Embedded C_Lesson3_Report

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Makefile_lab1(v1):

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson2_Assignment\Makefile - Notepad++

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app.c | uart.c | uart.h | Makefile.mak | Makefile

```
1  #@copyright : Shaimaa Khattab
2  CC=arm-none-eabi-
3  CFLAGS=-g -mcpu=arm926ej-s
4  INCS=-I .
5  LIBS=
6
7  all: learn-in-depth.bin
8
9      @echo "Build is done"
10
11 startup.o: startup.s
12     $(CC)as.exe $(CFLAGS) startup.s -o startup.o
13 uart.o: uart.c
14     $(CC)gcc.exe -c $(CFLAGS)  $(INCS) uart.c -o uart.o
15 app.o: app.c
16     $(CC)gcc.exe -c  $(CFLAGS) $(INCS)  app.c -o app.o
17 learn-in-depth.elf: startup.o app.o uart.o
18     $(CC)ld.exe -T Linker_Script.ld startup.o app.o uart.o -o learn-in-depth.elf -MAP=Map_file.map
19
20 learn-in-depth.bin: learn-in-depth.elf
21     $(CC)objcopy.exe  -O binary learn-in-depth.elf  learn-in-depth.bin
22
23 clean_all:
24      rm *.o *.bin *.elf
25
26 clean:
27      rm *.bin *.elf
```

The output:

MINGW64:/e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedded_...

```
Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$ make clean_all
rm *.o *.bin *.elf

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$ make
arm-none-eabi-as.exe -g -mcpu=arm926ej-s startup.s -o startup.o
arm-none-eabi-gcc.exe -c  -g -mcpu=arm926ej-s -I .  app.c -o app.o
arm-none-eabi-gcc.exe -c -g -mcpu=arm926ej-s  -I . uart.c -o uart.o
arm-none-eabi-ld.exe -T Linker_Script.ld startup.o app.o uart.o -o learn-in-depth.el
f -MAP=Map_file.map

Memory Configuration

Name             Origin             Length             Attributes
Mem              0x00000000         0x04000000         xrw
*default*        0x00000000         0xffffffff

Linker script and memory map

                0x00010000                . = 0x10000

.startup        0x00010000        0xc
 startup.o(.text)
 .text          0x00010000        0xc startup.o
                0x00010000                reset

.text           0x0001000c       0x78
 *(.text)
 .text          0x0001000c       0x1c app.o
                0x0001000c                main
 .text          0x00010028       0x5c uart.o
                0x00010028                Uart_send_string

.glue_7         0x00010084        0x0
 .glue_7        0x00010084        0x0 linker stubs

.glue_7t        0x00010084        0x0
 .glue_7t       0x00010084        0x0 linker stubs

.vfp11_veneer   0x00010084        0x0
 .vfp11_veneer  0x00010084        0x0 linker stubs
```

Makefile_lab1(V2):

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Makefile | app.c | uart.c | uart.h | Makefile.mak

```
1  #@copyright : Shaimaa Khattab
2  CC=arm-none-eabi-
3  CFLAGS=-g -mcpu=arm926ej-s
4  INCS=-I .
5  LIBS=
6
7  all: learn-in-depth.bin
8      @echo "Build is Done"
9  startup.o: startup.s
10     $(CC)as.exe $(CFLAGS) $< -o $@
11 uart.o: uart.c
12     $(CC)gcc.exe -c $(CFLAGS)  $(INCS) $< -o $@
13 app.o: app.c
14     $(CC)gcc.exe -c  $(CFLAGS) $(INCS)  $< -o $@
15 learn-in-depth.elf: startup.o app.o uart.o
16     $(CC)ld.exe -T Linker_Script.ld $(LIBS) startup.o app.o uart.o -o $@
17 learn-in-depth.bin: learn-in-depth.elf
18     $(CC)objcopy.exe -O binary $< $@
19 clean_all:
20     rm *.o *.bin *.elf
21 clean:
22     rm *.bin *.elf
```

The output:

```
Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
$ make clean_all
rm *.o *.bin *.elf

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$ make
arm-none-eabi-as.exe -g -mcpu=arm926ej-s startup.s -o startup.o
arm-none-eabi-gcc.exe -c  -g -mcpu=arm926ej-s -I .  app.c -o app.o
arm-none-eabi-gcc.exe -c -g -mcpu=arm926ej-s  -I . uart.c -o uart.o
arm-none-eabi-ld.exe -T Linker_Script.ld        startup.o app.o uart.o -o learn-in-d
epth.elf
arm-none-eabi-objcopy.exe -O binary learn-in-depth.elf learn-in-depth.bin
Build is Done

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$
```

