VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM

A
PROJECT REPORT
ON

"IOT BASED SOLAR POWERED SEED SPRAYER MACHINE"

Submitted in partial fulfillment of the requirements of the degree of

BACHELOR OF ENGINEERING
In
ELECTRONICS AND COMMUNICATION ENGINEERING

For the academic year
2025-2026

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CERTIFICATE

Certified that the Project work entitled **'IOT Based Solar Powered Seed Sprayer Machine'** is a bonafide work carried out by **Mr. Anish Regmi(1KN22EC003), Mr. Arif Alam(1KN22EC005)**, **Mr. Thaneshwor Adhikari(1KN22EC0051), Mr. Umesh Karki(1KN22EC053),** a bonafide students of **KNS Institute of Technology, Bengaluru** in partial fulfillment for the award of the degree of Bachelor of Engineering in **Electronics and Communication** of the **Visvesvaraya Technological University, Belagavi** during the Academic year 2025-2026. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the report deposited in the departmental library. The Project Phase 1 report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

Signature of the Guide	**Signature of the HOD**	**Signature of the Principal**

EXTERNAL VIVA

Name of the examiners	Signature with date
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ACKNOWLEDGEMENT

I am grateful to the Founder & Late Chairman of our college, **Mr. C. K. Jaffer Sharief,** for having provided us with excellent facilities in the college during the course to emerge as responsible citizen with Professional Engineering Skills and moral ethics.

I am indebted to the Chairman of our college, **Mr. Abdul Rahman Sharief,** for his constant support, motivation and encouragement to excel in academics and carryout project works.

I thank my Principal, **Dr. S. M. Prakash,** for facilitating a congenial academic environment in the College.

I am thankful to my HOD**, Dr. Aijaz Ali Khan,** for his kind support, guidance and motivation during the B.E Degree Course and especially during the Course of my project work.

I thank my Guide **Mrs. Lubna Afza**, Asst. prof. ECE for her valuable guidance, Suggestions and Encouragement throughout my project work.

I am also thankful to all the **staff members of the Department of Electronics and Communication** and all those who have directly or indirectly helped with their valuable suggestions in the successful completion of this project report.

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ABSTRACT

This project presents the design and development of an **IoT-based Solar Powered Seed Sprayer Machine** aimed at improving the efficiency and sustainability of agricultural practices. It is a shining example of agricultural technical innovation, provides a long term and efficient alternative to the traditional, labour- intensive procedure of seeding. By harnessing the power of the sun, this technology eliminates the need for fossil fuel- powered motors, lowering greenhouse gas emissions and boosting environmental sustainability.

The machine integrates solar energy as a renewable power source, eliminating dependency on conventional electricity or fossil fuels, and making it ideal for remote or off-grid farming areas. It employs a motorized spraying mechanism mounted on a mobile platform to evenly distribute seeds across farmland.

The system is equipped with IoT capabilities that allow real-time monitoring and control through a smartphone or web-based application. Sensors are used to collect data such as soil moisture, temperature, and GPS location, which are transmitted to a cloud platform for analysis and decision-making. The machine can be operated manually or automatically, enhancing flexibility and reducing labour costs. With its eco-friendly energy source, data-driven operation, and autonomous functionality, this system represents a significant step toward smart and sustainable agriculture.

CHAPTER- 1

INTRODUCTION

Agriculture plays a crucial role in sustaining the global economy and human livelihood. In recent decades, the agricultural sector has faced several challenges such as shortage of skilled labour, rising fuel costs, and inefficient manual farming techniques. Traditional seed sowing and pesticide spraying methods are time-consuming, labour-intensive, and often lack precision, resulting in poor crop yields and wastage of resources.

The proposed IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine is designed to automate essential agricultural processes using renewable energy and intelligent control systems. The system integrates solar power, sensors, and Internet of Things (IoT) technology to perform seed sowing, watering, and pesticide spraying operations autonomously. By harnessing solar energy, the machine operates efficiently even in remote or off-grid locations, reducing dependency on conventional power sources and minimizing environmental pollution.

At the core of the system is an ESP32 microcontroller, which collects data from sensors such as soil moisture, temperature, and humidity. Based on these inputs, it makes real-time decisions to control various actuators like the seed dispenser, water pump, and pesticide sprayer. The IoT connectivity allows the farmer to monitor and control the machine remotely through a smartphone application, ensuring convenience and operational flexibility.

This project not only enhances agricultural productivity but also contributes to sustainable farming by utilizing clean energy and automation. It represents a step toward smart and precision agriculture, where data-driven insights and renewable resources are combined to optimize field operations.

1.1 Motivation

In today's world, there is an urgent need to introduce automation and renewable energy into agriculture to make farming more efficient, sustainable, and less labour-intensive. The IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine project is motivated by this need to bridge the gap between conventional farming and modern smart agriculture.

The key motivations behind this project are:

Reducing Manual Effort: To minimize the physical labour required for repetitive tasks like seed sowing, watering, and spraying pesticides.

- Promoting Renewable Energy: To utilize solar power as a clean and sustainable energy source, reducing dependency on electricity and fossil fuels.
- Enhancing Efficiency and Accuracy: To achieve precise seed placement and uniform spraying, improving crop quality and yield.
- Introducing IoT in Agriculture: To enable remote monitoring and control of field operations using sensors and mobile applications.
- Supporting Small and Medium-Scale Farmers: To develop a low-cost, portable, and user-friendly solution that benefits farmers in rural and off-grid areas.

In essence, this project is driven by the vision of creating a smart, energy-efficient, and sustainable farming system that integrates modern technology with traditional agricultural practices — empowering farmers to achieve higher productivity and profitability with less effort.

1.2 Scope of the Project

The IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine is designed to revolutionize traditional agricultural practices by integrating automation, renewable energy, and IoT technologies into a single, efficient farming solution. The scope of this project extends from the design and development of the system to its practical application in the field, focusing on improving productivity, sustainability, and ease of operation.

This project primarily aims to automate three major farming operations seed sowing, watering, and pesticide spraying using solar energy as the main power source. By incorporating IoT-enabled sensors and smart control, the machine provides real-time monitoring and remote operation through a mobile application, making it suitable for both rural and off-grid areas.

The main areas covered under the scope include:

- Integration of Renewable Energy: Utilization of solar panels to power the machine, ensuring eco-friendly and uninterrupted operation even in areas without electricity.

- IoT-Based Monitoring and Control: Implementation of sensors such as soil moisture, temperature, and humidity sensors to collect real-time data and transmit it to a mobile application for remote supervision.
- Portability and Ease of Use: Development of a compact, lightweight, and mobile machine that can easily move across different types of farmlands.
- Scalability and Adaptability: The system can be modified or expanded in the future to include fertilizer spraying, GPS-based navigation, or AI-based crop monitoring.
- Sustainability and Cost-Effectiveness: By reducing manual labour and fuel consumption, the project ensures low operational cost and supports long-term sustainable agriculture.

1.3 Importance of the Project

The major importance of this project includes:

- Promotes Sustainable Agriculture: By using solar energy, the system minimizes reliance on non-renewable resources and reduces carbon emissions, contributing to environmentally friendly farming.
- Reduces Labor Dependency: Automating seeding and spraying operations helps overcome labour shortages and decreases the physical workload of farmers.
- Enhances Accuracy and Productivity: Sensors and programmed control ensure precise seed placement and uniform pesticide spraying, leading to improved crop yield and resource optimization.
- Enables Smart Monitoring: Through IoT integration, farmers can monitor soil and environmental conditions remotely using a smartphone, allowing data-driven decisions for better crop management.
- Cost-Effective and Energy-Efficient: The use of solar energy and low-power electronic components lowers operational costs, making it affordable even for small and medium-scale farmers.
- Supports Technological Advancement in Farming: Encourages the adaptation of modern technologies in rural areas and serves as a model for future innovations in precision agriculture.

CHAPTER- 2

LITERATURE SURVEY

[1] Yin Wu, Zenan Yang and Yanyi Liu," Internet-of-Things- Based Multiple-Sensor Monitoring System for Soil Information Diagnosis Using a Smartphone" Micromachines 2023, 14, 1395. Their study introduces an IoT-based system for real-time soil measurements, comprising sensors, a microprocessor, a cloud platform, and a mobile app. Energy-efficient hardware and a novel prediction model enhance accuracy and efficiency.

[2] E. Prasanthi, M. Poojitha, N. Sravani, N. Sravani, M. Vasundhara, "IOT based Solar Powered Agribot using Arduino Controller", Turkish Journal of Computer and Mathematics Education Vol.14 No.02 (2023),413- 421. This innovative system aims to harness solar power for automatic ploughing, seeding, and watering, facilitated through an IoT application. The Agricultural Robot is designed to monitor essential environmental parameters such as temperature, humidity, and soil moisture, with data uploaded to the IoT application for analysis.

[3] Hari Mohan Rai, Deepak Gupta, Sandeep Mishra, Himanshu Sharma, "Agri-Bot: IoT Based Unmanned Smart Vehicle for Multiple Agriculture Operation", 2021 International Conference on Simulation, Automation & Smart Manufacturing (SASM) GLA University, Mathura, India. August 20-21, 2021. They introduce the Agri-Bot, an autonomous smart agriculture robot capable of performing various tasks such as planting, ploughing, fertilizing, and harvesting without human intervention. The Agri-Bot functions as automated agricultural equipment, performing tasks like ploughing, sowing, and fertilizing across entire fields based solely on the field's dimensions as input.

[4] Kolekar Prathamesh Prashant, Patil Abhijeet Bhimrao, Patil Prathamesh Tanaji, Vanare Rohan Tanaji, "Solar powered remote controlled seed sowing machine with sprayer", International Journal of Advances in Engineering and Management (IJAEM)Volume 3, Issue 8 Aug 2021, pp:424-440 www.ijaem.net ISSN: 2395-5252. They aim to address these challenges through the design and development of a solar powered remote-controlled seed-sowing machine with a sprayer. Traditionally, seed sowing and fertilization in India rely on manual labour, oxen, or tractor operations, all of which are time-consuming and less productive. Additionally, tractor operations contribute to environmental pollution through fossil fuel emissions.

[5] Mr. Ashok Kumar M, Arun Kumar N, Hemanth M, Krishnan N, Anil Kumar N, “Design of IoT based Dam Controlling and Monitoring System”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 08 Issue: 05 May 2021. The system aims to provide real-time monitoring and control of dam operations, enhancing safety and efficiency. It utilizes IoT technologies to collect and transmit data on water levels, pressure, and other critical parameters, enabling remote monitoring and automated control. This system can help prevent dam failures, optimize water management, and improve overall dam operations.

CHAPTER- 3

BLOCK DIAGRAM

3.1 Block Diagram

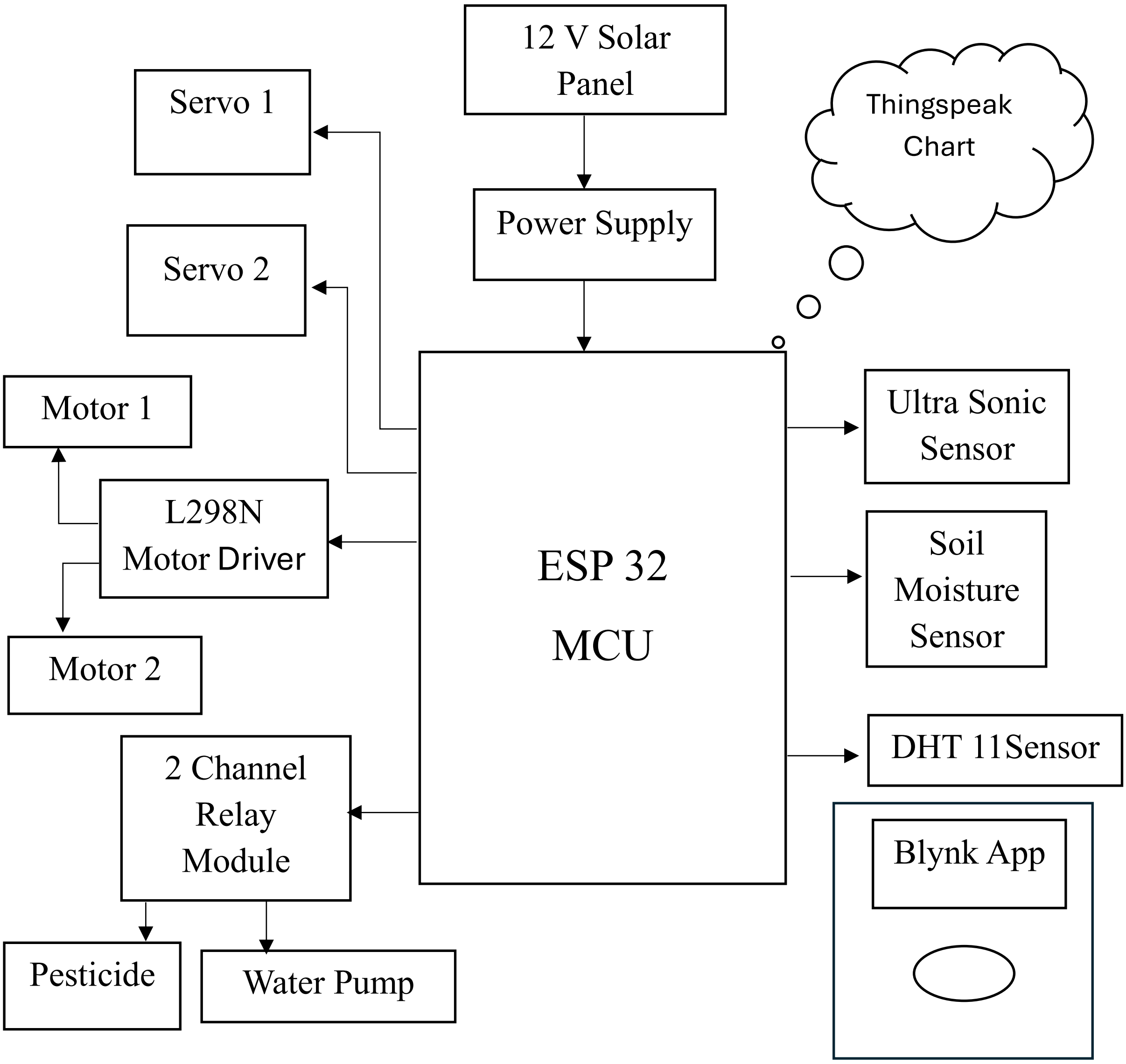

Fig 3.1 Block Diagram of proposed model

The proposed system uses an ESP32 microcontroller as the central unit, powered by a 12V solar panel. It connects various sensors like the ultrasonic sensor, soil moisture sensor, and DHT11 to monitor environmental parameters. The ESP32 controls motors and servo motors via an L298N motor driver and operates a water pump and pesticide sprayer using a 2-channel relay module. Data is displayed and monitored remotely through the Blynk app and ThingSpeak platform, enabling smart irrigation and pesticide management for efficient and sustainable farming.

3.2 Block Diagram Description

1. Solar Power Supply Unit

Components:
Solar Panel, Rechargeable Battery (12V), and Voltage Regulator.

Function:

- The solar panel converts sunlight directly into electrical energy (DC power).
- The generated energy is used to charge a 12V lead-acid or lithium battery .
- A voltage regulator (e.g., 7805) provides a stable 5V output for the ESP32 microcontroller and sensors.
- The battery stores energy for continuous operation, allowing the system to run even during low sunlight conditions.

Purpose:
To supply clean, renewable, and uninterrupted electrical power to all electronic and motor components in the system.

2. Microcontroller Unit (ESP32)

Components:
ESP32 Development Board (integrated with Wi-Fi and Bluetooth).

Function:

- Acts as the central processing unit of the entire system.
- Receives signals from all sensors and compares them with predefined threshold values.
- Controls the operation of DC motors, water pumps, and pesticide dispensers accordingly.
- Sends live sensor data to the Blynk App via Wi-Fi for remote monitoring and control.

Purpose:
To perform decision-making, automation, and communication tasks using embedded programming logic.

