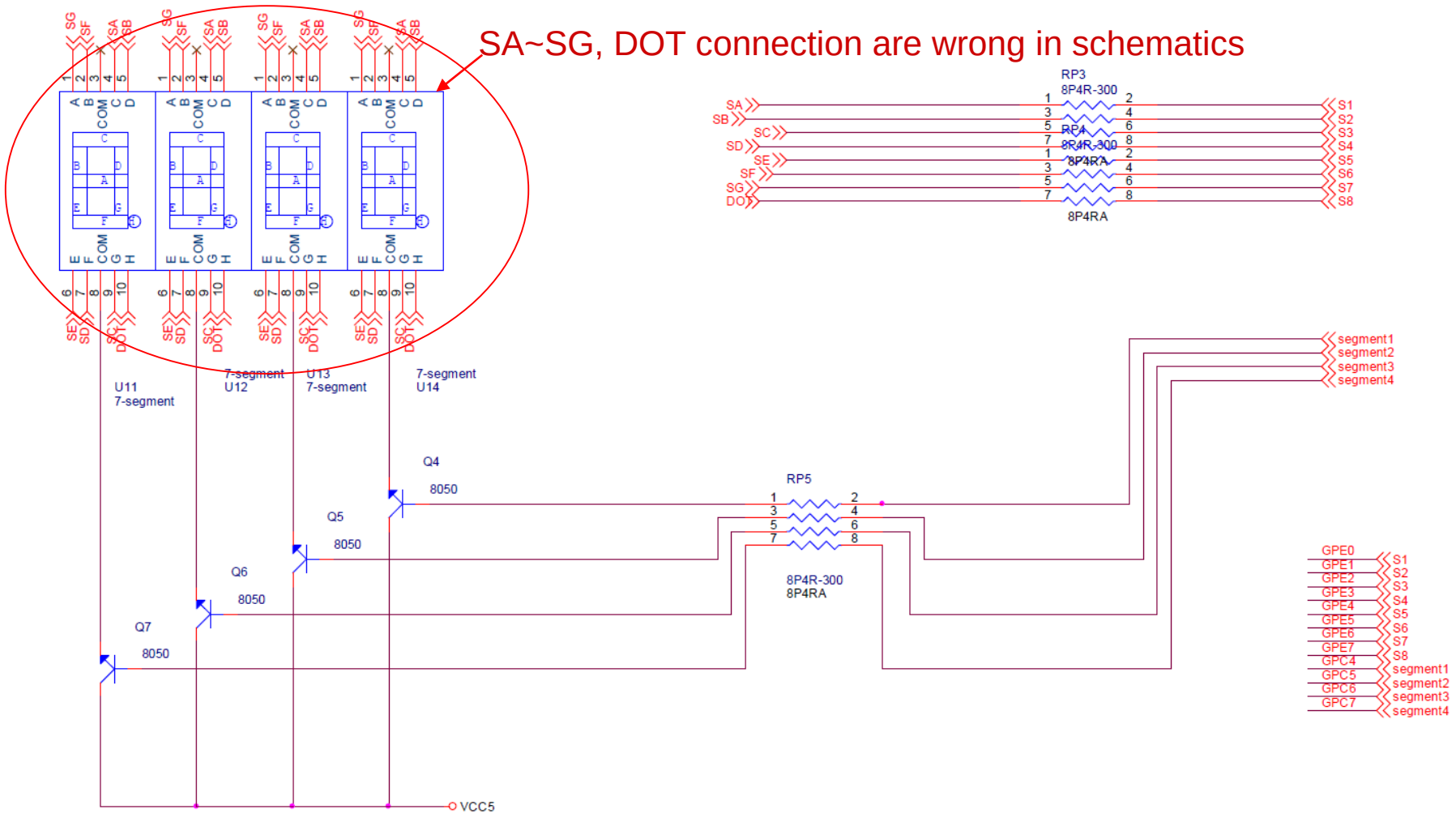
每個7段顯示器有8個LED，分別標示為a,b,c,d,e,f,g,p。

如果將a,b,c,d,e,f,g,p分別對應到GPIO的bit 0,1,2,3,4,5,6,7，則可由GPIO控制LED的明暗。

共陽極7段顯示器由低電位控制，共陰極7段顯示器由高電位控制。

顯示0000-9999，間隔0.5秒。

7.4Test_7seg– 7 段顯示器線路圖

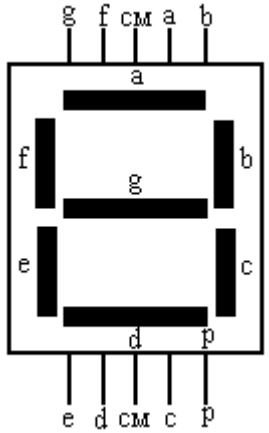


7.4Test_7seg– Control Pins used for

GPC4~7 control which 7-segment to turn on (1 = on, 0 = off)