Makefile_lab1(last Version) :

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson2_Assignment\Makefile - Notepad++

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Makefile | app.c | uart.c | uart.h | Linker_Script.ld | startup.s

```
1  #@copyright : Shaimaa Khattab
2
3  CC=arm-none-eabi-
4  CFLAGS=-g -mcpu=arm926ej-s
5  INCS=-I .
6  LIBS=
7  SRC= $(wildcard *.c)
8  OBJ = $(SRC:.c=.o)
9  As = $(wildcard *.s)
10 AsOBJ = $(As:.s=.o)
11 Project_name= learn-in-depth
12
13 all: $(Project_name).bin
14     @echo "=============Build is Done============"
15
16 %.o: %.s
17     $(CC)as.exe $(CFLAGS) $< -o $@
18
19 %.o: %.c
20     $(CC)gcc.exe -c  $(CFLAGS) $(INCS)  $< -o $@
21
22 $(Project_name).elf: $(OBJ) $(AsOBJ)
23     $(CC)ld.exe -T Linker_Script.ld $(LIBS) $(OBJ) $(AsOBJ) -o $@ -Map=Map_file.map
24
25 $(Project_name).bin: $(Project_name).elf
26     $(CC)objcopy.exe -O binary $< $@
27
28 clean_all:
29     rm *.o *.bin *.elf
30
31 clean:
32     rm *.bin *.elf
```

The output:

```
Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$ make clean_all
rm *.o *.bin *.elf

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$ make -f Makefile
arm-none-eabi-gcc.exe -c  -g -mcpu=arm926ej-s -I .  app.c -o app.o
arm-none-eabi-gcc.exe -c  -g -mcpu=arm926ej-s -I .  uart.c -o uart.o
arm-none-eabi-as.exe -g -mcpu=arm926ej-s startup.s -o startup.o
arm-none-eabi-ld.exe -T Linker_Script.ld        app.o uart.o startup.o -o learn-in-d
epth.elf -Map=Map_file.map
arm-none-eabi-objcopy.exe -O binary learn-in-depth.elf learn-in-depth.bin
============Build is Done============

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Embedde
d_Systems/Unit3_Embedded_C/Lesson2_Assignment (master)
$
```

lab 2 Assignment

1- main.c:

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson3_Assignment_Lab2\main.c - Notepad++

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Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```c
/*
 *********************************************
 * @file           : main.c
 * @author         : Shaimaa Khattab
 *********************************************
 */

typedef volatile unsigned int vuint32_t;
#include <stdint.h>
//register address
#define RCC_BASE      0x40021000
#define GPIOA_BASE    0x40010800
#define RCC_APB2ENR   *(volatile uint32_t *)(RCC_BASE + 0x18)
#define GPIOA_CRH     *(volatile uint32_t *)(GPIOA_BASE + 0x04)
#define GPIOA_ODR     *(volatile uint32_t *)(GPIOA_BASE + 0x0C)
//bit fields
#define RCC_IOPAEN   (1<<2)
#define GPIOA13      (1<<13)

typedef union {
    vuint32_t        all_fileds;
    struct{
        vuint32_t    reserved:13;
        vuint32_t    P_13:1;

    } Pin;
} R_ODR_t;

volatile R_ODR_t*  R_ODR =  (volatile R_ODR_t*)(GPIOA_BASE + 0x0C);


int main(void)
{
    RCC_APB2ENR  |= RCC_IOPAEN;
    GPIOA_CRH    &= 0xFF0FFFFF;
    GPIOA_CRH    |= 0x00200000;

    while(1)
    {
        R_ODR->Pin.P_13 = 1;
        for(int i =0; i<5000; i++); //arbitrary delay
        R_ODR->Pin.P_13 = 0;
        for(int i =0; i<5000; i++); //arbitrary delay

    }

    return 0;
}
```

2- Linker_script.ld:

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Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```
/* Linker_Script CortexM3
 Shaimaa Khattab
*/

MEMORY
{
flash(RX) : ORIGIN = 0x08000000, LENGTH = 128k
sram(RWX) : ORIGIN = 0x20000000, LENGTH = 20k
}

SECTIONS
{
    .text : {
            *(.vectors*)
            *(.text*)
            *(.rodata*)
            _E_text = . ;
    }> flash
    .data : {
            _S_DATA = . ;
            *(.data)
            _E_DATA = . ;
    }> sram AT> flash
    .bss  : {
            _S_bss = . ;
            *(.bss*)
            . = ALIGN(4);
            _E_bss = . ;

            . = ALIGN(4);
            . = . + 0x1000 ;
            _stack_top = . ;
    }> sram
}
```

