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Smart Plant Pot System

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ABSTRACT: The Smart Pot System functionalities as an automated plant caretaking solution that relies on Internet of Things (IoT) technology for operation. A combination of ESP32 microcontroller sensors including water level sensors as well as temperature sensors and moisture sensors and light-dependent resistor (LDR) sensors enables consistent monitoring of ideal plant growth conditions. This system includes an automatic DC fan controller and a pump motor for water supply along with a light bulb that sustains plant illumination during sunlight absence. The system provides real-time data availability through both web interface and mobile application for remote monitoring capabilities. Users receive warning alerts through a buzzer to detect all environmental changes and potential system issues. The automated plant management system merges effective plant maintenance with automated operations while allowing remote monitoring which makes it an optimal solution for plant gardeners and urban farmers.

KEYWORDS: ESP32 microcontroller, Water level sensors, temperature sensors, moisture sensors, LDR, DC fan, pump motor, buzzer.

I. INTRODUCTION

Modern advancements in sophisticated Internet of Things (IoT) transformed critical components of smart homes, healthcare frameworks and agricultural management operations. The integration of sensors with automation in smart pot technology provides an approach to achieve advanced plant care automation by minimizing human involvement. The typical plant care system demands person-to-person observations of environmental factors since soil moisture and water levels and light intensity and temperature need constant human intervention. Standard plant management methods cause time-consuming mistakes that lead to decreased operational effectiveness.

A water and temperature measuring system and soil moisture and light-dependent resistors (LDRs) supply data to the ESP32 microcontroller through its electronic digital solution. The device automatically turns on the DC fan system and artificial light functions and activates pump motors to set perfect growing environments following the processing of real-time environmental data. Web-based remote data access in the application enables users to view plant health conditions as well as immediate information distribution. The use of IoT technology allows smart pot control systems to enhance operations by conducting automated plant care through independent process execution which provides real-time feedback on system performances. The research analyzes smart pot applications in horticulture and agriculture through a breakdown of system arrangements and descriptions of operational benefits.

II. HARDWARE SYSTEM

2.1.ESP32 Microcontroller

An adapter functions as a connecting device that enables electric systems compatibility through modification of both power signals and interface connectors. The device combines with motherboard cards to create processor to peripheral data exchanges. The power adapter transforms 220-230V AC power standards to create 12V DC power for consumer electronics devices and allows both power supply and signal connection. The signal integrity remains stable when serial port adapters change 25-contact connectors into 9-contact connectors. The adaptation technology offers an economical power delivery solution that delivers a constant 1A current from 220-230V AC and 12V DC voltage structure. Enterprise systems use WSDL files that have J2CA extensions to help adapters automatically produce metadata which enhances the way different systems interact with one another. Adapters enable effortless data transfer operations which link back-end Oracle applications to integration server clients which leads to both cruising

communication paths and better operational effectiveness. The implementation of these adapters enhances system functionality while speeding up data transfer and automatically controls power and computing infrastructure communication.



Fig-1: ESP32 Microcontroller

2.2.Pump Motor

The transportation of fluids in vehicles differentiates into three sectors that require water pumps for well maintenance operations and domestic usage. The removal of water pumps becomes essential because seal deterioration blocks coolant circulation in vehicles. Water pressure remains stable throughout various locations within residential and commercial facilities because of pressure water pumps. The electromagnetic torque principles enable pumps that operate under DC motor power to transform direct current into mechanical motion. The motion control systems operate reciprocating or rotary styles and need energy for fluid movement. Pumps exist in a wide range of sizes from medical to industrial systems and receive energy from manual operation as well as electricity and motors and wind power sources. DC and AC versions of these devices run quietly while demanding either +12V DC or 230V AC voltage from the power supply.



Fig-2: Pump Motor

2.3.DC fan

Electronic circuits now use DC brushless cooling fans because of their powerful cooling capabilities. These fans derive their operation from the magnetic field effects on current-carrying conductors which create torque to produce motion. Such fans work with a standard voltage of 5V while drawing 360mA of current. The fan needs 10mA power from a 12VDC system to operate and control fan temperatures. DC brushless fans require designers to perform precise performance characteristics assessments which enables reliable operation while preventing operational problems. The fan assembly contains three components: a filter guard protects the equipment whereas the finger guard ensures user protection and the mounting clip provides a secure installation.



