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Automated System for Indoor Farming using Arduino

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ABSTRACT

Lighting is one of the most important key parameters for green house plant growth. Climate variation is the main limitation for the outdoor planting. Light emitting diode technology is paving the way to increase crop production efficiency with electric lamps. Nowadays agricultural sector is facing challenges to ensuring food security. Heavy rain destroys harvestready crops in many districts of Kerala. Indoor planting with LED light helps to overcome these limitations [1]. Aim of the project is to implement an automated system for indoor farming using Arduino. The programmable LED light strips fulfill the light application needed for the growth of the plants. External natural light source can be automatically detected by a light sensor. Thus automatic dimming can be achieved. RTC module is used to keep the time period division persistent water spray control. In addition to these, a sensor is also used to sense temperature and humidity. These sensors are interfaced to Arduino UNO.

INTRODUCTION

Indoor farming is an emerging technology in which agriculture industry needs to adapt to use less water and chemicals, make crop less vulnerable to changes in the climate, and produce more reliable yields. Crops from indoor farming are grown in three dimension, rather than two and can be grown all year round, independent of external weather conditions. There are some requirements for plant growth. Light Emitting Diode (LED) technology is paving the way to increase crop production efficiency with lamps [2]. Light energy is an important factor for plant growth. The regions where the natural light source (solar radiation) is not sufficient for growth optimization, additional light sources are being used. Traditional light sources such as high pressure sodium lamps and other metal halide lamps are not very efficient and generate high radiant heat [3]. Therefore, new sustainable solutions should be developed for energy efficient greenhouse lighting. Recent developments in the field of light source technologies have opened up new perspective for sustainable and highly efficient light source in the form of LEDs (Light Emitting Diode) for a greenhouse lighting. Water is essential for all plants, with some requiring more of it than others plant life require a fixed array of humidity and temperature without which the proper growth of outcome is not seen. By considering these parameters an automated system for indoor farming can be implemented [4].

SYSTEM DESCRIPTION

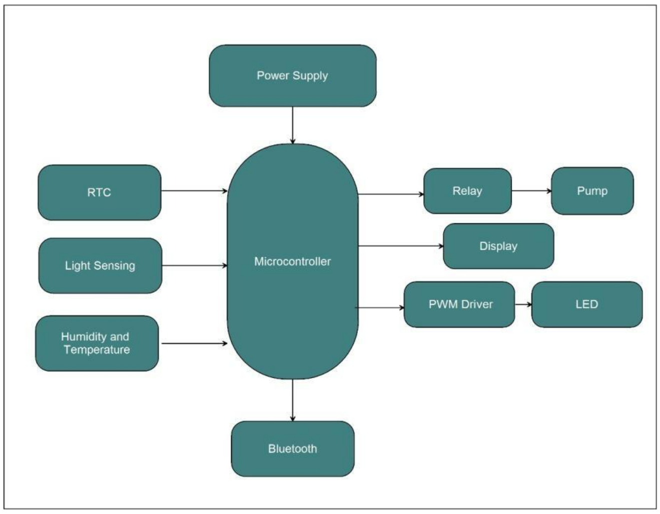

Fig.1: Block Diagram

Arduino UNO

Fig.2: Arduino UNO

The Arduino UNO is an open-source microcontroller board designed by Arduino.cc and based on the Microchip ATmega328P microprocessor [5]. The board has a number of digital and analog input/output (I/O) pins that can be used to connect different expansion boards and other circuits. The board features 14 digital I/O pins (six of which are capable of PWM output), 6 analog I/O pins, and is programmable through a type B USB cable using the Arduino IDE (Integrated Development Environment). It can be powered by a USB cable or an external 9-volt battery, with voltages ranging from 7 to 20 volts. It's similar to the Arduino Nano and Leonardo microcontrollers.

Table 1: Specifications of ArduinoUNO

Operating voltage	5 V
Digital I/O Pins	14
Analog Input Pins	6
SRAM	2 KB
EEPROM	1 KB
Flash Memory	32 KB of which 0.5 KB
Clock Speed	16MHz
Supply Voltage	7-12