- GPC4 : 1st 7-segment (LSB)
- GPC5 : 2nd 7-segment
- GPC6 : 3th 7-segment
- GPC7 : 4th 7-segment (MSB)

GPE0~7 control each segment to turn on (0 = on, 1 = off)



	g	**e**	**d**	**b**	**a**	**f**	**dp**	**c**	
	7	6	5	4	3	2	1	0	
0	1	0	0	0	0	0	1	0	0x82
1	1	1	1	0	1	1	1	0	0xEE
2	0	0	0	0	0	1	1	1	0x07
3	0	1	0	0	0	1	1	0	0x46
4	0	1	1	0	1	0	1	0	0x6A
5	0	1	0	1	0	0	1	0	0x52

7-Segment LED Driver

NUC100SeriesBSP/NuvotonPlatform_Keil/Src/NUC1xx-LB002/Seven_Segment.c

- #define SEG_N0 0x82 // define segment led on/off for digit 0
- #define SEG_N1 0xEE // define segment led on/off for digit1
- #define SEG_N2 0x07
- #define SEG_N3 0x46
- #define SEG_N4 0x6A
- #define SEG_N5 0x52
- #define SEG_N6 0x12
- #define SEG_N7 0xE6
- #define SEG_N8 0x02
- #define SEG_N9 0x62
- // array of segment led on/off value for digit 0~9
- unsigned char SEG_BUF[10]={SEG_N0, SEG_N1, SEG_N2, SEG_N3, SEG_N4, SEG_N5, SEG_N6, SEG_N7, SEG_N8, SEG_N9};

7-Segment LED Driver - show_seven_segment

- 功能：將number顯示在第no個7段顯示器
- 函數： void show_seven_segment(unsigned char no, unsigned char number)
- 參數： no:第no個7段顯示器，(0-3)
- 參數：number: 顯示的數字，(0-9)
- 範例：show_seven_segment(3,digit)
- 與下列指令的作用相同
- GPIOE->DOUT &= ~(0xFF); //clear 7 seg., GPIOE bit0-7
- GPIOE->DOUT |= SEG_BUF[digit[3]];//show 7 seg.,
- GPIOC->DOUT |= (1<<(3+4)); //display 4th 7 seg.,GPIOC bit 7=1

7-Segment LED Driver - close_seven_segment

- 功能：關閉7段顯示器。
- 函數：void close_seven_segment(void)
- 參數：
- 範例： close_seven_segment();
- 與下列指令的作用相同
- GPIOC->DOUT &= ~(0xF<<4);

7.4Test_7seg– main() (1/x)

```
int32_t main (void)
{
    seven_segment_open();          // Initial 7-seg.
    Init12M();                     // initial external 12M
    tm0freq=1000;                  //T=1/1000=1ms
    InitTimer0(tm0freq);           // Initial TIMER 0
// Display 0000-9999
    show_period=500;    //LED light time = 500ms
    show_number=show_period*tm0freq/1000;   // 500ms/1ms=500
    show_number_ith=show_number;      // the ith
    light_7seg=3;                     // the ith lighted LED
    count_number=0;                   // count 0000-9999
    while(1);
}
```

7.4Test_7seg (2/x)

```
void seven_segment_open(void)
{
    //Initial GPIOE [7:0] to output mode for 7-seg.
    DrvGPIO_Open(E_GPE, 0, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 1, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 2, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 3, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 4, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 5, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 6, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 7, E_IO_OUTPUT);
```

7.4Test_7seg (3/x)

```
    //Initial GPIOC [7:4] to output mode for nth 7-seg.
    DrvGPIO_Open(E_GPC, 4, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 5, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 6, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 7, E_IO_OUTPUT);
}
```

7.4Test_7seg– seven_segment_open() (4/x)

```
void TMR_Callback(void) // Timer0 interrupt subroutine
{
    uint32_t value;
    // count_number=0000-9999
    if(!show_number_ith--)
    {
        show_number_ith=show_number; //reset show_number

        if(count_number++ == 9999)count_number=0;
        // seperate number to single digit
        seg_data(count_number);
    }

    // change lighted LED
    seg_display();
}
```

7.4Test_7seg (5/x)

```
// seperate number to single digit
void seg_data(int16_t value)
{
        digit_7seg[3] = value / 1000;
        value = value - digit_7seg[3] * 1000;
        digit_7seg[2] = value / 100;
        value = value - digit_7seg[2] * 100;
        digit_7seg[1] = value / 10;
        value = value - digit_7seg[1] * 10;
        digit_7seg[0] = value; //4 states
}
```

7.4Test_7seg (6/x)

```
// display digit on 7-seg.
void seg_display(void)
{
    close_seven_segment(); //clear GPIOC bit4-7
   //GPIOC->DOUT &= ~(0xF<<4);//clear GPIOC[7:4] bit4-7

    show_seven_segment(light_7seg,digit_7seg[light_7seg]);
    //GPIOE->DOUT &= ~(0xFF);          //clear 7 seg., GPIOE[7:0]=0
    //GPIOE->DOUT |= SEG_BUF[digit[3]];//show 7 seg.,GPIOE[7:0]=
    //GPIOC->DOUT |= (1<<(3+4));   //display 4th 7 seg.,GPIOC[7]=1

    if(!light_7seg--)light_7seg=3;
}
```

