

Assignment 5- Implementing a closed loop control application in Zephyr V1.0

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Chapter 1

Bug List

File [main.h](#)

No known bugs.

Chapter 2

File Index

2.1 File List

Here is a list of all files with brief descriptions:

main.c	5
main.h	
Application to control the light intensity of a given region. The system comprises a light sensor, an illumination system and a Human-Machine Interface. The system can operate in two modes↔ : • Automatic: programmable via the terminal. Should allow setting On/Off periods and the corresponding light intensity; • Manual: interface via the DevKit buttons. Allows to turn the system On/Off (when in “Off” the system operates in automatic mode), via two of the buttons. The other two buttons allow to set (increase/decrease) the desired intensity	23

Chapter 3

File Documentation

3.1 CMakeLists.txt File Reference

Functions

- [cmake_minimum_required](#) (VERSION 3.20.0) find_package(Zephyr REQUIRED HINTS \$ENV

3.1.1 Function Documentation

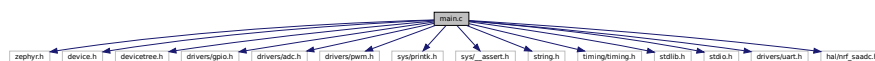
3.1.1.1 cmake_minimum_required()

```
cmake_minimum_required (
    VERSION 3.20.  0 )
```

3.2 main.c File Reference

```
#include <zephyr.h>
#include <device.h>
#include <devicetree.h>
#include <drivers/gpio.h>
#include <drivers/adc.h>
#include <drivers/pwm.h>
#include <sys/printk.h>
#include <sys/__assert.h>
#include <string.h>
#include <timing/timing.h>
#include <stdlib.h>
#include <stdio.h>
#include <drivers/uart.h>
#include <hal/nrf_saadc.h>
```

Include dependency graph for main.c:



Macros

- #define `len_dados` 10
- #define `STACK_SIZE` 1024
- #define `thread_A1_prio` 1
- #define `thread_A_prio` 1
- #define `thread_B_prio` 1
- #define `thread_C_prio` 1
- #define `thread_D_prio` 1
- #define `SAMP_PERIOD_MS` 1000
- #define `ADC_NID` DT_NODELABEL(adc)
- #define `ADC_RESOLUTION` 10
- #define `ADC_GAIN` ADC_GAIN_1_4
- #define `ADC_REFERENCE` ADC_REF_VDD_1_4
- #define `ADC_ACQUISITION_TIME` ADC_ACQ_TIME(ADC_ACQ_TIME_MICROSECONDS, 40)
- #define `ADC_CHANNEL_ID` 1
- #define `ADC_CHANNEL_INPUT` NRF_SAADC_INPUT_AIN1
- #define `BUFFER_SIZE` 1
- #define `GPIO0_NID` DT_NODELABEL(gpio0)
- #define `PWM0_NID` DT_NODELABEL(pwm0)
- #define `BOARDLED1` 0x0d
- #define `BOARDBUT1` 0xb /* Pin at which BUT1 is connected. Addressing is direct (i.e., pin number) */
- #define `BOARDBUT2` 0xc
- #define `BOARDBUT2` 0xc
- #define `BOARDBUT4` 0x19
- #define `FATAL_ERR` -1 /* Fatal error return code, app terminates */
- #define `UART_NID` DT_NODELABEL(uart0) /* UART Node label, see dts */
- #define `RXBUF_SIZE` 60 /* RX buffer size */
- #define `TXBUF_SIZE` 60 /* TX buffer size */
- #define `RX_TIMEOUT` 1000 /* Inactivity period after the instant when last char was received that triggers an rx event (in us) */
- #define `MAIN_SLEEP_TIME_MS` 10 /* Time between `main()` activations */

Functions

- `K_THREAD_STACK_DEFINE` (thread_A1_stack, `STACK_SIZE`)
- `K_THREAD_STACK_DEFINE` (thread_A_stack, `STACK_SIZE`)
- `K_THREAD_STACK_DEFINE` (thread_B_stack, `STACK_SIZE`)
- `K_THREAD_STACK_DEFINE` (thread_C_stack, `STACK_SIZE`)
- `K_THREAD_STACK_DEFINE` (thread_D_stack, `STACK_SIZE`)
- void `thread_A1_code` (void *argA, void *argB, void *argC)
- void `thread_A_code` (void *argA, void *argB, void *argC)

Lê o botão 1, faz o toggle entre o manual e o automatico, sendo periódico.
- void `thread_B_code` (void *argA, void *argB, void *argC)

É efectuada a filtragem, em que é realizado a média das últimas 10 amostras calculadas na Thread A e o filtro rejeita todos os valores que estejam abaixo ou acima de 10% da média.
- void `thread_C_code` (void *argA, void *argB, void *argC)

Modo manual, onde se faz o toggle sempre que carregar no botão 2 incrementa a luminosidade, ao clicar no botão 4 a luminosidade decrementa, ou seja, diminui a percentagem do PWM, quando está a 100% está no maximo e o duty-cycle corresponde é de 0%, que é quando está no máximo, e assim succesivamente.
- void `thread_D_code` (void *argA, void *argB, void *argC)

Modo automático: Recebe o valor da ADC e faz o take que vem do bd (após a filtragem); Se o valor for menor que 500, o led está apagado, ou seja, é detetada muita luminosidade logo; Quando estamos à luz ambiente o led está com a luminosidade a meio; Se não existir luminosidade o led acede.