HUMIDITY AND TEMPERATURE SENSOR

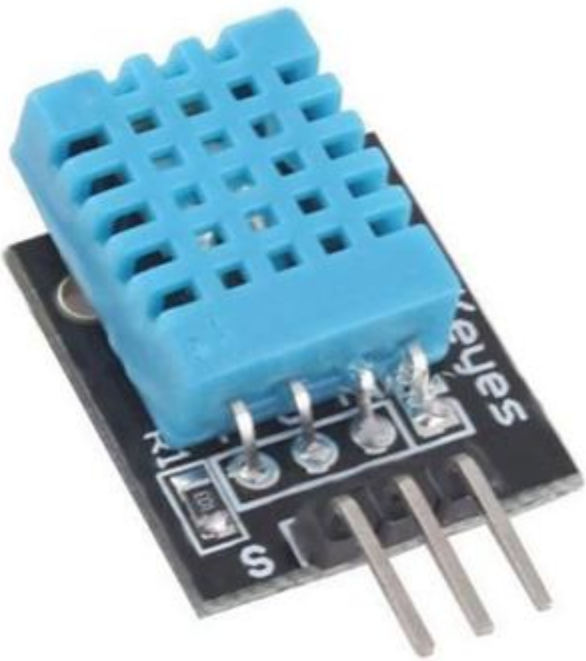

Fig.3: DHT11 Sensor

The DHT11 is a commonly used Temperature and Humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity asserial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from0ºC to 50ºC and humidity from 20% to 90% with an accuracy of ±1ºC and ±1%.

Table 2: Specifications of DHT11

Sensor Model:	**DHT11**
Voltage	+5 V
Input	Temperature andHumidity in Surroundings
Output	Digital Signal
Units	Temperature inCelsius and Humidity in Percentage

BLUETOOTH MODULE

Fig.4: HC 05 Bluetooth Module

HC-05 Bluetooth module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup [6]. Its communication is via serial communication which makes an easy way to interface with controller or PC. HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

Table 3: Specifications of HC-05Bluetooth module

Model Name	**HC-05**
IEEE Protocol	802.15.1
OperatingCurrent	30mA
Range	<100m
OperatingVoltage	5 V

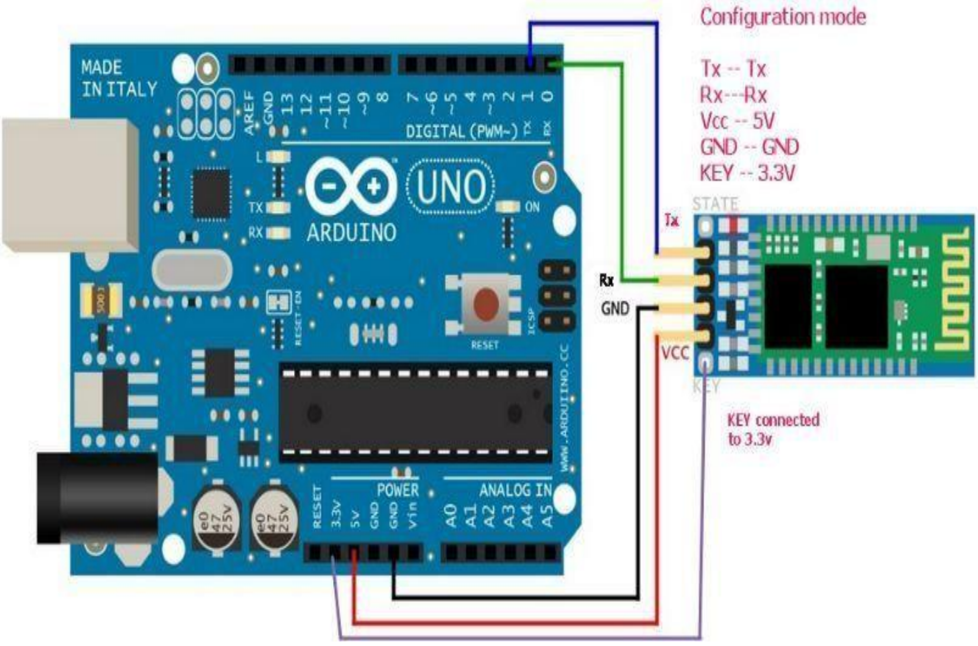

Fig.5: Interfacing of Arduino withBluetooth Module

RTC

The DS1307 IC is most widely used real time clock, it consists of 3V external lithium battery to keep functioning for over 10 years maximum in the lack of external power supply. This IC uses a CMOS technology to maintain low power consumption. This IC is used to keeptrack of the date, month and year,hours, minutes and seconds and also day of week [6]. This IC provides a leap year facility that is valid up to 2100. The compensation of the leap year is done by checking.

