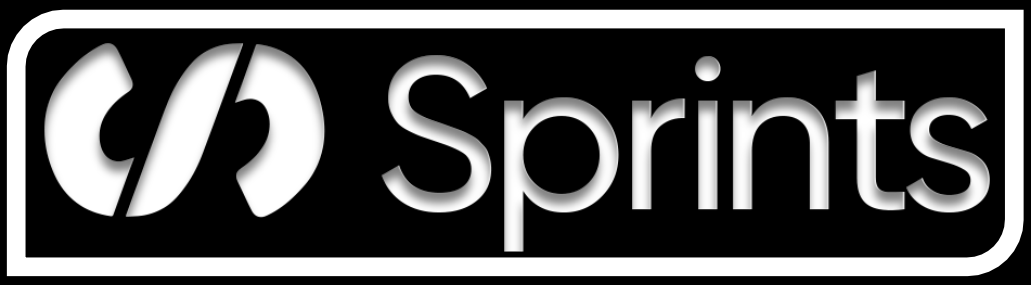


RGB LED Brightness Control

Design

Bassel Yasser Mahmoud

Mahmoud Adel

2023

Contents

Project Introduction

Read System Requirements

Hardware Requirements

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

Software Requirements

- The RGB LED is OFF initially
- The PWM signal has a 500ms duration
- The system has four states
    1. SW1 - First press
        1. The Green LED will be on with a 30% duty cycle
    2. SW1 - Second press
        1. The Green LED will be on with a 60% duty cycle
    3. SW1 -Third press
        1. The Green LED will be on with a 90% duty cycle
    4. SW1 - Fourth press will be off
        1. The Green LED will be off
    5. On the fifth press, system state will return to state 1

High Level Design

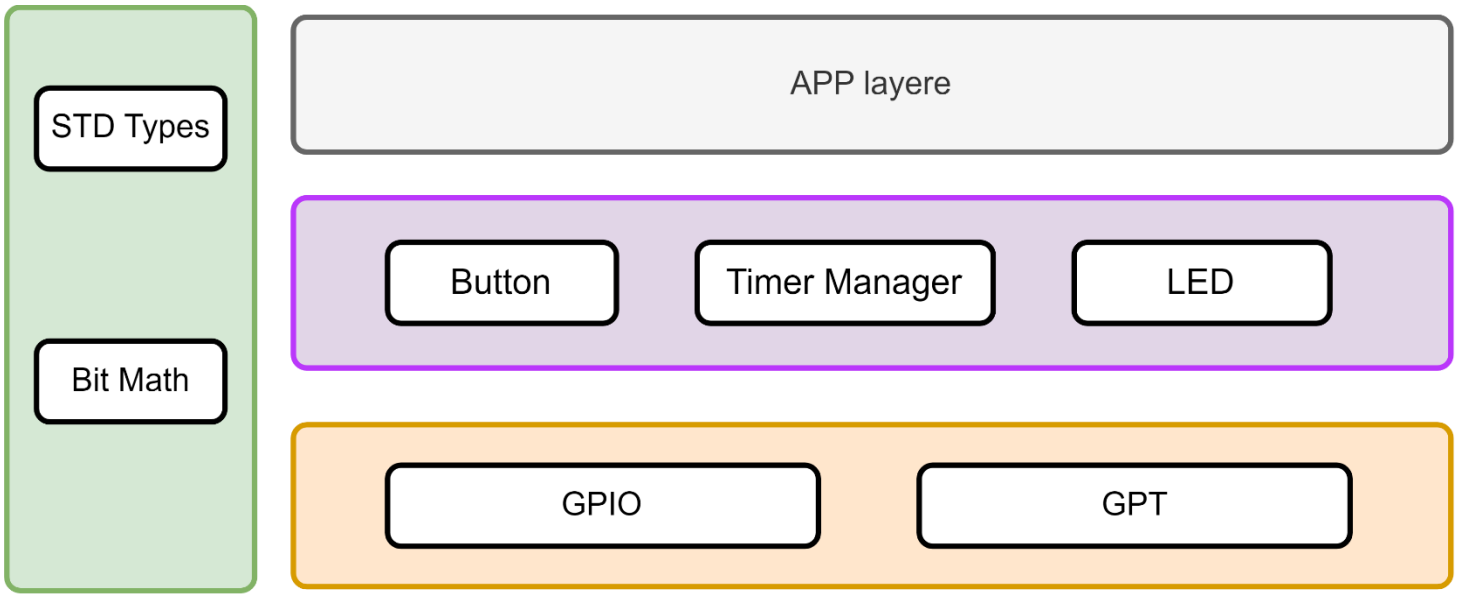
Layered Architecture

APP Layer: written in high level languages like java, C++, C# with rich GUI support. Application layer calls the middleware api in response to action by the user or an event.

HAL Layer: are a way to provide an interface between hardware and software so applications can be device independent.

MCAL Layer: 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. Details of the MCAL software module are shown below.

Common Layer: is the layer which consists of BIT_MATH and STD types



Module Description

- **APP Layer**
  - **App:** written in high level languages like java, C++, C# with rich GUI support. Application layer calls the middleware api in response to action by the user or an event.
- **HAL Layer**
  - **button:** Initialize selected button pin as input
  - **Led:** this led module configure selected pin as output and generate volt
- **MCAL Layer**
  - **GPIO:** The GPIO module is composed of six physical GPIO blocks, each corresponding to an individual GPIO port (Port A, Port B, Port C, Port D, Port E, Port F). The GPIO module supports up to 43 programmable input/output pins, depending on the peripherals being used.
  - **GPT:** Programmable timers 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
- **COMMON Layer**
  - **std_types:** having basic standard types like (Uint32_t, Uint8_t, …..)
  - **bit_math :** Consist of bit manipulation like (SetBit, ClrBit, GetBit, ..)

Drivers' documentation

APP

APP_vidInit

Service name	APP_vidInit
Description	This Function Make Modules Initialization
Syntax	void APP_vidInit (void)
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in)	void
Parameters (out)	None
Return	void
Available via	app.h

APP_vidStart

Service name	APP_vidStart
Description	This Function Start the Application.
Syntax	void APP_vidStart (void)
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in)	void
Parameters (out)	None
Return	void
Available via	app.h

HAL

HLED module

HLed_Init

Service name	HLed_Init
Description	This Function Init LED dio pin as output
Syntax	`enu_ledError_t HLed_Init (enu_pin en_pinNum)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinNum: dio pin selection**
Parameters (out)	None
Return	`en_ledError_t`
Available via	hled.h

HLed_on

Service name	HLed_on
Description	This Function give LED pin logic 1
Syntax	`enu_ledError_t HLed_on (enu_pin en_pinx);`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinNum: dio pin selection**
Parameters (out)	None
Return	`en_ledError_t`
Available via	hled.h

HLed_off

Service name	HLed_off
Description	This Function give LED pin logic 0
Syntax	`enu_ledError_t HLed_off (enu_pin en_pinx)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinNum: dio pin selection**
Parameters (out)	None
Return	`en_ledError_t`
Available via	hled.h

HLed_toggle

Service name	HLed_toggle
Description	This Function Change previous state of LED pin
Syntax	`enu_ledError_t HLed_toggle (enu_pin en_pinx)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinNum: dio pin selection**
Parameters (out)	None
Return	`en_ledError_t`
Available via	hled.h

Button module

HButton_Init

Service name	HButton_Init
Description	This Function Initialize button DIO pin as input and pull up
Syntax	`enu_buttonError_t HButton_Init (enu_pin en_pinx)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinx: DIO pin number**
Parameters (out)	None
Return	*BUTTON_OK: in case of successful operation*
	BUTTON_NOK: in case of failer operation
Available via	button.h

HButton_getPinVal

Service name	HButton_getPinVal
Description	This Function Get button state
Syntax	`enu_buttonError_t HButton_getPinVal (enu_pin en_pinx, Uint8_t* pu8_refVal)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**en_pinx:** DIO pin number
Parameters (out)	**pu8_refVal:** address of variable which button state to be stored
Return	*BUTTON_OK: in case of successful operation*
	BUTTON_NOK: in case of failer operation
Available via	button.h

MCAL

GPIO module

MGPIO_u8Init

Service name	MGPIO_u8Init
Description	This Function Initialize GPIO configuration
Syntax	`uint8_ MGPIO_u8Init (st_gpio_cfg_t* st_gpio_cfg)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**st_gpio_cfg:** Address of struct Instance
Parameters (out)	None
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio_Interface.h

MGPIO_u8SetPinData

Service name	MGPIO_u8SetPinData
Description	This Function Initialize Pin Value High or Low
Syntax	`uint8_ MGPIO_u8SetPinData (enu_pin_t Copy_enPinNum, uint8_ Copy_PinValue)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**Copy_enPinNum:** MGPIO_PINA_0 ~ MGPIO_PINF_7
	Copy_PinValue: MGPIO_PIN_LOW / MGPIO_PIN_HIGH
Parameters (out)	None
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio _Interface.h

MGPIO_u8GetPinData

Service name	MGPIO_u8GetPinData
Description	This Function Get value from selected pin
Syntax	`uint8_ MGPIO_u8GetPinData (enu_pin_t Copy_enPinNum, uint8_* Ref_puint8_PinVal)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**Copy_enPinNum:** MGPIO_PINA_0 ~ MGPIO_PINF_7
Parameters (out)	**Ref_puint8_PinVal:** Reference to variable where the value status store on it
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio _Interface.h

MGPIO_u8IRQEnable

Service name	MGPIO_u8IRQEnable
Description	This Function Get value from selected pin
Syntax	`uint8_ MGPIO_u8IRQEnable (enu_pin_t Copy_enPinNum, enu_int_sens_type_t enu_int_sens_type, enu_int_sens_ctrl_t enu_int_sens_ctrl)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**Copy_enPinNum:** MGPIO_PINA_0 ~ MGPIO_PINF_7
	enu_int_sens_type: MGPIO_INT_EDGE_SENSETIVE ~ MGPIO_INT_LEVEL_SENSETIVE
	enu_int_sens_ctrl: MGPIO_INT_BOTH_EDGES - MGPIO_INT_FALL_E_LOW_L - MGPIO_INT_RIS_E_HIGH_L
Parameters (out)	**NONE**
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio _Interface.h

