LAB2

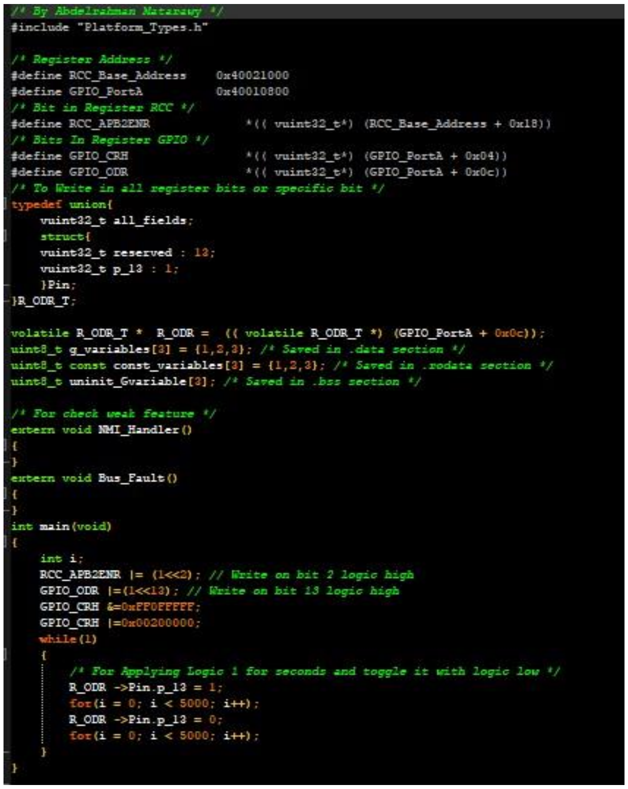
Toggle LED By STM32 and processor CortexM3

BY: ABDELRAHMAN MATARAWY

Lab

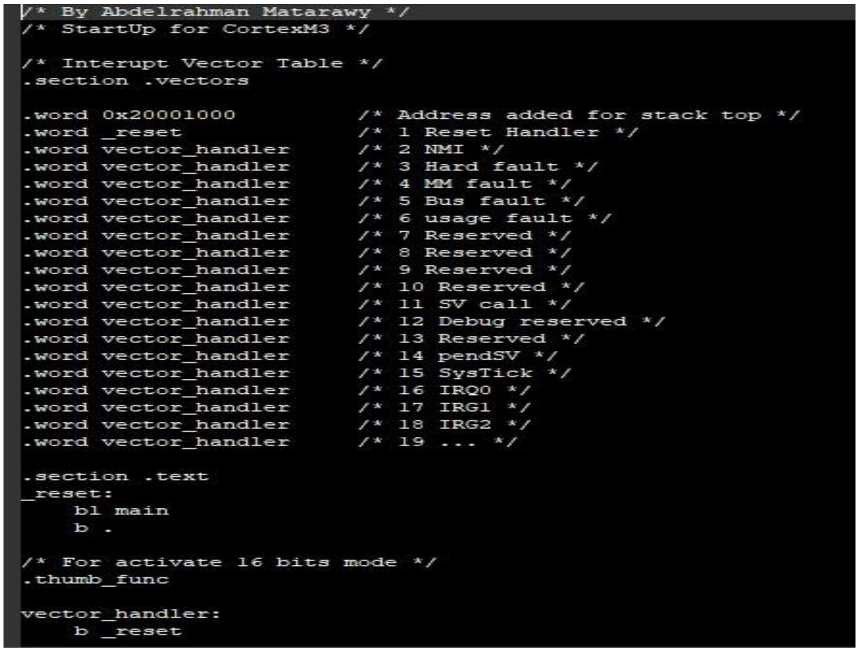
- ❖ Main.c :