7.4Test_7seg– TMR0_IRQHandler() (7/x)

```
void InitTIMER0(uint32_t freq)
{
        // Select TIMER0 clock source
        // 0=extgernal, 1=32k,2=hclk,7=22M
        DrvSYS_SelectIPClockSource (E_SYS_TMR0_CLKSRC, 0);

        // Enable TIMER0 engine clock
        DrvSYS_SetIPClock (E_SYS_TMR0_CLK, 1);

        // User must to call this function before any timer operations.
        DrvTIMER_Init ();
```

7.4Test_7seg (8/x)

```
        // Open the specified timer channel with operation mode.
        DrvTIMER_Open (E_TMR0, freq, E_PERIODIC_MODE);

        // enable the specified timer interrupt.
        DrvTIMER_EnableInt (E_TMR0);

        // Install the interrupt callback function
        DrvTIMER_SetTimerEvent (E_TMR0, 1,
(TIMER_CALLBACK) TMR_Callback, 0);

        // Start to count the specified timer channel.
        DrvTIMER_Start (E_TMR0);
}
```

7.4Test_7seg (9/x)

```
// Initial external 12M
void Init12M(void)
{
        UNLOCKREG();
        //1: enable, 0: disable
        DrvSYS_SetOscCtrl(E_SYS_XTL12M,1);
        //SYSCLK->PWRCON.XTL12M_EN = 1;
        LOCKREG();
}
```

7.5Test_7seg_Keypad–學習板電路圖

Control Pins used for 3x3 Keypad

Column control : GPA2, 1, 0

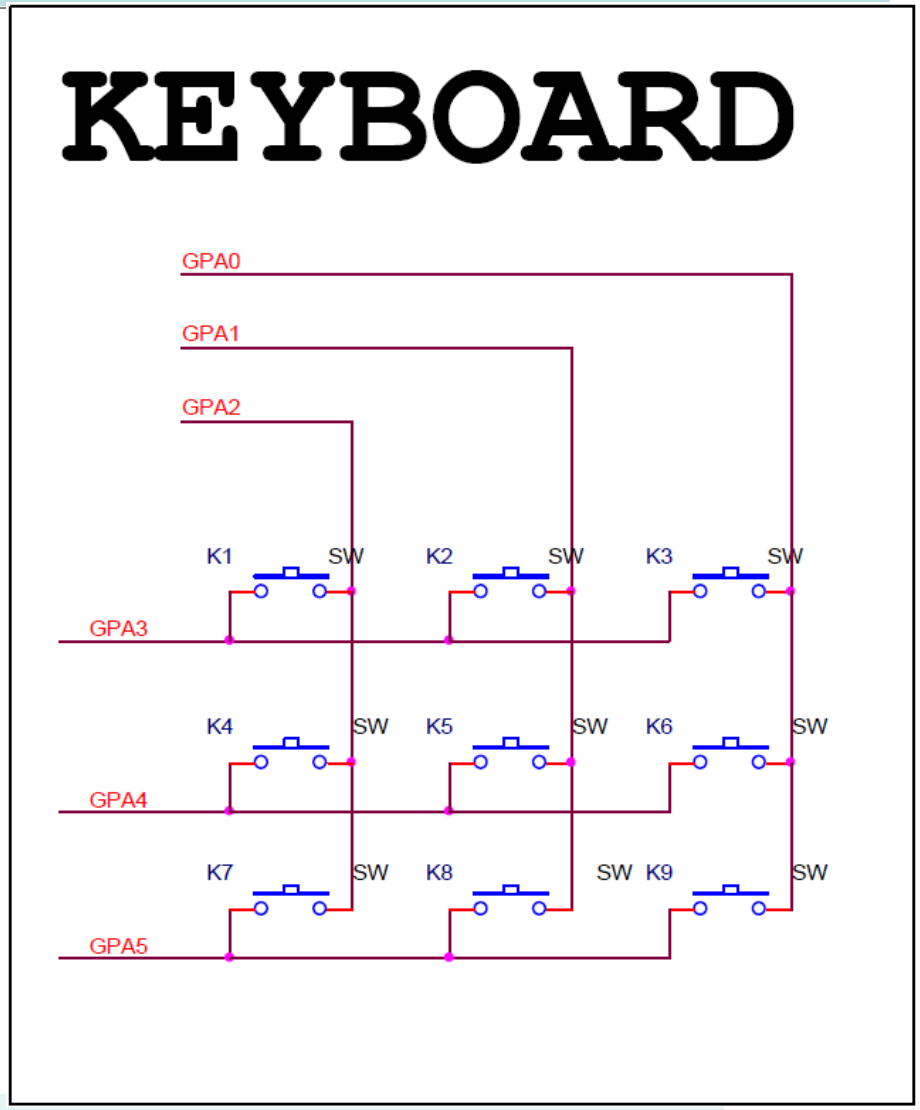
Raw control : GPA 3, 4, 5

- Key1 = GPA3 + GPA2
- Key2 = GPA3 + GPA1
- Key3 = GPA3 + GPA0
- Key4 = GPA4 + GPA2
- Key5 = GPA4 + GPA1
- Key6 = GPA4 + GPA0
- Key7 = GPA5 + GPA2
- Key8 = GPA5 + GPA1
- Key9 = GPA5 + GPA0