3. Actuator and Control Section

Components:
DC Motors, Seed Dispenser Motor, Water Pump, Pesticide Sprayer, Motor Driver (L298N), Vehicle Chassis.

Function:

- DC Motors: Drive the wheels and enable movement of the machine.
- Seed Dispenser Motor: Rotates a mechanical dispenser to release seeds at uniform intervals.
- Water Pump: Sprays water over the soil after seeding to maintain moisture.
- Pesticide Dispenser Motor: Activates the pesticide spray mechanism to prevent pest attacks.
- L298N Motor Driver: Interfaces between ESP32 and motors, providing required current and direction control.

Purpose:
To convert control signals from the microcontroller into physical motion and spraying actions on the field.

4. IoT and Monitoring Section

Components:
Blynk Mobile App, Wi-Fi Connectivity (via ESP32).

Function:

- Displays real-time data of soil moisture, temperature, and humidity.
- Allows the user to remotely control seed, water, or pesticide operations manually if needed.
- Provides data logging and visualization through the Blynk cloud platform.

Purpose:

To enable smart, user-friendly, and remote access to all machine operations through a smartphone.

5. Soil Moisture Sensor

Purpose:

To measure the amount of water present in the soil and help the user decide when irrigation is needed.

Working Principle:

- The soil moisture sensor measures the electrical resistance between two conductive probes.
- Wet soil → Low resistance → High moisture reading.
- Dry soil → High resistance → Low moisture reading.

Function in System:

- The sensor output is sent to the ESP32, which uploads the data to the ThingSpeak Cloud.
- The moisture percentage is displayed on both ThingSpeak and Blynk App dashboards.
- The farmer can manually turn ON/OFF the water pump using the Blynk control buttons based on this live soil data.
- Advantage:
  Provides accurate field moisture information to avoid overwatering or water scarcity.

6. DHT11 Sensor (Temperature and Humidity Sensor)

Purpose:
To measure the environmental temperature and humidity around the machine for effective monitoring of crop conditions.

Working Principle:

- The DHT11 uses a thermistor to detect temperature changes and a capacitive humidity sensor to measure air moisture content. The sensor converts these analog readings into digital data for the ESP32.

Function in System:

- The ESP32 collects temperature and humidity readings at regular intervals.

- These readings are transmitted to ThingSpeak Cloud, where they are displayed in graphical form for data logging and trend analysis.
- They are also shown on the Blynk App interface in real time.
- Advantage:
  Helps the farmer understand environmental conditions that affect seed germination and pesticide effectiveness.

7. Ultrasonic Sensor (Obstacle Detection)

Purpose:
To detect any obstacle in front of the machine during movement.

Working Principle:

- The ultrasonic sensor sends out high-frequency sound waves via the TRIG pin and receives the reflected echo on the ECHO pin. The ESP32 calculates the distance of the obstacle using the time delay between transmission and reception.

Function in System:

- The measured distance value is displayed on the ThingSpeak Cloud and Blynk App in real time.
- The sensor does not automatically stop the machine; instead, the operator can view the distance data and manually control movement from the Blynk App to avoid obstacles.

Advantage:

- Provides situational awareness for the user and helps safely navigate the machine through the field.

8. IoT Data Transmission and Monitoring

- All sensor readings (soil moisture, temperature, humidity, and distance) are transmitted via Wi-Fi from the ESP32.
- Blynk App: Used for manual control of all actuators (seed motor, water pump, pesticide sprayer).
- ThingSpeak Cloud: Used for continuous data logging and visualization of sensor readings in graph format.

CHAPTER- 4

HARDWARE AND SOFTWARE DESCRIPTION

4.1 Hardware Description

4.1.1 ESP 32

The ESP32 is a highly integrated, low-cost, and low-power System-on-Chip (SoC) microcontroller developed by Espressif Systems. It is one of the most advanced microcontrollers designed for IoT (Internet of Things), automation, and wireless communication applications. It features a dual-core 32-bit Tensilica Xtensa LX6 processor, built-in Wi-Fi and Bluetooth connectivity, and multiple peripheral interfaces such as ADC, DAC, UART, SPI, I2C, and PWM. This combination of processing capability, wireless communication, and low energy consumption makes the ESP32 ideal for smart systems, including IoT-based solar-powered agricultural automation like your Seed Sprayer and Pesticide Dispenser Machine.

The ESP32 follows a Harvard architecture, meaning it has separate memory and buses for program and data. It executes instructions from flash memory using its dual-core CPU for parallel tasks such as data processing and IoT communication. The analog data from sensors (like soil moisture and DHT11) is processed through the ADC channels, while digital data (like ultrasonic distance) is read through GPIO pins. The processed information is uploaded to the cloud, and control signals received from the Blynk app are used to operate different actuators via the motor driver.

This allows real-time monitoring and manual control through a smartphone, making ESP32 the central element of the entire IoT network.

Fig 4.1.1 ESP 32

Technical Specifications

1. Processor: Dual-core 32-bit Tensilica Xtensa LX6 CPU
2. Clock Speed: 160 MHz to 240 MHz
3. Operating Voltage: 3.3V (logic level)
4. Input Voltage (VIN): 5V DC (via USB or external supply)
5. Flash Memory: 4 MB
6. SRAM: 520 KB
7. Wi-Fi Connectivity: IEEE 802.11 b/g/n (2.4 GHz)
8. Bluetooth Version: v4.2 (Classic + BLE)
9. GPIO Pins: 30 multi-purpose input/output pins
10. ADC Channels: 18 channels (12-bit resolution)
11. DAC Channels: 2 channels (8-bit resolution)
12. Communication Interfaces: UART, SPI, I2C, I2S, CAN, PWM
13. USB-to-Serial Converter: CP2102 chip
14. Power Consumption: Approximately 80 mA (active mode)
15. Programming Platform: Arduino IDE / ESP-IDF

4.1.2 Soil Moisture Sensor

The Soil Moisture Sensor is one of the key sensing components in this IoT-based agricultural system. It is used to measure the volumetric water content in the soil and determine whether the soil is dry, moist, or wet. In this project, the sensor continuously monitors soil conditions and sends analog readings to the ESP32 microcontroller, which processes the data and uploads it to the ThingSpeak Cloud for visualization. The readings help farmers make data-driven decisions and manually operate the water pump using the Blynk App, ensuring optimal irrigation and water conservation.

The sensor consists of two conductive metal probes that are inserted into the soil to detect moisture levels. When the soil is wet, water molecules conduct electricity between the probes more effectively, resulting in lower resistance and higher output voltage. Conversely, dry soil has less conductivity, leading to higher resistance and lower output voltage. The ESP32's analog-to-digital converter (ADC) reads this voltage variation and converts it into a numerical value representing the soil's moisture percentage. The soil moisture sensor provides a reliable way to monitor soil water content in real time. Its integration with ESP32, Blynk, and

ThingSpeak makes the entire irrigation system intelligent and efficient, allowing farmers to control water usage directly from their smartphones.

This sensor operates on low voltage (3.3V–5V), making it directly compatible with microcontrollers like ESP32 and Arduino. It is a low-cost, low-power, and easy-to-use component, ideal for smart agriculture, automatic irrigation, and soil monitoring systems. By integrating it with IoT platforms, the sensor provides farmers with real-time soil data, improving water usage efficiency and supporting sustainable farming practices.

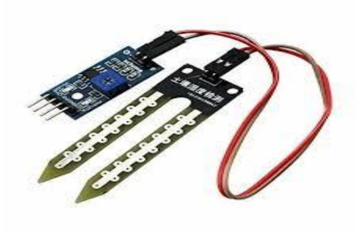

Fig 4.1.2 Soil Moisture Sensor

Technical Specifications

1. Operating Voltage: 3.3V – 5V DC
2. Operating Current: < 35 mA
3. Output Type: Analog and Digital
4. Analog Output Range: 0 – 4.2V DC
5. Digital Output Signal: High (wet) / Low (dry)
6. Sensing Element: Dual-probe resistive type
7. Measurement Range: 0% – 100% soil moisture
8. Sensitivity Adjustment: Using onboard potentiometer (for digital output)
9. Interface Type: Analog (A0) and Digital (D0) output pins
10. Response Time: < 1 second

4.1.3 DHT11 (Temperature and Humidity Sensor)

The DHT11 is a widely used digital temperature and humidity sensor designed for environmental monitoring applications. It combines a capacitive humidity sensor and a thermistor into a single module to provide reliable and calibrated temperature and humidity readings. In this project, the DHT11 plays a vital role in monitoring ambient climatic conditions around the agricultural field.

The sensor periodically measures the relative humidity and temperature, then sends the digital data to the ESP32 microcontroller using a single data pin. The ESP32 processes these readings and uploads them to the ThingSpeak Cloud, allowing the farmer to monitor real-time weather conditions remotely via graphs and dashboards. This helps in understanding the field's microclimate and making informed decisions about watering, spraying, and seeding operations.

The DHT11 sensor works by using a capacitive humidity sensing element, where the dielectric constant changes with humidity, altering the capacitance value. A Negative Temperature Coefficient (NTC) thermistor measures temperature by changing its resistance with temperature variation. The built-in 8-bit microcontroller inside the DHT11 converts analog signals from both sensing elements into digital output, ensuring high accuracy and easy interfacing.

It operates on low power (3.3V–5V) and communicates via a single-wire serial interface, making it highly suitable for IoT-based embedded systems like this solar-powered seed sprayer and pesticide dispenser. The DHT11 is cost-effective, easy to use, and durable, making it a dependable sensor for monitoring environmental parameters in smart agriculture applications. It provides precise and stable measurement of temperature and humidity, essential for optimizing agricultural processes. Integrated with ESP32, the data is uploaded to ThingSpeak Cloud, enabling farmers to monitor environmental conditions in real time. Its low cost, simple interface, and reliable performance make it an ideal choice for IoT-based smart farming and automation systems.

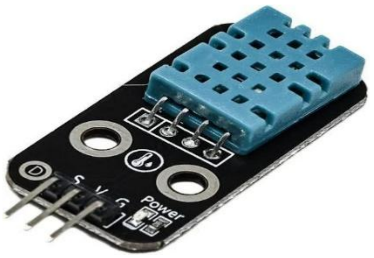

Fig 4.1.3 DHT 11 Sensor

Technical Specifications

1. Operating Voltage: 3.3V – 5V DC
2. Operating Current: 0.3 mA (measuring), 60 µA (standby)
3. Temperature Measuring Range: 0°C – 50°C
4. Humidity Measuring Range: 20% – 90% RH
5. Temperature Accuracy: ±2°C
6. Humidity Accuracy: ±5% RH
7. Sampling Rate: 1 Hz (one reading per second)
8. Signal Type: Digital (single-wire serial)

9. Interface: Single data pin connection to ESP32
10. Output Resolution: 8-bit (integrated digital signal)
11. Sensor Type: Capacitive humidity + NTC temperature
12. Response Time: <2 seconds

4.1.4 L298N Motor Driver

The L298N Motor Driver Module is a dual H-Bridge motor driver designed to control the direction and speed of two DC geared motors simultaneously. It is one of the most commonly used driver modules for robotics and automation projects that require high-current motor control.

In this project, the L298N motor driver is specifically used to control the DC geared motors that drive the chassis of the IoT-based solar-powered seed sprayer and pesticide dispenser machine. The chassis movement, including forward, reverse, left, and right turns, is managed through commands sent from the Blynk App, which are processed by the ESP32 microcontroller.

Since the ESP32 can only supply limited current from its GPIO pins, it cannot directly operate the high-torque DC motors used in the system. The L298N module acts as an interface, receiving low-current logic signals from the ESP32 and delivering sufficient current to the DC motors to control their motion. The module features two input pairs (IN1–IN4) for direction control and two enable pins (ENA and ENB) that can be driven by PWM signals from the ESP32 to regulate motor speed. The module operates on 12V DC, supplied by the rechargeable battery connected to the solar panel. It also has an onboard 5V regulator and freewheeling diodes to protect the circuit from voltage spikes caused by back EMF during motor switching.

Thus, the L298N motor driver plays a crucial role in providing safe, efficient, and stable control of the movement motors in the machine, ensuring smooth and reliable navigation over the field surface.

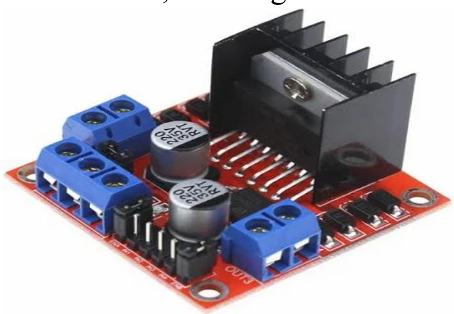

Fig 4.1.4 L298N Motor Driver

Technical Specifications

1. IC Used: L298N Dual H-Bridge Motor Driver IC
2. Operating Voltage: 5V – 35V DC
3. Logic Voltage (Control Input): 3.3V – 5V (compatible with ESP32)
4. Output Current: Up to 2A per channel
5. Number of Channels: 2 (for two DC geared motors)
6. Input Control Pins: IN1, IN2, IN3, IN4
7. Enable Pins: ENA, ENB (for PWM-based speed control)
8. Motor Voltage Drop: Approximately 2V
9. Power Dissipation: Up to 25W (with heat sink)
10. Onboard Regulator: 5V voltage regulator for logic circuitry

4.1.5 Ultrasonic Sensor

The HC-SR04 Ultrasonic Sensor is a non-contact distance measuring device that uses sound waves to detect the presence of objects or obstacles in front of it. It operates by emitting an ultrasonic pulse and measuring the time it takes for the echo to return after hitting an object. The ESP32 microcontroller then calculates the distance based on the time delay between transmission and reception of the ultrasonic wave.

In this project, the ultrasonic sensor is mounted on the front of the machine to detect obstacles in its path while moving across the agricultural field. The sensor continuously measures the distance of any object in front of the robot and sends the data to the ESP32, which then uploads it to the ThingSpeak Cloud. This allows the user to monitor obstacle distances remotely through the IoT dashboard.

It is important to note that in this system, the ultrasonic sensor only detects obstacles but does not automatically stop or control the movement of the machine. The farmer manually controls the direction and speed of the robot using the Blynk App.

The sensor is highly reliable, low-cost, and easy to interface with microcontrollers. It operates efficiently on a 5V DC power supply and provides stable readings for distances up to 400 cm. This makes it suitable for agricultural robotics applications where environmental awareness is required for safe operation.

Fig 4.1.5 Ultrasonic Sensor

Technical Specifications

1. Model: HC-SR04 Ultrasonic Sensor
2. Operating Voltage: 5V DC
3. Operating Current: 15 mA (typical)
4. Measuring Range: 2 cm – 400 cm
5. Measuring Angle: 15° cone angle
6. Accuracy: ±3 mm
7. Resolution: 1 cm
8. Operating Frequency: 40 kHz ultrasonic pulse
9. Trigger Input Signal: 10 µs HIGH pulse
10. Echo Output Signal: Pulse width proportional to distance
11. Interface Type: Digital I/O (Trigger and Echo pins)
12. Response Time: < 50 ms

4.1.6 Relay Module

The Relay Module is an electrically operated switch used to control high-power devices using low-power signals from a microcontroller. In this project, the relay module is used to control the water pump and pesticide dispenser pump, both of which operate on 12V DC.

Since the ESP32 microcontroller works at a logic level of 3.3V, it cannot directly drive high-current devices like pumps. The relay acts as an interface that allows the ESP32 to control these pumps safely. When the ESP32 sends a HIGH signal to the relay's input pin, the coil inside the relay energizes, creating a magnetic field that closes the switch contacts. This allows current from the 12V battery to flow to the connected pump, turning it ON. When the signal goes LOW, the coil de-energizes and the circuit opens, turning the pump OFF.

Each relay is connected to a separate control pin on the ESP32, enabling independent control of the water pump and pesticide pump via the Blynk App. The farmer can manually start or stop the pumps using their smartphone, allowing efficient control of spraying and irrigation operations.

The relay module includes optocouplers for signal isolation, indicator LEDs for switching status, and flyback diodes for protection from voltage spikes. It is a simple, reliable, and essential component for connecting low-power control circuits with high-power loads in IoT-based systems.

