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# WORKING MODEL OF IOT EMBEDDED SMART POLYHOUSE AGRICULTURE SYSTEM

**Ramandeep Sandhu[1*], Pichakuntla Sai Charn[2*], Dalavai Surya[3*], Mohammad Faiz[4*]**

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## Abstract

In the technological embedded world, IoT has taken a long gait towards making the society a smart society whether it is in terms of education, life style, health care or agriculture. Keeping into consideration various benefits of IoT, this research paper presents a working model of an IoT embedded smart polyhouse agriculture system. The system utilizes various sensors to collect environmental data, which is processed by a microcontroller and sent to the cloud for analysis. The proposed system is capable of controlling various actuators to maintain optimal growing conditions for crops, and alerts the farmer in case of critical environmental changes. Apart from this, it is a mobile connected agriculture system which connects mobile app with the farmer to remotely monitor and control the polyhouse environment, while data analytics provide insights that can help improve crop management. The proposed system has the potential to significantly increase crop yield and reduce water usage in agriculture, while also providing real-time monitoring and control for farmers.

**Keywords:** Smart Polyhouse Setup, Internet of Things, Soil Moisture sensor, DHT11 Sensor, Greenhouses, Smart Agriculture

[1,4]Assistant Professor, School of Computer Science and Engineering, Lovely Professional University, Phagwara, Punjab, India
[2,3]School of Computer Science and Engineering, Lovely Professional University, Phagwara, Punjab, India

ramandeep.28362@lpu.co.in[1], sai752392@gmail.com[2], suryadalavai@gmail.com[3], faiz.28700@lpu.co.in[4]

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# 1 Introduction

Agriculture is the backbone of the world's economy, and the food production industry has been undergoing rapid transformation in recent years due to advances in technology [1-6]. With the global population expected to reach 9.7 billion by 2050, food production needs to increase by 70% to meet the growing demand. In this context, the Internet of Things (IoT) technology plays a significant role in improving agricultural productivity. IoT embedded smart agriculture leads to the development of smart farming techniques, where data fromsensors, actuators, and other sources can be used to optimize crop management [7]. One such application of IoT in agriculture is the development of smart polyhouse agriculture systems [8-14].

A polyhouse is an enclosed structure designed to protect crops from external weather conditions and pests. It is a controlled environment where farmers can grow crops year-round, regardless of the external climate. A smart polyhouse agriculture system integrates IoT technology with the polyhouse environment to improve crop yields and reduce labor costs [15-16]. In this research paper, we present a working model of an IoT embedded smart polyhouse agriculture system. The system comprises sensors to collect data on environmental parameters, microcontrollers to process the data, actuators to control the environment, a cloud platform to store and analyze the data, a mobile app for remote monitoring and control, an alerting system for critical environmental changes, and data analytics for generating insights [17]. The proposed system can help farmers to optimize crop management by providing real-time data on environmental conditions and enabling remote monitoring and control. The system can also reduce labor costs by automating tasks like watering and ventilation. We believe that our proposed system can be a significant step towards sustainable and efficient food production [18-20].

Other than conventional agricultural practices, technique, and methods like usual agricultural operation (pre-harvest and post-harvest), one component which separates a Polyhouse from a traditional farm is the control and monitoring of the process parameters. In this study, a remote irrigation monitoring and control system was evaluated for precise control irrigation inwater-scarce locations. In India, there are currently very few businesses as well as service providers engaged in the control, supervision, and automation of polyhouses; in the states of Maharashtra, Gujarat, and Tamil Nadu has the major example. The acceptance of Polyhouses will automatically lead to a big leap in demand for better control and automation [21].

To offer more automated supervision, multiple greenhouse climate and crop models have been designed. In prior research, a summary of present-day greenhouse climate models is provided. An outline of greenhouse crop models and modeling methodologies are offered in previous research. Dynamic crop and greenhouse climate models have been utilized to establish set points automatically and replace grower decision-making. Automated algorithms can regulate greenhouse climate as well as crop growth if climate and crop simulation models are coupled and connected to a greenhouse's sensors and actuators. In Netherlands, similar studies with tomatoes and sweet peppers have been carried out successfully. In this experiment, climate simulations were done using actual weather conditions and projections. In order to forecast future crop growth and improvement for various sets of setpoints, crop growth simulation was conducted concurrently with the cropping cycle [22]. The best set was then automatically used in the greenhouse. The computations were performed daily basis, though this, crops were cultivated using an optimum management approach. Various tomato experiments also have been carried out in the recent past for this research point of view.

