RGB LED Brightness control

RGB LED brightness control based on TivaC board with a push button and GPT module.

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1. Project Introduction

This project involves developing the GPT Driver and using it to control RGB LED Brightness on the TivaC board based using the push button, led and GPT Module.

2. High Level Design

2.1. System Architecture

2.1.1. Definition

Layered Architecture (*Figure 1*) describes an architectural pattern composed of several separate horizontal layers that function together as a single unit of software.

Microcontroller Abstraction Layer (*MCAL*) is a software module that directly accesses on-chip MCU peripheral modules and external devices that are mapped to memory, and makes the upper software layer independent of the MCU.

Hardware Abstraction Layer (*HAL*) is a layer of programming that allows a computer OS to interact with a hardware device at a general or abstract level rather than at a detailed hardware level.

2.1.2. Layered Architecture

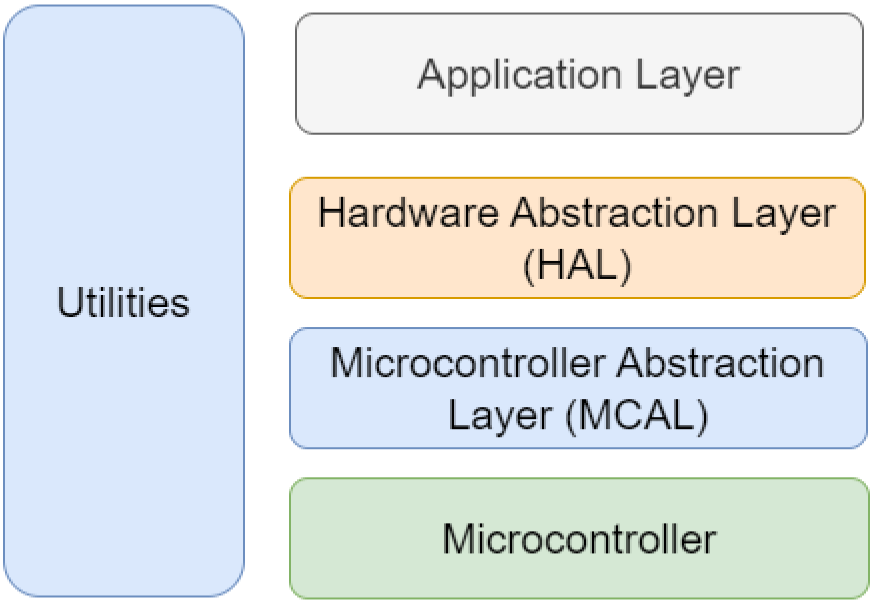

Utilities
Application Layer
Hardware Abstraction Layer (HAL)
Microcontroller Abstraction Layer (MCAL)
Microcontroller

Figure 1. Layered Architecture Design

2.1.3. System Modules

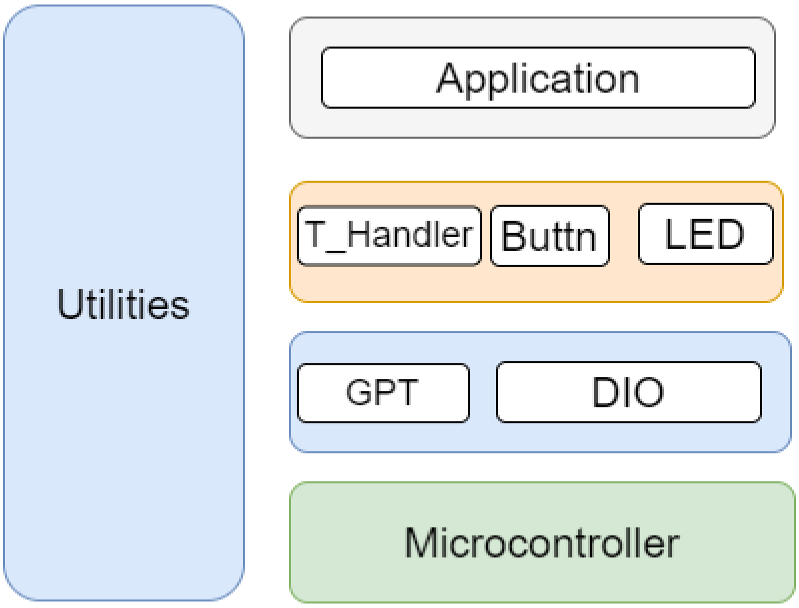


Figure 2. System Module Design

2.2. Modules Description

2.2.1. GPIO Module

The ***GPIO***, or ***General Purpose Input/Output***, is a simple form of interface used in a wide range of systems to effectively relay digital signals from sensors, transducers and mechanical equipment to other electrical circuits and devices.
Sometimes referred to as Digital Input/Output (DIO), GPIOutilizes a logic signal to transfer information.

2.2.3. Button Module

The ***Button*** can be considered the simplest input peripheral that can be connected to a microcontroller. Because of that, usually, every embedded development board is equipped with a button marked as "User Button" and this means it is actually connected to a GPIO pin you can read via software.

2.2.3. Led Module

The ***Led*** can be considered the simplest output peripheral that can be connected to a microcontroller. Because of that, usually, every embedded development board is equipped with a led marked as "Led" and this means it is actually connected to a GPIO pin you can turn it on or off or even toggle led via software.

2.2.4. GPT Module

A ***GPT*** (***General Purpose Timer***) module is a programmable timer that can be used to count or time external events that drive the Timer input pins. The TM4C123GH6PM General-Purpose Timer Module (GPTM) contains six 16/32-bit GPTM blocks and six 32/64-bit Wide GPTM blocks. Each 16/32-bit GPTM block provides two 16-bit timers/counters (referred to as Timer A and Timer B) that can be configured to operate independently as timers or event counters, or concatenated to operate as one 32-bit timer or one 32-bit Real-Time Clock (RTC). Each 32/64-bit Wide GPTM block provides 32-bit timers for Timer A and Timer B that can be concatenated to operate as a 64-bit timer. Timers can also be used to trigger µDMA transfers.

2.2.5. T_Handler Module

A ***T_Handler*** (***Timer Handle***r) module is a programmable handler that can be used to control the GPT driver from the HAL layer without calling the GPT in the APP Layer.

2.3. Drivers' Documentation (APIs)

2.3.1 Definition

An *API* is an *Application Programming Interface* that defines a set of *routines*, *protocols* and *tools* for creating an application. An *API* defines the high level interface of the behavior and capabilities of the component and its inputs and outputs.

An *API* should be created so that it is generic and implementation independent. This allows for the API to be used in multiple applications with changes only to the implementation of the API and not the general interface or behavior.

2.3.2. MCAL APIs

2.3.2.1. GPIO Driver

```
|@name       : GPIO_init
|@berif      : this function initialies GPIO pin as ( OUTPUT , INPUT OR INTERRUPT )
|@param[in]  : pointer to str_GPIO_configs_t type with desired option
               [REQUIRED OPTOINS]
               - enu_port_num          : Select Port Number
               - enu_pin_num           : Select Pin Number
               - enu_pin_direction     : Select Pin Direction
               - enu_pin_mode          : Select Pin Mode
              [Case Output]
               - enu_pin_level         : Select Output level
               - enu_pin_out_current   : Select output current
              [Case Input]
              - enu_pin_internal_type          : Select Internal attach type
              - bool_use_interrupt             : Select if it is interrupt or not
              - enu_GPIO_pin_event_trigger : Select sense trigger
              - ptr_GPIO_cb                    : Set call back to upper layer

|@return    : GPIO_OKAY                  (In case of success initialization)
              GPIO_NULL_REF              (In case of Null pointer argument )
              GPIO_PORT_ERROR            (In case of Invalid port number   )
              GPIO_PIN_ERROR             (In case of Invalid pin nimber    )
              GPIO_DIRECTION_ERROR  (In case of Invalid pin direction )
              GPIO_MODE_ERROR            (In case of Invalid mode selection)
              GPIO_OUT_CURRENT_ERROR       (In case of Invalid output current)
              GPIO_INTERNAL_TYPE_ERROR     (In case of Invalid internal type )
              GPIO_LEVEL_ERROR             (In case of Invalid output level  )
              GPIO_EVENT_TRIGGER_ERROR     (In case of Invalid sense trigger )
              GPIO_NULL_CB_REF              (In case of Null pointer to cbf   )
|
```

```
enu_GPIO_status_t GPIO_init(str_GPIO_configs_t  *ptr_GPIO_configs);
```

```
| write the desired digital logic on the pin
|Parameters
|                [in] arg_port_num    the desired port for initializing the port.
|                [in] arg_pin_num     the desired pin inside the pin..
|                [in] ptr__value      apply the desired logic level..
| Return
|                An enu_GPIO_status_t value indicating the success or failure of
|                the operation (GPIO_OK if the operation succeeded, GPIO_ERROR
|                otherwise)
|
```

```
enu_GPIO_status_t GPIO_write( enu_GPIO_port_num_t  arg_port_num,
                              enu_GPIO_pin_num_t  arg_pin_num,
                              boolean  *ptr_value);
```

```
| Read the applied digital logic on the pin
|Parameters
|                       [in] arg_port_num     the desired port for initializing the port.
|                       [in] arg_pin_num      the desired pin inside the pin..
|                       [in] ptr__value       stores the pin current logic..
| Return
|                       An enu_GPIO_status_t value indicating the success or failure of
|                       the operation (GPIO_OK if the operation succeeded, GPIO_ERROR otherwise)
|
enu_GPIO_status_t GPIO_read( enu_GPIO_port_num_t  arg_port_num,
                             enu_GPIO_pin_num_t  arg_pin_num,
                             boolean  *ptr_value);
| toggle digital logic on the pin
|Parameters
|                       [in] arg_port_num     the desired port for initializing the port.
|                       [in] arg_pin_num      the desired pin inside the pin..
|
| Return
|                       An enu_GPIO_status_t value indicating the success or failure of
|                       the operation (GPIO_OK if the operation succeeded, GPIO_ERROR
|                       otherwise)
|
enu_GPIO_status_t GPIO_toggle( enu_GPIO_port_num_t  arg_port_num,
                               enu_GPIO_pin_num_t  arg_pin_num);
| Enable the desired interrupt on the pin
|Parameters
|                       [in] arg_port_num     the desired port for initializing the port.
|                       [in] arg_pin_num      the desired pin inside the pin..
| Return                void
|
void GPIO_enable_interrupt( enu_GPIO_port_num_t  arg_port_num,
                            enu_GPIO_pin_num_t  arg_pin_num);
| Enable the desired interrupt on the pin
|Parameters
|                       [in] arg_port_num     the desired port for initializing the port.
|                       [in] arg_pin_num      the desired pin inside the pin..
| Return                void
|
void GPIO_disable_interrupt( enu_GPIO_port_num_t  arg_port_num,
                             enu_GPIO_pin_num_t  arg_pin_num);
```

2.3.2.2. GPT Driver

```
| Initializing the GPT Module
|Parameters
|                       none
| Return
|                        An enu_GPT_status_t value indicating the success or failure of
|                       the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                       otherwise)
enu_GPT_status_t GPT_init(str_GPT_configs_t * ptr_GPT_configs );
|Start the timer
|Parameters
```

```
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                   [in] u32_arg_time     the desired delay .
|                   [in] enu_arg_time_unit     the desired delay unit.
|
| Return
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
|
enu_GPT_status_t GPT_start_timer(enu_GPT_timer_select_t  enu_arg_GPT_timer_select,
                                 unit32_t                u32_arg_time,
                                  enu_time_unit_t enu_arg_time_unit );


| get the elapsed time
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                   [in] u32_ptr_time                    pointer to variable to store the remaining time.
| Return
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
|
enu_GPT_status_t GPT_get_elapsed_time(
                                            enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                             unit32_t                     *u32_ptr_time  );

|get the remaining timer
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|
| Return
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
|
enu_GPT_status_t GPT_get_remaining_time(
                                            enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                             unit32_t                     *u32_ptr_time  );


| enable the GPT interrupt
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
| Return
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
|
enu_GPT_status_t  GPT_enable_interrupt(
                                            enu_GPT_timer_select_t enu_arg_GPT_timer_select   );
```

```
| disable the GPT interrupt
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
enu_GPT_status_t  GPT_disable_interrupt(
                                                enu_GPT_timer_select_t enu_arg_GPT_timer_select   );
|stop the timer
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|
| Return
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
enu_GPT_status_t GPT_stop_timer(
                                                enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                                 );

|set the PWM
|Parameters
|                   [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                   [in] u16_arg_signal_duration_ms   the desired period.
|                   [in] u8_arg_duty_cycle    the desired duty cycle.
|
| Return
|                    An enu_GPT_status_t value indicating the success or failure of
|                   the operation (GPT_OK if the operation succeeded, GPT_ERROR
|                   otherwise)
|
enu_GPT_status_t GPT_set_pwm(
                                  enu_GPT_timer_select_t  enu_arg_GPT_timer_select,
                                    uint16_t             u16_arg_signal_duration_ms,
                                     uint8_t u8_arg_duty_cycle);
```

2.3.3. HAL APIs

2.3.3.1 LED Driver

```
| Initializing the desired led_pin as output
|Parameters
|                   none
| Return
|     An enu_led_error_t value indicating the success or failure of
|                   the operation (LED_OK if the operation succeeded, LED_ERROR
|          otherwise)
|
enu_led_error_t LED_init(void);
```

```
| Turn the LED on
|Parameters
|                       [in] uint8_t_led_id
| Return
|     An enu_led_error_t value indicating the success or failure of
|                       the operation (LED_OK if the operation succeeded, LED_ERROR
|           otherwise)
|
enu_led_error_t LED_on(uint8_t uint8_led_id);
```

```
| Turn the LED off
|Parameters
|                       [in] uint8_t_led_id
| Return
|     An enu_led_error_t value indicating the success or failure of
|                       the operation (LED_OK if the operation succeeded, LED_ERROR
|           otherwise)
|
enu_led_error_t LED_off(uint8_t uint8_led_id);
```

```
| Toggle the LED
|Parameters
|                       [in] uint8_t_led_id
| Return
|     An enu_led_error_t value indicating the success or failure of
|                       the operation (LED_OK if the operation succeeded, LED_ERROR
|           otherwise)
|
enu_led_error_t LED_toggle(uint8_t uint8_led_id);
```

2.3.3.2 Button Driver

```
| Initializing the desired pin as input
|Parameters
|                       [in] uint8_port     the desired port for initializing the pin.
|                       [in] uint8_pin      the desired pin inside the port..
| Return
|     An enu_buttn_error_t value indicating the success or failure of
|                       the operation (BUTTN_OK ) if the operation succeeded, BUTTN_ERROR
|           otherwise)
|
enu_buttn_error_t  BUTTN_init(void);
```

```
| Read the button status
|Parameters
|                  [in] uint8_button_id
| Return
|    An enu_buttn_error_t value indicating the success or failure of
|                  the operation (BUTTN_OK  if the operation succeeded, BUTTN_ERROR
|         otherwise)
enu_buttn_error_t BUTTN_read(uint8_t uint8_button_id);
```

2.3.3.3 T_Handler Driver

```
| Initializing the GPT Module
|Parameters
|                  none
| Return
|                   An enu_handler_error_status_tvalue indicating the success or failure of
|                  the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                  otherwise)
|
enu_handler_error_status_t HANDLER_init(str_GPT_configs_t * ptr_GPT_configs );

|Start the handler
|Parameters
|                  [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                  [in] u32_arg_time    the desired delay .
|                  [in] enu_arg_time_unit     the desired delay unit.
|
| Return
|                   An enu_handler_error_status_tvalue indicating the success or failure of
|                  the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                  otherwise)
|
enu_handler_error_status_t HANDLER_start_timer(
                              enu_GPT_timer_select_t  enu_arg_GPT_timer_select,
                                unit32_t              u32_arg_time,
                                 enu_time_unit_t enu_arg_time_unit );

|stop the timer
|Parameters
|                  [in] enu_arg_GPT_timer_select    the desired GPT channel.
|
| Return
|                   An enu_handler_error_status_tvalue indicating the success or failure of
|                  the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                  otherwise)
|
enu_handler_error_status_t HANDLER_stop_timer(
                                          enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                           );
```

```
| get the elapsed time
|Parameters
|                    [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                    [in] u32_ptr_time                pointer to variable to store the remaining time.
| Return
|                     An enu_handler_error_status_tvalue indicating the success or failure of
|                    the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                    otherwise)
|
enu_handler_error_status_t HANDLER_get_elapsed_time(
                                        enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                         unit32_t              *u32_ptr_time  );
```

```
|get the remaining timer
|Parameters
|                    [in] enu_arg_GPT_timer_select    the desired GPT channel.
|
| Return
|                     An enu_handler_error_status_tvalue indicating the success or failure of
|                    the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                    otherwise)
|
enu_handler_error_status_t HANDLER_get_remaining_time(
                                        enu_GPT_timer_select_t enu_arg_GPT_timer_select,
                                         unit32_t              *u32_ptr_time  );
```

```
| enable the GPT interrupt
|Parameters
|                    [in] enu_arg_GPT_timer_select    the desired GPT channel.
| Return
|                     An enu_handler_error_status_tvalue indicating the success or failure of
|                    the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                    otherwise)
|
enu_handler_error_status_t  HANDLER_enable_interrupt(
                                        enu_GPT_timer_select_t enu_arg_GPT_timer_select   );
| disable the GPT interrupt
|Parameters
|                     An enu_handler_error_status_tvalue indicating the success or failure of
|                    the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                    otherwise)
|
enu_handler_error_status_t HANDLER_disable_interrupt(
                                        enu_GPT_timer_select_t enu_arg_GPT_timer_select   );
```

```
|set the PWM
|Parameters
|                    [in] enu_arg_GPT_timer_select    the desired GPT channel.
|                    [in] u16_arg_signal_duration_ms   the desired period.
|                    [in] u8_arg_duty_cycle    the desired duty cycle.
|
| Return
|                     An enu_handler_error_status_tvalue indicating the success or failure of
|                    the operation (Handler_OK if the operation succeeded, Handler_ERROR
|                    otherwise)
|
enu_handler_error_status_t HANDLER_set_pwm(
                                    enu_GPT_timer_select_t  enu_arg_GPT_timer_select,
                                      uint16_t               u16_arg_signal_duration_ms,
                                       uint8_t               u8_arg_duty_cycle);
```

