

Lab 10 - squadra A15

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1 - Measure of the frequency and duty cycle of an external square waveform

file `main.c`:

```

/* USER CODE BEGIN Header */
/**
 * *****
 * @file           : main.c
 * @brief          : Main program body
 * *****
 * @attention
 *
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 *
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 * in the root directory of this software component.
 * If no LICENSE file comes with this software, it is provided AS-IS.
 *
 * *****
 */
/* USER CODE END Header */
/* Includes -----*/
#include "main.h"

/* Private includes -----*/
/* USER CODE BEGIN Includes */

/* USER CODE END Includes */

/* Private typedef -----*/
/* USER CODE BEGIN PTD */

/* USER CODE END PTD */

/* Private define -----*/
/* USER CODE BEGIN PD */
/* USER CODE END PD */

/* Private macro -----*/
/* USER CODE BEGIN PM */

/* USER CODE END PM */

```

```

/* Private variables -----*/
TIM_HandleTypeDef htim3;

UART_HandleTypeDef huart2;

/* USER CODE BEGIN PV */

/* USER CODE END PV */

/* Private function prototypes -----*/
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_USART2_UART_Init(void);
static void MX_TIM3_Init(void);
/* USER CODE BEGIN PFP */

/* USER CODE END PFP */

/* Private user code -----*/
/* USER CODE BEGIN 0 */

/* USER CODE END 0 */

/**
 * @brief The application entry point.
 * @retval int
 */
int main(void)
{
    /* USER CODE BEGIN 1 */

    /* USER CODE END 1 */

    /* MCU Configuration-----*/

    /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
    HAL_Init();

    /* USER CODE BEGIN Init */

    /* USER CODE END Init */

    /* Configure the system clock */
    SystemClock_Config();

    /* USER CODE BEGIN SysInit */

    /* USER CODE END SysInit */

    /* Initialize all configured peripherals */
    MX_GPIO_Init();
    MX_USART2_UART_Init();
    MX_TIM3_Init();
    /* USER CODE BEGIN 2 */

```

```

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
HAL_TIM_IC_Start_IT(&htim3, TIM_CHANNEL_1);

while (1)
{
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */
}

/**
 * @brief System Clock Configuration
 * @retval None
 */
void SystemClock_Config(void)
{
    RCC_OscInitTypeDef RCC_OscInitStruct = {0};
    RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};

    /** Configure the main internal regulator output voltage
    */
    __HAL_RCC_PWR_CLK_ENABLE();
    __HAL_PWR_VOLTAGESCALING_CONFIG(PWR_REGULATOR_VOLTAGE_SCALE2);
    /** Initializes the RCC Oscillators according to the specified parameters
    * in the RCC_OscInitTypeDef structure.
    */
    RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSI;
    RCC_OscInitStruct.HSISState = RCC_HSI_ON;
    RCC_OscInitStruct.HSICalibrationValue = RCC_HSICALIBRATION_DEFAULT;
    RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
    RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSI;
    RCC_OscInitStruct.PLL.PLLM = 16;
    RCC_OscInitStruct.PLL.PLLN = 336;
    RCC_OscInitStruct.PLL.PLLP = RCC_PLLP_DIV4;
    RCC_OscInitStruct.PLL.PLLQ = 7;
    if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK)
    {
        Error_Handler();
    }
    /** Initializes the CPU, AHB and APB buses clocks
    */
    RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
                                  |RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
    RCC_ClkInitStruct.SYSCLKSource = RCC_SYSCLKSOURCE_PLLCLK;
    RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCLK_DIV1;
    RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
    RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;

```

```

if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
{
    Error_Handler();
}
}

/**
 * @brief TIM3 Initialization Function
 * @param None
 * @retval None
 */
static void MX_TIM3_Init(void)
{
    /* USER CODE BEGIN TIM3_Init 0 */

    /* USER CODE END TIM3_Init 0 */

    TIM_ClockConfigTypeDef sClockSourceConfig = {0};
    TIM_MasterConfigTypeDef sMasterConfig = {0};
    TIM_IC_InitTypeDef sConfigIC = {0};

    /* USER CODE BEGIN TIM3_Init 1 */

    /* USER CODE END TIM3_Init 1 */
    htim3.Instance = TIM3;
    htim3.Init.Prescaler = 0;
    htim3.Init.CounterMode = TIM_COUNTERMODE_UP;
    htim3.Init.Period = 65535;
    htim3.Init.ClockDivision = TIM_CLOCKDIVISION_DIV1;
    htim3.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE;
    if (HAL_TIM_Base_Init(&htim3) != HAL_OK)
    {
        Error_Handler();
    }
    sClockSourceConfig.ClockSource = TIM_CLOCKSOURCE_INTERNAL;
    if (HAL_TIM_ConfigClockSource(&htim3, &sClockSourceConfig) != HAL_OK)
    {
        Error_Handler();
    }
    if (HAL_TIM_IC_Init(&htim3) != HAL_OK)
    {
        Error_Handler();
    }
    sMasterConfig.MasterOutputTrigger = TIM_TRGO_RESET;
    sMasterConfig.MasterSlaveMode = TIM_MASTERSLAVEMODE_DISABLE;
    if (HAL_TIMEx_MasterConfigSynchronization(&htim3, &sMasterConfig) != HAL_OK)
    {
        Error_Handler();
    }
    sConfigIC.ICPolarity = TIM_INPUTCHANNELPOLARITY_BOTHEDGE;
    sConfigIC.ICSelection = TIM_ICSELECTION_DIRECTTI;
    sConfigIC.ICPrescaler = TIM_ICPSC_DIV1;
    sConfigIC.ICFilter = 0;