Fig-3: DC fan

2.4.Power Supply

The modification of both power signals and interface connectors through adapters ensures electrical system compatibility. Through their functionality adapters allow processors to communicate with peripherals for integrated interface with motherboard cards. Power adapters combine power and signal attributes to produce 12V DC from standard 220-230V AC for system operations. Serial port adapters ensure signal quality during their role in transforming 25-contact serial into 9-contact serial interfaces. These cost-effective tools provide an uninterruptable 1A current output which operates between 220-230V AC and 12V DC. System interoperability increases through WSDL files using J2CA extensions which generate metadata for effective data exchange. Through enterprise adapter systems one can establish smooth communication between Oracle backend applications to enhance operational system performance and make interactions between hardware and power supply automatic.



Fig-4: Power Supply

2.5.Relay Board

The relay functions as an electromechanical switch that applies electrical power through electromagnet activation and contact operation to regulate low-power circuits along with multiple circuit switching capabilities with one signal. Electric motors function with contactors which are categorized as relays when operating in high-power scenarios. A typical four-relay board consists of three major circuits including driver operations along with power supply and isolation system, while switching functions come from transistor utilization. The IN4007 diode serves in the isolation circuit to prevent reverse voltage damage of both the controller and transistors. The relay operates under

microcontroller-generated input pulses to execute quick switching operations involving motor forward and reverse commands. The board accepts 12VDC power together with a ULN2003A driver that works in AC/DC load and motor switching systems.

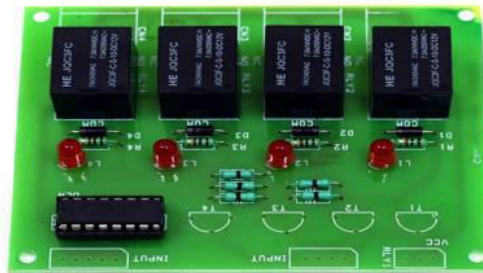


Fig-5: Relay Board

III. SYSTEM ARCHITECTURE AND MODULE INTERFACE

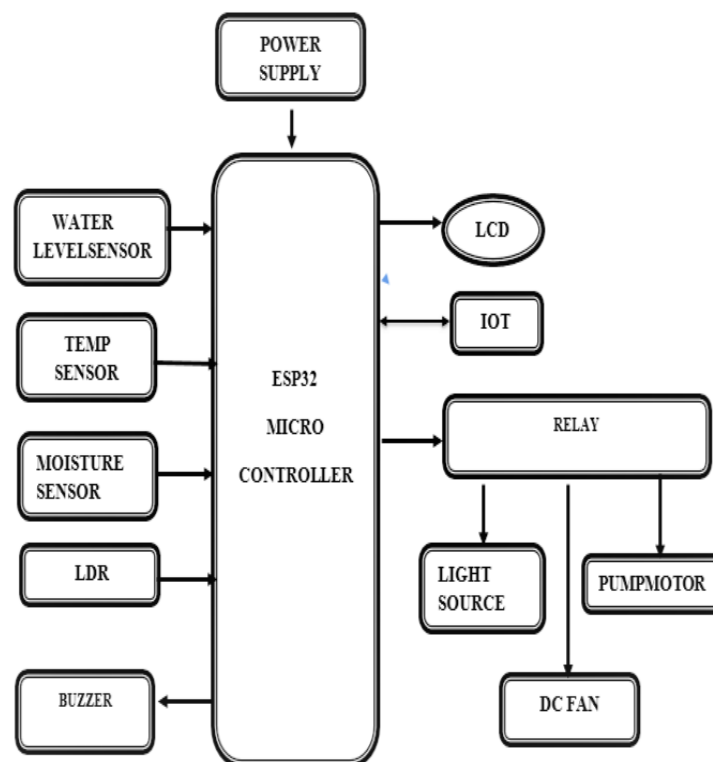


Fig-6: System Architecture

IV. BOARD HARDWARE RESOURCES FEATURES**4.1.Light Dependent Resistors**

Light Dependent Resistors (LDRs or photoresistors) function by photoconductivity because light absorption causes electrical resistance to decline through semiconductor valence-to-conduction band electron excitation. The application of light causes increased electrical conductivity and an associated decrease in resistance levels. LDRs represent high-resistance semiconductor materials which act as light-sensitive elements that find use in street lamps and alarm clocks and light intensity meters. This device functions with 5V power input and generates an analog signal while showing directional light patterns through its symbol.



