Design document

project title: RGB LED Control V2.0 Design

Represented by: Hazem Ashraf
Team: 3

Table of contents

High Level Design

• Project Description

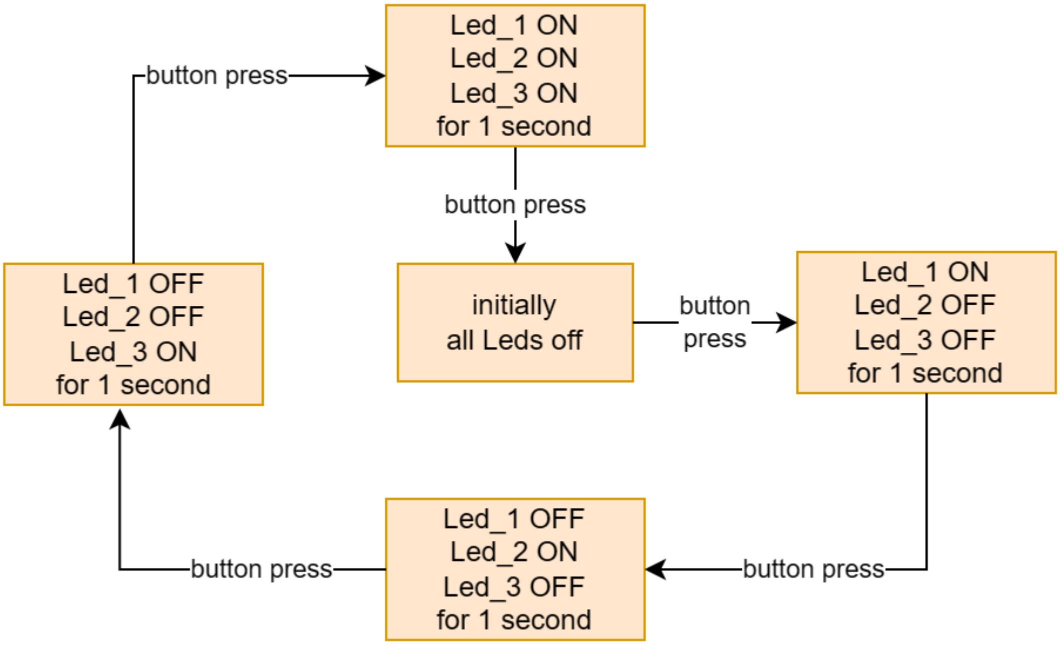
You are supposed to develop the GPIO Driver and use it to control RGB LED on the TivaC board based using the push button.

• Project components

Use the TivaC board
Use SW1 as an input button
Use the RGB LED

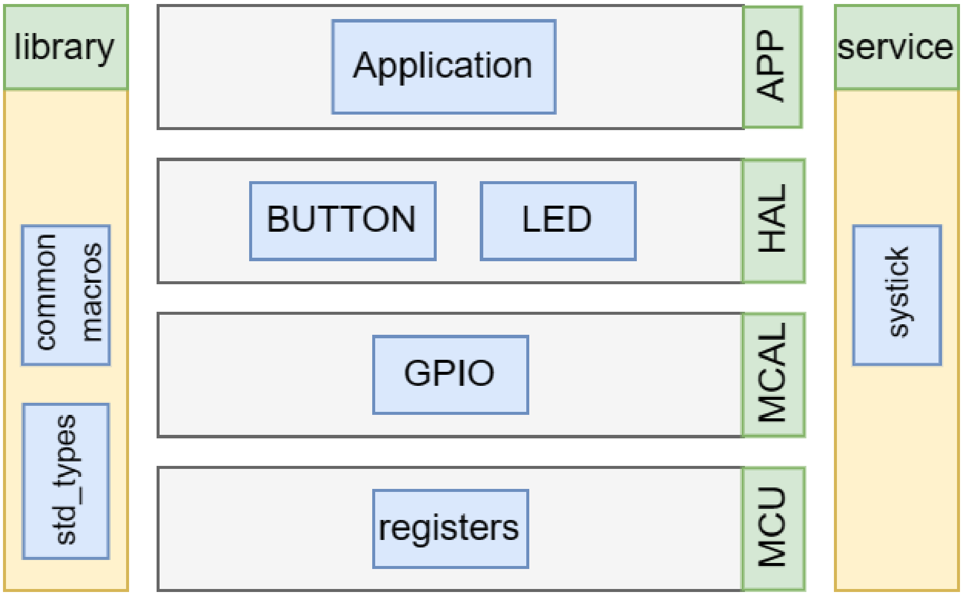
• Main Application Flow

1. The RGB LED is OFF initially
2. Pressing SW1:
   - After the first press, the Red led is on **for 1 second only**
   - After the second press, the Green Led is on **for 1 second only**
   - After the third press, the Blue led is on **for 1 second only**
   - After the fourth press, all LEDs are on **for 1 second only**
   - After the fifth press, should disable all LEDs
   - After the sixth press, repeat steps from 1 to 6



High Level Design

- Layered architecture



- **Layer Architecture Description**

  - **Application Layer**

refers to a software layer used for system- and application-specific purposes that is decoupled from the underlying hardware. The application code meets product-specific features and requirements.

  - **Hardware abstraction layer (HAL)**

refers to a firmware layer that replaces hardware-level accesses with higher-level function calls.

  - **Service layer**

refers to the software layer that contains low-level, microcontroller-specific software. And any layer could use the Service

  - **MCAL**

refers to the software layer that contains low-level, microcontroller-specific software. The driver layer forms the basis from which higher-level software interacts with and controls the microcontroller.

  - **Library**

Refers to the layer that contain system utilities and any software that could be used with any layer

High Level Design

- **Modules Description**

  - **APP Layer**

    Contain the implementation of application initialization and application start

  - **HAL modules**

    BUTTON

    Used to configure button pin as input and it is used for change LED state

    LED

    Used to configure LED pin as output and it is used to control LED state

  - **MCAL modules**

    GPIO

    Used to configure pins directions and read the pin if it is direction is input and write high / low if it is directions is output. Using GPIO for initialize BUTTON ,LED

  - **Service modules**

    Systick

    Cortex-M4 includes an integrated system timer, Systick, which provides a simple, 24-bit clear-on-write,
    used to make system time delay

- **APP APIs**

1- **app_init** function will initialize the button and led

Function Name	**app_init**
Syntax	**void app_init (void);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	None
Parameters (out):	None
Return	None

2- **app_start** function run while(1) to start program logic

Function Name	**app_start**
Syntax	**void app_start (void);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	None
Parameters (out):	None
Return	None