- void [but1press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)
If button 1 is pressed, Update Flag 1.
- void [but2press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)
If button 2 is pressed, Update Flag 2.
- void [but4press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)
If button 4 is pressed, Update Flag 4.
- void [main](#) (void)
Main funtion: Initialize semaphores and configure GPIO_PIN.

Variables

- struct k_thread [thread_A1_data](#)
- struct k_thread [thread_A_data](#)
- struct k_thread [thread_B_data](#)
- struct k_thread [thread_C_data](#)
- struct k_thread [thread_D_data](#)
- k_tid_t [thread_A1_tid](#)
- k_tid_t [thread_A_tid](#)
- k_tid_t [thread_B_tid](#)
- k_tid_t [thread_C_tid](#)
- k_tid_t [thread_D_tid](#)
- int [a1a](#) = 0
- int [ab](#) = 0
- int [bc](#) = 0
- int [bd](#) = 0
- struct k_sem [sem_a1a](#)
- struct k_sem [sem_ab](#)
- struct k_sem [sem_bc](#)
- struct k_sem [sem_bd](#)
- struct k_timer [my_timer](#)
- const struct device * [adc_dev](#) = NULL
- volatile int [Flag_1](#) = 0
- volatile int [Flag_3](#) = 0
- volatile int [Flag_2](#) = 0
- volatile int [Flag_4](#) = 0
- volatile bool [flag_flag](#) = 0
- const struct device * [gpio0_dev](#)
- const struct uart_config [uart_cfg](#)
- const struct device * [uart_dev](#)
- volatile int [uart_rx_rdy_flag](#)
- uint8_t [welcome_mesg](#) [] = "UART demo: Type a few chars in a row and then pause for a little while ...\n\r"
- uint8_t [rep_mesg](#) [TXBUF_SIZE]

3.2.1 Macro Definition Documentation

3.2.1.1 ADC_ACQUISITION_TIME

```
#define ADC_ACQUISITION_TIME ADC_ACQ_TIME(ADC_ACQ_TIME_MICROSECONDS, 40)
```

3.2.1.2 ADC_CHANNEL_ID

```
#define ADC_CHANNEL_ID 1
```

3.2.1.3 ADC_CHANNEL_INPUT

```
#define ADC_CHANNEL_INPUT NRF_SAADC_INPUT_AIN1
```

3.2.1.4 ADC_GAIN

```
#define ADC_GAIN ADC_GAIN_1_4
```

3.2.1.5 ADC_NID

```
#define ADC_NID DT_NODELABEL(adc)
```

ADC definitions and includes

3.2.1.6 ADC_REFERENCE

```
#define ADC_REFERENCE ADC_REF_VDD_1_4
```

3.2.1.7 ADC_RESOLUTION

```
#define ADC_RESOLUTION 10
```

3.2.1.8 BOARDBUT1

```
#define BOARDBUT1 0xb /* Pin at which BUT1 is connected. Addressing is direct (i.e., pin  
number) */
```

3.2.1.9 BOARD BUT2 [1/2]

```
#define BOARD BUT2 0xc
```

3.2.1.10 BOARD BUT2 [2/2]

```
#define BOARD BUT2 0xc
```

3.2.1.11 BOARD BUT4

```
#define BOARD BUT4 0x19
```

3.2.1.12 BOARD LED1

```
#define BOARD LED1 0x0d
```

3.2.1.13 BUFFER_SIZE

```
#define BUFFER_SIZE 1
```

3.2.1.14 FATAL_ERR

```
#define FATAL_ERR -1 /* Fatal error return code, app terminates */
```

3.2.1.15 GPIO0_NID

```
#define GPIO0_NID DT_NODELABEL(gpio0)
```

Refer to dts file

3.2.1.16 len_dados

```
#define len_dados 10
```

Number of samples for the average

3.2.1.17 MAIN_SLEEP_TIME_MS

```
#define MAIN_SLEEP_TIME_MS 10 /* Time between main() activations */
```

3.2.1.18 PWM0_NID

```
#define PWM0_NID DT_NODELABEL(pwm0)
```

3.2.1.19 RX_TIMEOUT

```
#define RX_TIMEOUT 1000 /* Inactivity period after the instant when last char was received  
that triggers an rx event (in us) */
```

3.2.1.20 RXBUF_SIZE

```
#define RXBUF_SIZE 60 /* RX buffer size */
```

3.2.1.21 SAMP_PERIOD_MS

```
#define SAMP_PERIOD_MS 1000
```

Therad periodicity (in ms)

3.2.1.22 STACK_SIZE

```
#define STACK_SIZE 1024
```

Size of stack area used by each thread (can be thread specific, if necessary)

3.2.1.23 thread_A1_prio

```
#define thread_A1_prio 1
```

Thread scheduling priority

3.2.1.24 thread_A_prio

```
#define thread_A_prio 1
```

3.2.1.25 thread_B_prio

```
#define thread_B_prio 1
```

3.2.1.26 thread_C_prio

```
#define thread_C_prio 1
```

3.2.1.27 thread_D_prio

```
#define thread_D_prio 1
```

3.2.1.28 TXBUF_SIZE

```
#define TXBUF_SIZE 60 /* TX buffer size */
```

3.2.1.29 UART_NID

```
#define UART_NID DT_NODELABEL(uart0) /* UART Node label, see dts */
```

3.2.2 Function Documentation

3.2.2.1 but1press_cbfunction()

```
void but1press_cbfunction (
    const struct device * dev,
    struct gpio_callback * cb,
    uint32_t pins )
```

