
ARDUINO UNO R3 BASED AUTOMATIC HYDROPONIC PLANT LIGHT REGULATOR USING LDR LIGHT SENSOR

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Abstract

Hydroponic plants are an innovative solution in modern agriculture, especially in areas with limited land. In urban areas there is usually little light entering the room due to the dense number of buildings or affected by the weather. This will certainly affect the process of plant growth itself. This study aims to determine the effect of LDR light sensor on hydroponic plant growth using experimental method. The results showed that the LDR sensor response is very accurate to the intensity of light entering the room. If the room has a high light intensity or more than 500 Lux, the LED will turn off. On the other hand, if the room has a low light intensity or less than 500 Lux and the plants are considered to lack light, the LED will turn on to provide optimal irradiation to the plants. Based on the research conducted, the LDR light sensor has high accuracy to respond to the light intensity in the room.

Keywords: Hydroponic plant, LDR sensor, Light controller, Light sensor, Plant growth.

INTRODUCTION

The dense population in urban areas is one of the factors of land limitation, especially in agriculture. Continuous population growth is accompanied by the population's increasing need for land, this has several impacts on the environment itself such as excessive forest clearing which causes forest area to decrease continuously and land conversion into settlements which were originally forests, fields, or community plantations. (Mardhatil1, 2020). This means that the more people who live in an area, the more the need for housing, facilities and infrastructure. Therefore, population density can affect building density. (Ta'ani1, 2024).

Urban farming and indoor farming are important solutions to overcome the problem of narrowing agricultural land and increasing food demand. This program is designed to be developed in dense urban areas that do not have a large amount of vacant land. (Sugihartini, 2023).

Urban farming has the disadvantage that tall buildings in urban areas affect the intensity of light that will enter the agricultural area. Light intensity affects plant photosynthesis. Buildings that are close to each other result in limited intensity of natural light that can enter the building, because the sides of adjacent buildings block sunlight. (Kurniawan1, 2022). Building shadows can also reduce the intensity of light in the shadowed area. Not only does it affect the intensity of light, the increase in building density is increasing resulting in an increase in atmospheric conditions around the area which will trigger land surface temperatures in an area. Reducing green space in dense building areas can reduce high surface temperatures. (Putri, 2023)

Based on the above problems, we provide a solution in the form of smart lighting to maximize plant growth, especially light intensity as photosynthesis material. In the application of urban farming, one of them is realized by using growlights to optimize indoor planting. Leveling the distance between growlights and plants can affect the effectiveness of planting duration and when compared to

planting without growlights, it increases by 25%. (Hendriarto, 2021). Smart lighting ensures that plants receive optimal lighting, even when natural sunlight is limited. Smart lighting automatically turns on when the light intensity in the agricultural area decreases to a predetermined limit. The purpose of our research is to optimize plant growth in urban agriculture.

LITERATURE REVIEW

LDR sensor formula

The ADC conversion on the LDR (Light Dependent Resistor) depends on the brightness of the light received by the LDR. The following is the formula:

- a. ADC conversion of LDR in bright light:

$$\begin{aligned} \text{Formula: } V_{LDR} &= \frac{R_{LDR}}{R_{LDR} + R_1} \times V_{REF} \\ DHK &= \frac{V_{LDR}}{SS} \end{aligned} \quad (2.1)$$

- b. ADC conversion on LDR when dim:

$$\begin{aligned} \text{Formula: } V_{LDR} &= \frac{R_{LDR}}{R_{LDR} + R_1} \times V_{REF} \\ DHK &= \frac{V_{LDR}}{SS} \end{aligned} \quad (2.2)$$

- c. ADC conversion of LDR in the dark:

$$\begin{aligned} \text{Formula: } V_{LDR} &= \frac{R_{LDR}}{R_{LDR} + R_1} \times V_{REF} \\ DHK &= \frac{V_{LDR}}{SS} \end{aligned} \quad (2.3)$$

Arduino Uno R3



Figure 1. Arduino UNO R3
Source: Wikipedia Bahasa Indonesia

Arduino UNO is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz Crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino UNO contains everything needed to support a microcontroller, easily connect it to a computer with a USB cable or supply it with an AC to DC adapter or use a battery to start it (Adriansyah & Hidyatama, 2013). In this research, Arduino UNO is used to process data from LDR sensors and control output components such as relays and LEDs.