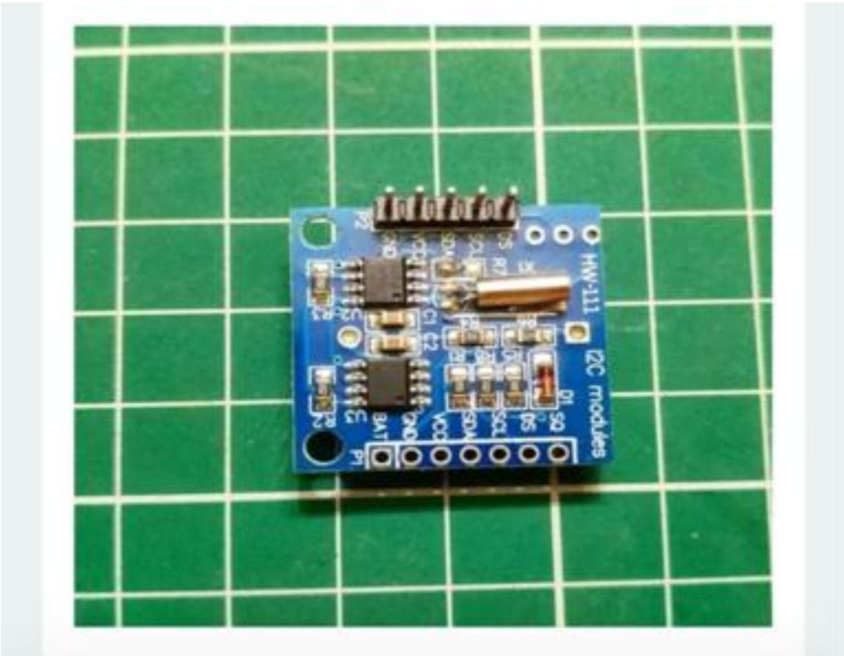

Fig.6: DS1307 RTC Module

The IC DS1307 is a low power serial real time clock which is integrated with BCD clock and 56 bytes of nonvolatile static RAM. Address and data are transferred serially through an I2C bus [6]. The real time clock provides the information about date, month, year and second, minute and hour. This IC operates with 12 hr or 24 hr format with an indicator of AM and PM. The DS1307 IC circuit built with a power sensing circuit. The sensing circuit is used to switch the backup supply when the power failures. This real time clock IC uses an external oscillator and it doesn't require any resistor or capacitor tooperate.

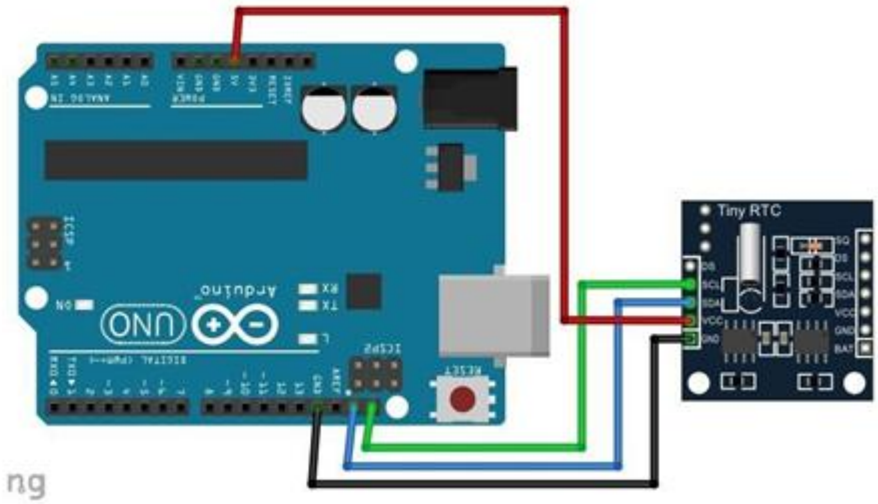

Fig.7: Interfacing of Arduino with DS1307 RTC

Table 4: Specifications of RTCModule

Sensor Model:	**DS1307 RTC Module**
Voltage	+5 V
Input	Starting time and dateof the clock
Output	Analog Signal

RELAY

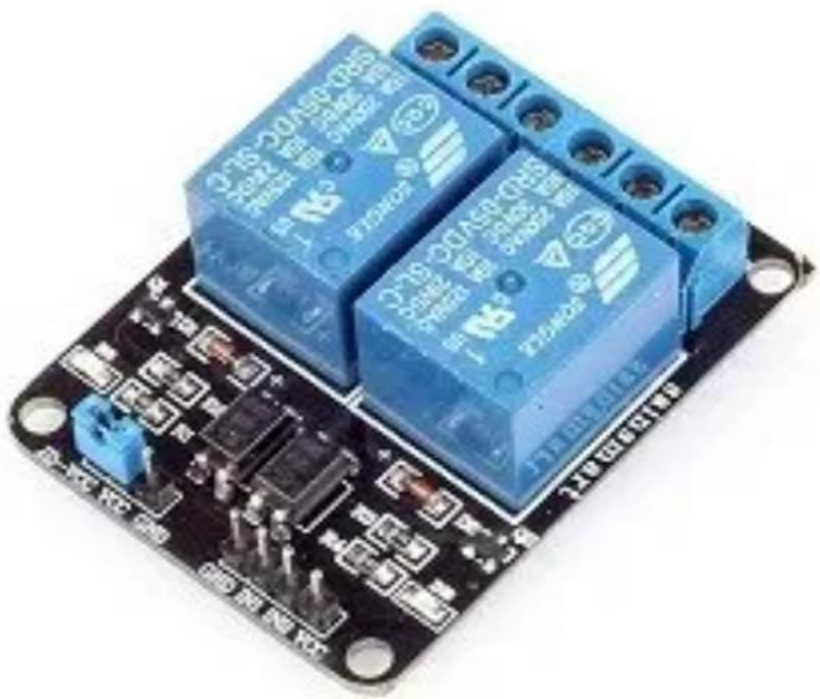

Fig.8: Relay

A relay is an electrically operated switch that can be turned on or off, letting the current go through or not, and can be controlled with lowvoltages, like the 5V provided by theArduino pins. This relay module has two channels. There are other modelswith one, four and eight channels.This module should be powered with5V, which is appropriate to use with an Arduino. The six pins of the left side of the relay module connect highvoltage, and the pins on the right sideconnected to the component thatrequires low voltage-Arduino pins.