If button 1 is pressed, Update Flag 1.

```
void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_1 = 1;
    flag_flag=!flag_flag;
    printk("but1 \n\r");
}
```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.2.2.2 but2press_cbfunction()

```
void but2press_cbfunction (
    const struct device * dev,
    struct gpio_callback * cb,
    uint32_t pins )
```

If button 2 is pressed, Update Flag 2.

```
void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_2 = 1;
}
```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.2.2.3 but4press_cbfunction()

```
void but4press_cbfunction (
    const struct device * dev,
    struct gpio_callback * cb,
    uint32_t pins )
```

If button 4 is pressed, Update Flag 4.

```
void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_4 = 1;
}
```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.2.2.4 K_THREAD_STACK_DEFINE() [1/5]

```
K_THREAD_STACK_DEFINE (
    thread_A1_stack ,
    STACK_SIZE )
```

Create thread stack space

3.2.2.5 K_THREAD_STACK_DEFINE() [2/5]

```
K_THREAD_STACK_DEFINE (
    thread_A_stack ,
    STACK_SIZE )
```

3.2.2.6 K_THREAD_STACK_DEFINE() [3/5]

```
K_THREAD_STACK_DEFINE (
    thread_B_stack ,
    STACK_SIZE )
```

3.2.2.7 K_THREAD_STACK_DEFINE() [4/5]

```
K_THREAD_STACK_DEFINE (
    thread_C_stack ,
    STACK_SIZE )
```

3.2.2.8 K_THREAD_STACK_DEFINE() [5/5]

```
K_THREAD_STACK_DEFINE (
    thread_D_stack ,
    STACK_SIZE )
```

3.2.2.9 main()

```
void main (
    void )
```

Main funtion: Initialize semaphores and configure GPIO_PIN.

```
void main(void) {
    int err=0;
    printf("\n\n Illustration of the use of shmem + semaphores\n\n");
    int ret = 0;
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT1, GPIO_INPUT | GPIO_PULL_UP);
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT2, GPIO_INPUT | GPIO_PULL_UP);
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT4, GPIO_INPUT | GPIO_PULL_UP);
    if (ret < 0) {
        printk("Error %d: Failed to configure BUT 1 \r", ret);
        return;
    }
    ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT1, GPIO_INT_EDGE_TO_ACTIVE);
    ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT2, GPIO_INT_EDGE_TO_ACTIVE);
    ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT4, GPIO_INT_EDGE_TO_ACTIVE);
    if (ret != 0) {
        printk("Error %d: failed to configure interrupt on BUT1 pin \r", ret);
        return;
    }
    gpio_init_callback(&but1_cb_data, but1press_cbfunction, BIT(BOARDBUT1));
    gpio_add_callback(gpio0_dev, &but1_cb_data);
    gpio_init_callback(&but2_cb_data, but2press_cbfunction, BIT(BOARDBUT2));
    gpio_add_callback(gpio0_dev, &but2_cb_data);
    gpio_init_callback(&but4_cb_data, but4press_cbfunction, BIT(BOARDBUT4));
    gpio_add_callback(gpio0_dev, &but4_cb_data);

    err=0;
    uint8_t welcome_mesg[] = "UART demo: Type a few chars in a row and then pause for a little while
        ... \n\n\r";
    uint8_t rep_mesg[TXBUF_SIZE];

    k_sem_init(&sem_ala, 0, 1);
    k_sem_init(&sem_ab, 0, 1);
    k_sem_init(&sem_bc, 0, 1);
    k_sem_init(&sem_bd, 0, 1);

    thread_A1_tid = k_thread_create(&thread_A1_data, thread_A1_stack,
        K_THREAD_STACK_SIZEOF(thread_A1_stack), thread_A1_code,
        NULL, NULL, NULL, thread_A1_prio, 0, K_NO_WAIT);
    thread_A_tid = k_thread_create(&thread_A_data, thread_A_stack,
        K_THREAD_STACK_SIZEOF(thread_A_stack), thread_A_code,
        NULL, NULL, NULL, thread_A_prio, 0, K_NO_WAIT);
    thread_B_tid = k_thread_create(&thread_B_data, thread_B_stack,
        K_THREAD_STACK_SIZEOF(thread_B_stack), thread_B_code,
        NULL, NULL, NULL, thread_B_prio, 0, K_NO_WAIT);
    thread_C_tid = k_thread_create(&thread_C_data, thread_C_stack,
        K_THREAD_STACK_SIZEOF(thread_C_stack), thread_C_code,
        NULL, NULL, NULL, thread_C_prio, 0, K_NO_WAIT);
    thread_D_tid = k_thread_create(&thread_D_data, thread_D_stack,
        K_THREAD_STACK_SIZEOF(thread_D_stack), thread_D_code,
        NULL, NULL, NULL, thread_D_prio, 0, K_NO_WAIT);

    return;
}
```

Parameters

<i>NO_args</i>	without arguments
----------------	-------------------

Returns

No returns

Welcome message

Create and init semaphores

Create tasks

3.2.2.10 thread_A1_code()

```
void thread_A1_code (
    void * argA,
    void * argB,
    void * argC )
```

Thread code prototypes

3.2.2.11 thread_A_code()

```
void thread_A_code (
    void * argA,
    void * argB,
    void * argC )
```