MGPIO_u8IRQDisable

Service name	MGPIO_u8IRQDisable
Description	This Function Get value from selected pin
Syntax	`uint8_ MGPIO_u8IRQDisable (enu_pin_t Copy_enPinNum)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	**Copy_enPinNum:** MGPIO_PINA_0 ~ MGPIO_PINF_7
Parameters (out)	**NONE**
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio _Interface.h

MGPIO_u8SetCallBack

Service name	MGPIO_u8SetCallBack
Description	This Function Get value from selected pin
Syntax	`uint8_ MGPIO_u8SetCallBack (enu_pin_t Copy_enPinNum, ptr_func_t ptr_func)`
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in)	**Copy_enPinNum:** MGPIO_PINA_0 ~ MGPIO_PINF_7
Parameters (out)	**ptr_func:** Address of application Function
Return	MGPIO_SUCCESS: *in case of successful operation*
	MGPIO_FAILED: *in case of failer operation*
Available via	mgpio _Interface.h

GPT module

GPT_u8Init

Service name	GPT_u8Init
Description	GPT Timer Initialization
Syntax	`uint8_ GPT_u8Init (st_gpt_timer_cfg_t* st_gpt_timer_cfg)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	`st_gpt_timer_cfg: Address of struct Instance`
Parameters (out)	None
Return	`SUCCESS: in case of successful operation`
	`FAILED: in case of failer operation`
Available via	gpt_Interface.h

GPT_u8Start

Service name	GPT_u8Start
Description	Start Timer count
Syntax	`uint8_ GPT_u8Start (void)`
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in)	`Void`
Parameters (out)	None
Return	`SUCCESS: in case of successful operation`
	`FAILED: in case of failer operation`
Available via	gpt_Interface.h

GPT_vidStop

Service name	GPT_vidStop
Description	Stop GPT Timer Counter
Syntax	`void GPT_vidStop (void)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	`void`
Parameters (out)	`NONE`
Return	`void`
Available via	gpt_Interface.h

GPT_vidIRQEnable

Service name	GPT_vidIRQEnable
Description	GPT enable Interrupt
Syntax	`void GPT_vidIRQEnable (void)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	`void`
Parameters (out)	`NONE`
Return	`void`
Available via	gpt_Interface.h

GPT_vidIRQDisable

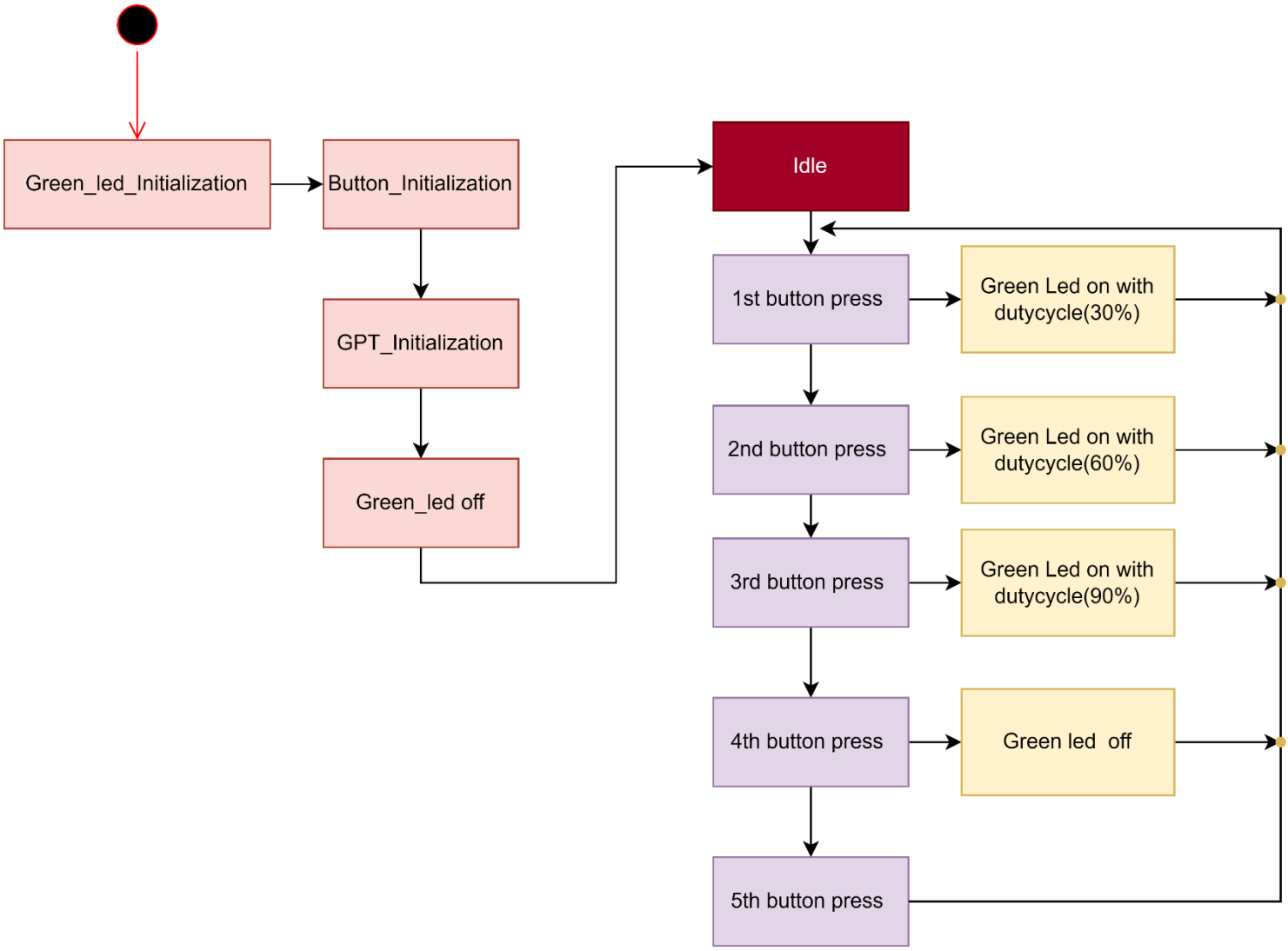
Service name	GPT_vidIRQDisable
Description	GPT Disable Interrupt
Syntax	`uint8_ GPT_vidIRQDisable (void)`
Sync/Async	Synchronous
Reentrancy	Reentrant
Parameters (in)	`Void`
Parameters (out)	**NONE**
Return	`SUCCESS:` *in case of successful operation*
	`FAILED:` *in case of failer operation*
Available via	gpt_Interface.h

GPT_u8GetCurrentVal

Service name	GPT_u8GetCurrentVal
Description	Get GPT current value
Syntax	`Void GPT_u8GetCurrentVal (uint64_* p_u64_int_cur_val)`
Sync/Async	Synchronous
Reentrancy	Non-Reentrant
Parameters (in)	**void**
Parameters (out)	**p_u64_int_cur_val:** Reference to variable where the value status store on it
Return	`SUCCESS:` *in case of successful operation*
	`FAILED:` *in case of failer operation*
Available via	gpt_Interface.h

