HOME LIGHTING AUTOMATION

Introduction

Scope

This Documents describes about the functionality of a motion sensor lighting along with its Software and Hardware design.

Overview

The Motion Sensor Light is a light which responds according to the inputs given by sensor. An Ultrasonic sensor is used here. An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. So, we can detect motion by using this sensor. Whenever a person passes by or when the presence of a person is detected by Ultrasonic Sensor the LED glows. Moreover, when a person is a bit far from the LED it glows with less intensity and when the person comes closer the intensity increases. We can enable security mode where the Red LED alerts by blinking when anyone tries to enter the area. The User can set the high and low-level intensity. The user can set the maximum distance and timeout. For the above operation, we used STM32F407G DISC1 Board. A TTL 232R cable is used for serial UART communication by which the user can control and set parameters easily.

References

- https://www.st.com/en/evaluation-tools/stm32f4discovery.html#documentation (STM32F407G DISC1 Board related documentation and resources).
- https://developer.arm.com/documentation/100166/0001/ (ARM Cortex M4 Documentation).
- https://lastminuteengineers.com/arduino-sr04-ultrasonic-sensor-tutorial/ (Ultrasonic sensor details).

Equipment, tools and technologies

Hardware:

- STM32F407G-DISC1 board
- HC-SR04 Ultrasonic Sensor
- 2 LEDs of Red and Green color
- Type A to Mini B USB Connector
- FTDI TTL 232R cable

Firmware:

- Bare Metal Programming
- C language
- Timers
- GPIO
- PWM
- Input capture and output compare modes
- UART

Software:

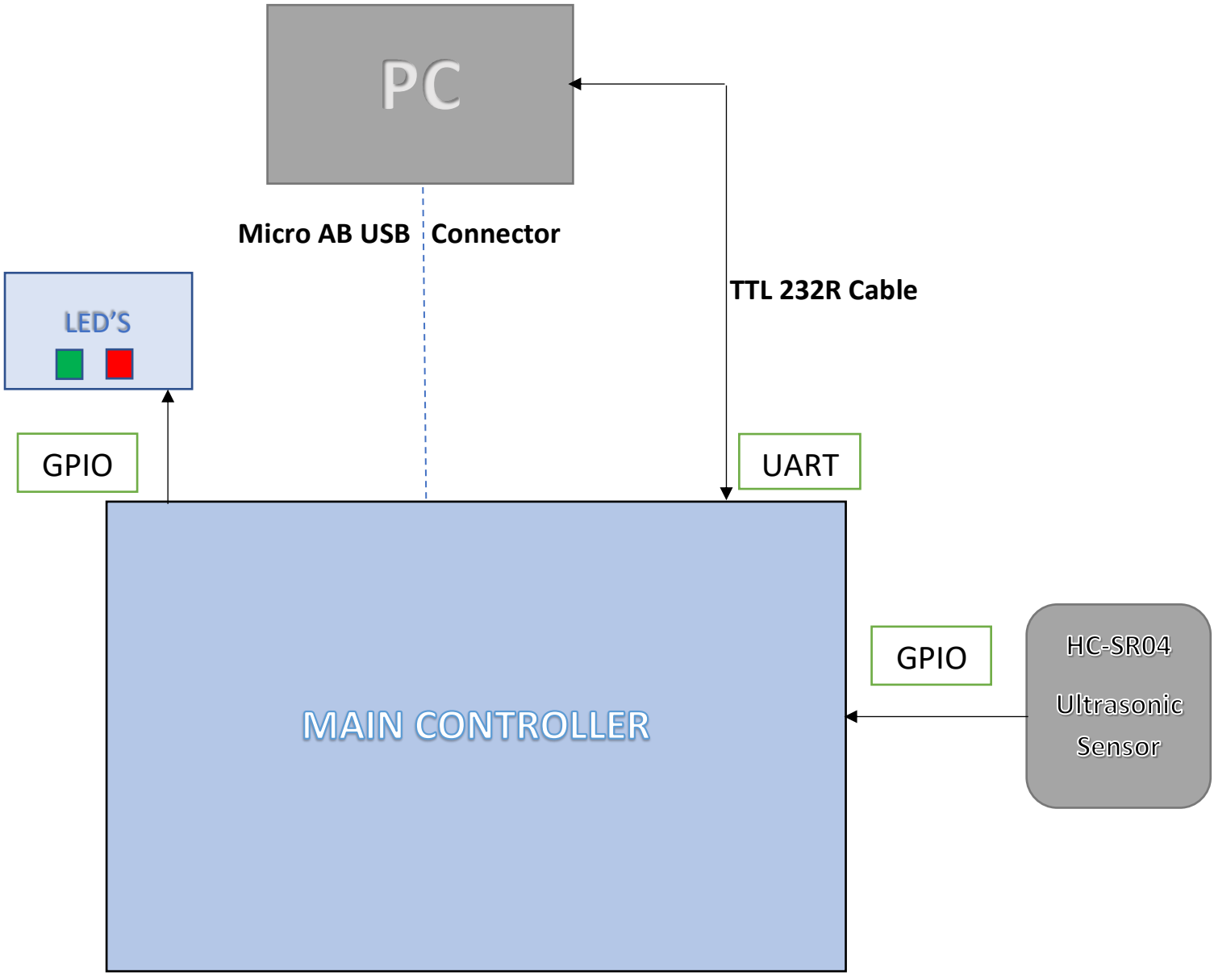
- STM32CubeIDE 1.7.0
- Bitbucket
- Jira
- Confluence
- Docklight