  ➢



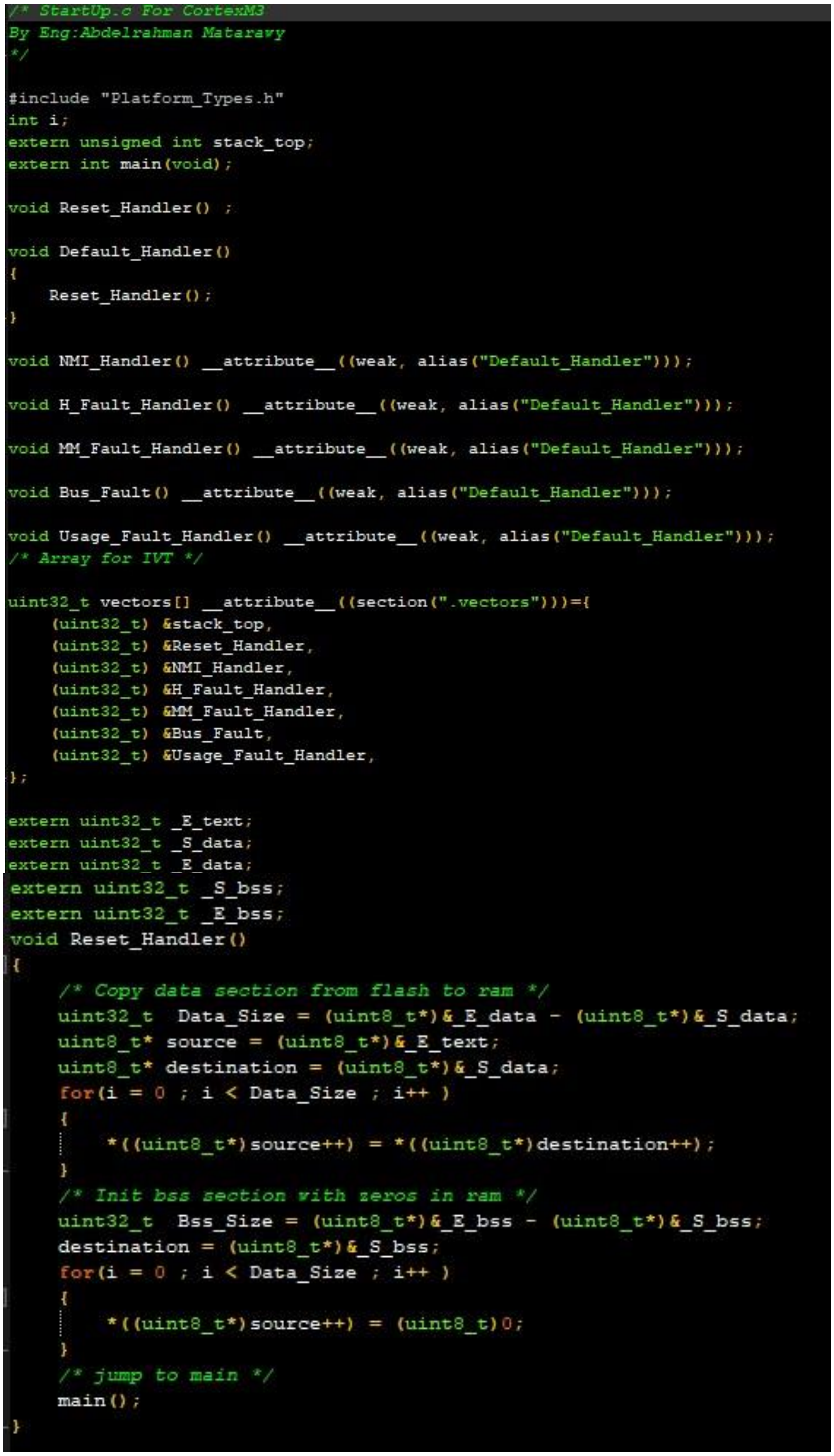
```c
/* By Abdelrahman Matarawy */
#include "Platform_Types.h"

/* Register Address */
#define RCC_Base_Address    0x40021000
#define GPIO_PortA          0x40010800
/* Bit in Register RCC */
#define RCC_APB2ENR              *(( vuint32_t*) (RCC_Base_Address + 0x18))
/* Bits In Register GPIO */
#define GPIO_CRH                 *(( vuint32_t*) (GPIO_PortA + 0x04))
#define GPIO_ODR                 *(( vuint32_t*) (GPIO_PortA + 0x0c))
/* To Write in all register bits or specific bit */
typedef union{
    vuint32_t all_fields;
    struct{
    vuint32_t reserved : 13;
    vuint32_t p_13 : 1;
    }Pin;
}R_ODR_T;

volatile R_ODR_T *  R_ODR =  (( volatile R_ODR_T *) (GPIO_PortA + 0x0c));
uint8_t g_variables[3] = {1,2,3}; /* Saved in .data section */
uint8_t const const_variables[3] = {1,2,3}; /* Saved in .rodata section */
uint8_t uninit_Gvariable[3]; /* Saved in .bss section */

/* For check weak feature */
extern void NMI_Handler()
{
}
extern void Bus_Fault()
{
}
int main(void)
{
    int i;
    RCC_APB2ENR |= (1<<2); // Write on bit 2 logic high
    GPIO_ODR |=(1<<13); // Write on bit 13 logic high
    GPIO_CRH &=0xFF0FFFFF;
    GPIO_CRH |=0x00200000;
    while(1)
    {
        /* For Applying Logic 1 for seconds and toggle it with logic low */
        R_ODR ->Pin.p_13 = 1;
        for(i = 0; i < 5000; i++);
        R_ODR ->Pin.p_13 = 0;
        for(i = 0; i < 5000; i++);
    }
}
```

