Adaptive Brightness Control Using LDR Sensor on STM32F412 Nucleo Board

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Abstract

This project aims to develop an adaptive brightness control system for LED lighting using an LDR sensor, the STM32F412ZX board, and Embedded C programming. The system will use an LDR sensor to detect the surrounding environmental light conditions and adjust the brightness of the LED lights accordingly. The microcontroller will be programmed to read the LDR sensor data and use it to calculate the appropriate brightness levels. The system will be designed to be energy-efficient and reliable, with a focus on minimizing power consumption while maintaining optimal lighting conditions. This project will contribute to the development of smart and sustainable lighting solutions that can improve energy efficiency and reduce costs.

1 Introduction

The increasing demand for energy-efficient and sustainable technologies has led to a growing interest in adaptive brightness control systems. These systems use sensors to detect the surrounding environmental conditions and adjust the brightness of lighting systems accordingly. In this project, we aim to develop an adaptive brightness control system for LED lighting using an LDR sensor and a potentiometer interfaced with the STM32F412ZX board and Embedded C programming. The LDR sensor will detect the ambient light levels, while the potentiometer will provide an analog input to the microcontroller for calculating the appropriate brightness levels. This system will operate efficiently and reliably, with a focus on minimizing energy consumption while maintaining optimal lighting conditions

2 Components Used

2.1 STM32F412ZX Board

Pins Used:

A) For Input
1.LDR Sensor: PA1
2.Potentiometer:PA0

B)For Output
1.Seven Segment LED: PA4 to PA11
2.External LED:PB0

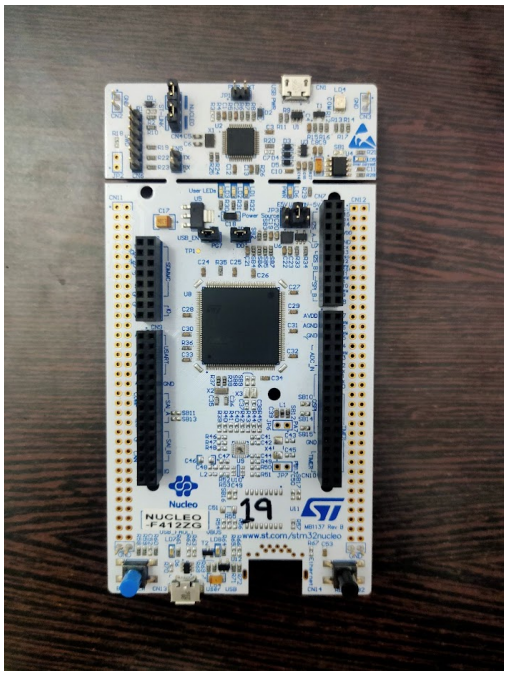

Figure 1: STM32F412 Board

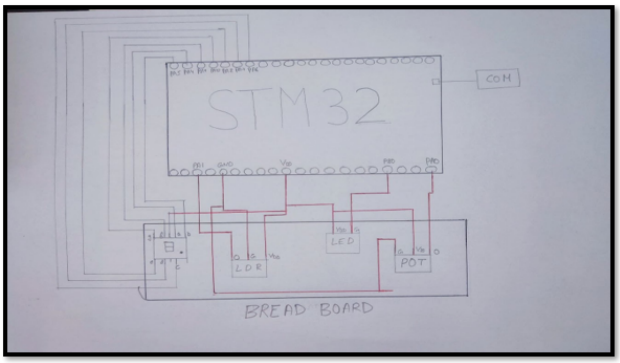

Figure 2: Circuit Diagram

2.2 LDR(Light Dependent Resistor) Sensor

An LDR (Light Dependent Resistor) module is a type of sensor that detects the presence and intensity of light in its surrounding environment. The module consists of a photoconductive cell made of a semiconductor material, which changes its resistance in response to variations in light intensity.

Typically, an LDR module has three pins - DO (Digital Output), VCC (Power Supply), and GND (Ground). The DO pin outputs a digital signal (either high or low) depending on the presence or absence of light, with the threshold level set by an onboard potentiometer. The VCC pin provides the power supply voltage to the module (usually 3.3V or 5V), while the GND pin is connected to the ground