Requirements

S.NO	Requirement
1	LED should turn ON when a person enters or approaches.
2	LED should turn OFF when the person leaves.
3	LED intensity should be changing according to the distance of person.
4	LED glows with less intensity when a person is bit far.
5	LED intensity increases gradually when person comes closer.
6	Low and high intensity levels can be set by the User by using PC which is interfaced to MCU using serial interface.

7	When User is out of station, security mode can be turned ON by using PC which is interfaced to MCU using serial interface.
8	In Security mode, when a person enters the area, a Red LED will alert
9	Maximum Distance can be set by User by using PC which is interfaced to MCU using serial interface.
10	Time Out can be set by User by using PC which is interfaced to MCU using serial interface.

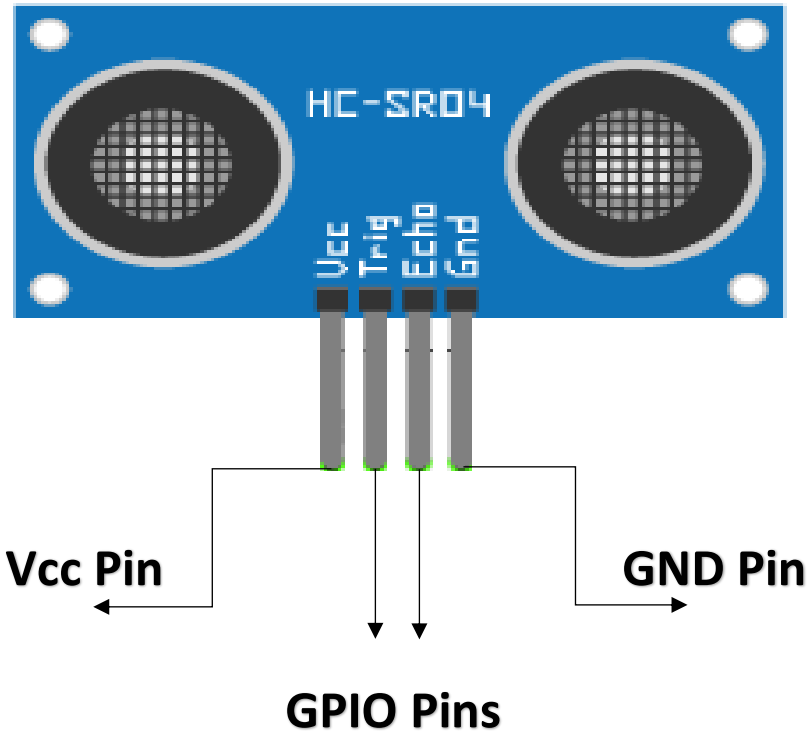
Basic Block Diagram



1. The Board used in our project is STM32F407-DISC1 Board which has STM32F407VG Microcontroller in it.

2. There are 4 LED's in STM32 board. They are: -
    - LD3 is Orange LED connected to PD13.
    - LD4 is Green LED connected to PD12.
    - LD5 is Red LED connected to PD14.
    - LD6 is Blue LED connected to PD15.