UML

State Machine

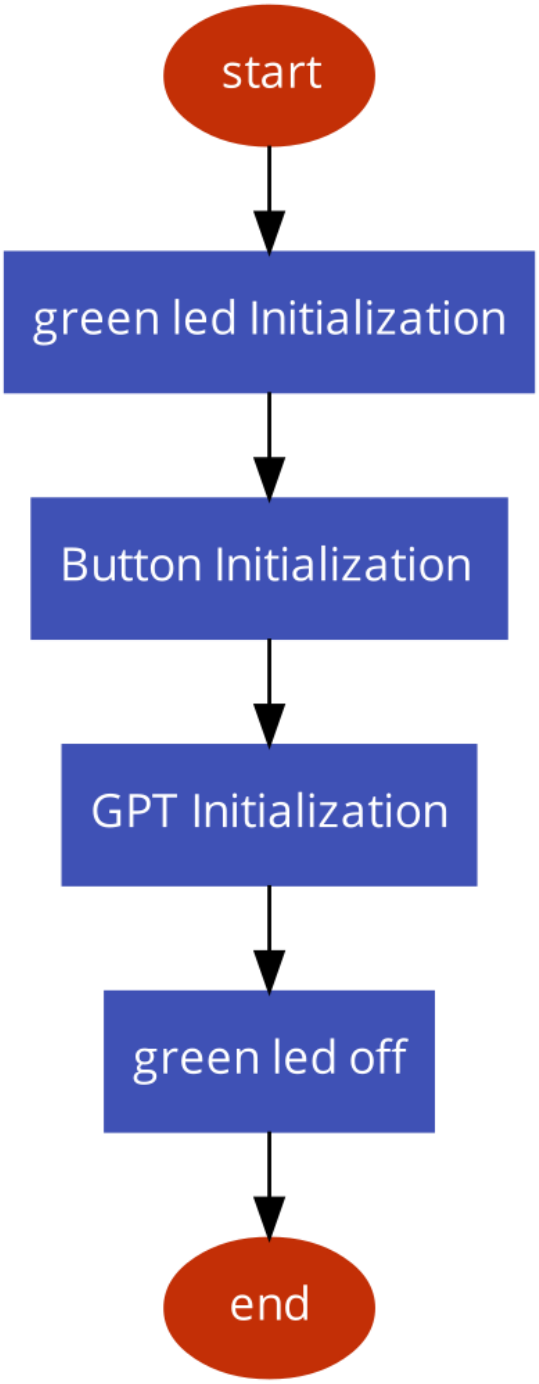


Low Level Design

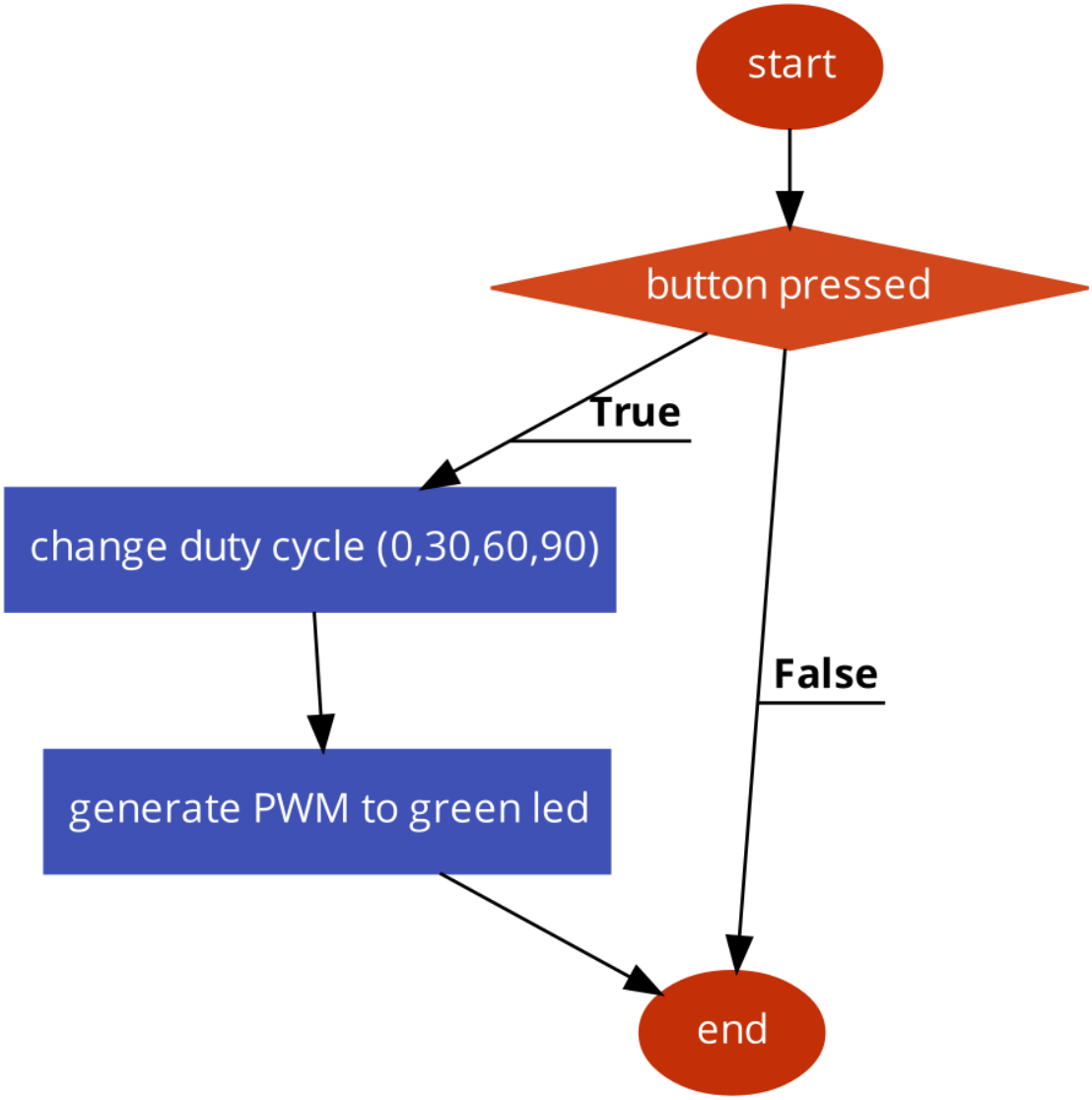
Flowchart

APP

APP_vidInit

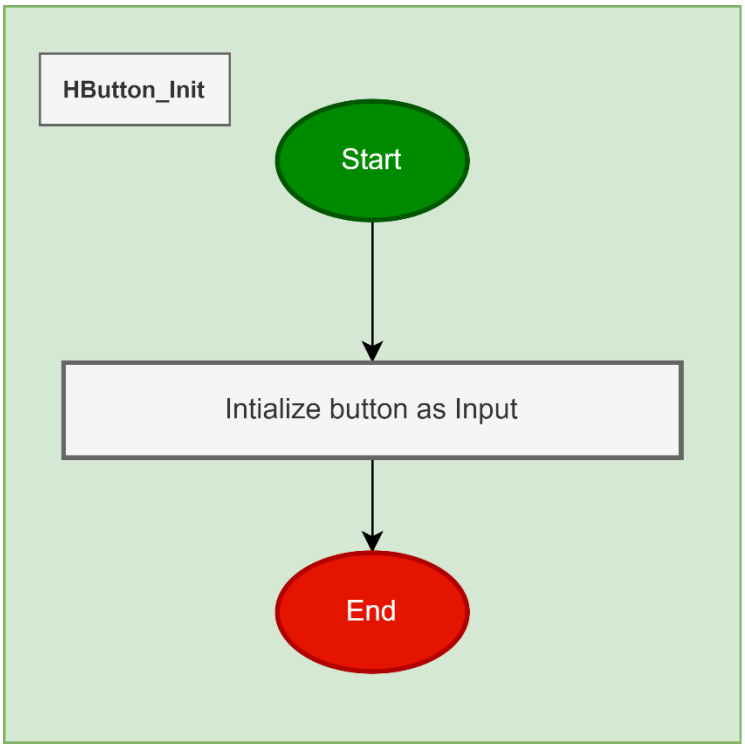


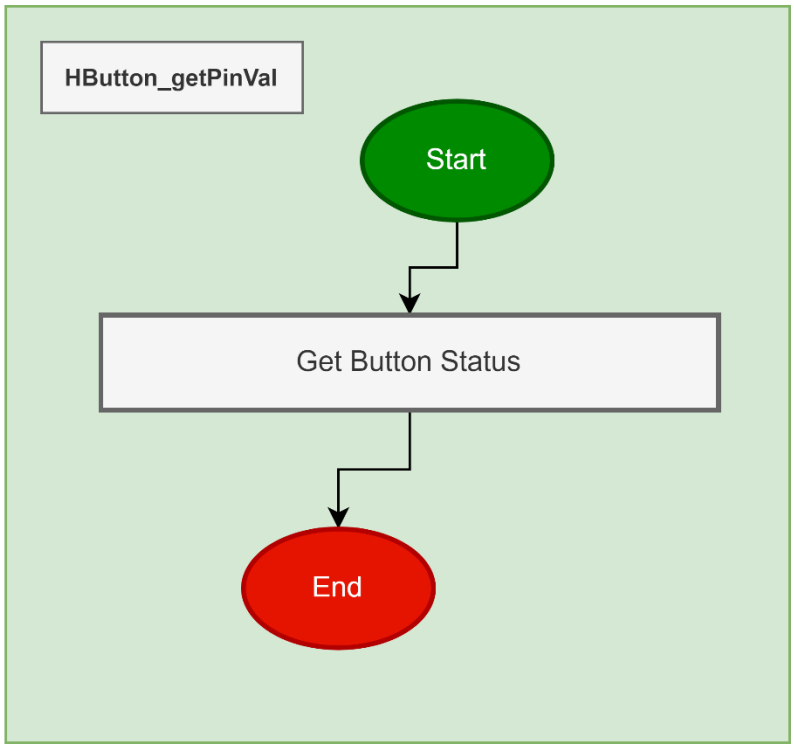
APP_vidStart



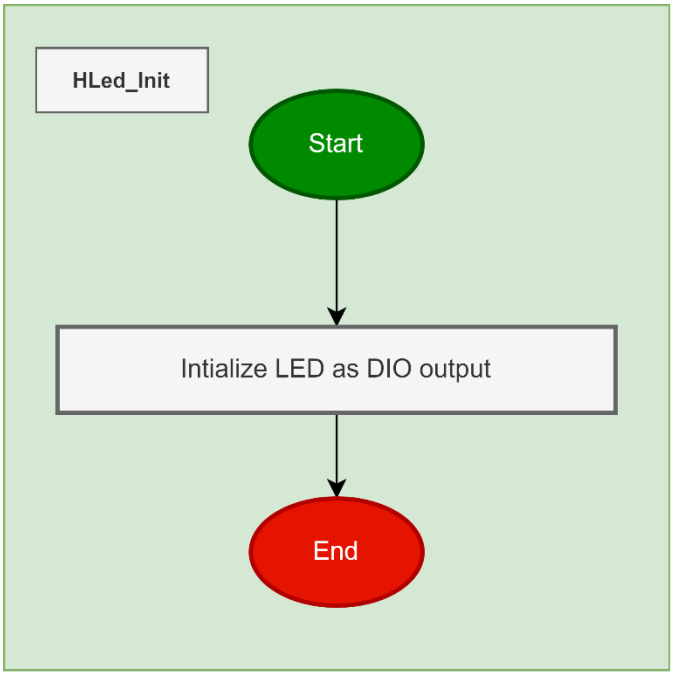
HAL

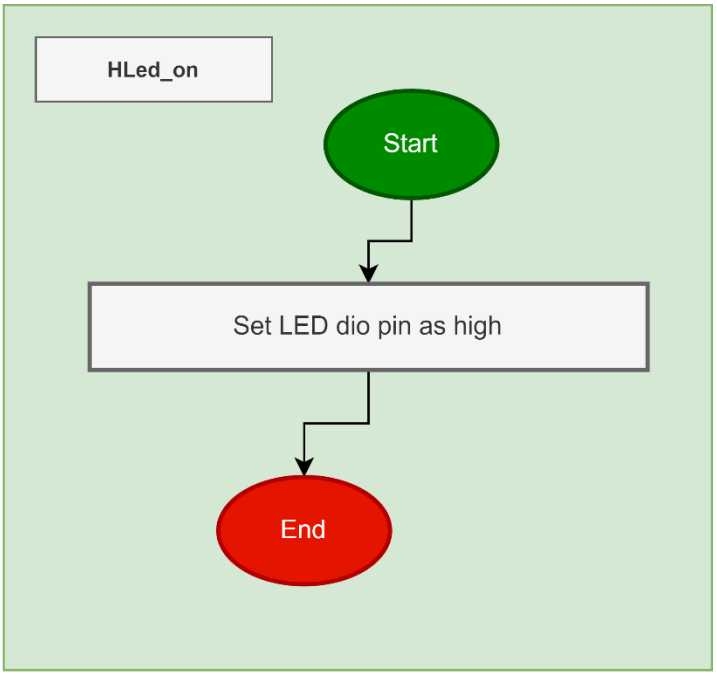
Button module

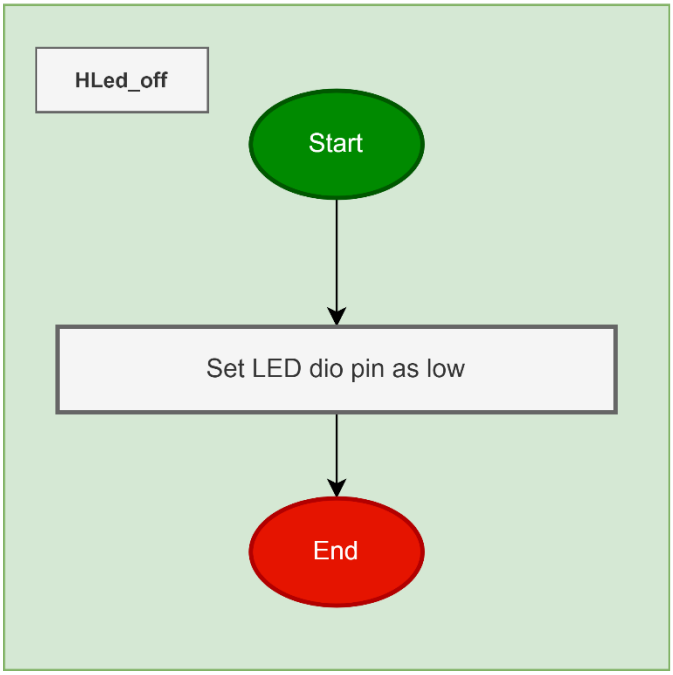


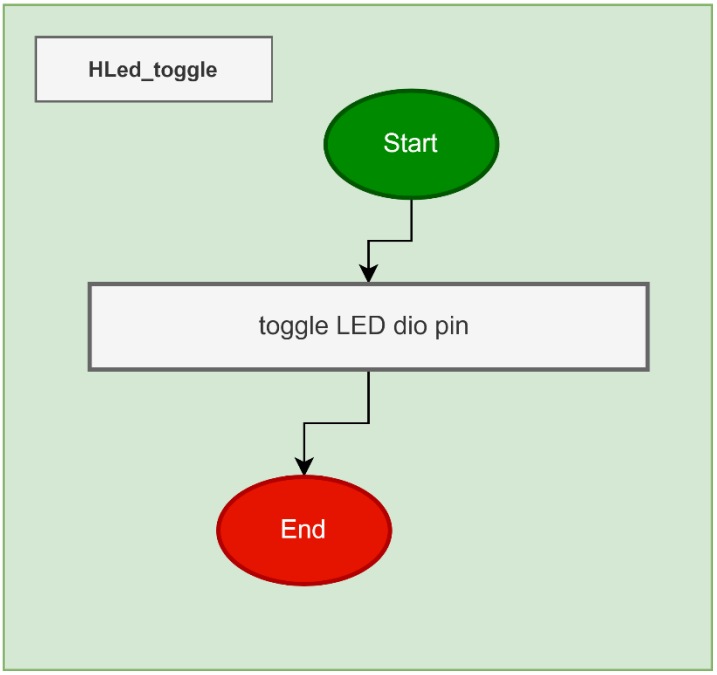


HLED module


HLed_Init
Start
Intialize LED as DIO output
End


HLed_on
Start
Set LED dio pin as high
End

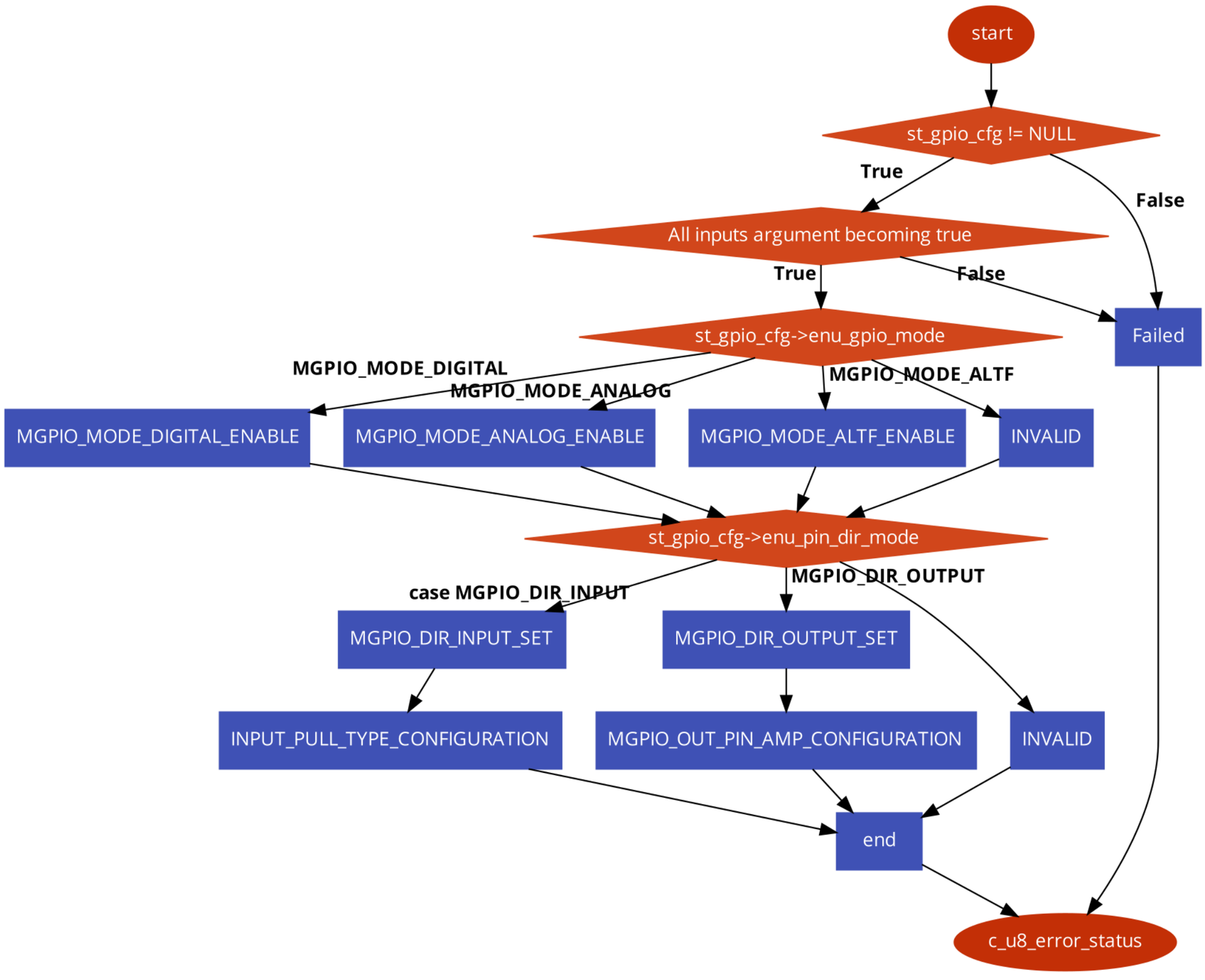

HLed_off
Start
Set LED dio pin as low
End


HLed_toggle
Start
toggle LED dio pin
End

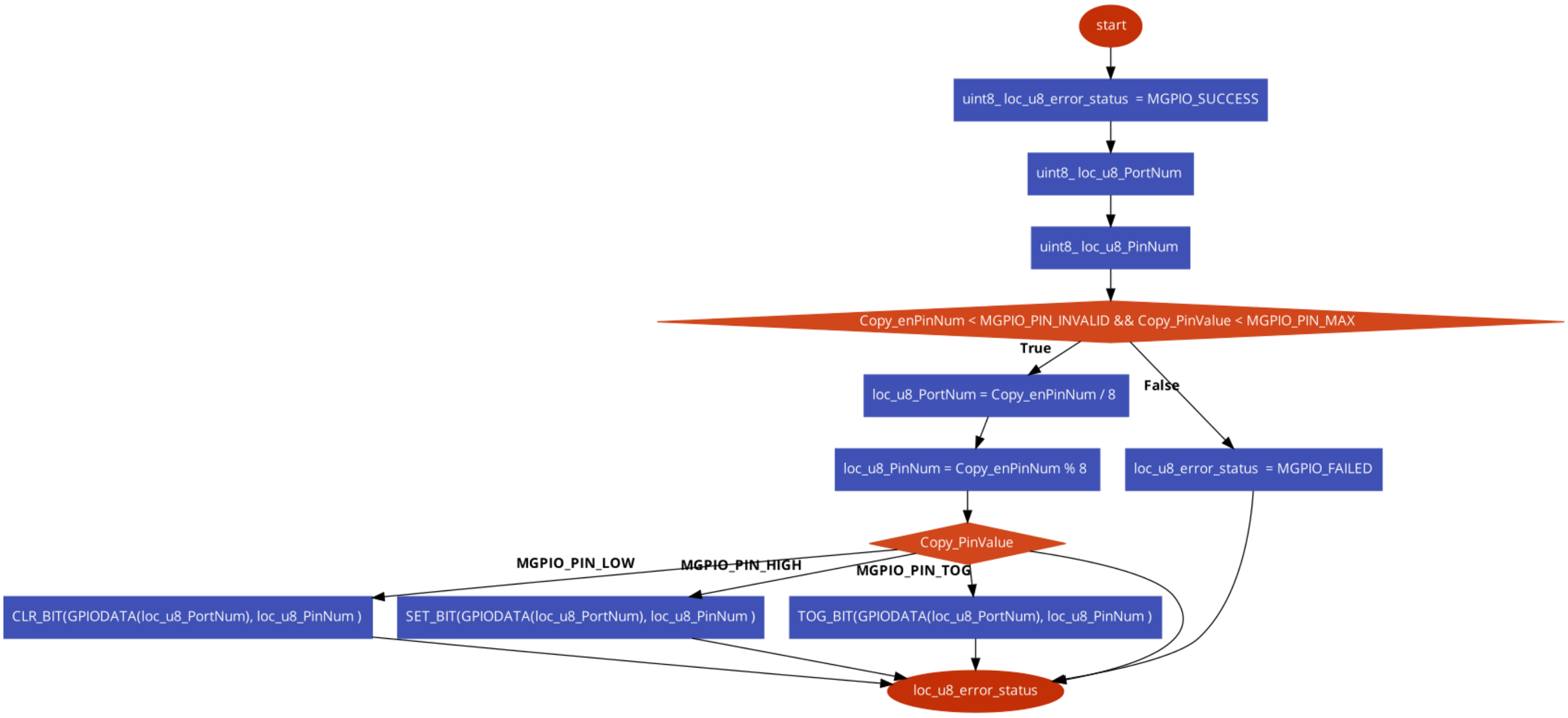
MCAL

GPIO module

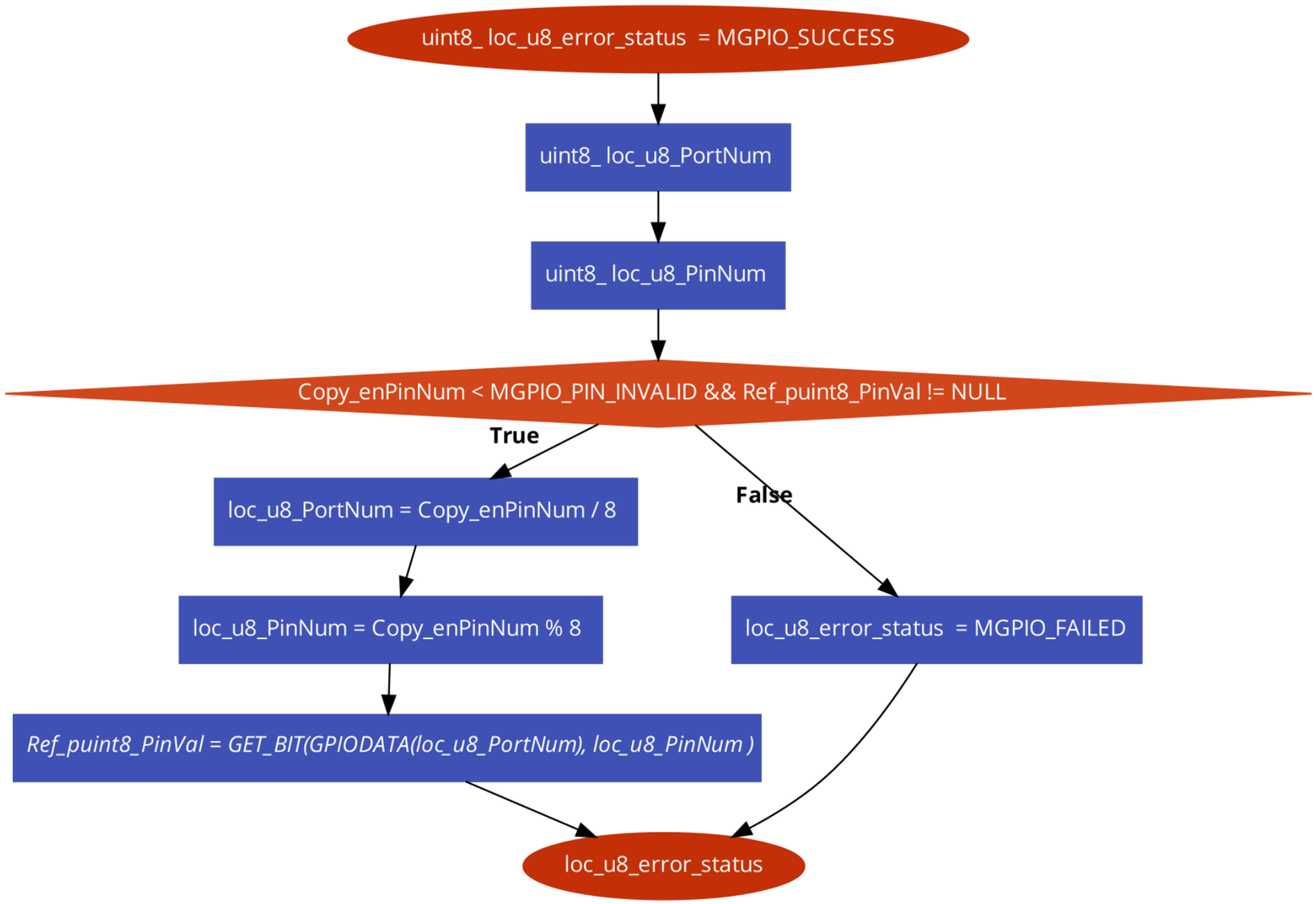
MGPIO_u8Init



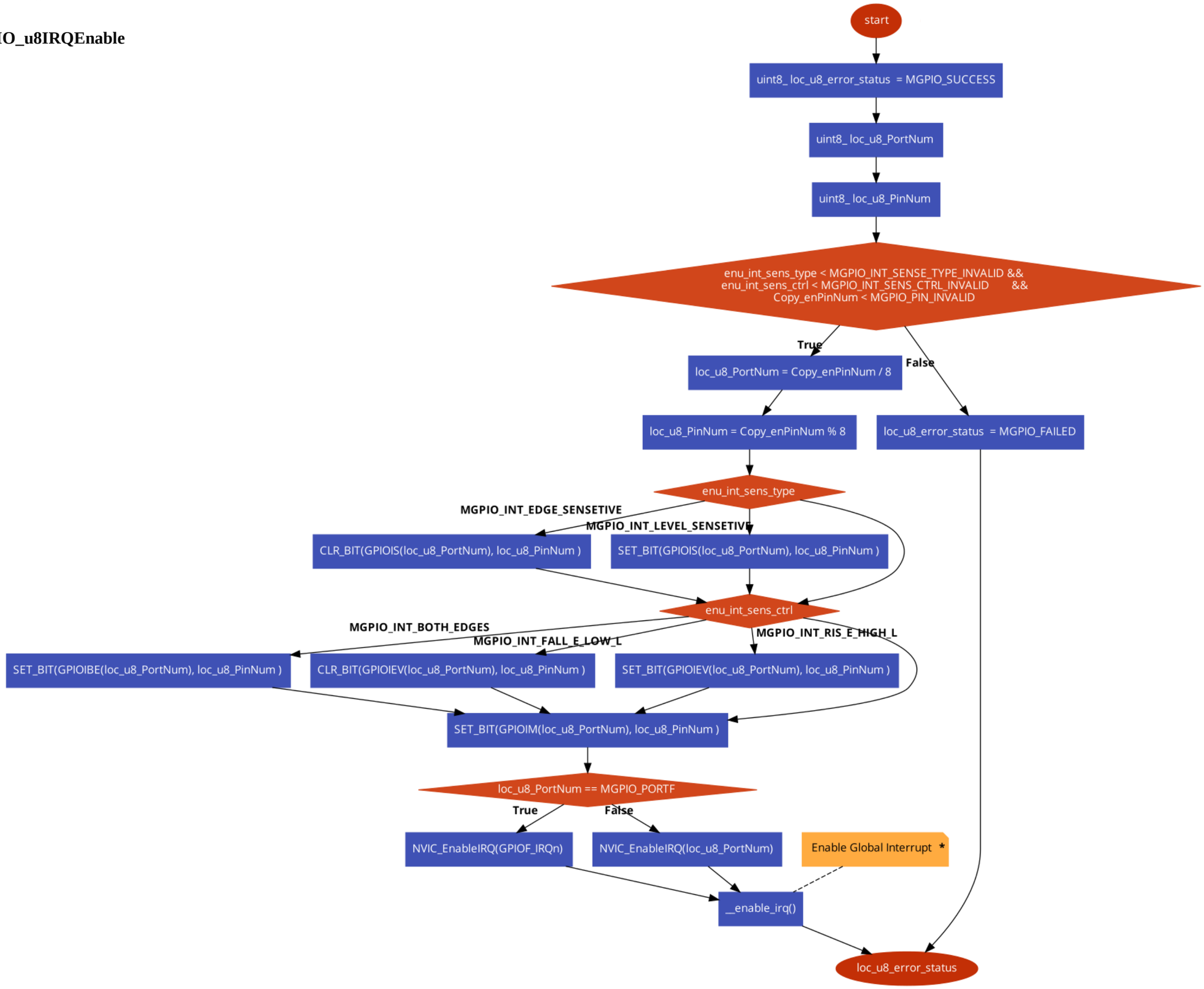
MGPIO_u8SetPinData



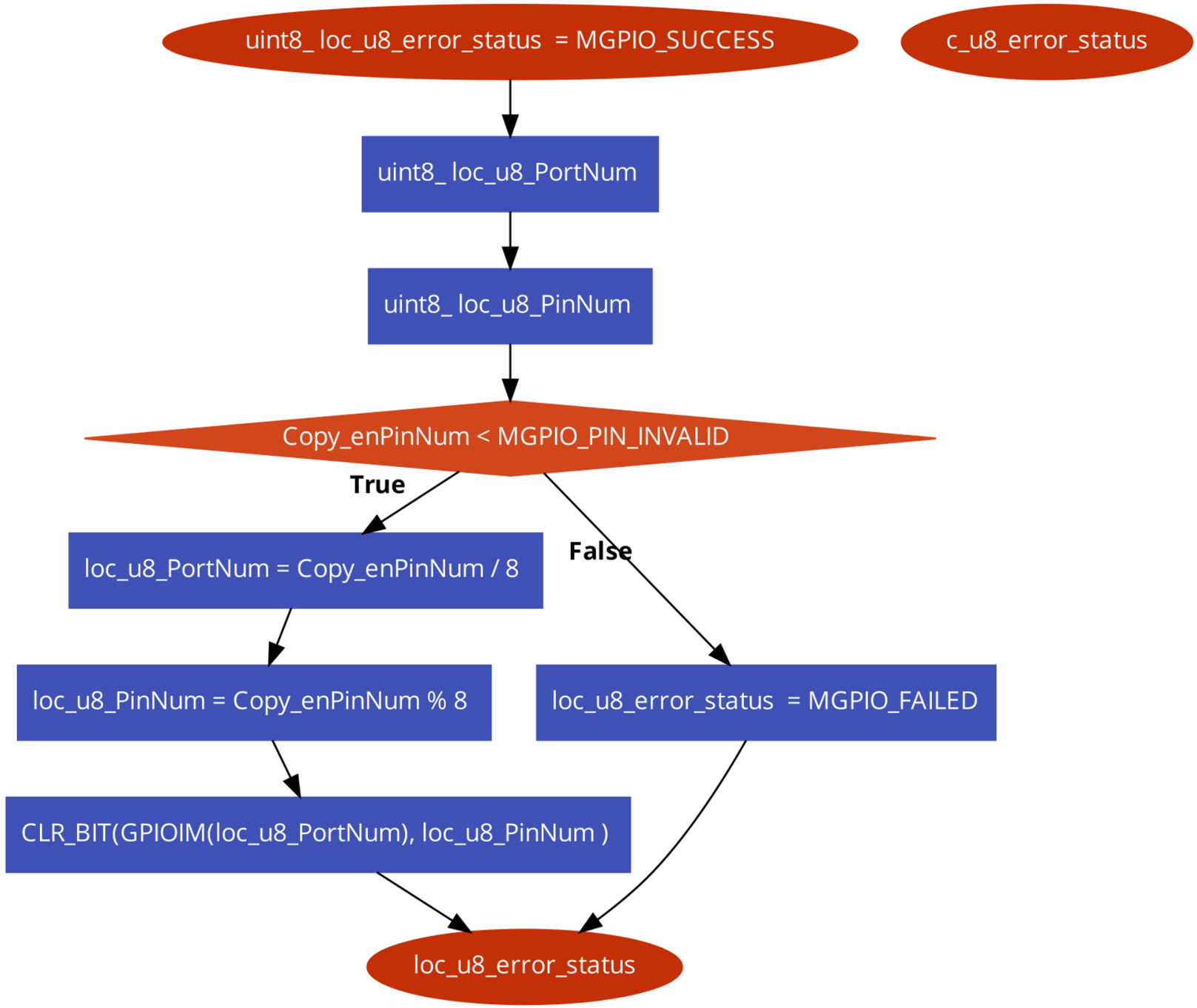