- ❖ StartUp.s :



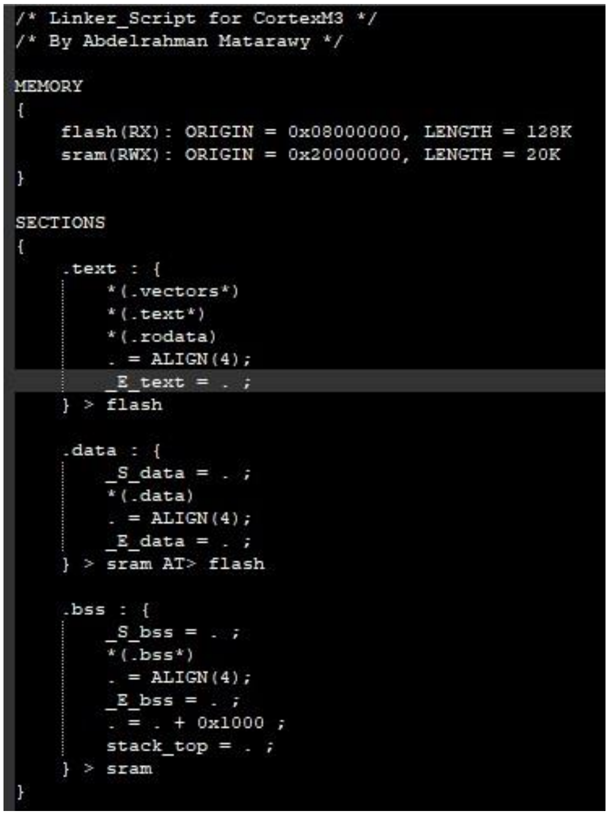
```
/* By Abdelrahman Matarawy */
/* StartUp for CortexM3 */

/* Interupt Vector Table */
.section .vectors

.word 0x20001000          /* Address added for stack top */
.word _reset              /* 1 Reset Handler */
.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 IRG1 */
.word vector_handler      /* 18 IRG2 */
.word vector_handler      /* 19 ... */

.section .text
_reset:
    bl main
    b .

/* For activate 16 bits mode */
.thumb_func

vector_handler:
    b _reset
```

❖StartUp.c :



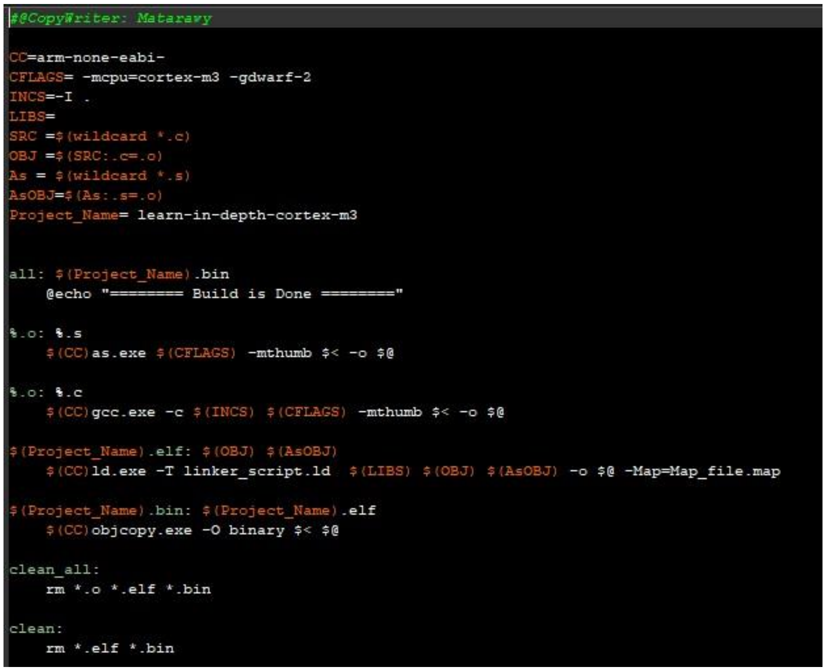
```c
/* StartUp.c For CortexM3
By Eng:Abdelrahman Matarawy
*/

#include "Platform_Types.h"
int i;
extern unsigned int stack_top;
extern int main(void);

void Reset_Handler() ;

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")));
/* Array for IVT */

uint32_t vectors[] __attribute__((section(".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 uint32_t _E_text;
extern uint32_t _S_data;
extern uint32_t _E_data;
extern uint32_t _S_bss;
extern uint32_t _E_bss;
void Reset_Handler()
{
    /* Copy data section from flash to ram */
    uint32_t  Data_Size = (uint8_t*)&_E_data - (uint8_t*)&_S_data;
    uint8_t* source = (uint8_t*)&_E_text;
    uint8_t* destination = (uint8_t*)&_S_data;
    for(i = 0 ; i < Data_Size ; i++ )
    {
        *((uint8_t*)source++) = *((uint8_t*)destination++);
    }
    /* Init bss section with zeros in ram */
    uint32_t  Bss_Size = (uint8_t*)&_E_bss - (uint8_t*)&_S_bss;
    destination = (uint8_t*)&_S_bss;
    for(i = 0 ; i < Data_Size ; i++ )
    {
        *((uint8_t*)source++) = (uint8_t)0;
    }
    /* jump to main */
    main();
}
```