Fig 4.1.6 Relay Module

Technical Specifications

1. Relay Type: Electromagnetic (SPDT or SPST)
2. Operating Voltage: 5V DC (input trigger)
3. Control Signal Voltage: 3.3V – 5V (compatible with ESP32)
4. Contact Rating: 10A at 250V AC / 10A at 30V DC
5. Trigger Current: 15 – 20 mA
6. Switching Time: <10 ms
7. Protection Circuit: Flyback diode across relay coil
8. Indicator LED: Status LED for each relay channel
9. Number of Channels: 1, 2, or 4 (2-channel used in project)
10. Input Interface: IN1, IN2 (control inputs)
11. Common Terminals: COM, NO (Normally Open), NC (Normally Closed)

4.1.7 Submersible Pump

The submersible water pump is used for spraying water or liquid pesticide from the tank. It operates on 12V DC and is controlled via the relay module connected to the ESP32. The user can manually turn the pump ON or OFF using the Blynk App.

This mini-DC pump works by using a small DC motor connected to an impeller that forces liquid through an outlet when powered. Being submersible, it can be placed directly inside the water or pesticide tank. Its compact size, light weight, and low power consumption make it ideal for small-scale agricultural spraying applications.

The pump ensures uniform spraying of water or pesticide over the crops when activated. Since the relay is used as the switching interface, the ESP32 controls the operation remotely and safely. The pump draws power directly from the 12V rechargeable battery, which in turn is charged by the solar panel.

This setup ensures energy efficiency, cost-effectiveness, and reliability for field use. The pump's simple design, corrosion resistance, and waterproof body make it durable even in outdoor agricultural environments.

Fig 4.1.7 Submersible Pump

Technical Specifications

1. Operating Voltage: 12V DC
2. Operating Current: 0.3A – 0.8A
3. Power Consumption: 5W – 10W
4. Flow Rate: 120 – 180 L/h
5. Maximum Head: 1.5 – 2 meters
6. Pump Type: Submersible centrifugal pump
7. Material: Plastic housing (waterproof)
8. Control Method: ON/OFF through relay module
9. Drive Mechanism: DC motor with impeller
10. Noise Level: < 50 dB
11. Operating Temperature: 0°C – 60°C
12. Pump Efficiency: 70% – 80%

4.1.8 Solar Panel

The solar panel serves as the main renewable power source for the IoT-based solar-powered seed sprayer and pesticide dispenser machine. It converts sunlight into electrical energy through the photovoltaic (PV) effect, providing the necessary power to charge the 12V rechargeable battery, which in turn supplies energy to the ESP32, sensors, motor driver, and pumps.

In this project, two 6V solar panels are used, each rated at around 10W, and they are connected in series to obtain a combined output of approximately 12V DC. This configuration ensures adequate voltage for charging the 12V battery directly without the need for an MPPT or charge controller. During daylight, the solar panels generate current that flows directly into the battery, replenishing its charge. The stored energy is then used to operate all electronic and mechanical components of the system, making it self-sustaining and independent of grid power.

The panels consist of polycrystalline solar cells, which are cost-effective, durable, and efficient under various light conditions. The use of solar energy in this project not only ensures environmental sustainability but also reduces operational costs and promotes clean, renewable energy utilization in farming operations.

Fig 4.1.8 Solar Panel

Technical Specifications

1. Type: Polycrystalline Solar Panel
2. Number of Panels Used: 2 units connected in series
3. Voltage (each panel): 6V DC
4. Combined Output Voltage: ~12V DC (in series)
5. Rated Power (each): 10W
6. Total Power Output: 20W (combined)
7. Current Output (each): 1.6A (approx.)
8. Combined Current Output: 1.6A (same current in series connection)
9. Open Circuit Voltage (combined): 13V – 14V (approx.)

10. Material: Polycrystalline silicon cells with tempered glass cover

4.1.9 Batteries

The Agribot uses two separate batteries to ensure reliable operation of both control electronics and high-current devices. The first is a Li-ion rechargeable battery, which powers the ESP32 microcontroller, sensors, DC gear motors, and servo motor. Li-ion batteries are lightweight, have high energy density, and provide a stable voltage output, making them ideal for mobile robotic applications. This battery ensures continuous operation of the control and mobility systems even while the robot moves across uneven terrain. The second battery is a 9V Hi-Watt battery, dedicated to powering the water pump and pesticide dispenser pump through relay modules. By using a separate battery for high-current pumps, voltage drops and interference with the microcontroller and sensors are avoided, enhancing system stability and safety. The 9V Hi-Watt battery delivers sufficient current to operate the pumps reliably for irrigation and pesticide spraying, independent of the control electronics.

Fig 4.1.9 Batteries

Technical Specifications

1. Battery Types: Li-ion rechargeable battery (for control and mobility), 9V Hi-Watt battery (for pumps)
2. Nominal Voltage: Li-ion: 3.7 V, 9V Hi-Watt: 9 V
3. Full Charge Voltage: Li-ion: 4.2 V, 9V Hi-Watt: 9–9.5 V
4. Capacity: Li-ion: ~2200 mAh, 9V Hi-Watt: ~500–600 mAh
5. Maximum Continuous Discharge Current: Li-ion: 1–2 A, 9V Hi-Watt: 500–800 mA (peak up to ~1 A)
6. Cycle Life: Li-ion: 300–500 cycles, 9V Hi-Watt: 200–400 cycles (if rechargeable)
7. Energy Density: Li-ion: ~150–200 Wh/kg, 9V Hi-Watt: ~100–150 Wh/kg
8. Purpose in Agribot: Li-ion: Powers ESP32, sensors, DC gear motors, and servo motor, 9V Hi-Watt: Powers water pump and pesticide dispenser pump via relay modules

4.1.10 Servo Motor

A servo motor is a rotary actuator that allows precise control of angular position, speed, and acceleration. It consists of a DC motor, a feedback sensor (usually a potentiometer), and a control circuit. Servo motors differ from regular DC motors because they can rotate to a specific angle rather than spinning continuously, making them ideal for applications requiring precision.

In the Agribot project, the servo motor is used for seed dispensing and ploughing mechanisms. For seed dispensing, the servo rotates a mechanism to release seeds at precise intervals, ensuring even planting. For ploughing, it can adjust the position or angle of the ploughing tool to maintain proper soil engagement, providing consistent ploughing depth. The servo receives Pulse Width Modulation (PWM) signals from the ESP32 microcontroller, which determines the rotation angle.

Servo motors are compact, lightweight, and highly reliable, making them suitable for mobile robots like the Agribot. They require low power, are easy to integrate with microcontrollers, and can maintain their position under load, which is critical for energy efficiency in battery-operated systems. The precise control enables the Agribot to perform tasks automatically under operator commands via the Blynk app.

Fig 4.1.10 Servo Motor

Technical Specifications

1. Motor Type: DC Servo Motor
2. Control Type: Pulse Width Modulation (PWM)
3. Operating Voltage: 4.8V – 6.0V
4. Operating Current: 100–250 mA (no load), up to 500 mA (under load)
5. Stall Current: ~1 A (depends on model)
6. Speed: ~0.1–0.2 sec/60° (standard micro servo)
7. Torque: 1.5–2.5 kg·cm (sufficient for seed dispensing and ploughing)

8. Rotation Range: 0° – 180° (standard), some models 360° continuous
9. Deadband Width: 2–5 µs (PWM signal resolution)
10. Applications in Agribot: Seed dispensing and ploughing mechanisms
11. Mounting: Standard servo horn with screws for mechanical attachment

4.1.11 D.C Gear Motor

A DC gear motor is an electric motor combined with a gearbox to provide high torque at low speed, making it ideal for driving mobile robots. The gearbox reduces the speed of the motor while increasing torque, which is essential for moving a robot like the Agribot over uneven soil and carrying loads such as water, pesticide, or ploughing equipment.

In the Agribot project, two DC gear motors are used to drive the wheels, enabling forward, backward, and turning movements. The motors are connected to an L298N motor driver module, which allows control of direction and speed via the ESP32 microcontroller. The motors receive PWM signals for speed control and digital signals for direction control.

DC gear motors are durable, efficient, and capable of providing continuous torque under load, which is important for agricultural tasks where the robot may encounter soil resistance or slopes. Their compact size and high torque-to-weight ratio make them ideal for mobile platforms. Using two motors allows differential drive, meaning the Agribot can turn and navigate accurately based on commands from the Blynk app. These motors are powered by the three Li-ion batteries, ensuring portable operation in the field.

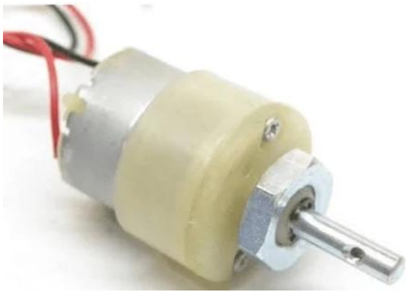

Fig 4.1.11 D.C Gear Motor

Technical Specifications

1. Motor Type: DC Gear Motor
2. Number Used: 2 (for left and right wheels)
3. Operating Voltage: 6V – 12V DC
4. No-load Speed: ~100–200 RPM (depends on gear ratio)
5. Rated Torque: ~2–5 kg·cm (depends on model)
6. Stall Current: ~1–2 A

7. Gear Ratio: Typically, 1:50, 1:100, or 1:200 (depending on required speed/torque)
8. Direction Control: Forward / Reverse via motor driver
9. Speed Control: Pulse Width Modulation (PWM)
10. Application in Agribot: Provides mobility — forward, backward, and turning movements
11. Power Source: 3 Li-ion batteries via L298N motor driver

4.2 Software Requirements

4.2.1 Arduino IDE

The Arduino Integrated Development Environment (IDE) is an open-source, cross-platform software application designed for writing, compiling, and uploading code to microcontrollers such as the ESP32. It provides a simple and intuitive interface for developing programs, making it accessible to beginners and experts alike. Users can write sketches in C/C++ language, with features like syntax highlighting, auto-indentation, and line numbering, which help in reducing coding errors and improving readability. One of the key strengths of the Arduino IDE is its extensive library support, which includes ready-made code for a wide range of sensors, actuators, and communication protocols. For the Agribot project, this enables easy interfacing with components like the DHT temperature and humidity sensor, ultrasonic sensor, servo motor for seed dispensing and ploughing, DC gear motors for movement, and relay-controlled water and pesticide pumps. The IDE also allows selection of the target microcontroller board (ESP32 DOIT Devkit V1) and the appropriate communication port to upload compiled code directly to the board. Additionally, it includes a Serial Monitor for real-time debugging and monitoring of sensor readings, which is crucial for testing and calibration. When combined with the ESP32 Board Support Package (BSP), the Arduino IDE supports advanced ESP32 features such as Wi-Fi, Bluetooth, multiple GPIO pins, PWM, ADC, and DAC, allowing seamless integration with IoT platforms like Blynk and Thingspeak. Its simplicity, large community support, and powerful library ecosystem make the Arduino IDE an ideal software platform for programming and managing the Agribot efficiently, ensuring reliable sensor monitoring, actuator control, and IoT connectivity.

4.2.2 Blynk App

The Blynk app is a versatile IoT (Internet of Things) platform that allows users to remotely monitor and control electronic devices using a smartphone or tablet. It is compatible with various microcontrollers, including the ESP32, making it ideal for the Agribot project. Blynk provides a graphical user interface (GUI) where users can create custom dashboards with widgets such as buttons, sliders, displays, and graphs to interact with hardware components in real-time. In the Agribot, the Blynk app is used to control actuators like the DC gear motors for mobility, servo motors for seed dispensing and ploughing, and relay-controlled pumps for water and pesticide spraying. It also displays real-time sensor data, including soil moisture, temperature, humidity, and ultrasonic distance readings, allowing the operator to monitor field conditions remotely. The app communicates with the ESP32 over Wi-Fi, sending control commands from the smartphone to the microcontroller and receiving sensor data in return. Blynk simplifies IoT implementation by handling communication protocols and data synchronization, eliminating the need for complex server setup. Its intuitive interface, cross-platform support (Android and iOS), and customizable dashboards make it easy for users to operate the Agribot from anywhere, ensuring precise and efficient agricultural operations while maintaining a clear record of environmental data.

4.2.3 Thingspeak Cloud

ThingSpeak is a cloud-based IoT platform designed for collecting, analysing, and visualizing sensor data in real time. It allows microcontrollers like the ESP32 to send data over the internet, where it can be stored and displayed on customizable dashboards. In the Agribot project, ThingSpeak is used to record environmental and field data such as soil moisture, temperature, humidity, and ultrasonic distance measurements. The platform enables users to create time-series graphs, charts, and real-time visualizations of this data, which can be accessed from any device with an internet connection. ThingSpeak also supports data analysis and alerts, allowing farmers or operators to monitor field conditions efficiently and make informed decisions. The ESP32 communicates with ThingSpeak via HTTP requests, sending sensor readings at regular intervals, ensuring that the data is continuously updated on the cloud. By integrating ThingSpeak with the Blynk app, the Agribot combines remote control with data logging and monitoring, giving users a complete IoT solution for automated agricultural operations. Its cloud storage, user-friendly interface, and compatibility with multiple sensors make ThingSpeak an essential tool for tracking and optimizing the performance of the Agribot in real-world agricultural environments.

CHAPTER- 5

SYSTEM DESIGN

5.1 Problem Statement

Agriculture is the backbone of many economies, especially in countries like India, where a large portion of the population depends on farming for livelihood. Traditional farming methods, however, face several challenges that limit productivity, increase labor costs, and reduce efficiency. The following problems are commonly observed in conventional agricultural practices:

1. Manual Seed Sowing and Labor Dependency

- Traditionally, farmers manually sow seeds, which is time-consuming and physically demanding.
- In large fields, sowing by hand is inefficient and may not cover the entire area uniformly.

2. Inconsistent Irrigation

- Crop growth depends on optimal soil moisture levels.
- Overwatering can cause seed rot or waterlogging, while underwatering reduces germination and plant growth.

3. Pest and Crop Protection Challenges

- Pests and insects can severely damage crops if not controlled in time.
- Manual pesticide spraying is labor-intensive, hazardous to human health, and often not applied uniformly.

4. Lack of Real-Time Monitoring and Data Collection

- Traditional farming lacks real-time monitoring of environmental conditions like temperature, humidity, and soil moisture.
- Without accurate data, farmers cannot make informed decisions, leading to poor crop management and lower productivity.

5. Machine Operation Challenges

- Automated agricultural machines (if used) may face obstacles such as uneven terrain, rocks, or irrigation ditches.
- Without proper detection systems, these obstacles can damage machinery or stop operations.

5.2 Proposed Solution

This Project is designed to assist farmers in performing multiple agricultural tasks such as seed dispensing, watering, and pesticide spraying with the help of IoT technology. The system focuses on manual control through the Blynk App and real-time monitoring using ThingSpeak Cloud, making farming operations more convenient, efficient, and sustainable.

The ESP32 microcontroller acts as the central control unit of the system. It is responsible for receiving control commands from the Blynk App via Wi-Fi and operating the connected components such as the DC geared motors (for chassis movement), seed dispenser motor, and relay-controlled water and pesticide pumps. The ESP32 also collects data from various sensors the DHT11 (temperature and humidity sensor), soil moisture sensor, and ultrasonic sensor (for obstacle detection). These readings are continuously sent to the ThingSpeak Cloud for monitoring and analysis.

Unlike fully automated systems, this design gives complete control to the farmer, who can operate each function of the machine manually through the Blynk mobile application. For example, the farmer can control when to move the machine, start or stop seed dispensing, turn on the water pump, or spray pesticide, all with simple button clicks.

This proposed solution eliminates the need for physical labour in field operations while still allowing the farmer to make precise, real-time decisions based on the data displayed on the ThingSpeak Dashboard. The combination of IoT-based control, renewable energy, and wireless monitoring makes this system efficient, cost-effective, and sustainable for modern precision agriculture.

In summary, the proposed system provides a smart, solar-powered, remotely operated agricultural machine that helps farmers perform key field tasks more easily while monitoring environmental conditions through IoT platforms.