Lê o botão 1, faz o toggle entre o manual e o automatico, sendo periódico.

```
void thread_A_code(void *argA , void *argB, void *argC)
{
    int err=0;

    printk("Thread A init\n");

    adc_dev = device_get_binding(DT_LABEL(ADC_NID));
    if (!adc_dev) {
        printk("ADC device_get_binding() failed\n");
    }
    err = adc_channel_setup(adc_dev, &my_channel_cfg);
    if (err) {
        printk("adc_channel_setup() failed with error code %d\n", err);
    }

    NRF_SAADC->TASKS_CALIBRATEOFFSET = 1;
    while(1) {
        k_sem_take(&sem_ala, K_FOREVER);

        err=adc_sample();
        if(err) {
            printk("adc_sample() failed with error code %d\n",err);
        }
        else {
            if(adc_sample_buffer[0] > 1023) {
                printk("adc reading out of range\n");
            }
            else {
                ab=adc_sample_buffer[0];
            }
        }
        printk("Thread A set ab value to: %d ",ab);

        k_sem_give(&sem_ab);
    }
}
```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

3.2.2.12 thread_B_code()

```
void thread_B_code (
    void * argA,
    void * argB,
    void * argC )
```

É efectuada a filtragem, em que é realizado a média das últimas 10 amostras calculadas na Thread A e o filtro rejeita todos os valores que estejam abaixo ou acima de 10% da média.

```
void thread_B_code(void *argA , void *argB, void *argC)
{
    int Array_dados[len_dados]={0};
    int k=0;
    printk("Thread B init (sporadic, waits on a semaphore by task A)\n");
    while(1) {
        int sumador=0,somador_2=0,media=0, media_filtered=0;
        int contador=0;

        k_sem_take(&sem_ab, K_FOREVER);

        printk("Task B read ab value: %d\n",ab);
        for(int k=len_dados-1; k>0;k--){

            Array_dados[k]= Array_dados[k-1];
        }
        Array_dados[0]= ab;

        for(int i = 0; i < len_dados; i++){
            if(Array_dados[i] != 0){
                sumador = sumador + Array_dados[i];
            }
        }
        media=sumador/len_dados;
        contador=0;

        for(int j = 0; j < len_dados; j++){
            if(Array_dados[j] < (media - media*0.1) || Array_dados[j] > (media + media*0.1))
                somador_2=somador_2;
            else{
                somador_2 = somador_2 + Array_dados[j];
                contador =contador +1;
            }
        }
        if(somador_2 != 0)
            media_filtered=somador_2/contador;
        else
            media_filtered = 0;
        bd=ab;
        printk("Thread B set bc value to: %d\n",bc);
        k_sem_give(&sem_bd);
    }
}
```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

array de dados da adc

3.2.2.13 thread_C_code()

```
void thread_C_code (
    void * argA,
```

```
void * argB,
void * argC )
```

Modo manual, onde se faz o toggle sempre que carregar no botão 2 incrementa a luminosidade, ao clicar no botão 4 a luminosidade decrementa, ou seja, diminui a percentagem do PWM, quando está a 100% está no maximo e o duty-cycle corresponde é de 0%, que é quando está no máximo, e assim sucessivamente.

```
void thread_C_code(void *argA , void *argB, void *argC)
{
    const struct device *gpio0_dev;
    const struct device *pwm0_dev;
    int ret=0;
    unsigned int dcValue[]={100,90,80,70,60,50,40,30,20,10,0};
    unsigned int dcIndex=0;
    unsigned int pwmPeriod_us = 100;
    printk("Thread C init (sporadic, waits on a semaphore by task B)\n");

    gpio0_dev = device_get_binding(DT_LABEL(GPIO0_NID));
    if (gpio0_dev == NULL) {
        printk("Error: Failed to bind to GPIO0\n r");
        return;
    }

    pwm0_dev = device_get_binding(DT_LABEL(PWM0_NID));
    if (pwm0_dev == NULL) {
        printk("Error: Failed to bind to PWM0\n r");
        return;
    }

    while(1) {
        k_sem_take(&sem_bc, K_FOREVER);
        ret=0;

        if(Flag_2) {
            dcIndex++;
            if(dcIndex == 11)
                dcIndex = 0;
            Flag_2 = 0;
            printk("PWM DC value set to %u %%\n r",dcValue[dcIndex]);
            ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                pwmPeriod_us,(unsigned int)((pwmPeriod_us*dcValue[dcIndex])/100), PWM_POLARITY_NORMAL);
            if (ret) {
                printk("Error %d: failed to set pulse width\n", ret);
                return;
            }
        }
        if(Flag_4) {
            if(dcIndex == 0)
                dcIndex = 11;
            dcIndex--;
            Flag_4 = 0;
            printk("PWM DC value set to %u %%\n r",dcValue[dcIndex]);
            ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                pwmPeriod_us,(unsigned int)((pwmPeriod_us*dcValue[dcIndex])/100), PWM_POLARITY_NORMAL);
            if (ret) {
                printk("Error %d: failed to set pulse width\n", ret);
                return;
            }
        }

        printk("Task C - PWM: %u % n", (unsigned int)((pwmPeriod_us*bc)/1023)/10));
    }
}
```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

Prints dutty-cycle

3.2.2.14 thread_D_code()

```
void thread_D_code (
    void * argA,
    void * argB,
    void * argC )
```