**Software Application:**

YOLOv5 is an open-source object detection model that can quickly and accurately identify objects in images or videos of any size, shape, or color. It has many applications, including autonomous driving, security and surveillance, object tracking, and object recognition. Makesense AI is a software platform that provides tools and services for creating and managing AI-powered applications. By using Makesense AI, it is possible to identify healthy and diseased leaves with the help of YOLOv5. This allows to process data easily by uploading photos or videos to quickly detect and differentiate between healthy and diseased leaves [23-25].

In this work, various sensors have been used for the purpose of monitoring different parameters like temperature, humidity, soil moisture, a real-time sensing device, and an Arduino. It has been noted that various growth conditions are required for tomato crop which are most favorable for their growth and prevents various pest and disease infestation. The working of proposed device is performed in the Lovely Professional University field polyhouse according to predefined parameters [26][27][28].

## 2 Literature Review

Polyhouse with automation is latest trend which is taking long strides towards its inclusion in farming. More return on investment has become need of an hour in today's technological era not only in farming society but in all fields of the world. Table 1 as described below explores the findings by different authors during their research work [29][30][31].

Table 1: Research Findings Details

| **Authors** | **Findings of the Research work** |
|---|---|
| Kuthada et.al., (2018) in [26] | Researchers in the proposed approach stated that relative humidity influences photosynthesis and growth of leaves. Hence high temperature or dryness in the environment causes crops to not properly function. Hence it is important to control humidity and temperature of the environment where crop is grown. For controlling these factors, we need to monitor these factors carefully and continuedly. This task is done by sensors. So as these factors reaches a pre-set threshold, the sensor sends signal to the microcontroller, and hence turning on foggers that sprinkles water and hence creates a humid environment. |
| Kulkarni et. al., (2020) in [27] | Researchers in their proposed method stated that fully automatic set up mode inside a greenhouse can efficiently react to climatic changes by well-equipped systems. And its effectiveness provides quick and effective results. As this set up works on feedback system, the greenhouse can quickly adapt and respond to external stimuli like change in temperature and humidity. As developments for automatic set ups are going on with the help of IoT, the probability for errors can be significantly reduced. |
| Raja et. al., (2018) in [28] | The authors worked upon irrigation with the help of sensor as well as IoT sensors. Hence by using these methods, farmers can be relieved of physical presence at the time of irrigation. and by using these technologies, monitoring of temperature, humidity, moisture and water level in greenhouses or polyhouses can be done efficiently and with ease. |

| | |
|---|---|
| Kumari et.al., (2021) in [29] | The proposed work stated that as traditional irrigation methods face several problems like over irrigation, leaching etc., the need for new irrigation systems is necessary. One such system which is recently developed is called automatic irrigation system which uses soil moisture sensor to detect soil water and ESP32 microcontroller which is used to regulate water flow and to control different devices through URL of the user's mobile phone. |
| Ahonen et. al., (2008) in [30] | The researchers proposed various important parameters linked with greenhouse. The team worked upon various signals generated in polyhouse system. It is a controlled version of greenhouse with better outcomes. |

Smart polyhouse monitoring is helpful to control the environment conditions inside polyhouse without human intervention [31-34].

## 3. Proposed System Modelling Components

**Various Components used for Smart Agriculture:** Following are the various components used for the proposed smart agriculture system [32][33].

**Node MCU ESP32**

As shown in **Fig. 1**, It is an open-source software & development kit that allows people to prototype their Internet of Things (IoT) devices. It is based on the ESP8266, a low-cost Wi-Fi microcontroller with an integrated TCP/IP stack and a microcontroller. The Lua scripting language is used to programme NodeMCU. It is an ideal platform for rapidly prototyping and developing IoT applications. NodeMCU is widely used in applications such as home automation, robotics, remote control, sensor monitoring, etc. It is popular for being user friendly and user friendly. The latest version of NodeMCU is the ESP32, which features an improved processor and more memory. The ESP32 offers improved performance, more features and wider range of applications [34][35].