Fig-7: Light Dependent Resistor

4.2Water Level Sensors

Level sensors provide measurements of both liquid heights and mixtures containing slurry together with heights of granules and powdered materials when free surfaces exist above. Selection of sensors demands evaluation of phase along with temperature, pressure, chemistry, dielectric constant, density, agitation, noise, vibration and container size and shape. Point-level sensors in these measurement systems provide binary output signals when levels reach preset set points. Continuous sensors monitor the continuous movement of substances in measurements. The device accepts 5V power supply for input while offering adjustable analog output signals ranging from 0 to 3V and provides detection measurement reaching up to 0.2 meters based on resistance values for level determination. System performance reaches its maximum when appropriate sensors used for measurement are selected.



Fig-8: Water Level Sensor

4.3 Temperature Sensor

As a precision temperature sensor from LM35 produces a linear output which directly corresponds to Celsius temperature measurements while maintaining approximations at $\pm\frac{1}{3}^{\circ}\text{C}$ for room conditions and $\pm\frac{3}{4}^{\circ}\text{C}$ for the complete -55°C to 150°C spectrum. This device self-heats at below 0.1°C level in static air conditions while supporting single and dual power sources and consuming $60\text{ }\mu\text{A}$ power consumption. The LM35 operates best as an ideal temperature sensor for power supplies and battery management and HVAC systems and appliances because it offers $+10\text{ mV}/^{\circ}\text{C}$ scale factor coupled with 0.5°C accuracy at 25°C .

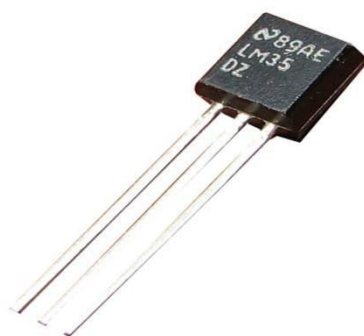


Fig-9: Temperature Sensor

4.4 Soil Moisture Sensor

The water content within the soil gets measured using soil moisture sensors via two methods which include electrical resistance or dielectric constant detection. This device provides two output modes which include digital for basic usage and analog for precision control while offering voltage outputs between 0-5V and adjustable sensitivity and threshold configurations. This type of sensor enables automated watering systems in agriculture production and landscape management and research applications through its portable design. The module functions with a 5V power source and gives digital and analog and serial output signals.

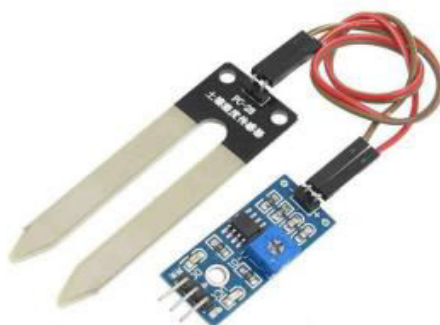


Fig-10: Soil Moisture Sensor

4.5 Liquid Crystal Display

An alphanumeric LCD display present in E-blocks shows 16 characters along each line while displaying 224 available characters and symbols. An 5V power supply connects to this device through the 9-way D-type connector during serial operation. Users can program this low-cost display through Flow code icons because it operates with different E-blocks I/O ports to serve as a monitoring instrument.



Fig-11: Liquid Crystal Display

4.6 Buzzer

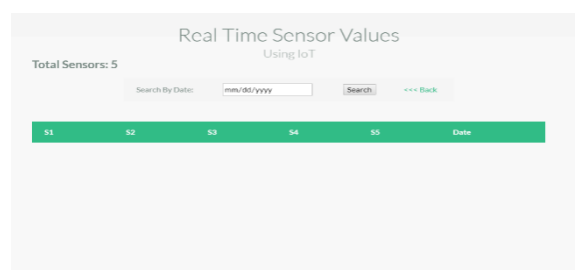
User input confirmation along with alarm systems and time counting functions use buzzer or beeper as an audio signaling device. The device produces continuous sounds when supplied with DC voltage and it appears in electronic toys and automotive equipment plus telephones. Operating at 5V DC power the device consumes 9.0 mA current to produce sounds reaching at least 85 dB with a frequency range between 3.0 to 0.5 kHz. The buzzer serves three main applications that include user input verification, electronic metronome features and annunciator panel functions.