Sensor Cahaya LDR

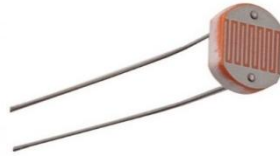


Figure 2. LDR light sensor
Source: Arduino Indonesia

One sensor that is often used in various electronic circuits is a light sensor (LDR). A light sensor is a device used in electronics that functions to convert light quantities into electrical quantities. Light sensor LDR (Light Dependent Resistor) is a type of resistor that is sensitive to light. The resistance value of the LDR will change according to the intensity of the light received. If the LDR is not exposed to light, the resistance value will be large (around 10M Ω) and if exposed to light the resistance value will be small (around 1k Ω). (Novianty, Lubis & Tony, 2012: 1). In this research, the LDR sensor is used to detect the light intensity around the room which is used to determine the need for additional lighting on plants.

LCD 16x2 + I2C



Figure 4. LCD 16x2 + I2C
Source: Toughthware

LCD (Liquid Crystal Display) is an electronic circuit used to display information or indicators given to the microcontroller. LCDs have been used in various fields such as electronic devices such as televisions, calculators, or computer screens. In the application post, the LCD used is a dot matrix LCD with 2 x 16 characters. LCD really functions as a viewer which will be used to display the working status of the tool (Suryantoro & Budiyanto, 2019). In this research, the LCD serves to display real-time information about whether or not the light intensity is sufficient for plants.

LED Strip Grow Lights



Figure 5. LED module
Source: Tokokadounik.com

Light emitting diodes (LEDs) can be used to enhance plant growth as they do not emit high temperatures (Morrow, 2008). Light quality is also very important when manipulating light to grow plants i.e. the light source must have the right quality of light to initiate and sustain photosynthesis. Plants require light with wavelengths of 400-520 nm and 610-720 nm wavelengths of blue and red light (Promratrak, 2017). In this research, LEDs were used to provide additional lighting to the plants.

Relay 1 Channel



Figure 6. Relay 1 channel
Source: Superbtech

Relay is an electrical component whose open or close state can affect other components in the same circuit or in other circuits. Relays function as electronic switches and are driven by electric current. In principle, a relay is a lever switch with a wire wound on an iron rod nearby. This iron rod is called a solenoid. When the iron rod is electrified, a magnetic force will arise so that the switch contacts will close while when the electric current is removed from the solenoid, the magnetic force will disappear and the switch contacts will open again. Relays are usually used to drive circuits with large electric currents using small currents (Simanjuntak, Pramana, & Nusyirwan, 2013). In this research, the relay functions to control the electric circuit of the lamp based on the signal from the Arduino.

ADAPTOR DC 12V



Figure 7. Adaptor DC 12V
Source: E-Katalog LKPP

An adapter is a circuit that is useful for converting high AC voltage into low DC. The adapter is an alternative to DC voltage (such as; Battery, Battery) because the use of AC voltage is longer and everyone can use it as long as there is electricity in that place (Nugraha *et al.*, 2023). Adapters that are assembled separately are usually universal adapters that have an output voltage that can be adjusted as needed, for example 3 Volts, 4.5 Volts, 6 Volts, 9 Volts, 12 Volts and so on. But besides that, there are also adapters that only provide certain voltages and are intended for certain electronic

circuits, for example laptop adapters and monitor adapters (Amaliah, 2020). In this research, a 12V adapter is used to connect the components used to the power source.

RESEARCH METHOD

Time and Place of Research

The research entitled "Arduino Uno R3 Based Automatic Hydroponic Plant Light Regulator Using LDR Light Sensor" was carried out in 2 weeks in 2024. This research was carried out at the Railway Laboratory Building Campus 2, Madiun State Polytechnic on West Ring Road Road, Winongo, Manguharjo District, Madiun City, East Java 63162.