❖Linker Script:



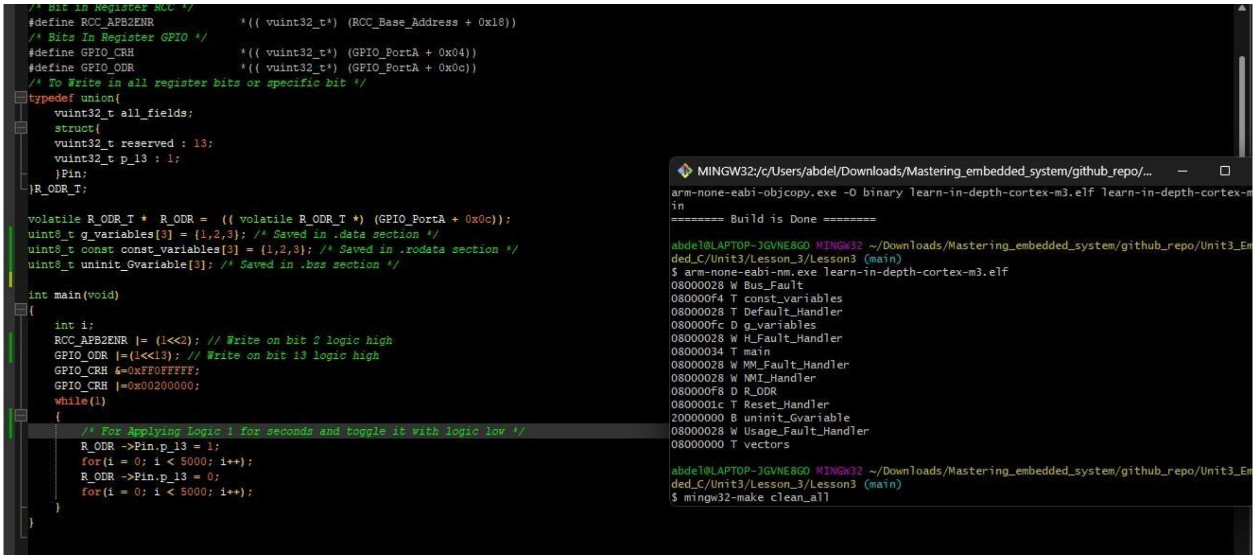
```
/* Linker_Script for CortexM3 */
/* By Abdelrahman Matarawy */

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

SECTIONS
{
    .text : {
        *(.vectors*)
        *(.text*)
        *(.rodata)
        . = ALIGN(4);
        _E_text = . ;
    } > flash

    .data : {
        _S_data = . ;
        *(.data)
        . = ALIGN(4);
        _E_data = . ;
    } > sram AT> flash

    .bss : {
        _S_bss = . ;
        *(.bss*)
        . = ALIGN(4);
        _E_bss = . ;
        . = . + 0x1000 ;
        stack_top = . ;
    } > sram
}
```