Fig-12: Buzzer

4.7 Internet of Things (IoT)

Everyday objects connected through the Internet of Things (IoT) obtain data exchange ability by receiving electronics and software and sensor capabilities. The ESP32 microcontroller from Espressif Systems serves IoT applications excellently due to its Wi-Fi integrated solution which includes a 32-bit processor and onboard SRAM combined with low-power operation modes. The device provides support for multiple interfaces (SPI, SDIO, I2C, UART) together with features like adaptive radio biasing and signal processing and power management. The ESP32 offers dependable 2.4 GHz Wi-Fi connectivity and energy-efficient design which enables its use for traffic monitoring and health monitoring and logistics tracking and domestic applications while running real-time data updates through web platforms.

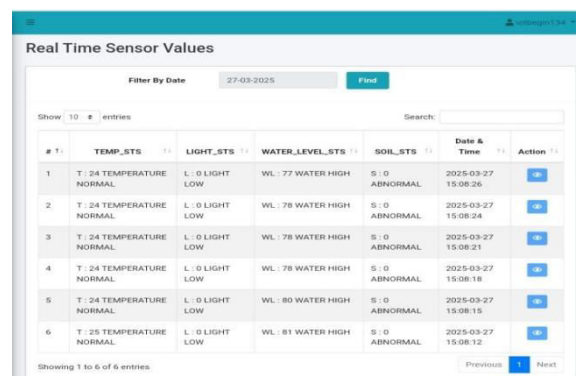


4.8 Embedded C

The ESP32 microcontroller from Espressif Systems is ideal for IoT applications, featuring integrated 2.4 GHz Wi-Fi, a 32-bit processor, SRAM, and low-power modes, supporting interfaces like SPI, SDIO, I2C, and UART. It excels in signal processing and power management for traffic, health, and logistics monitoring. While assembly programming remains essential for DSP optimization, Embedded C enhances performance by providing efficient memory access and hardware I/O addressing, improving portability and reducing code modifications. The Arduino UNO, with 54 digital I/O pins, 16 analog inputs, and support for UART, SPI, and I2C, offers ease of use, automatic reset via DTR, USB overcurrent protection, and compatibility with most shields, making it suitable for a wide range of applications.

4.9 Bluetooth Module and Android Application

The Bluetooth Low Energy module establishes wireless connection to an Android app for monitoring real-time soil moisture measurements and simultaneous temperature and humidity readings. Low Energy Bluetooth technology keeps its energy conservation features to enable prolonged system functioning. Users can retrieve plant health information through the Android application user interface by interacting with screens which also offer simple controls. Plant water management alerts become possible through this system because users can examine historical reports while making care adjustments to enhance their plant management approaches. The application interface enables automatic alerts led by AI suggestions for plant care which helps users maintain their smart plant tracking comfortably.



#	TEMP_STS	LIGHT_STS	WATER_LEVEL_STS	SOIL_STS	Date & Time	Action
1	T : 24 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 77 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:26	✖
2	T : 24 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 78 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:24	✖
3	T : 24 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 78 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:21	✖
4	T : 24 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 78 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:18	✖
5	T : 24 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 80 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:15	✖
6	T : 25 TEMPERATURE NORMAL	L : 0 LIGHT LOW	WL : 81 WATER HIGH	S : 0 ABNORMAL	2025-03-27 15:08:12	✖

Cellular applications need to connect to web server IP addresses or domains to allow remote IoT device monitoring and control using mobile phones.

V. CONCLUSION

Multiple sensors along with components form the SMART POT system for automated plant care. System coordination happens through the ESP32 controller which receives sensor data from water level and temperature and moisture and light monitoring devices. The pump motor operates automatically to apply water when the water tank reaches a low level. The DC fan operates through temperature-based adjustments for maintaining optimal plant environment conditions. The bulb operates as an additional illumination source when no artificial light source is available. The system allows remote real-time checks and adjustments through both web pages and smartphone applications for IoT control. An alert system through the buzzer helps the user maintain efficient plant management.

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