Drivers Documentation Project Modules APIs

- **GPIO APIs**

1- GPIO_init function will initialize a specific pin with the required configuration

Function Name	**GPIO_init**
Syntax	**enu_gpio_error_state_t GPIO_init** **(const str_gpio_config_t* str_gpio_config);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**str_gpio_config:** pointer to structure of gpio configuration type
Parameters (out):	None
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

2- GPIO_digitalWrite used to write high/ low to specific pin

Function Name	**GPIO_digitalWrite**
Syntax	**enu_gpio_error_state_t GPIO_digitalWrite** **(enu_gpio_port_id_t enu_gpio_port_id ,enu_gpio_pin_id_t enu_gpio_pin_id ,enu_gpio_pin_level_t enu_gpio_pin_level);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7] **enu_gpio_pin_level :**the value of the pin ,should be [ENU_PIN_LOW, ENU_PIN_HIGH]
Parameters (out):	None
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

- **GPIO APIs**

3- GPIO_digitalRead used to read high/ low from specific pin

Function Name	**GPIO_digitalRead**
Syntax	**enu_gpio_error_state_t GPIO_digitalRead (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id,uint8* P_value);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**P_value:** the value of the required pin
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

4- GPIO_togglePin used to toggle value of specific pin

Function Name	**GPIO_togglePin**
Syntax	**enu_gpio_error_state_t GPIO_togglePin (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**None**
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

- **GPIO APIs**

5- GPIO_interruptEnable used set or enable interrupt configuration

Function Name	**GPIO_digitalRead**
Syntax	**enu_gpio_error_state_t GPIO_interruptEnable (enu_interrupt_edge_t enu_interrupt_edge,enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_interrupt_edge :** the interrupt trigger type it should be [ENU_LEVEL, ENU_RISING, ENU_FALLING, ENU_ANY_EDGE_CHANGE] **enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**None**
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

6- GPIO_interruptDisable used disable interrupt

Function Name	**GPIO_interruptDisable**
Syntax	**void GPIO_interruptDisable (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**None**
Return	None

- **GPIO APIs**

7- GPIO_interruptEnable used set or enable interrupt configuration

Function Name	**GPIO_Setcallback**
Syntax	**enu_gpio_error_state_t GPIO_Setcallback (void (*Fptr)(void), enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**Fptr :** pointer to the callback function **enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**None**
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

Drivers Documentation Project Modules APIs

- **LED APIs**

1- **LED_init** function will initialize LED

Function Name	LED_init
Syntax	**enu_error_state_t LED_init (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	None
Return	ENU_INVALID : in case invalid passing parameter ENU_VALID : in case valid passing parameter

2- **LED_digitalWrite** used to write high/ low to specific LED

Function Name	LED_digitalWrite
Syntax	**enu_error_state_t LED_digitalWrite (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id,enu_gpio_pin_level_t enu_gpio_pin_level);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7] **enu_gpio_pin_level :**the value of the pin ,should be [ENU_PIN_LOW, ENU_PIN_HIGH]
Parameters (out):	None
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

Drivers Documentation Project Modules APIs

- **BUTTON APIs**

1- BUTTON_init function will initialize button

Function Name	**BUTTON_init**
Syntax	**enu_error_state_t BUTTON_init (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	None
Return	ENU_INVALID : in case invalid passing parameter ENU_VALID : in case valid passing parameter

2- BUTTON_digitalRead used to write high/ low to specific LED

Function Name	**BUTTON_digitalRead**
Syntax	**enu_error_state_t BUTTON_digitalRead (enu_gpio_port_id_t enu_gpio_port_id,enu_gpio_pin_id_t enu_gpio_pin_id,uint8* p_value);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**enu_gpio_port_id :** port id should be one of the following [ENU_PORT_A, ENU_PORT_B, ENU_PORT_C, ENU_PORT_D, ENU_PORT_E, ENU_PORT_F] **enu_gpio_pin_id** :pin id should be one of the following [ENU_PIN_0, ENU_PIN_1, ENU_PIN_2, ENU_PIN_3, ENU_PIN_4, ENU_PIN_5, ENU_PIN_6, ENU_PIN_7]
Parameters (out):	**P_value:** the value of the required pin
Return	ENU_INVALID : in case invalid configuration parameter ENU_VALID : in case valid configuration parameter

- **Systick APIs**

1- **systick_init** function will initialize Systick

Function Name	**systick_init**
Syntax	**enu_systick_error_t systick_init (str_systick_config_t* str_systick_config);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**str_systick_config:** pointer to structure of Systick configuration type Configure the clock source and the interrupt state
Parameters (out):	None
Return	INVALID_OPERATION: in case invalid passing parameter VALID_OPERATION: in case valid passing parameter

2- **systick_enableInt** function will enable the interrupt

Function Name	**systick_enableInt**
Syntax	**void systick_enableInt (void);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	None
Parameters (out):	None
Return	None

3- **systick_disableInt** function will disable the interrupt

Function Name	**systick_disableInt**
Syntax	**void systick_disableInt (void);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	None
Parameters (out):	None
Return	None