Figure 8. Research location

Flowchart System

In this study, there is a process that contains a flowchart of the system to be built. The following can explain the system flowchart process, namely in Figure 9.

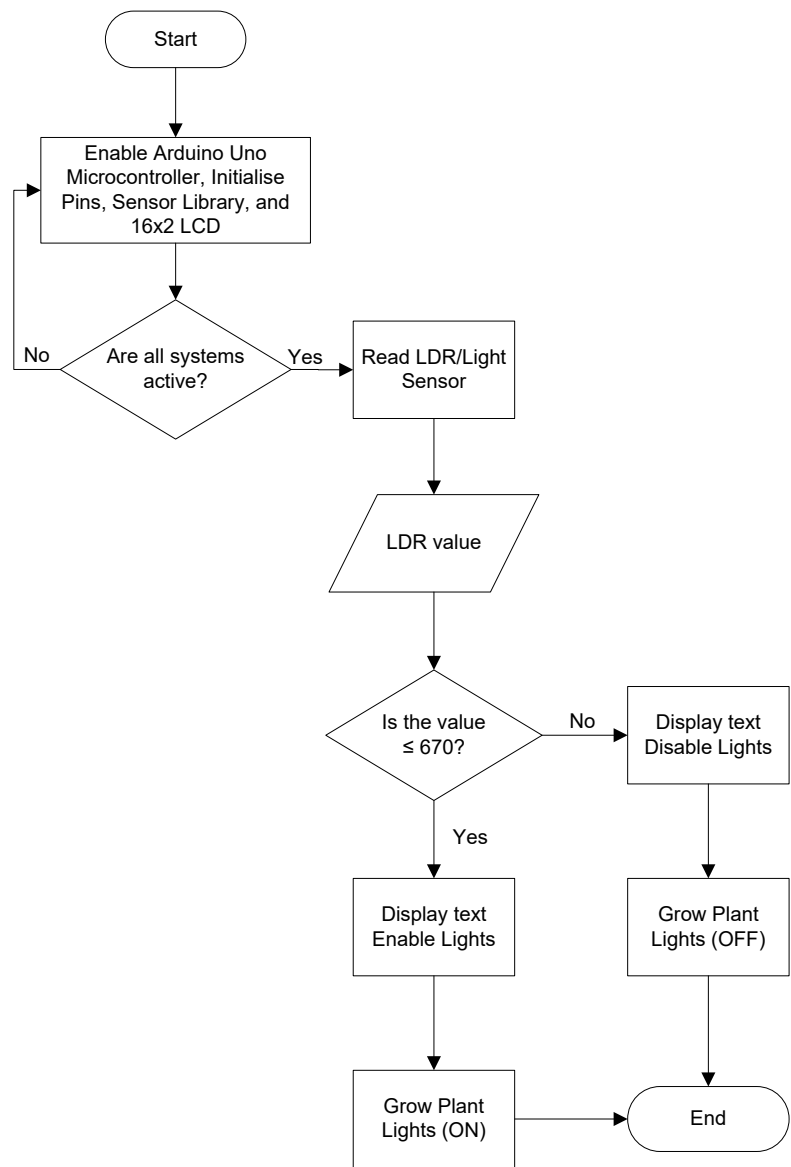


Figure 9. Flowchart System

System Block Diagram

In this study, there is a process that contains a block diagram of the system to be built. The following is in Figure 10.