LDR SENSOR

LDR is a component that has a resistance that changes with the light intensity that falls upon on it. Light Dependent Resistors (LDR) are also called photo resistors. Photosensitive sensor module is the most sensitive for the environmental light intensity and it is generally used for detecting the ambient brightness and intensity of the environment. Without light intensity it will not reach the threshold resulting for low level output but, when the external environmental light intensity exceedsthe set threshold it will result for a high-level output.

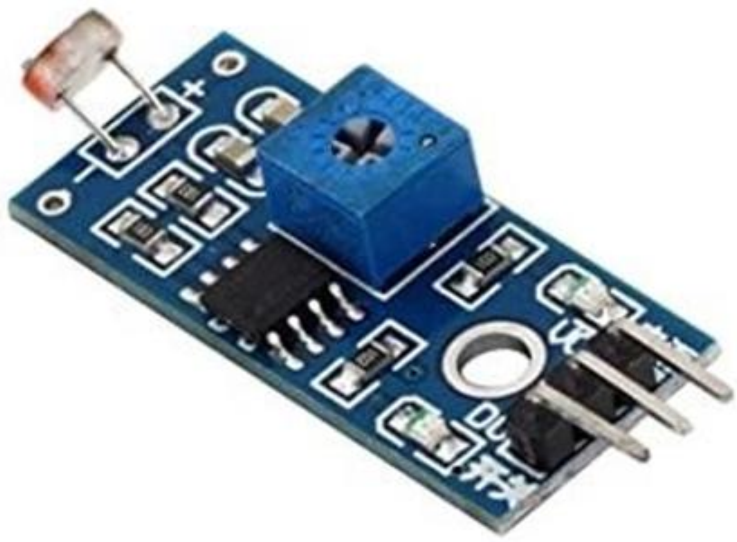

Fig.9: LDR Sensor

The output is directly connected withthe microcontroller, for the microcontroller to detect the light level, thereby to detect environmental intensity change. Small digital output can directly drive the relay module, which can be composed of a photoelectric switch [7]. Small analog output, through the AD conversion, can obtain more accurate numerical value of environmental light intensity.

Table 5: Specification of LDR Sensor

Sensor Model	**LDR**
Voltage	+3.3V
Input	Light
Output	Analog signal
Units	LUX

SYSTEM CONFIGURATION

The proposed model is implemented using the below circuit diagram shown in figure13. This diagram is designed with software calledfritzing. An external board box kept the circuit connections safe from the main structure as it involves water. Abread board achieved the networkingamong the sensors and Arduino. The circuit setup and actual structural model is shown in Figure 10. TheArduino has software called ArduinoIDE that is used to command the arduino with our desired task completion and for this project weused the some built-in methods ofcommands from the Arduino library.

The proposed system is modelled using Arduino UNO which contains input and output units. It connect to light sensor for measuring the light intensity, temperature and humiditysensor for getting the temperature andhumidity in the surroundings. Various plant species have distinct ideal temperature and humidity ranges. Examining and controlling temperature and humidity of the plants surroundings is a must to protect the plant from drought and extreme temperatures.