寫一程式，當按鍵按下時，顯示最後出現的4個數字。

GPA[2:0]依序輸出低電位(011, 101, 110)供按鍵讀取

GPA[5:3]讀取低電位



7.5Test_7seg_Keypad–學習板電路圖

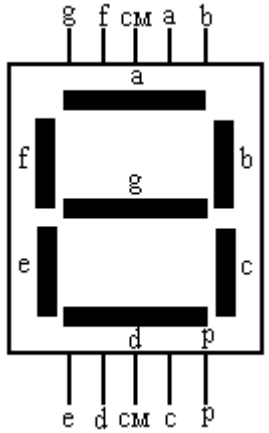
- 鍵盤按下時輸入信號為0，鬆開時輸入信號為1
- 通常按下或鬆開時間都會大於40ms，彈跳時間在10ms以內就會結束
- 若每5ms紀錄一次按鍵的狀態，當有按鍵完成時(按下_鬆開)，會出現00xx11的狀態，xx為彈跳期間。
- 程式設計1：
- 1.timer每5ms中斷一次，
- 2.檢查keypad是否有按鍵。若有按鍵，記錄按鍵的數字，和其狀態為0；否則紀錄狀態1。
- 3.檢查累積的狀態是否=00xx11。是：紀錄對應的數字，reset鍵盤狀態。
- 4.顯示下一個7seg.的數字
- 缺點：按鍵鬆開才能判斷一個數字。

7.5Test_7seg_Keypad– 7-seg. Control Pins

GPC4~7 control which 7-segment to turn on (1 = on, 0 = off)

- GPC4 : 1st 7-segment (LSB)
- GPC5 : 2nd 7-segment
- GPC6 : 3th 7-segment
- GPC7 : 4th 7-segment (MSB)

GPE0~7 control each segment to turn on (0 = on, 1 = off)



	g	**e**	**d**	**b**	**a**	**f**	**dp**	**c**	
	7	6	5	4	3	2	1	0	
0	1	0	0	0	0	0	1	0	0x82
1	1	1	1	0	1	1	1	0	0xEE
2	0	0	0	0	0	1	1	1	0x07
3	0	1	0	0	0	1	1	0	0x46
4	0	1	1	0	1	0	1	0	0x6A
5	0	1	0	1	0	0	1	0	0x52

ScanKeyDriver - OpenKeyPad

- 功能：將ScanKey的控制GPIOA[5:0]設定為雙向
- 函數： void OpenKeyPad(void)
- 範例：OpenKeyPad ()
- 與下列指令的作用相同
- GPIOA->PMDPMD0 = 0x03;
- GPIOA->PMDPMD1 = 0x03;
- GPIOA->PMDPMD2 = 0x03;
- GPIOA->PMDPMD3 = 0x03;
- GPIOA->PMDPMD4 = 0x03;
- GPIOA->PMDPMD5 = 0x03;

myNUC1xx-LB_002.c - KeyPadOpen

- 功能：將ScanKey的控制GPIOA[2:0]設定為輸出，GPIOA[5:3]設定為輸入
- 函數： void KeyPadOpen (void)
- 範例：KeyPadOpen ()
- 與下列指令的作用相同
- GPIOA->PMDPMD0 = 0x01;
- GPIOA->PMDPMD1 = 0x01;
- GPIOA->PMDPMD2 = 0x01;
- GPIOA->PMDPMD3 = 0x00;
- GPIOA->PMDPMD4 = 0x00;
- GPIOA->PMDPMD5 = 0x00;

7-Segment LED Driver - show_seven_segment

- 功能：將number顯示在第no個7段顯示器
- 函數： void show_seven_segment(unsigned char no, unsigned char number)
- 參數： no:第no個7段顯示器，(0-3)
- 參數：number: 顯示的數字，(0-9)
- 範例：show_seven_segment(3,digit)
- 與下列指令的作用相同
- GPIOE->DOUT &= ~(0xFF); //clear 7 seg., GPIOE bit0-7
- GPIOE->DOUT |= SEG_BUF[digit[3]];//show 7 seg.,
- GPIOC->DOUT |= (1<<(3+4)); //display 4th 7 seg.,GPIOC bit 7=1