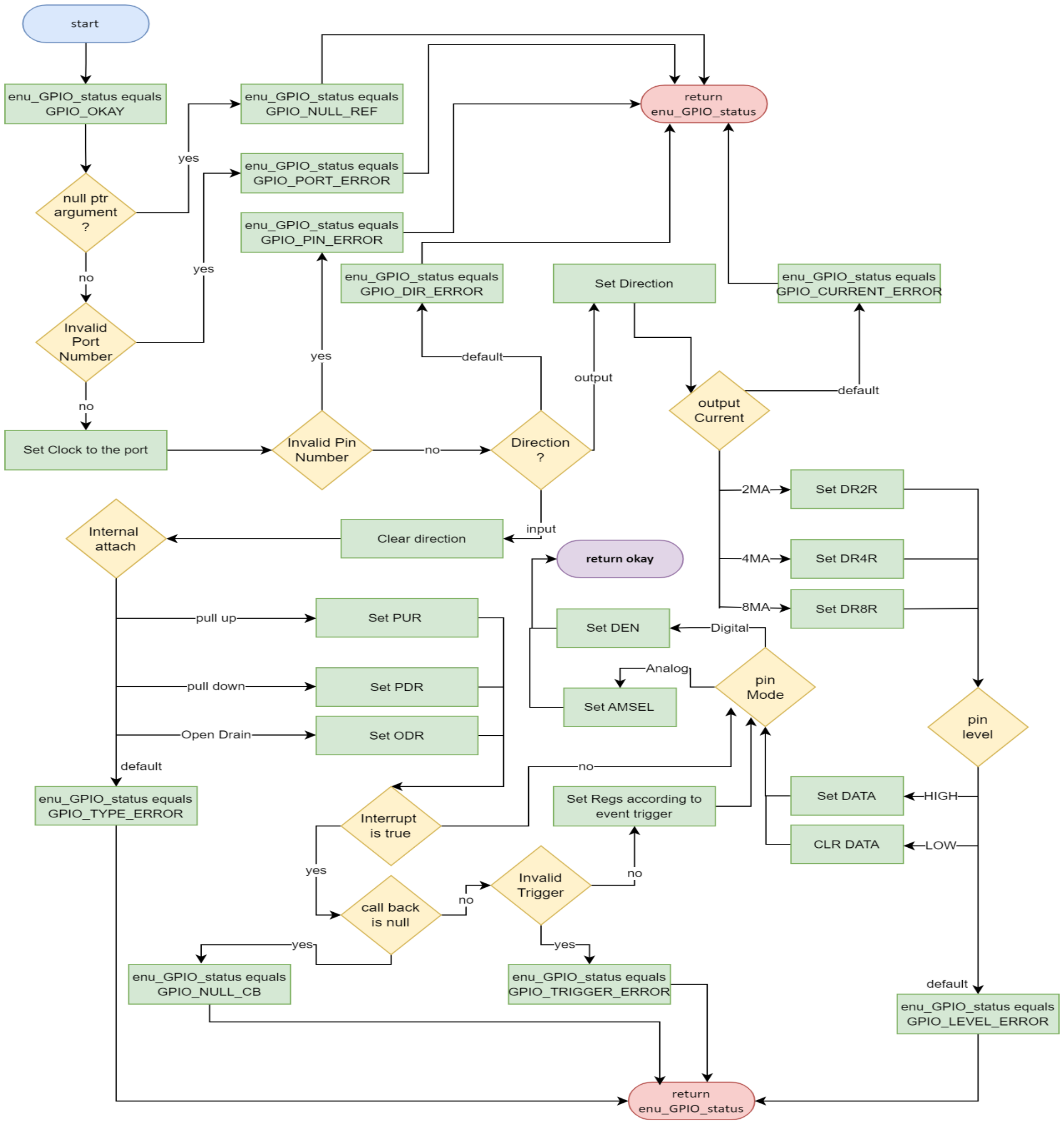
3.Low Level Design

3.1. MCAL Flowcharts

3.1.1 GPIO Module

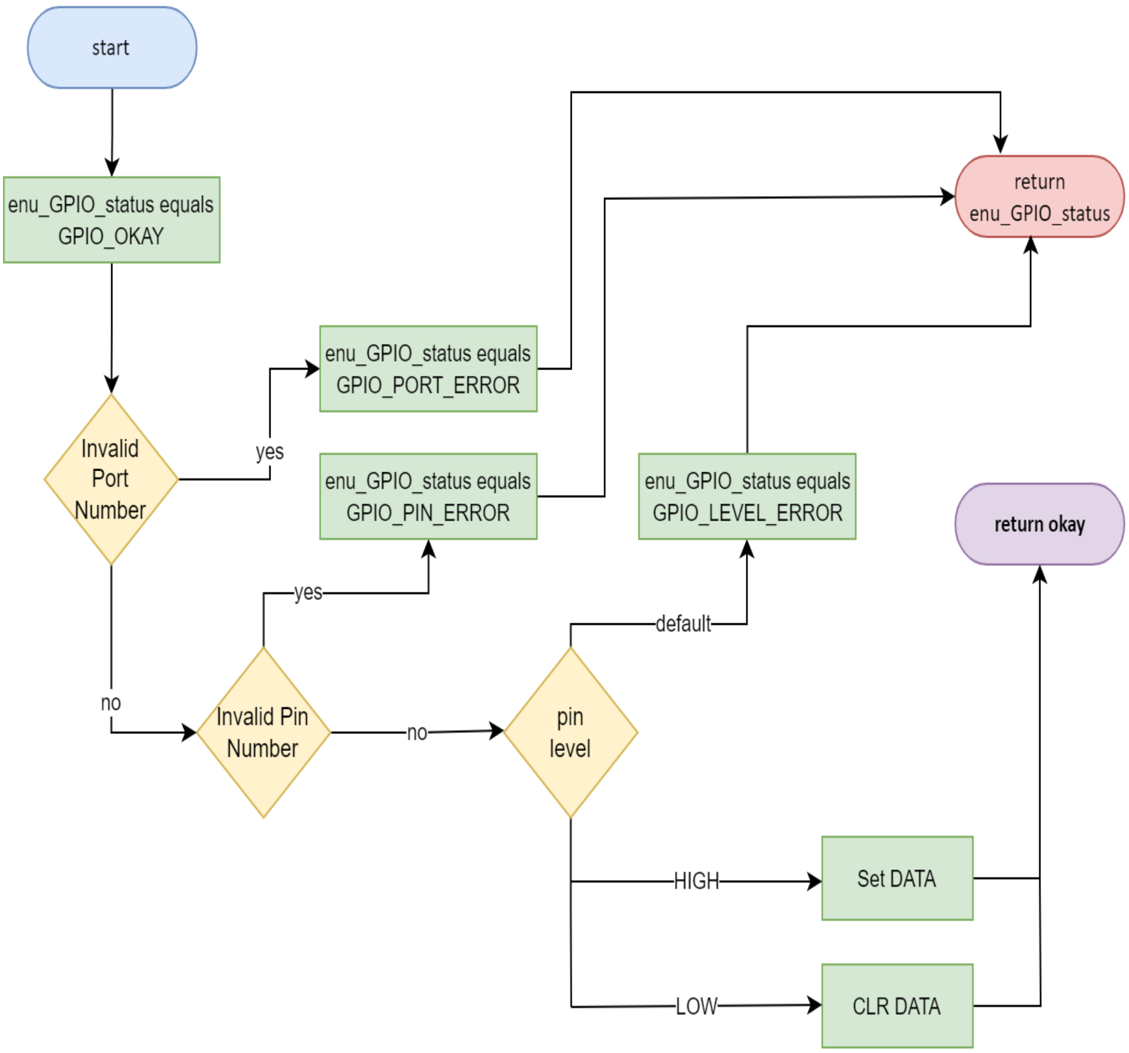
3.1.1.1 GPIO_init

enu_GPIO_status_t **GPIO_init** (str_GPIO_configs_t *ptr_GPIO_configs);



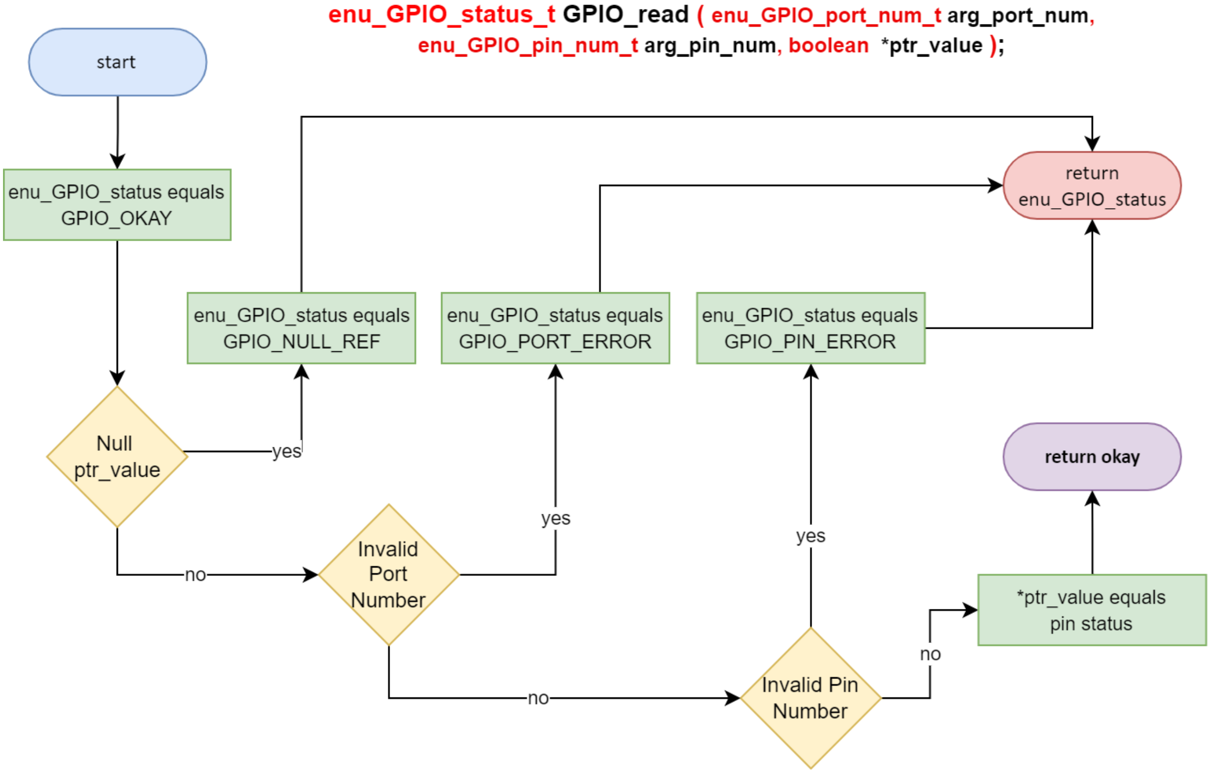
3.1.1.2 GPIO_write

enu_GPIO_status_t GPIO_write (enu_GPIO_port_num_t arg_port_num, enu_GPIO_pin_num_t arg_pin_num, enu_GPIO_pin_level_t arg_level);


start
enu_GPIO_status equals GPIO_OKAY
Invalid Port Number
yes
enu_GPIO_status equals GPIO_PORT_ERROR
no
Invalid Pin Number
yes
enu_GPIO_status equals GPIO_PIN_ERROR
no
pin level
default
enu_GPIO_status equals GPIO_LEVEL_ERROR
return enu_GPIO_status
HIGH
Set DATA
LOW
CLR DATA
return okay

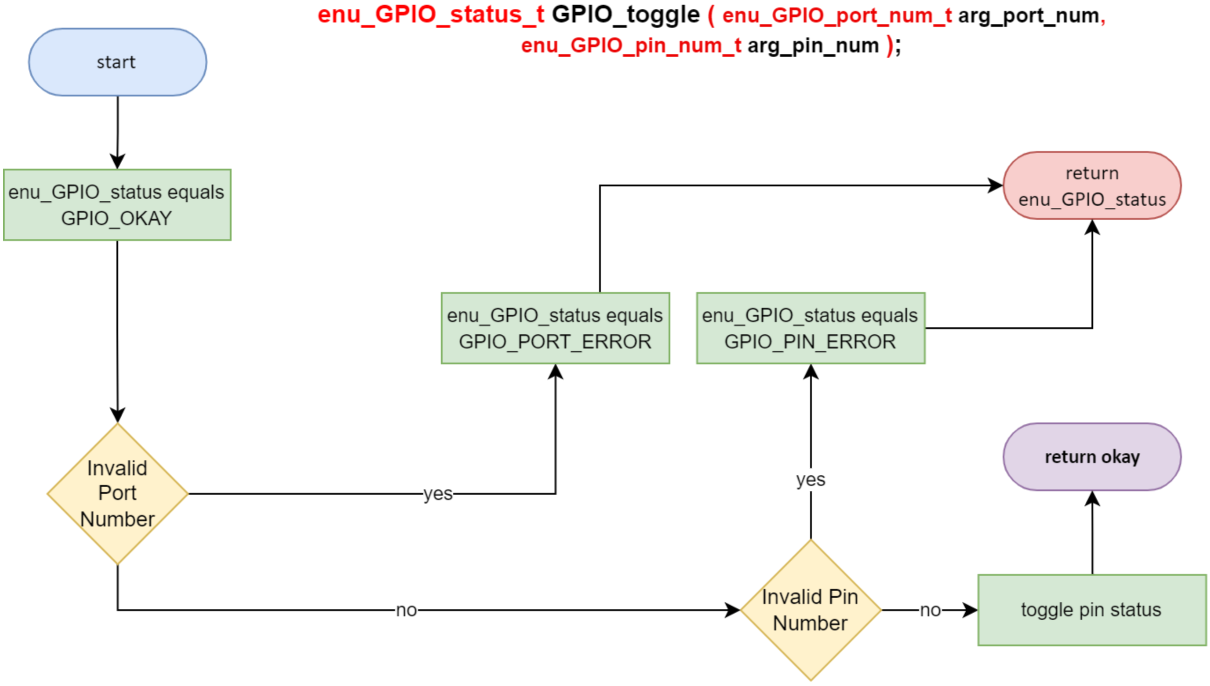
3.1.1.3 GPIO_read

enu_GPIO_status_t GPIO_read (enu_GPIO_port_num_t arg_port_num, enu_GPIO_pin_num_t arg_pin_num, boolean *ptr_value);


start
enu_GPIO_status equals GPIO_OKAY
Null ptr_value
yes
no
enu_GPIO_status equals GPIO_NULL_REF
Invalid Port Number
yes
no
enu_GPIO_status equals GPIO_PORT_ERROR
Invalid Pin Number
yes
no
enu_GPIO_status equals GPIO_PIN_ERROR
*ptr_value equals pin status
return enu_GPIO_status
return okay

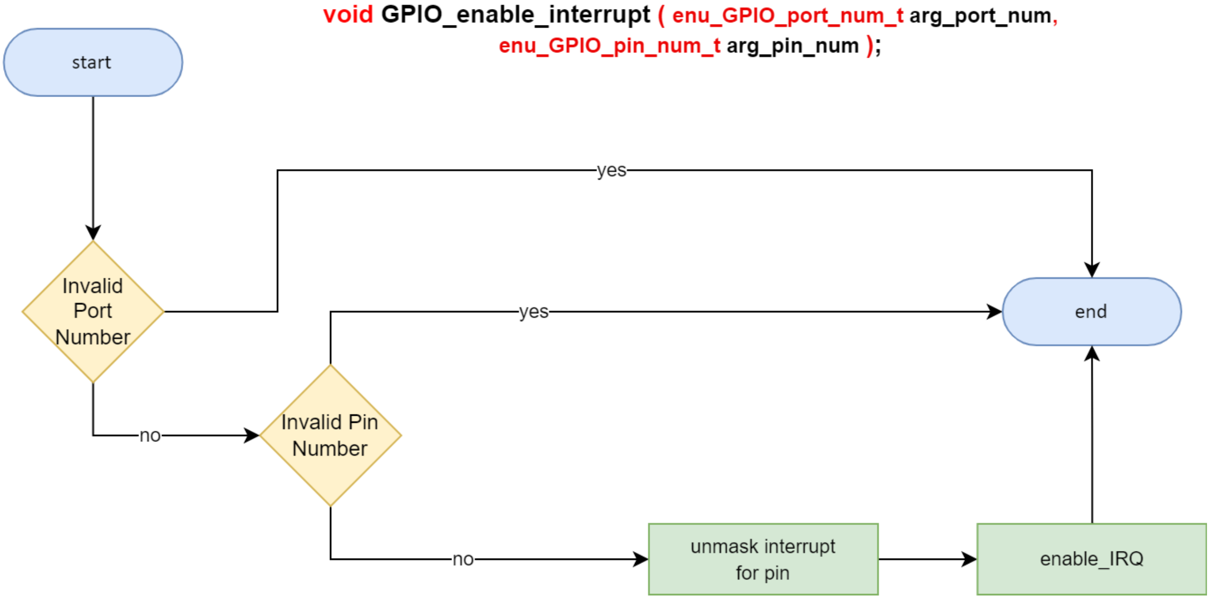
3.1.1.4 GPIO_toggle

enu_GPIO_status_t GPIO_toggle (enu_GPIO_port_num_t arg_port_num, enu_GPIO_pin_num_t arg_pin_num);


start
enu_GPIO_status equals GPIO_OKAY
Invalid Port Number
yes
no
enu_GPIO_status equals GPIO_PORT_ERROR
Invalid Pin Number
yes
no
enu_GPIO_status equals GPIO_PIN_ERROR
toggle pin status
return enu_GPIO_status
return okay

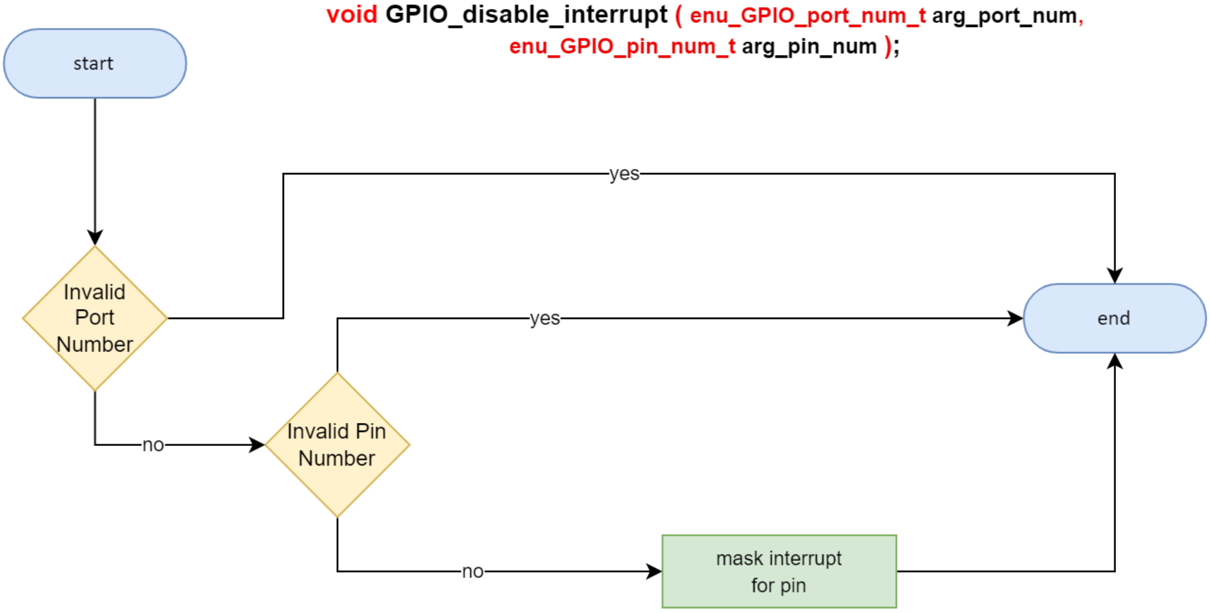
3.1.1.5 GPIO_enable_interrupr

void GPIO_enable_interrupt (enu_GPIO_port_num_t arg_port_num, enu_GPIO_pin_num_t arg_pin_num);