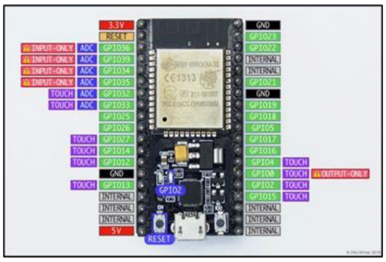

**Fig. 1**: NodeMCU Board

**Specification: Following are various specification points of Board**

- Model type used - ESP32
- Processor- Tensilica LX6 Dual-Core
- Standard clocking frequency - 240 MHz
- SRAM & Memory – 512 kb & 4mb
- Wireless Standard - 802.11 b/g/n
- FREQUENCY – 2, 4 GHz
- Bluetooth Connectivity - Classic / LE
- Interface- DC/DAC/ADC/12C/SPI/UART
- Voltage – 3.3V which is operated by a 5v microusb
- Functional temperature – from -40°C to about 125°C

**NodeMCU Board** is an open-source software & development kit that allows people to prototype their Internet of Things (IoT) devices as shown in **Fig. 2**.[36][37].

**Fig. 2:** NodeMCU Board

**Bread board**

A breadboard is a type of solder less electronic prototyping board. It is used to build and test circuits temporarily without having to solder components together. Breadboards are often used to create prototypes and to experiment with circuit designs before creating a permanent circuit board. **Fig. 3** represents the configuration of bread board. Breadboard is a type of solder less electronic prototyping board. Breadboards are used to build and test circuits temporarily without having to solder components together. Breadboards are often used to create prototypes and to experiment with circuit designs before creating a permanent circuit board [38][39].

**Specification of Bread board:**

Various important parameters required for working of bread board are listed below.

- 2 Distribution Strips
- 21 to 26 AWG wire
- 200 tie points
- 630 tie points inside IC
- Withstanding Voltage is 1,000V Maximum voltage – about 1000
- 500MΩ - resistance of insulation
- Dimension is 6.5x4.4x0.3 In
- Maximum current is 5 Amps
- Distortion Temperature of ABS 183° F (84° C)
- Pitch Style - 2.54 mm

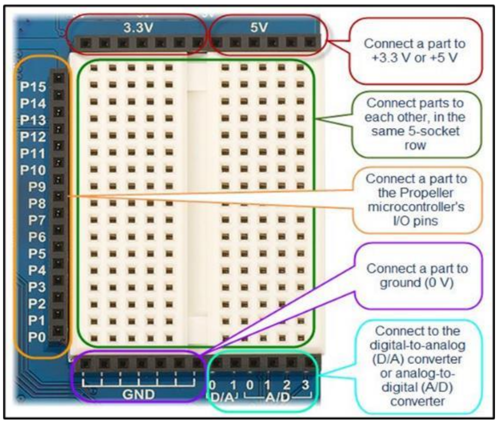


**Fig. 3:** Bread Board

**Soil moisture sensor**

Soil moisture sensors are instruments that monitor the level of moisture in the soil. They are used in agriculture and gardening to monitor the amount of water in the soil and to make sure that plants are getting the right amount of water. Soil moisture sensors can detect moisture levels in a variety of soil types and moisture levels, including dry, wet, and saturated soils. They are available in various types and sizes, and can be used to monitor a single area or multiple areas at once. Soil moisture sensors can be used to help farmers and gardeners better manage their irrigation schedules, saving water and energy and helping to protect the environment [40][41].

Specification of soil moisture sensor are listed below.

- Range- Can measure on a range of 0 – 45% is soil volumetric water.
- Accuracy –of about ±4%
- Power - 3 mA @ 5VDC
- Operational temperature - 104°F - 140°F
- Active sensor length - 5 cm
- Calibration is stored inside
- Slope & intercept - 108%/ volt & -42%

**DHT 11 sensor**

The DHT11 is a relatively affordable digital humidity & temperature sensor. It measures the ambient air with a thermistor and a capacitive humidity sensor and sends a digital signal via the data pin. It also features an 8-bit microcontroller, which can be used to output data in a variety of formats, including ASCII, binary, and even a dedicated protocol. This sensor is ideal for applications such as air conditioning, weather forecasting, and home automation. The DHT11 is often used in combination with an Arduino board or Raspberry Pi board to create a variety of projects [42][43][44].