Modo automático: Recebe o valor da ADC e faz o take que vem do bd (após a filtragem); Se o valor for menor que 500, o led está apagado, ou seja, é detetada muita luminosidade logo; Quando estamos à luz ambiente o led está com a luminosidade a meio; Se não existir luminosidade o led acede.

```
void thread_D_code(void *argA , void *argB, void *argC)
{
    const struct device *gpio0_dev;
    const struct device *pwm0_dev;
    int ret=0;
    unsigned int dcValue[]={100,90,80,70,60,50,40,30,20,10,0};
    unsigned int dcIndex=0;
    unsigned int pwmPeriod_us = 100;
    printk("Thread C init (sporadic, waits on a semaphore by task B)\n");

    gpio0_dev = device_get_binding(DT_LABEL(GPIO0_NID));
    if (gpio0_dev == NULL) {
        printk("Error: Failed to bind to GPIO0\n r");
        return;
    }

    pwm0_dev = device_get_binding(DT_LABEL(PWM0_NID));
    if (pwm0_dev == NULL) {
        printk("Error: Failed to bind to PWM0\n r");
        return;
    }

    while(1) {
        k_sem_take(&sem_bd, K_FOREVER);
        printk("Valor lido para automatico %d\n r",bd);
        ret=0;

        if(bd<500) {

            ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                pwmPeriod_us, (unsigned int) (pwmPeriod_us), PWM_POLARITY_NORMAL);
            if (ret) {
                printk("Error %d: failed to set pulse width\n", ret);
                return;
            }
        }
        else {

            ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                pwmPeriod_us, (unsigned int) (0), PWM_POLARITY_NORMAL);
            if (ret) {
                printk("Error %d: failed to set pulse width\n", ret);
                return;
            }
        }
    }
}
```

Parameters

<i>NO_args</i>	without arguments
<i>arg3</i>	void *argA , void *argB, void *argC.

Takes one adc_sample

```
static int adc_sample(void)
{
    int ret;
    const struct adc_sequence sequence = {
        .channels = BIT(ADC_CHANNEL_ID),
        .buffer = adc_sample_buffer,
        .buffer_size = sizeof(adc_sample_buffer),
        .resolution = ADC_RESOLUTION,
    };
    if (adc_dev == NULL) {
```



```
        printk("adc_sample(): error, must bind to adc first \r");
        return -1;
    }
    ret = adc_read(adc_dev, &sequence);
    if (ret) {
        printk("adc_read() failed with code %d\n", ret);
    }
    return ret;
}
```

Parameters

<i>NO_args</i>	without arguments
----------------	-------------------

Returns

Read ADC_sample value (static int)

3.2.3 Variable Documentation

3.2.3.1 a1a

```
int a1a =0
```

Global vars (shared memory between tasks A/B and B/C, resp)

3.2.3.2 ab

```
int ab = 0
```

3.2.3.3 adc_dev

```
const struct device* adc_dev = NULL
```

3.2.3.4 bc

```
int bc = 0
```

3.2.3.5 bd

```
int bd = 0
```

3.2.3.6 Flag_1

```
volatile int Flag_1 = 0
```

3.2.3.7 Flag_2

```
volatile int Flag_2 = 0
```

3.2.3.8 Flag_3

```
volatile int Flag_3 = 0
```

3.2.3.9 Flag_4

```
volatile int Flag_4 = 0
```

3.2.3.10 flag_flag

```
volatile bool flag_flag = 0
```

3.2.3.11 gpio0_dev

```
const struct device* gpio0_dev
```

3.2.3.12 my_timer

```
struct k_timer my_timer
```

Global vars

3.2.3.13 rep_mesg

```
uint8_t rep_mesg[TXBUF\_SIZE]
```

3.2.3.14 sem_a1a

```
struct k_sem sem_a1a
```

Semaphores for task synch

3.2.3.15 sem_ab

```
struct k_sem sem_ab
```

3.2.3.16 sem_bc

```
struct k_sem sem_bc
```

3.2.3.17 sem_bd

```
struct k_sem sem_bd
```

3.2.3.18 thread_A1_data

```
struct k_thread thread_A1_data
```

Create variables for thread data

3.2.3.19 thread_A1_tid

```
k_tid_t thread_A1_tid
```

Create task IDs

3.2.3.20 thread_A_data

```
struct k_thread thread_A_data
```

3.2.3.21 thread_A_tid

```
k_tid_t thread_A_tid
```

3.2.3.22 thread_B_data

```
struct k_thread thread_B_data
```

3.2.3.23 thread_B_tid

```
k_tid_t thread_B_tid
```

3.2.3.24 thread_C_data

```
struct k_thread thread_C_data
```

3.2.3.25 thread_C_tid

```
k_tid_t thread_C_tid
```

3.2.3.26 thread_D_data

```
struct k_thread thread_D_data
```

3.2.3.27 thread_D_tid

```
k_tid_t thread_D_tid
```

3.2.3.28 uart_cfg

```
const struct uart_config uart_cfg
```

Initial value:

```
= {  
    .baudrate = 115200,  
    .parity = UART_CFG_PARITY_NONE,  
    .stop_bits = UART_CFG_STOP_BITS_1,  
    .data_bits = UART_CFG_DATA_BITS_8,  
    .flow_ctrl = UART_CFG_FLOW_CTRL_NONE  
}
```

3.2.3.29 uart_dev

```
const struct device* uart_dev
```

3.2.3.30 uart_rx_rdy_flag

```
volatile int uart_rx_rdy_flag
```

3.2.3.31 welcome_mesg

```
uint8_t welcome_mesg[] = "UART demo: Type a few chars in a row and then pause for a little  
while ...\n\r"
```

Main function

3.3 main.h File Reference

Application to control the light intensity of a given region. The system comprises a light sensor, an illumination system and a Human-Machine Interface. The system can operate in two modes: • Automatic: programmable via the terminal. Should allow setting On/Off periods and the corresponding light intensity; • Manual: interface via the DevKit buttons. Allows to turn the system On/Off (when in “Off” the system operates in automatic mode), via two of the buttons. The other two buttons allow to set (increase/decrease) the desired intensity.

