Lab 4

In this lab we will simulate and debug code on Teva C kit that has tm4c123 SOC and arm-cortexM4 processor .

The scope is toggling a LED connected to pin3 of PORTF,

We will write Main.c , Startup.c, linker script and make file from scratch

According to specs we found out these information:

- Flash memory starts with address 0x00000000 and has size of 512M.
- Sram memory starts 0x20000000 and has size of 512M.

- SYSCTL is system control module that we will use to enable clock for PORTF has base address of 0x400FE000

- SYSCTL_RCGC2_R has offset address of 0x108 under SYSCTL we will assign this register with value of 0x00000020 to enable clock for PORTF
- GPIO module has base address of 0x40025000 and we will use three registers inside
  First GPIO_PORTF_DIR_R has offset of 0x400 and we will assign value of 1 in pin3 to define this pin as an output
  First GPIO_PORTF_DEN_R has offset of 0x51c and we will assign value of 1 in pin3 to enable this pin

- GPIO_PORTF_DR_R has offset of 0x400 and we will assign

  value of 1 in pin3 and 0 to toggle the output.

Main.c

```c
                    uint32_t pin18:1;
                    uint32_t pin19:1;
                    uint32_t pin20:1;
                    uint32_t pin21:1;
                    uint32_t pin22:1;
                    uint32_t pin23:1;
                    uint32_t pin24:1;
                    uint32_t pin25:1;
                    uint32_t pin26:1;
                    uint32_t pin27:1;
                    uint32_t pin28:1;
                    uint32_t pin29:1;
                    uint32_t pin30:1;
                    uint32_t pin31:1;

                      };

} reg_pin;
volatile reg_pin *SYSCTL_RCGC2_R=(volatile reg_pin*)(SYSCTL_BASE+0x108); // to enable GPIO clock
volatile reg_pin *GPIO_PORTF_DIR_R=(volatile reg_pin*)(GPIOF_BASE+0X400); // to set direction of port input or output
volatile reg_pin *GPIO_PORTF_DEN_R=(volatile reg_pin*)(GPIOF_BASE+0X51C); // to enable pin
volatile reg_pin *PORTF=(volatile reg_pin*)(GPIOF_BASE+0X3FC); // it is called GPIO_PORTF_DATA_R but we simplfy it

int main(void)
{    volatile int i ; // volatile to not be deleted by optimizer
    SYSCTL_RCGC2_R->all_pins=0x20;
    // delay to make sure GPIOF is up and running
    for(i=0;i<200;i++){};
    GPIO_PORTF_DIR_R->pin3=1;
    GPIO_PORTF_DEN_R->pin3=1;

    while(1)
    {    for(i=0;i<50000;i++){};
        PORTF->pin3=1;
        for(i=0;i<50000;i++);
        PORTF->pin3=0;
    }

}
```

Make file :

-we will make some changes on make file : project name and we will copy a .axf file to run on kiel micro vision tool and processor name

```makefile
#@copyright : Mostafa

CC=arm-none-eabi-
CFLAG= -mcpu=cortex-m4 -gdwarf-2 -g
INCS=-I .
LIBS=
SRC = $(wildcard *.c)
OBJ = $(SRC:.c=.o)
AS = $(wildcard *.s)
ASOBJ= $(AS:.s=.o)
Project_name=learn-in-depth_cortex_m4


all:$(Project_name).bin
    @echo "====================Build is Done====================="




%.o: %.c
    $(CC)gcc.exe -c $(CFLAG) $(INCS)  $< -o $@


$(Project_name).elf: $(OBJ) $(ASOBJ)
    $(CC)ld.exe -T linker_script.ld $(LIBS)  $(OBJ) -o $@ -Map=Map_file.map
    cp $(Project_name).elf $(Project_name).axf

$(Project_name).bin: $(Project_name).elf
    $(CC)objcopy.exe -O binary $< $@

clean_all:
    rm *.o *.bin *.elf

clean:
    rm *.bin *.elf
```

Startup.c :

In this lab we will use a new approach by initialize SP in Startup.c

Instead of create it’s symbol in Linker script our scope here to fix SP after 1024 byte of .bss section

We will use an uninitialized array of integers with 256 elements

That the total size of array will be 1024 byte and this is where SP will be at the end of the array.

Then we will make an array of pointers to functions take nothing and return void these pointers will points to each function that will handle it’s relative interrupt according to interrupt vector table .

```c
#include <stdint.h>
extern int main(void);
void Reset_Handler();

void Default_Handler(void)
{
    Reset_Handler();
}


void NMI_Handler ()__attribute__ ((weak,alias("Default_Handler")));;
void H_fault_Handler ()__attribute__ ((weak,alias("Default_Handler")));;

static unsigned long Stack_top[256];


void (* const g_p_fn_vector[]) ()= {
    (void(*)()) ((unsigned long)Stack_top + sizeof(Stack_top)),
     &Reset_Handler,
     &NMI_Handler,
     &H_fault_Handler
};

 extern unsigned int _E_text;
 extern unsigned int _S_DATA;
 extern unsigned int _E_DATA;
 extern unsigned int _S_bss;
 extern unsigned int _E_bss;
void Reset_Handler()
{
    unsigned int DATA_size = (unsigned char*)&_E_DATA - (unsigned char*)&_S_DATA;
    unsigned char* P_scr = (unsigned char*)&_E_text;
    unsigned char* P_dst = (unsigned char*)&_S_DATA;

    for (int i=0;i<DATA_size;i++)
    {
        *((unsigned char*)P_dst++) = *((unsigned char*)P_scr++);
    }

    unsigned int bss_size = (unsigned char*)&_E_bss - (unsigned char*)&_S_bss;
    P_dst= (unsigned char*)&_S_bss;

    for (int i=0; i<bss_size;i++)
    {
        *((unsigned char*)P_dst++) = (unsigned char)0;
    }

    main();

}
```