3- startup.s

*E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson3_Assignment_Lab2\startup.s - Notepad++

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Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```
.section .vectors

.word 0x20001000 /*stack top address */
.word _reset              /* 1 Reset */
.word Vector_handler      /* 2 NMI */
.word Vector_handler      /* 3 Hard Fault */
.word Vector_handler      /* 4 MM Fault */
.word Vector_handler      /* 5 Bus Fault */
.word Vector_handler      /* 6 Usage Fault */
.word Vector_handler      /* 7 RESERVED */
.word Vector_handler      /* 8 RESERVED */
.word Vector_handler      /* 9 RESERVED */
.word Vector_handler      /* 10 RESERVED */
.word Vector_handler      /* 11 SV call */
.word Vector_handler      /* 12 Debug reserved */
.word Vector_handler      /* 13 RESERVED */
.word Vector_handler      /* 14 PendSV */
.word Vector_handler      /* 15 SysTick */
.word Vector_handler      /* 16 IRQ0 */
.word Vector_handler      /* 17 IRQ1 */
.word Vector_handler      /* 18 IRQ2 */
.word Vector_handler      /* 19 ... */
    /* On to IRQ67 */

.section .text

_reset:
     bl main
     b .

.thumb_func

Vector_handler:
```

4- startup.c:

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson3_Assignment_Lab2\startup.c - Notepad++

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Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```c
//startup.c
//Shaimaa Khattab

#include <stdint.h>

void Reset_Handler ();
extern int main(void);

void Default_Handler()
{
    Reset_Handler();
}

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

extern unsigned int _stack_top;
uint32_t vectors[] __attribute__((sections(".vectors"))) = {

(uint32_t) &_stack_top,
(uint32_t) &Reset_Handler,
(uint32_t) &NMI_Handler,
(uint32_t) &H_fault_Handler,
(uint32_t) &MM_Fault_Handler,
(uint32_t) &Bus_Fault,
(uint32_t) &Usage_Fault_Handler


};

extern unsigned int _E_text ;
extern unsigned int _S_DATA ;
extern unsigned int _E_DATA ;
```

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson3_Assignment_Lab2\startup.c - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```c
extern unsigned int _S_bss ;
extern unsigned int _E_bss ;


void Reset_Handler ()
{
    //copy data section from flash to RAM
    unsigned int DATA_size =  (unsigned char*)&_E_DATA - (unsigned char*)&_S_DATA ;
    unsigned char* P_src = (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_src++);
    }

    //init .bss section in SRAM=0

    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 ;
    }

    //jump main




    main();