- **Systick APIs**

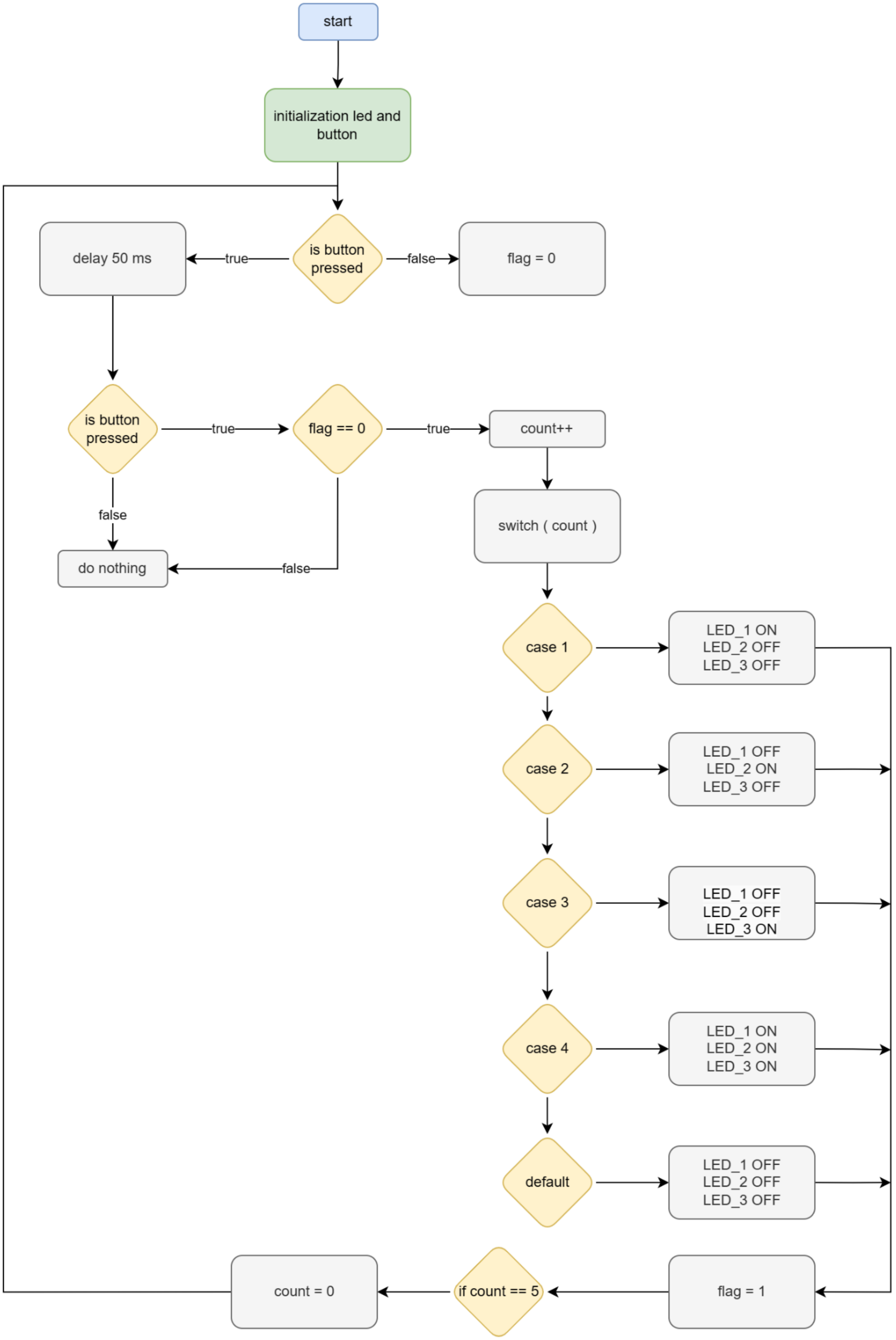
4- systick_delay_ms function used to start delay in ms

Function Name	**systick_delay_ms**
Syntax	**void systick_delay_ms (uint32 delay);**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**Delay :** the required time of delay in ms
Parameters (out):	None
Return	None

5- systick_waitEvent function used to call function after time elapse

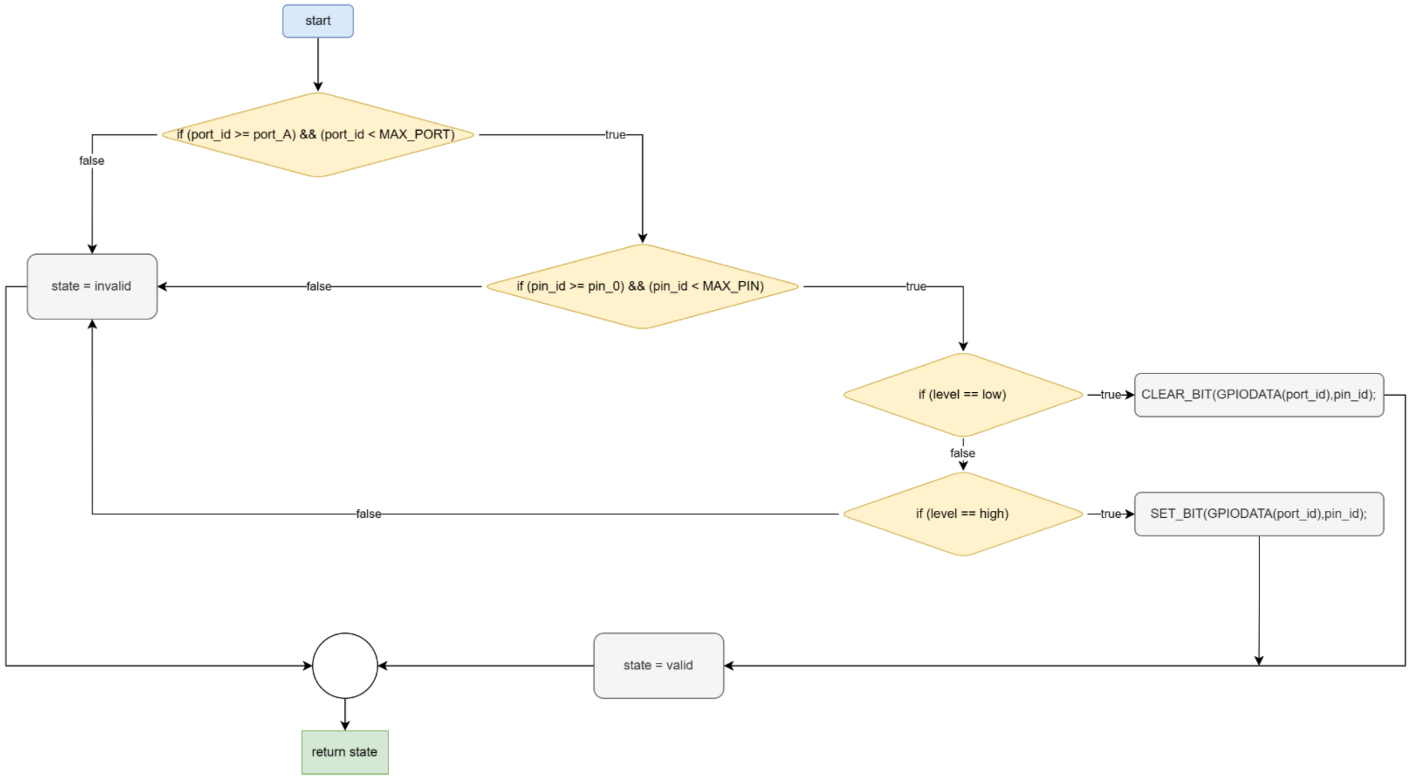
Function Name	**systick_waitEvent**
Syntax	**enu_systick_error_t systick_waitEvent (uint32 delay, void (*F_ptr)(void));**
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in):	**Delay :** the required time of delay in ms **F_ptr :** pointer to callback function
Parameters (out):	None
Return	INVALID_OPERATION: in case invalid passing parameter VALID_OPERATION: in case valid passing parameter