Linker script :

We will just edit sizes and delete stack top symbol

```
/* linker_scrip
Eng. Mostafa
*/


MEMORY
{
flash(RX) : ORIGIN = 0x00000000, LENGTH = 512M
sram(RWX) : ORIGIN = 0x20000000, LENGTH = 512M
}

SECTIONS
{
    .text : {
            *(.vector*)
            *(.text*)
            *(.redata)
            _E_text = .;
    }> flash

    .data : {
    _S_DATA = . ;
    *(.data*)
    _E_DATA = . ;

    }> sram AT> flash

    .bss : {
    _S_bss = . ;
    *(.bss*)
    _E_bss = . ;
    }>sram
}

```

Map file :

.bss section starts with address of 0x20000010 and ends with 0x20000410 that has been incremented by 0x400 that equivalent to 1024 in decimal

```
.bss            0x20000010      0x400 load address 0x00000140
                0x20000010                _S_bss = .
 *(.bss*)
 .bss           0x20000010        0x0 main.o
 .bss           0x20000010      0x400 startup.o
                0x20000410                . = ALIGN (0x4)
                0x20000410                _E_bss = .
LOAD main.o
```

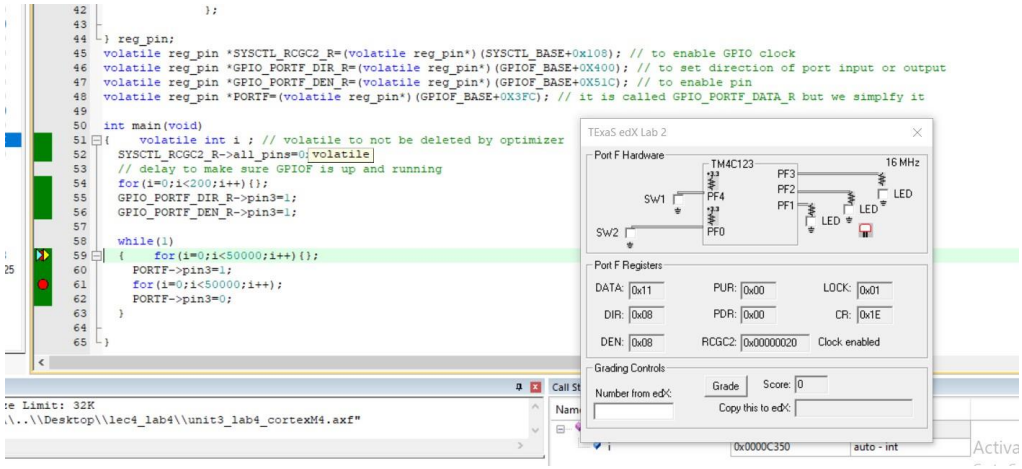
- Flash starts with 0x0000000 and the first section is .vectors section

```
Memory Configuration

Name             Origin             Length             Attributes
flash            0x00000000         0x20000000         xr
sram             0x20000000         0x20000000         xrw
*default*        0x00000000         0xffffffff

Linker script and memory map


.text           0x00000000      0x130
 *(.vectors*)
 .vectors       0x00000000       0x10 startup.o
                0x00000000               g_p_fn_vectors
 *(.text*)
 .text          0x00000010       0x90 main.o
                0x00000010               main
 .text          0x000000a0       0x90 startup.o
                0x000000a0               Reset_Handler
                0x00000124               H_fault_Handler
                0x00000124               Default_handler
                0x00000124               NMI_Handler
 *(.rodata)
                0x00000130               _E_text = .
```

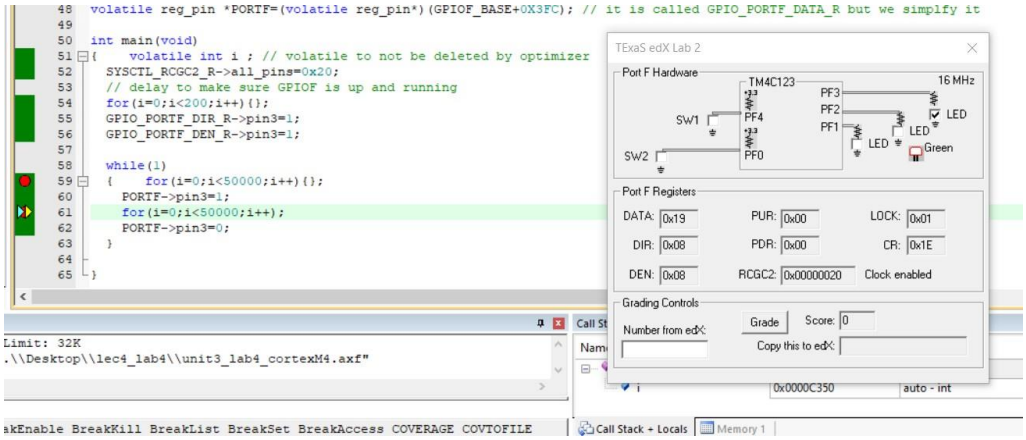
Debugging using kiel Microvision :

Here we show led blinking and the values of register using Texas virtual board

At low level :



At high level :



The value of PORTF data register that changes frequently :