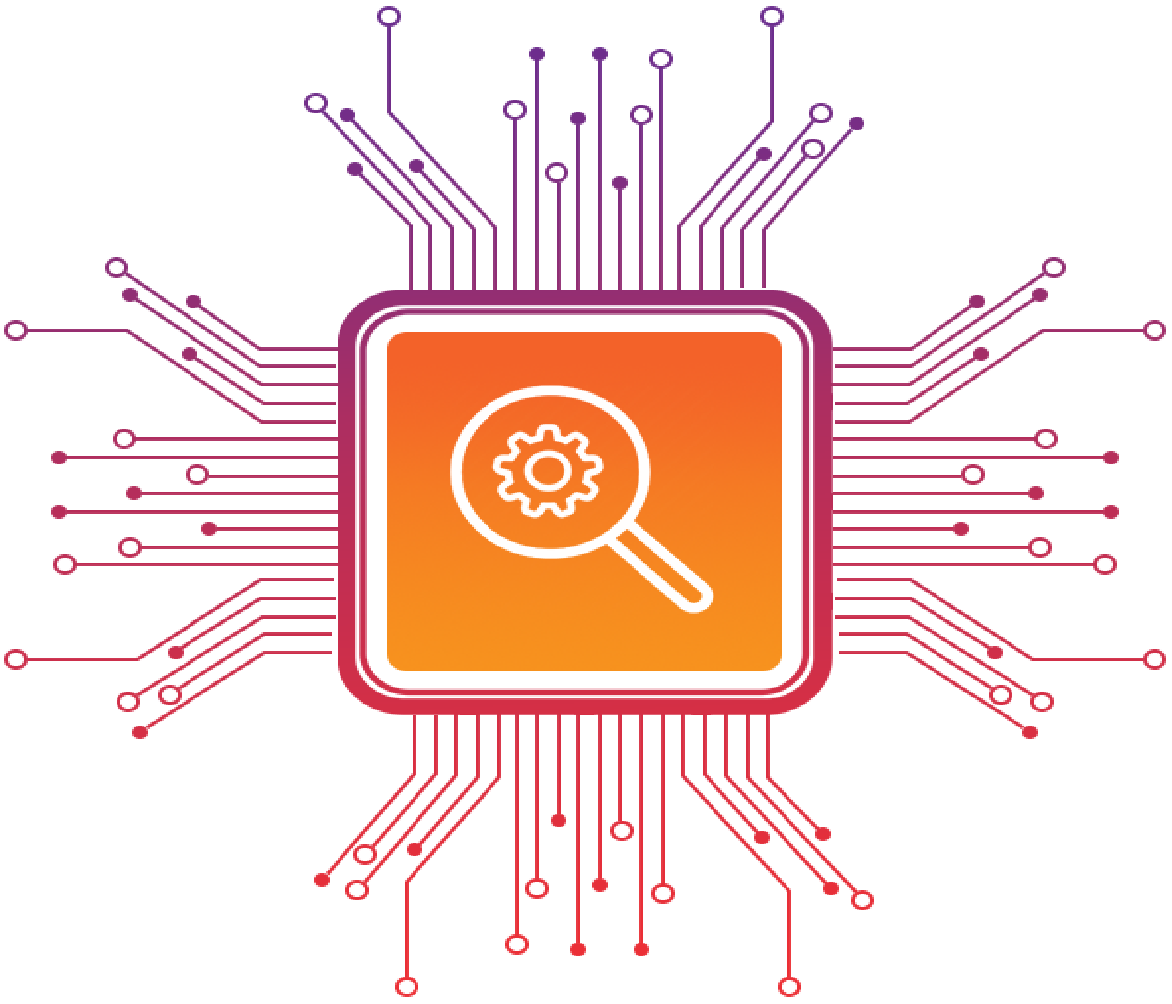

Basic Communication Manager

By: Mario Saad

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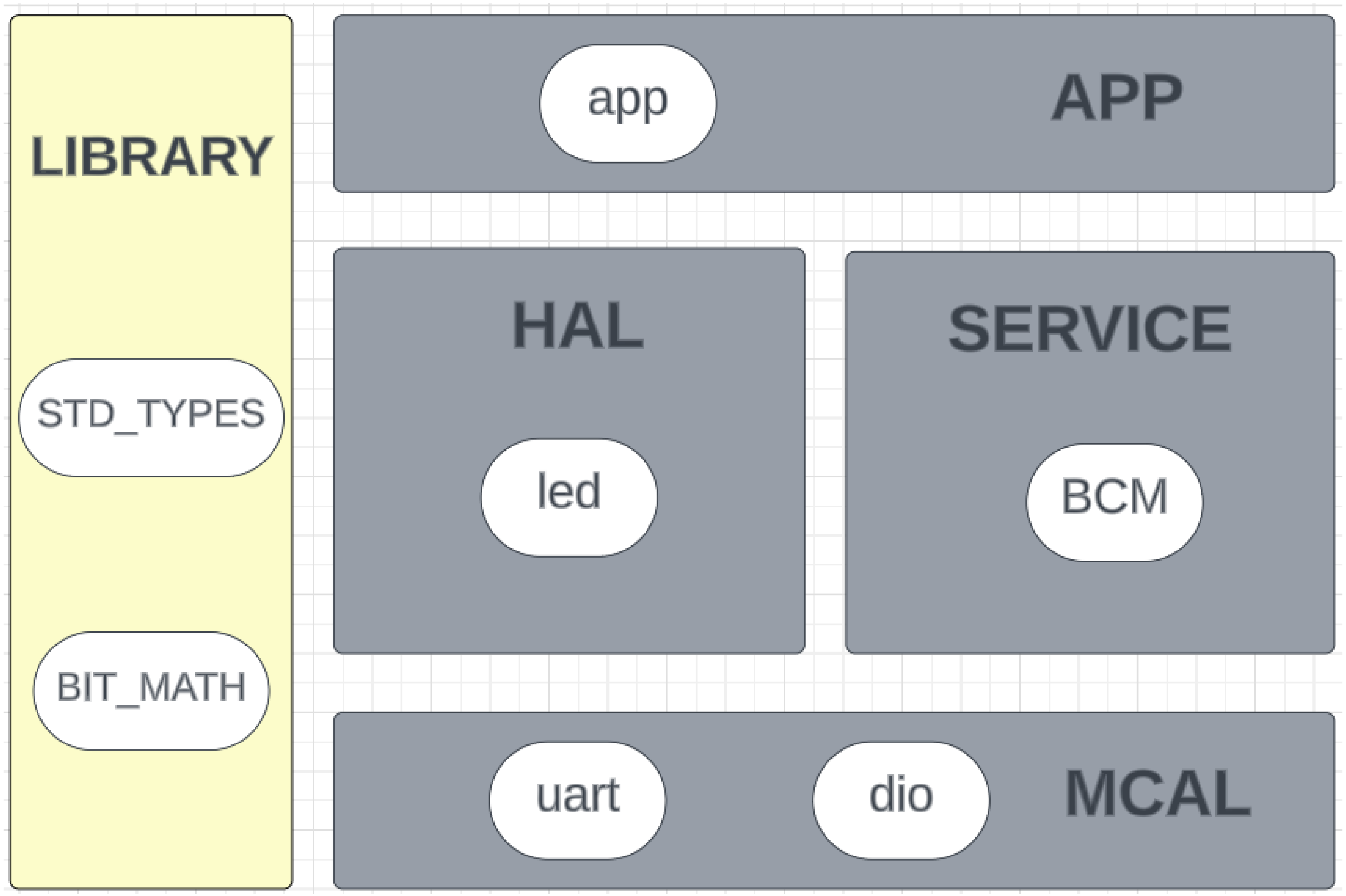
1. Introduction:

In the domain of embedded systems, effective data transmission management plays a pivotal role in application development. Whether you're engaged in projects related to IoT devices, robotics, or industrial automation, the ability to ensure the reliable, efficient, and timely exchange of data is of paramount importance.

Introducing the BCM project, which offers a unified platform designed to streamline the handling of various communication protocols. It simplifies the intricacies associated with data transmission and reception while maintaining a strong focus on reliable and error-free communication. Leveraging Interrupt Service Routines (ISRs) and implementing efficient data buffering, the BCM project attains optimal throughput, rendering it exceptionally well-suited for use in resource-constrained embedded systems.

1. High Level Design:

2.1 Layered Architecture:



2.2 Modules Description:

DIO (Digital Input/Output):

- Purpose: DIO is responsible for controlling the GPIO (General-Purpose Input/Output) pins on the microcontroller.
- Description: It manages the configuration and state of these pins, allowing you to set them as inputs or outputs and manipulate their digital values.

UART (Universal Asynchronous Receiver-Transmitter):

- Purpose: UART facilitates communication between your microcontroller and other MCUs or external devices.
- Description: It handles the sending and receiving of data through serial communication, enabling data exchange and interaction with other hardware components.

LED (Light Emitting Diode):

- Purpose: LED control is crucial for managing the state of LEDs within your program.
- Description: It provides control over the illumination state of LEDs in your application, allowing you to turn them on or off as needed.

BCM (Bus Communication Manager):

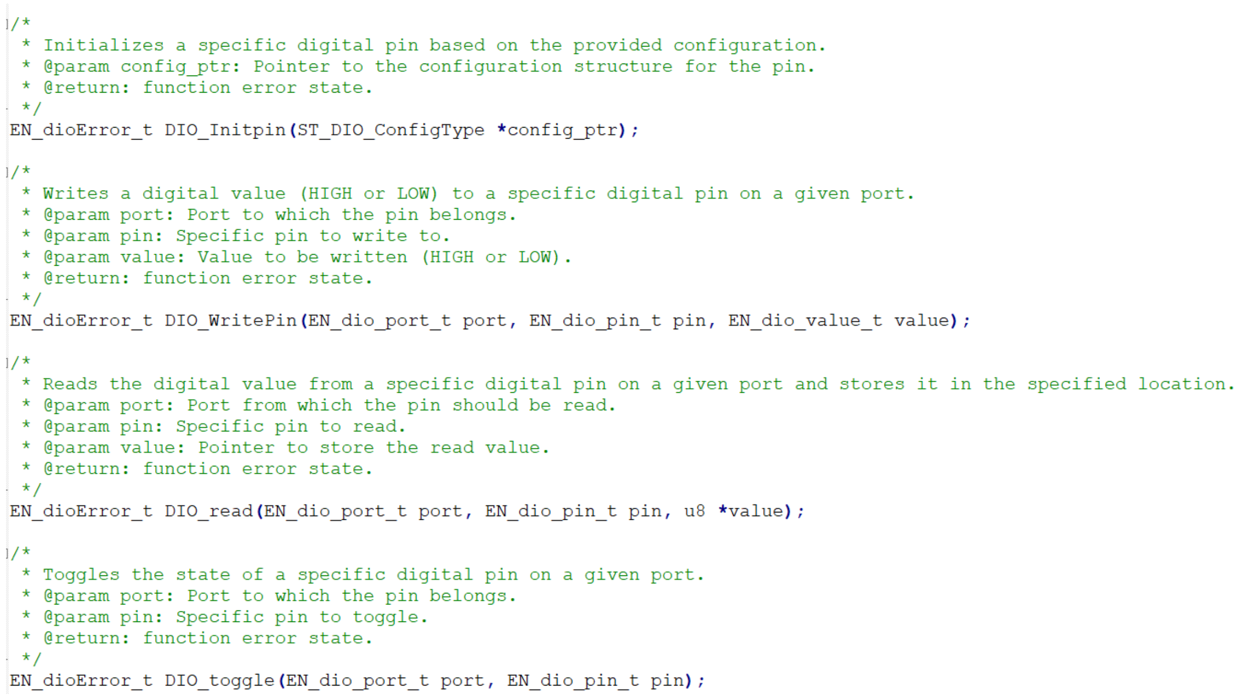
- Purpose: The BCM module serves as a communication manager responsible for facilitating data exchange between different MCUs.
- Description: It simplifies the complexities of inter-MCU communication, ensuring robust and error-free data transmission. The BCM achieves optimal throughput through the use of Interrupt Service Routines (ISRs) and efficient data buffering, making it well-suited for resource-constrained embedded systems.