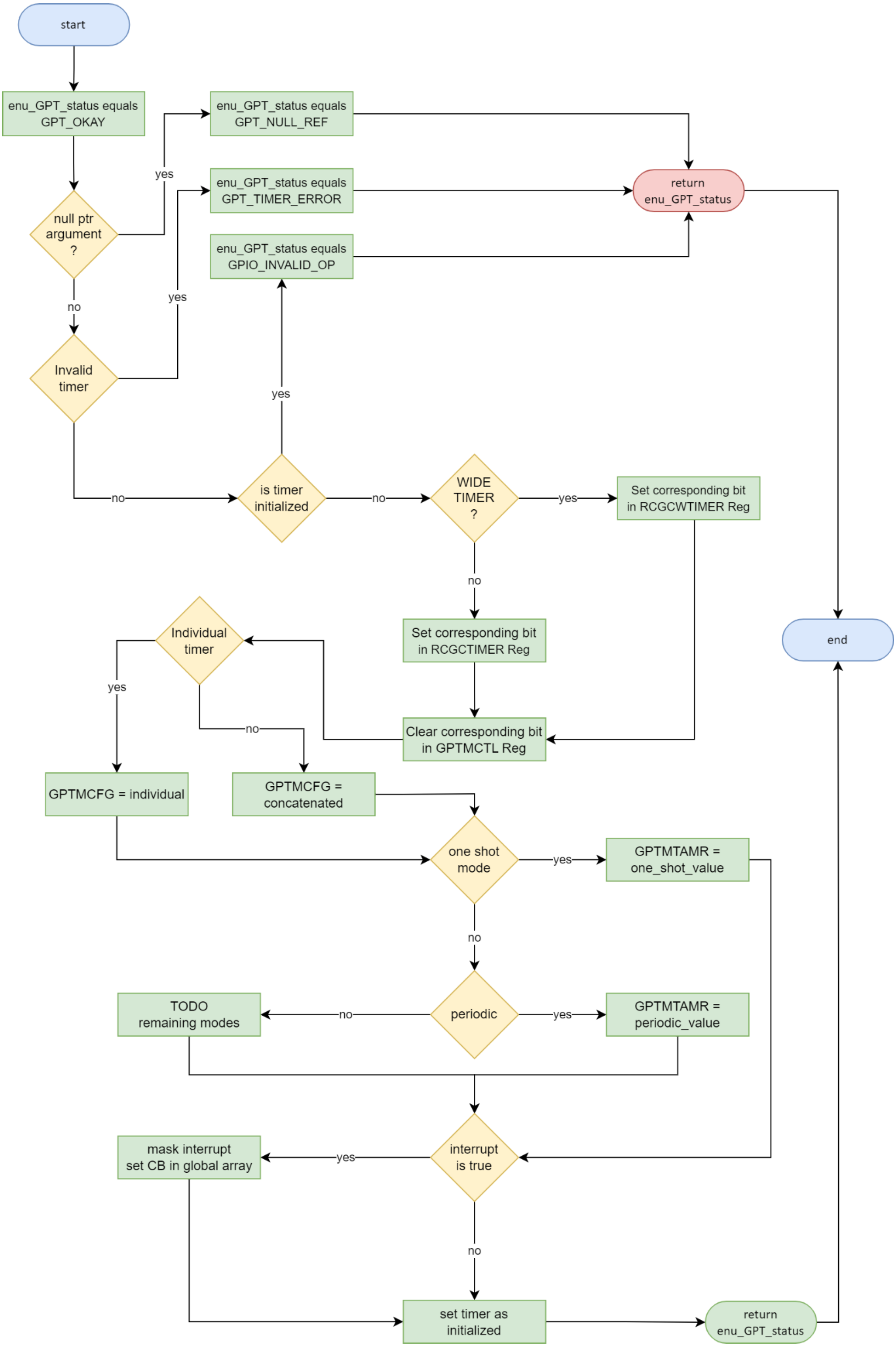
3.1.1.6 GPIO_desable_interrupr

void GPIO_disable_interrupt (enu_GPIO_port_num_t arg_port_num, enu_GPIO_pin_num_t arg_pin_num);

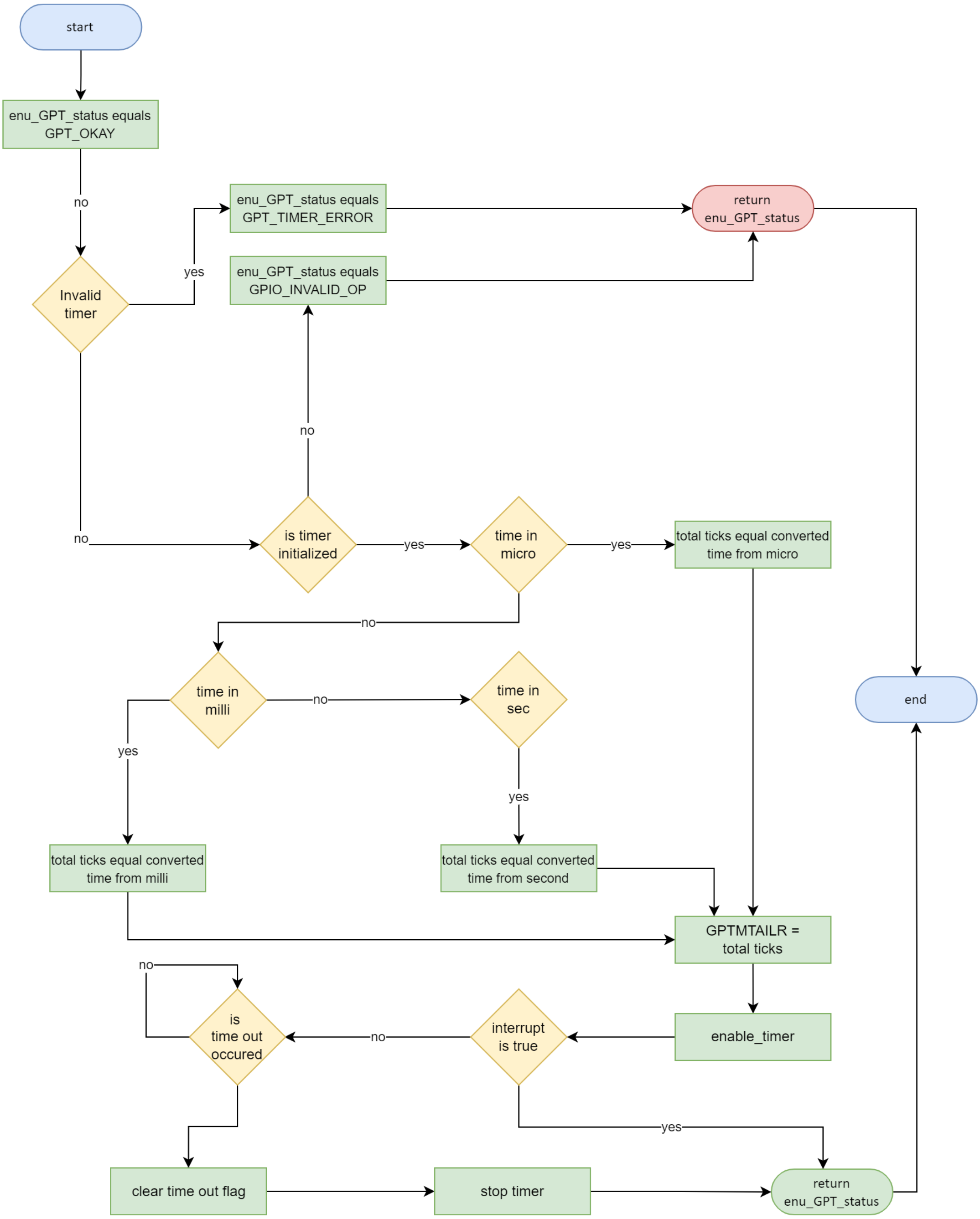


3.1.2. T_Handler Module

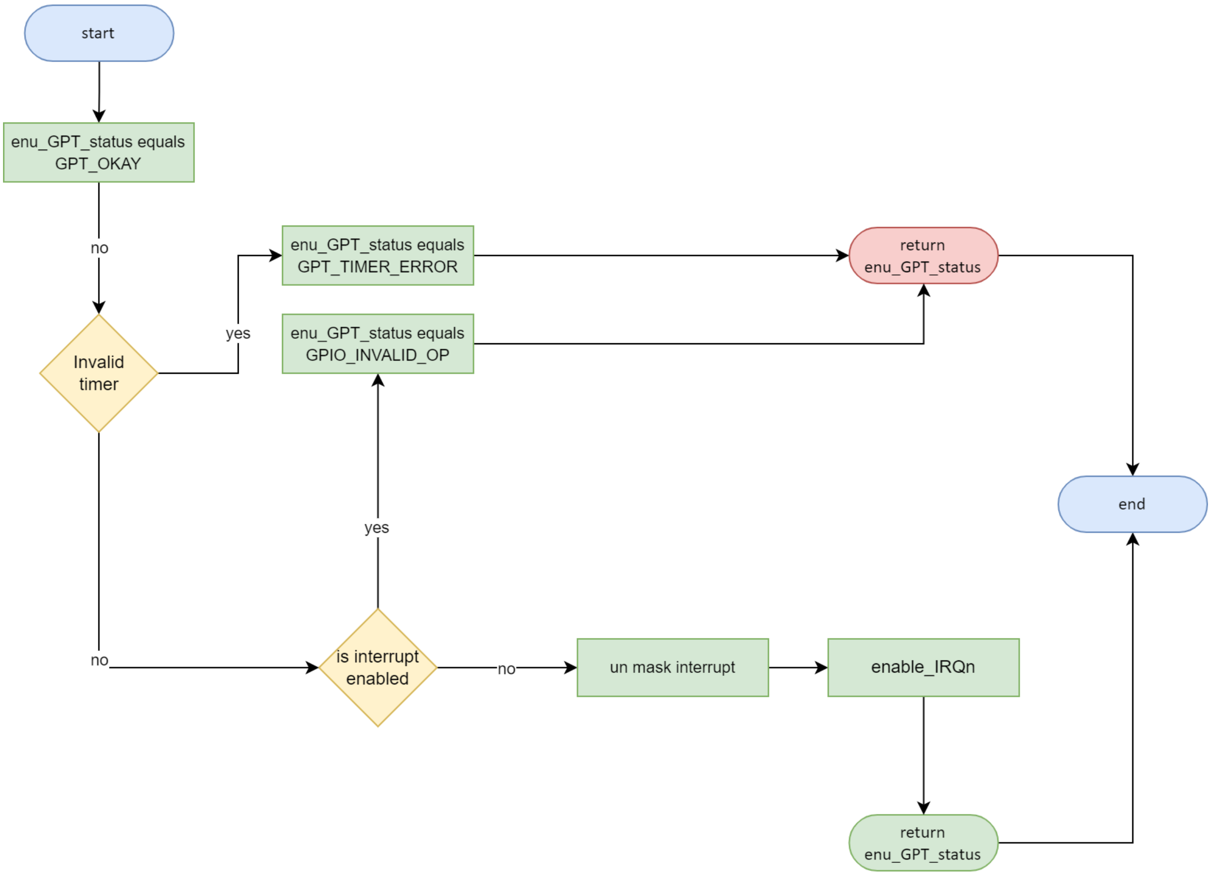
3.1.2.1 GPT_init


start
enu_GPT_status equals GPT_OKAY
null ptr argument ?
yes
enu_GPT_status equals GPT_NULL_REF
no
Invalid timer
yes
enu_GPT_status equals GPT_TIMER_ERROR
return enu_GPT_status
enu_GPT_status equals GPIO_INVALID_OP
yes
no
is timer initialized
no
WIDE TIMER ?
yes
Set corresponding bit in RCGCWTIMER Reg
no
Set corresponding bit in RCGCTIMER Reg
end
Individual timer
yes
no
Clear corresponding bit in GPTMCTL Reg
GPTMCFG = individual
GPTMCFG = concatenated
one shot mode
yes
GPTMAMR = one_shot_value
no
TODO remaining modes
no
periodic
yes
GPTMAMR = periodic_value
mask interrupt set CB in global array
yes
interrupt is true
no
set timer as initialized
return enu_GPT_status