MGPIO_u8GetPinData



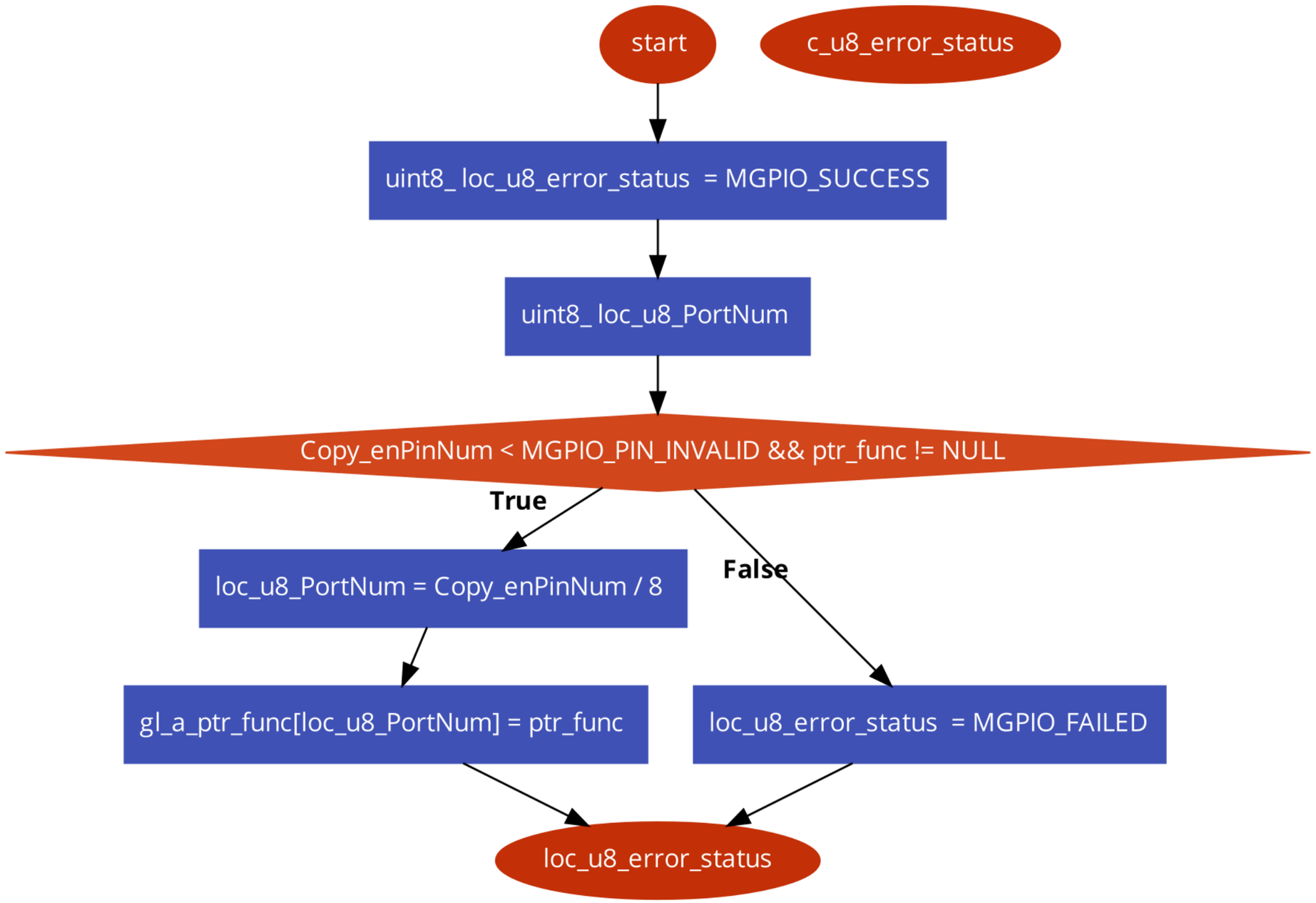
MGPIO_u8IRQEnable



MGPIO_u8IRQDisable

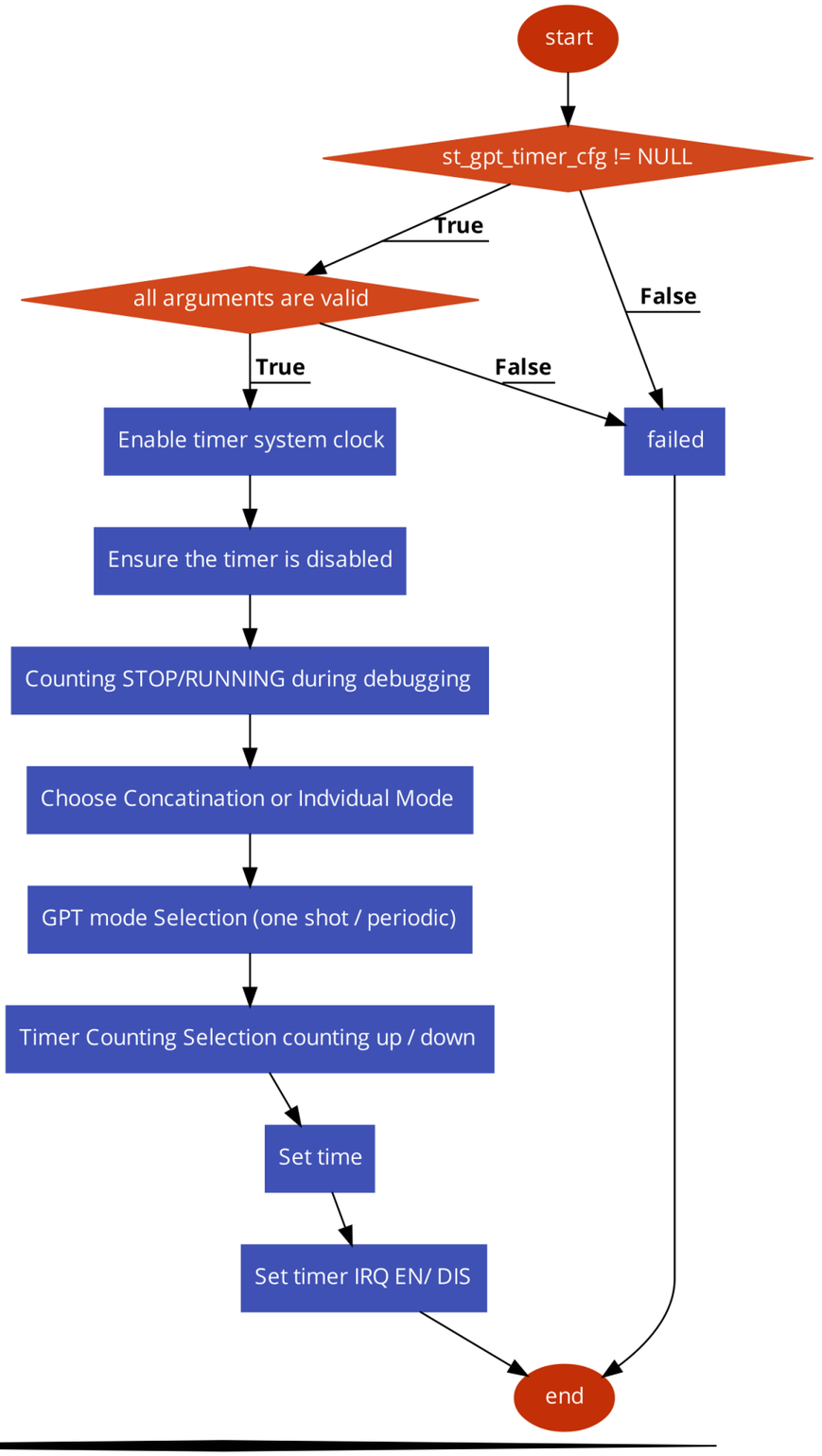


MGPIO_u8SetCallBack

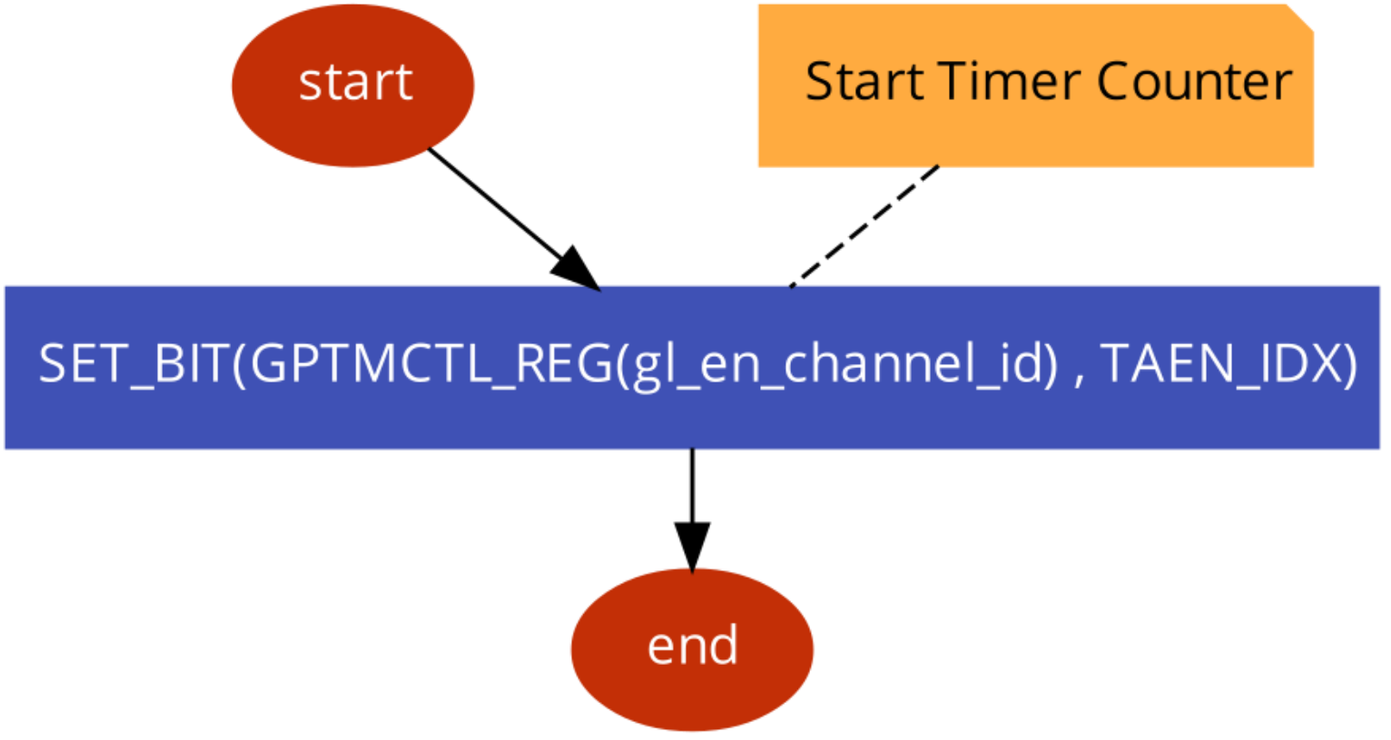


SYSTICK module

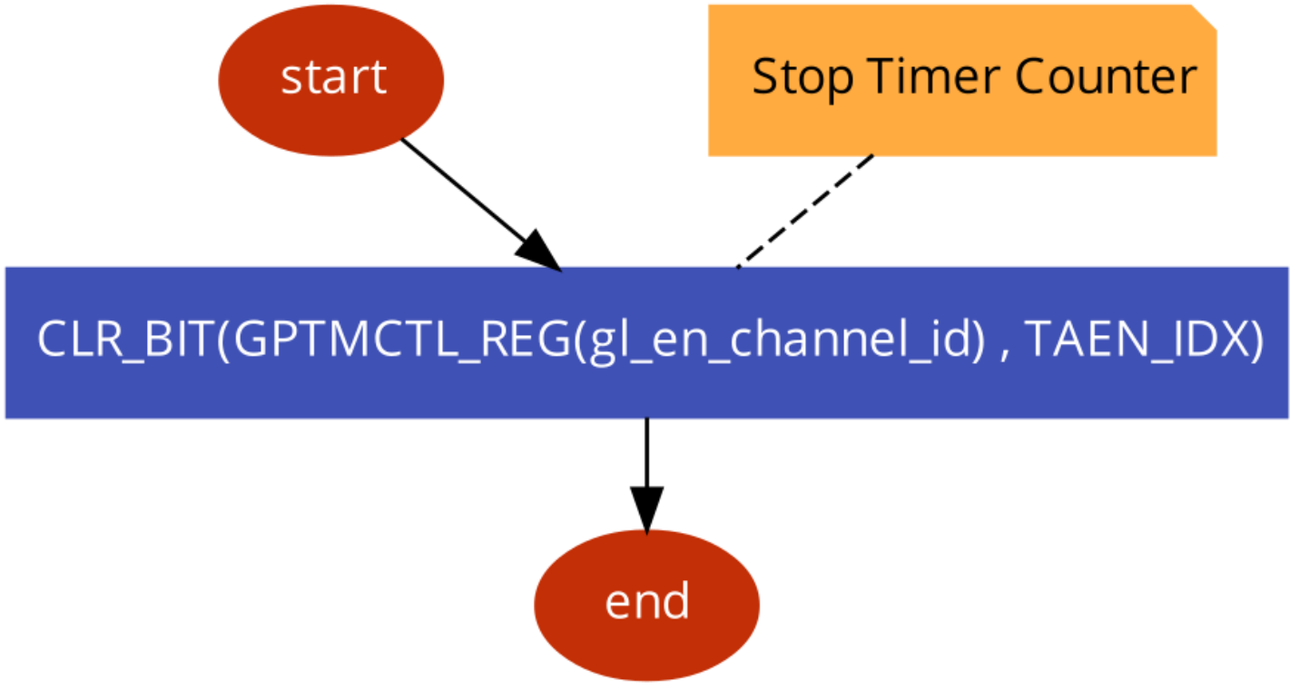
GPT_u8Init



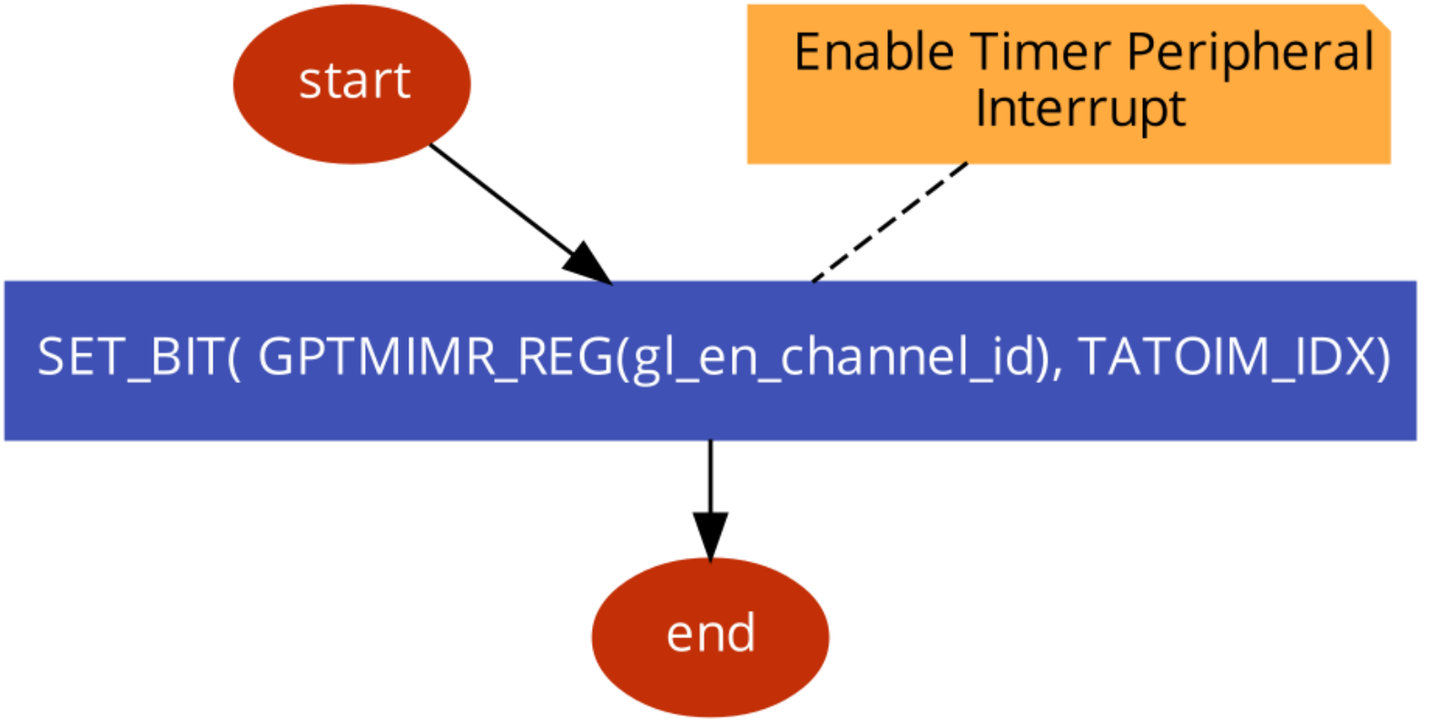
GPT_u8Start


start
Start Timer Counter
SET_BIT(GPTMCTL_REG(gl_en_channel_id) , TAEN_IDX)
end

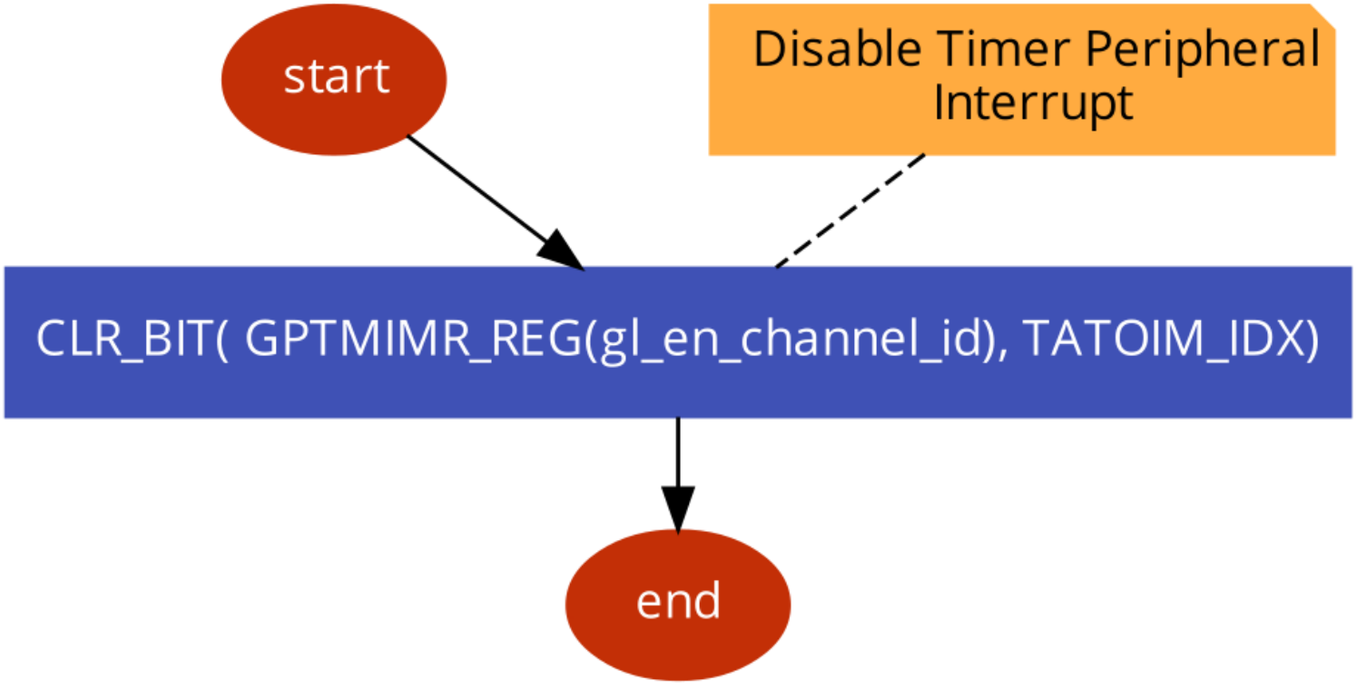
GPT_vidStop


start
Stop Timer Counter
CLR_BIT(GPTMCTL_REG(gl_en_channel_id) , TAEN_IDX)
end

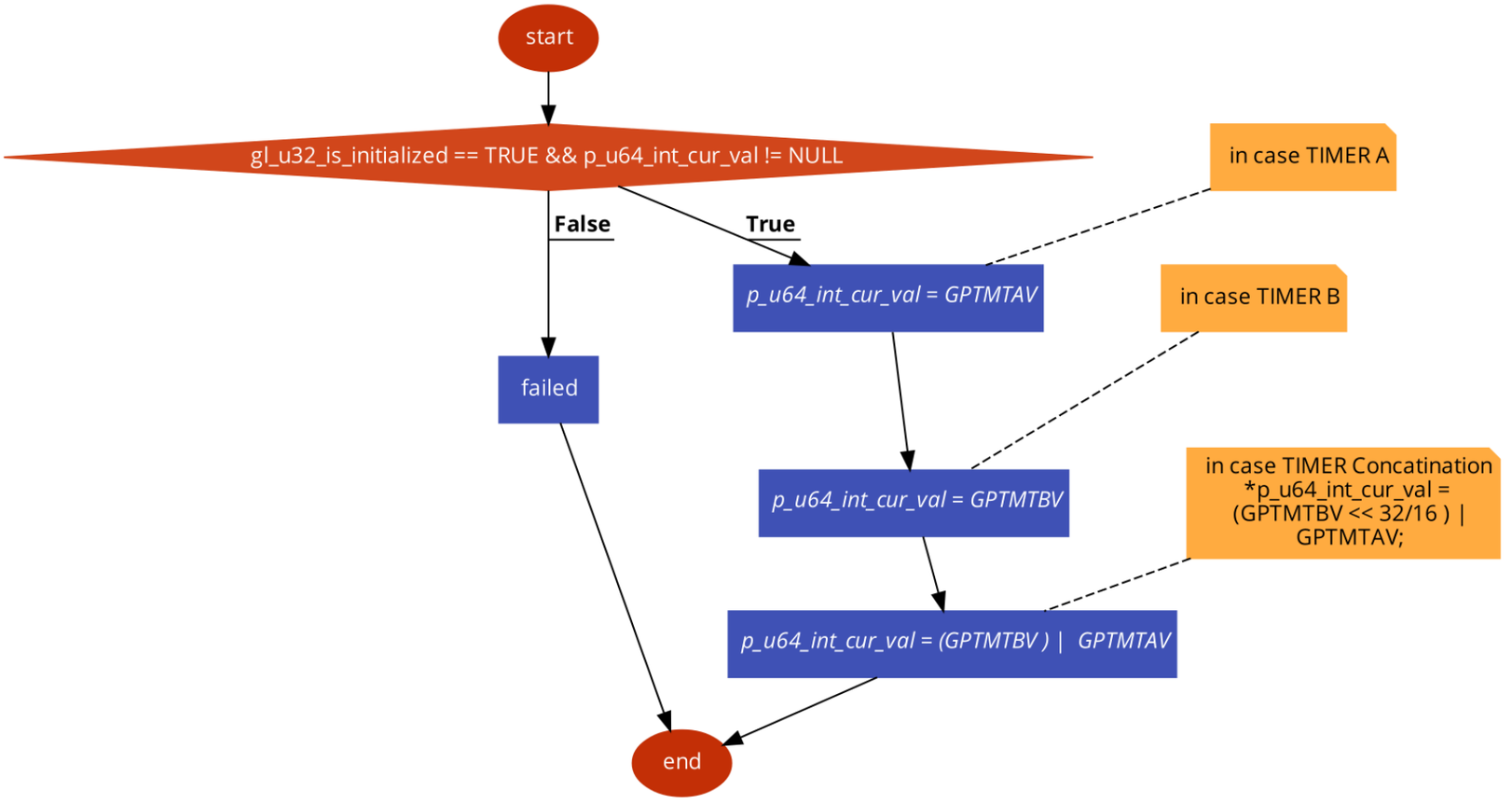
GPT_vidIRQEnable



GPT_vidIRQDisable



GPT_u8GetCurrentVal



Pre-compiling configuration

MCAL

MGPIO module

GPIO_BUS_TYPE

Name	GPIO_BUS_TYPE
Type	MACRO
Description	Define GPIO_bus
Configuration	***GPIO_APB***
	GPIO_AHB
Found in	mgpio_private.h

GPT module