App (Application):

- Purpose: The App component holds the core logic of your code, governing the main functionality of the program.
- Description: This section houses the essential program logic, including algorithms, decision-making processes, and overall application behavior. It dictates how the microcontroller operates and interacts with various hardware and software components.

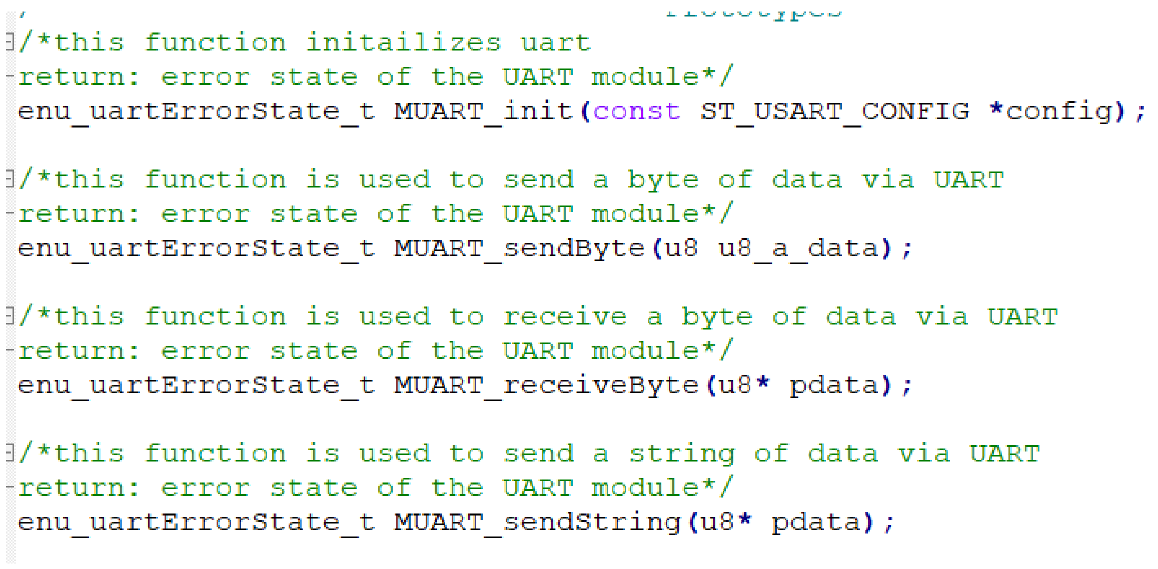
2.3 Drivers' Documentation:

2.3.1 DIO:



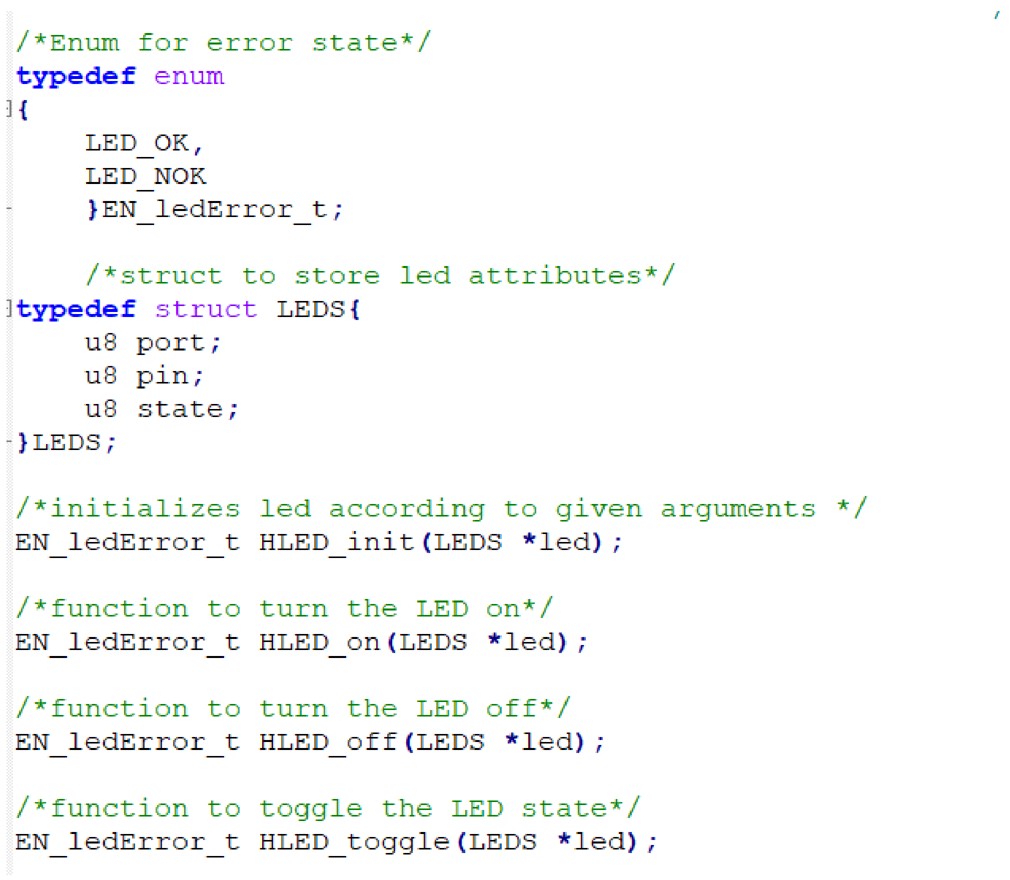
```c
/*
 * Initializes a specific digital pin based on the provided configuration.
 * @param config_ptr: Pointer to the configuration structure for the pin.
 * @return: function error state.
 */
EN_dioError_t DIO_Initpin(ST_DIO_ConfigType *config_ptr);

/*
 * Writes a digital value (HIGH or LOW) to a specific digital pin on a given port.
 * @param port: Port to which the pin belongs.
 * @param pin: Specific pin to write to.
 * @param value: Value to be written (HIGH or LOW).
 * @return: function error state.
 */
EN_dioError_t DIO_WritePin(EN_dio_port_t port, EN_dio_pin_t pin, EN_dio_value_t value);

/*
 * Reads the digital value from a specific digital pin on a given port and stores it in the specified location.
 * @param port: Port from which the pin should be read.
 * @param pin: Specific pin to read.
 * @param value: Pointer to store the read value.
 * @return: function error state.
 */
EN_dioError_t DIO_read(EN_dio_port_t port, EN_dio_pin_t pin, u8 *value);

/*
 * Toggles the state of a specific digital pin on a given port.
 * @param port: Port to which the pin belongs.
 * @param pin: Specific pin to toggle.
 * @return: function error state.
 */
EN_dioError_t DIO_toggle(EN_dio_port_t port, EN_dio_pin_t pin);
```

2.3.2 UART:



```c
/*this function initailizes uart
return: error state of the UART module*/
enu_uartErrorState_t MUART_init(const ST_USART_CONFIG *config);

/*this function is used to send a byte of data via UART
return: error state of the UART module*/
enu_uartErrorState_t MUART_sendByte(u8 u8_a_data);

/*this function is used to receive a byte of data via UART
return: error state of the UART module*/
enu_uartErrorState_t MUART_receiveByte(u8* pdata);

/*this function is used to send a string of data via UART
return: error state of the UART module*/
enu_uartErrorState_t MUART_sendString(u8* pdata);
```

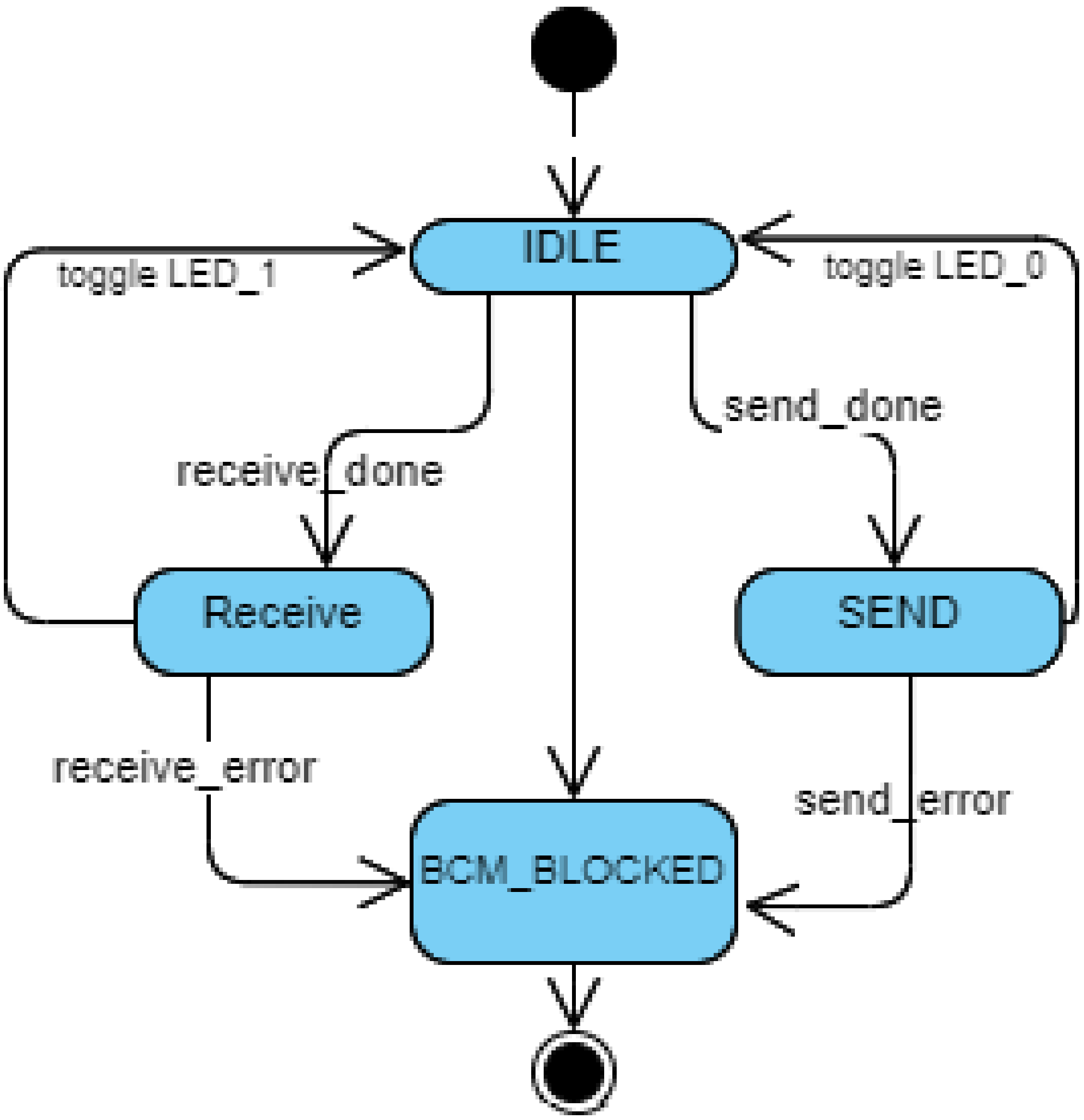
2.3.3 LED:



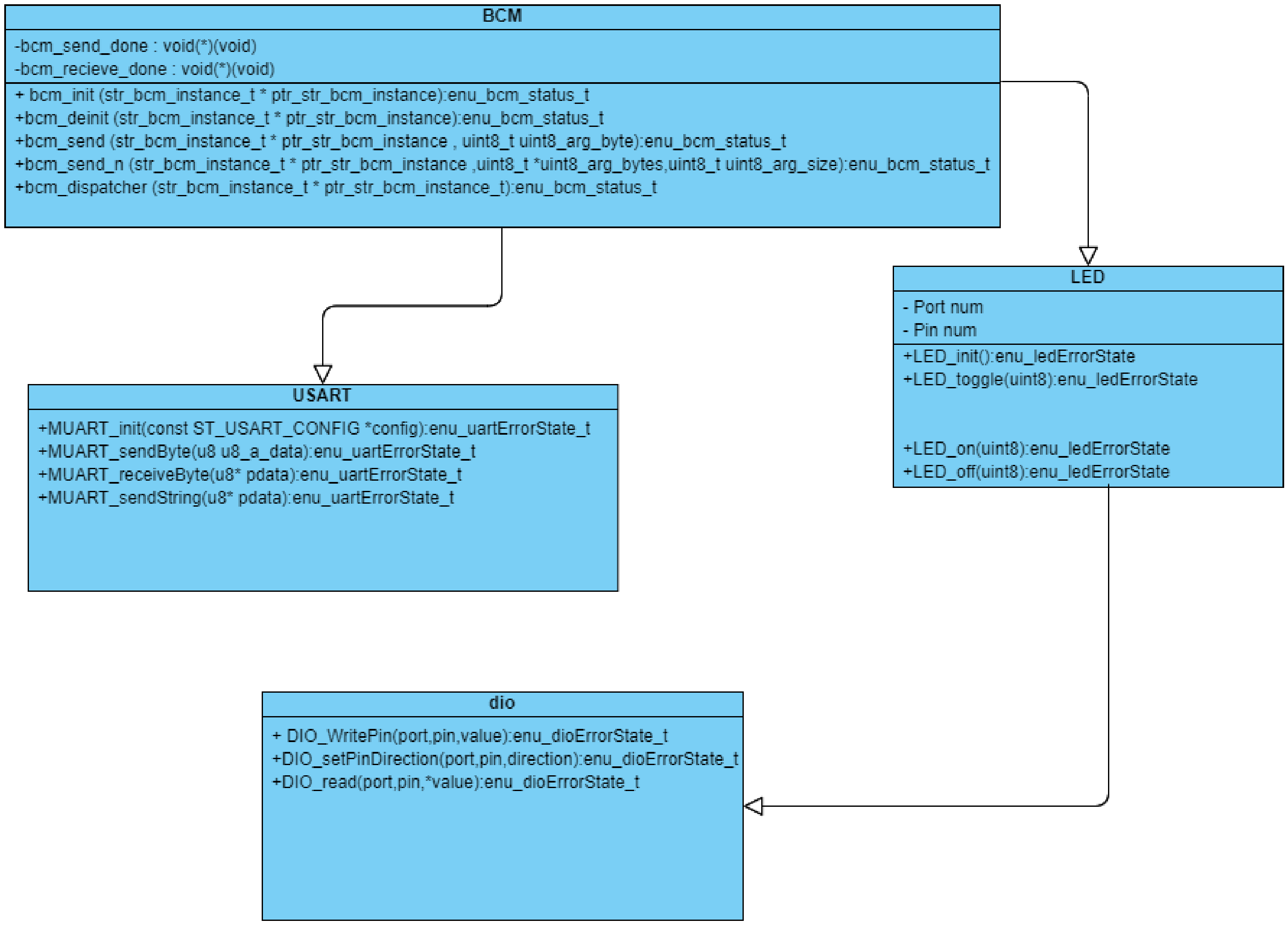
```
/*Enum for error state*/
typedef enum
{
    LED_OK,
    LED_NOK
    }EN_ledError_t;

    /*struct to store led attributes*/
typedef struct LEDS{
    u8 port;
    u8 pin;
    u8 state;
}LEDS;

/*initializes led according to given arguments */
EN_ledError_t HLED_init(LEDS *led);

/*function to turn the LED on*/
EN_ledError_t HLED_on(LEDS *led);

/*function to turn the LED off*/
EN_ledError_t HLED_off(LEDS *led);

/*function to toggle the LED state*/
EN_ledError_t HLED_toggle(LEDS *led);
```

2.4 UML :

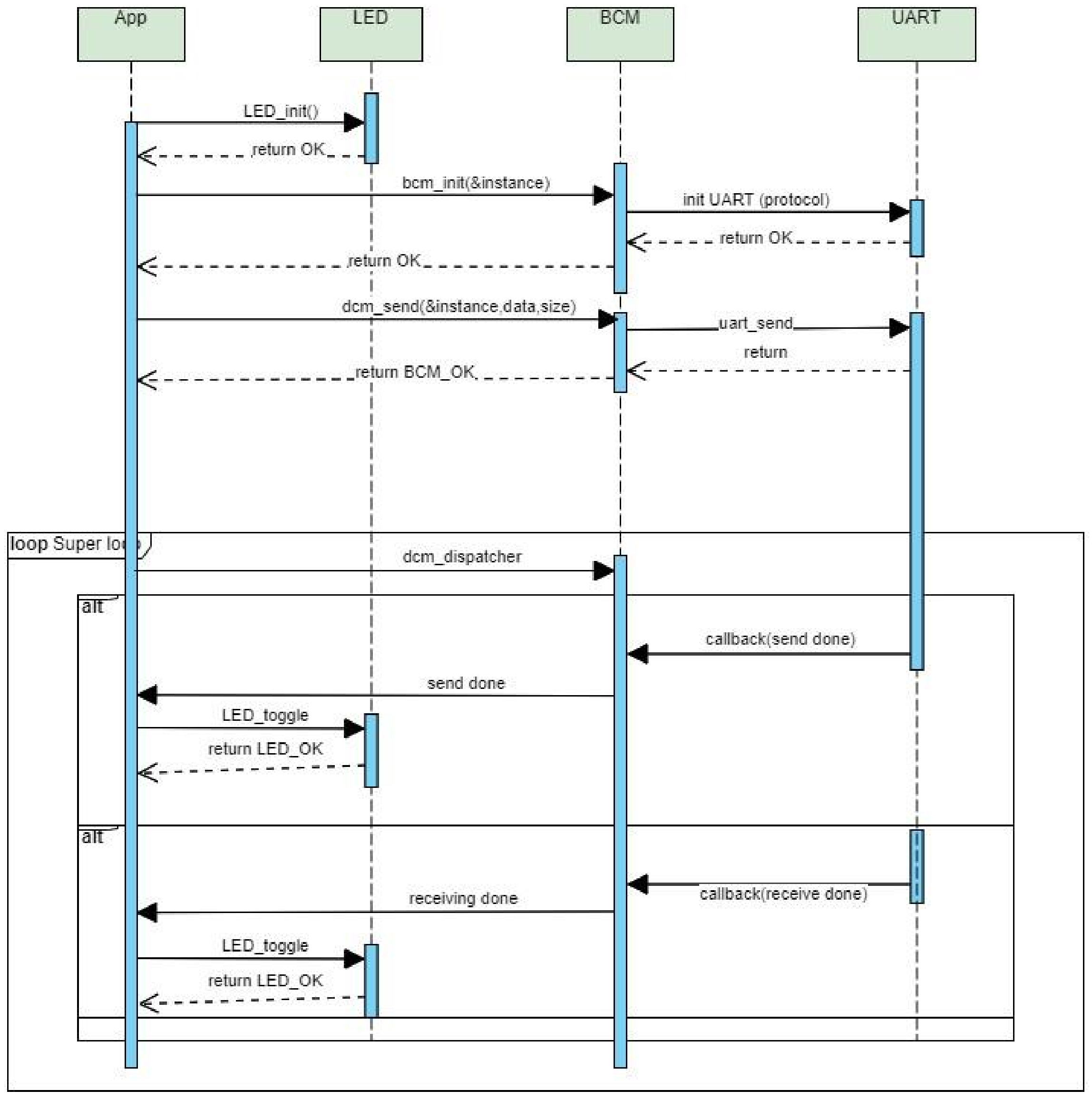
2.4.1. BCM state machine diagram :



2.4.2. BCM class diagram :


BCM
-bcm_send_done : void(*)(void)
-bcm_recieve_done : void(*)(void)
+ bcm_init (str_bcm_instance_t * ptr_str_bcm_instance):enu_bcm_status_t
+bcm_deinit (str_bcm_instance_t * ptr_str_bcm_instance):enu_bcm_status_t
+bcm_send (str_bcm_instance_t * ptr_str_bcm_instance , uint8_t uint8_arg_byte):enu_bcm_status_t
+bcm_send_n (str_bcm_instance_t * ptr_str_bcm_instance ,uint8_t *uint8_arg_bytes,uint8_t uint8_arg_size):enu_bcm_status_t
+bcm_dispatcher (str_bcm_instance_t * ptr_str_bcm_instance_t):enu_bcm_status_t
LED
- Port num
- Pin num
+LED_init():enu_ledErrorState
+LED_toggle(uint8):enu_ledErrorState
+LED_on(uint8):enu_ledErrorState
+LED_off(uint8):enu_ledErrorState
USART
+MUART_init(const ST_USART_CONFIG *config):enu_uartErrorState_t
+MUART_sendByte(u8 u8_a_data):enu_uartErrorState_t
+MUART_receiveByte(u8* pdata):enu_uartErrorState_t
+MUART_sendString(u8* pdata):enu_uartErrorState_t
dio
+ DIO_WritePin(port,pin,value):enu_dioErrorState_t
+DIO_setPinDirection(port,pin,direction):enu_dioErrorState_t
+DIO_read(port,pin,*value):enu_dioErrorState_t