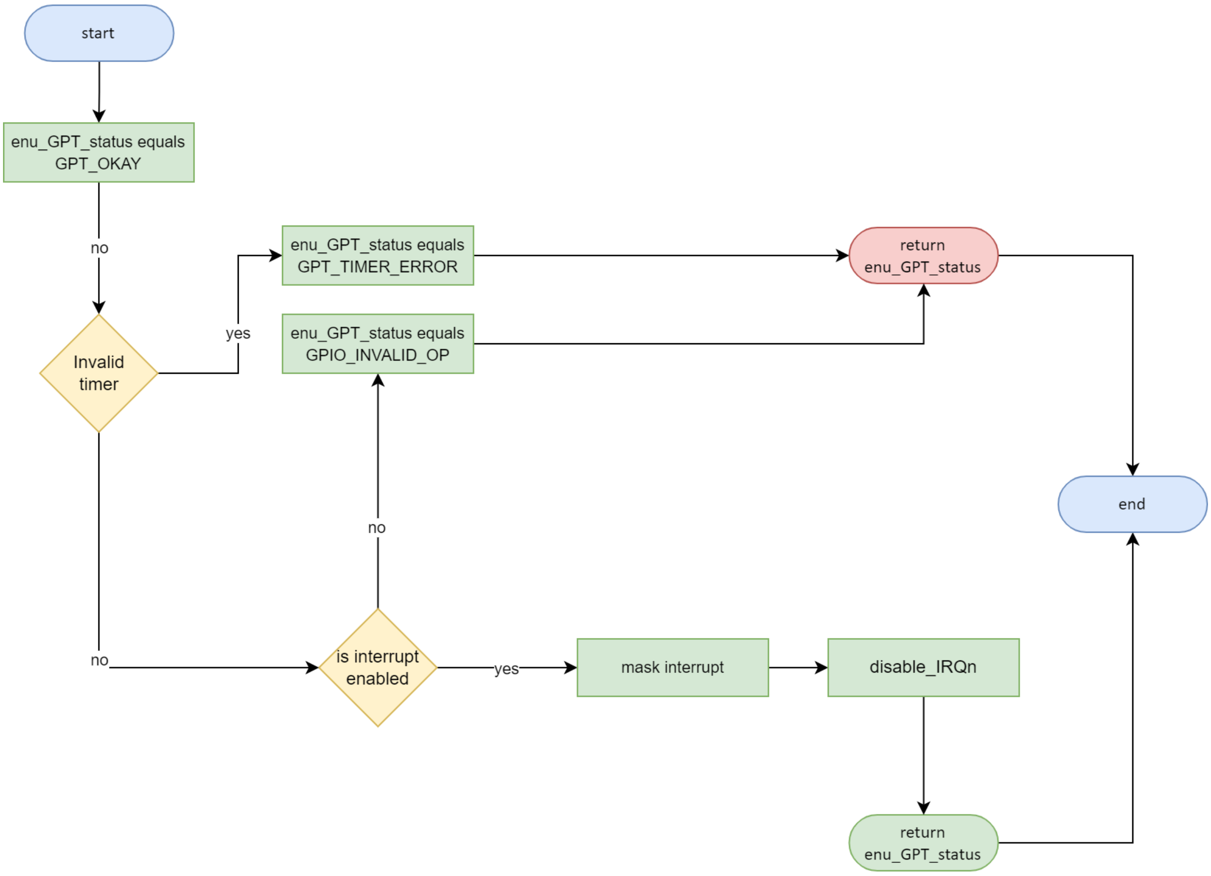
3.1.2.2 GPT_start_timer



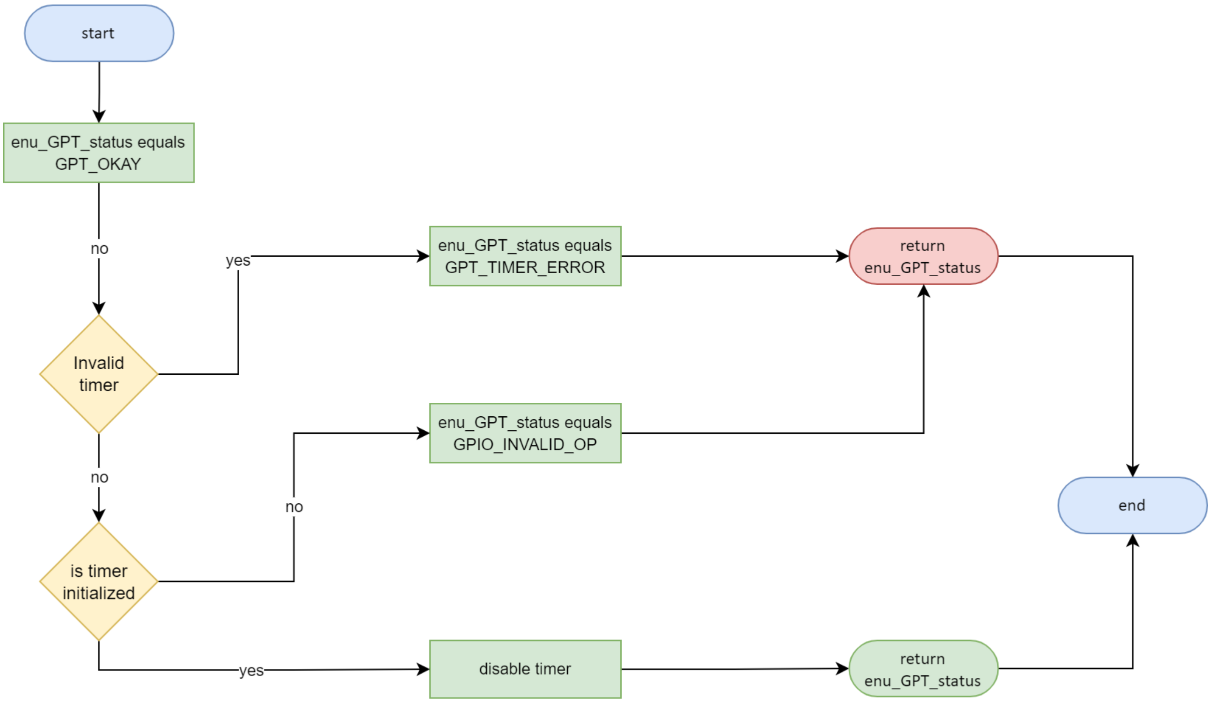
3.1.2.3 GPT_enable_interrupt



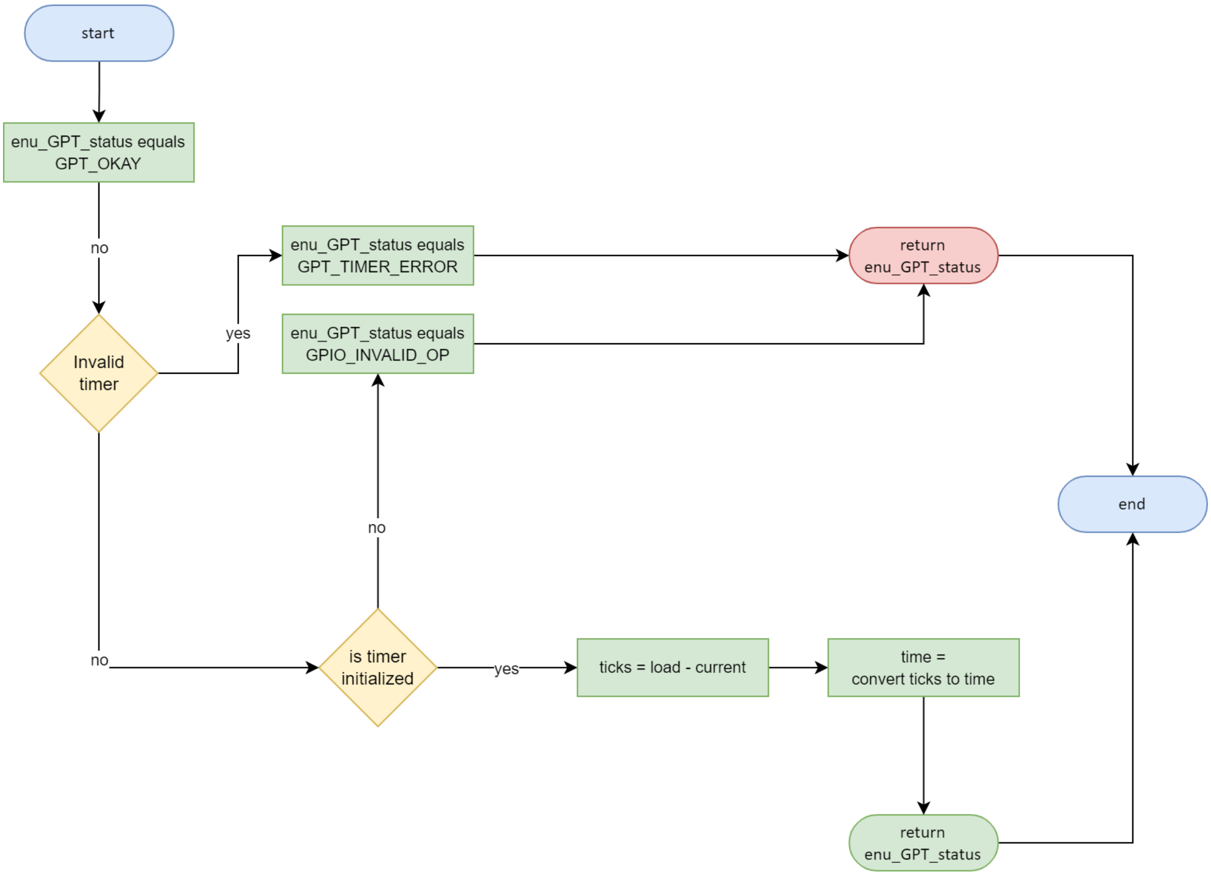
3.1.2.4 GPT_disable_interrupt



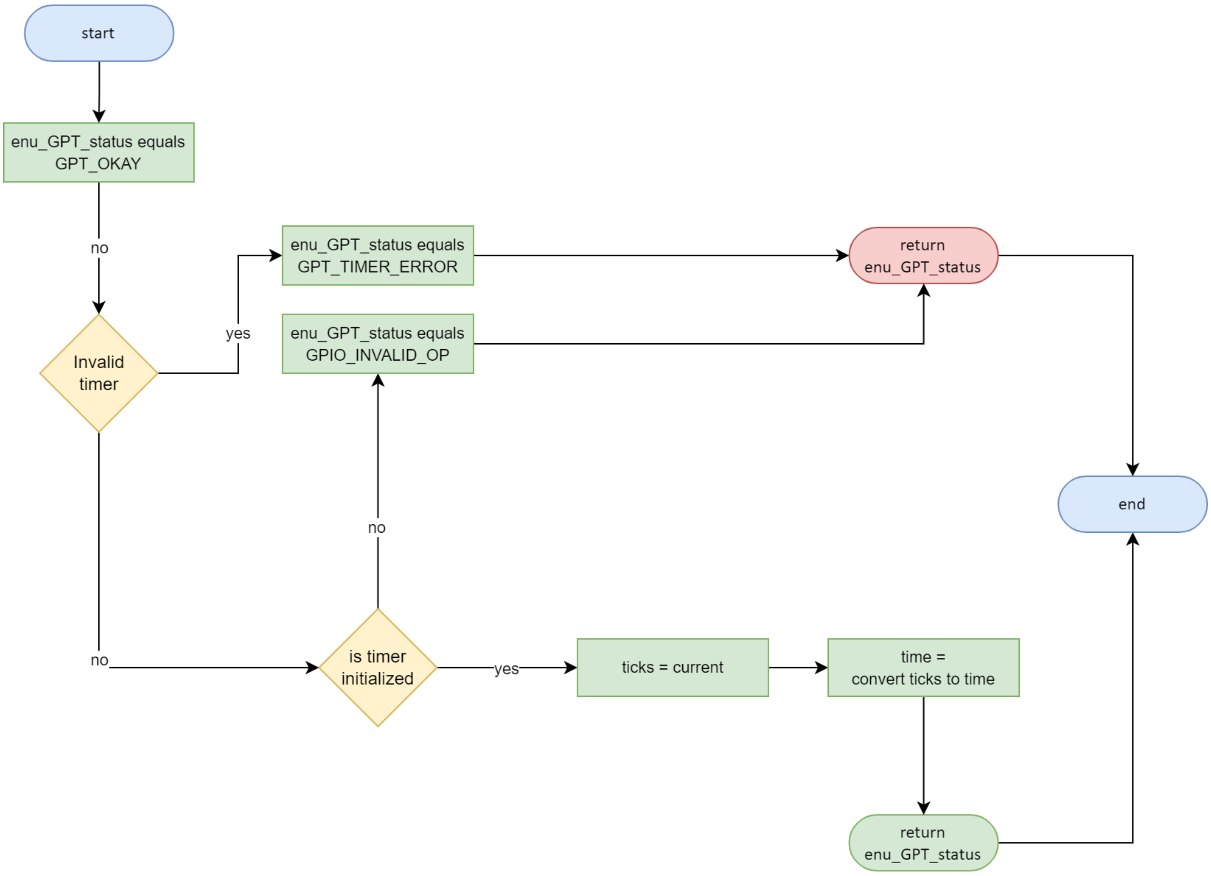
3.1.2.5 GPT_stop_timer



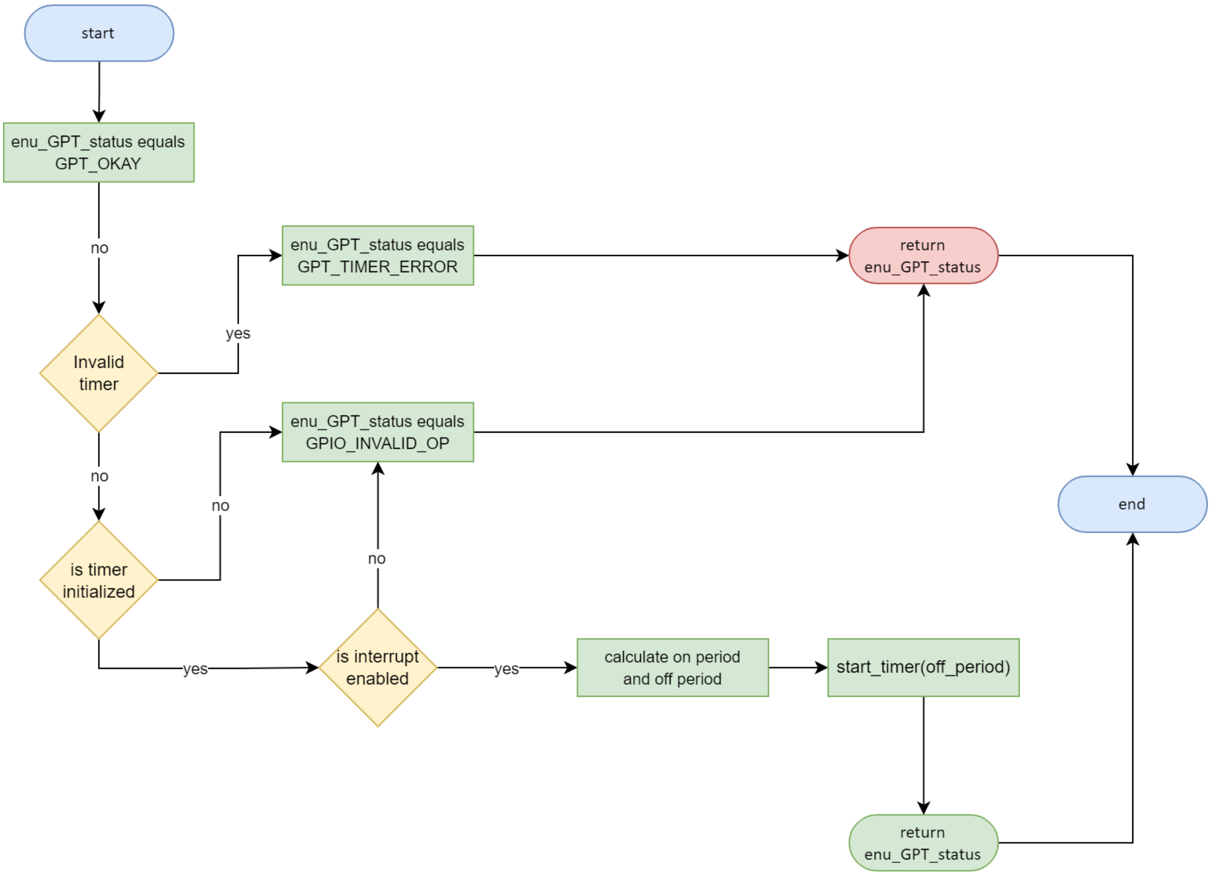
3.1.2.6 GPT_get_elapsed_time


start
enu_GPT_status equals GPT_OKAY
no
Invalid timer
yes
enu_GPT_status equals GPT_TIMER_ERROR
enu_GPT_status equals GPIO_INVALID_OP
return enu_GPT_status
end
no
no
is timer initialized
yes
ticks = load - current
time = convert ticks to time
return enu_GPT_status

3.1.2.7 GPT_get_remaining_time


start
enu_GPT_status equals GPT_OKAY
no
Invalid timer
yes
enu_GPT_status equals GPT_TIMER_ERROR
enu_GPT_status equals GPIO_INVALID_OP
return enu_GPT_status
end
no
no
is timer initialized
yes
ticks = current
time = convert ticks to time
return enu_GPT_status

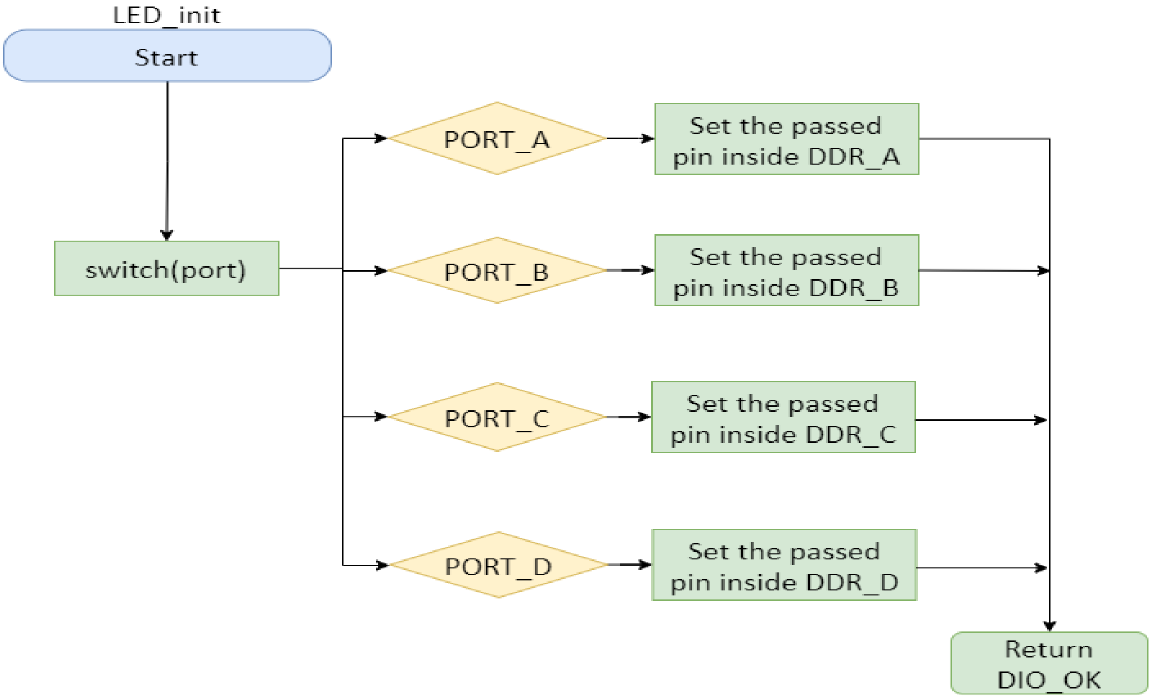
3.1.2.8 GPT_set_pwm



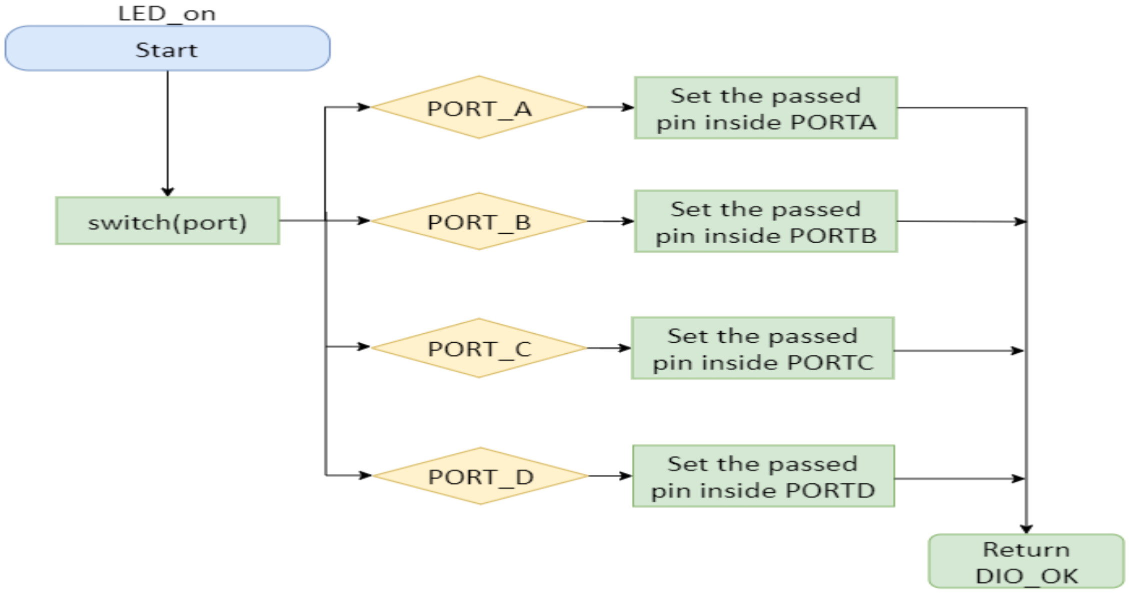
3.2. HAL Flowcharts

3.2.1 LED Module

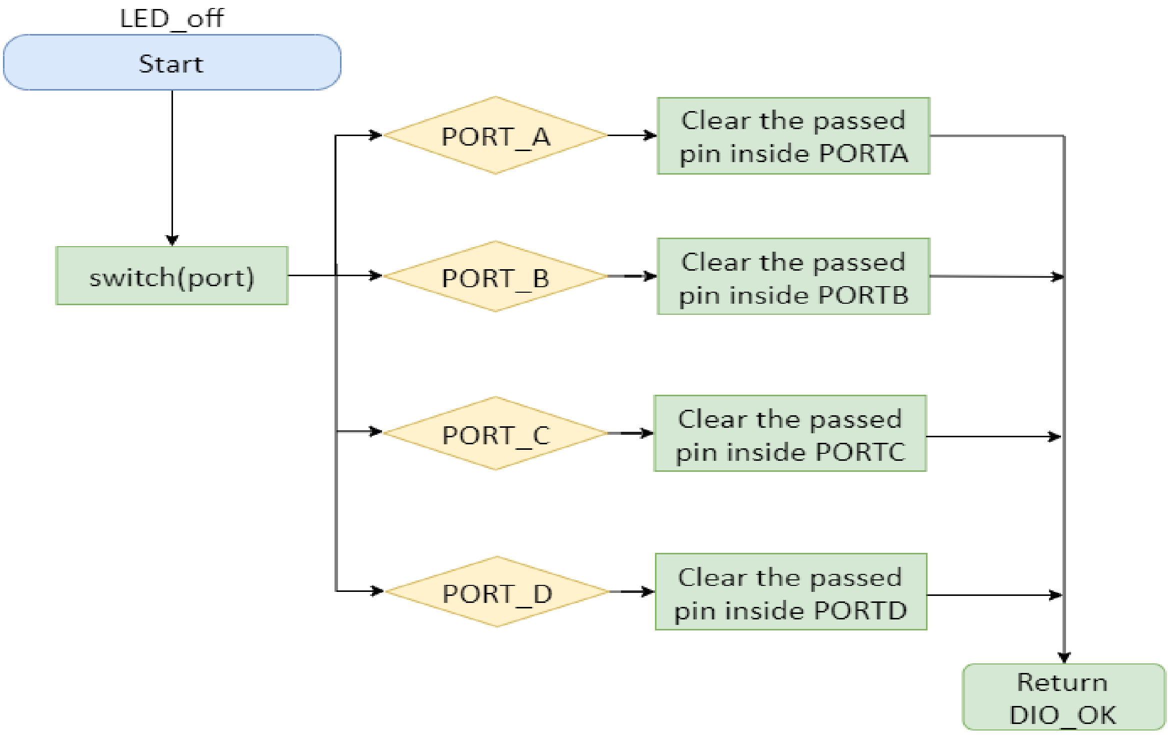
3.2.1.1 LED_init


LED_init
Start
switch(port)
PORT_A
PORT_B
PORT_C
PORT_D
Set the passed pin inside DDR_A
Set the passed pin inside DDR_B
Set the passed pin inside DDR_C
Set the passed pin inside DDR_D
Return DIO_OK