7-Segment LED Driver - close_seven_segment

- 功能：關閉7段顯示器。
- 函數：void close_seven_segment(void)
- 參數：
- 範例： close_seven_segment();
- 與下列指令的作用相同
- GPIOC->DOUT &= ~(0xF<<4);

7.5Test_7seg_Keypad– (1/x)

```
#include "NUC1xx.h"
#include "Driver\DrvSYS.h"
#include "Driver\DrvGPIO.h"
#include "Driver\DrvTIMER.h"
#include "Seven_Segment.h"
#include "scankey.h"

    uint32_t tm0freq; //T=1/250=4ms
    uint8_t light_7seg_ith;
    uint8_t digit_7seg[4];

    uint8_t keynumber=0;
    uint8_t keypress=0;
    uint8_t keyrepeat=0xFF;
```

7.5Test_7seg_Keypad– (2/x)

```
int32_t main (void)
{
    //Initial GPIOC [7:4] to output mode
    seven_segment_open();   //set GPIOC_PMD[7:4]
    close_seven_segment();   //tuen off 7-seg. GPIOC[7:4]
    //Initial GPIOA [5:0]=11,QUASI mode
    OpenKeyPad();
    Init12M();
    tm0freq=250;            // frequency=250,4ms
    InitTimer0(tm0freq); // Initial Timer
    // main loop
    light_7seg_ith=3;
    while(1);
}
```

7.5 Timer 0 interrupt routine (3/x)

```
void seven_segment_open(void)
{   //Initial GPIOE [7:0] to output mode for 7-seg.
    DrvGPIO_Open(E_GPE, 0, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 1, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 2, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 3, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 4, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 5, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 6, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPE, 7, E_IO_OUTPUT);

    //Initial GPIOC [7:4] to output mode for nth 7-seg.
    DrvGPIO_Open(E_GPC, 4, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 5, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 6, E_IO_OUTPUT);
    DrvGPIO_Open(E_GPC, 7, E_IO_OUTPUT);
}
```

7.5 Timer 0 interrupt routine (4/x)

```
// Initial external 12M
void Init12M(void)
{
        UNLOCKREG();
        //1: enable, 0: disable
        DrvSYS_SetOscCtrl(E_SYS_XTL12M,1);
        //SYSCLK->PWRCON.XTL12M_EN = 1;
        LOCKREG();
}
```

7.5 Timer 0 interrupt routine (5/x)

```
void InitTimer0(uint32_t freq)
{
        // Select TIMER0 clock source
        // 0=extgernal, 1=32k,2=hclk,7=22M
        DrvSYS_SelectIPClockSource (E_SYS_TMR0_CLKSRC, 0);

        // Enable TIMER0 engine clock
        DrvSYS_SetIPClock (E_SYS_TMR0_CLK, 1);

        // User must to call this function before any timer operations.
        DrvTIMER_Init ();
```

7.5 Timer 0 interrupt routine (6/x)

```
    // Open the specified timer channel with operation mode.
    DrvTIMER_Open (E_TMR0, freq, E_PERIODIC_MODE);

    // enable the specified timer interrupt.
    DrvTIMER_EnableInt (E_TMR0);

    // Install the interrupt callback function
    DrvTIMER_SetTimerEvent (E_TMR0, 1,
(TIMER_CALLBACK) TMR_Callback, 0);

    // Start to count the specified timer channel.
    DrvTIMER_Start (E_TMR0);
}
```

7.5Test_7seg_Keypad– (7/x)

```
void TMR_Callback(void) // Timer0 interrupt subroutine
{
    //286clock,12.9us(22M),23.8us(12M)
    Scankeypad();

    //30clock,1.36us(22M),2.5us(12M)
    seg_keypad();
    //813clock,36.8us(22M),67.8us(12M)
    seg_display();
    while(keybufferptr)keybufferptr--;
}
```

RTC05： Test_RTC 8/x

```
void Scankeypad(void)
{
        int8_t irow,keyno=0;
        for (irow=1; irow <4; irow++)
        {
                GPIOA->DOUT |= (0x7);          //xxxx-x111
                GPIOA->DOUT &= ~(1<<(3-irow));  //011, 101, 110
                //scan row1 GPIOA[3] for 1,2,3
                if((GPIOA->PIN & (0x1<<3)) == 0)keyno = irow;
                //scan row2 GPIOA[4] for 4,5,6
                if((GPIOA->PIN & (0x1<<4)) == 0)keyno = irow+3;
                //scan row3 GPIOA[5] for 7,8,9
                if((GPIOA->PIN & (0x1<<5)) == 0)keyno = irow+6;
        }
```

RTC05： Test_RTC 9/x

```
//record key status
if (keyno)
{    // key pressed
     if (keyno == keynumber )                    // same key
          keystatus = (keystatus<<1 );           // record key status=0
     else //different key
          {
               keystatus = 0xFE;// initial key status=HHHHHHHL
               keynumber=keyno;// record key number
          }
}
else  // key not pressed
{     keystatus = (keystatus<<1 | 1 );// record key status=1
}
```