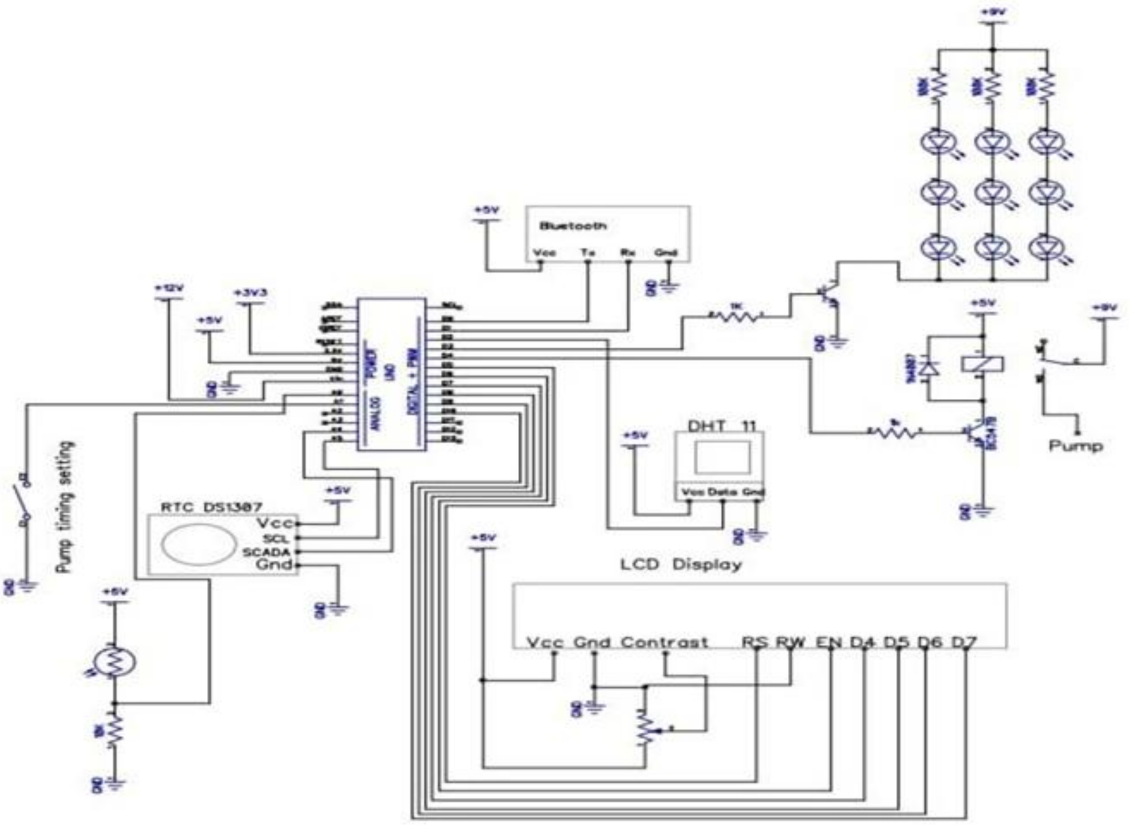

Fig.10: Circuit diagram of proposed system

Arduino UNO integrates all sensors and display the sensor readings on theLCD screen. Control signals from thelight sensor is given to PWM driver, which controls the intensity of LED light. RTC module provides time period division persistent water spraycontrol to the pump through the relay. Moreover the system has a Bluetoothmodule, which is used for wireless communication between Bluetoothenabled devices like smartphone.

EXPERIMENTAL SETUP &RESULT

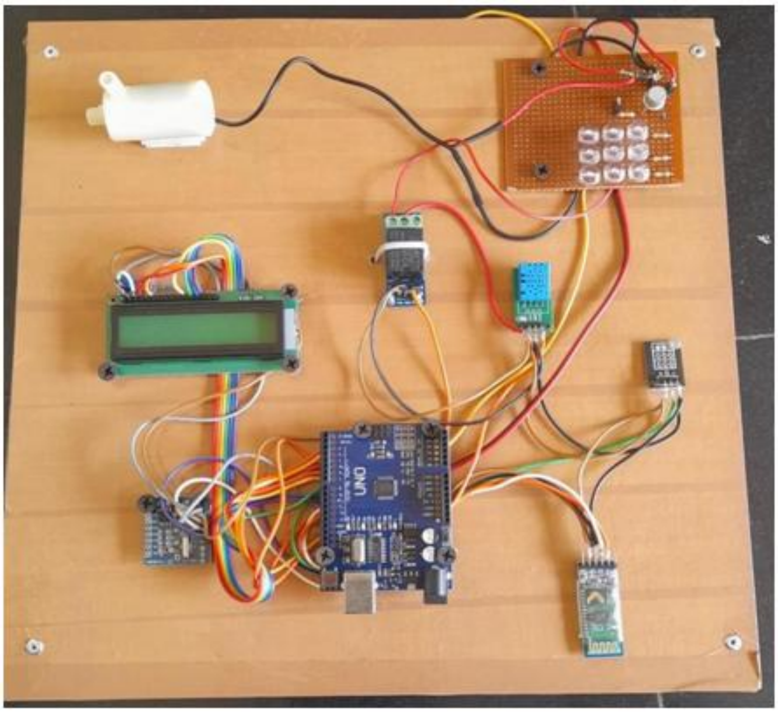

Fig.11: Proposed Prototype

This is the prototype fig (11) we proposed. Here the sensors are interfaced with arduino. You can see the time, temperature and humidity values in the display here.