❖Make file:



```
#@CopyWriter: Matarawy

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) -mthumb $< -o $@

%.o: %.c
    $(CC)gcc.exe -c $(INCS) $(CFLAGS) -mthumb $< -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 *.elf *.bin

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

- Before Weak and alias :

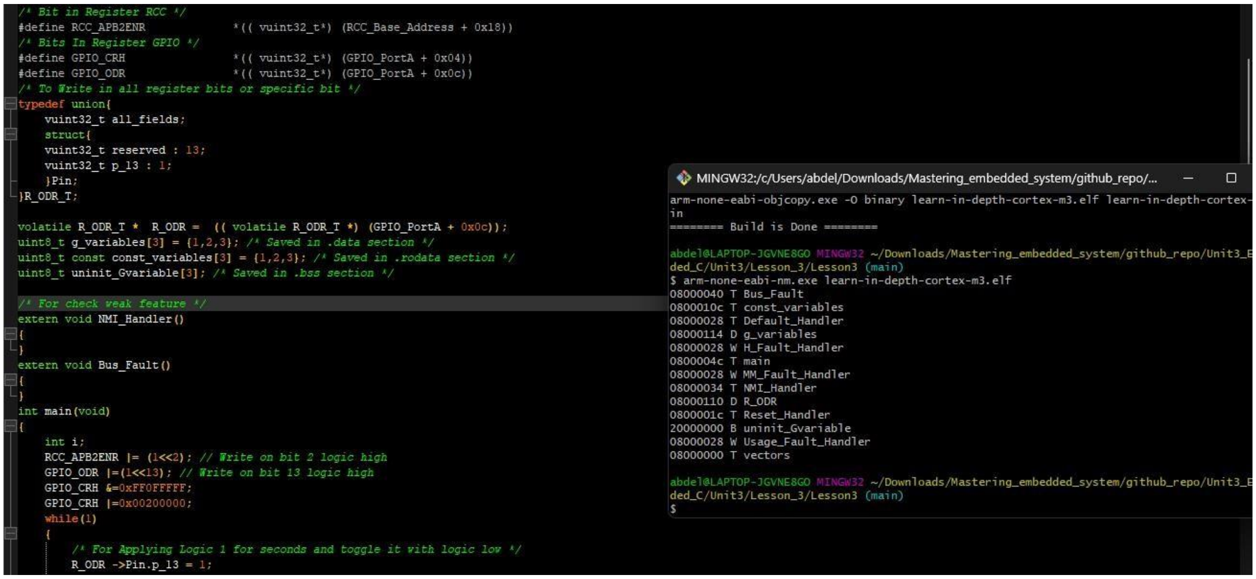


```c
/* Bit in Register RCC */
#define RCC_APB2ENR             *(( vuint32_t*) (RCC_Base_Address + 0x18))
/* Bits In Register GPIO */
#define GPIO_CRH                *(( vuint32_t*) (GPIO_PortA + 0x04))
#define GPIO_ODR                *(( vuint32_t*) (GPIO_PortA + 0x0c))
/* To Write in all register bits or specific bit */
typedef union{
    vuint32_t all_fields;
    struct{
    vuint32_t reserved : 13;
    vuint32_t p_13 : 1;
    }Pin;
}R_ODR_T;

volatile R_ODR_T *  R_ODR =  (( volatile R_ODR_T *) (GPIO_PortA + 0x0c));
uint8_t g_variables[3] = {1,2,3}; /* Saved in .data section */
uint8_t const const_variables[3] = {1,2,3}; /* Saved in .rodata section */
uint8_t uninit_Gvariable[3]; /* Saved in .bss section */

int main(void)
{
    int i;
    RCC_APB2ENR |= (1<<2); // Write on bit 2 logic high
    GPIO_ODR |=(1<<13); // Write on bit 13 logic high
    GPIO_CRH &=0xFF0FFFFF;
    GPIO_CRH |=0x00200000;
    while(1)
    {
        /* For Applying Logic 1 for seconds and toggle it with logic low */
        R_ODR ->Pin.p_13 = 1;
        for(i = 0; i < 5000; i++);
        R_ODR ->Pin.p_13 = 0;
        for(i = 0; i < 5000; i++);
    }
}
```

MINGW32:/c/Users/abdel/Downloads/Mastering_embedded_system/github_repo/...