2.5 BCM Sequence Diagram:

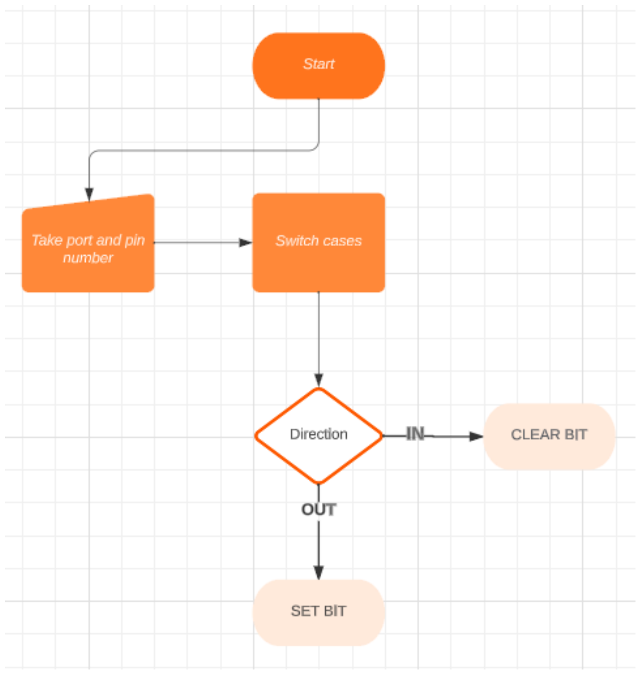


3. Low Level Design:

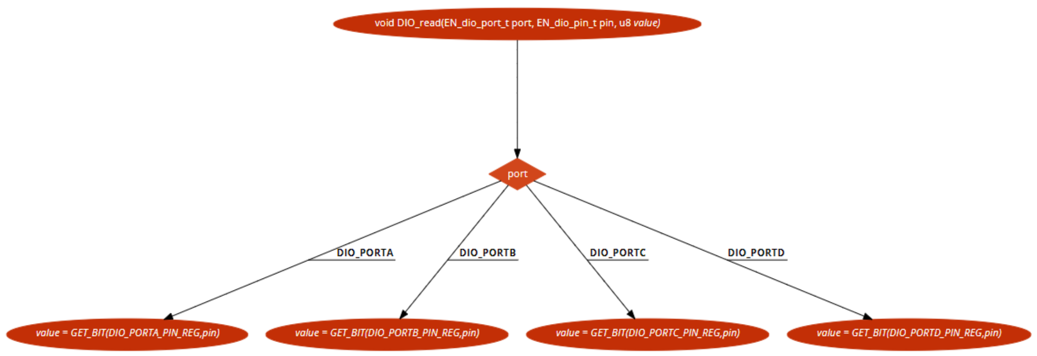
3.1Flowcharts:

DIO:

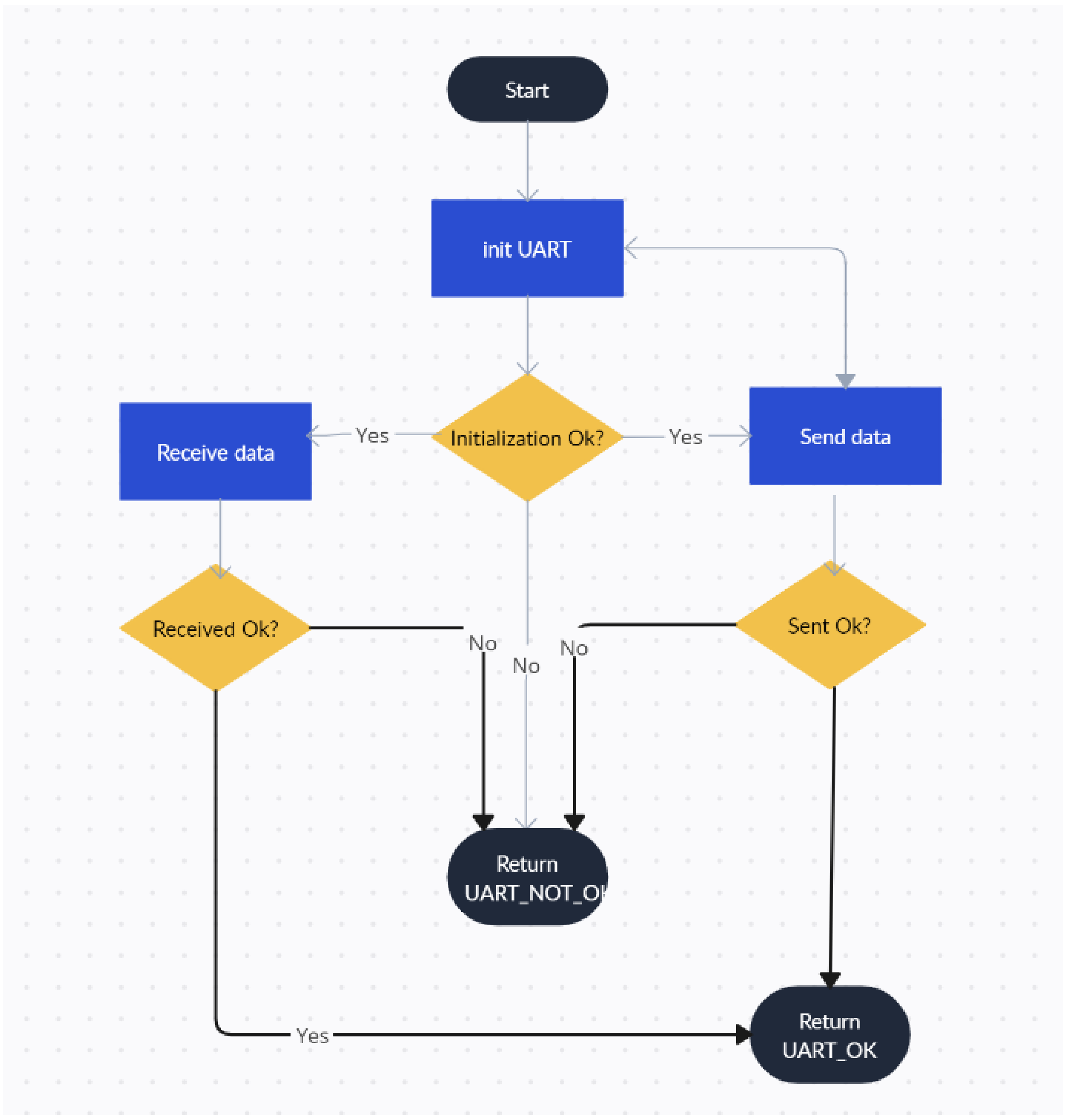
EN_dioError_t DIO_WritePin(EN_dio_port_t port, EN_dio_pin_t pin, EN_dio_value_t value)



EN_dioError_t DIO_read(EN_dio_port_t port, EN_dio_pin_t pin, u8 *value)

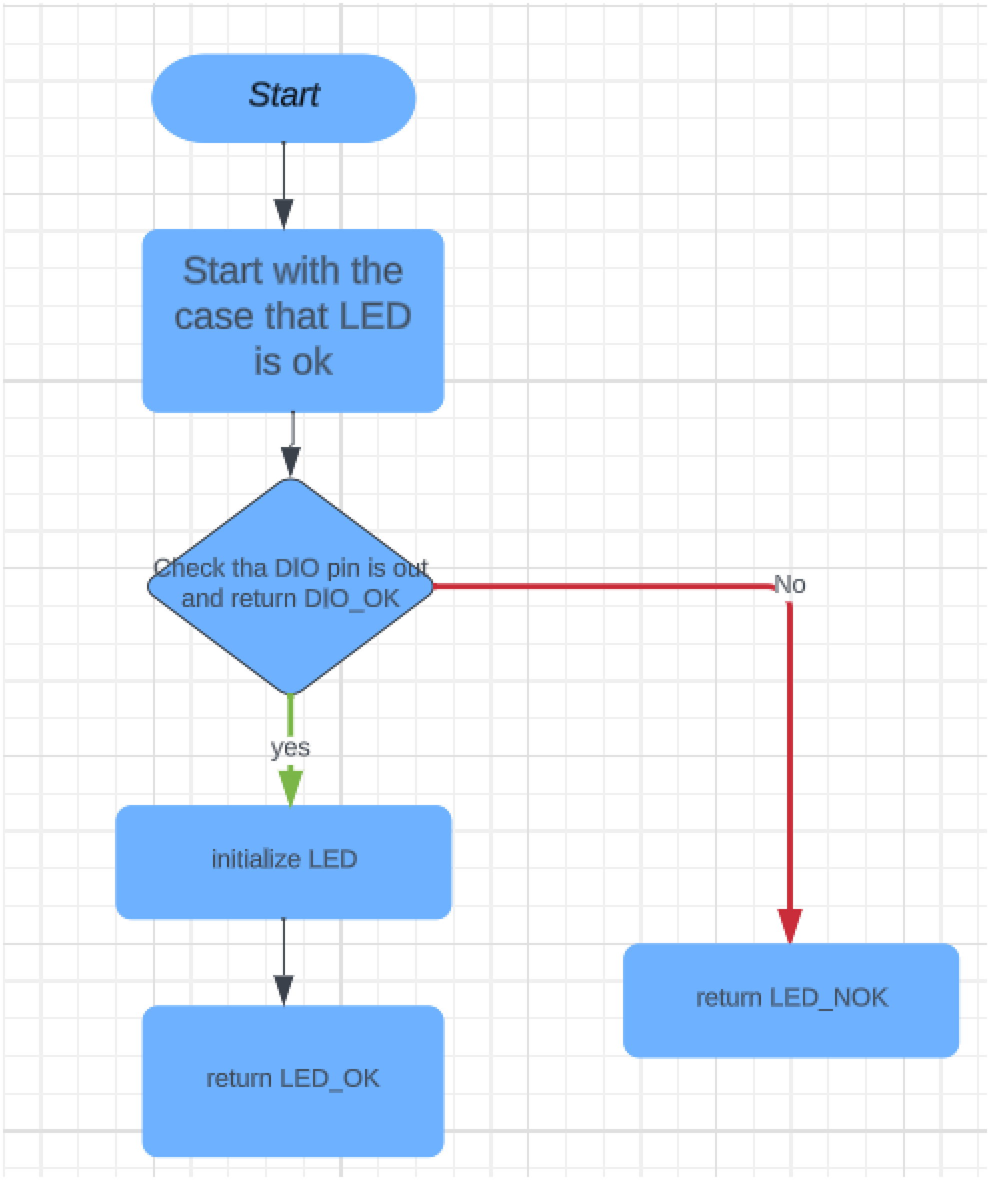

void DIO_read(EN_dio_port_t port, EN_dio_pin_t pin, u8 value)
port
DIO_PORTA
DIO_PORTB
DIO_PORTC
DIO_PORTD
value = GET_BIT(DIO_PORTA_PIN_REG,pin)
value = GET_BIT(DIO_PORTB_PIN_REG,pin)
value = GET_BIT(DIO_PORTC_PIN_REG,pin)
value = GET_BIT(DIO_PORTD_PIN_REG,pin)

UART:

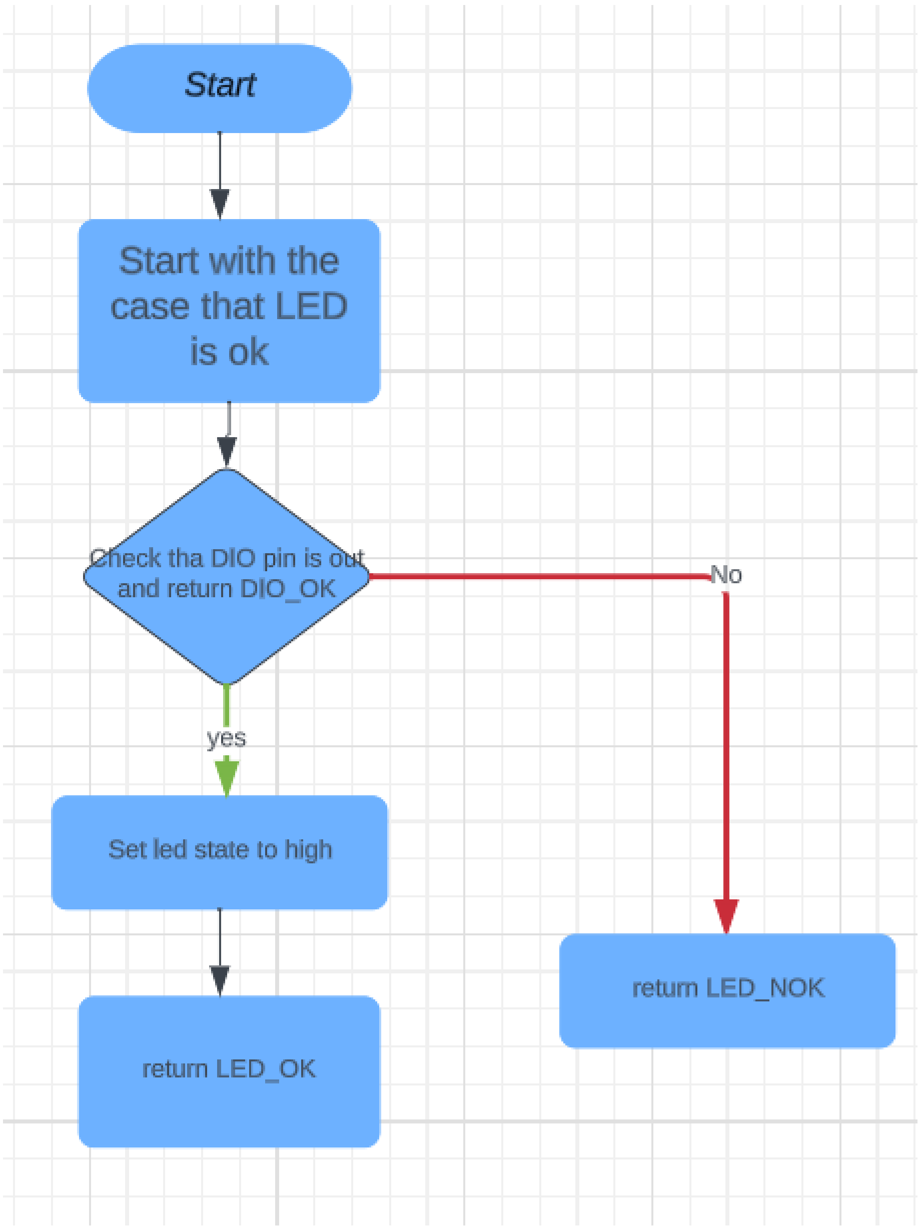

Start
init UART
Initialization Ok?
Yes
Yes
Receive data
Send data
Received Ok?
Sent Ok?
No
No
No
Return UART_NOT_OK
Yes
Return UART_OK

LED:

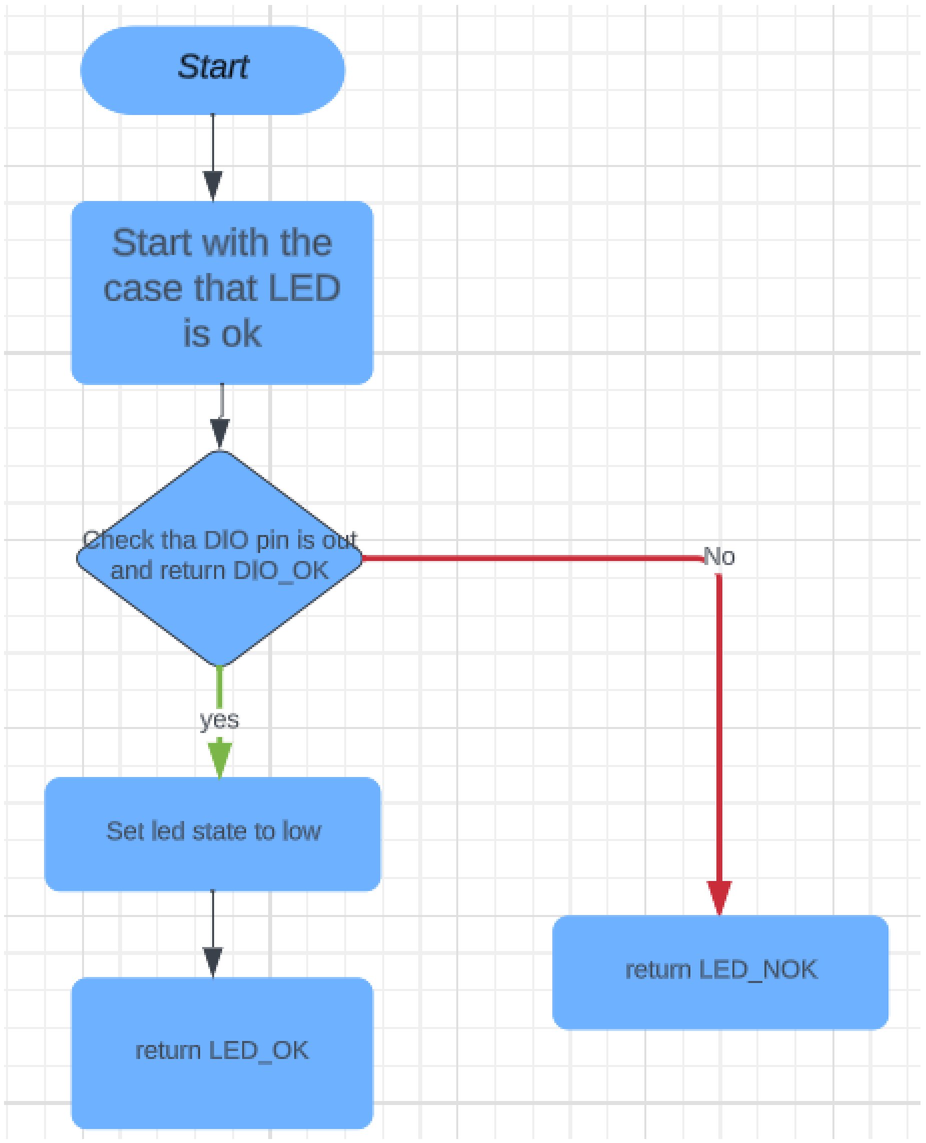
EN_ledError_t HLED_init(LEDS *led)


Start
Start with the case that LED is ok
Check tha DIO pin is out and return DIO_OK
No
yes
initialize LED
return LED_OK
return LED_NOK

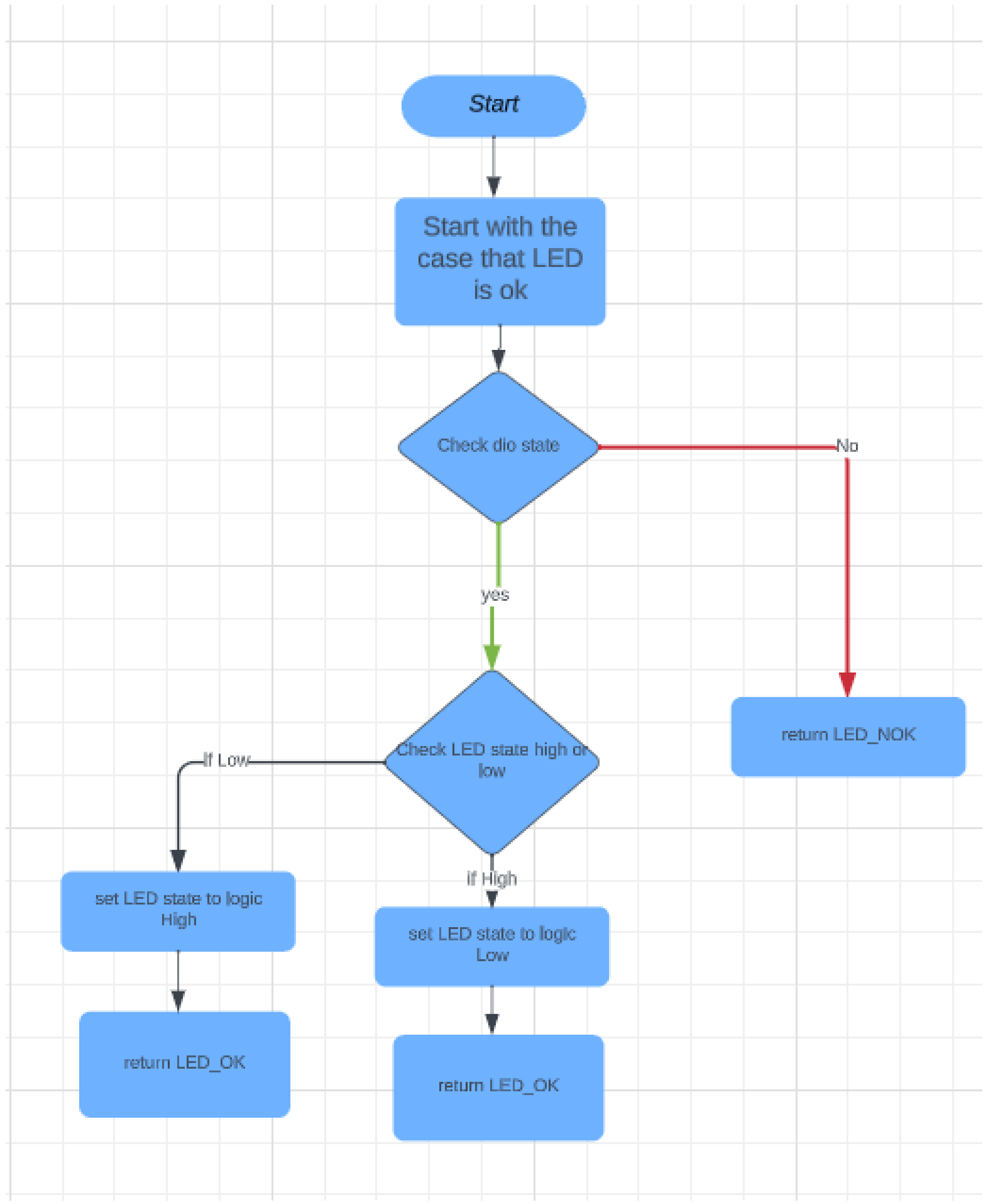
EN_ledError_t HLED_on(LEDS *led)


Start
Start with the case that LED is ok
Check tha DIO pin is out and return DIO_OK
No
yes
Set led state to high
return LED_NOK
return LED_OK