3. A HC-SR04 Ultrasonic Sensor is used which is connected to the STM32 Board. It has 4 pins: -
    - VCC of sensor is connected to VCC of STM Board
    - GND of sensor is connected to GND of STM Board
    - Trigger pin of sensor is connected to GPIO pin of STM Board
    - Eco pin of sensor is connected to GPIO pin of STM Board



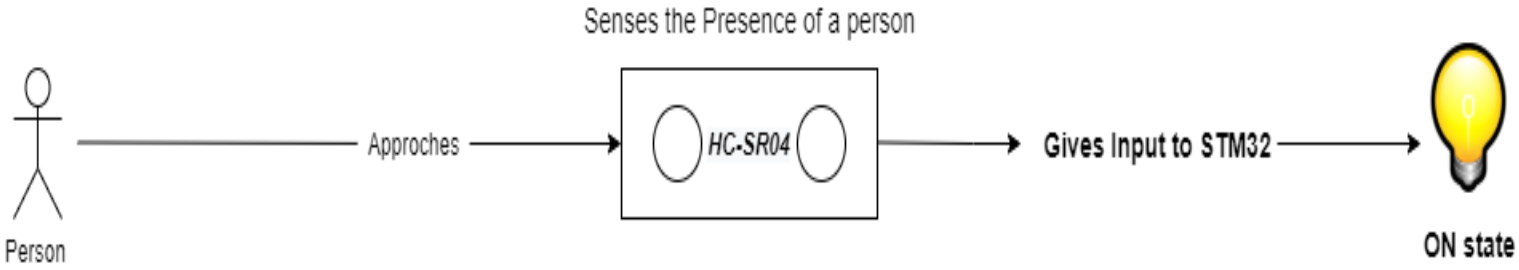
For more details regarding Ultrasonic sensor: - https://lastminuteengineers.com/arduino-sr04-ultrasonic-sensor-tutorial/

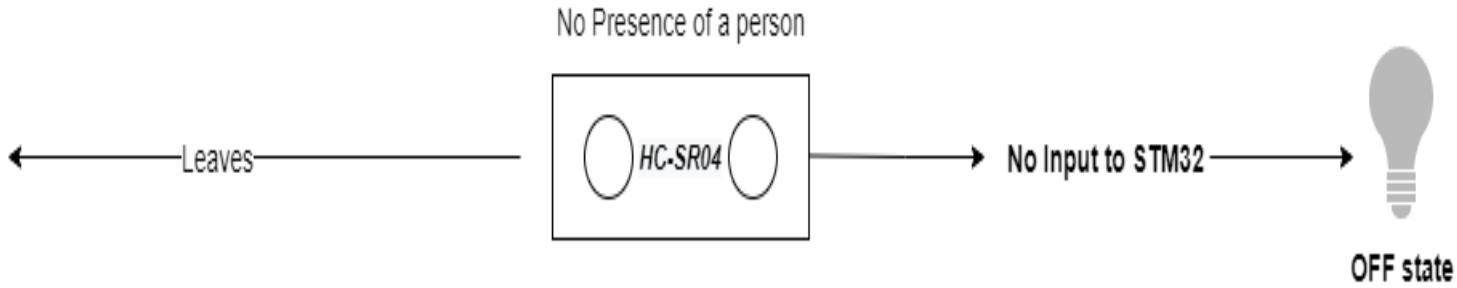
4. Power Supply is given to Microcontroller Board from PC by using a Micro AB USB Connector. One end of Micro USB is connected to PC and the other end is connected to ST-Link Micro USB Connector.

5. A FTDI TTL 232R Cable is a USB serial Converter used for Serial UART Communication. One end of the Cable is connected to PC and the other end is connected to UART Pins.