```
arm-none-eabi-objcopy.exe -O binary learn-in-depth-cortex-m3.elf learn-in-depth-cortex-m
in
======== Build is Done ========

abdel@LAPTOP-JGVNE8GO MINGW32 ~/Downloads/Mastering_embedded_system/github_repo/Unit3_Em
ded_C/Unit3/Lesson_3/Lesson3 (main)
$ arm-none-eabi-nm.exe learn-in-depth-cortex-m3.elf
08000028 W Bus_Fault
080000f4 T const_variables
08000028 T Default_Handler
080000fc D g_variables
08000028 W H_Fault_Handler
08000034 T main
08000028 W MM_Fault_Handler
08000028 W NMI_Handler
080000f8 D R_ODR
0800001c T Reset_Handler
20000000 B uninit_Gvariable
08000028 W Usage_Fault_Handler
08000000 T vectors

abdel@LAPTOP-JGVNE8GO MINGW32 ~/Downloads/Mastering_embedded_system/github_repo/Unit3_Em
ded_C/Unit3/Lesson_3/Lesson3 (main)
$ mingw32-make clean_all
```

- After weak and alias :

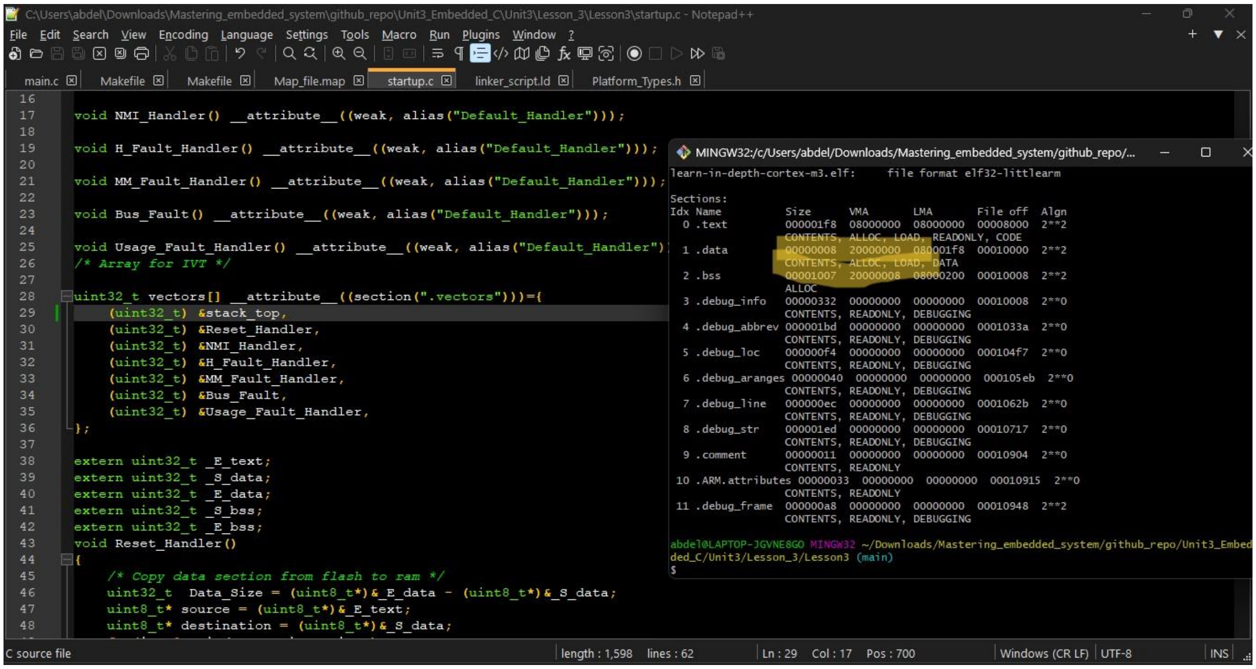


```c
/* Bit in Register RCC */
#define RCC_APB2ENR             *(( vuint32_t*) (RCC_Base_Address + 0x18))
/* Bits In Register GPIO */
#define GPIO_CRH                *(( vuint32_t*) (GPIO_PortA + 0x04))
#define GPIO_ODR                *(( vuint32_t*) (GPIO_PortA + 0x0c))
/* To Write in all register bits or specific bit */
typedef union{
    vuint32_t all_fields;
    struct{
    vuint32_t reserved : 13;
    vuint32_t p_13 : 1;
    }Pin;
}R_ODR_T;

volatile R_ODR_T *  R_ODR =  (( volatile R_ODR_T *) (GPIO_PortA + 0x0c));
uint8_t g_variables[3] = {1,2,3}; /* Saved in .data section */
uint8_t const const_variables[3] = {1,2,3}; /* Saved in .rodata section */
uint8_t uninit_Gvariable[3]; /* Saved in .bss section */

/* For check weak feature */
extern void NMI_Handler()
{
}
extern void Bus_Fault()
{
}
int main(void)
{
    int i;
    RCC_APB2ENR |= (1<<2); // Write on bit 2 logic high
    GPIO_ODR |=(1<<13); // Write on bit 13 logic high
    GPIO_CRH &=0xFF0FFFFF;
    GPIO_CRH |=0x00200000;
    while(1)
    {
        /* For Applying Logic 1 for seconds and toggle it with logic low */
        R_ODR ->Pin.p_13 = 1;
```

MINGW32:/c/Users/abdel/Downloads/Mastering_embedded_system/github_repo/...