Functions

- void [main](#) (void)

Main funtion: Initialize semaphores and configure GPIO_PIN.
- void [thread_A_code](#) (void *argA, void *argB, void *argC)

Lê o botão 1, faz o toggle entre o manual e o automatico, sendo periódico.
- void [thread_A1_code](#) (void *argA, void *argB, void *argC)
- void [thread_B_code](#) (void *argA, void *argB, void *argC)

É efectuada a filtragem, em que é realizado a média das últimas 10 amostras calculadas na Thread A e o filtro rejeita todos os valores que estejam abaixo ou acima de 10% da média.
- void [thread_C_code](#) (void *argA, void *argB, void *argC)

Modo manual, onde se faz o toggle sempre que carregar no botão 2 incrementa a luminosidade, ao clicar no botão 4 a luminosidade decrementa, ou seja, diminui a percentagem do PWM, quando está a 100% está no maximo e o duty-cycle corresponde é de 0%, que é quando está no máximo, e assim succesivamente.
- void [thread_D_code](#) (void *argA, void *argB, void *argC) static int [adc_sample](#)(void)

Modo automático: Recebe o valor da ADC e faz o take que vem do bd (após a filtragem); Se o valor for menor que 500, o led está apagado, ou seja, é detetada muita luminosidade logo; Quando estamos à luz ambiente o led está com a luminosidade a meio; Se não existir luminosidade o led acede.
- void [but1press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)

If button 1 is pressed, Update Flag 1.
- void [but2press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)

If button 2 is pressed, Update Flag 2.
- void [but4press_cbfunction](#) (const struct device *dev, struct gpio_callback *cb, uint32_t pins)

If button 4 is pressed, Update Flag 4.

3.3.1 Detailed Description

Application to control the light intensity of a given region. The system comprises a light sensor, an illumination system and a Human-Machine Interface. The system can operate in two modes: • Automatic: programmable via the terminal. Should allow setting On/Off periods and the corresponding light intensity; • Manual: interface via the DevKit buttons. Allows to turn the system On/Off (when in “Off” the system operates in automatic mode), via two of the buttons. The other two buttons allow to set (increase/decrease) the desired intensity.

Author

Frederico Moreira, Ana Sousa, Pedro Rodrigues

Date

21 June 2022

Bug No known bugs.

3.3.2 Function Documentation

3.3.2.1 but1press_cbfunction()

```
void but1press_cbfunction (
    const struct device * dev,
    struct gpio_callback * cb,
    uint32_t pins )
```

If button 1 is pressed, Update Flag 1.

```
void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_1 = 1;
    flag_flag=!flag_flag;
    printk("but1 \n\r");
}
```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.3.2.2 but2press_cbfunction()

```
void but2press_cbfunction (
    const struct device * dev,
```

```

    struct gpio_callback * cb,
    uint32_t pins )

```

If button 2 is pressed, Update Flag 2.

```

void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_2 = 1;
}

```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.3.2.3 but4press_cbfunction()

```

void but4press_cbfunction (
    const struct device * dev,
    struct gpio_callback * cb,
    uint32_t pins )

```

If button 4 is pressed, Update Flag 4.

```

void but1press_cbfunction(const struct device *dev, struct gpio_callback *cb, uint32_t pins)
{
    Flag_4 = 1;
}

```

Parameters

<i>arg3</i>	const struct device *dev, struct gpio_callback *cb, uint32_t pins.
-------------	--

Returns

No returns

3.3.2.4 main()

```

void main (
    void )

```

Main funtion: Initialize semaphores and configure GPIO_PIN.

```

void main(void) {
    int err=0;
    printf("\n\r Illustration of the use of shmem + semaphores\n\r");
    int ret = 0;
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT1, GPIO_INPUT | GPIO_PULL_UP);
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT2, GPIO_INPUT | GPIO_PULL_UP);
    ret = gpio_pin_configure(gpio0_dev, BOARDBUT4, GPIO_INPUT | GPIO_PULL_UP);
    if (ret < 0) {