Operation

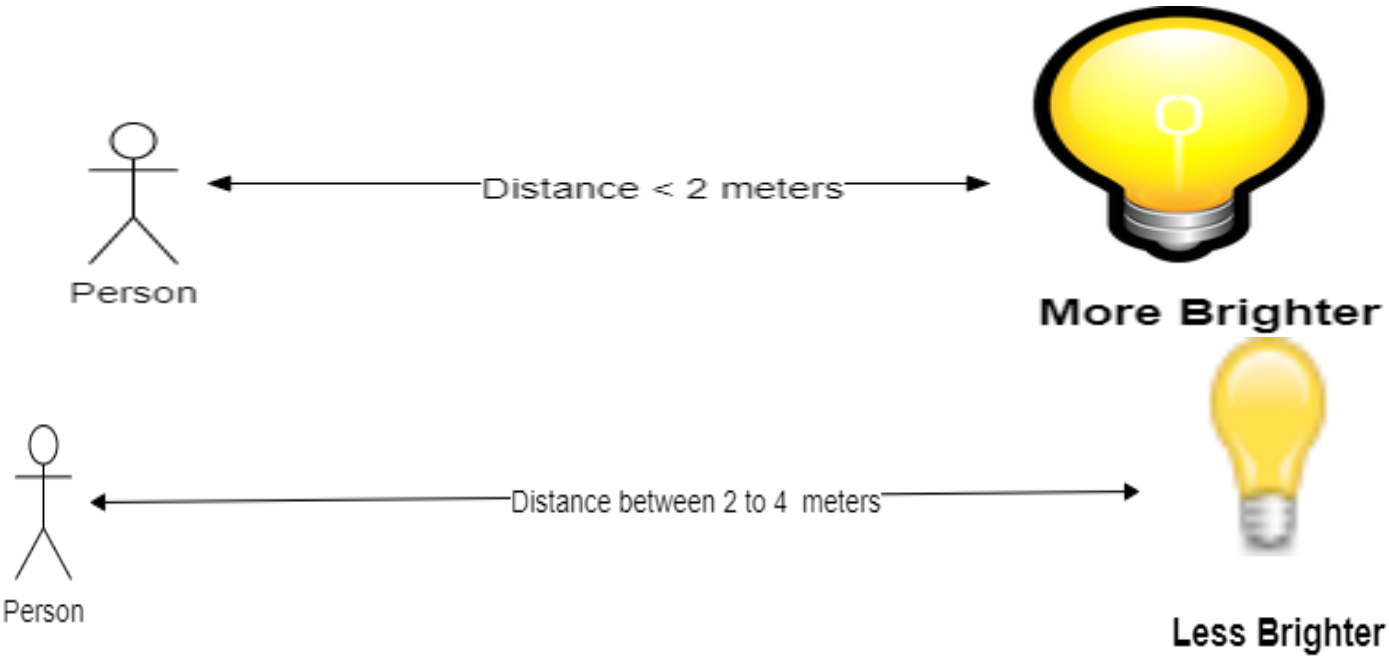
- The main objective of this project is to control the light with a sensor.
- A HC-SR04 Ultrasonic sensor is used as a motion sensor. The below diagrams explain different scenarios.





- First scenario when a person approaches near to the area the ultrasonic sensor will sense it and give input to STM32 board. And the LED turns ON.

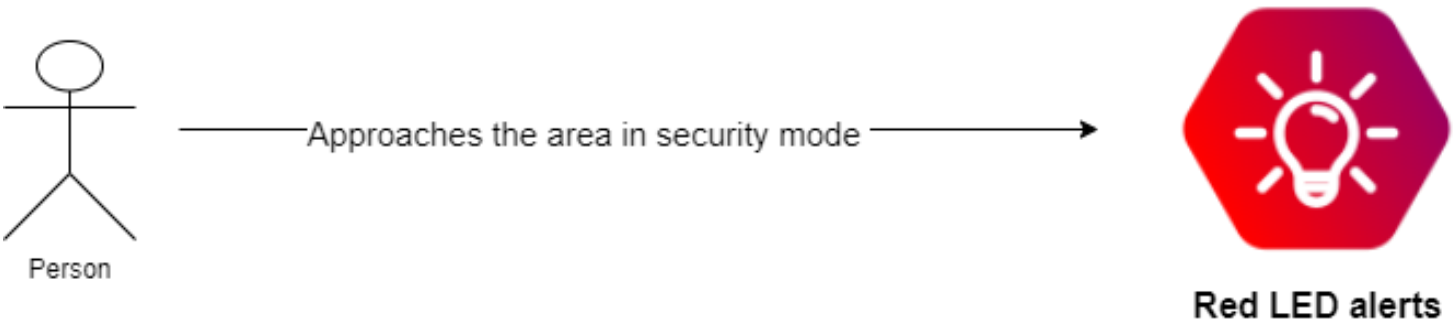
- Second scenario when a person leaves the area the ultrasonic sensor will not sense any presence and no input is given to STM32 board. And the LED turns OFF.