5.3 Objectives

The project “IoT-Based Solar Powered Seed Sprayer Machine” aims to integrate solar energy, IoT technology, and automation into a single smart agricultural system. The following objectives outline the purpose, scope, and expected outcomes of this work.

1. **To design and develop a solar-powered agricultural machine**

   The machine performs seed dispensing, watering, and pesticide spraying operations using solar energy as the primary power source.

2. **To control all functions manually through the Blynk App**

   All operations like movement, spraying, and dispensing are manually controlled via a smartphone using the Blynk IoT platform.

3. **To monitor real-time sensor data on ThingSpeak Cloud**

   Sensor readings such as soil moisture, temperature, humidity, and obstacle distance are displayed online for real-time observation.

4. **To use ESP32 microcontroller for IoT control**

   The ESP32 acts as the main controller, handling wireless communication, data processing, and interfacing with sensors and actuators.

5. **To reduce manual labour in farming activities**

   The machine reduces farmers’ physical effort by allowing remote operation through a mobile application.

6. **To ensure accurate control and minimize resource wastage**

   Controlled operations prevent overuse of seeds, water, or pesticides, promoting sustainable farming practices.

7. **To design a compact, portable, and user-friendly system**

   The machine’s design is simple, lightweight, and easy to operate on different field conditions.

8. **To promote smart and sustainable agriculture using IoT**

   The project integrates IoT technology and renewable energy to support digital, eco-friendly, and modern farming.

5.4 Implementation

The implementation of the IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine combines IoT technology, renewable energy, and embedded control to develop an efficient, manually operated agricultural system. The heart of the project is the ESP32 DOIT Devkit V1 microcontroller, which controls all operations and enables IoT connectivity. The system is powered by two 6V solar panels connected in series, producing around 12V DC that charges a 12V Li-ion battery. The stored energy powers all electronic components including the ESP32, sensors, motors, and relay modules. The ESP32 receives commands from the Blynk App via Wi-Fi, allowing the farmer to manually control machine movement, seed dispensing, and pump operations directly from a smartphone. For mobility, DC geared motors are driven using an L298N motor driver, while the seed dispenser motor is directly controlled by the ESP32. Two relay modules operate the water and pesticide pumps, enabling controlled spraying when activated from the app. The system also includes sensors the DHT11 for temperature and humidity measurement, the soil moisture sensor for soil condition detection, and the ultrasonic sensor for obstacle distance measurement. All sensor readings are continuously uploaded to ThingSpeak Cloud, where farmers can monitor real-time environmental data such as soil moisture, temperature, humidity, and obstacle distance. The combination of solar power, IoT-based manual control, and real-time cloud monitoring ensures that the machine operates efficiently even in remote locations without electricity. This implementation successfully demonstrates a self-powered, IoT-enabled, and user-friendly agricultural machine, helping farmers perform essential tasks like seed sowing, watering, and pesticide spraying conveniently through smart control.

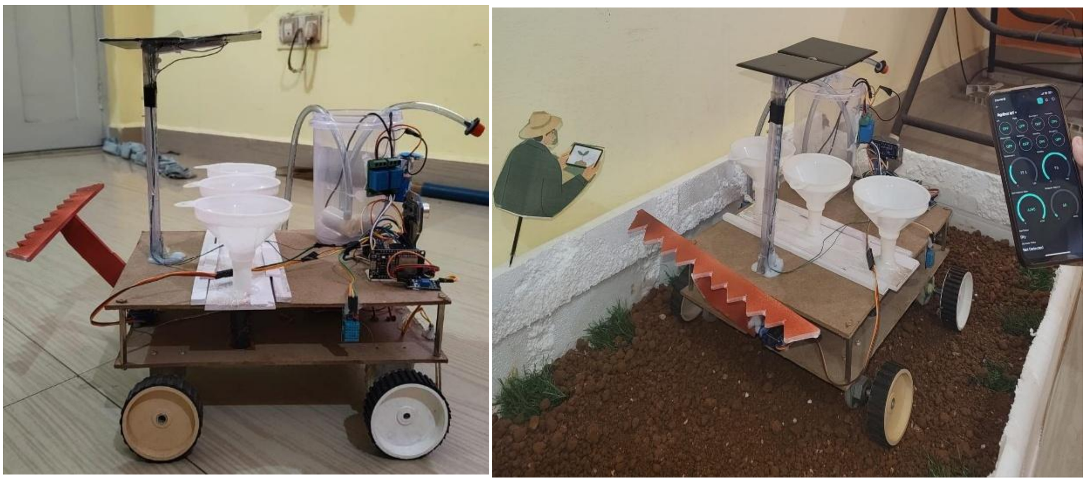

Fig 5.4.1 Experimental Setup for the Project

5.5 Methodology

The of the IoT-based Solar Powered Seed Dispenser Machine outlines the systematic approach used to design, develop, and implement the project. It focuses on the integration of hardware components, sensors, actuators, and IoT platforms to automate seed dispensing, irrigation, and pest control. The methodology can be divided into several stages as described below:

1. Requirement Analysis

- **Objective:** Identify the requirements of the project based on the problems faced in traditional farming methods.
- **Activities:**
  - Determined the need for automated seed sowing, irrigation, and pest control.
  - Listed the essential environmental parameters to monitor (temperature, humidity, soil moisture).
  - Defined remote monitoring requirements using IoT platforms like Blynk and ThingSpeak**.**
  - Established energy requirements and decided to incorporate solar power for off-grid operation.

2. System Design

- **Objective:** Create a blueprint for the system architecture and data flow.
- **Activities:**
  - Designed a block diagram showing connections between the ESP32 microcontroller, sensors, motors, servos, pumps, and relays.
  - Planned the control logic for automatic and manual operation via Blynk App.
  - Defined thresholds for soil moisture, obstacle detection, and environmental conditions for seed dispensing.
  - Selected appropriate components such as DHT11, soil moisture sensor, ultrasonic sensor, L298N motor driver, DC motors, servo motors, water pump, and pesticide sprayer.

3. Hardware Integration

- **Objective:** Assemble and connect all physical components.

- **Activities:**
  - ESP32 microcontroller is the central unit that interfaces with all sensors and actuators.
  - DHT11 sensor connected to monitor temperature and humidity.
  - Soil moisture sensor connected to analog input for soil monitoring.
  - Ultrasonic sensor connected to detect obstacles and ensure safe navigation.
  - DC motors connected via L298N motor driver for movement of seed dispensing unit.
  - Servo motors attached to seed hoppers for precise seed release.
  - Relay module connected to water pump and pesticide sprayer for automatic control.
  - Solar power supply connected to provide sustainable energy.

4. Software Development

- **Objective:** Program the microcontroller to read sensor data, control actuators, and send data to IoT platforms.
- **Activities:**
  - Developed code using Arduino IDE and integrated Blynk and ThingSpeak libraries.
  - Implemented sensor reading functions:
    - DHT11 for temperature and humidity.
    - Soil moisture sensor for irrigation control.
    - Ultrasonic sensor for obstacle detection.
  - Implemented actuator control logic:
    - DC motors for movement.
    - Servo motors for seed dispensing.
    - Relay module for water pump and pesticide sprayer.
  - Programmed IoT features:
    - Real-time data display on Blynk App.
    - Data logging on ThingSpeak for historical analysis.
  - Implemented safety logic to stop the machine when obstacles are detected.

5. System Testing and Calibration

- **Objective:** Ensure the system operates as intended under real-world conditions.
- **Activities:**
    - Tested seed dispensing mechanism for uniformity and precision.
    - Calibrated soil moisture sensor thresholds for optimal irrigation.
    - Verified DHT11 readings with external instruments for accuracy.
    - Tested obstacle detection and verified correct stopping behaviour.
    - Validated IoT connectivity to Blynk and ThingSpeak for real-time monitoring.
    - Adjusted motor speeds and servo angles to achieve smooth operation.

6. Remote Monitoring and IoT Integration

- **Objective:** Allow farmers to monitor and control the system remotely.
- **Activities:**
    - Connected the ESP32 to Wi-Fi for internet access.
    - Configured Blynk App to display sensor values and control motors, pumps, and servos.
    - Uploaded sensor data to ThingSpeak for cloud-based analysis.
    - Ensured the system can send real-time alerts in case of obstacles or abnormal sensor readings.

7. Deployment in Field Conditions

- **Objective:** Implement and test the machine in actual agricultural environments.
- **Activities:**
    - Deployed the system in a farm plot.
    - Monitored performance of seed dispensing, irrigation, and pesticide spraying.
    - Recorded environmental data over time using ThingSpeak.
    - Collected feedback on machine efficiency, reliability, and ease of use.

5.6 Algorithm

1. Start / Power ON

- The system is powered on using solar energy or an external power supply.
- The ESP32 microcontroller initializes all sensors, actuators, and IoT connections (Blynk and ThingSpeak).
- The microcontroller establishes a Wi-Fi connection to enable IoT-based monitoring and control.

2. Sensor Initialization

- Sensors such as DHT11**,** soil moisture sensor**,** and ultrasonic sensor are initialized.
- Actuators like **DC** motors, servo motors, water pump, and pesticide sprayer are set to their default state (OFF or neutral).

3. Read Sensor Data

- DHT11 reads ambient temperature and humidity**.**
- Soil moisture sensor measures the soil water content**.**
- Ultrasonic sensor measures the distance to obstacles in front of the machine.

4. Check Obstacle

- The system checks if an obstacle is detected within a pre-defined distance (e.g., 30 cm).
- If obstacle detected:
  - Stop all motor movement.
  - Wait or change direction to avoid collision.
- If no obstacle:
  - Continue the normal operation of the machine.

5. Check Soil Moisture

- The system compares the soil moisture reading against a threshold value.
- If soil is dry:
  - Activate the water pump to irrigate the soil.
- If soil is wet:
  - Keep the pump OFF to avoid overwatering.

6. Check Environmental Conditions

- Temperature and humidity readings are evaluated to ensure optimal conditions for seed sowing**.**

- If conditions are suitable:
    - Proceed with seed dispensing**.**
- If conditions are not suitable:
    - Delay seed dispensing and monitor the environment continuously.

7. Seed Dispensing Operation

- The servo motors operate the seed hoppers to release seeds in a controlled manner.
- DC motors drive the machine forward to cover the field while seeds are dispensed.

8. Pesticide Spraying (Optional / Scheduled)

- Based on pre-defined conditions or manual input via Blynk**,** the relay-controlled pesticide sprayer is activated to protect crops.

9. IoT Data Transmission

- Sensor readings (temperature, humidity, soil moisture, obstacle distance) are sent to the Blynk App for real-time monitoring.
- Data is also uploaded to ThingSpeak for historical analysis and cloud-based logging.

10. Loop / Repeat

- The system continuously loops through steps 3–9.
- This ensures real-time monitoring, automated irrigation, seed dispensing, obstacle detection, and IoT data logging throughout the operation.

11. Stop / Power OFF

- The machine stops automatically when the sowing task is completed or manually via the Blynk App.
- All actuators are switched OFF, and sensor readings are logged for future analysis.

CHAPTER- 6

ADVANTAGES AND LIMITATIONS

6.1 Advantages

1. **Eco-Friendly Operation**

   The system uses solar energy as its primary power source, reducing dependency on electricity or fossil fuels and promoting sustainable farming.

2. **Low Operating Cost**

   Since it runs on solar power, there are no fuel or electricity costs, making the machine affordable and cost-effective for small-scale farmers.

3. **IoT-Based Remote Control**

   All machine operations such as movement, seed dispensing, watering, and pesticide spraying are controlled manually via the Blynk App, offering convenience and flexibility.

4. **Real-Time Monitoring**

   The integration of ThingSpeak Cloud allows real-time monitoring of soil moisture, temperature, humidity, and obstacle distance, helping farmers make informed decisions.

5. **Reduces Manual Labor**

   The system eliminates the need for physical effort in spraying and sowing activities, making farming operations easier, especially for elderly or physically challenged farmers.

6. **Renewable and Continuous Power Supply**

   With two 6V solar panels and a 12V Li-ion battery, the machine can operate continuously even in areas without access to grid electricity.

7. **Energy Efficient and Reliable**

   The use of energy-efficient components such as ESP32, DC motors, and relays ensures reliable performance with minimal power consumption.

8. **Improved Resource Management**

   Controlled operation of pumps and dispensers reduces wastage of seeds, water, and pesticides, promoting efficient use of agricultural resources.

9. **Compact and Portable Design**

   The lightweight structure and simple mechanical setup make the machine easy to transport and operate in small or uneven fields.

10. Promotes Smart Agriculture

By combining IoT, automation, and renewable energy, the project introduces farmers to smart farming techniques and supports digital transformation in agriculture.

6.2 Limitations

1. Limited Wi-Fi Range

The ESP32's Wi-Fi range is restricted, meaning the machine can only be operated within a certain distance from a Wi-Fi hotspot or mobile hotspot.

2. Weather Dependency for Solar Power

The performance of the solar panels depends on sunlight availability; cloudy or rainy conditions may reduce charging efficiency.

3. Limited Load Capacity

The machine can carry only a limited amount of seeds, water, or pesticide due to its compact size and battery capacity.

4. Internet Connectivity Requirement

Continuous internet access is required for Blynk control and ThingSpeak data monitoring; poor connectivity can affect performance.

5. Field Area Limitation

The system is best suited for small to medium-sized fields scaling up for large farms would require more power and larger components.

CHAPTER- 7

RESULTS AND FUTURE SCOPE

7.1 Results

The IoT-Based Solar Powered Seed Sprayer Machine was successfully designed, constructed, and tested, meeting all the expected objectives of the project. The developed system performed multiple agricultural tasks such as seed dispensing, watering, and pesticide spraying, all powered by solar energy and controlled through IoT technology. The hardware implementation using the ESP32 microcontroller provided reliable control over all components and ensured stable Wi-Fi communication with the Blynk App and ThingSpeak Cloud. The system operated efficiently using two 6V solar panels connected in series, which generated sufficient energy to charge the 12V Li-ion battery, powering the motors, pumps, and sensors continuously during field operation.

All functions of the machine were manually controlled through the Blynk App, allowing the user to operate the chassis movement, activate the water and pesticide pumps, and control the seed dispenser motor remotely. The sensors, including DHT11, soil moisture sensor, and ultrasonic sensor, provided accurate and consistent readings of temperature, humidity, soil moisture, and obstacle distance. These readings were successfully transmitted to the ThingSpeak Cloud, where they were displayed in graphical form for real-time monitoring and analysis.

The prototype functioned as expected under various test conditions, confirming the feasibility of integrating solar power and IoT control in small-scale agricultural automation. The system proved to be energy-efficient, portable, user-friendly, and reliable, offering farmers an effective tool to perform multiple operations with minimal effort and zero fuel cost. Overall, the project achieved its goal of promoting smart, sustainable, and technology-driven agriculture.