GPT_TIMER_INDV_CONC_SELECTION

Name	GPT_TIMER_INDV_CONC_SELECTION
Type	MACRO
Description	Individual Timer Mode or Concatenation Timer mode selection
Configuration	***GPT_TIMER_INDVIDUAL_TIMER_A***
	GPT_TIMER_INDVIDUAL_TIMER_B
	GPT_TIMER_CONCATINATION
Found in	gpt_Interface.h

GPT_TIMER_COUNT_SELECTION

Name	GPT_TIMER_COUNT_SELECTION
Type	MACRO
Description	Timer Counting UP / Counting DOWN
Configuration	***GPT_COUNT_DOWN***
	GPT_COUNT_UP
Found in	gpt_Interface.h

Linking Configuration

MCAL

MGPIO module

st_gpio_cfg_t

<table>
<tr><td>Name</td><td colspan="2">st_gpio_cfg_t</td></tr>
<tr><td>Type</td><td colspan="2">struct</td></tr>
<tr><td>Description</td><td colspan="2">GPIO pin configuration</td></tr>
<tr><td rowspan="5">Members</td><td colspan="2">enu_pin</td></tr>
<tr><td colspan="2">enu_gpio_mode</td></tr>
<tr><td colspan="2">enu_pin_dir_mode</td></tr>