```
arm-none-eabi-objcopy.exe -O binary learn-in-depth-cortex-m3.elf learn-in-depth-cortex-
in
======== Build is Done ========

abdel@LAPTOP-JGVNE8GO MINGW32 ~/Downloads/Mastering_embedded_system/github_repo/Unit3_E
ded_C/Unit3/Lesson_3/Lesson3 (main)
$ arm-none-eabi-nm.exe learn-in-depth-cortex-m3.elf
08000040 T Bus_Fault
0800010c T const_variables
08000028 T Default_Handler
08000114 D g_variables
08000028 W H_Fault_Handler
0800004c T main
08000028 W MM_Fault_Handler
08000034 T NMI_Handler
08000110 D R_ODR
0800001c T Reset_Handler
20000000 B uninit_Gvariable
08000028 W Usage_Fault_Handler
08000000 T vectors

abdel@LAPTOP-JGVNE8GO MINGW32 ~/Downloads/Mastering_embedded_system/github_repo/Unit3_E
ded_C/Unit3/Lesson_3/Lesson3 (main)
$
```

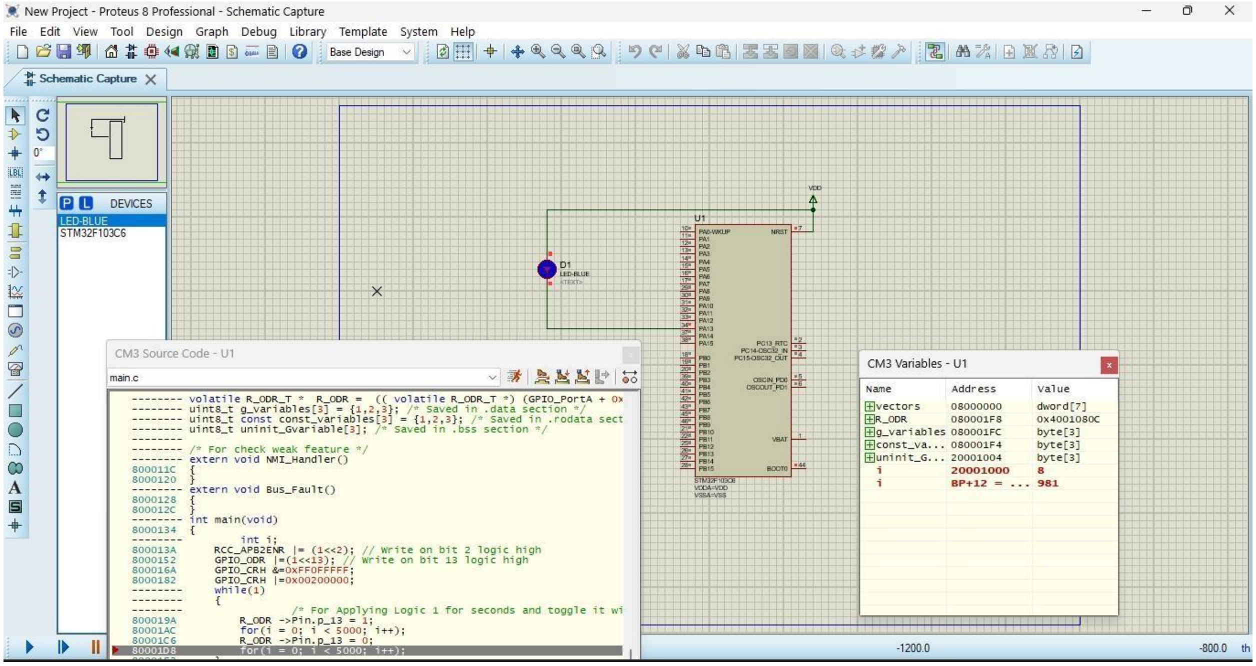
❖ Copy data section and init bss section :


C:\Users\abdel\Downloads\Mastering_embedded_system\github_repo\Unit3_Embedded_C\Unit3\Lesson_3\Lesson3\startup.c - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
main.c
Makefile
Makefile
Map_file.map
startup.c
linker_script.ld
Platform_Types.h
C source file
length : 1,598 lines : 62
Ln : 29 Col : 17 Pos : 700
Windows (CR LF)
UTF-8
INS
MINGW32:/c/Users/abdel/Downloads/Mastering_embedded_system/github_repo/...