App flowchart

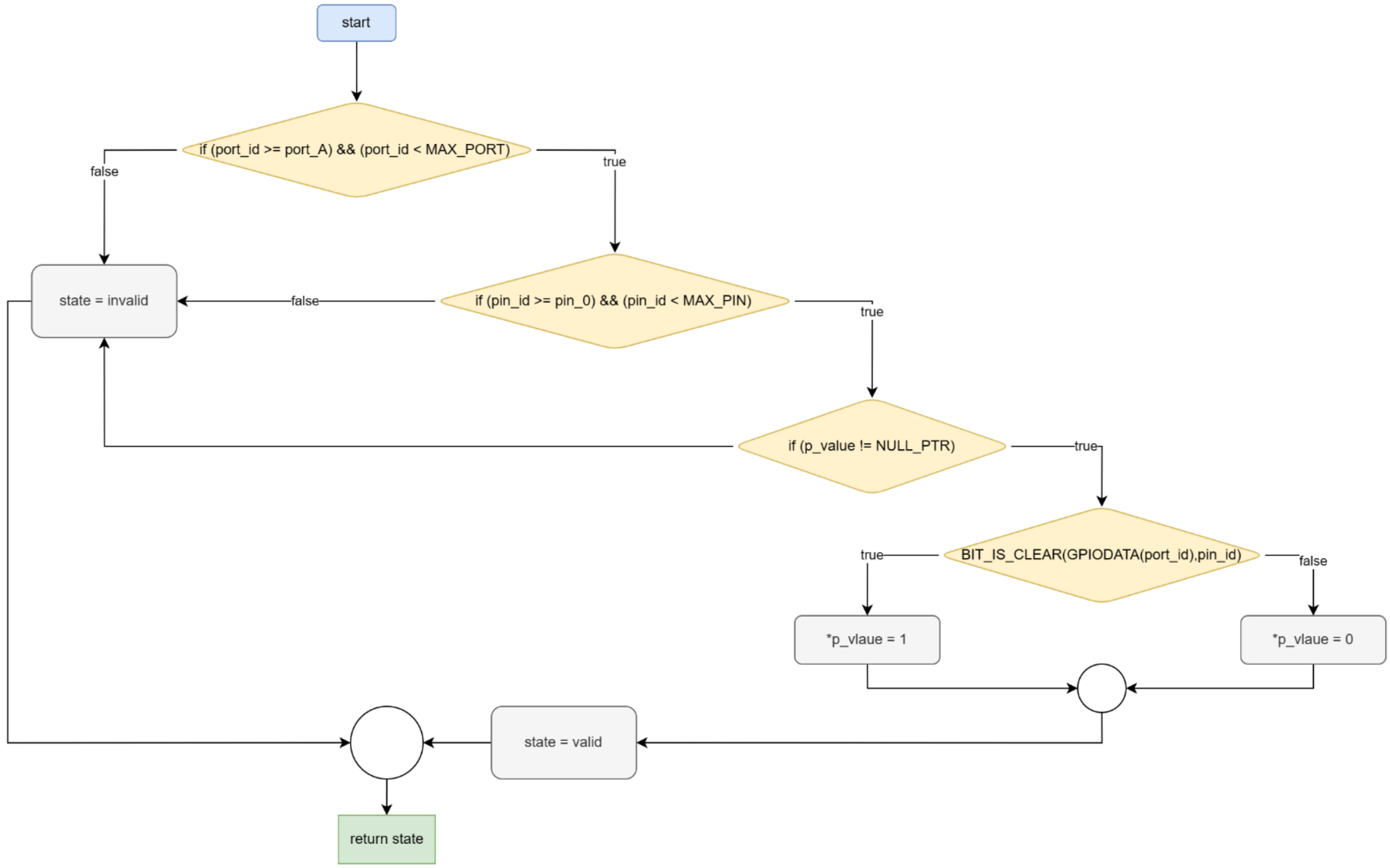


GPIO flowchart

- **GPIO_digitalWrite**

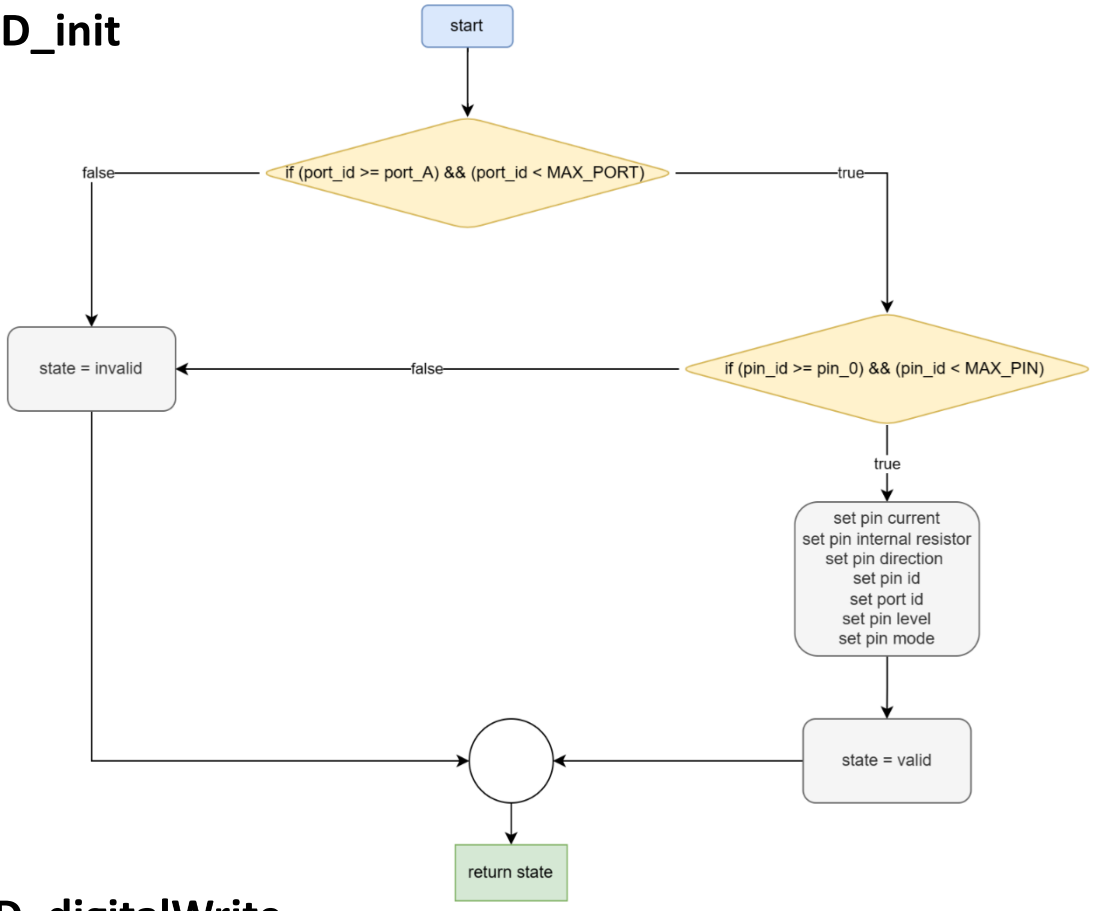

start
if (port_id >= port_A) && (port_id < MAX_PORT)
false
true
state = invalid
false
if (pin_id >= pin_0) && (pin_id < MAX_PIN)
true
if (level == low)
true
CLEAR_BIT(GPIODATA(port_id),pin_id);
false
false
if (level == high)
true