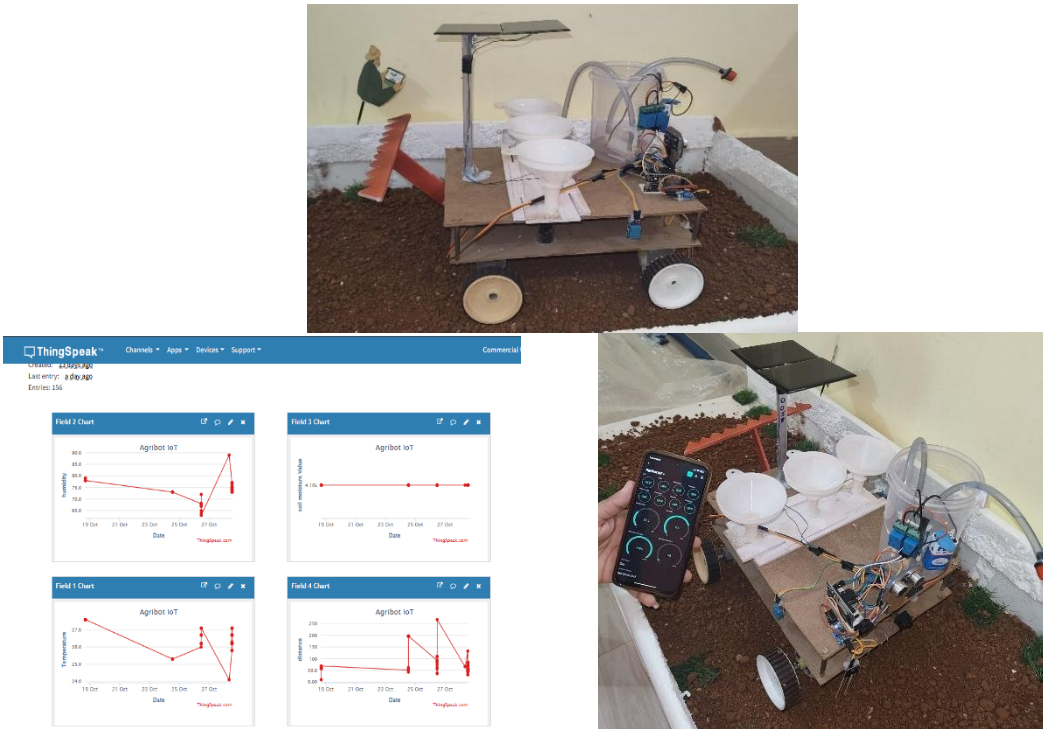

Fig 7.1.1 Real time monitoring and controlling the machine using Thingspeak and Blynk app

7.2 Future Scope

The IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine can be further improved to enhance its functionality, efficiency, and automation. In the future, the system can be upgraded from manual control to automatic operation by integrating advanced sensors and algorithms to make decisions based on real-time environmental data. For example, the machine could automatically start watering or spraying when soil moisture or temperature levels reach certain thresholds.

The inclusion of GPS and GSM modules would enable remote monitoring and control without depending solely on Wi-Fi, allowing farmers to operate the system from any location. The use of higher-capacity Li-ion batteries, more efficient solar panels, or an MPPT charge controller could increase power efficiency and operating time. Mechanically, improvements such as stronger DC motors, a more robust chassis, and precision nozzles can help handle larger loads and improve spraying accuracy.

In future versions, data analytics and cloud-based dashboards can be integrated to analyse long-term field data and assist in better decision-making. These advancements will help evolve the project into a more intelligent, fully automated, and scalable smart farming system, contributing to sustainable and modern agriculture.

CHAPTER- 8

CONCLUSION

The project "IoT-Based Solar Powered Seed Sprayer and Pesticide Dispenser Machine" was successfully designed, developed, and tested to support modern agricultural needs. The system effectively integrates IoT technology and renewable solar energy to perform essential farming operations such as seed dispensing, watering, and pesticide spraying with improved convenience and efficiency. Using an ESP32 microcontroller, the machine was able to receive manual commands from the Blynk App and transmit sensor data to ThingSpeak Cloud for real-time monitoring.

The use of two 6V solar panels connected in series to charge a 12V Li-ion battery ensured continuous operation without dependency on external power sources, making the system eco-friendly and cost-efficient. The results confirmed that all modules including sensors, pumps, and motors functioned reliably under different conditions.

Overall, the project achieved its objective of providing a smart, energy-efficient, and farmer-friendly solution that reduces manual labour while encouraging the use of IoT in agriculture. This work demonstrates how combining technology with renewable energy can promote sustainable farming, improve productivity, and serve as a foundation for more advanced automation in the future.

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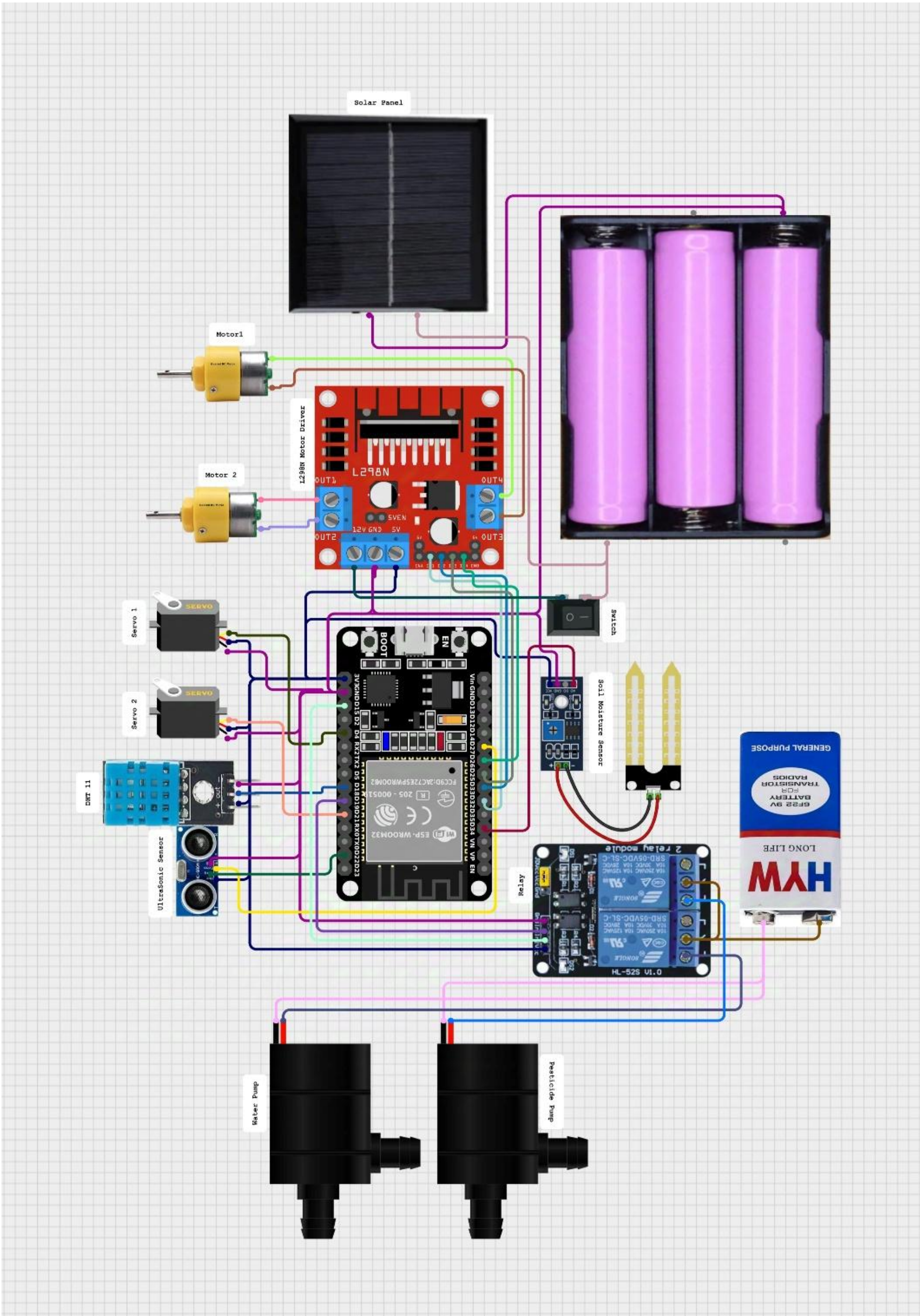
APPENDIX- A

1. Circuit Diagram



2. Component List

2.1 Hardware Components

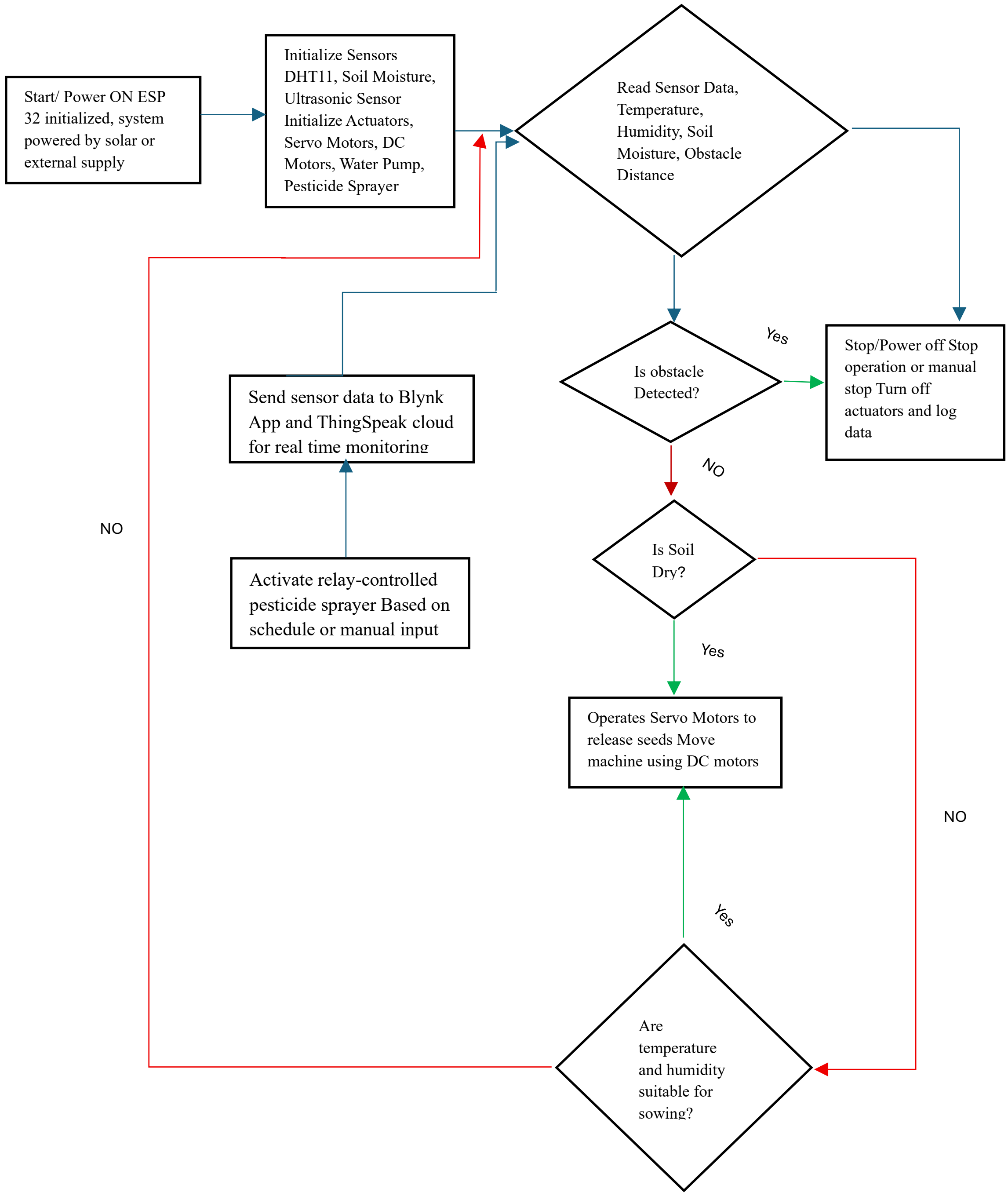
1. ESP32 Microcontroller
2. Soil Moisture Sensor
3. Ultrasonic Sensor
4. DHT11 Sensor
5. D.C Gear Motor
6. Relay Module
7. Servo Motor
8. Switch
9. Two Batteries (Li Ion battery and 9V Hi- Watt battery)
10. L298N Motor Driver
11. Submersible Pump
12. Solar panel

2.2 Software Requirements

1. Arduino IDE
2. Blynk App
3. Thingspeak Cloud

APPENDIX- B

1. Flowchart



Start/ Power ON ESP 32 initialized, system powered by solar or external supply
Initialize Sensors DHT11, Soil Moisture, Ultrasonic Sensor Initialize Actuators, Servo Motors, DC Motors, Water Pump, Pesticide Sprayer
Read Sensor Data, Temperature, Humidity, Soil Moisture, Obstacle Distance
Yes
Stop/Power off Stop operation or manual stop Turn off actuators and log data
Is obstacle Detected?
NO
Send sensor data to Blynk App and ThingSpeak cloud for real time monitoring
NO
Activate relay-controlled pesticide sprayer Based on schedule or manual input
Is Soil Dry?
Yes
Operates Servo Motors to release seeds Move machine using DC motors
NO
Yes
Are temperature and humidity suitable for sowing?

2. Software Code

```
#define BLYNK_TEMPLATE_ID "TMPL3ZsVe39j9"
#define BLYNK_TEMPLATE_NAME "Agribot IoT"
#define BLYNK_AUTH_TOKEN "_MHv_t_QI7k2wAYIl9zMuhaDRpE1GFez"
#define BLYNK_PRINT Serial

#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <ESP32Servo.h>
#include <DHT.h>
#include <HTTPClient.h>

// Blynk credentials
char auth[] = "_MHv_t_QI7k2wAYIl9zMuhaDRpE1GFez";
char ssid[] = "api";
char pass[] = "12345678";

// ThingSpeak details
const char* thingspeak_api_key = "O31HXEPVT7RFV9N1"; // Replace this
const char* thingspeak_server = "http://api.thingspeak.com/update";

// DHT11 sensor setup
#define DHTPIN 18
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
#define TRIG_PIN 22
#define ECHO_PIN 27
#define SOIL_MOISTURE_PIN 34
int fw1 = 32;
int bw1 = 33;
```

```
int fw2 = 25;
int bw2 = 26;
int pesti  = 15;
int pump = 19;
Servo myServo1;
Servo myServo2;
BlynkTimer timer;
void setup() {
  Serial.begin(115200);
  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);
  pinMode(fw1, OUTPUT);
  pinMode(bw1, OUTPUT);
  pinMode(fw2, OUTPUT);
  pinMode(bw2, OUTPUT);
  pinMode(pump, OUTPUT);
  pinMode(pesti, OUTPUT);
  digitalWrite(pesti, LOW);
  myServo1.attach(21);
  myServo2.attach(4);
  dht.begin();
  WiFi.begin(ssid, pass);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("\nWiFi connected");
  Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
  timer.setInterval(5000L, readAndSendSensorData);
}
void loop() {
  Blynk.run();
```

```
  timer.run();
}
long readUltrasonicDistance() {
  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);
  long duration = pulseIn(ECHO_PIN, HIGH, 30000); // 30ms timeout
  long distance = duration * 0.034 / 2;
  if (duration == 0) {
    return -1;
  }
  return distance;
}
void readAndSendSensorData() {
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();
  int soilMoistureValue = analogRead(SOIL_MOISTURE_PIN);
  long distance = readUltrasonicDistance();
  String soilStatus = (soilMoistureValue < 1500) ? "Wet" : "Dry"; // Adjust threshold if needed
  const int OBSTACLE_THRESHOLD = 30; // in cm
  String obstacleStatus;

   if (distance <= OBSTACLE_THRESHOLD) {
    obstacleStatus = "Detected";
  } else {
    obstacleStatus = "Not Detected";
  }
  if (!isnan(temperature) && !isnan(humidity)) {
    Blynk.virtualWrite(V8, temperature);
    Blynk.virtualWrite(V9, humidity);
```

```
  } else {
    Serial.println("Failed to read from DHT11 sensor");
  }
  Blynk.virtualWrite(V10, soilMoistureValue);          // Soil moisture raw value
   Blynk.virtualWrite(V11, soilStatus);                 // Soil status text
  Blynk.virtualWrite(V12, obstacleStatus);              // Obstacle status text
 Blynk.virtualWrite(V13, distance); // Distance in cm
  // Debug output
  Serial.print("Temp: "); Serial.print(temperature); Serial.print(" °C, ");
  Serial.print("Humidity: "); Serial.print(humidity); Serial.print(" %, ");
  Serial.print("Soil Moisture: "); Serial.print(soilMoistureValue); Serial.print(", ");
  Serial.print("Soil Status: "); Serial.print(soilStatus); Serial.print(", ");
  Serial.print("Distance: "); Serial.print(distance); Serial.print(" cm, ");
  Serial.print("Obstacle: "); Serial.println(obstacleStatus);
  // Send data to ThingSpeak
  sendToThingSpeak(temperature, humidity, soilMoistureValue, distance);
}
void sendToThingSpeak(float temp, float hum, int soilVal, long dist) {
  if (WiFi.status() == WL_CONNECTED) {
    HTTPClient http;
    String url = String(thingspeak_server) + "?api_key=" + thingspeak_api_key +
                 "&field1=" + String(temp) +
                 "&field2=" + String(hum) +
                 "&field3=" + String(soilVal) +
                 "&field4=" + String(dist);
    http.begin(url);
    int httpCode = http.GET();
    if (httpCode > 0) {
      String payload = http.getString();
      Serial.print("ThingSpeak Response: ");
      Serial.println(payload);
    } else {
```

```
      Serial.print("ThingSpeak request failed, error: ");
      Serial.println(httpCode);
    }
    http.end();
  } else {
    Serial.println("WiFi not connected - ThingSpeak not updated");
  }
}
BLYNK_WRITE(V0) {
  int pinstate1 = param.asInt();
  if (pinstate1 == 1) {
    digitalWrite(fw1, HIGH);
    digitalWrite(fw2, HIGH);
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, LOW);
  } else {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, LOW);
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, LOW);
  }
}
BLYNK_WRITE(V1) {
  int pinstate2 = param.asInt();
  if (pinstate2 == 1) {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, LOW);
    digitalWrite(bw1, HIGH);
    digitalWrite(bw2, HIGH);
  } else {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, LOW);
```

```
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, LOW);
  }
}
BLYNK_WRITE(V2) {
  int pinstate3 = param.asInt();
  if (pinstate3 == 1) {
    digitalWrite(fw1, HIGH);
    digitalWrite(fw2, LOW);
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, HIGH);
  } else {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, LOW);
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, LOW);
  }
}
BLYNK_WRITE(V3) {
  int pinstate9 = param.asInt();
  if (pinstate9 == 1) {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, HIGH);
    digitalWrite(bw1, HIGH);
    digitalWrite(bw2, LOW);
  } else {
    digitalWrite(fw1, LOW);
    digitalWrite(fw2, LOW);
    digitalWrite(bw1, LOW);
    digitalWrite(bw2, LOW);
  }
}
```

```
BLYNK_WRITE(V4) {
  int pinstate6=param.asInt();
  if(pinstate6==1) {
    digitalWrite(pump,HIGH);
  } else {
    digitalWrite(pump,LOW);
  }
}
BLYNK_WRITE(V5) {
  int pinstate5=param.asInt();
  if(pinstate5==1) {
    digitalWrite(pesti,HIGH);
  } else {
    digitalWrite(pesti,LOW);
  }
}
BLYNK_WRITE(V6) {
  int pinstate4=param.asInt();
  if(pinstate4==0) {
    myServo1.write(90);
  } else {
    myServo1.write(0);
  }
}
BLYNK_WRITE(V7) {
  int pinstate7=param.asInt();
  if(pinstate7==0) {
    myServo2.write(90);
  } else {
    myServo2.write(0);
  }
}
```