```c
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")
/* Array for IVT */

uint32_t vectors[] __attribute__((section(".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 uint32_t _E_text;
extern uint32_t _S_data;
extern uint32_t _E_data;
extern uint32_t _S_bss;
extern uint32_t _E_bss;
void Reset_Handler()
{
    /* Copy data section from flash to ram */
    uint32_t  Data_Size = (uint8_t*)&_E_data - (uint8_t*)&_S_data;
    uint8_t* source = (uint8_t*)&_E_text;
    uint8_t* destination = (uint8_t*)&_S_data;
```

```
learn-in-depth-cortex-m3.elf:     file format elf32-littlearm

Sections:
Idx Name          Size      VMA       LMA       File off  Algn
  0 .text         000001f8  08000000  08000000  00008000  2**2
                  CONTENTS, ALLOC, LOAD, READONLY, CODE
  1 .data         00000008  20000000  080001f8  00010000  2**2
                  CONTENTS, ALLOC, LOAD, DATA
  2 .bss          00001007  20000008  08000200  00010008  2**2
                  ALLOC
  3 .debug_info   00000332  00000000  00000000  00010008  2**0
                  CONTENTS, READONLY, DEBUGGING
  4 .debug_abbrev 000001bd  00000000  00000000  0001033a  2**0
                  CONTENTS, READONLY, DEBUGGING
  5 .debug_loc    000000f4  00000000  00000000  000104f7  2**0
                  CONTENTS, READONLY, DEBUGGING
  6 .debug_aranges 00000040  00000000  00000000  000105eb  2**0
                  CONTENTS, READONLY, DEBUGGING
  7 .debug_line   000000ec  00000000  00000000  0001062b  2**0
                  CONTENTS, READONLY, DEBUGGING
  8 .debug_str    000001ed  00000000  00000000  00010717  2**0
                  CONTENTS, READONLY, DEBUGGING
  9 .comment      00000011  00000000  00000000  00010904  2**0
                  CONTENTS, READONLY
 10 .ARM.attributes 00000033  00000000  00000000  00010915  2**0
                  CONTENTS, READONLY
 11 .debug_frame  000000a8  00000000  00000000  00010948  2**2
                  CONTENTS, READONLY, DEBUGGING

abdel@LAPTOP-JGVNE8GO MINGW32 ~/Downloads/Mastering_embedded_system/github_repo/Unit3_Embedded_C/Unit3/Lesson_3/Lesson3 (main)
$
```

❖ When led on :



```
-------- volatile R_ODR_T *  R_ODR =  (( volatile R_ODR_T *) (GPIO_PortA + 0x
-------- uint8_t g_variables[3] = {1,2,3}; /* Saved in .data section */
-------- uint8_t const const_variables[3] = {1,2,3}; /* Saved in .rodata sect
-------- uint8_t uninit_Gvariable[3]; /* Saved in .bss section */
--------
-------- /* For check weak feature */
-------- extern void NMI_Handler()
800011C  {
8000120  }
-------- extern void Bus_Fault()
8000128  {
800012C  }
-------- int main(void)
8000134  {
--------         int i;
800013A      RCC_APB2ENR |= (1<<2); // Write on bit 2 logic high
8000152      GPIO_ODR |=(1<<13); // Write on bit 13 logic high
800016A      GPIO_CRH &=0xFF0FFFFF;
8000182      GPIO_CRH |=0x00200000;
--------     while(1)
--------     {
--------             /* For Applying Logic 1 for seconds and toggle it wi
800019A          R_ODR ->Pin.p_13 = 1;
80001AC          for(i = 0; i < 5000; i++);
80001C6          R_ODR ->Pin.p_13 = 0;
80001D8          for(i = 0; i < 5000; i++);
```

Name	Address	Value
⊞vectors	08000000	dword[7]
⊞R_ODR	080001F8	0x4001080C
⊞g_variables	080001FC	byte[3]
⊞const_va...	080001F4	byte[3]
⊞uninit_G...	20001004	byte[3]
i	20001000	8
i	BP+12 = ...	981