SET_BIT(GPIODATA(port_id),pin_id);
state = valid
return state

- **GPIO_digitalRead**

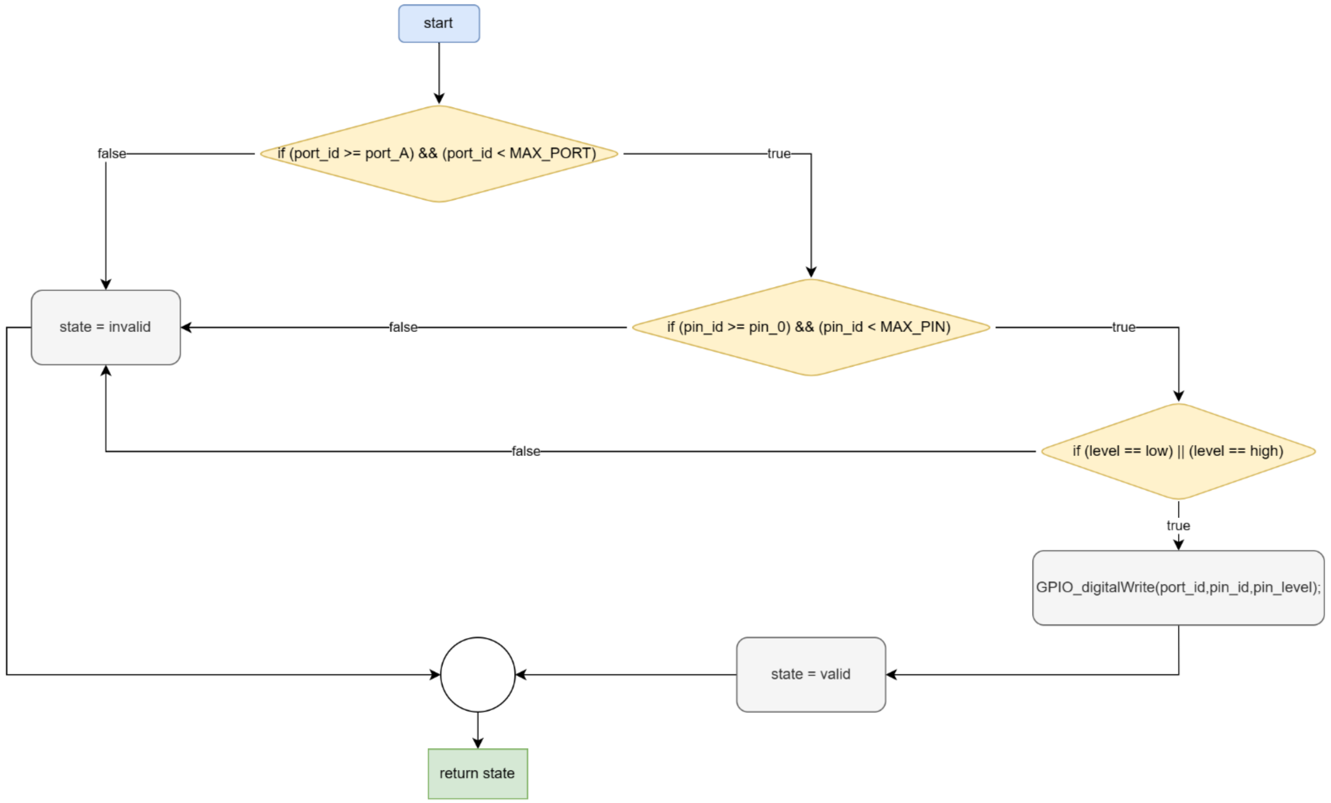

start
if (port_id >= port_A) && (port_id < MAX_PORT)
false
true
state = invalid
false
if (pin_id >= pin_0) && (pin_id < MAX_PIN)
true
if (p_value != NULL_PTR)
true
BIT_IS_CLEAR(GPIODATA(port_id),pin_id)
true
false
*p_vlaue = 1
*p_vlaue = 0
state = valid
return state