```

```

    printk("Error %d: Failed to configure BUT 1 \r", ret);
    return;
}
ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT1, GPIO_INT_EDGE_TO_ACTIVE);
ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT2, GPIO_INT_EDGE_TO_ACTIVE);
ret = gpio_pin_interrupt_configure(gpio0_dev, BOARDBUT4, GPIO_INT_EDGE_TO_ACTIVE);
if (ret != 0) {
    printk("Error %d: failed to configure interrupt on BUT1 pin \r", ret);
    return;
}
gpio_init_callback(&but1_cb_data, but1press_cbfunction, BIT(BOARDBUT1));
gpio_add_callback(gpio0_dev, &but1_cb_data);
gpio_init_callback(&but2_cb_data, but2press_cbfunction, BIT(BOARDBUT2));
gpio_add_callback(gpio0_dev, &but2_cb_data);
gpio_init_callback(&but4_cb_data, but4press_cbfunction, BIT(BOARDBUT4));
gpio_add_callback(gpio0_dev, &but4_cb_data);

err=0;
uint8_t welcome_mesg[] = "UART demo: Type a few chars in a row and then pause for a little while
    ...\n\r";
uint8_t rep_mesg[TXBUF_SIZE];

k_sem_init(&sem_a1a, 0, 1);
k_sem_init(&sem_ab, 0, 1);
k_sem_init(&sem_bc, 0, 1);
k_sem_init(&sem_bd, 0, 1);

    thread_A1_tid = k_thread_create(&thread_A1_data, thread_A1_stack,
        K_THREAD_STACK_SIZEOF(thread_A1_stack), thread_A1_code,
        NULL, NULL, NULL, thread_A1_prio, 0, K_NO_WAIT);
    thread_A_tid = k_thread_create(&thread_A_data, thread_A_stack,
        K_THREAD_STACK_SIZEOF(thread_A_stack), thread_A_code,
        NULL, NULL, NULL, thread_A_prio, 0, K_NO_WAIT);
    thread_B_tid = k_thread_create(&thread_B_data, thread_B_stack,
        K_THREAD_STACK_SIZEOF(thread_B_stack), thread_B_code,
        NULL, NULL, NULL, thread_B_prio, 0, K_NO_WAIT);
    thread_C_tid = k_thread_create(&thread_C_data, thread_C_stack,
        K_THREAD_STACK_SIZEOF(thread_C_stack), thread_C_code,
        NULL, NULL, NULL, thread_C_prio, 0, K_NO_WAIT);
    thread_D_tid = k_thread_create(&thread_D_data, thread_D_stack,
        K_THREAD_STACK_SIZEOF(thread_D_stack), thread_D_code,
        NULL, NULL, NULL, thread_D_prio, 0, K_NO_WAIT);

    return;
}

```

Parameters

<i>NO_args</i>	without arguments
----------------	-------------------

Returns

No returns

Welcome message

Create and init semaphores

Create tasks

3.3.2.5 thread_A1_code()

```

void thread_A1_code (
    void * argA,
    void * argB,
    void * argC )

```


Lê o valor da ADC e guarda numa variável global (shared memory between tasks A/B) no nosso Código denominada por “ab” e no final faz give do semáforo AB. É o valor da ADC que é guardado numa variável global (shared memory between tasks A/B) no nosso Código denominada por “ab” e no final faz give do semáforo AB.

```
void thread_A1_code(void *argA , void *argB, void *argC)
{
```

```
    int64_t fin_time=0, release_time=0;
    int err=0;
    printk("Thread A1 init (periodic)\n");

    release_time = k_uptime_get() + SAMP_PERIOD_MS;
    while(1) {

        if (flag_flag==0){
            printk("Modo manual\n");
            printk("Modo key 2 e 4\n");
            k_sem_give(&sem_bc);}

        else{

            printk("Modo automatico\n");

            k_sem_give(&sem_ala);
        }
        fin_time = k_uptime_get();
        if( fin_time < release_time) {
            k_msleep(release_time - fin_time);
            release_time += SAMP_PERIOD_MS;
        }
    }
}
```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

Thread code prototypes

3.3.2.6 thread_A_code()

```
void thread_A_code (
    void * argA,
    void * argB,
    void * argC )
```

Lê o botao 1, faz o toggle entre o manual e o automatico, sendo periódico.

```
void thread_A_code(void *argA , void *argB, void *argC)
{
    int err=0;

    printk("Thread A init\n");

    adc_dev = device_get_binding(DT_LABEL(ADC_NID));
    if (!adc_dev) {
        printk("ADC device_get_binding() failed\n");
    }
    err = adc_channel_setup(adc_dev, &my_channel_cfg);
    if (err) {
        printk("adc_channel_setup() failed with error code %d\n", err);
    }

    NRF_SAADC->TASKS_CALIBRATEOFFSET = 1;
    while(1) {
```

```

    k_sem_take(&sem_a1a, K_FOREVER);

    err=adc_sample();
    if(err) {
        printk("adc_sample() failed with error code %d\n",err);
    }
    else {
        if(adc_sample_buffer[0] > 1023) {
            printk("adc reading out of range\n");
        }
        else {

            ab=adc_sample_buffer[0];
        }
    }
    printk("Thread A set ab value to: %d ",ab);

    k_sem_give(&sem_ab);

}
}

```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

3.3.2.7 thread_B_code()

```

void thread_B_code (
    void * argA,
    void * argB,
    void * argC )

```

É efectuada a filtragem, em que é realizado a média das últimas 10 amostras calculadas na Thread A e o filtro rejeita todos os valores que estejam abaixo ou acima de 10% da média.

```

void thread_B_code(void *argA , void *argB, void *argC)
{
    int Array_dados[len_dados]={0};
    int k=0;
    printk("Thread B init (sporadic, waits on a semaphore by task A)\n");
    while(1) {
        int sumador=0,somador_2=0,media=0, media_filtered=0;
        int contador=0;

        k_sem_take(&sem_ab, K_FOREVER);

        printk("Task B read ab value: %d\n",ab);
        for(int k=len_dados-1; k>0;k--){

            Array_dados[k]= Array_dados[k-1];
        }
        Array_dados[0]= ab;

        for(int i = 0; i < len_dados; i++){
            if(Array_dados[i] != 0){
                sumador = sumador + Array_dados[i];
            }
        }
        media=sumador/len_dados;
        contador=0;

        for(int j = 0; j < len_dados; j++){
            if(Array_dados[j] < (media - media*0.1) || Array_dados[j] > (media + media*0.1))

```

```

        somador_2=somador_2;
    else{
        somador_2 = somador_2 + Array_dados[j];
        contador =contador +1;
    }
}
if(somador_2 != 0)
    media_filtered=somador_2/contador;
else
    media_filtered = 0;
bd=ab;
printk("Thread B set bc value to: %d\n",bc);
k_sem_give(&sem_bd);
}
}