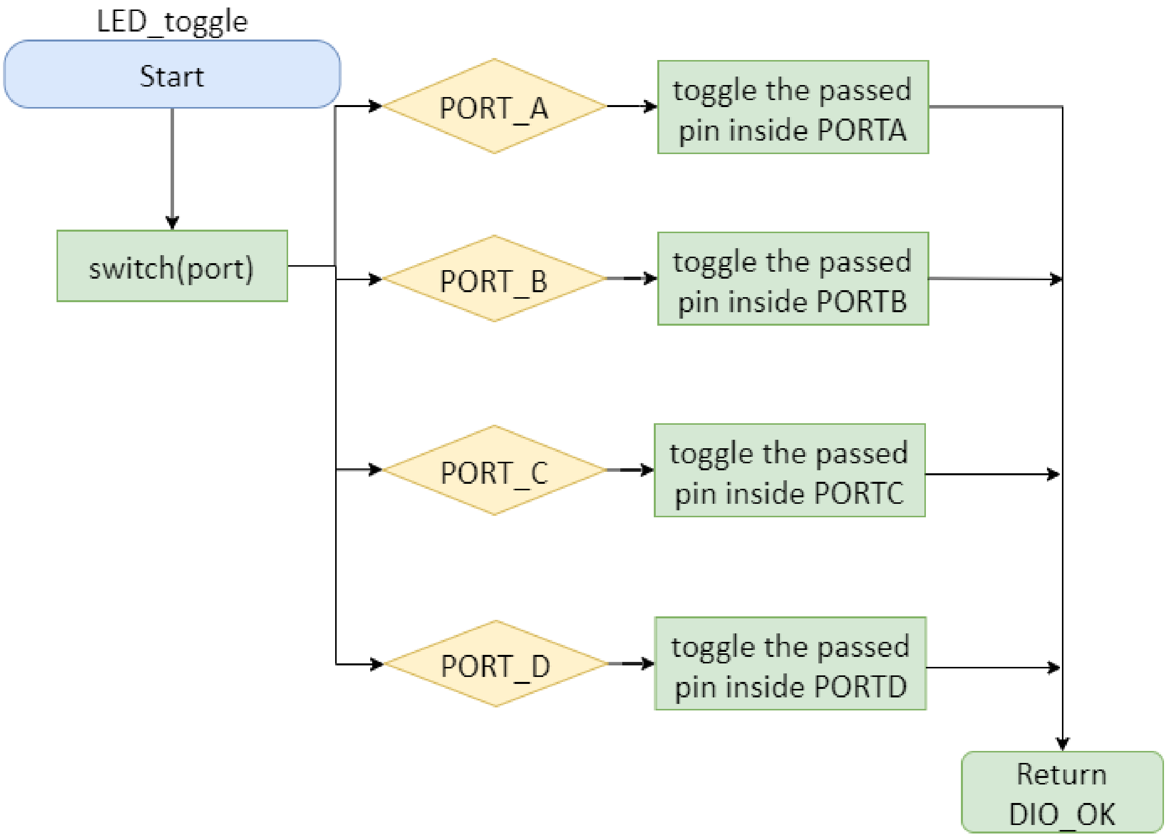
3.2.1.2 LED_on


LED_on
Start
switch(port)
PORT_A
PORT_B
PORT_C
PORT_D
Set the passed pin inside PORTA
Set the passed pin inside PORTB
Set the passed pin inside PORTC
Set the passed pin inside PORTD
Return DIO_OK

3.2.1.3 LED_off

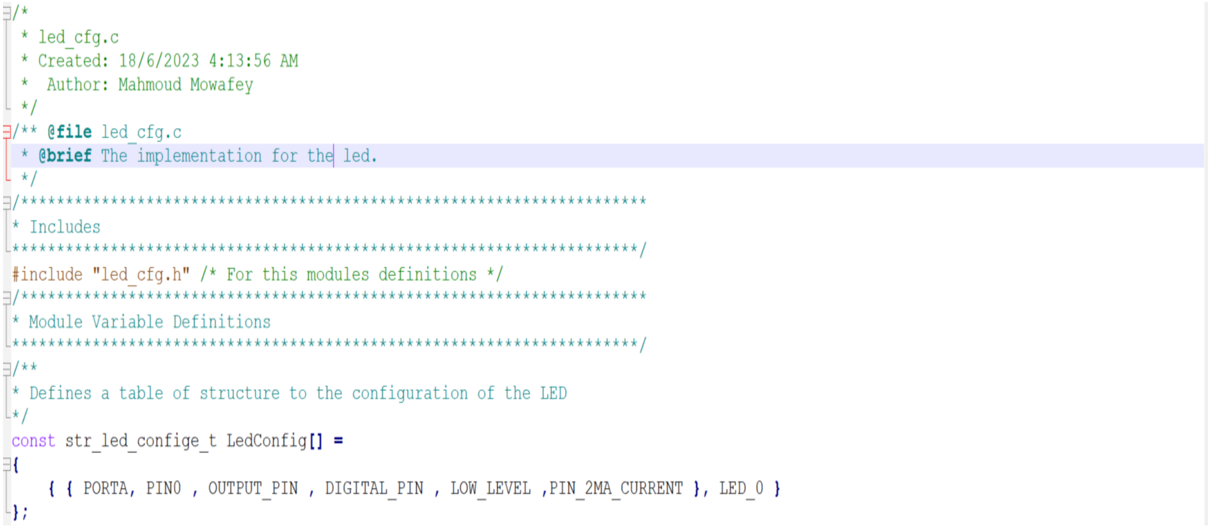

LED_off
Start
switch(port)
PORT_A
PORT_B
PORT_C
PORT_D
Clear the passed pin inside PORTA
Clear the passed pin inside PORTB
Clear the passed pin inside PORTC
Clear the passed pin inside PORTD
Return DIO_OK

3.2.1.4 LED_toggle

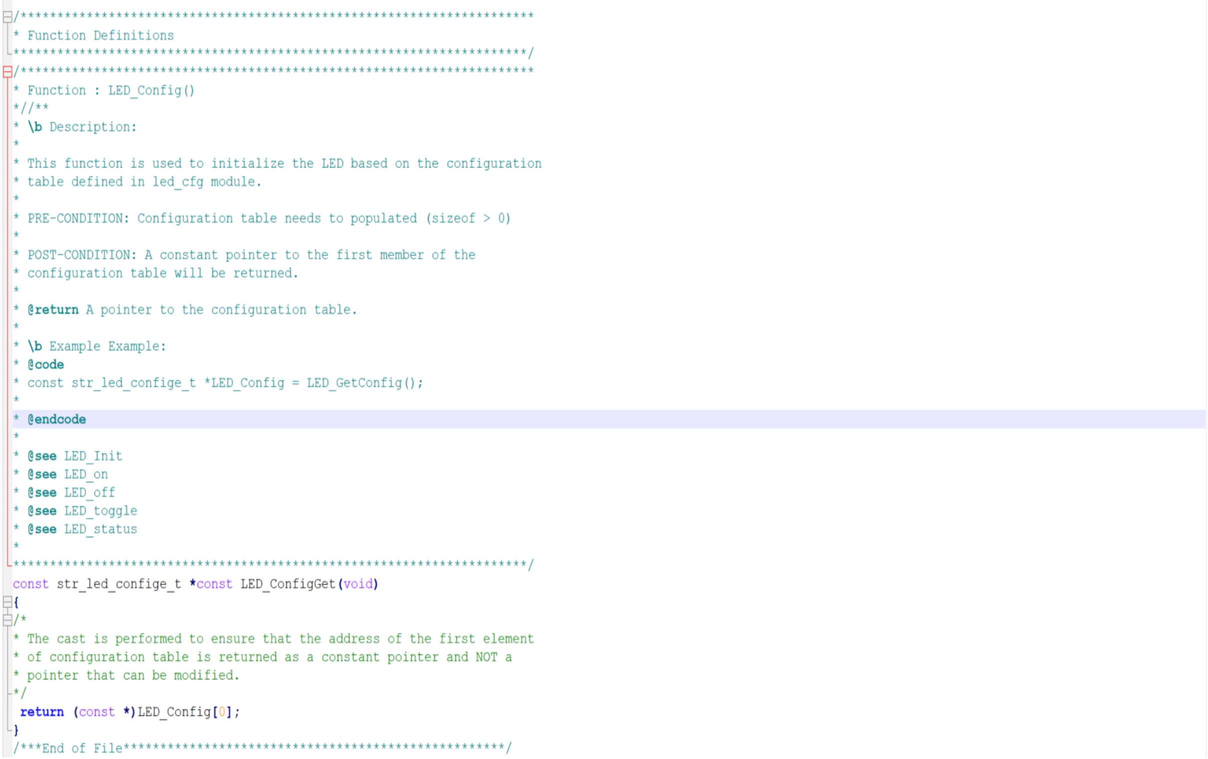

LED_toggle
Start
switch(port)
PORT_A
PORT_B
PORT_C
PORT_D
toggle the passed pin inside PORTA
toggle the passed pin inside PORTB
toggle the passed pin inside PORTC
toggle the passed pin inside PORTD
Return DIO_OK

3.2.1.5 LED_Linking Configuration

3.2.1.5.1 LED_cfg.c

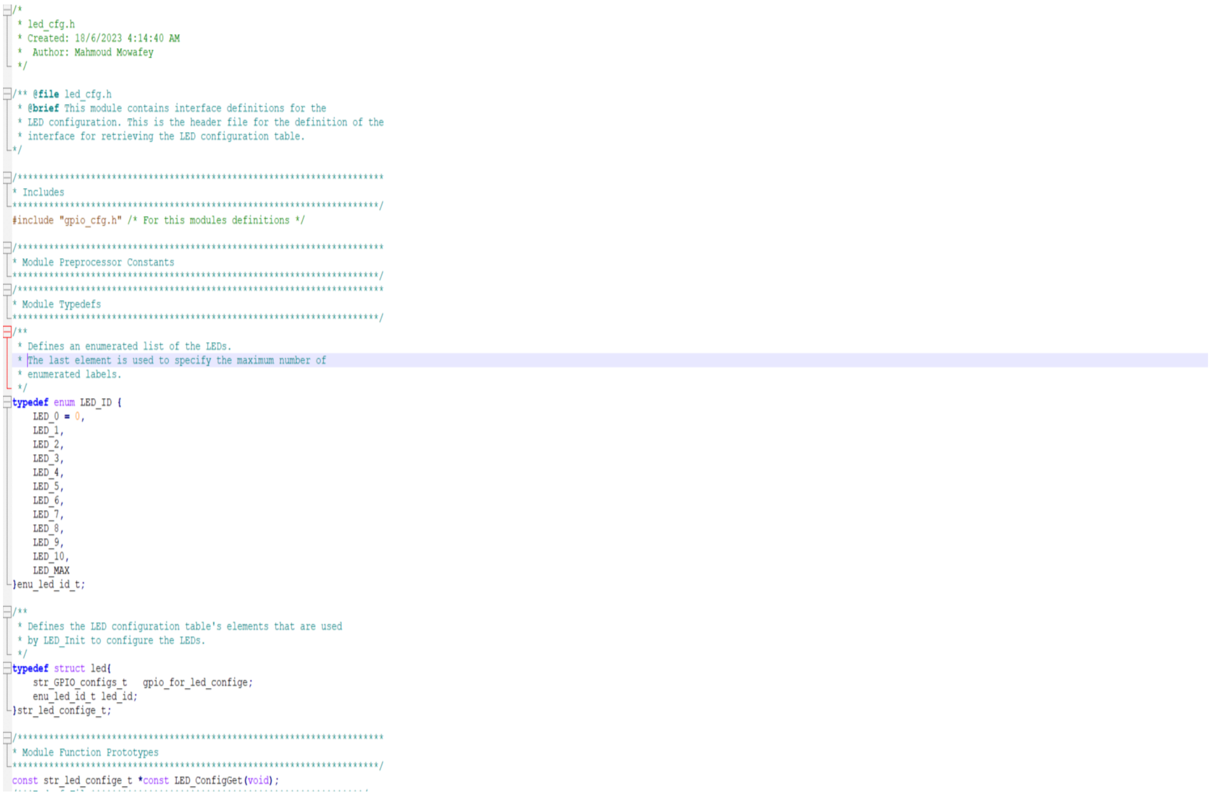


```c
/*
 * led_cfg.c
 * Created: 18/6/2023 4:13:56 AM
 *  Author: Mahmoud Mowafey
 */
/** @file led_cfg.c
 * @brief The implementation for the led.
 */
/***********************************************************************
* Includes
***********************************************************************/
#include "led_cfg.h" /* For this modules definitions */
/***********************************************************************
* Module Variable Definitions
***********************************************************************/
/**
* Defines a table of structure to the configuration of the LED
*/
const str_led_confige_t LedConfig[] =
{
    { { PORTA, PIN0 , OUTPUT_PIN , DIGITAL_PIN , LOW_LEVEL ,PIN_2MA_CURRENT }, LED_0 }
};
```



```
/**********************************************************************
* Function Definitions
**********************************************************************/
/**********************************************************************
* Function : LED_Config()
*//**
* \b Description:
*
* This function is used to initialize the LED based on the configuration
* table defined in led_cfg module.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
*
* POST-CONDITION: A constant pointer to the first member of the
* configuration table will be returned.
*
* @return A pointer to the configuration table.
*
* \b Example Example:
* @code
* const str_led_confige_t *LED_Config = LED_GetConfig();
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
**********************************************************************/
const str_led_confige_t *const LED_ConfigGet(void)
{
/*
* The cast is performed to ensure that the address of the first element
* of configuration table is returned as a constant pointer and NOT a
* pointer that can be modified.
*/
 return (const *)LED_Config[0];
}
/***End of File****************************************************/
```

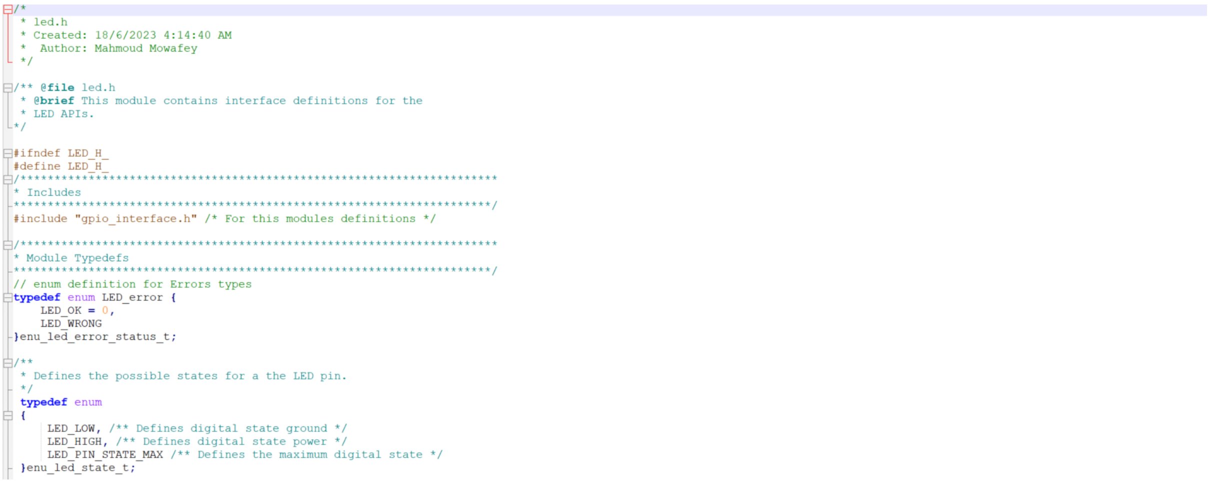
3.2.1.5.2 LED_cfg.h



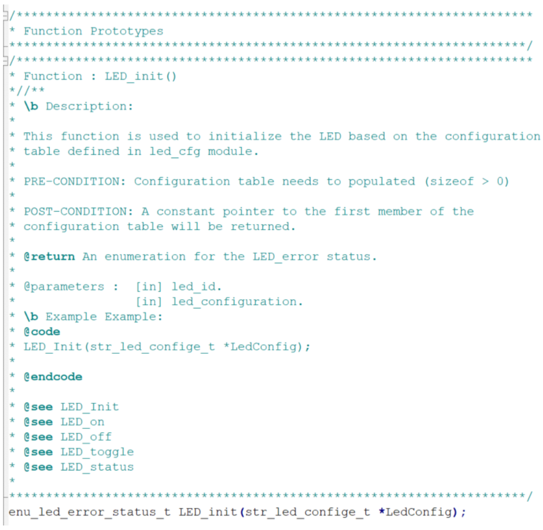
```
/*
 * led_cfg.h
 * Created: 18/6/2023 4:14:40 AM
 *  Author: Mahmoud Mowafey
 */

/** @file led_cfg.h
 * @brief This module contains interface definitions for the
 * LED configuration. This is the header file for the definition of the
 * interface for retrieving the LED configuration table.
*/

/**********************************************************************
* Includes
**********************************************************************/
#include "gpio_cfg.h" /* For this modules definitions */

/**********************************************************************
* Module Preprocessor Constants
**********************************************************************/
/**********************************************************************
* Module Typedefs
**********************************************************************/
/**
 * Defines an enumerated list of the LEDs.
 * The last element is used to specify the maximum number of
 * enumerated labels.
 */
typedef enum LED_ID {
    LED_0 = 0,
    LED_1,
    LED_2,
    LED_3,
    LED_4,
    LED_5,
    LED_6,
    LED_7,
    LED_8,
    LED_9,
    LED_10,
    LED_MAX
}enu_led_id_t;

/**
 * Defines the LED configuration table's elements that are used
 * by LED_Init to configure the LEDs.
 */
typedef struct led{
    str_GPIO_configs_t   gpio_for_led_confige;
    enu_led_id_t led_id;
}str_led_confige_t;

/**********************************************************************
* Module Function Prototypes
**********************************************************************/
const str_led_confige_t *const LED_ConfigGet(void);
```