```

```

    if (HAL_TIM_IC_ConfigChannel(&htim3, &sConfigIC, TIM_CHANNEL_1) != HAL_OK)
    {
        Error_Handler();
    }
    /* USER CODE BEGIN TIM3_Init 2 */

    /* USER CODE END TIM3_Init 2 */

}

/**
 * @brief USART2 Initialization Function
 * @param None
 * @retval None
 */
static void MX_USART2_UART_Init(void)
{
    /* USER CODE BEGIN USART2_Init 0 */

    /* USER CODE END USART2_Init 0 */

    /* USER CODE BEGIN USART2_Init 1 */

    /* USER CODE END USART2_Init 1 */
    huart2.Instance = USART2;
    huart2.Init.BaudRate = 115200;
    huart2.Init.WordLength = UART_WORDLENGTH_8B;
    huart2.Init.StopBits = UART_STOPBITS_1;
    huart2.Init.Parity = UART_PARITY_NONE;
    huart2.Init.Mode = UART_MODE_TX_RX;
    huart2.Init.HwFlowCtl = UART_HWCONTROL_NONE;
    huart2.Init.OverSampling = UART_OVERSAMPLING_16;
    if (HAL_UART_Init(&huart2) != HAL_OK)
    {
        Error_Handler();
    }
    /* USER CODE BEGIN USART2_Init 2 */

    /* USER CODE END USART2_Init 2 */

}

/**
 * @brief GPIO Initialization Function
 * @param None
 * @retval None
 */
static void MX_GPIO_Init(void)
{
    GPIO_InitTypeDef GPIO_InitStruct = {0};

    /* GPIO Ports Clock Enable */
    __HAL_RCC_GPIOC_CLK_ENABLE();

```

```

__HAL_RCC_GPIOH_CLK_ENABLE();
__HAL_RCC_GPIOA_CLK_ENABLE();
__HAL_RCC_GPIOB_CLK_ENABLE();

/*Configure GPIO pin Output Level */
HAL_GPIO_WritePin(LD2_GPIO_Port, LD2_Pin, GPIO_PIN_RESET);

/*Configure GPIO pin : B1_Pin */
GPIO_InitStruct.Pin = B1_Pin;
GPIO_InitStruct.Mode = GPIO_MODE_IT_FALLING;
GPIO_InitStruct.Pull = GPIO_NOPULL;
HAL_GPIO_Init(B1_GPIO_Port, &GPIO_InitStruct);

/*Configure GPIO pin : LD2_Pin */
GPIO_InitStruct.Pin = LD2_Pin;
GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
GPIO_InitStruct.Pull = GPIO_NOPULL;
GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
HAL_GPIO_Init(LD2_GPIO_Port, &GPIO_InitStruct);

}

/* USER CODE BEGIN 4 */

uint16_t capture, oldcapture, high;

void HAL_TIM_IC_CaptureCallback(TIM_HandleTypeDef *htim){
    if(htim == &htim3){

        capture = HAL_TIM_ReadCapturedValue(htim, TIM_CHANNEL_1);
        uint16_t T;
        float duty;

        if (HAL_GPIO_ReadPin (GPIOC, GPIO_PIN_6) == 1){
            T = capture - oldcapture;
            duty = (float)high/((float)T;

            oldcapture = capture;
        }else{
            high = capture - oldcapture;
        }

    }
}

/* USER CODE END 4 */

/**
 * @brief This function is executed in case of error occurrence.
 * @retval None
 */
void Error_Handler(void)
{
    /* USER CODE BEGIN Error_Handler_Debug */

```

```

/* User can add his own implementation to report the HAL error return state */
__disable_irq();
while (1)
{
}
/* USER CODE END Error_Handler_Debug */
}

#ifdef  USE_FULL_ASSERT
/**
 * @brief Reports the name of the source file and the source line number
 *        where the assert_param error has occurred.
 * @param file: pointer to the source file name
 * @param line: assert_param error line source number
 * @retval None
 */
void assert_failed(uint8_t *file, uint32_t line)
{
    /* USER CODE BEGIN 6 */
    /* User can add his own implementation to report the file name and line number,
       ex: printf("Wrong parameters value: file %s on line %d\r\n", file, line) */
    /* USER CODE END 6 */
}
#endif /* USE_FULL_ASSERT */

```

2.1 - Square wave generation

file **main.c**:

```

/* USER CODE BEGIN Header */
/**
 * *****
 * @file           : main.c
 * @brief          : Main program body
 * *****
 * @attention
 *
 * Copyright (c) 2023 STMicroelectronics.
 * All rights reserved.
 *
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 * in the root directory of this software component.
 * If no LICENSE file comes with this software, it is provided AS-IS.
 *
 * *****
 */
/* USER CODE END Header */
/* Includes -----*/
#include "main.h"

/* Private includes -----*/