<tr><td rowspan="2">un_gpio_conf</td><td>enu_gpio_amp_mode</td></tr>
<tr><td>u8_input_pull_type</td></tr>
<tr><td>Found in</td><td colspan="2">mgpio_Interface.h</td></tr>
</table>

enu_pin_t

Name	enu_pin_t
Type	enum
Description	GPIO pin Selection
Configuration	*MGPIO_PINA_0 ~ MGPIO_PINA_7*
	MGPIO_PINB_0 ~ MGPIO_PINB_7
	MGPIO_PINC_0 ~ MGPIO_PINC_7
	MGPIO_PIND_0 ~ MGPIO_PIND_7
	MGPIO_PINE_0 ~ MGPIO_PINE_7
	MGPIO_PINF_0 ~ MGPIO_PINF_7
Found in	mgpio_Interface.h

enu_gpio_mode_t

Name	enu_gpio_mode_t
Type	enum
Description	GPIO Mode Selection
Configuration	*MGPIO_DIR_INPUT*
	MGPIO_DIR_OUTPUT
	MGPIO_DIR_INVALID
Found in	mgpio_Interface.h

enu_gpio_amp_mode_t

Name	enu_gpio_amp_mode_t
Type	enum
Description	GPIO Ampere mode Selection
Configuration	***MGPIO_OPEN_DRAIN***
	MGPIO_MAMP_2
	MGPIO_MAMP_4
	MGPIO_MAMP_8
	MGPIO_MAMP_INVALID
Found in	mgpio_Interface.h

enu_gpio_int_t