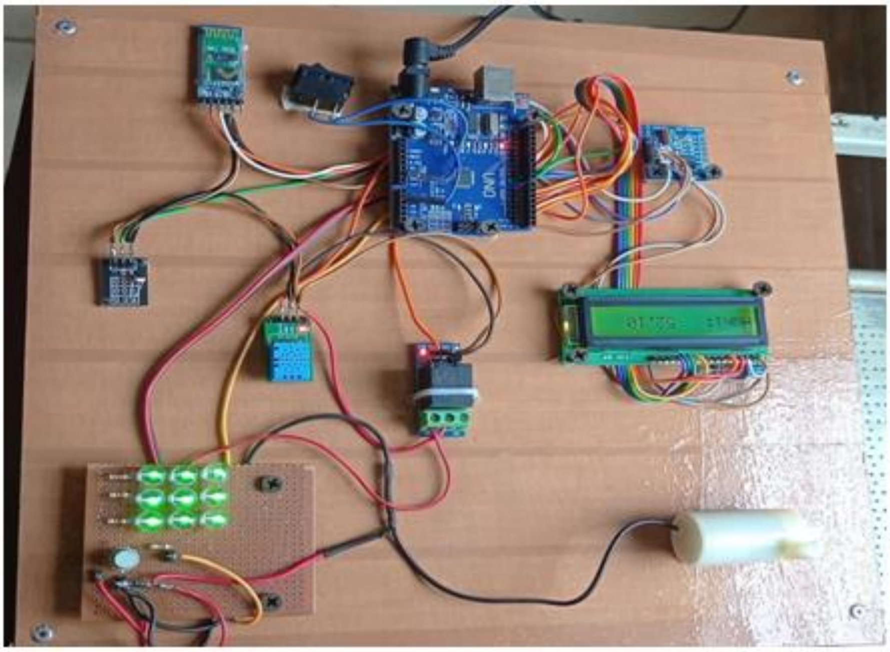

Fig.12: LED turned on in a darksurrounding.

In fig (11) the LEDs are off. Becausethere is sufficient light for the plant photosynthesis. But in fig (12) theLEDs turn on, because here we close the ldr sensor using our hand to makea darker surrounding.

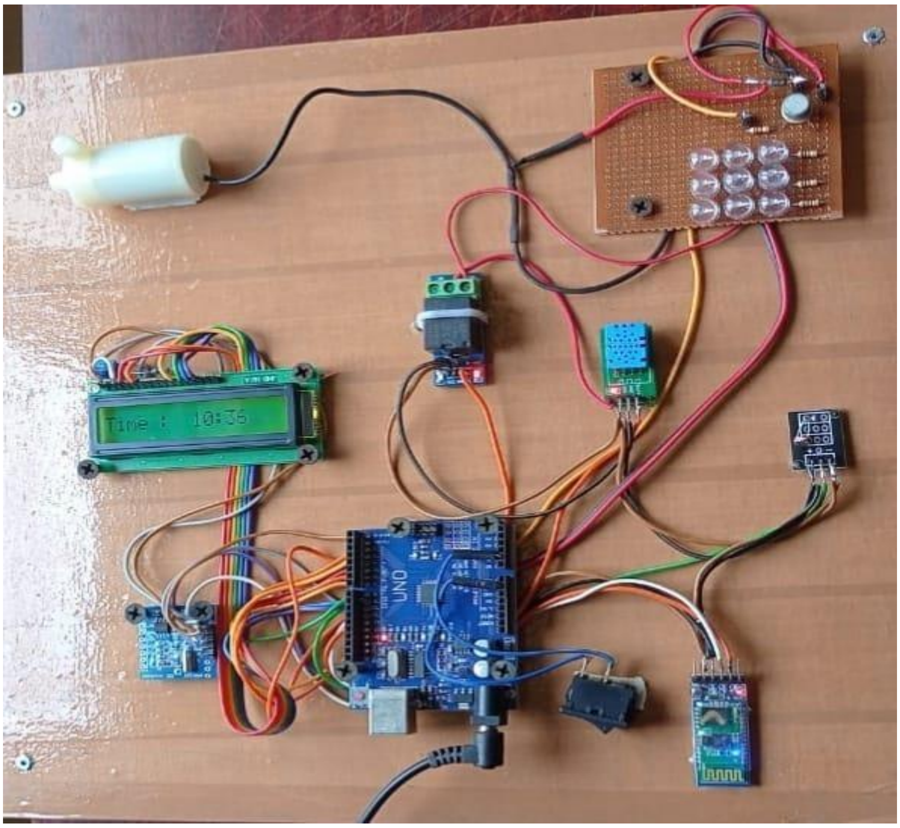

Fig.13: Display shows the time asoutput.

Here we develop an application usingMIP. This app is used for knowing thetemperature and humidity status aswell as for the activation status of Pump. After open the application and connect with the device (here HC 05) the time, humidity and temperature values are shown in the display. At the same time the pump value shownas zero. These are shown in fig (13) (14) (15) (16) respectively. Then on the relay switch and set a time in the application for pump. After that the pump time can see in the display. From that time pump start pumping water in every 30 second up to the time of turned off the relay. Fromthese values we can determine whichcrop can cultivate in that particular place. This is a small model prototypeshown here. If we want to cultivate ina large room, we can use led grow light and we can provide the differentsensors in different places.