```

```

/* USER CODE BEGIN Includes */

/* USER CODE END Includes */

/* Private typedef -----*/
/* USER CODE BEGIN PTD */

/* USER CODE END PTD */

/* Private define -----*/
/* USER CODE BEGIN PD */
/* USER CODE END PD */

/* Private macro -----*/
/* USER CODE BEGIN PM */

/* USER CODE END PM */

/* Private variables -----*/
TIM_HandleTypeDef htim3;
TIM_HandleTypeDef htim4;

UART_HandleTypeDef huart2;

/* USER CODE BEGIN PV */

/* USER CODE END PV */

/* Private function prototypes -----*/
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_USART2_UART_Init(void);
static void MX_TIM3_Init(void);
static void MX_TIM4_Init(void);
/* USER CODE BEGIN PFP */

/* USER CODE END PFP */

/* Private user code -----*/
/* USER CODE BEGIN 0 */

/* USER CODE END 0 */

/**
 * @brief The application entry point.
 * @retval int
 */
int main(void)
{
    /* USER CODE BEGIN 1 */

    /* USER CODE END 1 */

    /* MCU Configuration-----*/

```



```

/* Reset of all peripherals, Initializes the Flash interface and the SysTick. */
HAL_Init();

/* USER CODE BEGIN Init */

/* USER CODE END Init */

/* Configure the system clock */
SystemClock_Config();

/* USER CODE BEGIN SysInit */

/* USER CODE END SysInit */

/* Initialize all configured peripherals */
MX_GPIO_Init();
MX_USART2_UART_Init();
MX_TIM3_Init();
MX_TIM4_Init();
/* USER CODE BEGIN 2 */

/* USER CODE END 2 */

/* Infinite loop */
/* USER CODE BEGIN WHILE */
HAL_TIM_IC_Start_IT(&htim3, TIM_CHANNEL_1); // inizializzo timer 3
HAL_TIM_PWM_Start(&htim4, TIM_CHANNEL_1);   // inizializzo timer 4

while (1)
{
    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */
}

/**
 * @brief System Clock Configuration
 * @retval None
 */
void SystemClock_Config(void)
{
    RCC_OscInitTypeDef RCC_OscInitStruct = {0};
    RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};

    /** Configure the main internal regulator output voltage
    */
    __HAL_RCC_PWR_CLK_ENABLE();
    __HAL_PWR_VOLTAGESCALING_CONFIG(PWR_REGULATOR_VOLTAGE_SCALE2);
    /** Initializes the RCC Oscillators according to the specified parameters
    * in the RCC_OscInitTypeDef structure.
    */

```

```

RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSI;
RCC_OscInitStruct.HSIState = RCC_HSI_ON;
RCC_OscInitStruct.HSICalibrationValue = RCC_HSICALIBRATION_DEFAULT;
RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSI;
RCC_OscInitStruct.PLL.PLLM = 16;
RCC_OscInitStruct.PLL.PLLN = 336;
RCC_OscInitStruct.PLL.PLLP = RCC_PLLP_DIV4;
RCC_OscInitStruct.PLL.PLLQ = 7;
if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK)
{
    Error_Handler();
}
/** Initializes the CPU, AHB and APB buses clocks
 */
RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
                             |RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
RCC_ClkInitStruct.SYSClkSource = RCC_SYSCCLKSOURCE_PLLCLK;
RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCCLK_DIV1;
RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;

if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
{
    Error_Handler();
}
}

/**
 * @brief TIM3 Initialization Function
 * @param None
 * @retval None
 */
static void MX_TIM3_Init(void)
{
    /* USER CODE BEGIN TIM3_Init 0 */

    /* USER CODE END TIM3_Init 0 */

    TIM_ClockConfigTypeDef sClockSourceConfig = {0};
    TIM_MasterConfigTypeDef sMasterConfig = {0};
    TIM_IC_InitTypeDef sConfigIC = {0};

    /* USER CODE BEGIN TIM3_Init 1 */

    /* USER CODE END TIM3_Init 1 */
    htim3.Instance = TIM3;
    htim3.Init.Prescaler = 1;
    htim3.Init.CounterMode = TIM_COUNTERMODE_UP;
    htim3.Init.Period = 65535;
    htim3.Init.ClockDivision = TIM_CLOCKDIVISION_DIV1;
    htim3.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE;
    if (HAL_TIM_Base_Init(&htim3) != HAL_OK)

```

```

{
    Error_Handler();
}
sClockSourceConfig.ClockSource = TIM_CLOCKSOURCE_INTERNAL;
if (HAL_TIM_ConfigClockSource(&htim3, &sClockSourceConfig) != HAL_OK)
{
    Error_Handler();
}
if (HAL_TIM_IC_Init(&htim3) != HAL_OK)
{
    Error_Handler();
}
sMasterConfig.MasterOutputTrigger = TIM_TRGO_RESET;
sMasterConfig.MasterSlaveMode = TIM_MASTERSLAVEMODE_DISABLE;
if (HAL_TIMEx_MasterConfigSynchronization(&htim3, &sMasterConfig) != HAL_OK)
{
    Error_Handler();
}
sConfigIC.ICPolarity = TIM_INPUTCHANNELPOLARITY_RISING;
sConfigIC.ICSelection = TIM_ICSELECTION_DIRECTTI;
sConfigIC.ICPrescaler = TIM_ICPSC_DIV1;
sConfigIC.ICFilter = 0;
if (HAL_TIM_IC_ConfigChannel(&htim3, &sConfigIC, TIM_CHANNEL_1) != HAL_OK)
{
    Error_Handler();
}
/* USER CODE BEGIN TIM3_Init 2 */

/* USER CODE END TIM3_Init 2 */

}

/**
 * @brief TIM4 Initialization Function
 * @param None
 * @retval None
 */
static void MX_TIM4_Init(void)
{
    /* USER CODE BEGIN TIM4_Init 0 */

    /* USER CODE END TIM4_Init 0 */

    TIM_ClockConfigTypeDef sClockSourceConfig = {0};
    TIM_MasterConfigTypeDef sMasterConfig = {0};
    TIM_OC_InitTypeDef sConfigOC = {0};

    /* USER CODE BEGIN TIM4_Init 1 */

    /* USER CODE END TIM4_Init 1 */
    htim4.Instance = TIM4;
    htim4.Init.Prescaler = 0;
    htim4.Init.CounterMode = TIM_COUNTERMODE_UP;