**Specification**:

- Voltage: 3.5V - 5.5V
- current: measuring current of 0.3mA & standby current of 60uA
- Output data type: Serial
- Sensing temperature: 0°C - 50°C
- Sensing humidity: 20% - 90%
- Temperature and humidity resolution: 16-bit
- Accuracy: ±1(% or °C)

**Relay Module**

A relay which technically resembles an electrical switch is used to control an electrical regulate by opening and closing contacts in the circuit system. It is usually used when a circuit needs to be controlled remotely or when the current in the circuit is too high to be handled by a switch. Relays are commonly used in automobiles and home appliances. The four-model relay system is a type of relay system that consists of four relays wired together in series. This relay system is used for applications that require multiple stages of switching. The first relay is usually used to power the other relays, while the remaining three relays are used to control different parts of the circuit. This system is often used in industrial applications, where multiple stages of switching are needed for safety or to control multiple functions.

**Jumper wires**

Jumper wires are short pieces of wire used to connect two points in an electronic circuit. These are commonly used to connect two points on a circuit board, such as a power supply and a ground, or a resistor and a capacitor. They can also be used to connect two points on a breadboard, such as a power rail and a row of pins. Additionally, these are used to jump across components to bypass them in order to test a circuit. Jumper wires are classified into three types: male to male, male to female, and female to female. Jumper wires are used to make the circuit connections.

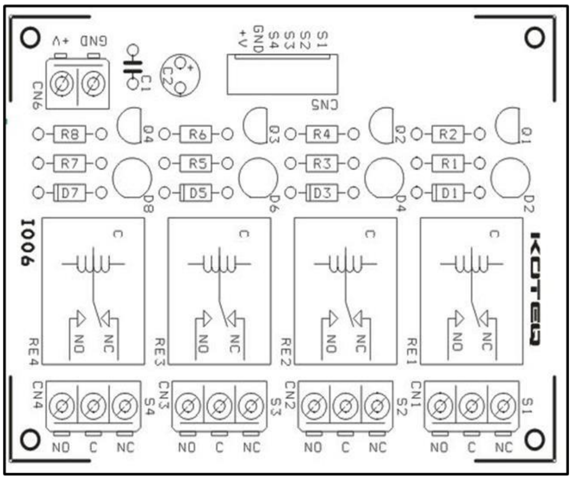


**Fig. 4:** Relay Module circuit

**Mini submersible water motor pump**

A mini submersible water motor pump is a type of submersible pump that is designed to pump water from a lower to a higher level. It consists of a motor, an impeller and a pump casing. The motor is usually enclosed in a sealed casing, and the impeller is mounted on the motor shaft. Water is drawn into the impeller and then forced out, creating a pressure differential that causes the water to rise. Mini submersible pumps are typically used in applications such as aquariums, sprinkler systems, and water features.

**Specification:**

- Wire Length: 25cm
- Functioning Voltage: 12V
- Functioning Current: 130 - 220mA
- Rate of flow: 80 - 120 liters/hour
- Max. Lift: 40 - 110 mm
- Outlet diameter (outside): 7.35 mm
- Outlet diameter (inside): 4.5 mm

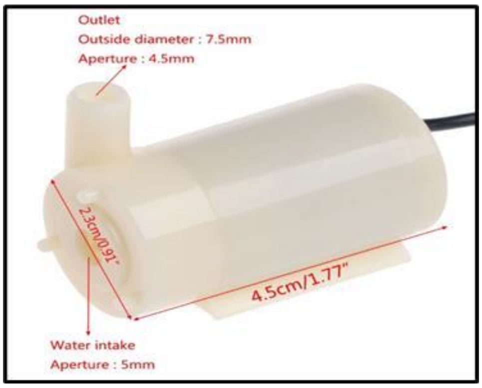


**Fig. 5:** Motor pump

As depicted in **Fig. 5**, Motor pump is used to pump the water.