}
```

5-Makefile:

E:\Embedded_in_depth\Embedded_System_Diploma\Mastering-Embedded_Systems\Unit3_Embedded_C\Lesson3_Assignment_Lab2\Makefile - Notepad++

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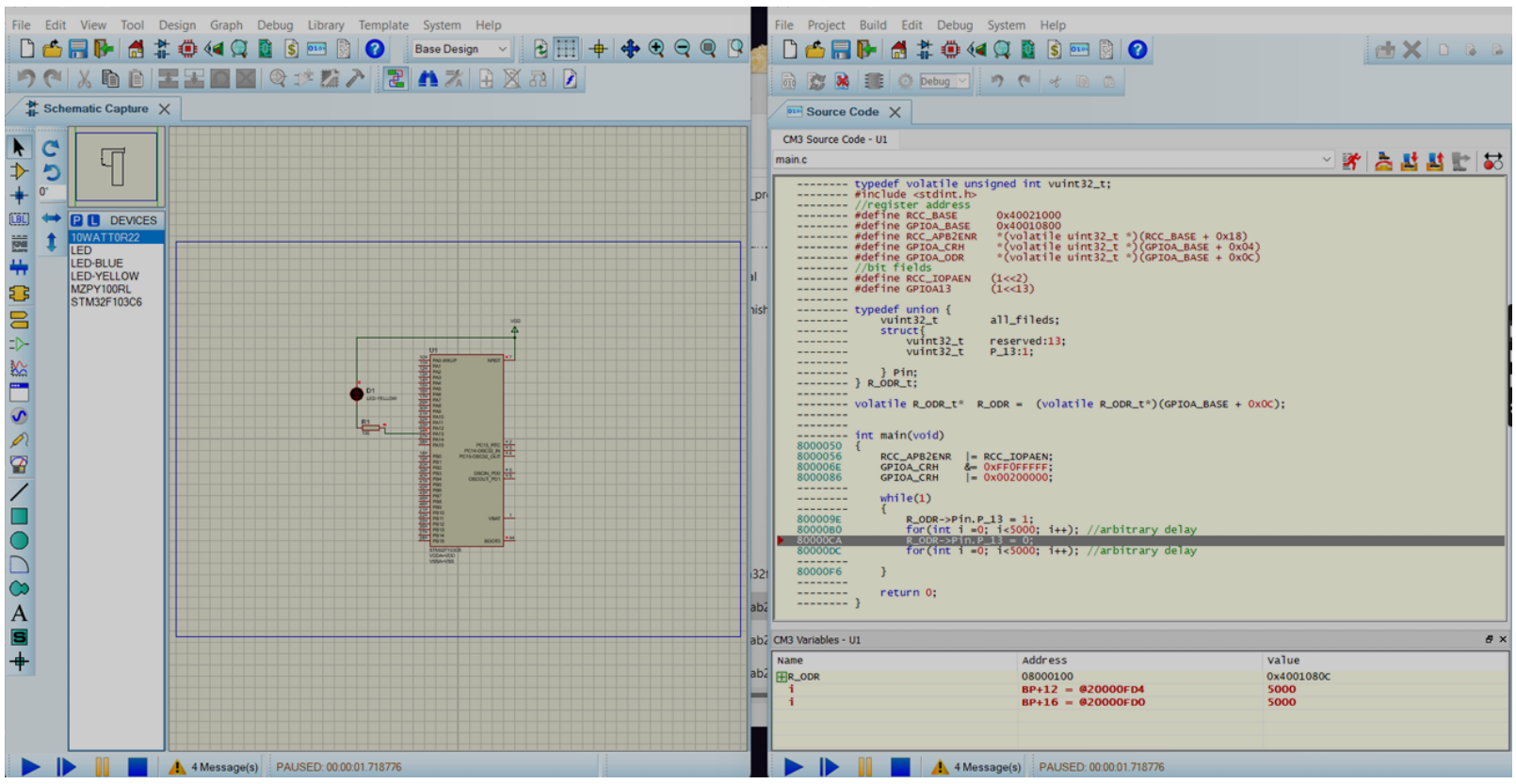
Makefile | main.c | startup.s | Linker_Script.ld | startup.c

```
#@copyright : Shaimaa Khattab

CC=arm-none-eabi-
CFLAGS= -mcpu=cortex-m3 -gdwarf-2
INCS=-I .
LIBS=
SRC= $(wildcard *.c)
OBJ = $(SRC:.c=.o)
As = $(wildcard *.s)
AsOBJ = $(As:.s=.o)
Project_name= learn_in_depth_cortex_m3

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

%.o: %.s
    $(CC)as.exe $(CFLAGS) $< -o $@

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

$(Project_name).elf: $(OBJ) $(AsOBJ)
    $(CC)ld.exe -T Linker_Script.ld $(LIBS) $(OBJ) $(AsOBJ) -o $@ -Map=Map_file.map

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

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

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

6- Run/Debug



7- Text file showing symbols of each object:

```
Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Emb
edded_Systems/Unit3_Embedded_C/Lesson3_Assignment_Lab2 (master)
$ arm-none-eabi-nm.exe learn_in_depth_cortex_m3.elf
20000020 B _E_bss
20000020 D _E_DATA
0800010c T _E_text
20000020 B _S_bss
20000000 D _S_DATA
20001020 B _stack_top
0800007c W Bus_Fault
0800007c T Default_Handler
0800007c W H_fault_Handler
08000000 T main
0800007c W MM_Fault_Handler
0800007c W NMI_Handler
20000000 D R_ODR
08000088 T Reset_Handler
0800007c W Usage_Fault_Handler
20000004 D vectors

Shima@Shaimaa MINGW64 /e/Embedded_in_depth/Embedded_System_Diploma/Mastering-Emb
edded_Systems/Unit3_Embedded_C/Lesson3_Assignment_Lab2 (master)
$
```