```

```

htim4.Init.Period = 8533;
htim4.Init.ClockDivision = TIM_CLOCKDIVISION_DIV1;
htim4.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE;
if (HAL_TIM_Base_Init(&htim4) != HAL_OK)
{
    Error_Handler();
}
sClockSourceConfig.ClockSource = TIM_CLOCKSOURCE_INTERNAL;
if (HAL_TIM_ConfigClockSource(&htim4, &sClockSourceConfig) != HAL_OK)
{
    Error_Handler();
}
if (HAL_TIM_PWM_Init(&htim4) != HAL_OK)
{
    Error_Handler();
}
sMasterConfig.MasterOutputTrigger = TIM_TRGO_RESET;
sMasterConfig.MasterSlaveMode = TIM_MASTERSLAVEMODE_DISABLE;
if (HAL_TIMEx_MasterConfigSynchronization(&htim4, &sMasterConfig) != HAL_OK)
{
    Error_Handler();
}
sConfigOC.OCMode = TIM_OCMODE_PWM1;
sConfigOC.Pulse = 0;
sConfigOC.OCpolarity = TIM_OCPOLARITY_HIGH;
sConfigOC.OCFastMode = TIM_OCFAST_DISABLE;
if (HAL_TIM_PWM_ConfigChannel(&htim4, &sConfigOC, TIM_CHANNEL_1) != HAL_OK)
{
    Error_Handler();
}
/* USER CODE BEGIN TIM4_Init 2 */

/* USER CODE END TIM4_Init 2 */
HAL_TIM_MspPostInit(&htim4);

}

/**
 * @brief USART2 Initialization Function
 * @param None
 * @retval None
 */
static void MX_USART2_UART_Init(void)
{
    /* USER CODE BEGIN USART2_Init 0 */

    /* USER CODE END USART2_Init 0 */

    /* USER CODE BEGIN USART2_Init 1 */

    /* USER CODE END USART2_Init 1 */
    huart2.Instance = USART2;
    huart2.Init.BaudRate = 115200;

```

```

huart2.Init.WordLength = UART_WORDLENGTH_8B;
huart2.Init.StopBits = UART_STOPBITS_1;
huart2.Init.Parity = UART_PARITY_NONE;
huart2.Init.Mode = UART_MODE_TX_RX;
huart2.Init.HwFlowCtl = UART_HWCONTROL_NONE;
huart2.Init.OverSampling = UART_OVERSAMPLING_16;
if (HAL_UART_Init(&huart2) != HAL_OK)
{
    Error_Handler();
}
/* USER CODE BEGIN USART2_Init 2 */

/* USER CODE END USART2_Init 2 */

}

/**
 * @brief GPIO Initialization Function
 * @param None
 * @retval None
 */
static void MX_GPIO_Init(void)
{
    GPIO_InitTypeDef GPIO_InitStruct = {0};

    /* GPIO Ports Clock Enable */
    __HAL_RCC_GPIOC_CLK_ENABLE();
    __HAL_RCC_GPIOH_CLK_ENABLE();
    __HAL_RCC_GPIOA_CLK_ENABLE();
    __HAL_RCC_GPIOB_CLK_ENABLE();

    /*Configure GPIO pin Output Level */
    HAL_GPIO_WritePin(LD2_GPIO_Port, LD2_Pin, GPIO_PIN_RESET);

    /*Configure GPIO pin : B1_Pin */
    GPIO_InitStruct.Pin = B1_Pin;
    GPIO_InitStruct.Mode = GPIO_MODE_IT_FALLING;
    GPIO_InitStruct.Pull = GPIO_NOPULL;
    HAL_GPIO_Init(B1_GPIO_Port, &GPIO_InitStruct);

    /*Configure GPIO pin : LD2_Pin */
    GPIO_InitStruct.Pin = LD2_Pin;
    GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
    GPIO_InitStruct.Pull = GPIO_NOPULL;
    GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
    HAL_GPIO_Init(LD2_GPIO_Port, &GPIO_InitStruct);

}

/* USER CODE BEGIN 4 */
uint16_t capture, oldcapture, high;

void HAL_TIM_IC_CaptureCallback(TIM_HandleTypeDef *htim){
    if(htim == &htim3){