**LED**

An LED (light-emitting diodes) is an electric light bulb which uses a heavily doped P- N junction diode which converts electric to mechanical energy. The blubs using LEDs are designed to last longer and use far less energy than traditional incandescent bulbs. LED bulbs are available in a variety of shapes, sizes, and color temperatures, making them a great choice for both residential and commercial lighting applications.

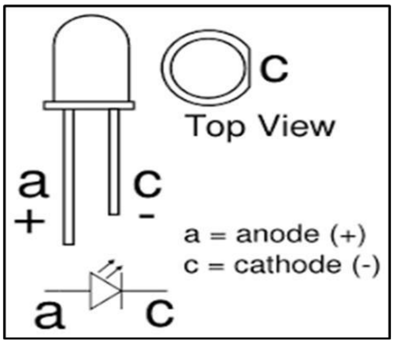


**Fig. 6:** LED Circuit

**Fig. 6** shows the LED view. LED is a light emitting diode which converts electrical energy into mechanical energy and produce light.

**Working Model Using Circuit Connections:**

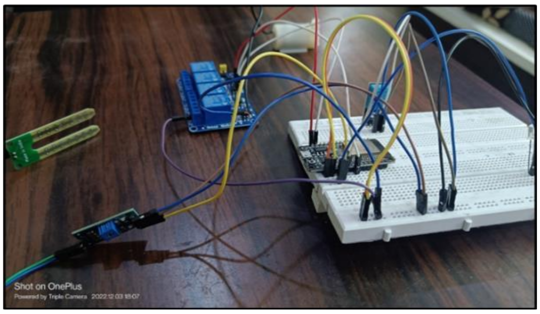


**Fig: 7:** The implemented Connections

**Fig. 7** depicts that the soil moisture is possible to check through inserting the probes of the soil moisture sensors into the soil. If the soil doesn't meet the desired conditions, a signal is sent from the DO pin of the sensor to the ESP32 Microcontroller. The processor will give instructions to the cooling pad to turn on as the temperature is higher that the pre-set value of the DHT11 sensor. Then the cooling pad will provide cooling to the crop.

**Output of implemented IOT enabled Setup:**

As this innovative model has been implemented in real field. The work has used polyhouse of LPU (indoor implementation). As shown in Fig. 8, it can be identified that the implemented approach is successfully recording the temperature of the agriculture. The x-axis of the graph represents date and y-axis represents temperature. It makes anote of temperatures recorded every day.

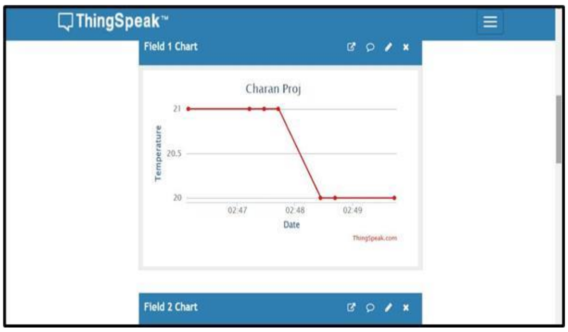


**Fig: 8:** The Temperature data chart

**Conclusion:**

The proposed system is a cost-effective and efficient solution for plant growth, surpassing traditional methods. It offers both manual and automatic control options and has a user-friendly interface that allows for easy monitoring of greenhouse conditions. The hardware and software components are seamlessly integrated with a user-friendly design that ensures optimal yield. Additionally, data can be stored in the cloud for future use. The control unit collects vital information about plant growth, including humidity, temperature, and light sensor data, and can be operated manually or automatically with precautionary measures in place to prevent climate fluctuations. The intelligent greenhouse prototype employs three control systems - Cooling/Heating, Irrigation, and Light - managed by Fuzzy controllers that are designed and programmed within the microcontroller, eliminating the need for external processing. The IoT features incorporated in the system make it easy for farmers to monitor their plants remotely and adjust set-points as necessary. The work also includes solutions for Global IP, Dynamic IP, and blocking ports by ISP companies, ensuring reliable connectivity.

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