LED flowchart

- **LED_init**

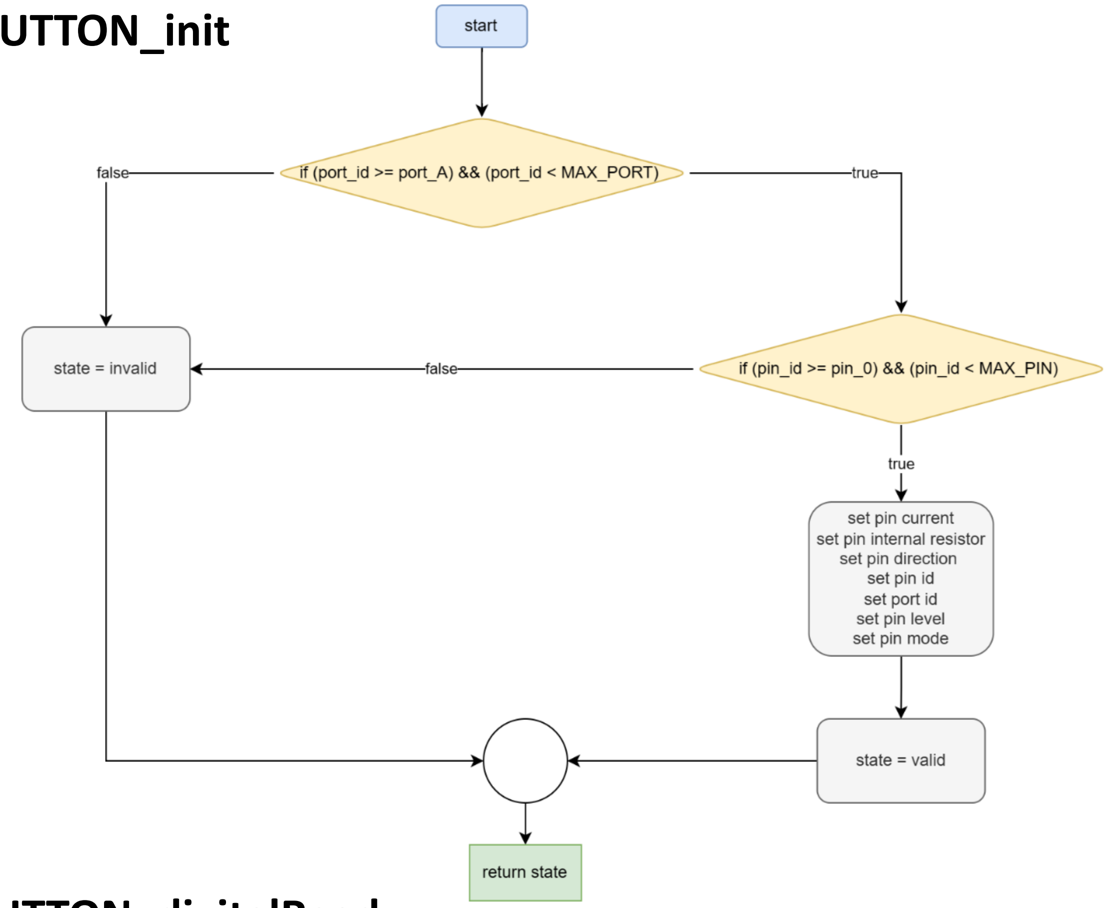


- **LED_digitalWrite**

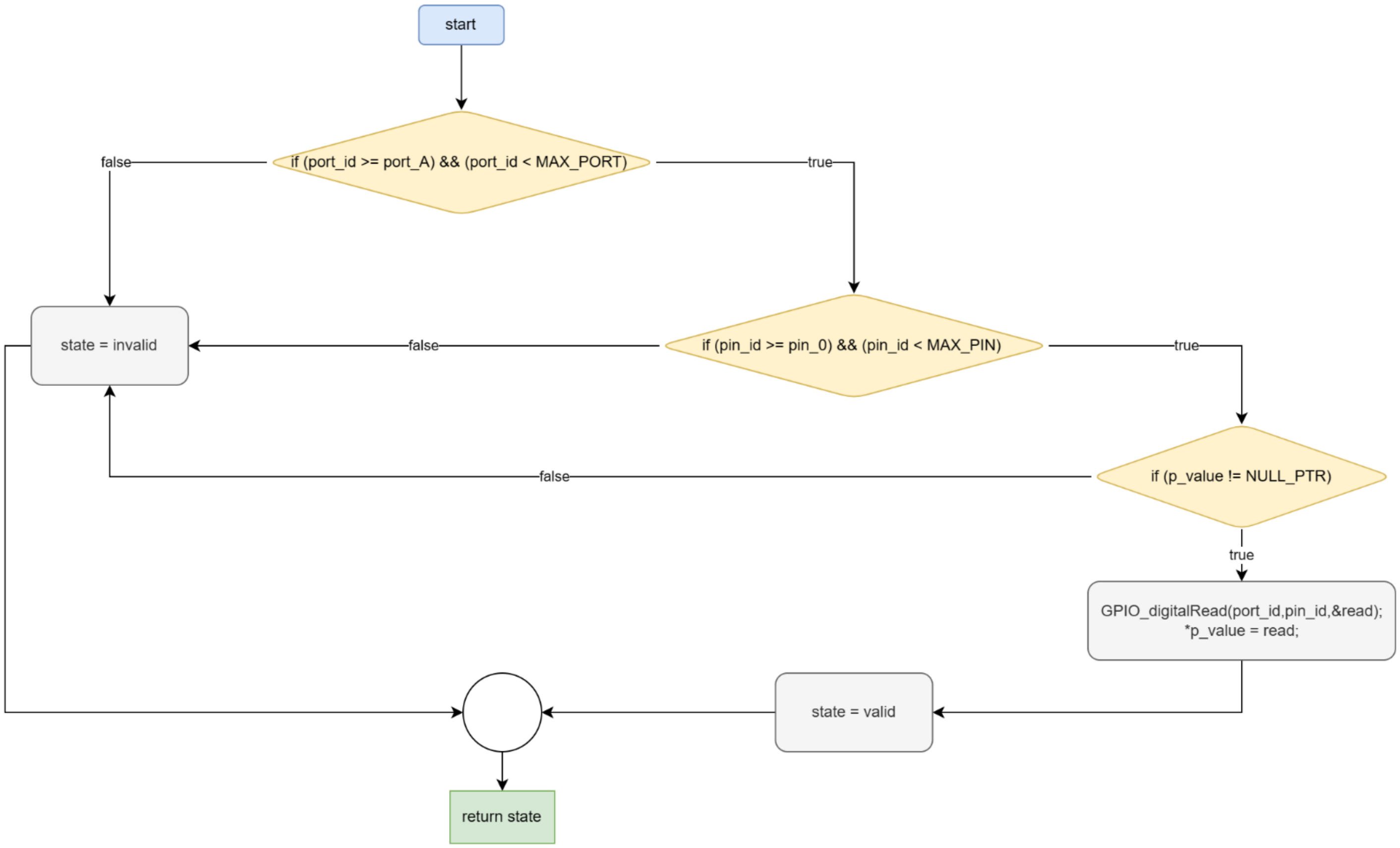

start
if (port_id >= port_A) && (port_id < MAX_PORT)
false
true
state = invalid
false
if (pin_id >= pin_0) && (pin_id < MAX_PIN)
true
false
if (level == low) || (level == high)
true
GPIO_digitalWrite(port_id,pin_id,pin_level);
state = valid
return state