```

```

    capture = HAL_TIM_ReadCapturedValue(htim, TIM_CHANNEL_1);
    uint16_t T;
    float duty;

    if (HAL_GPIO_ReadPin (GPIOC, GPIO_PIN_6) == 1){
        T = capture - oldcapture;
        float f= 1/(T*2.38E-8);
        float DC_out = (4.529E-5*(float)f+0.214);
        if(DC_out<0) DC_out = 0;
        if(DC_out>1) DC_out = 1;
        __HAL_TIM_SET_COMPARE(&htim4, TIM_CHANNEL_1, DC_out*8533);

        duty = (float)high/(float)T;

        oldcapture = capture;
    }else{
        high = capture - oldcapture;
    }

}

}
/* USER CODE END 4 */

/**
 * @brief This function is executed in case of error occurrence.
 * @retval None
 */
void Error_Handler(void)
{
    /* USER CODE BEGIN Error_Handler_Debug */
    /* User can add his own implementation to report the HAL error return state */
    __disable_irq();
    while (1)
    {
    }
    /* USER CODE END Error_Handler_Debug */
}

#ifdef USE_FULL_ASSERT
/**
 * @brief Reports the name of the source file and the source line number
 * where the assert_param error has occurred.
 * @param file: pointer to the source file name
 * @param line: assert_param error line source number
 * @retval None
 */
void assert_failed(uint8_t *file, uint32_t line)
{
    /* USER CODE BEGIN 6 */
    /* User can add his own implementation to report the file name and line number,
    ex: printf("Wrong parameters value: file %s on line %d\r\n", file, line) */
    /* USER CODE END 6 */

```

```

}
#endif /* USE_FULL_ASSERT */

```

2.2 - LED dimmer

file `main.c`:

```

/* USER CODE BEGIN Header */
/**
 * *****************************************************************************
 * @file      : main.c
 * @brief     : Main program body
 * *****************************************************************************
 * @attention
 *
 * Copyright (c) 2023 STMicroelectronics.
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 *
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 * in the root directory of this software component.
 * If no LICENSE file comes with this software, it is provided AS-IS.
 *
 * *****************************************************************************
 */
/* USER CODE END Header */
/* Includes -----*/
#include "main.h"

/* Private includes -----*/
/* USER CODE BEGIN Includes */

/* USER CODE END Includes */

/* Private typedef -----*/
/* USER CODE BEGIN PTD */

/* USER CODE END PTD */

/* Private define -----*/
/* USER CODE BEGIN PD */
/* USER CODE END PD */

/* Private macro -----*/
/* USER CODE BEGIN PM */

/* USER CODE END PM */

/* Private variables -----*/
TIM_HandleTypeDef htim2;

UART_HandleTypeDef huart2;

```

```

/* USER CODE BEGIN PV */

/* USER CODE END PV */

/* Private function prototypes -----*/
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_USART2_UART_Init(void);
static void MX_TIM2_Init(void);
/* USER CODE BEGIN PFP */

/* USER CODE END PFP */

/* Private user code -----*/
/* USER CODE BEGIN 0 */

/* USER CODE END 0 */

/**
 * @brief The application entry point.
 * @retval int
 */
int main(void)
{
    /* USER CODE BEGIN 1 */

    /* USER CODE END 1 */

    /* MCU Configuration-----*/

    /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
    HAL_Init();

    /* USER CODE BEGIN Init */

    /* USER CODE END Init */

    /* Configure the system clock */
    SystemClock_Config();

    /* USER CODE BEGIN SysInit */

    /* USER CODE END SysInit */

    /* Initialize all configured peripherals */
    MX_GPIO_Init();
    MX_USART2_UART_Init();
    MX_TIM2_Init();
    /* USER CODE BEGIN 2 */
    HAL_TIM_PWM_Start(&htim2, TIM_CHANNEL_1);

    /* USER CODE END 2 */

```



```

/* Infinite loop */
/* USER CODE BEGIN WHILE */
while (1)
{
    for(int i=0;i<1000;i++){
        __HAL_TIM_SET_COMPARE(&htim2, TIM_CHANNEL_1, i*10);
        HAL_Delay(1);
    }
    for(int i=1000;i>0;i--){
        __HAL_TIM_SET_COMPARE(&htim2, TIM_CHANNEL_1, i*10);
        HAL_Delay(1);
    }

    /* USER CODE END WHILE */

    /* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */
}

/**
 * @brief System Clock Configuration
 * @retval None
 */
void SystemClock_Config(void)
{
    RCC_OscInitTypeDef RCC_OscInitStruct = {0};
    RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};

    /** Configure the main internal regulator output voltage
    */
    __HAL_RCC_PWR_CLK_ENABLE();
    __HAL_PWR_VOLTAGESCALING_CONFIG(PWR_REGULATOR_VOLTAGE_SCALE2);
    /** Initializes the RCC Oscillators according to the specified parameters
    * in the RCC_OscInitTypeDef structure.
    */
    RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSI;
    RCC_OscInitStruct.HSISState = RCC_HSI_ON;
    RCC_OscInitStruct.HSICalibrationValue = RCC_HSICALIBRATION_DEFAULT;
    RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
    RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSI;
    RCC_OscInitStruct.PLL.PLLM = 16;
    RCC_OscInitStruct.PLL.PLLN = 336;
    RCC_OscInitStruct.PLL.PLLP = RCC_PLLP_DIV4;
    RCC_OscInitStruct.PLL.PLLQ = 7;
    if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK)
    {
        Error_Handler();
    }
    /** Initializes the CPU, AHB and APB buses clocks
    */
    RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
                                |RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
    RCC_ClkInitStruct.SYSClkSource = RCC_SYSCCLKSOURCE_PLLCLK;