3.2.1.6 LED_Pre-compiling Configuration

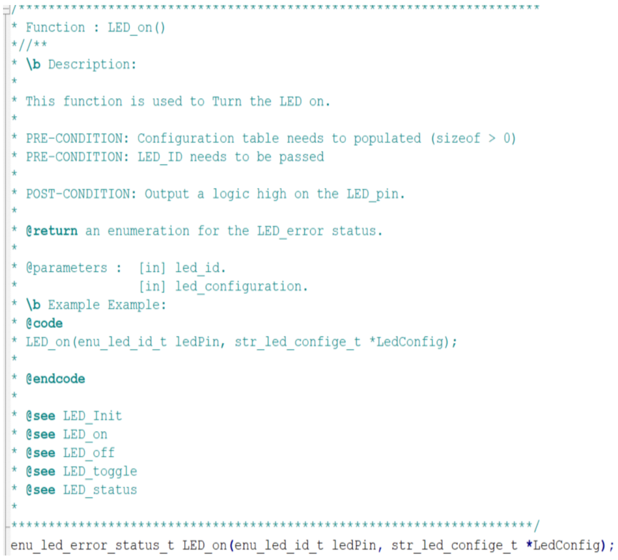
3.2.1.6.1 LED.h



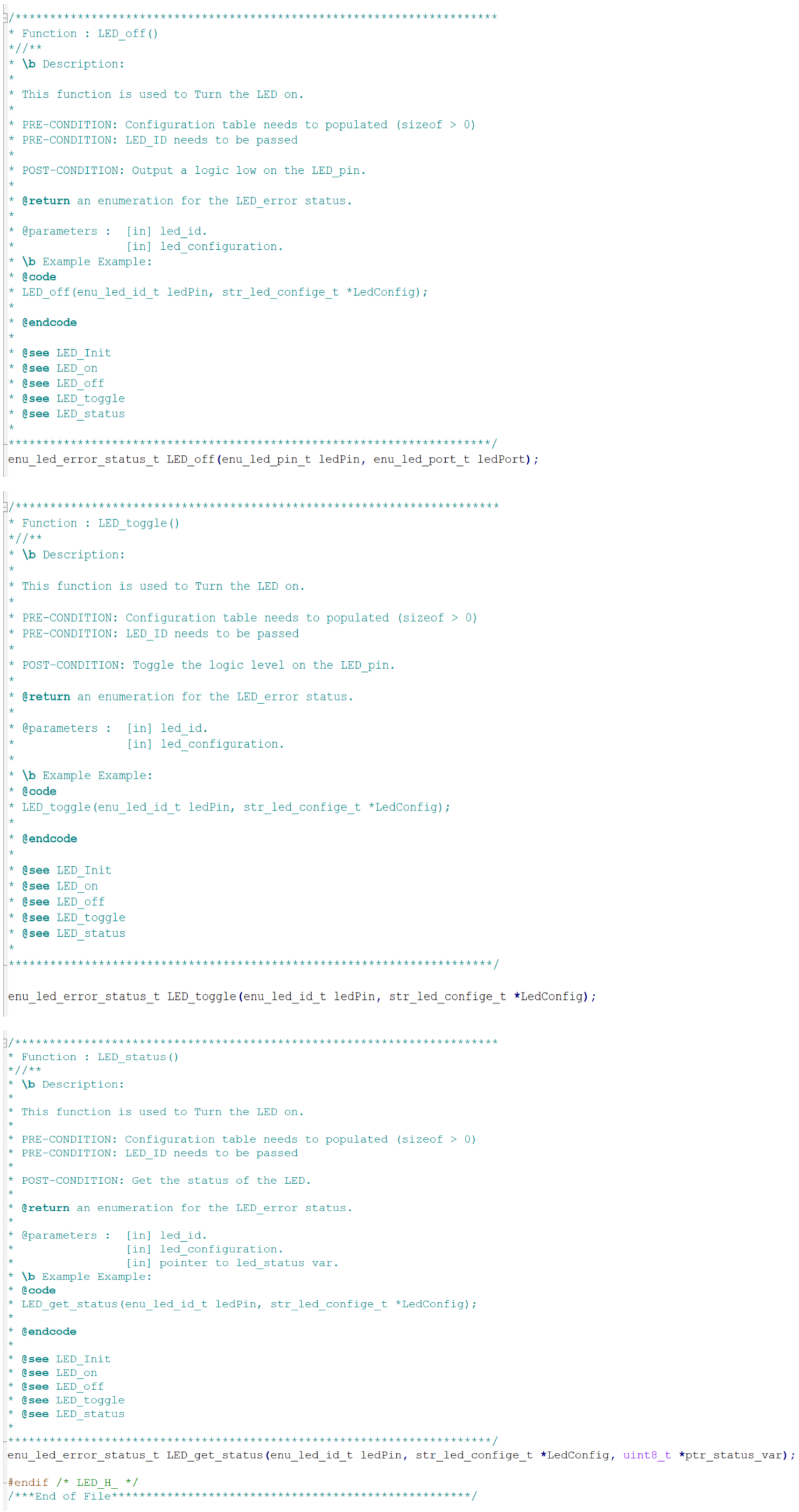
```
/*
 * led.h
 * Created: 18/6/2023 4:14:40 AM
 *  Author: Mahmoud Mowafey
 */

/** @file led.h
 * @brief This module contains interface definitions for the
 * LED APIs.
*/

#ifndef LED_H_
#define LED_H_
/**********************************************************************
* Includes
**********************************************************************/
#include "gpio_interface.h" /* For this modules definitions */

/**********************************************************************
* Module Typedefs
**********************************************************************/
// enum definition for Errors types
typedef enum LED_error {
    LED_OK = 0,
    LED_WRONG
}enu_led_error_status_t;

/**
 * Defines the possible states for a the LED pin.
 */
 typedef enum
 {
    LED_LOW, /** Defines digital state ground */
    LED_HIGH, /** Defines digital state power */
    LED_PIN_STATE_MAX /** Defines the maximum digital state */
 }enu_led_state_t;
```



```
/**********************************************************************
* Function Prototypes
**********************************************************************/
/**********************************************************************
* Function : LED_init()
*//**
* \b Description:
*
* This function is used to initialize the LED based on the configuration
* table defined in led_cfg module.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
*
* POST-CONDITION: A constant pointer to the first member of the
* configuration table will be returned.
*
* @return An enumeration for the LED_error status.
*
* @parameters :  [in] led_id.
*               [in] led_configuration.
* \b Example Example:
* @code
* LED_Init(str_led_confige_t *LedConfig);
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
**********************************************************************/
enu_led_error_status_t LED_init(str_led_confige_t *LedConfig);
```



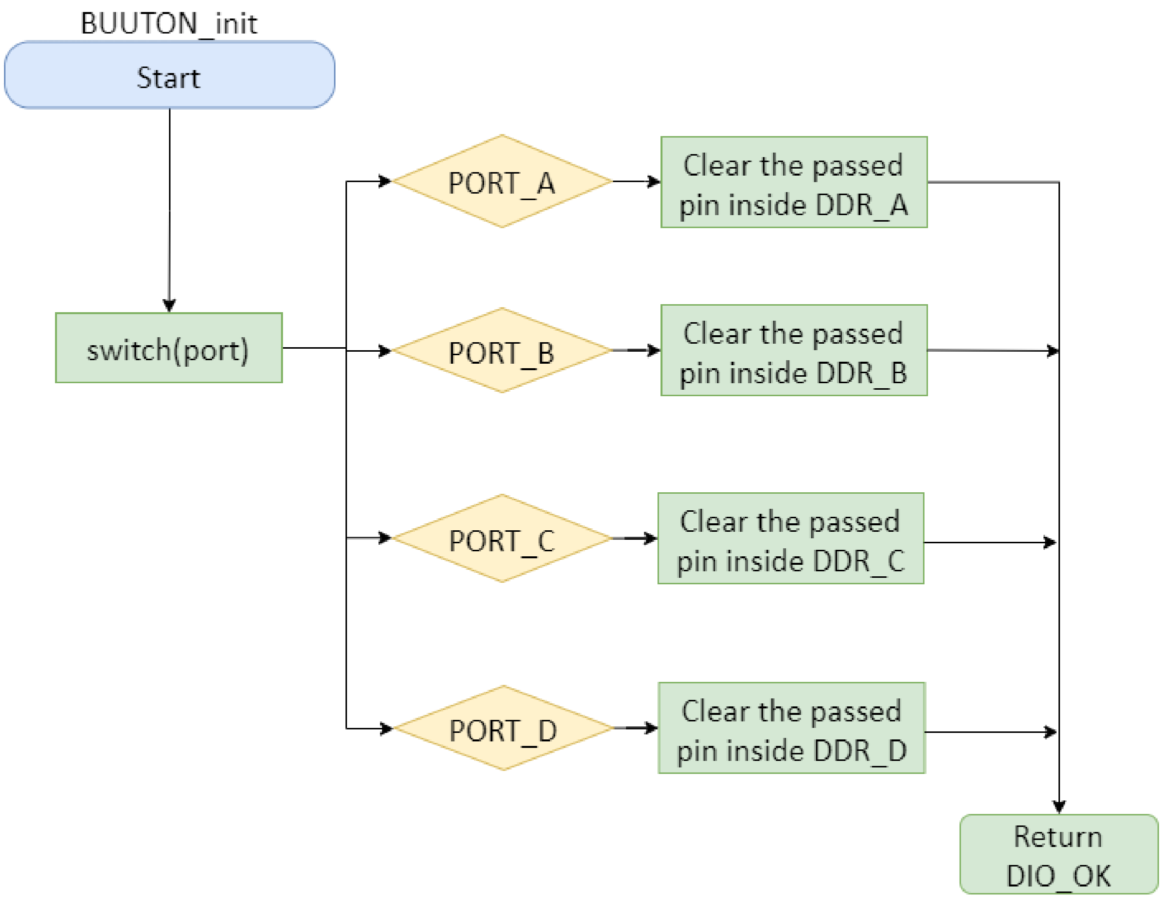
```
/**********************************************************************
* Function : LED_on()
*//**
* \b Description:
*
* This function is used to Turn the LED on.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
* PRE-CONDITION: LED_ID needs to be passed
*
* POST-CONDITION: Output a logic high on the LED_pin.
*
* @return an enumeration for the LED_error status.
*
* @parameters :  [in] led_id.
*               [in] led_configuration.
* \b Example Example:
* @code
* LED_on(enu_led_id_t ledPin, str_led_confige_t *LedConfig);
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
**********************************************************************/
enu_led_error_status_t LED_on(enu_led_id_t ledPin, str_led_confige_t *LedConfig);
```



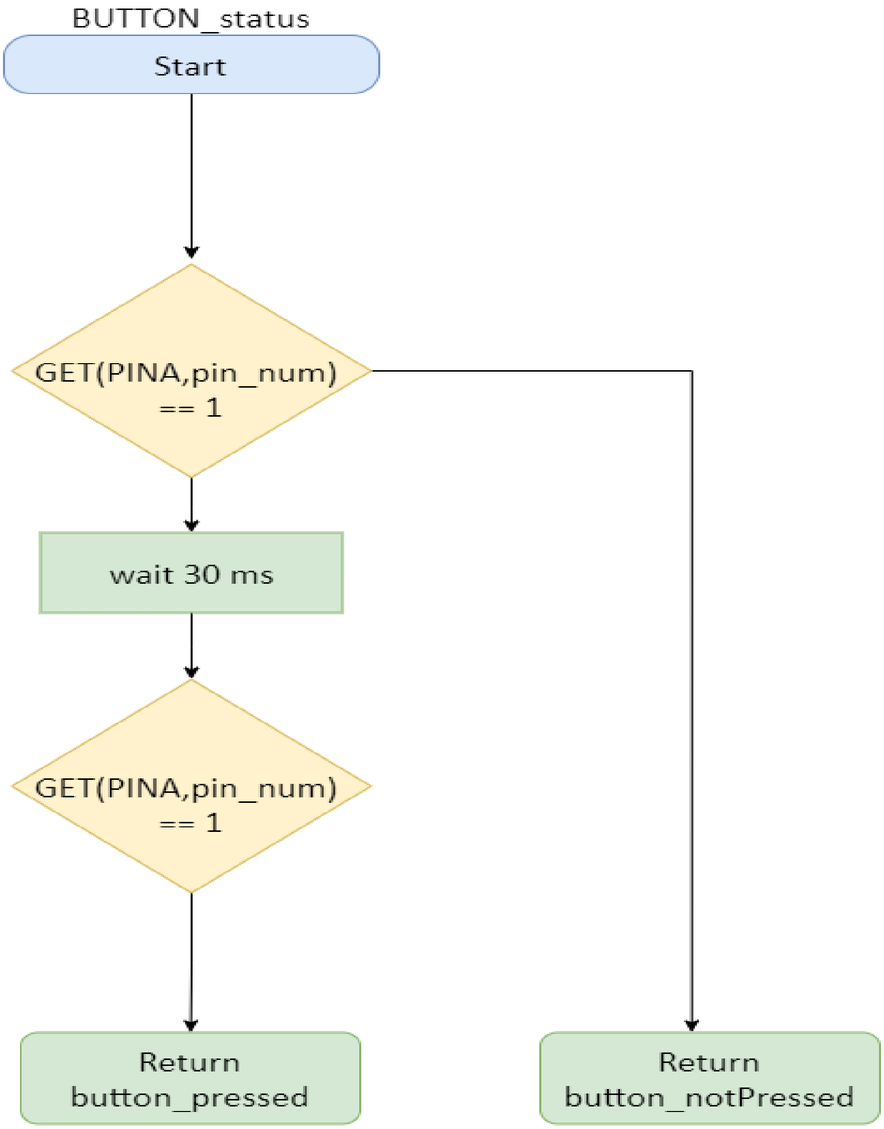
```
/***********************************************************************
* Function : LED_off()
*//**
* \b Description:
*
* This function is used to Turn the LED on.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
* PRE-CONDITION: LED_ID needs to be passed
*
* POST-CONDITION: Output a logic low on the LED_pin.
*
* @return an enumeration for the LED_error status.
*
* @parameters :  [in] led_id.
*                [in] led_configuration.
* \b Example Example:
* @code
* LED_off(enu_led_id_t ledPin, str_led_confige_t *LedConfig);
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
***********************************************************************/
enu_led_error_status_t LED_off(enu_led_pin_t ledPin, enu_led_port_t ledPort);

/***********************************************************************
* Function : LED_toggle()
*//**
* \b Description:
*
* This function is used to Turn the LED on.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
* PRE-CONDITION: LED_ID needs to be passed
*
* POST-CONDITION: Toggle the logic level on the LED_pin.
*
* @return an enumeration for the LED_error status.
*
* @parameters :  [in] led_id.
*                [in] led_configuration.
*
* \b Example Example:
* @code
* LED_toggle(enu_led_id_t ledPin, str_led_confige_t *LedConfig);
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
***********************************************************************/

enu_led_error_status_t LED_toggle(enu_led_id_t ledPin, str_led_confige_t *LedConfig);

/***********************************************************************
* Function : LED_status()
*//**
* \b Description:
*
* This function is used to Turn the LED on.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
* PRE-CONDITION: LED_ID needs to be passed
*
* POST-CONDITION: Get the status of the LED.
*
* @return an enumeration for the LED_error status.
*
* @parameters :  [in] led_id.
*                [in] led_configuration.
*                [in] pointer to led_status var.
* \b Example Example:
* @code
* LED_get_status(enu_led_id_t ledPin, str_led_confige_t *LedConfig);
*
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
***********************************************************************/
enu_led_error_status_t LED_get_status(enu_led_id_t ledPin, str_led_confige_t *LedConfig, uint8_t *ptr_status_var);

#endif /* LED_H_ */
/***End of File****************************************************/
```

3.2.2 BUTTON Module

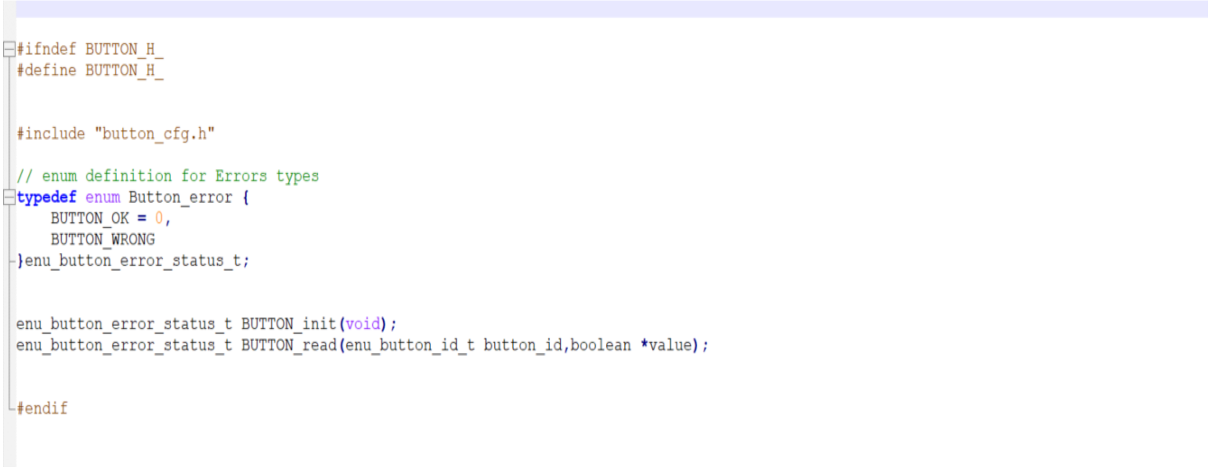
3.2.2.1 BUTT_init


BUUTON_init
Start
switch(port)
PORT_A
Clear the passed pin inside DDR_A
PORT_B
Clear the passed pin inside DDR_B
PORT_C
Clear the passed pin inside DDR_C
PORT_D
Clear the passed pin inside DDR_D
Return DIO_OK

3.2.2.2 BUTT_status



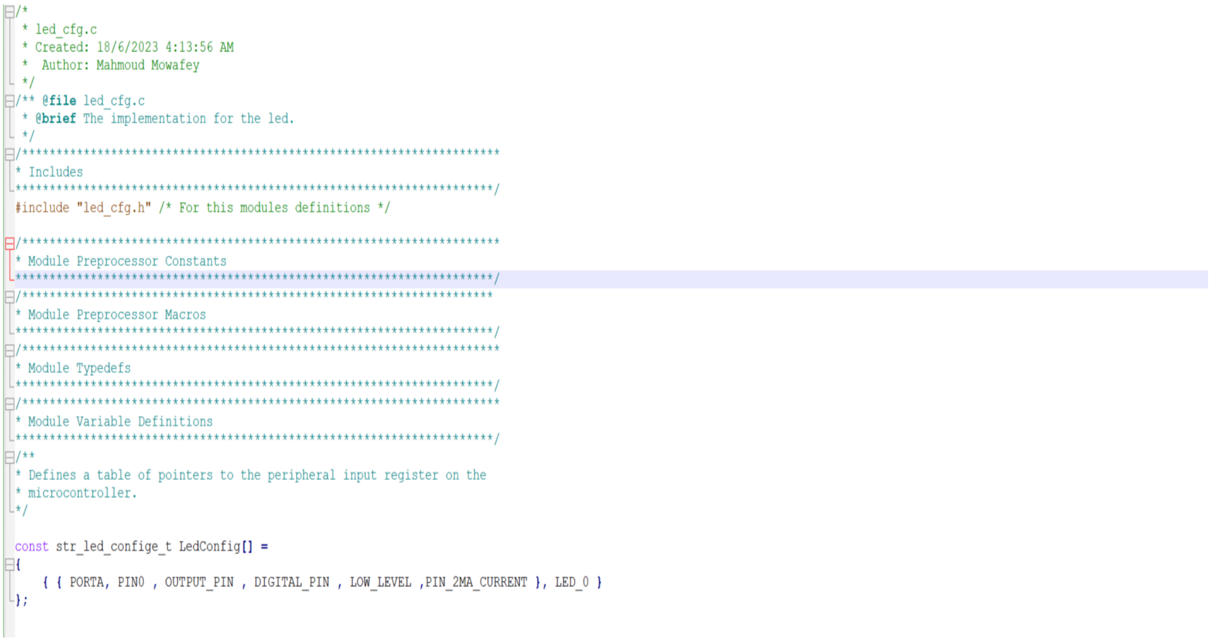
3.2.2.3 Precompiling Configuration



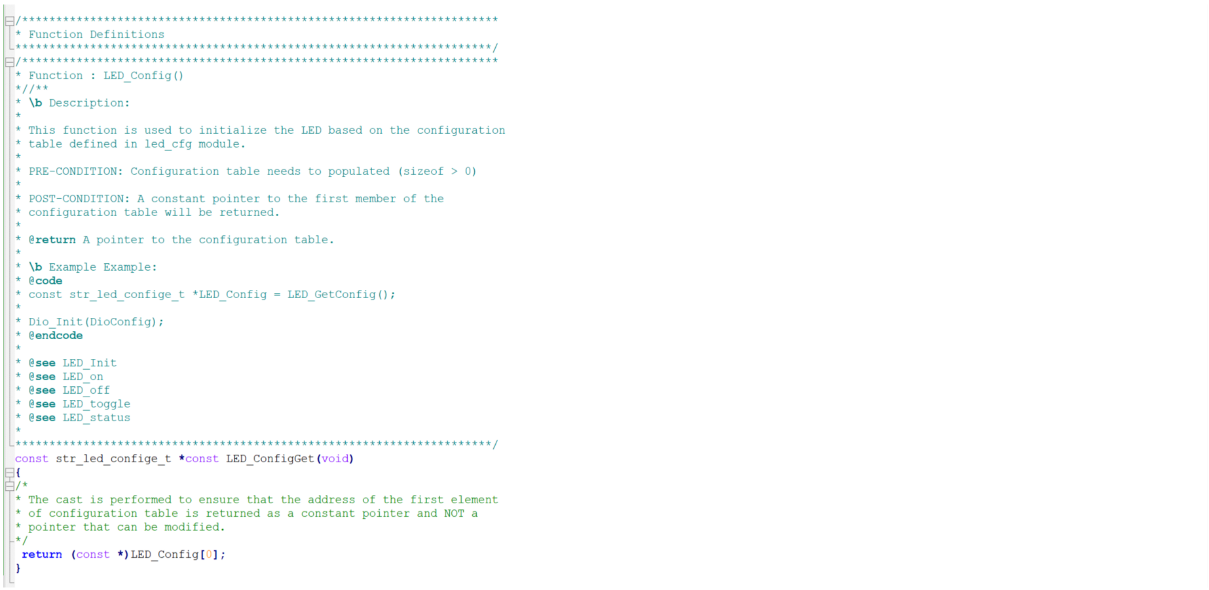
```
#ifndef BUTTON_H_
#define BUTTON_H_


#include "button_cfg.h"

// enum definition for Errors types
typedef enum Button_error {
    BUTTON_OK = 0,
    BUTTON_WRONG
}enu_button_error_status_t;


enu_button_error_status_t BUTTON_init(void);
enu_button_error_status_t BUTTON_read(enu_button_id_t button_id,boolean *value);


#endif
```