RTC05： Test_RTC 10/x

```
// if keystatus = LLxxHH, the key is pressed and released
        if( (keystatus & 0x33) == 0x3)
        {
                keybuffer[keybufferptr++]=keynumber;
                keystatus = 0xFF; //reset key status=HHHHHHHH
                keynumber=0;      //reset key number
                keypress=0;       //key released
        }
}
```

RTC05： Test_RTC 11/x

```
void seg_keypad(void)
{
        uint8_t irow;
        //: store keypad number to 7-seg
        if(keybufferptr)
        {
                for (irow=3; irow >0; irow--)
                        digit_7seg[irow]=digit_7seg[irow-1];
                digit_7seg[0]=keybuffer[0];
        }
}
```

RTC05： Test_RTC 12/x

```
void seg_display(void)
{
        close_seven_segment(); //clear GPIOC bit4-7
        //GPIOC->DOUT &= ~(0xF<<4);//clear GPIOC[7:4] bit4-7
        show_seven_segment(light_7seg,digit[light_7seg]);
        //GPIOE->DOUT &= ~(0xFF);  //clear 7 seg.,
        //GPIOE->DOUT |= SEG_BUF[digit[3]];//show 7 seg.,
        //GPIOC->DOUT |= (1<<(3+4));//display 4th 7 seg.
        if(!light_7seg--)light_7seg=3;
}
```

7.6Test_7seg_Keypad–學習板電路圖

Control Pins used for 3x3 Keypad

Column control : GPA2, 1, 0

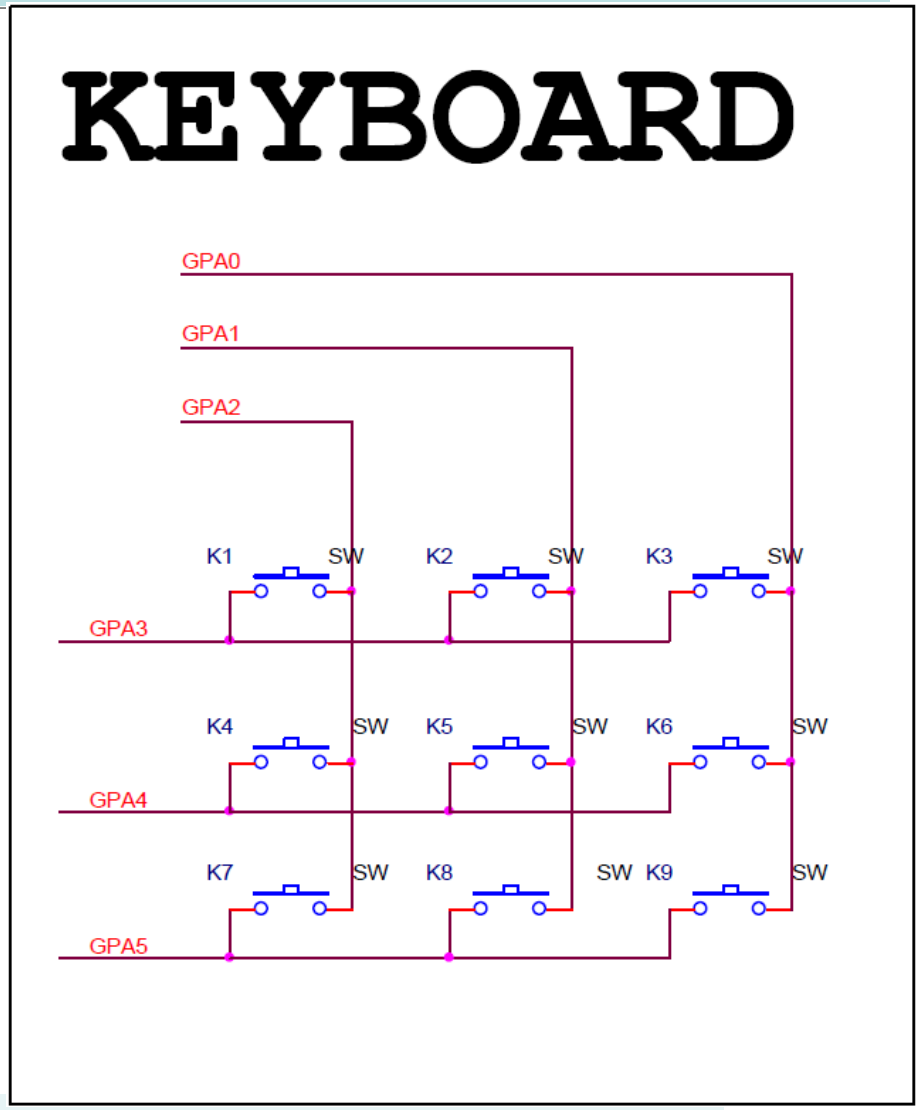
Raw control : GPA 3, 4, 5

- Key1 = GPA3 + GPA2
- Key2 = GPA3 + GPA1
- Key3 = GPA3 + GPA0
- Key4 = GPA4 + GPA2
- Key5 = GPA4 + GPA1
- Key6 = GPA4 + GPA0
- Key7 = GPA5 + GPA2
- Key8 = GPA5 + GPA1
- Key9 = GPA5 + GPA0