```

```

RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCLK_DIV1;
RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;

if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
{
    Error_Handler();
}
}

/**
 * @brief TIM2 Initialization Function
 * @param None
 * @retval None
 */
static void MX_TIM2_Init(void)
{
    /* USER CODE BEGIN TIM2_Init 0 */

    /* USER CODE END TIM2_Init 0 */

    TIM_ClockConfigTypeDef sClockSourceConfig = {0};
    TIM_MasterConfigTypeDef sMasterConfig = {0};
    TIM_OC_InitTypeDef sConfigOC = {0};

    /* USER CODE BEGIN TIM2_Init 1 */

    /* USER CODE END TIM2_Init 1 */
    htim2.Instance = TIM2;
    htim2.Init.Prescaler = 0;
    htim2.Init.CounterMode = TIM_COUNTERMODE_UP;
    htim2.Init.Period = 10000;
    htim2.Init.ClockDivision = TIM_CLOCKDIVISION_DIV1;
    htim2.Init.AutoReloadPreload = TIM_AUTORELOAD_PRELOAD_DISABLE;
    if (HAL_TIM_Base_Init(&htim2) != HAL_OK)
    {
        Error_Handler();
    }
    sClockSourceConfig.ClockSource = TIM_CLOCKSOURCE_INTERNAL;
    if (HAL_TIM_ConfigClockSource(&htim2, &sClockSourceConfig) != HAL_OK)
    {
        Error_Handler();
    }
    if (HAL_TIM_PWM_Init(&htim2) != HAL_OK)
    {
        Error_Handler();
    }
    sMasterConfig.MasterOutputTrigger = TIM_TRGO_RESET;
    sMasterConfig.MasterSlaveMode = TIM_MASTERSLAVEMODE_DISABLE;
    if (HAL_TIMEx_MasterConfigSynchronization(&htim2, &sMasterConfig) != HAL_OK)
    {
        Error_Handler();
    }
}

```

```

sConfigOC.OCMode = TIM_OCMode_PWM1;
sConfigOC.Pulse = 0;
sConfigOC.OCpolarity = TIM_OCPOLARITY_HIGH;
sConfigOC.OCFastMode = TIM_OCFAST_DISABLE;
if (HAL_TIM_PWM_ConfigChannel(&htim2, &sConfigOC, TIM_CHANNEL_1) != HAL_OK)
{
    Error_Handler();
}
/* USER CODE BEGIN TIM2_Init 2 */

/* USER CODE END TIM2_Init 2 */
HAL_TIM_MspPostInit(&htim2);

}

/**
 * @brief USART2 Initialization Function
 * @param None
 * @retval None
 */
static void MX_USART2_UART_Init(void)
{
    /* USER CODE BEGIN USART2_Init 0 */

    /* USER CODE END USART2_Init 0 */

    /* USER CODE BEGIN USART2_Init 1 */

    /* USER CODE END USART2_Init 1 */
    huart2.Instance = USART2;
    huart2.Init.BaudRate = 115200;
    huart2.Init.WordLength = UART_WORDLENGTH_8B;
    huart2.Init.StopBits = UART_STOPBITS_1;
    huart2.Init.Parity = UART_PARITY_NONE;
    huart2.Init.Mode = UART_MODE_TX_RX;
    huart2.Init.HwFlowCtl = UART_HWCONTROL_NONE;
    huart2.Init.OverSampling = UART_OVERSAMPLING_16;
    if (HAL_UART_Init(&huart2) != HAL_OK)
    {
        Error_Handler();
    }
    /* USER CODE BEGIN USART2_Init 2 */

    /* USER CODE END USART2_Init 2 */

}

/**
 * @brief GPIO Initialization Function
 * @param None
 * @retval None
 */
static void MX_GPIO_Init(void)

```

```

{
    GPIO_InitTypeDef GPIO_InitStructure = {0};

    /* GPIO Ports Clock Enable */
    __HAL_RCC_GPIOC_CLK_ENABLE();
    __HAL_RCC_GPIOH_CLK_ENABLE();
    __HAL_RCC_GPIOA_CLK_ENABLE();
    __HAL_RCC_GPIOB_CLK_ENABLE();

    /*Configure GPIO pin : B1_Pin */
    GPIO_InitStructure.Pin = B1_Pin;
    GPIO_InitStructure.Mode = GPIO_MODE_IT_FALLING;
    GPIO_InitStructure.Pull = GPIO_NOPULL;
    HAL_GPIO_Init(B1_GPIO_Port, &GPIO_InitStructure);

}

/* USER CODE BEGIN 4 */

/* USER CODE END 4 */

/**
 * @brief This function is executed in case of error occurrence.
 * @retval None
 */
void Error_Handler(void)
{
    /* USER CODE BEGIN Error_Handler_Debug */
    /* User can add his own implementation to report the HAL error return state */
    __disable_irq();
    while (1)
    {
    }
    /* USER CODE END Error_Handler_Debug */
}

#ifdef USE_FULL_ASSERT
/**
 * @brief Reports the name of the source file and the source line number
 * where the assert_param error has occurred.
 * @param file: pointer to the source file name
 * @param line: assert_param error line source number
 * @retval None
 */
void assert_failed(uint8_t *file, uint32_t line)
{
    /* USER CODE BEGIN 6 */
    /* User can add his own implementation to report the file name and line number,
    ex: printf("Wrong parameters value: file %s on line %d\r\n", file, line) */
    /* USER CODE END 6 */
}
#endif /* USE_FULL_ASSERT */