EN_ledError_t HLED_off(LEDS *led)

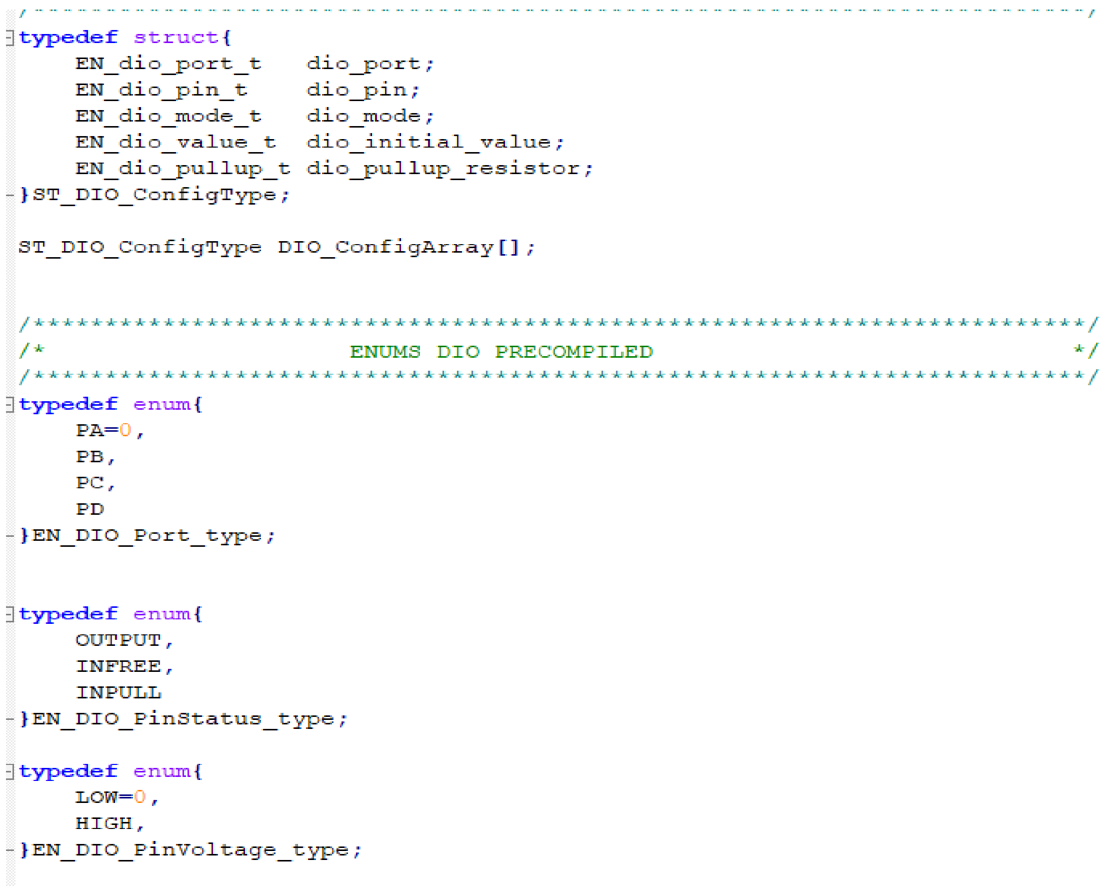

Start
Start with the case that LED is ok
Check tha DIO pin is out and return DIO_OK
No
yes
Set led state to low
return LED_NOK
return LED_OK

EN_ledError_t HLED_toggle(LEDS *led)

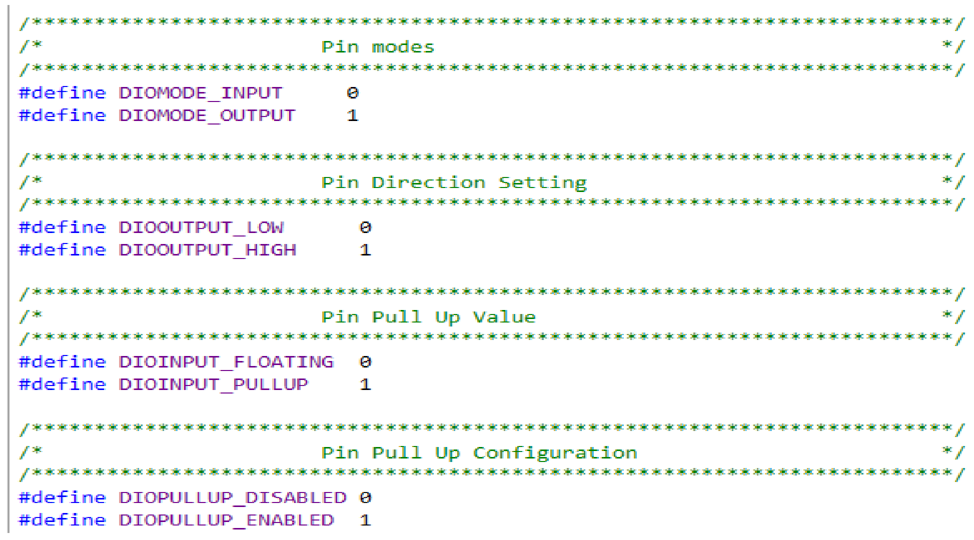

Start
Start with the case that LED is ok
Check dio state
No
return LED_NOK
yes
Check LED state high or low
If Low
if High
set LED state to logic High
set LED state to logic Low
return LED_OK
return LED_OK

3.2 Configurations:

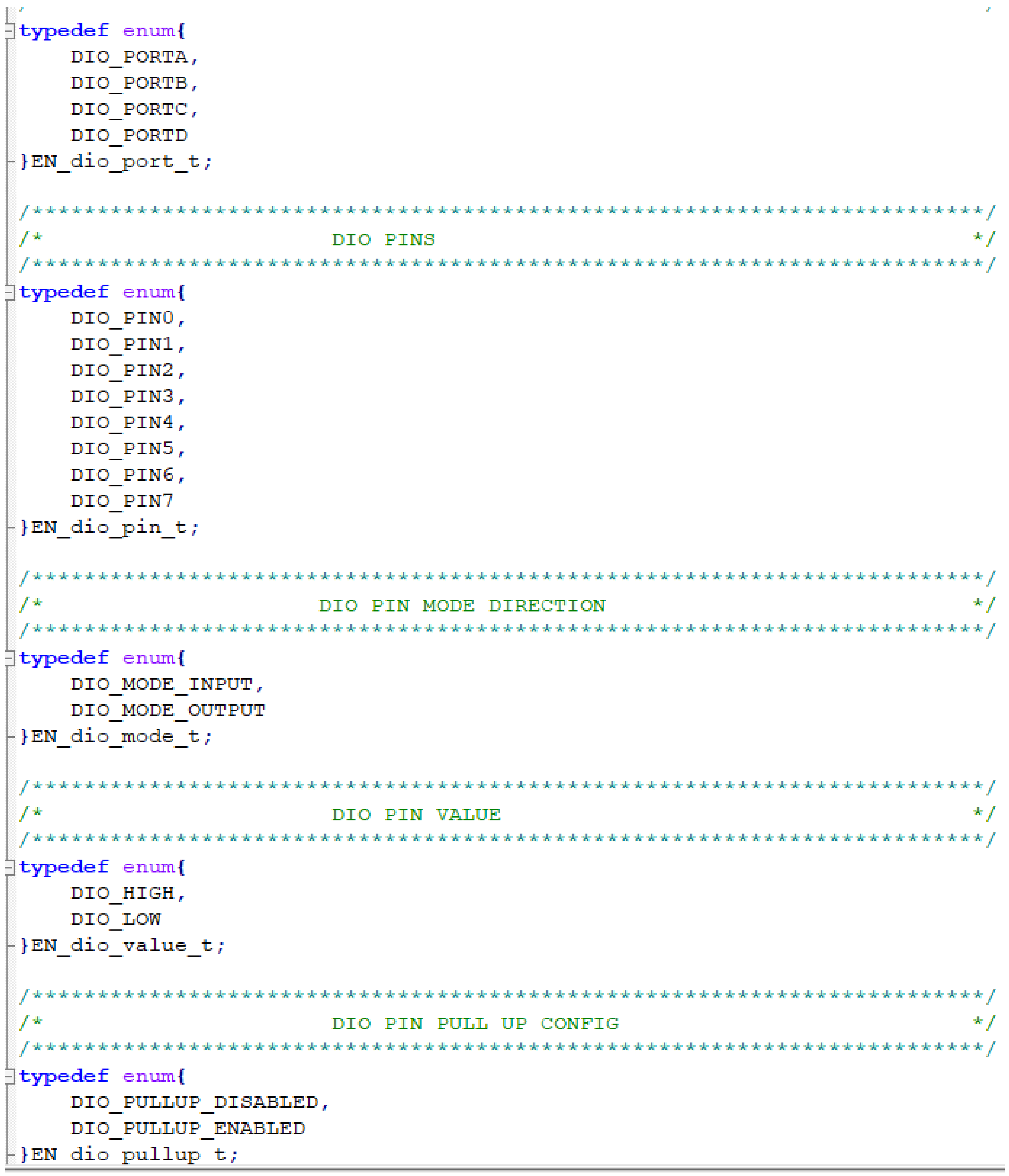
3.2.1 DIO:



```
/*************************************************************************/
typedef struct{
    EN_dio_port_t   dio_port;
    EN_dio_pin_t    dio_pin;
    EN_dio_mode_t   dio_mode;
    EN_dio_value_t  dio_initial_value;
    EN_dio_pullup_t dio_pullup_resistor;
}ST_DIO_ConfigType;

ST_DIO_ConfigType DIO_ConfigArray[];


/*************************************************************************/
/*                       ENUMS DIO PRECOMPILED                           */
/*************************************************************************/
typedef enum{
    PA=0,
    PB,
    PC,
    PD
}EN_DIO_Port_type;


typedef enum{
    OUTPUT,
    INFREE,
    INPULL
}EN_DIO_PinStatus_type;

typedef enum{
    LOW=0,
    HIGH,
}EN_DIO_PinVoltage_type;
```