```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

array de dados da adc

3.3.2.8 thread_C_code()

```

void thread_C_code (
    void * argA,
    void * argB,
    void * argC )

```

Modo manual, onde se faz o toggle sempre que carregar no botão 2 incrementa a luminosidade, ao clicar no botão 4 a luminosidade decrementa, ou seja, diminui a percentagem do PWM, quando está a 100% está no maximo e o duty-cycle corresponde é de 0%, que é quando está no máximo, e assim sucessivamente.

```

void thread_C_code(void *argA , void *argB, void *argC)
{
    const struct device *gpio0_dev;
    const struct device *pwm0_dev;
    int ret=0;
    unsigned int dcValue[]={100,90,80,70,60,50,40,30,20,10,0};
    unsigned int dcIndex=0;
    unsigned int pwmPeriod_us = 100;
    printk("Thread C init (sporadic, waits on a semaphore by task B)\n");

    gpio0_dev = device_get_binding(DT_LABEL(GPIO0_NID));
    if (gpio0_dev == NULL) {
        printk("Error: Failed to bind to GPIO0\nr");
        return;
    }

    pwm0_dev = device_get_binding(DT_LABEL(PWM0_NID));
    if (pwm0_dev == NULL) {
        printk("Error: Failed to bind to PWM0\n r");
        return;
    }

    while(1) {
        k_sem_take(&sem_bc, K_FOREVER);
        ret=0;

        if(Flag_2) {
            dcIndex++;
            if(dcIndex == 11)
                dcIndex = 0;
            Flag_2 = 0;
            printk("PWM DC value set to %u %%\nr",dcValue[dcIndex]);
            ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                pwmPeriod_us, (unsigned int)((pwmPeriod_us*dcValue[dcIndex])/100), PWM_POLARITY_NORMAL);

```

```

        if (ret) {
            printk("Error %d: failed to set pulse width\n", ret);
            return;
        }
    }
    if(Flag_4) {
        if(dcIndex == 0)
            dcIndex = 11;
        dcIndex--;
        Flag_4 = 0;
        printk("PWM DC value set to %u %%\n\r",dcValue[dcIndex]);
        ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
            pwmPeriod_us, (unsigned int)((pwmPeriod_us*dcValue[dcIndex])/100), PWM_POLARITY_NORMAL);
        if (ret) {
            printk("Error %d: failed to set pulse width\n", ret);
            return;
        }
    }

    printk("Task C - PWM: %u % n", (unsigned int)((pwmPeriod_us*bc)/1023)/10));
}
}

```

Parameters

<i>arg3</i>	void *argA , void *argB, void *argC.
-------------	--------------------------------------

Returns

No returns

Prints dutty-cycle

3.3.2.9 thread_D_code()

```

void thread_D_code (
    void * argA,
    void * argB,
    void * argC )

```

Modo automático: Recebe o valor da ADC e faz o take que vem do bd (após a filtragem); Se o valor for menor que 500, o led está apagado, ou seja, é detetada muita luminosidade logo; Quando estamos à luz ambiente o led está com a luminosidade a meio; Se não existir luminosidade o led acede.

```

void thread_D_code(void *argA , void *argB, void *argC)
{
    const struct device *gpio0_dev;
    const struct device *pwm0_dev;
    int ret=0;
    unsigned int dcValue[]={100,90,80,70,60,50,40,30,20,10,0};
    unsigned int dcIndex=0;
    unsigned int pwmPeriod_us = 100;
    printk("Thread C init (sporadic, waits on a semaphore by task B)\n");

    gpio0_dev = device_get_binding(DT_LABEL(GPIO0_NID));
    if (gpio0_dev == NULL) {
        printk("Error: Failed to bind to GPIO0\n\r");
        return;
    }

    pwm0_dev = device_get_binding(DT_LABEL(PWM0_NID));
    if (pwm0_dev == NULL) {
        printk("Error: Failed to bind to PWM0\n r");
        return;
    }

    while(1) {
        k_sem_take(&sem_bd, K_FOREVER);
        printk("Valor lido para automatico %d\n r",bd);
        ret=0;
    }
}

```

```

    if (bd < 500) {
        ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                               pwmPeriod_us, (unsigned int) (pwmPeriod_us), PWM_POLARITY_NORMAL);
        if (ret) {
            printk("Error %d: failed to set pulse width\n", ret);
            return;
        }
    }
    else {
        ret = pwm_pin_set_usec(pwm0_dev, BOARDLED1,
                               pwmPeriod_us, (unsigned int) (0), PWM_POLARITY_NORMAL);
        if (ret) {
            printk("Error %d: failed to set pulse width\n", ret);
            return;
        }
    }
}
}

```

Parameters

<i>NO_args</i>	without arguments
<i>arg3</i>	void *argA , void *argB, void *argC.

Takes one adc_sample

```

static int adc_sample(void)
{
    int ret;
    const struct adc_sequence sequence = {
        .channels = BIT(ADC_CHANNEL_ID),
        .buffer = adc_sample_buffer,
        .buffer_size = sizeof(adc_sample_buffer),
        .resolution = ADC_RESOLUTION,
    };
    if (adc_dev == NULL) {
        printk("adc_sample(): error, must bind to adc first \r");
        return -1;
    }
    ret = adc_read(adc_dev, &sequence);
    if (ret) {
        printk("adc_read() failed with code %d\n", ret);
    }
    return ret;
}

```

Parameters

<i>NO_args</i>	without arguments
----------------	-------------------

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