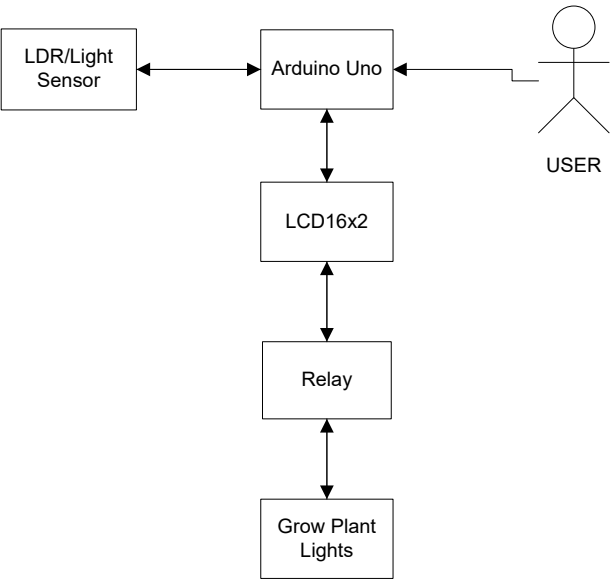


Figure 10. System Block Diagram

Tool Prototype Design

In the design of the tool there is a circuit design, sensors and actuators that are connected and connected to the microcontroller, the designed tool is used to monitor hydroponic plants and around these plants, the data is sent by the tool to the server so that the data can be processed, can be seen in Figure 11.

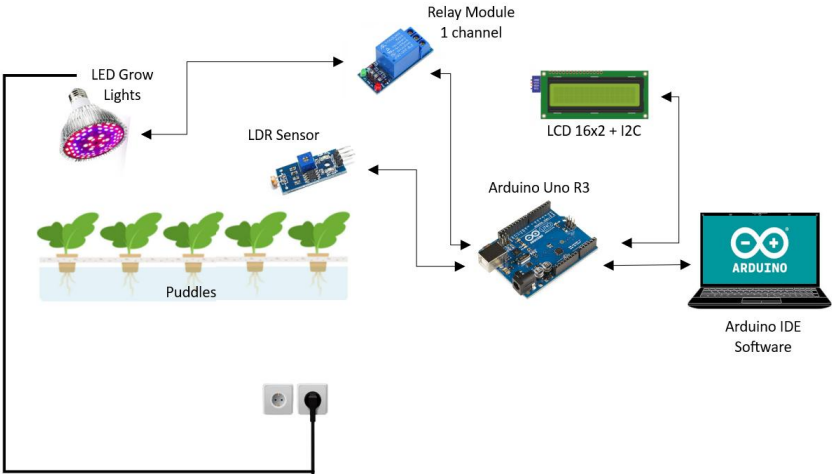


Figure 11. Tool prototype design

In Figure 11 is the design of the prototype system to be developed, where there are several devices namely LDR sensors, 1 channel relay modules, and LED grow lights. These components are connected to the Arduino Uno R3 as a control centre and data retrieval from all components that have been programmed through the Arduino IDE. The LED grow light will be regulated by the Arduino Uno R3 through the relay module as an automatic switch when the hydroponic plants require intensive light. Table 1 below details the devices and their functions in this study.

Table 1. Tool prototype design

Tools	Function
Arduino Uno R3	As the centre of data collection from sensors and LED grow light controller integrated with LDR sensor to turn the lights on or off automatically.
Arduino IDE	As a programmer maker to upload on the Arduino Uno R3 microcontroller by specifying commands to the LDR sensor and relay module.
Relay Module 1 Channel	As an automatic switch to disconnect and connect the electric current to the LED grow lights
LED Grow Lights	As a tool to help the plant growth process by providing additional light at night so that plants can grow stronger in the future.
LCD+I2C	as a text viewer when the light is switched on or off

Data Analysis Techniques

The collected data is analysed using mathematical formulas to calculate the voltage from the ldr sensor and evaluate the performance of the system.

$$V_{out} = \frac{ADC\ Value}{1023} \times V_{in}$$

V_{out} = Calculated output voltage.

ADC Value = LDR sensor result

V_{in} = Input voltage to LDR (5V)

RESULTS AND DISCUSSION

Wiring and Prototype Result

The wiring configuration of the prototype involves several components connected through specific pins on the microcontroller. The LDR sensor uses the VCC pin connected to the 5V input voltage and the GND pin connected to the GND of the Arduino Uno. Pin A0 or analogue pin is connected to pin A0 on the Arduino Uno to read the output voltage of the LDR sensor with a value that varies according to the light intensity. The LED grow lights are controlled through a relay module connected to digital pin 7. The LCD module, connected via I2C, displays text when the LED grow lights are activated or deactivated, making the system easy to use. Power for the components is supplied via a microcontroller that is powered via a USB connection. This arrangement ensures smooth communication between the components and efficient operation of the light control system.