3.2.2.4 Button_Linking Configuration

3.2.2.4.1 Button_cfg.c

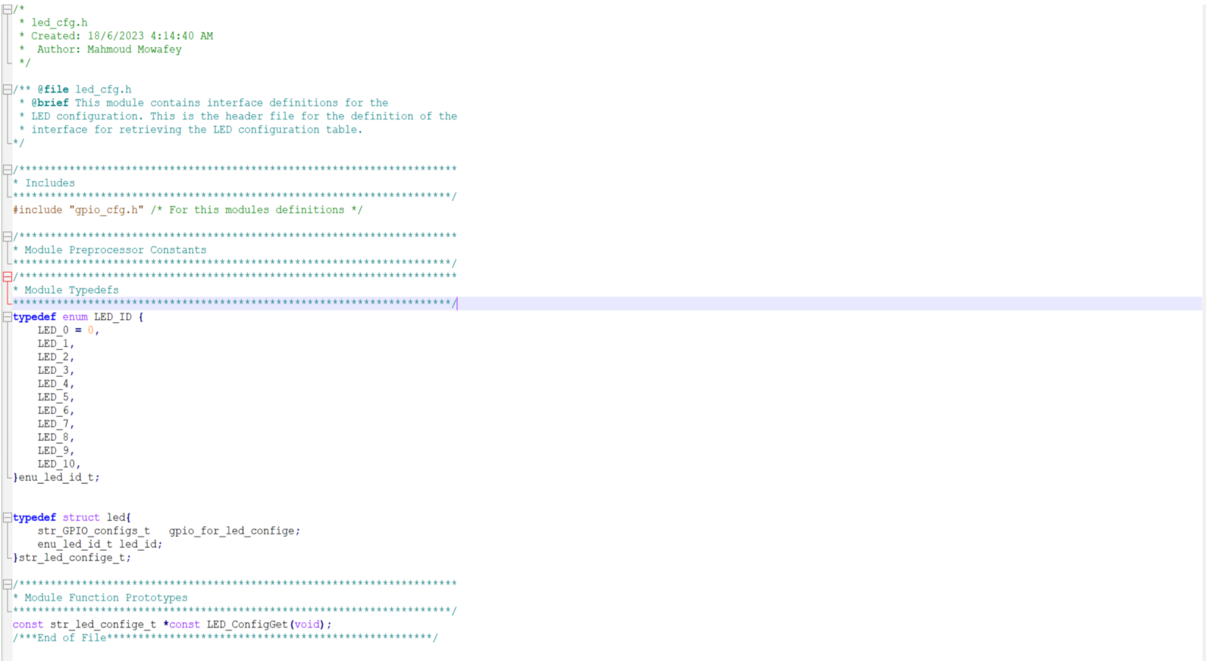


```
/*
 * led_cfg.c
 * Created: 18/6/2023 4:13:56 AM
 *  Author: Mahmoud Mowafey
 */
/** @file led_cfg.c
 * @brief The implementation for the led.
 */
/**********************************************************************
* Includes
**********************************************************************/
#include "led_cfg.h" /* For this modules definitions */

/**********************************************************************
* Module Preprocessor Constants
**********************************************************************/
/*********************************************************************
* Module Preprocessor Macros
**********************************************************************/
/**********************************************************************
* Module Typedefs
**********************************************************************/
/**********************************************************************
* Module Variable Definitions
**********************************************************************/
/**
* Defines a table of pointers to the peripheral input register on the
* microcontroller.
*/

const str_led_confige_t LedConfig[] =
{
    { { PORTA, PIN0 , OUTPUT_PIN , DIGITAL_PIN , LOW_LEVEL ,PIN_2MA_CURRENT }, LED_0 }
};
```



```
/***********************************************************************
* Function Definitions
***********************************************************************/
/***********************************************************************
* Function : LED_Config()
*//**
* \b Description:
*
* This function is used to initialize the LED based on the configuration
* table defined in led_cfg module.
*
* PRE-CONDITION: Configuration table needs to populated (sizeof > 0)
*
* POST-CONDITION: A constant pointer to the first member of the
* configuration table will be returned.
*
* @return A pointer to the configuration table.
*
* \b Example Example:
* @code
* const str_led_confige_t *LED_Config = LED_GetConfig();
*
* Dio_Init(DioConfig);
* @endcode
*
* @see LED_Init
* @see LED_on
* @see LED_off
* @see LED_toggle
* @see LED_status
*
***********************************************************************/
const str_led_confige_t *const LED_ConfigGet(void)
{
/*
* The cast is performed to ensure that the address of the first element
* of configuration table is returned as a constant pointer and NOT a
* pointer that can be modified.
*/
 return (const *)LED_Config[0];
}
```

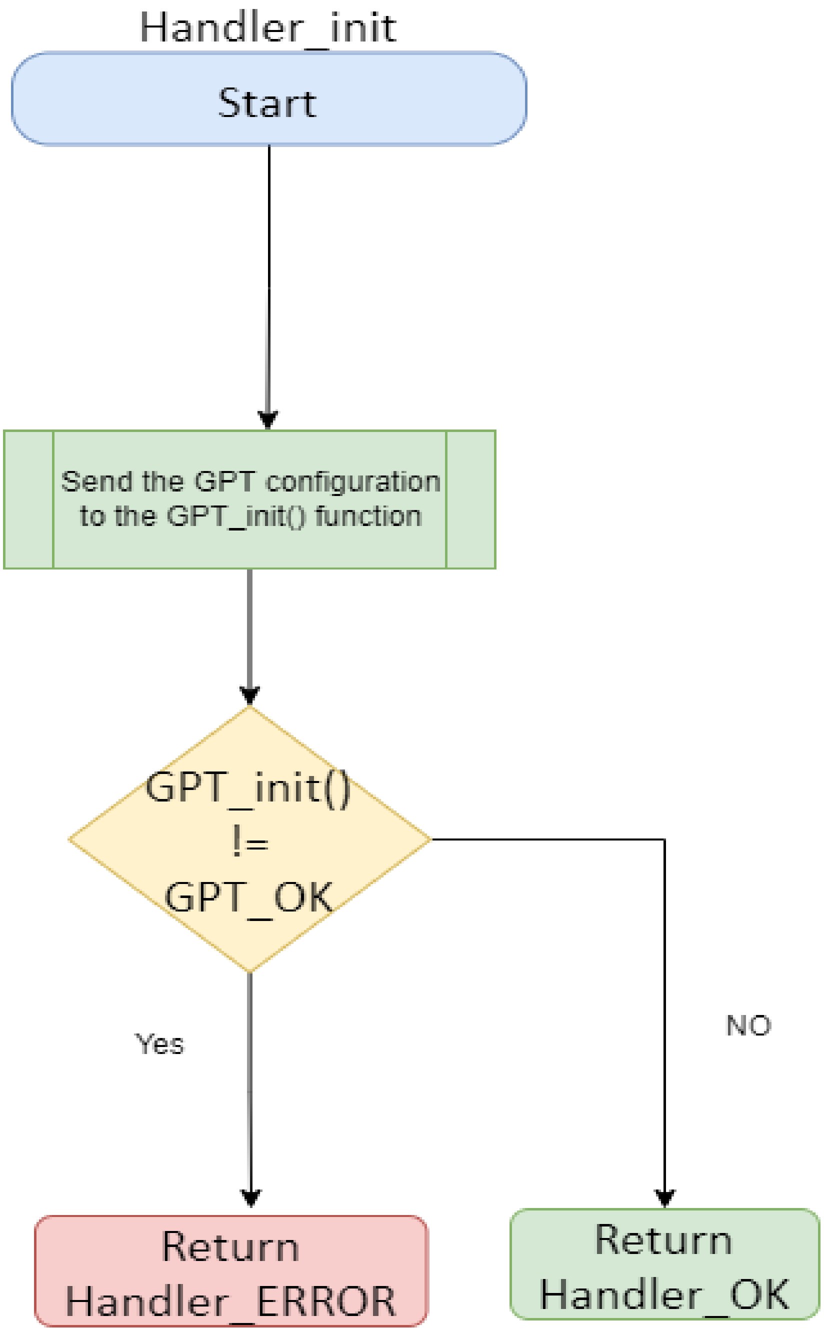
3.2.2.4.2 Button_cfg.h



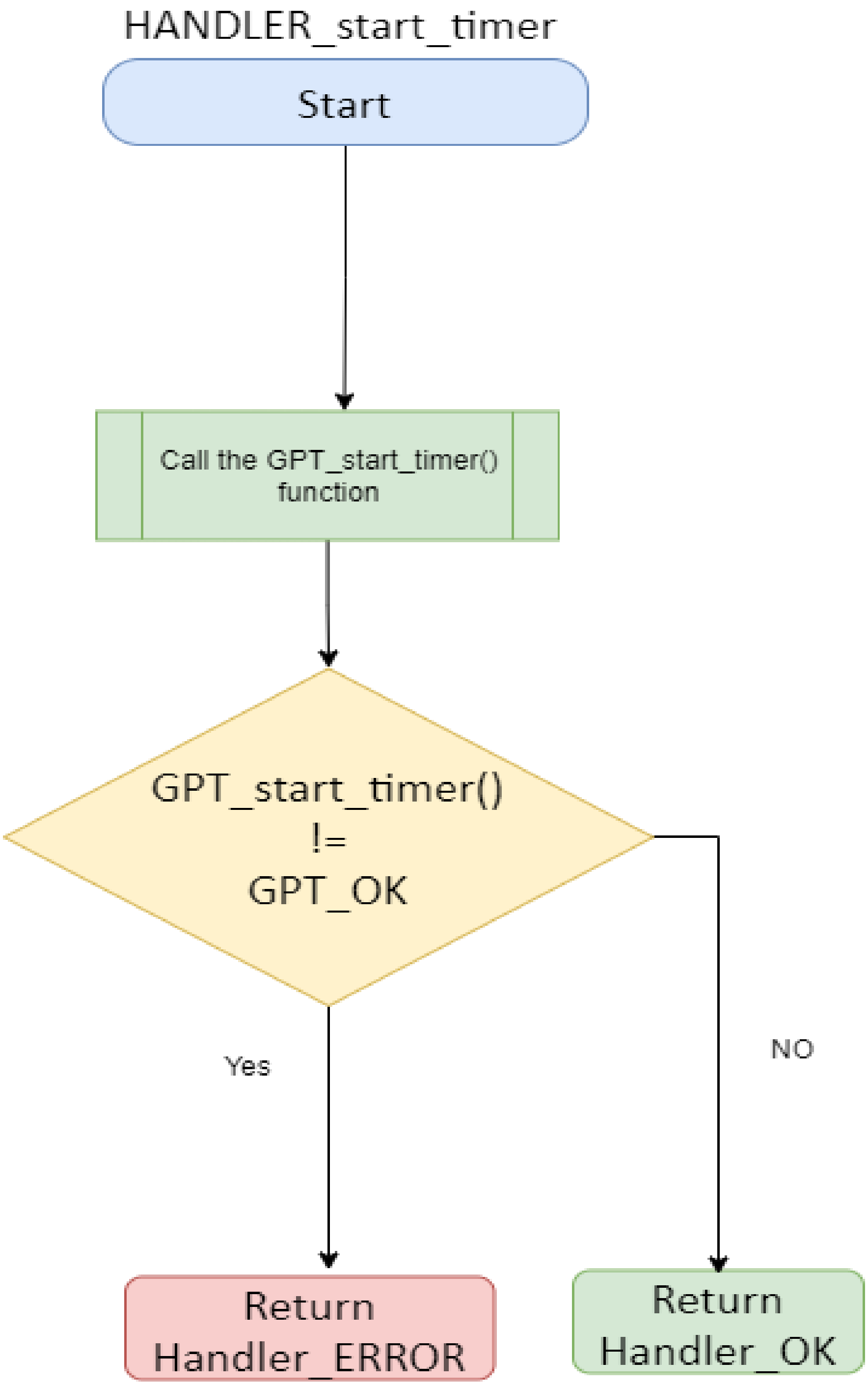
```
/*
 * led_cfg.h
 * Created: 18/6/2023 4:14:40 AM
 *  Author: Mahmoud Mowafey
 */

/** @file led_cfg.h
 * @brief This module contains interface definitions for the
 * LED configuration. This is the header file for the definition of the
 * interface for retrieving the LED configuration table.
*/

/**********************************************************************
* Includes
**********************************************************************/
#include "gpio_cfg.h" /* For this modules definitions */

/**********************************************************************
* Module Preprocessor Constants
**********************************************************************/
/**********************************************************************
* Module Typedefs
**********************************************************************/
typedef enum LED_ID {
    LED_0 = 0,
    LED_1,
    LED_2,
    LED_3,
    LED_4,
    LED_5,
    LED_6,
    LED_7,
    LED_8,
    LED_9,
    LED_10,
}enu_led_id_t;


typedef struct led{
    str_GPIO_configs_t   gpio_for_led_confige;
    enu_led_id_t led_id;
}str_led_confige_t;

/**********************************************************************
* Module Function Prototypes
**********************************************************************/
const str_led_confige_t *const LED_ConfigGet(void);
/***End of File****************************************************/
```