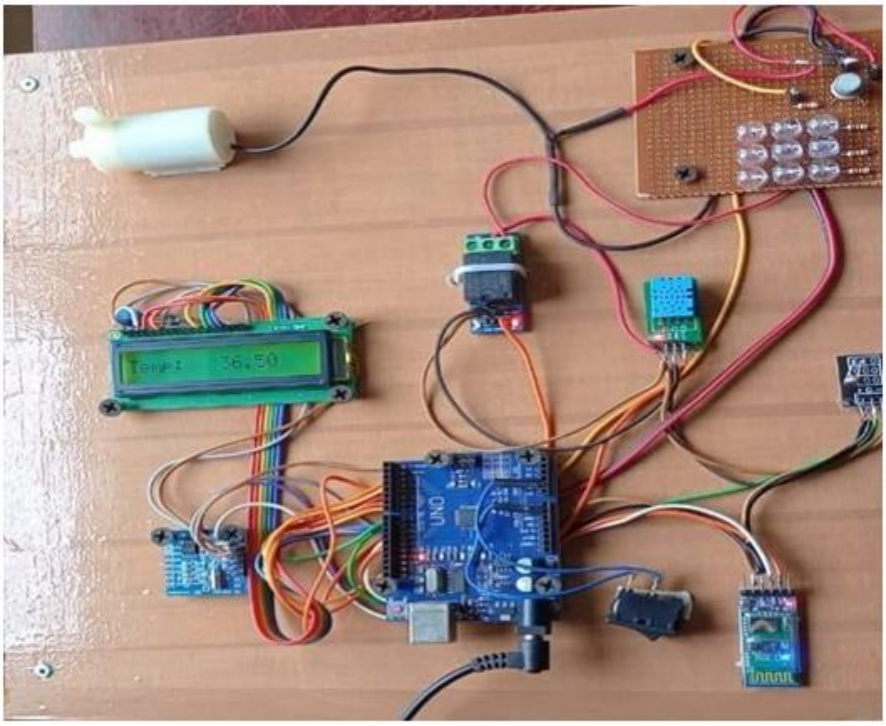

Fig.14: Display shows Temperatureas output.

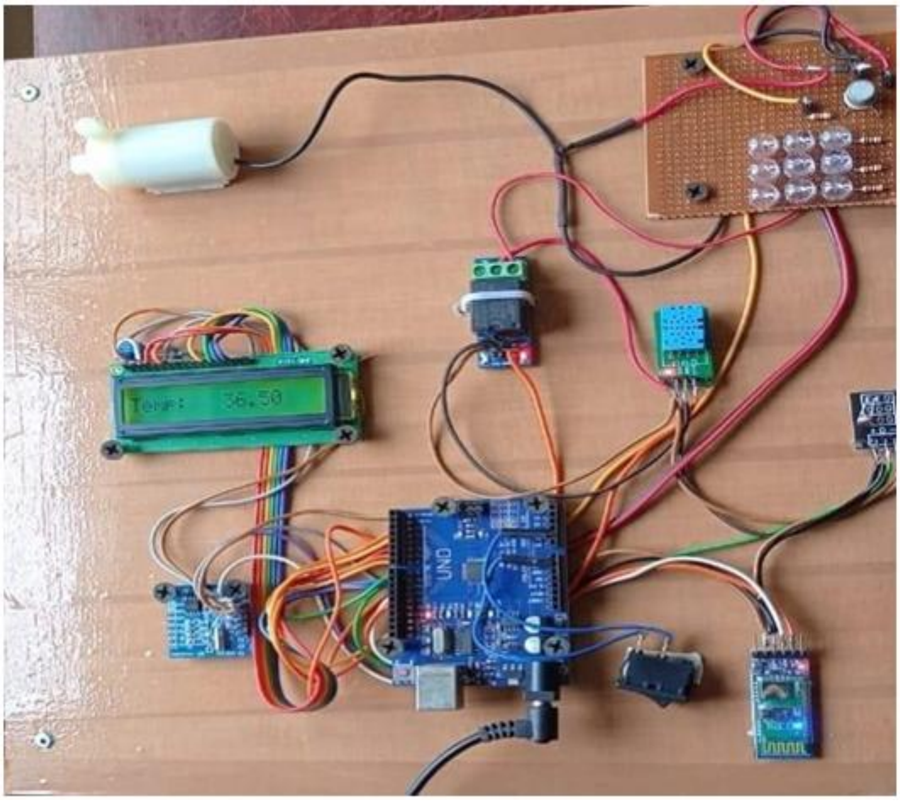

Fig.15: Display shows Humidity asoutput.