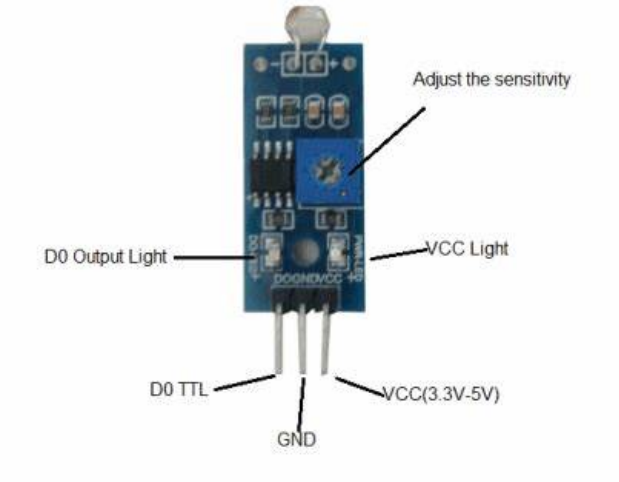

Figure 3: LDR Sensor

2.3 External LED

External LEDs typically consist of a small semiconductor chip enclosed in a transparent plastic or epoxy case. The chip is connected to two metal leads, with one lead connected to the anode and the other lead connected to the cathode. The anode is the positive (+) lead, while the cathode is the negative (-) lead. The anode is typically the longer of the two leads and is often marked with a "+" symbol or a small protrusion on the case. The cathode is usually the shorter lead and is often marked with a "-" symbol or a flat area on the case.

To use an external LED, the anode is connected to

Figure 4: External LED

the positive (+) terminal of the power source, while the cathode is connected to the negative (-) terminal of the power source.When a voltage is applied to the anode and cathode, the LED emits light, with the color and intensity of the light determined by the properties of the semiconductor material.

2.4 Seven Segment Display

Seven-segment display (SSD) is a form of the electronic display device for displaying decimal numerals. The seven elements of the display can be selected in different combinations to represent the decimal numerals. Seven-segment displays may use a light-emitting diode (LED) or a liquid crystal display (LCD), for each segment, or other light-generating or controlling techniques. There are two types of simple LED package 7-Segment display: Common Anode and Common Cathode. We are using Common anode type. In this type, the common pin on the 7-segment display is connected to all the eight Anode pins of the LEDs. To make this type of seven segment display to work we should connect the Com pin to the Vcc (+3.3V typically) and ground the required segment pin to turn it on.

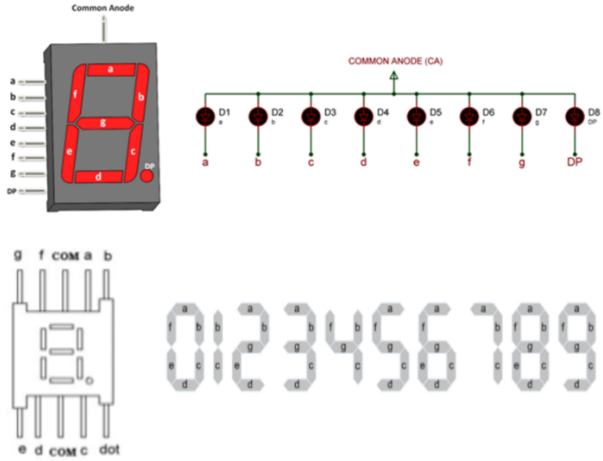

Figure 5: Seven Segment Display with Configuration

2.5 Potentiometer

A potentiometer, also known as a pot, is a type of variable resistor that allows you to adjust the resistance in a circuit by turning a knob or dial. The potentiometer has three pins: VCC, ground, and output.
The VCC pin is connected to the positive supply voltage, and the ground pin is connected to the negative supply voltage or ground. The output pin is connected to the circuit and provides a variable resistance based on the position of the potentiometer knob.
The voltage controller refers to the potentiometer's ability to control the voltage in a circuit. By adjusting the position of the potentiometer knob, the resistance in the circuit changes, which in turn affects the voltage. As the resistance increases, the voltage decreases, and as the resistance decreases, the voltage increases

Figure 6: Potentiometer

3 Brief Explanation with Practical Implementation

We have done this project keeping in mind two applications. The major one is first one.
1. Adaptive Brightness used in Mobile phones and Night clocks.
2. Automatic Turning on lights in Dark used in Cars headlamp and even in homes.
Input is taken from LDR sensor and based on the value of input LED will be turned on and off in case of headlamps and homes.
While in case of adaptive brightness we will be changing duty cycle depending on the input received from potentiometer which will further change the brightness of LED.
We have also shown numbers on seven segment display which can be replaced by a LCD screen in practical implementation, in which we can show the brightness percentage in our device.

4 Conclusion

We conclude that the brightness of LED can be controlled using LDR sensor by changing the duty cycle which can be achieved by altering on and off time of LED.
We can also turn on and off the LED as soon as it becomes darks by capturing the input from LDR sensor.
So we can use it for making energy efficient systems which not only saves power but can also be used according to our purpose.

5 Future Work

1.We can also integrate LDR sensor with Analog Output and directly map it to change brightness of LED.
2. We can also integrate LCD screen to show the brightness percentage on it.

6 References

1.Datasheet, Reference Manual and Board Schematic of STM32F412 nucleo board.
2.Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C. By Dr. Yifeng Zhu