APPENDIX- C

APPENDIX- D

ESP32-WROOM-32E
ESP32-WROOM-32UE

Datasheet Version 2.0

2.4 GHz Wi-Fi + Bluetooth® + Bluetooth LE module
Built around ESP32 series of SoCs, Xtensa® dual-core 32-bit LX6 microprocessor
4/8/16 MB flash available
26 GPIOs, rich set of peripherals
On-board PCB antenna or external antenna connector

ESP32-WROOM-32E

ESP32-WROOM-32UE

ESPRESSIF

www.espressif.com

1 Module Overview

Note:

Check the link or the QR code to make sure that you use the latest version of this document:
https://espressif.com/documentation/esp32-wroom-32e_esp32-wroom-32ue_datasheet_en.pdf

1.1 Features

CPU and On-Chip Memory

- ESP32-D0WD-V3 or ESP32-D0WDR2-V3 embedded, Xtensa dual-core 32-bit LX6 microprocessor, up to 240 MHz
- 448 KB ROM
- 520 KB SRAM
- 16 KB SRAM in RTC

Wi-Fi

- 802.11b/g/n
- Bit rate: 802.11n up to 150 Mbps
- A-MPDU and A-MSDU aggregation
- 0.4 μs guard interval support
- Center frequency range of operating channel: 2412 ~ 2484 MHz

Bluetooth®

- Bluetooth V4.2 BR/EDR and Bluetooth LE specification
- Class-1, class-2 and class-3 transmitter
- AFH
- CVSD and SBC

Peripherals

- Up to 26 GPIOs
  - 5 strapping GPIOs
- SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I2S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC, TWAI® (compatible with ISO 11898-1, i.e. CAN Specification 2.0)

Integrated Components on Module

- 40 MHz crystal oscillator
- 4/8/16 MB SPI flash
- ESP32-D0WDR2-V3 also provides 2 MB PSRAM

Antenna Options

- ESP32-WROOM-32E: On-board PCB antenna
- ESP32-WROOM-32UE: external antenna via a connector

Operating Conditions

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature:
  - 85 °C version: –40 ~ 85 °C
  - 105 °C version: –40 ~ 105 °C. Note that only the modules embedded with a 4/8 MB flash support this version.

Certification

- Bluetooth certification: BQB
- RF certification: See certificates for ESP32-WROOM-32E and ESP32-WROOM-32UE
- Green certification: REACH/RoHS

Test

- HTOL/HTSL/uHAST/TCT/ESD

1.2 Series Comparison

ESP32-WROOM-32E and ESP32-WROOM-32UE are two powerful, generic Wi-Fi MCU modules that have a rich set of peripherals. They are an ideal choice for a wide variety of application scenarios related to Internet of Things (IoT), such as embedded systems, smart home, wearable electronics, etc.

ESP32-WROOM-32E comes with a PCB antenna, and ESP32-WROOM-32UE with a connector for an external antenna. **The information in this datasheet is applicable to both modules.**

The Series Comparison for the two modules is as follows:

Table 1: ESP32-WROOM-32E Series Comparison[1]

Ordering Code	Flash[2]	PSRAM	Ambient Temp.[3] (°C)	Size[4] (mm)
ESP32-WROOM-32E-N4	4 MB (Quad SPI)	—	–40 ~ 85	18.0 × 25.5 × 3.1
ESP32-WROOM-32E-N8	8 MB (Quad SPI)	—	–40 ~ 85	
ESP32-WROOM-32E-N16	16 MB (Quad SPI)	—	–40 ~ 85	
ESP32-WROOM-32E-H4	4 MB (Quad SPI)	—	–40 ~ 105	
ESP32-WROOM-32E-H8	8 MB (Quad SPI)	—	–40 ~ 105	
ESP32-WROOM-32E-N4R2	4 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	
ESP32-WROOM-32E-N8R2	8 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	
ESP32-WROOM-32E-N16R2	16 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	

[1] This table shares the same notes presented in the table 2 below.

Table 2: ESP32-WROOM-32UE Series Comparison

Ordering Code	Flash[2]	PSRAM	Ambient Temp.[3] (°C)	Size[4] (mm)
ESP32-WROOM-32UE-N4	4 MB (Quad SPI)	—	–40 ~ 85	18.0 × 19.2 × 3.2
ESP32-WROOM-32UE-N8	8 MB (Quad SPI)	—	–40 ~ 85	
ESP32-WROOM-32UE-N16	16 MB (Quad SPI)	—	–40 ~ 85	
ESP32-WROOM-32UE-H4	4 MB (Quad SPI)	—	–40 ~ 105	
ESP32-WROOM-32UE-H8	8 MB (Quad SPI)	—	–40 ~ 105	
ESP32-WROOM-32UE-N4R2	4 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	
ESP32-WROOM-32UE-N8R2	8 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	
ESP32-WROOM-32UE-N16R2	16 MB (Quad SPI)	2 MB (Quad SPI)[5]	–40 ~ 85	

[2] For specifications, refer to Section 6.5 *Memory Specifications*.

[3] Ambient temperature specifies the recommended temperature range of the environment immediately outside the Espressif module.

[4] For details, refer to Section 10.1 *Module Dimensions*.

[5] This module uses PSRAM integrated in the chip's package.

At the core of the module is the ESP32-D0WD-V3 chip or ESP32-D0WDR2-V3 chip. The chip embedded is designed to be scalable and adaptive. There are two CPU cores that can be individually controlled, and the CPU clock frequency is adjustable from 80 MHz to 240 MHz. You can power off the CPU and make use of the low-power coprocessor to constantly monitor the peripherals for changes or crossing of thresholds.

Note:

- For more information on ESP32-D0WD-V3 and ESP32-D0WDR2-V3 chip, please refer to *ESP32 Series Datasheet*.
- For chip revision identification, ESP-IDF release that supports a specific chip revision, and other information on chip revisions, please refer to *ESP32 Series SoC Errata* > Section *Chip Revision*.

1.3 Applications

- Smart Home
- Industrial Automation
- Health Care
- Consumer Electronics
- Smart Agriculture
- POS Machines
- Service Robot
- Audio Devices
- Generic Low-power IoT Sensor Hubs
- Generic Low-power IoT Data Loggers
- Cameras for Video Streaming
- Speech Recognition
- Image Recognition
- SDIO Wi-Fi + Bluetooth Networking Card

2 Block Diagram

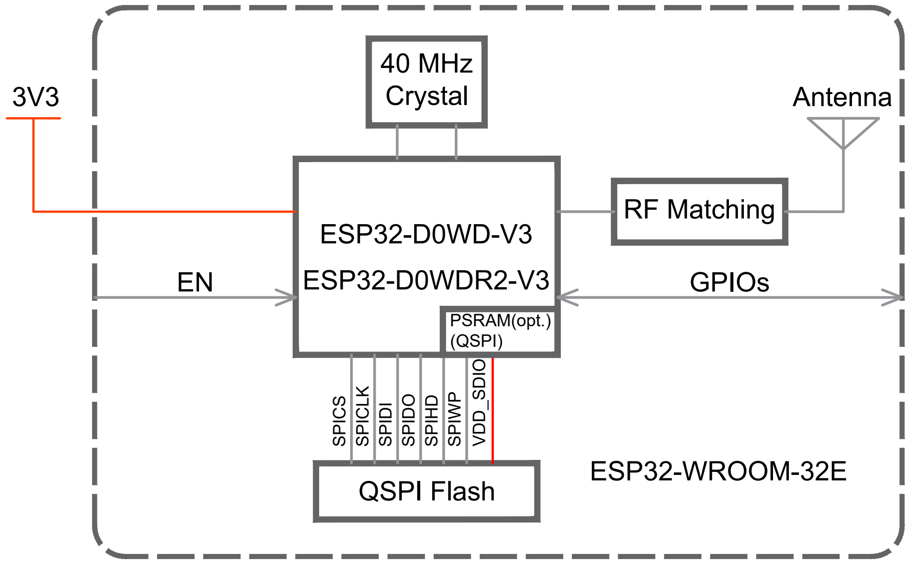


Figure 1: ESP32-WROOM-32E Block Diagram

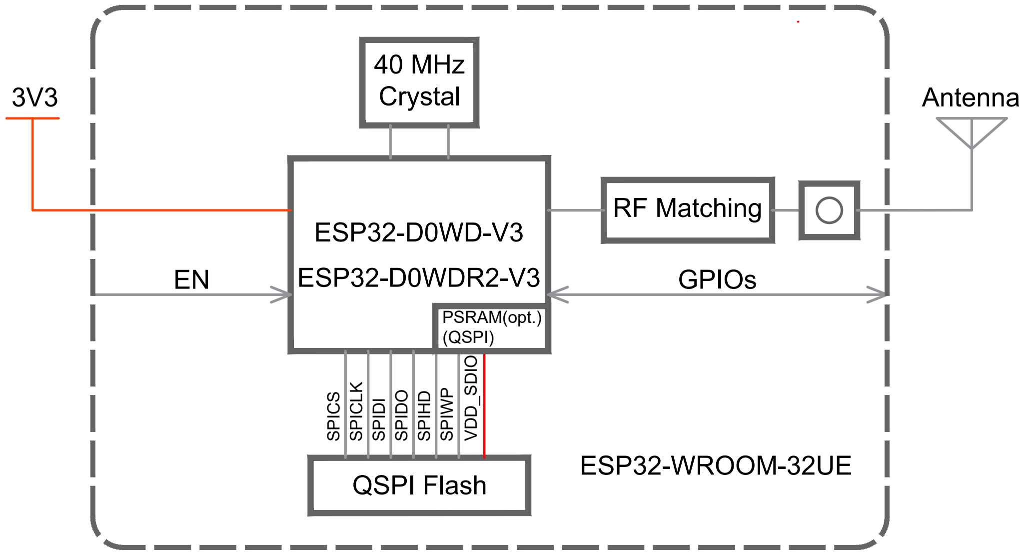


Figure 2: ESP32-WROOM-32UE Block Diagram

Note:

For the pin mapping between the chip and the in-package flash/PSRAM, please refer to *ESP32 Series Datasheet* > Table *Pin Mapping Between Chip and In-package Flash/PSRAM*.

3 Pin Definitions

3.1 Pin Layout

The pin diagram below shows the approximate location of pins on the module. For the actual diagram drawn to scale, please refer to Figure 10.1 *Module Dimensions*.

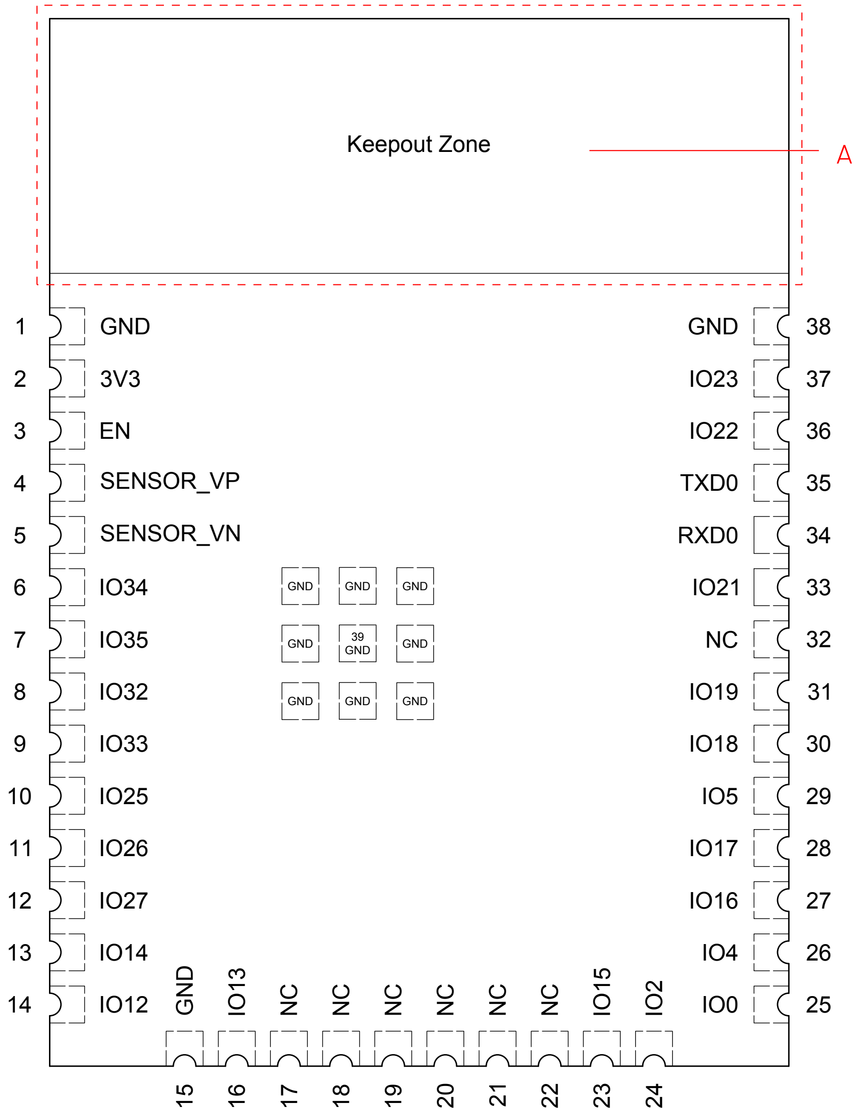


Figure 3: Pin Layout (Top View)

Note A:

- The zone marked with dotted lines is the antenna keepout zone. The pin layout of ESP32-WROOM-32UE is the same as that of ESP32-WROOM-32E, except that ESP32-WROOM-32UE has no keepout zone.
- To learn more about the keepout zone for module's antenna on the base board, please refer to ESP32 Hardware Design Guidelines > Section *Positioning a Module on a Base Board*.