Name	enu_gpio_int_t
Type	enum
Description	GPIO Interrupt mode Selection
Configuration	***MGPIO_INT_ENABLE***
	MGPIO_INT_DISABLE
	MGPIO_INT_INVALID
Found in	mgpio_Interface.h

enu_int_sens_type_t

Name	enu_int_sens_type_t
Type	enum
Description	GPIO Ampere mode Selection
Configuration	***MGPIO_INT_EDGE_SENSETIVE***
	MGPIO_INT_LEVEL_SENSETIVE
	MGPIO_INT_SENSE_TYPE_INVALID
Found in	mgpio_Interface.h

enu_int_sens_ctrl_t

Name	enu_int_sens_ctrl_t
Type	enum
Description	GPIO Ampere mode Selection
Configuration	*MGPIO_INT_BOTH_EDGES*
	MGPIO_INT_FALL_E_LOW_L
	MGPIO_INT_RIS_E_HIGH_L
	MGPIO_INT_SENS_CTRL_INVALID
Found in	mgpio_Interface.h

SYSTICK module

st_gpt_timer_cfg_t

Name	st_gpt_timer_cfg_t
Type	struct
Description	GPT configuration
Members	*en_gpt_ch_id*
	en_gpt_mode
	en_gpt_stall
	en_gpt_time_x
	u32_set_time
	en_gpt_irq;
	ptr_func
Found in	gpt_Interface.h

en_gpt_ch_id_t