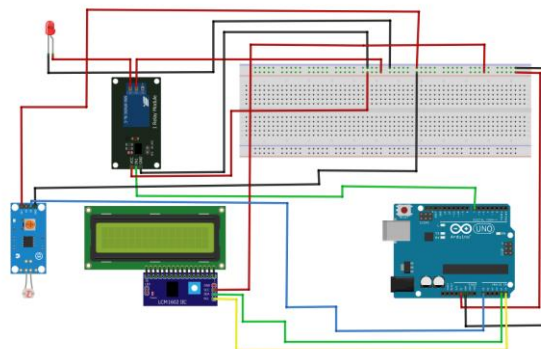


Figure 12. Wiring configuration

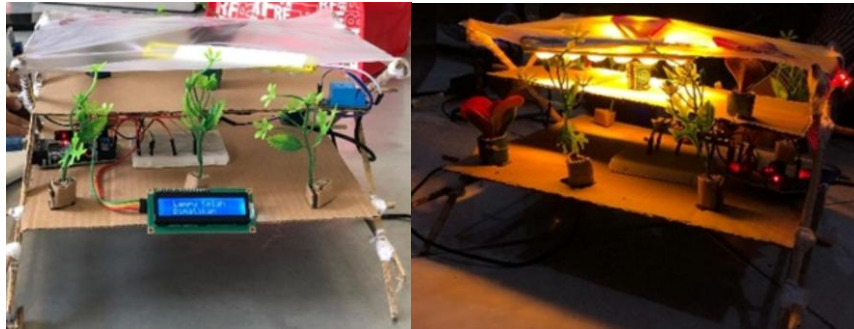


Figure 13. Prototype result

Data Result

Table 2. Data result LDR sensor

Testing	LDR Value(Lux)	Voltage(V)	Light Status	Light Status (ON/OFF)
1	400	1.95	Dim	ON
2	450	2.20	Dim	ON
3	500	2.44	Dim	ON
4	600	2.93	Moderately bright	OFF
5	700	3.42	Moderately bright	OFF

The results of the table above present several LDR sensor values along with voltage, light conditions and lamp status. Calculation of the sensor output voltage as follows

ADC Value = 500lux

$V_{in} = 5V$

calculating output voltage :

$$V_{out} = \frac{500}{1023} \times 5$$

$$V_{out} = 2,44 V$$

After the calculation, it can be proven that the value in the table is in accordance with the calculation formula where the lamp will turn on when the light intensity is below 500 lux and the lamp will turn off when the light intensity is above 500 lux with an output voltage in the range of 1.95volt to 3.42volt. This calculation confirms the reliability of the system by showing stability in detecting the surrounding light intensity.

CONCLUSION

The automatic hydroponic plant light regulator prototype successfully fulfils its intended function. The device accurately measures light intensity using an LDR sensor and displays the data in real-time on the LCD. The control logic of the relay module as an automatic switch effectively activates the LED grow lights when the light intensity is less than or equal to 500lux which means the hydroponic plants need intensive light until the surrounding light is sufficient for the plants, the LED grow lights will be deactivated. This mechanism increases lamp power and energy efficiency because the lamp will only be active when needed. From the test, it is found that for a light intensity of 500 lux to activate the lamp, an output voltage of 2.44 volts is generated, the system shows

stability in its output voltage and the system functions properly. In other results obtained 700lux will produce an output voltage of 4.42 volts which indicates that the surrounding conditions are bright enough so that it does not require lights. These results validate the accuracy of the control logic and data processing. Overall, this system is a reliable alternative for automatic light intensity regulation, making it a practical solution for monitoring the growth of hydroponic plants with sufficient lighting as needed.

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