3.2 Pin Description

The module has 38 pins. See pin definitions in Table 3 *Pin Description*.

For peripheral pin configurations, please refer to Section 5.2 *Digital Peripherals*.

Table 3: Pin Definitions

Name	No.	Type[1]	Function
GND	1	P	Ground
3V3	2	P	Power supply
EN	3	I	High: On; enables the chip Low: Off; the chip shuts down Note: Do not leave the pin floating.
SENSOR_VP	4	I	GPIO36, ADC1_CH0, RTC_GPIO0
SENSOR_VN	5	I	GPIO39, ADC1_CH3, RTC_GPIO3
IO34	6	I	GPIO34, ADC1_CH6, RTC_GPIO4
IO35	7	I	GPIO35, ADC1_CH7, RTC_GPIO5
IO32	8	I/O	GPIO32, XTAL_32K_P (32.768 kHz crystal oscillator input), ADC1_CH4, TOUCH9, RTC_GPIO9
IO33	9	I/O	GPIO33, XTAL_32K_N (32.768 kHz crystal oscillator output), ADC1_CH5, TOUCH8, RTC_GPIO8
IO25	10	I/O	GPIO25, DAC_1, ADC2_CH8, RTC_GPIO6, EMAC_RXD0
IO26	11	I/O	GPIO26, DAC_2, ADC2_CH9, RTC_GPIO7, EMAC_RXD1
IO27	12	I/O	GPIO27, ADC2_CH7, TOUCH7, RTC_GPIO17, EMAC_RX_DV
IO14	13	I/O	GPIO14, ADC2_CH6, TOUCH6, RTC_GPIO16, MTMS, HSPICLK, HS2_CLK, SD_CLK, EMAC_TXD2
IO12	14	I/O	GPIO12, ADC2_CH5, TOUCH5, RTC_GPIO15, MTDI, HSPIQ, HS2_DATA2, SD_DATA2, EMAC_TXD3
GND	15	P	Ground
IO13	16	I/O	GPIO13, ADC2_CH4, TOUCH4, RTC_GPIO14, MTCK, HSPID, HS2_DATA3, SD_DATA3, EMAC_RX_ER
NC	17	-	See note [2]
NC	18	-	See note [2]
NC	19	-	See note [2]
NC	20	-	See note [2]
NC	21	-	See note [2]
NC	22	-	See note [2]
IO15	23	I/O	GPIO15, ADC2_CH3, TOUCH3, MTDO, HSPICS0, RTC_GPIO13, HS2_CMD, SD_CMD, EMAC_RXD3
IO2	24	I/O	GPIO2, ADC2_CH2, TOUCH2, RTC_GPIO12, HSPIWP, HS2_DATA0, SD_DATA0
IO0	25	I/O	GPIO0, ADC2_CH1, TOUCH1, RTC_GPIO11, CLK_OUT1, EMAC_TX_CLK
IO4	26	I/O	GPIO4, ADC2_CH0, TOUCH0, RTC_GPIO10, HSPIHD, HS2_DATA1, SD_DATA1, EMAC_TX_ER
IO16[3]	27	I/O	GPIO16, HS1_DATA4, U2RXD, EMAC_CLK_OUT

Cont'd on next page

Table 3 – cont'd from previous page

Name	No.	Type[1]	Function
IO17	28	I/O	GPIO17, HS1_DATA5, U2TXD, EMAC_CLK_OUT_180
IO5	29	I/O	GPIO5, VSPICS0, HS1_DATA6, EMAC_RX_CLK
IO18	30	I/O	GPIO18, VSPICLK, HS1_DATA7
IO19	31	I/O	GPIO19, VSPIQ, U0CTS, EMAC_TXD0
NC	32	-	-
IO21	33	I/O	GPIO21, VSPIHD, EMAC_TX_EN
RXD0	34	I/O	GPIO3, U0RXD, CLK_OUT2
TXD0	35	I/O	GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2
IO22	36	I/O	GPIO22, VSPIWP, U0RTS, EMAC_TXD1
IO23	37	I/O	GPIO23, VSPID, HS1_STROBE
GND	38	P	Ground

[1] P: power supply; I: input; O: output.

[2] Pins GPIO6 to GPIO11 on the ESP32-D0WD-V3/ESP32-D0WDR2-V3 chip are connected to the SPI flash integrated on the module and are not led out.

[3] In module variants that have embedded QSPI PSRAM, i.e., that embed ESP32-D0WDR2-V3, IO16 is connected to the embedded PSRAM and can not be used for other functions.

SMR110
SOIL MOISTURE RECORDER

Features

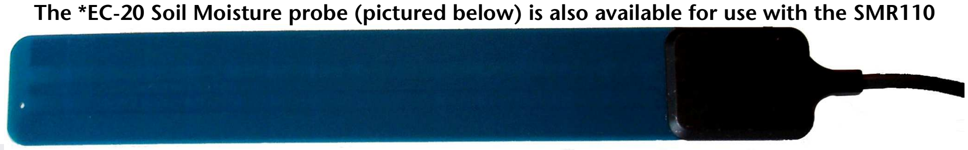
- High accuracy sensor
- Fast response time
- Simple soil insertion (vertical or horizontal orientation)
- Programmable start time and date
- Miniature size
- User calibration through MadgeTech software
- Weatherproof enclosure
- Probe is powered from data recorder's battery. No external power required.

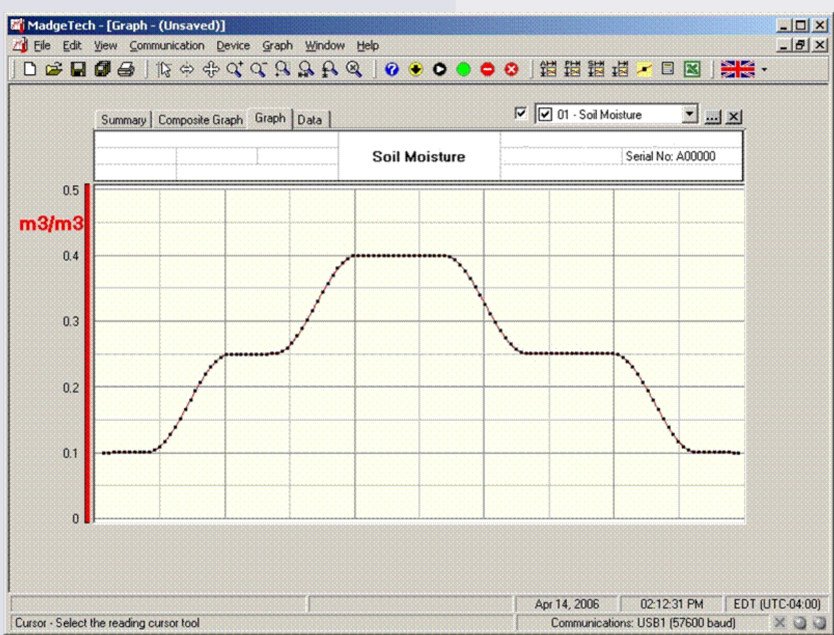
Applications

- Irrigation Management
- Potted plant and greenhouse monitoring
- Soil moisture trends
- Plant growth studies
- Peat Moss and organic soil studies

The SMR110 is a small, battery powered, soil moisture data recorder in a weatherproof enclosure. It provides accurate volumetric water content measurements over a complete range from dry to saturated. The SMR110 features a 10-year battery for long-term deployments and soil studies, over multiple seasons. With it's built-in memory, the data recorder can monitor and record over 32,767 soil moisture measurements. The EC-5, a high accuracy soil moisture probe (pictured above), has a response time of 10ms and can be placed in any type of soil. The EC-20* probe (below) is designed for use in medium-textured soils. For easy soil moisture analysis and trend information, MadgeTech software provides a time and date stamped graph. This data may be viewed, printed or exported to third-party programs (Excel, etc…) for more detailed analysis and irrigation management. Soil moisture data is essential in determining and scheduling irrigation for proper plant growth, care and research. This data is also useful in determining the health of the soil and plant root systems.

The *EC-20 Soil Moisture probe (pictured below) is also available for use with the SMR110





MadgeTech Data Recorder Software

displays water per soil content data in an easy to use graph.

The Windows®-based software package allows the user to effortlessly collect, display and analyze data. A variety of powerful tools allow you to examine, export, and print professional looking data with just a click of the mouse.

Click MadgeTech Software for more information or to download the software.

879 Maple Street · Contoocook, NH 03229
PO Box 50 · Warner, NH 03278 · Phone: (603) 456-2011 · Fax: (603) 456-2012

SOIL MOISTURE RECORDER SPECIFICATIONS

Data Recorder

Measurement Range:	+/- 1200mV
Accuracy:	+/-0.01% FSR
Input range:	0 to 2.5V DC
Memory:	32,767 readings; software configurable memory wrap
Reading Rate:	1 reading every 2 seconds to 1 every 12 hours
Input Connection:	Removable screw terminal plug
Operating Environment:	-40 to +80°C (-40 to +176°F), 0-95% RH, non-condensing
Battery Type:	3.6V Lithium Battery included; **user replaceable**
Battery Life:	10 years typical @ 15 min reading rate
Dimensions:	0.8"x1.7"x2.7"(21mmx44mmx69mm)
Weight:	2 oz. (56 g)
Weatherproof Enclosure:	Anodized aluminum case w/mounting flange. Communications port plug 3.5"x2.9"x1.1"(87mmx73mmx27mm) 7 oz. (198 g)

Soil Moisture Probes

Measurement Range:	(EC-5) 0 to 100% VWC saturation (EC-20) 0 to 40% VWC saturation
Measurement Type:	VWC (Volumetric Water Content)
Measurement Accuracy:	(EC-5) +/- 3% typical, ALL soils (EC-20) +/- 4% typical on low EC and medium textured soils (Both models) +/-1% with soil specific calibration
Calibration:	Digital calibration through software
Calibration Date:	Automatically recorded within device
Life Expectancy (probes):	3-5 years
Measurement Time:	10ms
Measurement Resolution:	0.002m^3/m^3
Operating Environment:	-40 to +60 degC (-40 t0 +140 degF), 0-100% RH (EC-5 and EC-20 models)
Power Requirement: (probes)	Powered from data recorder's internal battery. No external power required.
Dimensions (probes):	(EC-5) 2.1"x0.6"x0.06" (55mm x 15mm x 1.5mm) (Cable length) - 16' (5 m), (tinned, wire leads) (EC-20) 10"x1.25"x0.06" (255mmx32mm x1.5mm) Cable length) - 16' (5 m), (tinned, wire leads)

SOFTWARE FEATURES

Multiple Graphs:	Simultaneously analyze data from several units or deployments; easily switch to a single data series
Real-Time Recording:	Collect and display data in real-time while continuing to log
Data Table:	Instantly access tabular view for detailed dates, times, values, and annotations
Scaling Options:	Autoscale function fits data to the screen, or allows user to manually enter their own values
Printing:	Automatically print graphical or tabular data
Statistics:	Calculate averages, min, max and standard deviation
Export Data:	Export data in a variety of common formats, or switch to Excel® with a single click
Calibration:	Automatically calculate and store calibration parameters
Logger Configuration:	Easy set up and launch of data loggers with immediate or delayed start, preferred sample rate, and device ID
Communications:	Automatic or user-enabled communications port configuration (Baud rate, COM port selection)

ORDERING INFORMATION

Model	Description	Price (U.S.)
SMR110-5	Soil Moisture recorder w/EC-5 probe, weatherproof enclosure (Software NOT included)	$299.00
SMR110-20	Soil moisture recorder w/EC-20 probe, weatherproof enclosure (Software NOT included)	$299.00
EC-5	Soil moisture probe, ONLY	$130.00
EC-20	Soil moisture probe, ONLY	$130.00
IFC110	Software, manual and serial interface cable	$99.00
IFC200	Software, manual and USB interface cable	$119.00
LTC-7PN	Replacement battery for data recorder	$10.00

BATTERY WARNING: FIRE, EXPLOSION, AND SEVERE BURN HAZARD. DO NOT RECHARGE, DISASSEMBLE, HEAT ABOVE 212ºF, INCINERATE OR EXPOSE CONTENTS TO WATER.

ASK ABOUT OUR OTHER DATA RECORDERS

Temperature	Pulse/Event/State
Humidity	Low Level Current
Pressure	Low Level Voltage
pH	RF Transmitters
Level	Intrinsically Safe
Shock	Spectral Vibration
LCD Display	

For Quantity Discounts call 603-456-2011 or email sales@madgetech.com

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WE BUILD DATA LOGGERS

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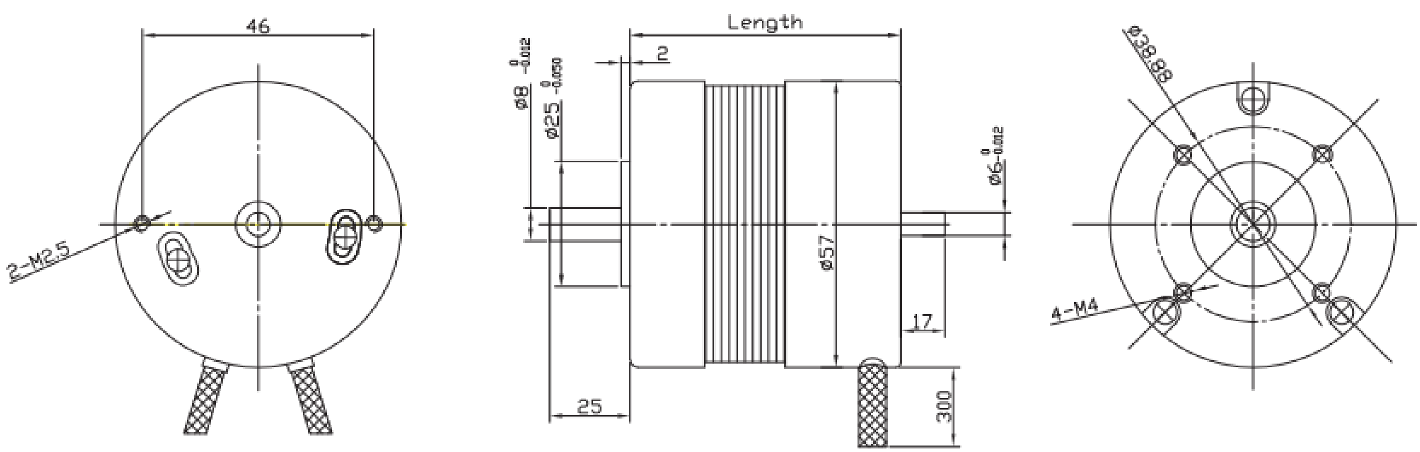
ENGLISH

Datasheet

RS Pro Brushless DC Motor

Stock No: 536-6046

A brushless DC motor is a synchronous electric motor which is powered by direct-current electricity (DC) and which has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related.