- The third scenario is when the person is closer to the light i.e., Less than 2m then the LED glows with more brightness.

- The fourth scenario is when the person is moving away from light i.e., distance between the person and light is more than 2m then the LED glows with less brightness.

- When the person moves further away from light, i.e., distance between the person and light is more than 4m then the LED will turn OFF.



- If the user is going to be out of station, might be on a vacation, then the user can turn on security mode.

- This mode can be turned on by using a PC. Moreover, all the required customizations can be done by the user by using a PC.
- In security mode, if a person tries to approach the area a Red LED will give an alert.
- The above diagram represents the security mode scenario.

Test Plan

Device test plan

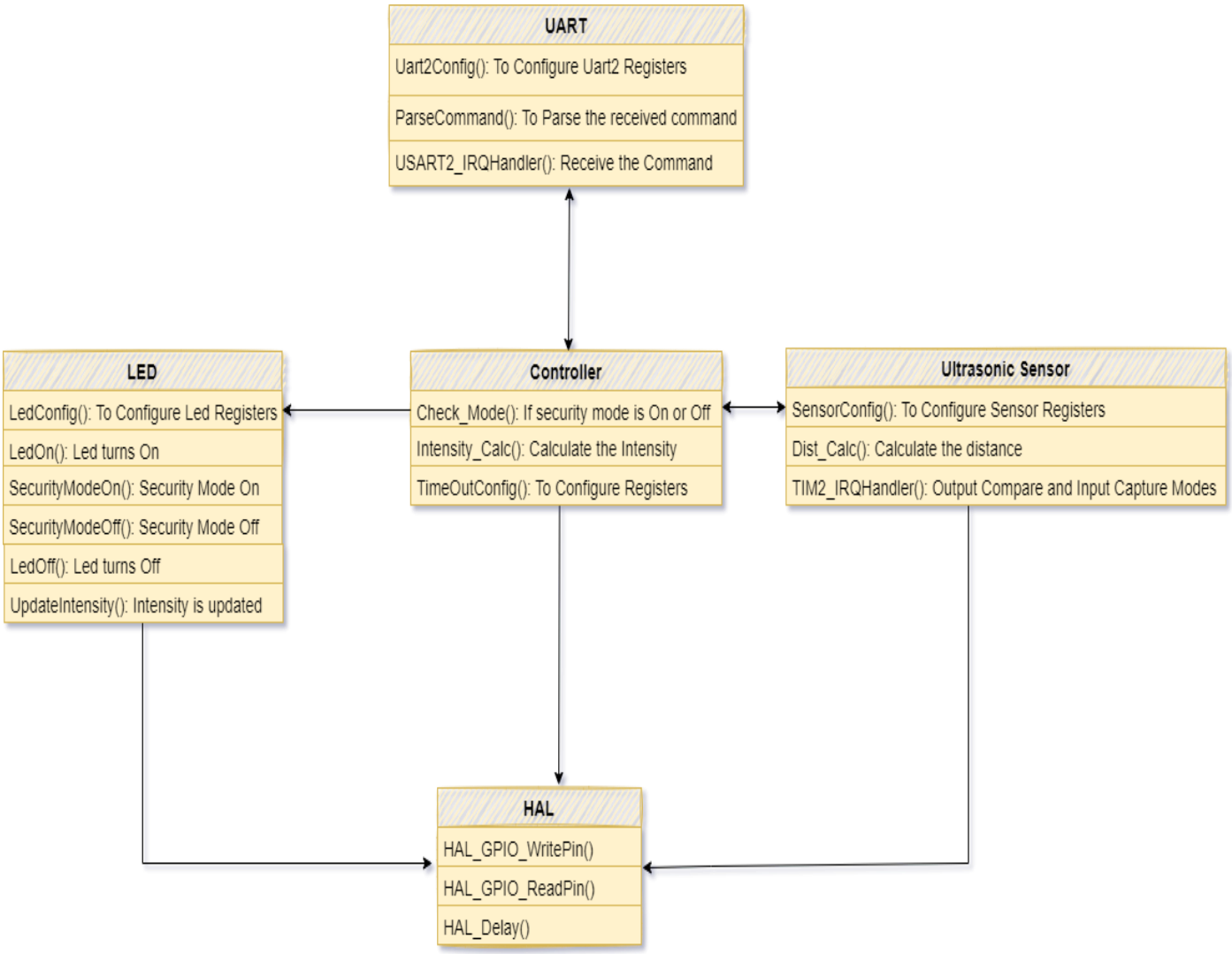
S.NO	Description	Input	Expected Output
1	LED should turn ON when a person enters or approaches	Test object approaching the area	LED turned ON
2	LED should turn OFF when the person leaves	Test object moved away from the area	LED turned OFF
3	Setting the maximum intensity of light	Set the maximum intensity in PC which is interfaced with MCU using serial interface. Test object moved close to LED (2cm near) after setting	LED glows with the set maximum intensity only
4	Setting the minimum intensity of light	Set the minimum intensity in PC which is interfaced with MCU using serial interface. Test object moved far from light (4m away) after setting	LED glows with the set minimum intensity only
5	LED glows with less brightness when a person is bit far	Test object placed at a distance between 2 to 4 meters from the light	LED glows with less brightness
6	LED intensity increases when person comes closer	Test object placed at a distance less than 2 meters from the light	LED glows with more brightness