BUTTON flowchart

- **BUTTON_init**

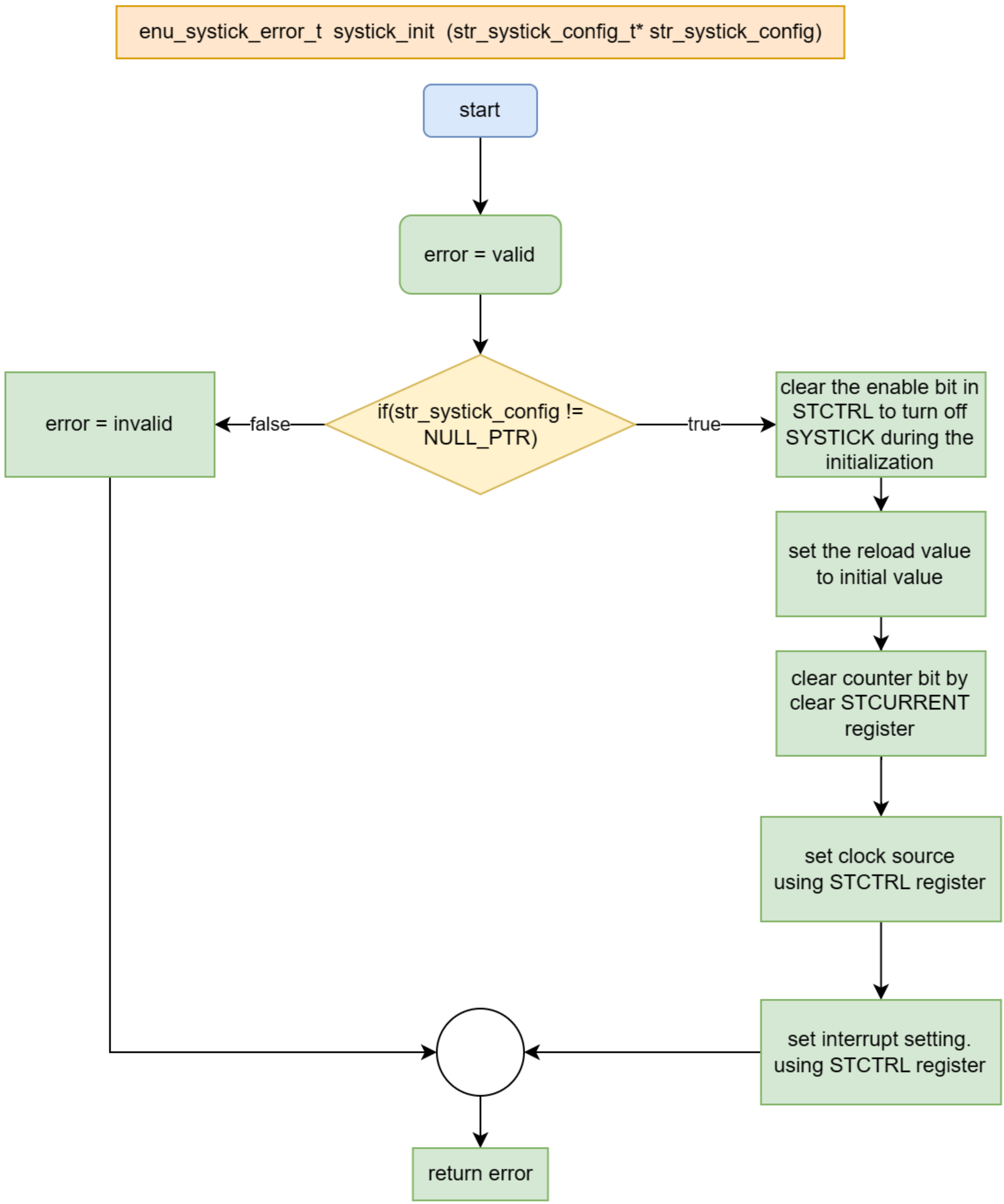


- **BUTTON_digitalRead**


start
if (port_id >= port_A) && (port_id < MAX_PORT)
false
true
state = invalid
false
if (pin_id >= pin_0) && (pin_id < MAX_PIN)
true
false
if (p_value != NULL_PTR)
true
GPIO_digitalRead(port_id,pin_id,&read);
*p_value = read;
state = valid
return state