寫一程式，當按鍵按下時，顯示最後出現的4個數字。

GPA[2:0]依序輸出低電位(011, 101, 110)供按鍵讀取

GPA[5:3]讀取低電位



7.6Test_7seg_Keypad

- 鍵盤按下時輸入信號為0，鬆開時輸入信號為1
- 通常按下或鬆開時間都會大於40ms，彈跳時間在10ms以內就會結束
- 若每5ms紀錄一次按鍵的狀態，當有按鍵完成時(按下_鬆開)，若出現0000表示按鍵已經按下，出現11表示按鍵鬆開。
- 程式設計2：
- 1.timer每5ms中斷一次，
- 2.檢查keypad是否有按鍵。若有按鍵，記錄按鍵的數字，和其狀態為0；否則紀錄狀態1。
- 3.檢查按鍵狀態。若按鍵未按下(狀態=0)且累積的狀態=0000，則按鍵按下(紀錄對應的數字，按鍵狀態=1)。若按鍵已按下(狀態=1)且累積的狀態=11，則按鍵鬆開(按鍵狀態=0)。
- 4.顯示下一個7seg.的數字

7.6Test_7seg_Keypad 1/x

```
void Scankeypad(void)
{
        int8_t irow,keyno=0;
        for (irow=1; irow <4; irow++)
        {
                GPIOA->DOUT |= (0x7);          //xxxx-x111
                GPIOA->DOUT &= ~(1<<(3-irow));  //011, 101, 110
                //scan row1 GPIOA[3] for 1,2,3
                if((GPIOA->PIN & (0x1<<3)) == 0)keyno = irow;
                //scan row2 GPIOA[4] for 4,5,6
                if((GPIOA->PIN & (0x1<<4)) == 0)keyno = irow+3;
                //scan row3 GPIOA[5] for 7,8,9
                if((GPIOA->PIN & (0x1<<5)) == 0)keyno = irow+6;
        }
```

7.6Test_7seg_Keypad 2/x

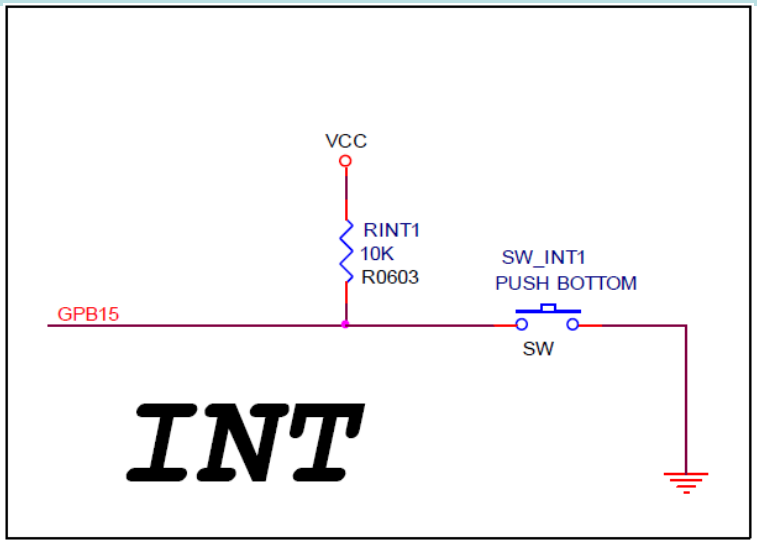
```
//record key status
if (keyno)
{    // key pressed
     if (keyno == keynumber )                    // same key
          keystatus = (keystatus<<1 );           // record key status=0
     else //different key
          {
               keystatus = 0xFE;// initial key status=HHHHHHHL
               keynumber=keyno;// record key number
          }
}
else  // key not pressed
{     keystatus = (keystatus<<1 | 1 );// record key status=1
}
```

7.6Test_7seg_Keypad 3/x

```
// if get 4 continuous low level, the key is pressed.
                    if( !keypress && !(keystatus & 0x0F) )
                    {
                            keypress=1;
                            keybuffer[keybufferptr++]=keynumber;
                    }
// check key released
                    if(keypress && ((keystatus & 0x3)==3) )
                    {
                            keystatus = 0xFF; //reset key status
                            keynumber=0;      //reset key number
                            keypress=0;       //key released
                    }
}
```