7	LED intensity changes according to person movement	Test object moved randomly in the area	LED brightness according to the movement of the object
8	Enabling the security mode	Security mode enabled by using PC which is interfaced with MCU using serial interface. Test object approaches after enabling	Red LED glows
9	In Security mode, when a person enters the area a Red LED will alert	Test object approaching the area in security mode	Red LED glows
10	Disabling the security mode	Security mode can be disabled by using PC which is interfaced with MCU using serial interface. Test object approaches after disabling	Red LED doesn't glow. Instead, the green LED glows
11	Setting the Maximum Distance	Set the maximum distance in PC which is interfaced with MCU using serial interface. Test object moved within maximum distance	LED glows
12	Testing Maximum Distance	Test object moved outside maximum distance	LED doesn't glow
13	Setting the Time Out	Set the Time Out in PC which is interfaced with MCU using serial interface. Test object is within maximum distance	LED doesn't glow if the object is stationary for Set Time Out period
14	During Time Out period if the object moves	Test object moved during Time Out period	LED glows and the Time Out gets restarted
15	During Time Out period if the user sets new Time Out value	Test Object is stationary	LED Should glow till the New Set Time Out Value

Low Level test plan

S.NO	Description	Input	Expected Output
1	USB enumeration taking place	Cable inserted	ST-LINK COM LED will be Blinking Red
2	Communication between PC and ST-LINK is established (end of enumeration)	Cable inserted	ST-LINK COM LED will be Red
3	Data is being exchanged between the PC and STM32 Board	Code is being dumped	ST-LINK COM LED will be Blinking Green and Red alternately
4	Communication has been successful	Code uploaded	ST-LINK COM LED will be Green
5	ST-LINK communication with STM32 Board failed	Code didn’t upload	ST-LINK COM LED will be Orange

Software Architecture



- Ultrasonic sensor needs a 10microsec signal at trigger pin to detect externally motion or in other words to operate. And when it detects an Echo pulse is generated. The above action is done by TIM2_IRQHANDLER ().
- We get the value of time taken by the Ultrasonic sound to transmit and come back. But we need the distance at which the object or person is detected. So, for that calculation Dist_Calc () function is useful.
- The ParseCommand () is used to verify the received command is meant for which application (Security mode or Intensity or Maximum distance).
- The User enters security mode by using PC and after that only Red Led should blink. So, for that application SecurityModeOn () and SecurityModeOff () functions are useful.

Commands and Responses

S.NO	Command	Response	Notes
1	$SIH<xxx>#	Received command is sent back $SIH<xxx>#	Set the High-Level Intensity
2	$SIL<xx>#	Received command is sent back $SIL<xx>#	Set the Low-Level Intensity
3	$SMON#	Received command is sent back $SMON#	To on the Security Mode
4	$SMOFF#	Received command is sent back $SMOFF#	To off the Security Mode
5	$MD<xxx>#	Received command is sent back $MD<xxx>#	To set the Maximum distance
6	$TO<xxx>#	Received command is sent back $TO<xxx>#	To set the Timeout

Applications

- It can be used for residential and commercial purposes.
- Can be used for affective museum exhibits.
- Can be used in safe houses.
- Can be used in bank vault.
- Can be used near the tunnel entryway.
- Modern way of lighting to replace the old school lights for more aesthetic ambience.
- Traditional lights can be replaced by modern lights for saving energy.