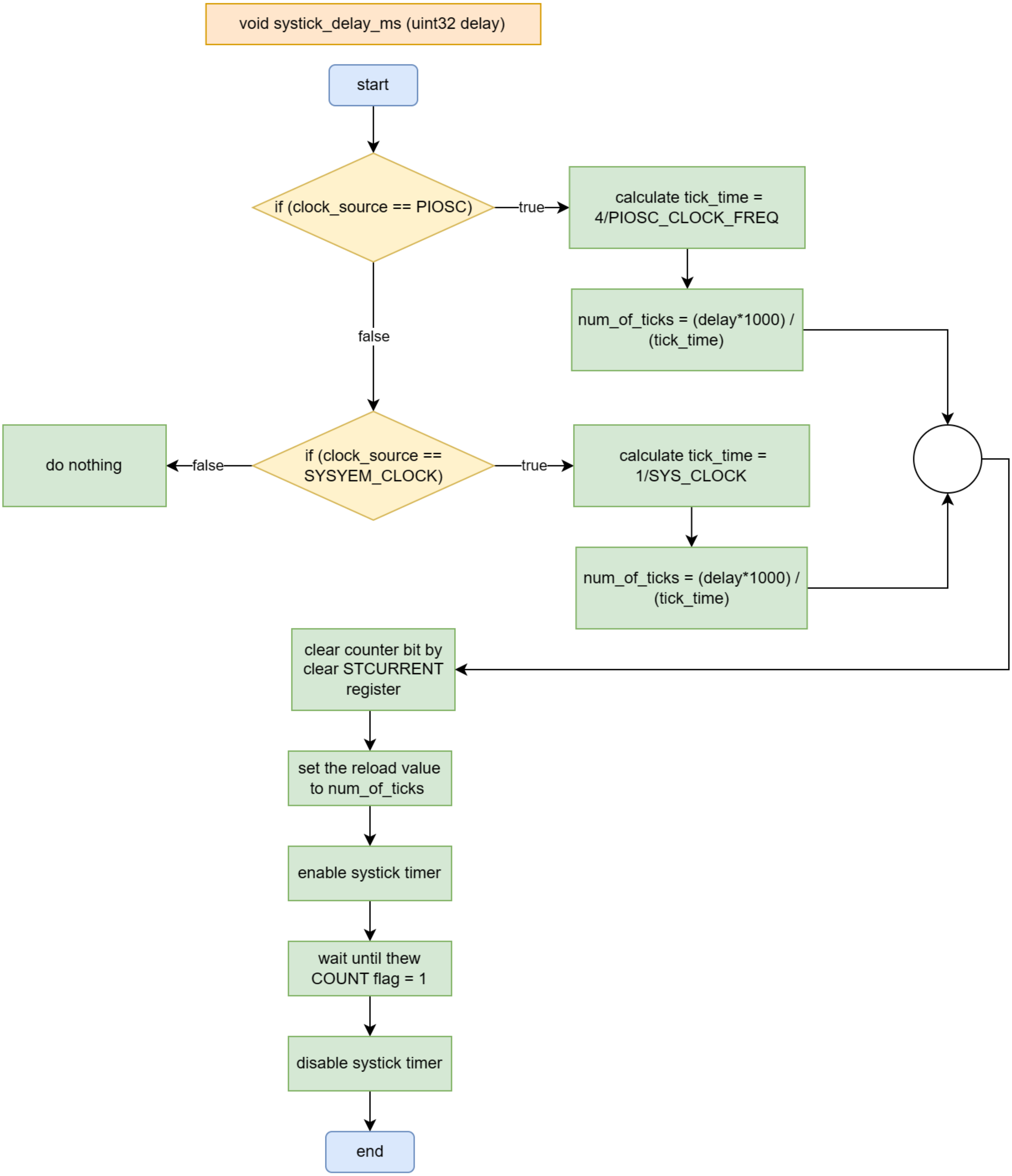
Systick flowchart

- **systick_init**


enu_systick_error_t systick_init (str_systick_config_t* str_systick_config)
start
error = valid
if(str_systick_config != NULL_PTR)
false
error = invalid
true
clear the enable bit in STCTRL to turn off SYSTICK during the initialization
set the reload value to initial value
clear counter bit by clear STCURRENT register
set clock source using STCTRL register
set interrupt setting. using STCTRL register
return error

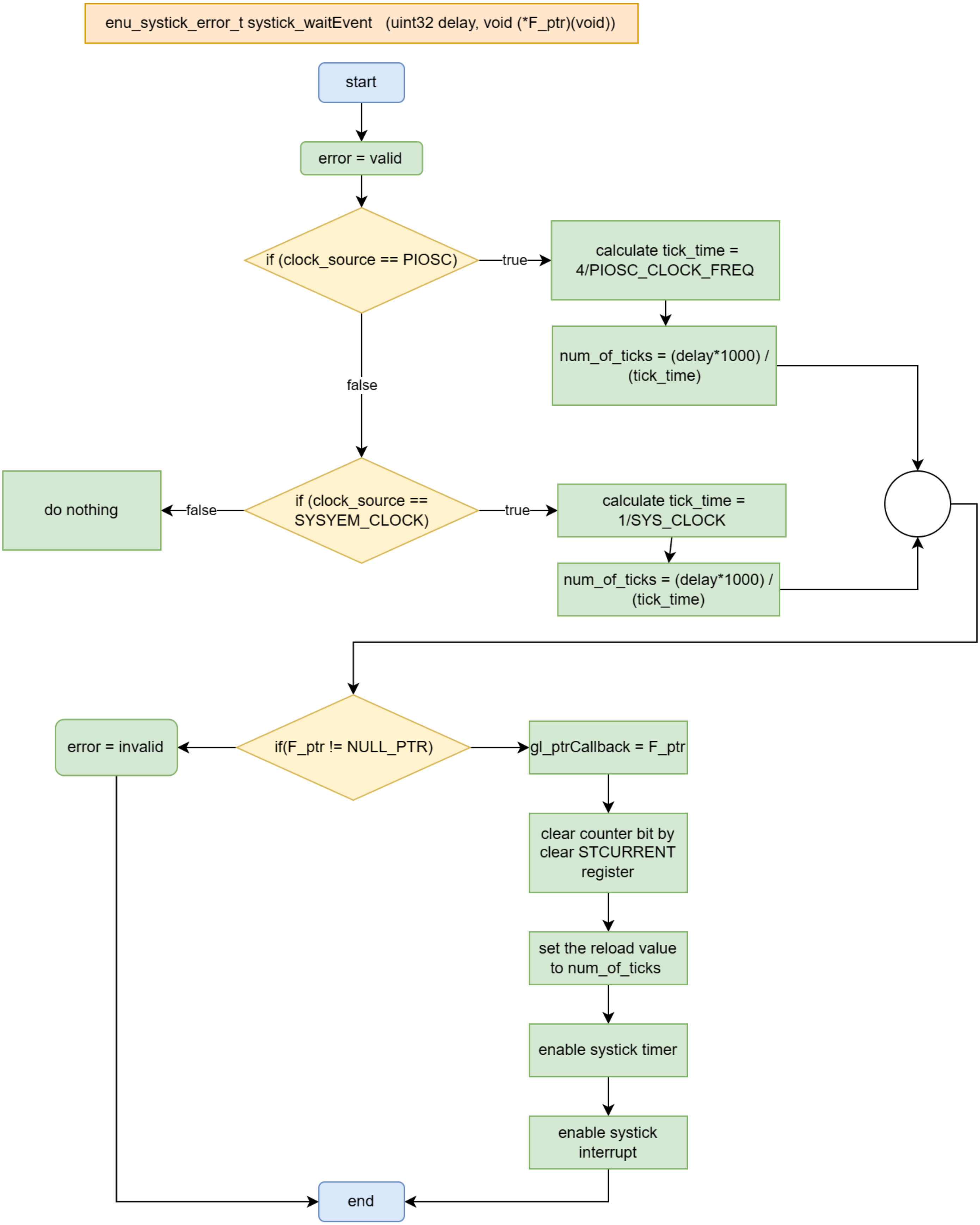
Systick flowchart

- **systick_delay_ms**


void systick_delay_ms (uint32 delay)
start
if (clock_source == PIOSC)
true
calculate tick_time = 4/PIOSC_CLOCK_FREQ
num_of_ticks = (delay*1000) / (tick_time)
false
do nothing
false
if (clock_source == SYSYEM_CLOCK)
true
calculate tick_time = 1/SYS_CLOCK
num_of_ticks = (delay*1000) / (tick_time)
clear counter bit by clear STCURRENT register
set the reload value to num_of_ticks
enable systick timer
wait until thew COUNT flag = 1
disable systick timer
end

Systick flowchart

- **systick_waitEvent**


enu_systick_error_t systick_waitEvent (uint32 delay, void (*F_ptr)(void))
start
error = valid
if (clock_source == PIOSC)
true
calculate tick_time = 4/PIOSC_CLOCK_FREQ
num_of_ticks = (delay*1000) / (tick_time)
false
if (clock_source == SYSYEM_CLOCK)
false
do nothing
true
calculate tick_time = 1/SYS_CLOCK
num_of_ticks = (delay*1000) / (tick_time)
if(F_ptr != NULL_PTR)
error = invalid
gl_ptrCallback = F_ptr
clear counter bit by clear STCURRENT register
set the reload value to num_of_ticks
enable systick timer
enable systick interrupt
end