```

2.3 - Control the LED and read the pushbutton through serial communication

file `main.c`:

```

/* USER CODE BEGIN Header */
/**
 * *****
 * @file      : main.c
 * @brief     : Main program body
 * *****
 * @attention
 *
 * Copyright (c) 2023 STMicroelectronics.
 * All rights reserved.
 *
 * This software is licensed under terms that can be found in the LICENSE file
 * in the root directory of this software component.
 * If no LICENSE file comes with this software, it is provided AS-IS.
 *
 * *****
 */
/* USER CODE END Header */
/* Includes -----*/
#include "main.h"

/* Private includes -----*/
/* USER CODE BEGIN Includes */

/* USER CODE END Includes */

/* Private typedef -----*/
/* USER CODE BEGIN PTD */

/* USER CODE END PTD */

/* Private define -----*/
/* USER CODE BEGIN PD */
/* USER CODE END PD */

/* Private macro -----*/
/* USER CODE BEGIN PM */

/* USER CODE END PM */

/* Private variables -----*/
UART_HandleTypeDef huart2;

/* USER CODE BEGIN PV */
volatile int correctlyReceivedData;
volatile int correctlySentData;

```

```

/* USER CODE END PV */

/* Private function prototypes -----*/
void SystemClock_Config(void);
static void MX_GPIO_Init(void);
static void MX_USART2_UART_Init(void);
/* USER CODE BEGIN PFP */

/* USER CODE END PFP */

/* Private user code -----*/
/* USER CODE BEGIN 0 */

/* USER CODE END 0 */

/**
 * @brief The application entry point.
 * @retval int
 */
int main(void)
{
    /* USER CODE BEGIN 1 */

    /* USER CODE END 1 */

    /* MCU Configuration-----*/

    /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
    HAL_Init();

    /* USER CODE BEGIN Init */

    /* USER CODE END Init */

    /* Configure the system clock */
    SystemClock_Config();

    /* USER CODE BEGIN SysInit */

    /* USER CODE END SysInit */

    /* Initialize all configured peripherals */
    MX_GPIO_Init();
    MX_USART2_UART_Init();
    /* USER CODE BEGIN 2 */
    HAL_UART_Transmit_IT(&huart2, "1: LED toggle\n2: read button\n3: print menu\n",
sizeof("1: LED toggle\n2: read button\n3: print menu\n"));
    // Prepare UART to receive a single character
    char character[2]; // Pointer to received data
    HAL_UART_Receive_IT(&huart2, character, 1);

    /* USER CODE END 2 */

    /* Infinite loop */

```

```

/* USER CODE BEGIN WHILE */
while (1)
{
    // Check TX flag
    if (correctlySentData == 1) {
        correctlySentData = 0;
        // ...
    }
    // Check RX flag
    if (correctlyReceivedData == 1) {
        correctlyReceivedData = 0;

        if(character[0]=='1'){
            //HAL_UART_Transmit_IT(&huart2, "Ricevuto1", sizeof("Ricevuto1"));
            HAL_GPIO_TogglePin(GPIOA, GPIO_PIN_5);
        } else if(character[0]=='2'){
            if(HAL_GPIO_ReadPin(GPIOC, GPIO_PIN_13)){
                HAL_UART_Transmit_IT(&huart2, "RELEASED\n", sizeof("RELEASED\n"));
            }else{
                HAL_UART_Transmit_IT(&huart2, "PRESSED\n", sizeof("PRESSED\n"));
            }
        }else if(character[0]=='3'){
            HAL_UART_Transmit_IT(&huart2, "1: LED toggle\n2: read button\n3:
print menu\n", sizeof("1: LED toggle\n2: read button\n3: print menu\n"));
        }else{
            HAL_UART_Transmit_IT(&huart2, "comando sbagliato\n", sizeof("comando
sbagliato\n"));
        }
        HAL_UART_Receive_IT(&huart2, character, 1);
        // ...
    }

}

/* USER CODE END WHILE */

/* USER CODE BEGIN 3 */
}
/* USER CODE END 3 */
}

/**
 * @brief System Clock Configuration
 * @retval None
 */
void SystemClock_Config(void)
{
    RCC_OscInitTypeDef RCC_OscInitStruct = {0};
    RCC_ClkInitTypeDef RCC_ClkInitStruct = {0};

    /** Configure the main internal regulator output voltage
    */
    __HAL_RCC_PWR_CLK_ENABLE();
    __HAL_PWR_VOLTAGESCALING_CONFIG(PWR_REGULATOR_VOLTAGE_SCALE2);
    /** Initializes the RCC Oscillators according to the specified parameters