7.7Test_7seg_SWInt_Bounce–計算彈跳的接觸時間

- SW Int: GPB15
  - **GPB15**: 0=pressed, 1= not pressed

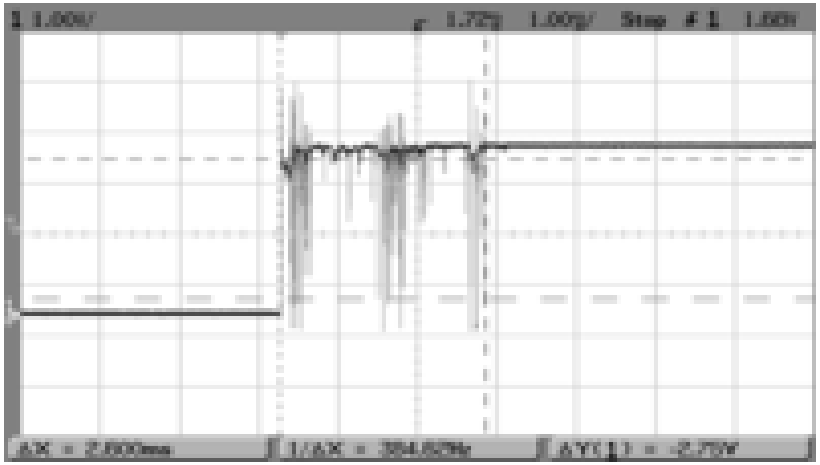


寫一程式，當按鍵按下時，啟動計時器，紀錄一秒內每一次電壓變化的時間點。然後將每一段時間顯示在7段顯示器。

顯示的時間以msec為單位，顯示小數點。

7.7Test_7seg_SWInt_Bounce–計算彈跳的次數

- 接觸彈跳(bounce)是機械開關常見的問題。當開關接觸時，由於動量和彈性造成彈跳。
- 彈跳時間通常在10ms以內。
- 彈跳可以藉由硬體電路消除，或使用軟體處理。



- 鍵盤的掃描頻率是 2.64ms，共掃描 8 次= 2.64ms * 8 = 約 21.12ms，與下次間隔0.88ms，合計22ms。
- 軟體：第一次偵測到低電位，延遲20ms，再檢測一次是否為低電位?若是高電位表示一個雜訊，不予處理。若是低電位，表示一個有效的按鍵。

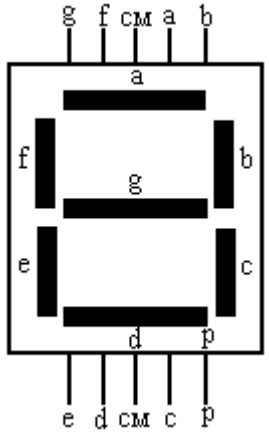
http://www.embedded.com/electronics-blogs/break-points/4024944/The-secret-life-of-switches

Test_7seg_SWInt_Bounce– Control Pins used for

GPC4~7 control which 7-segment to turn on (1 = on, 0 = off)

- GPC4 : 1st 7-segment (LSB)
- GPC5 : 2nd 7-segment
- GPC6 : 3th 7-segment
- GPC7 : 4th 7-segment (MSB)

GPE0~7 control each segment to turn on (0 = on, 1 = off)



	g	e	d	b	a	f	dp	c	
	7	6	5	4	3	2	1	0	
0	1	0	0	0	0	0	1	0	0x82
1	1	1	1	0	1	1	1	0	0xEE
2	0	0	0	0	0	1	1	1	0x07
3	0	1	0	0	0	1	1	0	0x46
4	0	1	1	0	1	0	1	0	0x6A
5	0	1	0	1	0	0	1	0	0x52

7.7Test_7seg_SWInt_Bounce (1/x)

```
int main (void)
{
    int32_t  time_limit,value;

    seven_segment_open(); //743 states
    //GPIOE->PMD.PMD0 = 1; GPIOE[7:0]=output
    //GPIOC->PMD>PMD4 = 1; GPIOC[7-4]=output
    close_seven_segment(); //clear GPIOC[7:0] //151 states

    // Initial GPIO GPB15(SW Int) to input mode
    DrvGPIO_Open(E_GPB, 15, E_IO_INPUT);
    //GPIOB->PMD.PMD15 = 0x00;            //13 states

    while (1)
    {
        value = 0;
```

7.7Test_7seg_SWInt_Bounce (2/x)

```
while (1)
{

    // wait for SW_INT button pressed or time limited
    // get GPIOB bit15 GPIOB->PIN & 0x8000
    time_limit=1500000;
    //while((DrvGPIO_GetBit(E_GPB,15)!=0) && (--time_limit)); //39 states
    while(((GPIOB->PIN & (1<<15))!=0)  && (--time_limit)); //14 states
    //if time limited, the  key did not press
    if(! time_limit) break;
    //the key pressed, imcrease times
    value++;
    //wait for key release
    while((GPIOB->PIN & (1<<15))==0 ); //14 states
}
```

7.7Test_7seg_SWInt_Bounce (3/x)

```
    if(value)
    {       //show bounce times
            show_seven_segment(0,value); //448 states
            // delay
            Delay(5000000); //30013 states
            //turn off 7-seg.
            close_seven_segment(); //clear GPIOC bit4-7 //151 states
    }
  }
}
```

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