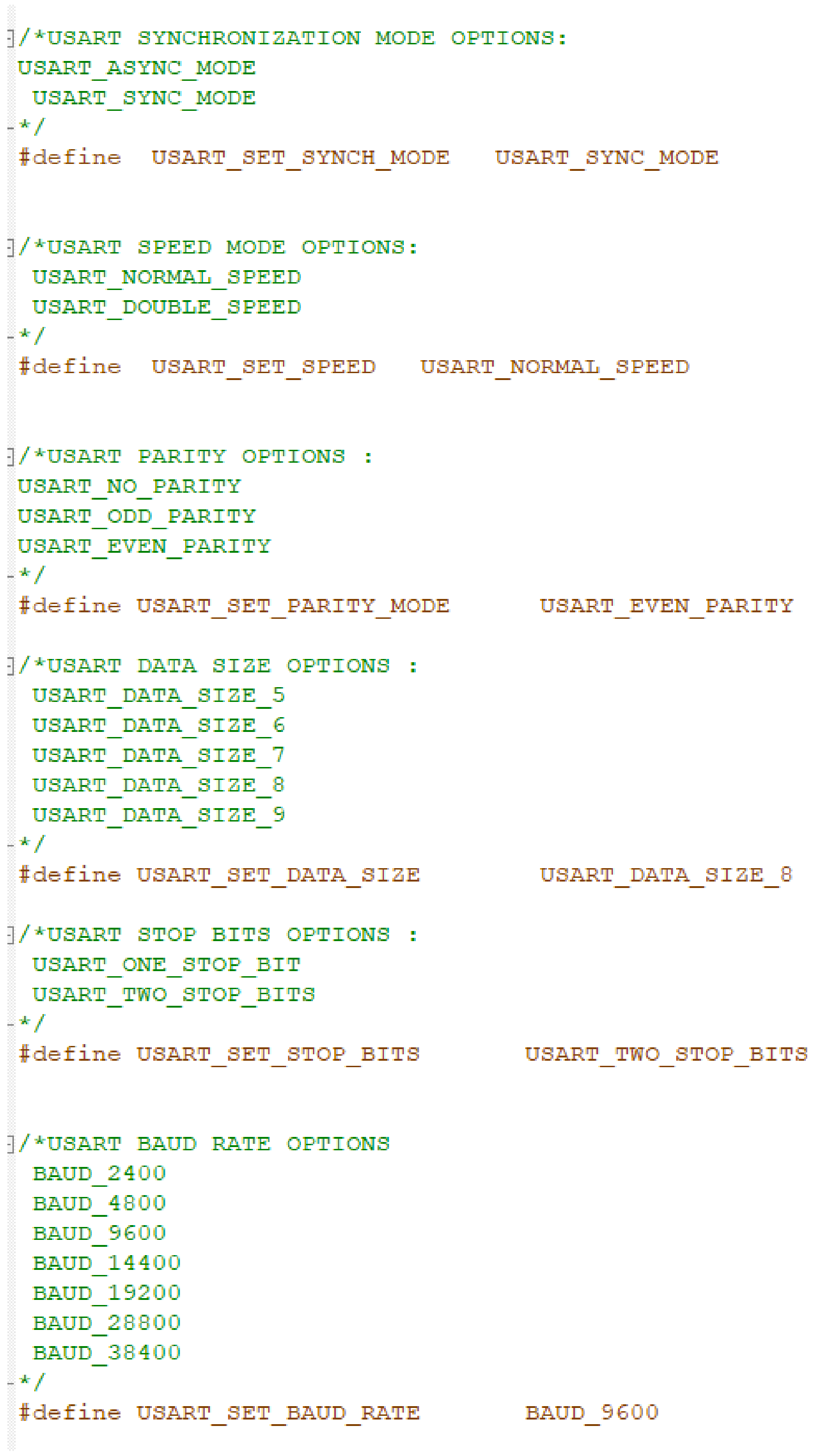


```
/*************************************************************************/
/*                        Pin modes                                      */
/*************************************************************************/
#define DIOMODE_INPUT       0
#define DIOMODE_OUTPUT      1

/*************************************************************************/
/*                        Pin Direction Setting                          */
/*************************************************************************/
#define DIOOUTPUT_LOW        0
#define DIOOUTPUT_HIGH       1

/*************************************************************************/
/*                        Pin Pull Up Value                              */
/*************************************************************************/
#define DIOINPUT_FLOATING   0
#define DIOINPUT_PULLUP      1

/*************************************************************************/
/*                        Pin Pull Up Configuration                      */
/*************************************************************************/
#define DIOPULLUP_DISABLED 0
#define DIOPULLUP_ENABLED   1
```

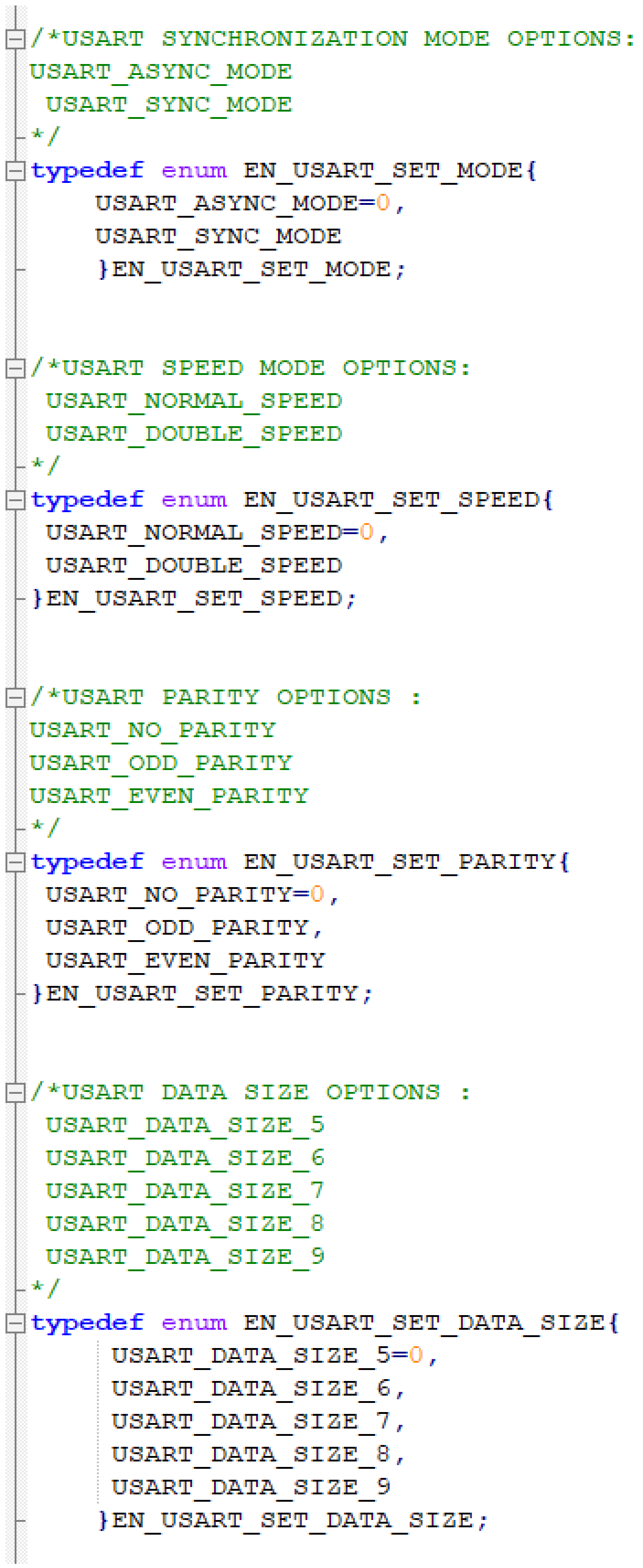


```c
typedef enum{
    DIO_PORTA,
    DIO_PORTB,
    DIO_PORTC,
    DIO_PORTD
}EN_dio_port_t;

/***************************************************************************/
/*                       DIO PINS                                          */
/***************************************************************************/
typedef enum{
    DIO_PIN0,
    DIO_PIN1,
    DIO_PIN2,
    DIO_PIN3,
    DIO_PIN4,
    DIO_PIN5,
    DIO_PIN6,
    DIO_PIN7
}EN_dio_pin_t;

/***************************************************************************/
/*                      DIO PIN MODE DIRECTION                             */
/***************************************************************************/
typedef enum{
    DIO_MODE_INPUT,
    DIO_MODE_OUTPUT
}EN_dio_mode_t;

/***************************************************************************/
/*                       DIO PIN VALUE                                     */
/***************************************************************************/
typedef enum{
    DIO_HIGH,
    DIO_LOW
}EN_dio_value_t;

/***************************************************************************/
/*                       DIO PIN PULL UP CONFIG                            */
/***************************************************************************/
typedef enum{
    DIO_PULLUP_DISABLED,
    DIO_PULLUP_ENABLED
}EN dio pullup t;
```

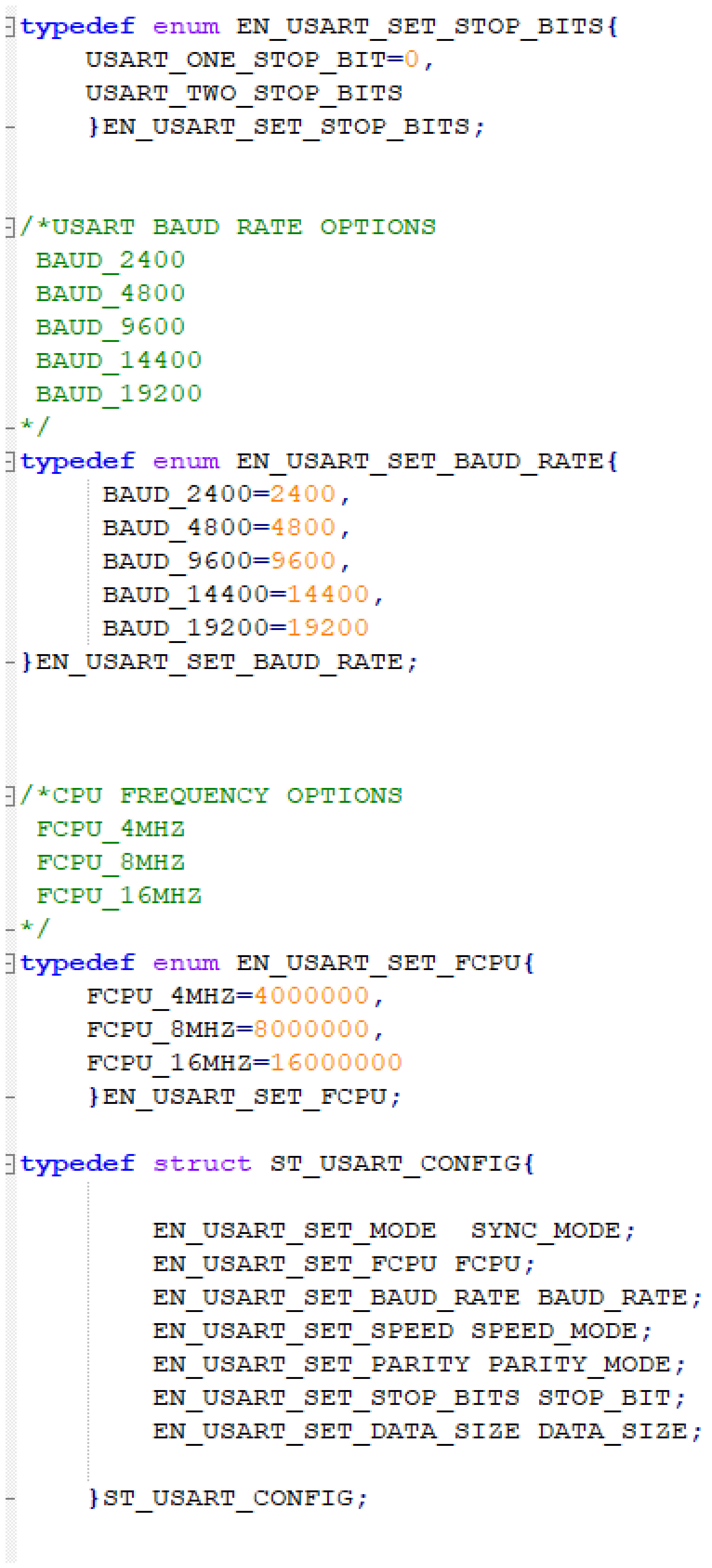
3.2.3 UART:



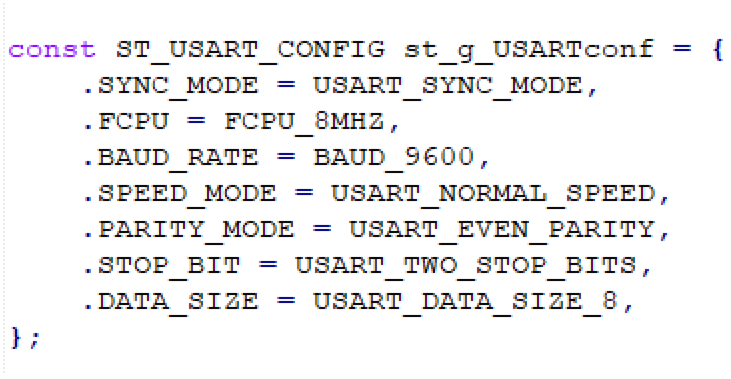
```
/*USART SYNCHRONIZATION MODE OPTIONS:
USART_ASYNC_MODE
 USART_SYNC_MODE
*/
#define  USART_SET_SYNCH_MODE   USART_SYNC_MODE


/*USART SPEED MODE OPTIONS:
 USART_NORMAL_SPEED
 USART_DOUBLE_SPEED
*/
#define  USART_SET_SPEED   USART_NORMAL_SPEED


/*USART PARITY OPTIONS :
USART_NO_PARITY
USART_ODD_PARITY
USART_EVEN_PARITY
*/
#define USART_SET_PARITY_MODE      USART_EVEN_PARITY

/*USART DATA SIZE OPTIONS :
 USART_DATA_SIZE_5
 USART_DATA_SIZE_6
 USART_DATA_SIZE_7
 USART_DATA_SIZE_8
 USART_DATA_SIZE_9
*/
#define USART_SET_DATA_SIZE        USART_DATA_SIZE_8

/*USART STOP BITS OPTIONS :
 USART_ONE_STOP_BIT
 USART_TWO_STOP_BITS
*/
#define USART_SET_STOP_BITS       USART_TWO_STOP_BITS


/*USART BAUD RATE OPTIONS
 BAUD_2400
 BAUD_4800
 BAUD_9600
 BAUD_14400
 BAUD_19200
 BAUD_28800
 BAUD_38400
*/
#define USART_SET_BAUD_RATE       BAUD_9600
```



```c
/*USART SYNCHRONIZATION MODE OPTIONS:
USART_ASYNC_MODE
 USART_SYNC_MODE
*/
typedef enum EN_USART_SET_MODE{
    USART_ASYNC_MODE=0,
    USART_SYNC_MODE
    }EN_USART_SET_MODE;


/*USART SPEED MODE OPTIONS:
 USART_NORMAL_SPEED
 USART_DOUBLE_SPEED
*/
typedef enum EN_USART_SET_SPEED{
 USART_NORMAL_SPEED=0,
 USART_DOUBLE_SPEED
}EN_USART_SET_SPEED;


/*USART PARITY OPTIONS :
USART_NO_PARITY
USART_ODD_PARITY
USART_EVEN_PARITY
*/
typedef enum EN_USART_SET_PARITY{
 USART_NO_PARITY=0,
 USART_ODD_PARITY,
 USART_EVEN_PARITY
}EN_USART_SET_PARITY;


/*USART DATA SIZE OPTIONS :
 USART_DATA_SIZE_5
 USART_DATA_SIZE_6
 USART_DATA_SIZE_7
 USART_DATA_SIZE_8
 USART_DATA_SIZE_9
*/
typedef enum EN_USART_SET_DATA_SIZE{
     USART_DATA_SIZE_5=0,
     USART_DATA_SIZE_6,
     USART_DATA_SIZE_7,
     USART_DATA_SIZE_8,
     USART_DATA_SIZE_9
    }EN_USART_SET_DATA_SIZE;
```

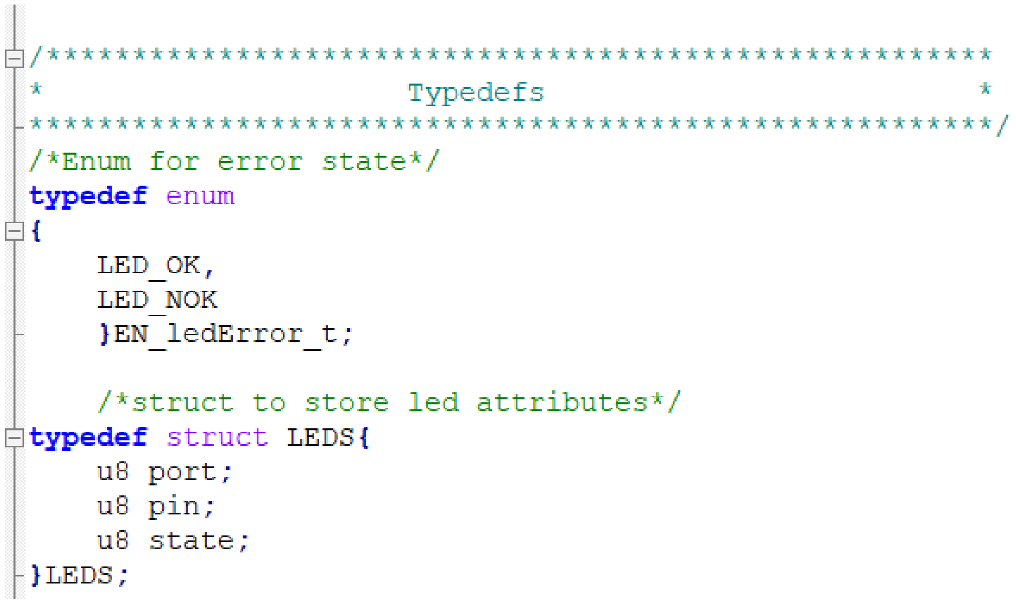


```
typedef enum EN_USART_SET_STOP_BITS{
    USART_ONE_STOP_BIT=0,
    USART_TWO_STOP_BITS
    }EN_USART_SET_STOP_BITS;


/*USART BAUD RATE OPTIONS
 BAUD_2400
 BAUD_4800
 BAUD_9600
 BAUD_14400
 BAUD_19200
*/
typedef enum EN_USART_SET_BAUD_RATE{
     BAUD_2400=2400,
     BAUD_4800=4800,
     BAUD_9600=9600,
     BAUD_14400=14400,
     BAUD_19200=19200
}EN_USART_SET_BAUD_RATE;



/*CPU FREQUENCY OPTIONS
 FCPU_4MHZ
 FCPU_8MHZ
 FCPU_16MHZ
*/
typedef enum EN_USART_SET_FCPU{
    FCPU_4MHZ=4000000,
    FCPU_8MHZ=8000000,
    FCPU_16MHZ=16000000
    }EN_USART_SET_FCPU;

typedef struct ST_USART_CONFIG{

        EN_USART_SET_MODE  SYNC_MODE;
        EN_USART_SET_FCPU FCPU;
        EN_USART_SET_BAUD_RATE BAUD_RATE;
        EN_USART_SET_SPEED SPEED_MODE;
        EN_USART_SET_PARITY PARITY_MODE;
        EN_USART_SET_STOP_BITS STOP_BIT;
        EN_USART_SET_DATA_SIZE DATA_SIZE;

    }ST_USART_CONFIG;
```



```
const ST_USART_CONFIG st_g_USARTconf = {
    .SYNC_MODE = USART_SYNC_MODE,
    .FCPU = FCPU_8MHZ,
    .BAUD_RATE = BAUD_9600,
    .SPEED_MODE = USART_NORMAL_SPEED,
    .PARITY_MODE = USART_EVEN_PARITY,
    .STOP_BIT = USART_TWO_STOP_BITS,
    .DATA_SIZE = USART_DATA_SIZE_8,
};
```

3.2.3 LED:



```
/*******************************************************
*                       Typedefs                      *
*******************************************************/
/*Enum for error state*/
typedef enum
{
    LED_OK,
    LED_NOK
    }EN_ledError_t;

    /*struct to store led attributes*/
typedef struct LEDS{
    u8 port;
    u8 pin;
    u8 state;
}LEDS;
```

BCM APIs:

BCM_init()

Function Name	bcm_init
Syntax	enu_system_status_t bcm_init (str_bcm_instance_t* ptr_str_bcm_instance);
Sync/Async	Synchronous
Reentrancy	Non Reentrant
Parameters (in):	ptr_str_bcm_instance: Address of the BCM Instance
Parameters (out):	None
Parameters (in, out):	None
Return:	BCM_STATUS_SUCCESS: In case of Successful Operation BCM_STATUS_INVALID_STATE: In case of Failed Operation

BCM_deInit()

Function Name	bcm_deInit
Syntax	enu_system_status_t bcm_init (str_bcm_instance_t* ptr_str_bcm_instance);
Sync/Async	Synchronous
Reentrancy	Non Reentrant
Parameters (in):	ptr_str_bcm_instance: Address of the BCM Instance
Parameters (out):	None
Parameters (in, out):	None
Return:	BCM_STATUS_SUCCESS: In case of Successful Operation BCM_STATUS_INVALID_STATE: In case of Failed Operation

BCM_send()

Function Name	BCM_send
Syntax	enu_system_status_t bcm_init (str_bcm_instance_t* ptr_str_bcm_instance,u8* ptr_u8_a_byte);
Sync/Async	Asynchronous
Reentrancy	Reentrant
Parameters (in):	ptr_str_bcm_instance: Address of the BCM Instance ptr_u8_a_byte : Address of the sending byte
Parameters (out):	None
Parameters (in, out):	None
Return:	BCM_STATUS_SUCCESS: In case of Successful Operation BCM_STATUS_INVALID_STATE: In case of Failed Operation

bcm_dispatcher ()

Function Name	BCM_dispatcher
Syntax	enu_system_status_t BCM_dispatcher(str_bcm_instance_t* ptr_str_bcm_instanc)
Sync/Async	Synchronous
Reentrancy	Non Reentrant
Parameters (in):	ptr_str_bcm_instance: Address of the BCM Instance
Parameters (out):	None
Parameters (in, out):	None
Return:	BCM_STATUS_SUCCESS: In case of Successful Operation BCM_STATUS_INVALID_STATE: In case of Failed Operation

BCM_send_n()

Function Name	BCM_send_n
Syntax	enu_system_status_t bcm_init (str_bcm_instance_t* ptr_str_bcm_instance, u8* ptr_u8_a_byte);
Sync/Async	ASynchronous
Reentrancy	Reentrant
Parameters (in):	ptr_str_bcm_instance: Address of the BCM Instance ptr_u8_a_byte : Address of the sending bytes uint16_size: Variable contains data size
Parameters (out):	None
Parameters (in, out):	None
Return:	BCM_STATUS_SUCCESS: In case of Successful Operation BCM_STATUS_INVALID_STATE: In case of Failed Operation