```

```

* in the RCC_OscInitTypeDef structure.
*/
RCC_OscInitStruct.OscillatorType = RCC_OSCILLATORTYPE_HSI;
RCC_OscInitStruct.HSIState = RCC_HSI_ON;
RCC_OscInitStruct.HSICalibrationValue = RCC_HSICALIBRATION_DEFAULT;
RCC_OscInitStruct.PLL.PLLState = RCC_PLL_ON;
RCC_OscInitStruct.PLL.PLLSource = RCC_PLLSOURCE_HSI;
RCC_OscInitStruct.PLL.PLLM = 16;
RCC_OscInitStruct.PLL.PLLN = 336;
RCC_OscInitStruct.PLL.PLLP = RCC_PLLP_DIV4;
RCC_OscInitStruct.PLL.PLLQ = 7;
if (HAL_RCC_OscConfig(&RCC_OscInitStruct) != HAL_OK)
{
    Error_Handler();
}
/** Initializes the CPU, AHB and APB buses clocks
*/
RCC_ClkInitStruct.ClockType = RCC_CLOCKTYPE_HCLK|RCC_CLOCKTYPE_SYSCLK
                               |RCC_CLOCKTYPE_PCLK1|RCC_CLOCKTYPE_PCLK2;
RCC_ClkInitStruct.SYSCLKSource = RCC_SYSCLKSOURCE_PLLCLK;
RCC_ClkInitStruct.AHBCLKDivider = RCC_SYSCLK_DIV1;
RCC_ClkInitStruct.APB1CLKDivider = RCC_HCLK_DIV2;
RCC_ClkInitStruct.APB2CLKDivider = RCC_HCLK_DIV1;

if (HAL_RCC_ClockConfig(&RCC_ClkInitStruct, FLASH_LATENCY_2) != HAL_OK)
{
    Error_Handler();
}
}

/**
 * @brief USART2 Initialization Function
 * @param None
 * @retval None
 */
static void MX_USART2_UART_Init(void)
{
    /* USER CODE BEGIN USART2_Init 0 */

    /* USER CODE END USART2_Init 0 */

    /* USER CODE BEGIN USART2_Init 1 */

    /* USER CODE END USART2_Init 1 */
    huart2.Instance = USART2;
    huart2.Init.BaudRate = 115200;
    huart2.Init.WordLength = UART_WORDLENGTH_8B;
    huart2.Init.StopBits = UART_STOPBITS_1;
    huart2.Init.Parity = UART_PARITY_NONE;
    huart2.Init.Mode = UART_MODE_TX_RX;
    huart2.Init.HwFlowCtl = UART_HWCONTROL_NONE;
    huart2.Init.OverSampling = UART_OVERSAMPLING_16;
    if (HAL_UART_Init(&huart2) != HAL_OK)

```



```

{
    Error_Handler();
}
/* USER CODE BEGIN USART2_Init 2 */

/* USER CODE END USART2_Init 2 */

}

/**
 * @brief GPIO Initialization Function
 * @param None
 * @retval None
 */
static void MX_GPIO_Init(void)
{
    GPIO_InitTypeDef GPIO_InitStruct = {0};

    /* GPIO Ports Clock Enable */
    __HAL_RCC_GPIOC_CLK_ENABLE();
    __HAL_RCC_GPIOH_CLK_ENABLE();
    __HAL_RCC_GPIOA_CLK_ENABLE();
    __HAL_RCC_GPIOB_CLK_ENABLE();

    /*Configure GPIO pin Output Level */
    HAL_GPIO_WritePin(LD2_GPIO_Port, LD2_Pin, GPIO_PIN_RESET);

    /*Configure GPIO pin : B1_Pin */
    GPIO_InitStruct.Pin = B1_Pin;
    GPIO_InitStruct.Mode = GPIO_MODE_IT_FALLING;
    GPIO_InitStruct.Pull = GPIO_NOPULL;
    HAL_GPIO_Init(B1_GPIO_Port, &GPIO_InitStruct);

    /*Configure GPIO pin : LD2_Pin */
    GPIO_InitStruct.Pin = LD2_Pin;
    GPIO_InitStruct.Mode = GPIO_MODE_OUTPUT_PP;
    GPIO_InitStruct.Pull = GPIO_NOPULL;
    GPIO_InitStruct.Speed = GPIO_SPEED_FREQ_LOW;
    HAL_GPIO_Init(LD2_GPIO_Port, &GPIO_InitStruct);

}

/* USER CODE BEGIN 4 */

void HAL_UART_TxCpltCallback (UART_HandleTypeDef *huart){
    //Set TX flag
    correctlySentData = 1;
}

void HAL_UART_RxCpltCallback (UART_HandleTypeDef *huart){
    // Set RX flag
    correctlyReceivedData = 1;
}

```

```

/* USER CODE END 4 */

/**
 * @brief This function is executed in case of error occurrence.
 * @retval None
 */
void Error_Handler(void)
{
    /* USER CODE BEGIN Error_Handler_Debug */
    /* User can add his own implementation to report the HAL error return state */
    __disable_irq();
    while (1)
    {
    }
    /* USER CODE END Error_Handler_Debug */
}

#ifdef USE_FULL_ASSERT
/**
 * @brief Reports the name of the source file and the source line number
 * where the assert_param error has occurred.
 * @param file: pointer to the source file name
 * @param line: assert_param error line source number
 * @retval None
 */
void assert_failed(uint8_t *file, uint32_t line)
{
    /* USER CODE BEGIN 6 */
    /* User can add his own implementation to report the file name and line number,
    ex: printf("Wrong parameters value: file %s on line %d\r\n", file, line) */
    /* USER CODE END 6 */
}
#endif /* USE_FULL_ASSERT */

```