Name	en_gpt_ch_id_t
Type	enum
Description	GPT channel Id selection
Configuration	*GPT_CHANNEL_0 ~ GPT_CHANNEL_5*
	GPT_WIDE_CHANNEL_0 ~ GPT_WIDE_CHANNEL_5
Found in	gpt_Interface.h

en_gpt_irq_t

Name	en_gpt_irq_t
Type	enum
Description	GPT IRQ EN/DIS
Configuration	*GPT_IRQ_DISABLE*
	GPT_IRQ_ENABLE
Found in	gpt_Interface.h

en_gpt_mode_t

Name	en_gpt_mode_t
Type	enum
Description	GPT channel mode selection
Configuration	*GPT_CH_MODE_ONE_SHOT*
	GPT_CH_MODE_PERIODIC
Found in	gpt_Interface.h

en_gpt_stall_t

Name	en_gpt_stall_t
Type	enum
Description	Counting stop or still running during debug
Configuration	*GPT_STALL_DISABLE*
	GPT_STALL_ENABLE
Found in	gpt_Interface.h

en_gpt_time_x_t

Name	en_gpt_time_x_t
Type	enum
Description	Set time in (micro seconds, milli seconds, seconds) selection
Configuration	*GPT_TIME_US*
	GPT_TIME_MS
	GPT_TIME_S
Found in	gpt_Interface.h