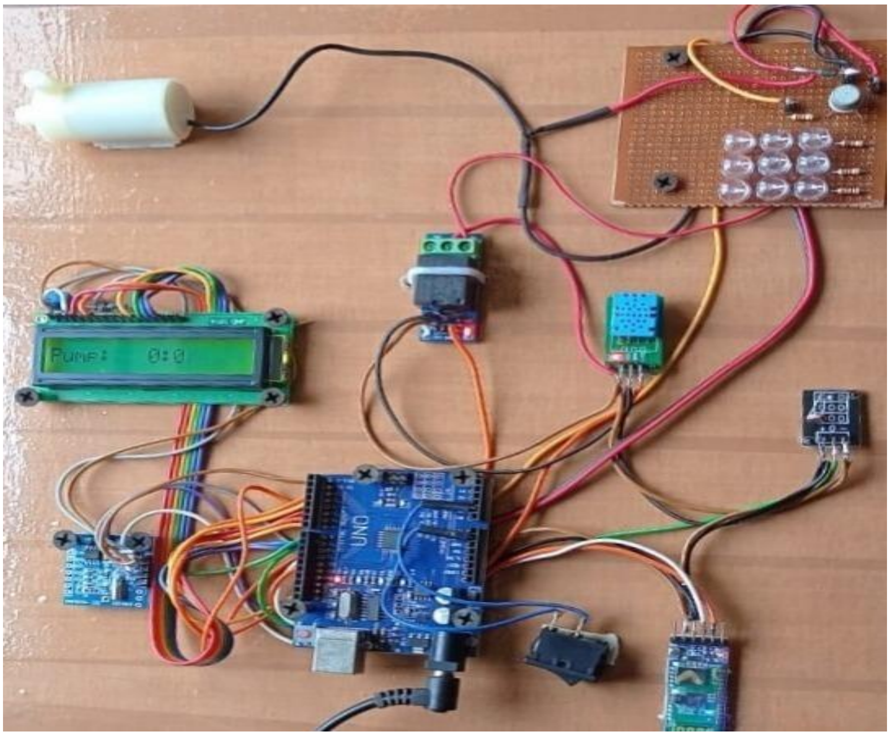

Fig.16: Display shows Pump asoutput.

FUTURE SCOPE

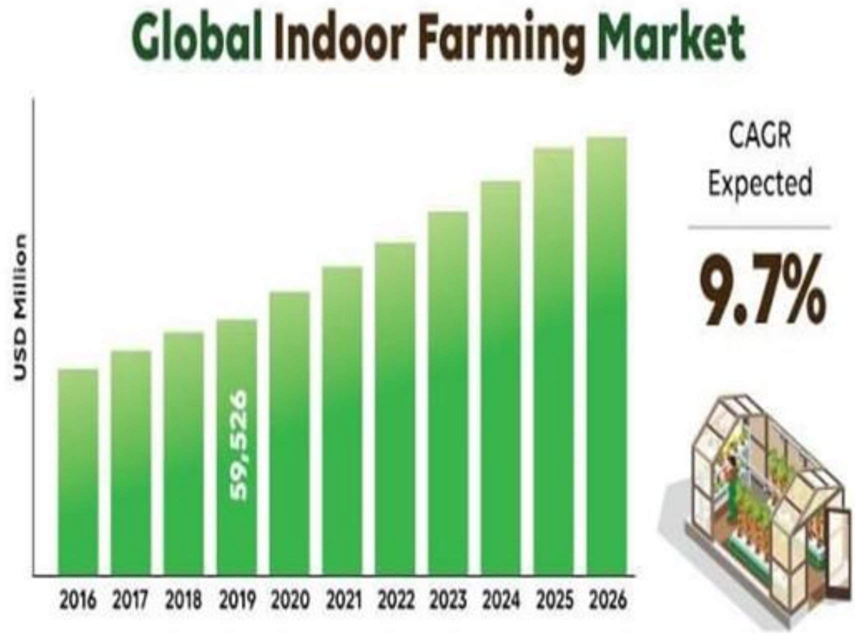

Fig. 17 Graph represent indoor farming in 2027

In the last few years, indoor farming has been witnessing significant recognition among the producers across the globe. Several producers inNorth America and Europe are shifting their approach fromtraditional to indoor farming as it requires less space and water, and the product is relatively high [8]. Some ofthe factors driving the market include the rapidly growing population, changing climatic conditions, exhausting natural resources, increasing urbanization and scarcity of water resources [9]. To attend to the situation, umpteen companies are actively participating in verticalfarming and are offering a wide variety of fruits, vegetables, andmicro greens on a daily basis, such as Aero farms, Gotham Greens andplenty among others.

Global indoor farming market wasvalued at USD 59,526 million in 2019and is expected to reach USD 117,214 million by 2027 at a CAGR OF 9.7%.

CONCLUSION

The results obtained from the systemhave indicated that the performance iswell, especially in collecting, loggingand analyzing the data from the sensors. Further investigation is planned for developing mobile based application for monitoring,controlling of the device. Light intensity from LED is observed. The device can easily operate by the end users and can be implemented in small as well as large scale farming.

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