3.2.3 T_Handler Module

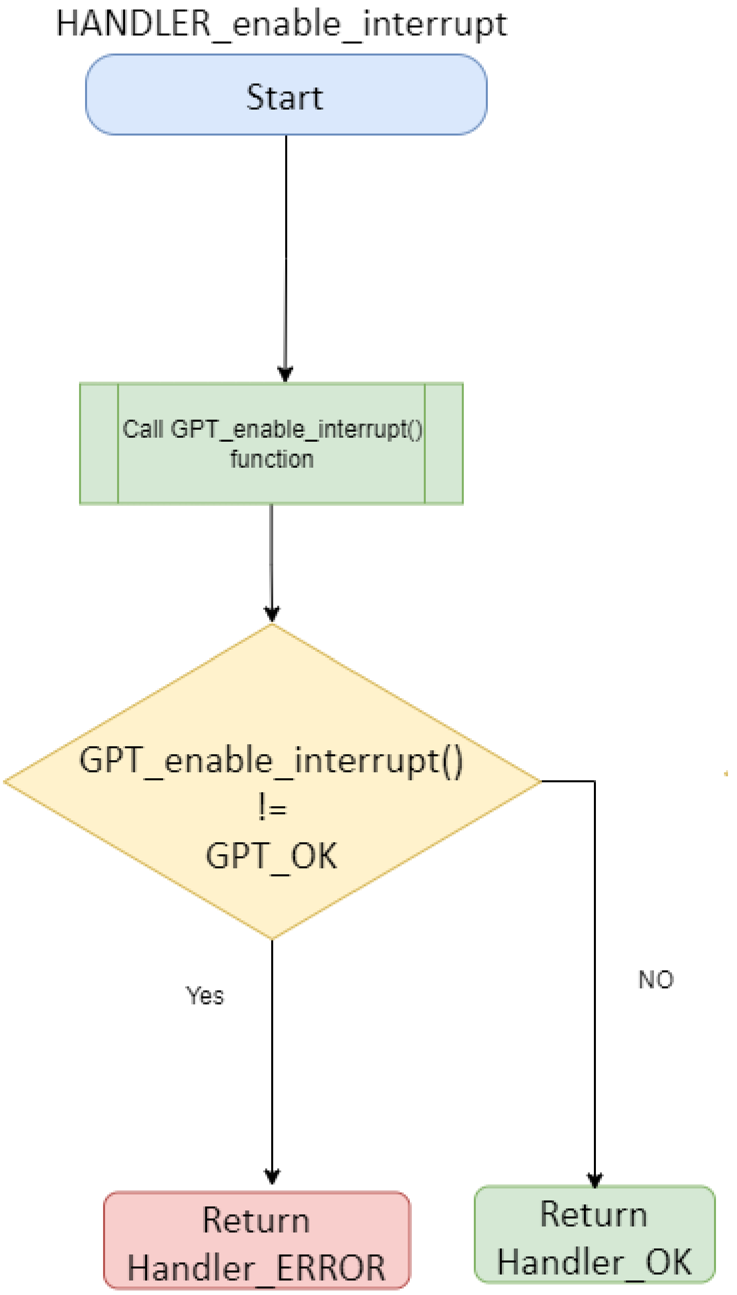
3.2.3.1 HANDLER_init



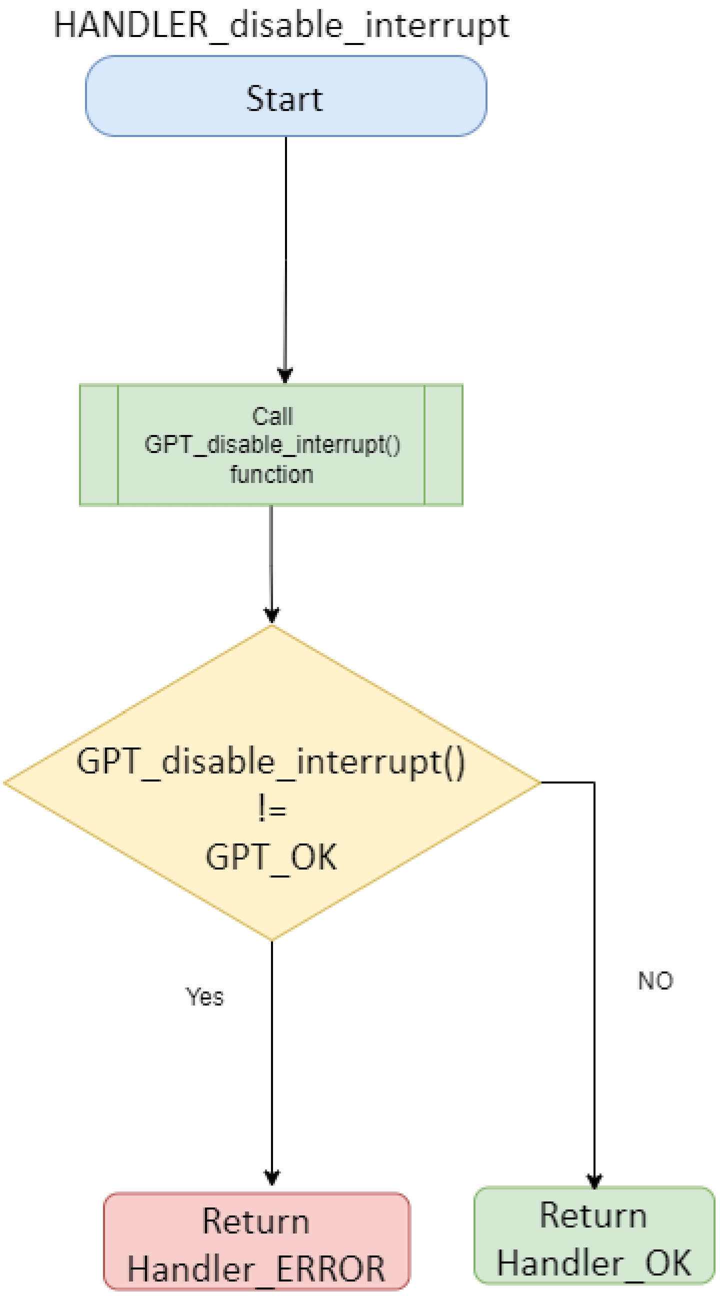
3.2.3.2 HANDLER_start_timer



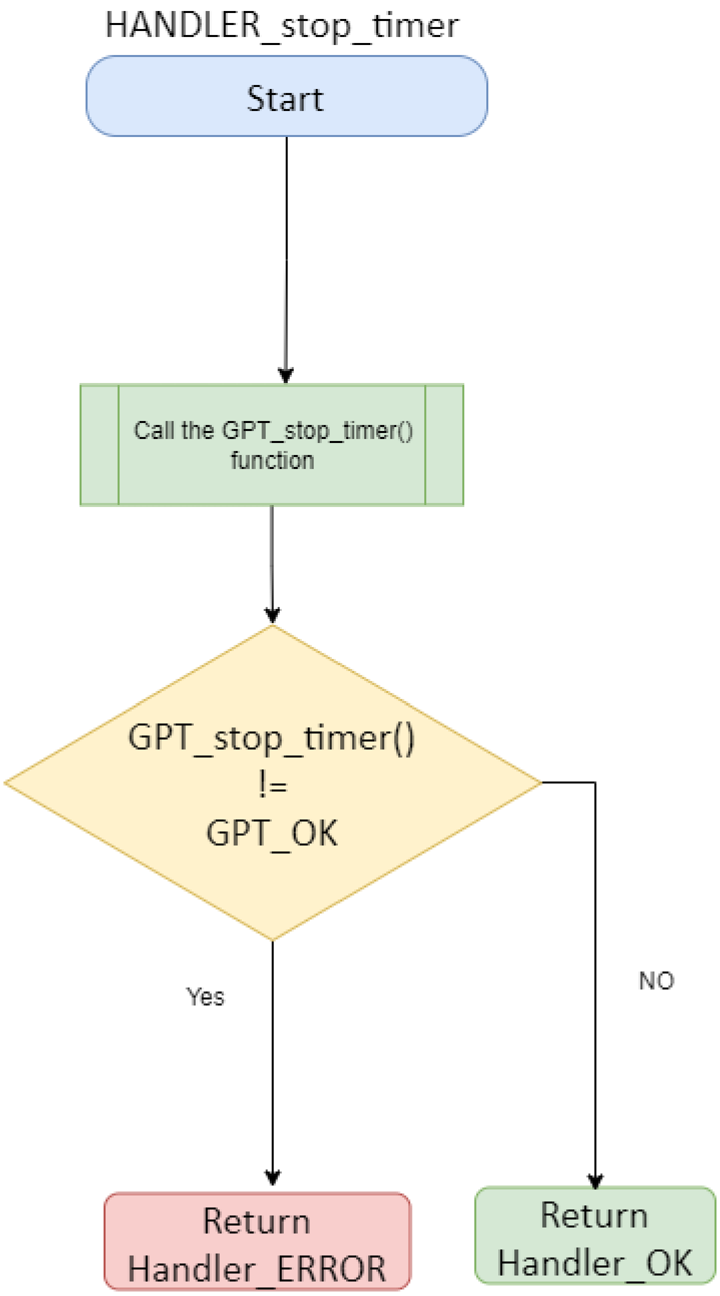
3.2.3.3 HANDLER_enable_interrupt



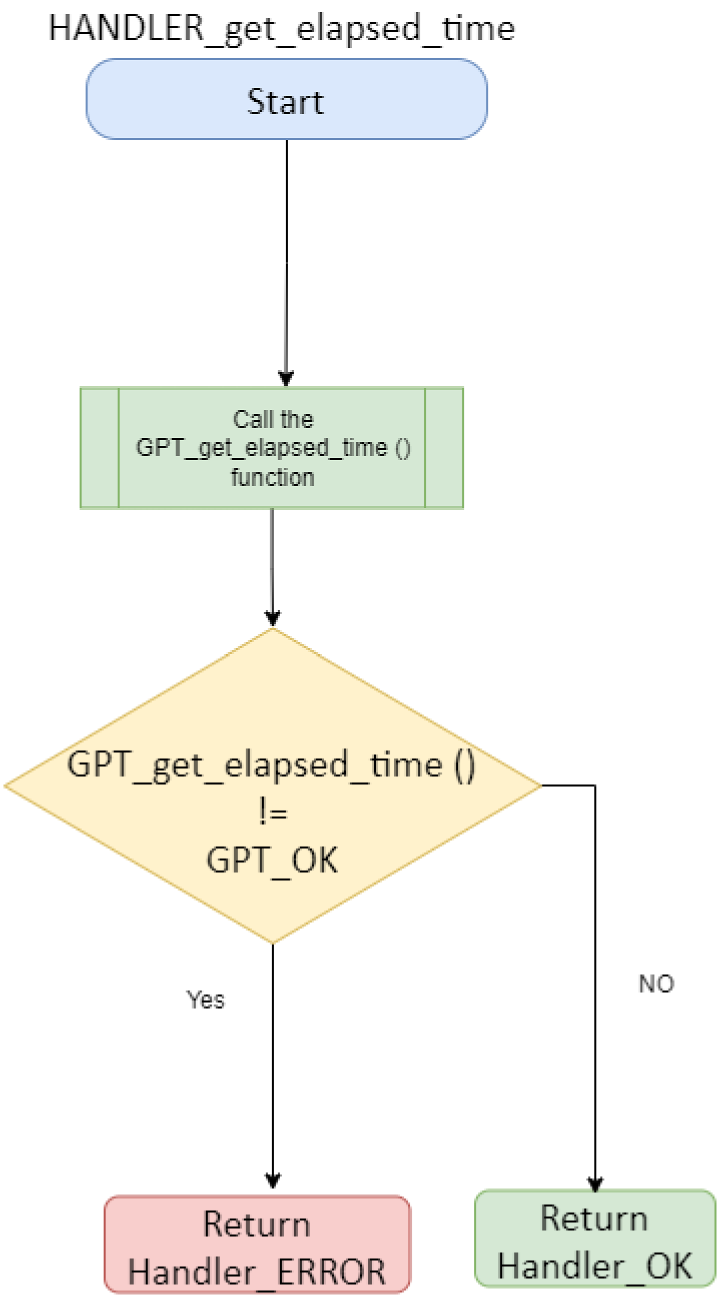
3.2.3.4 HANDLER_disable_interrupt


HANDLER_disable_interrupt
Start
Call GPT_disable_interrupt() function
GPT_disable_interrupt() != GPT_OK
Yes
NO
Return Handler_ERROR
Return Handler_OK

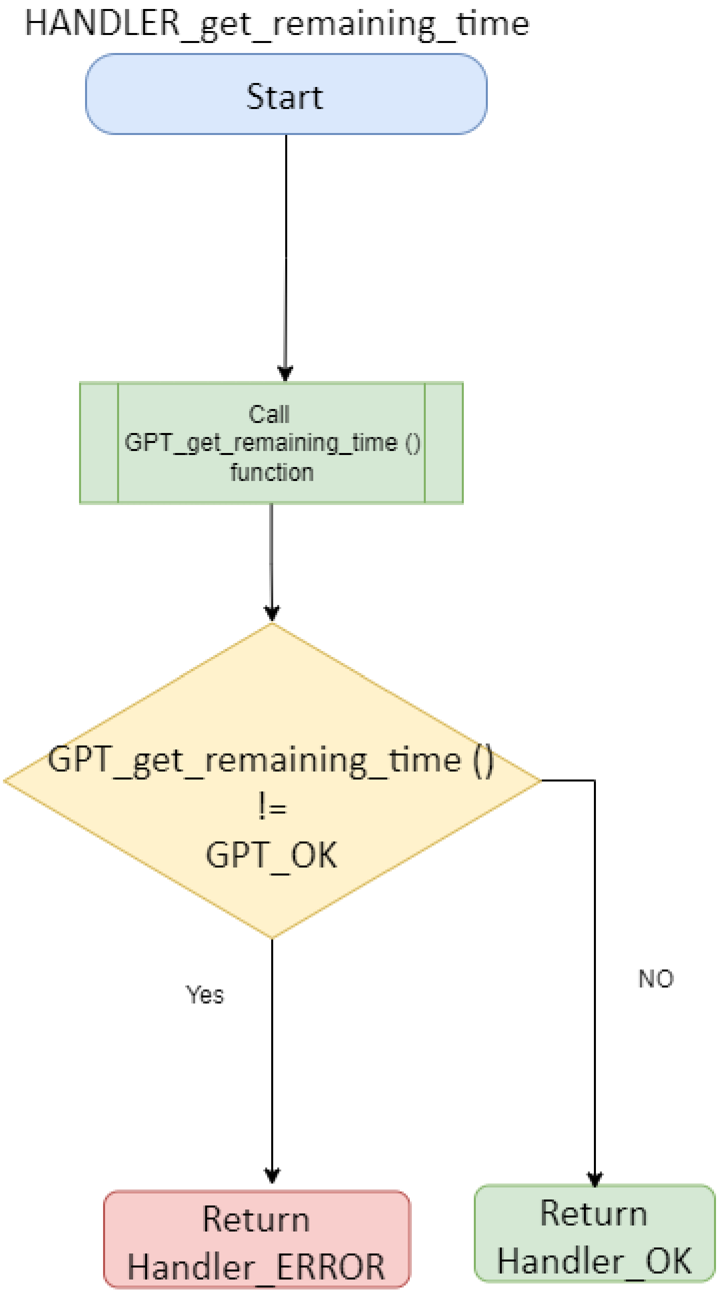
3.2.3.5 HANDLER_stop_timer



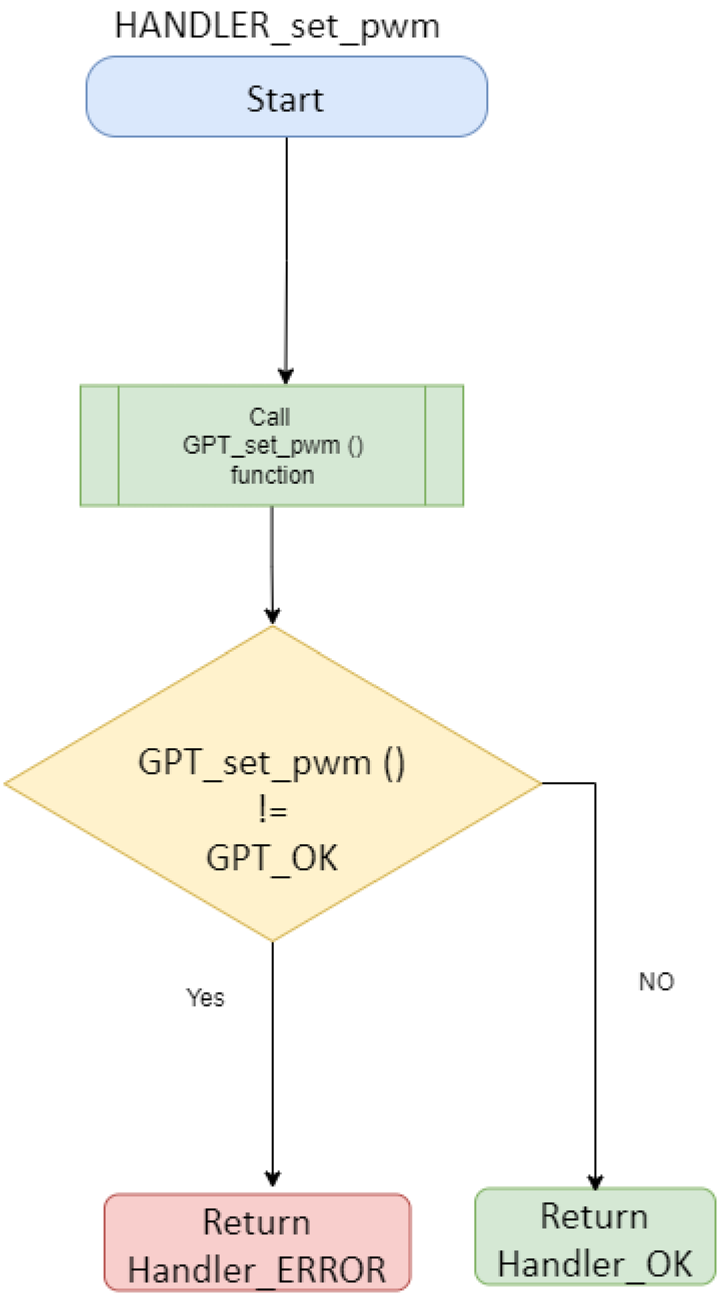
3.2.3.6 HANDLER_get_elapsed_time


HANDLER_get_elapsed_time
Start
Call the GPT_get_elapsed_time () function
GPT_get_elapsed_time () != GPT_OK
Yes
NO
Return Handler_ERROR
Return Handler_OK

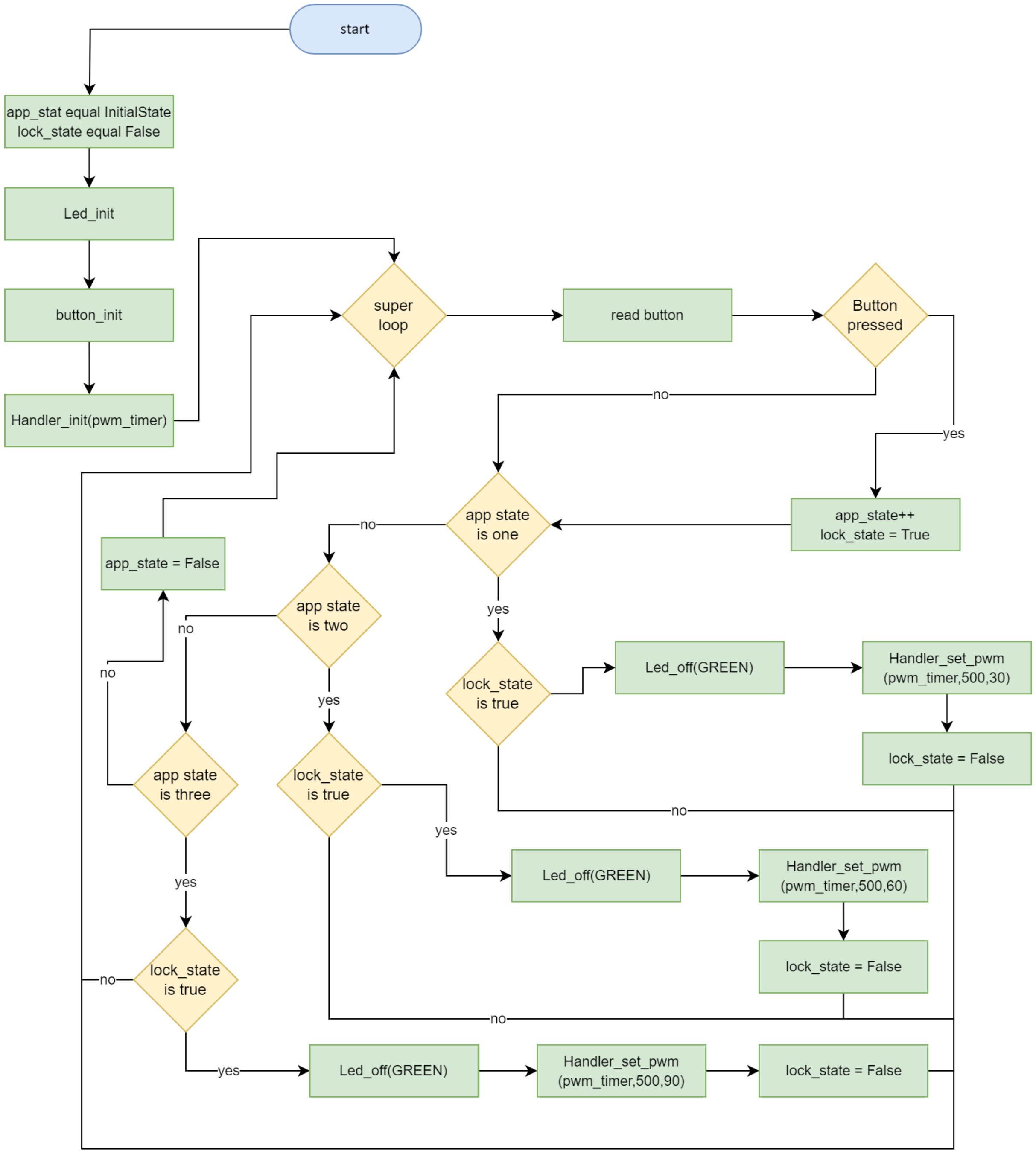
3.2.3.7 HANDLER_get_remaining_time


HANDLER_get_remaining_time
Start
Call GPT_get_remaining_time () function
GPT_get_remaining_time () != GPT_OK
Yes
NO
Return Handler_ERROR
Return Handler_OK

3.2.3.8 HANDLER_set_pwm



3.3. APP Flowchart


start
app_stat equal InitialState
lock_state equal False
Led_init
button_init
Handler_init(pwm_timer)
super loop
read button
Button pressed
no
yes
app_state++
lock_state = True
app state is one
no
yes
app state is two
lock_state is true
Led_off(GREEN)
Handler_set_pwm (pwm_timer,500,30)
lock_state = False
no
app_state = False
no
no
yes
app state is three
lock_state is true
yes
Led_off(GREEN)
Handler_set_pwm (pwm_timer,500,60)
lock_state = False
yes
no
lock_state is true
no
yes
Led_off(GREEN)
Handler_set_pwm (pwm_timer,500,90)
lock_state = False