Specifications

No of Pole		4
No of Phase		3
Rated Voltage	V	36
Rated Speed	RPM	4000
Rated Torque	Nm	0.22
Max Peak Torque	Nm	0.68
Torque Constant	Nm/A	0.063
Line to Line Resistance	Ω	0.65
Line to Line Inductance	MH	2.1
Max Peak Current	A	9.8
Length	mm	74
Rotor Inertia	G-CM²	119
Weight	Kg	0.75

Characteristics

Hall Effect Angle	120° Electric Angle
Shaft Run Out	0.025 mm
Insulation Class	B
Radial Play	0.02 mm (450 G Load)
Axial Play	0.08 mm (450 G Load)
Max Radial Force	75 N (10 mm from Flange)
Max Axial Force	15 N
Dielectric Strength	500 Vdc for one minute
Insulation Resistance	100 M ohm min. 500 Vdc

Connection

Lead No	Colour	Gauge	Function
1	Red	UL1430 AWG26	Vcc HallSensor +5 to +24 Vdc
2	Blue	UL1430 AWG26	Hall A
3	Green	UL1430 AWG26	Hall B
4	White	UL1430 AWG26	Hall C
5	Black	UL1430 AWG26	GND Hall Sensor
6	Yellow	UL1430 AWG20	Phase U
7	Red	UL1430 AWG20	Phase V
8	Black	UL1430 AWG20	Phase W

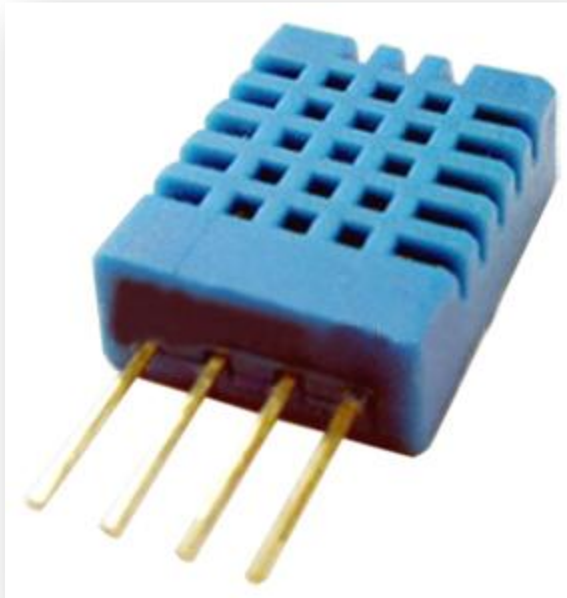
DHT11 Humidity & Temperature Sensor

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output.

DHT 11 Humidity & Temperature Sensor

1. Introduction

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.



Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

2. Technical Specifications:

Overview:

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5％RH	±2℃	1	4 Pin Single Row

Detailed Specifications:

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃，1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

3. Typical Application (Figure 1)

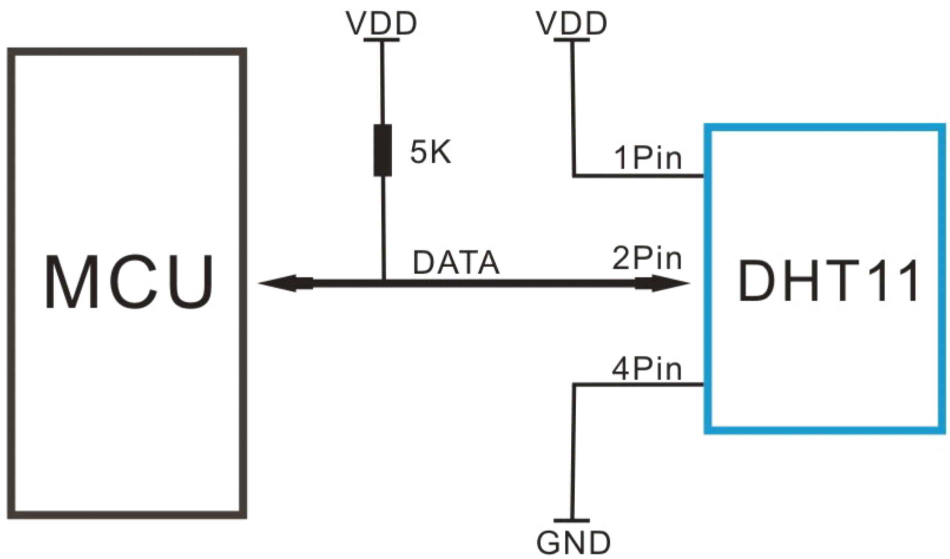


Figure 1 Typical Application

Note: 3Pin – Null; MCU = Micro-computer Unite or single chip Computer

When the connecting cable is shorter than 20 metres, a 5K pull-up resistor is recommended; when the connecting cable is longer than 20 metres, choose a appropriate pull-up resistor as needed.

4. Power and Pin

DHT11's power supply is 3-5.5V DC. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

5. Communication Process: Serial Interface (Single-Wire Two-Way)

Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms.

Data consists of decimal and integral parts. A complete data transmission is **40bit**, and the sensor sends **higher data bit** first.

Data format: 8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data + 8bit check sum. If the data transmission is right, the check-sum should be the last 8bit of "8bit integral RH data + 8bit decimal RH data + 8bit integral T data + 8bit decimal T data".

5.1 Overall Communication Process (Figure 2, below)

When MCU sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for MCU completing the start signal. Once it is completed, DHT11 sends a response signal of 40-bit data that include the relative humidity and temperature information to MCU. Users can choose to collect (read) some data. Without the start signal from MCU, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the low-power-consumption mode until it receives a start signal from MCU again.

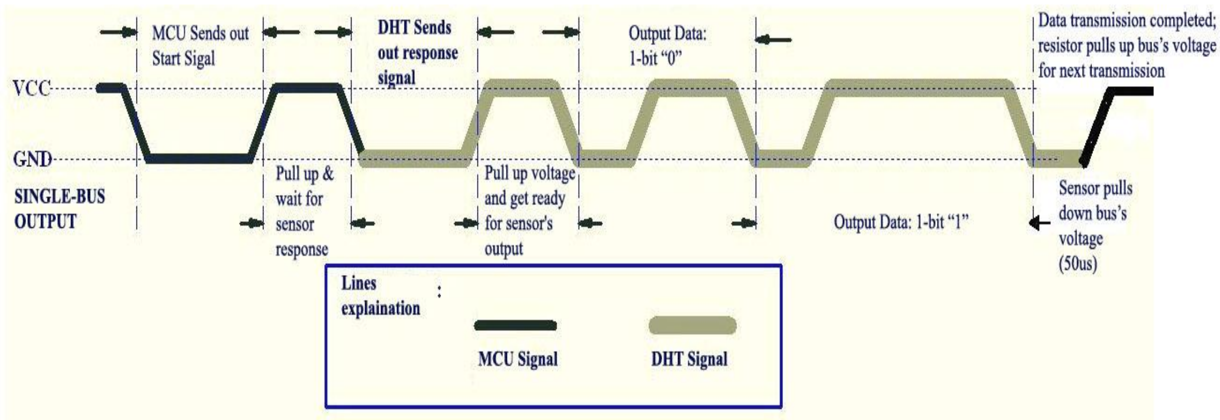


Figure 2 Overall Communication Process

5.2 MCU Sends out Start Signal to DHT (Figure 3, below)

Data Single-bus free status is at high voltage level. When the communication between MCU and DHT11 begins, the programme of MCU will set Data Single-bus voltage level from high to low and this process must take at least 18ms to ensure DHT's detection of MCU's signal, then MCU will pull up voltage and wait 20-40us for DHT's response.

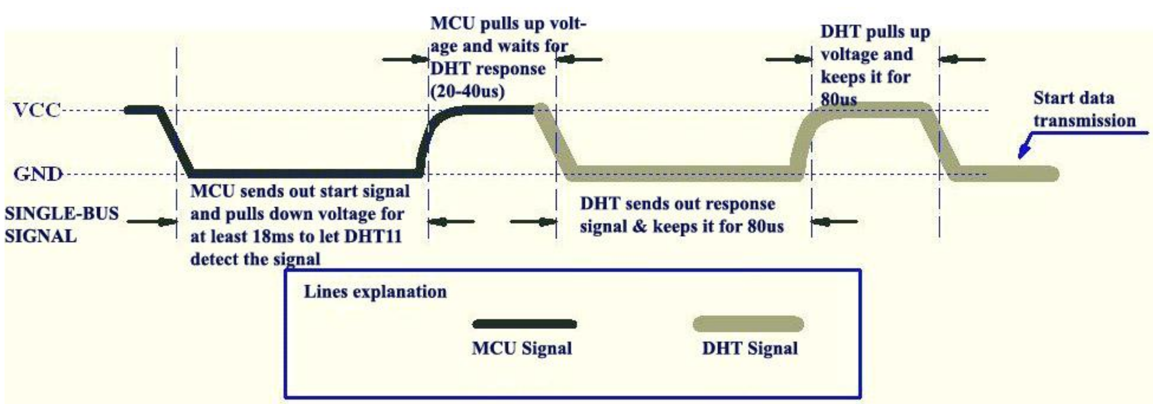


Figure 3 MCU Sends out Start Signal & DHT Responses

5.3 DHT Responses to MCU (Figure 3, above)

Once DHT detects the start signal, it will send out a low-voltage-level response signal, which lasts 80us. Then the programme of DHT sets Data Single-bus voltage level from low to high and keeps it for 80us for DHT's preparation for sending data.

When DATA Single-Bus is at the low voltage level, this means that DHT is sending the response signal. Once DHT sent out the response signal, it pulls up voltage and keeps it for 80us and prepares for data transmission.

When DHT is sending data to MCU, every bit of data begins with the 50us low-voltage-level and the length of the following high-voltage-level signal determines whether data bit is "0" or "1" (see Figures 4 and 5 below).

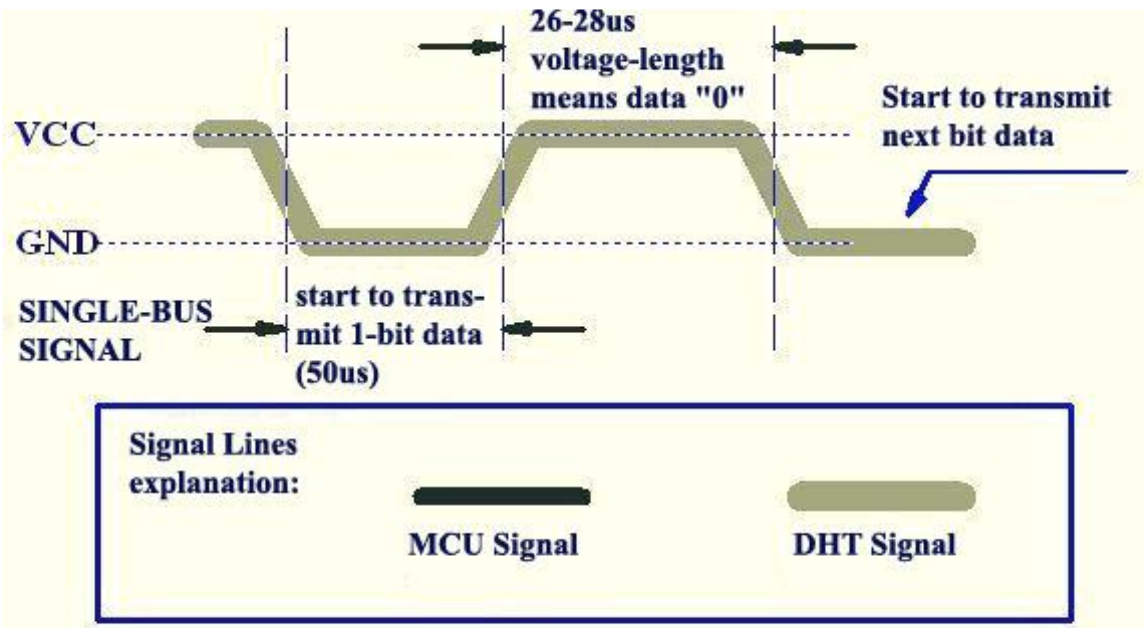


Figure 4 Data "0" Indication

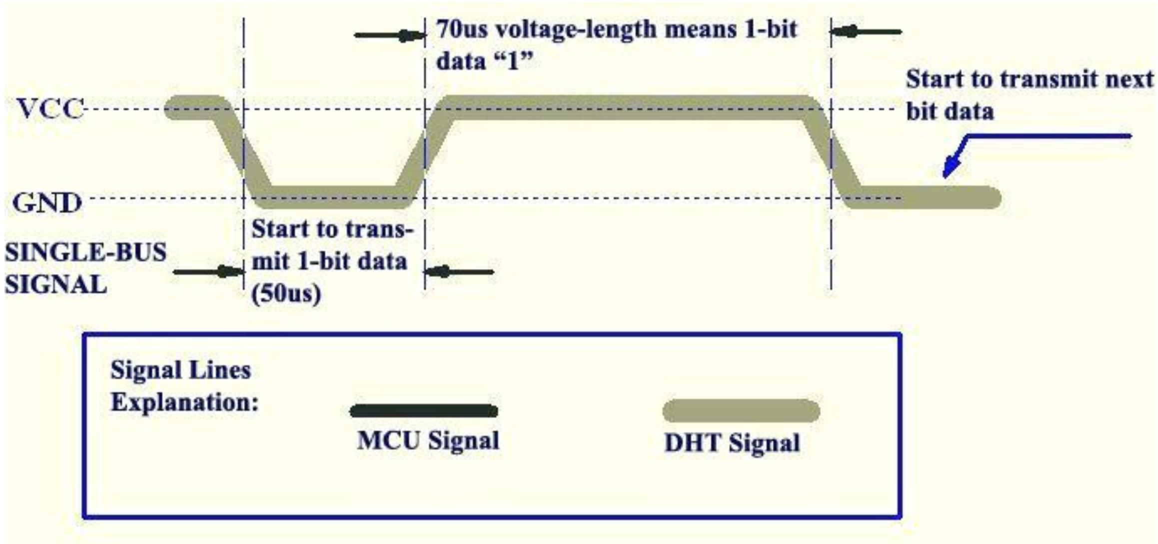


Figure 5 Data "1" Indication

If the response signal from DHT is always at high-voltage-level, it suggests that DHT is not responding properly and please check the connection. When the last bit data is transmitted, DHT11 pulls down the voltage level and keeps it for 50us. Then the Single-Bus voltage will be pulled up by the resistor to set it back to the free status.

6. Electrical Characteristics

VDD=5V, T = 25℃ (unless otherwise stated)

	Conditions	Minimum	Typical	Maximum
Power Supply	DC	3V	5V	5.5V
Current Supply	Measuring	0.5mA		2.5mA
	Average	0.2mA		1mA
	Standby	100uA		150uA
Sampling period	Second	1		

Note: Sampling period at intervals should be no less than 1 second.

7. Attentions of application

(1) Operating conditions

Applying the DHT11 sensor beyond its working range stated in this datasheet can result in 3%RH signal shift/discrepancy. The DHT11 sensor can recover to the calibrated status gradually when it gets back to the normal operating condition and works within its range. Please refer to (3) of

HC-SR04 Ultrasonic Sensor

Elijah J. Morgan

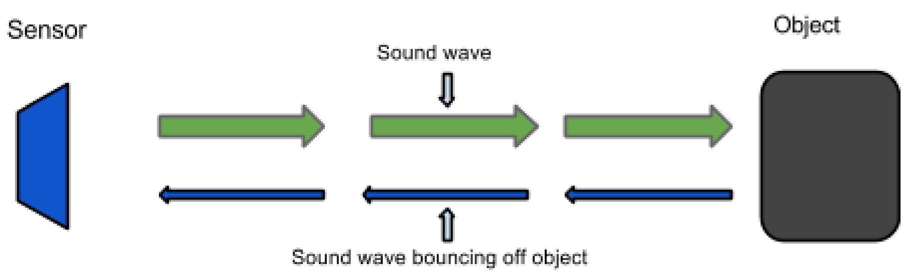
Nov. 16 2014

The purpose of this file is to explain how the HC-SR04 works. It will give a brief explanation of how ultrasonic sensors work in general. It will also explain how to wire the sensor up to a microcontroller and how to take/interpret readings. It will also discuss some sources of errors and bad readings.

1. **How Ultrasonic Sensors Work**
2. **HC-SR04 Specifications**
3. **Timing chart, Pin explanations and Taking Distance Measurements**
4. **Wiring HC-SR04 with a microcontroller**
5. **Errors and Bad Readings**

1. How Ultrasonic Sensors Work

Ultrasonic sensors use sound to determine the distance between the sensor and the closest object in its path. How do ultrasonic sensors do this? Ultrasonic sensors are essentially sound sensors, but they operate at a frequency above human hearing.



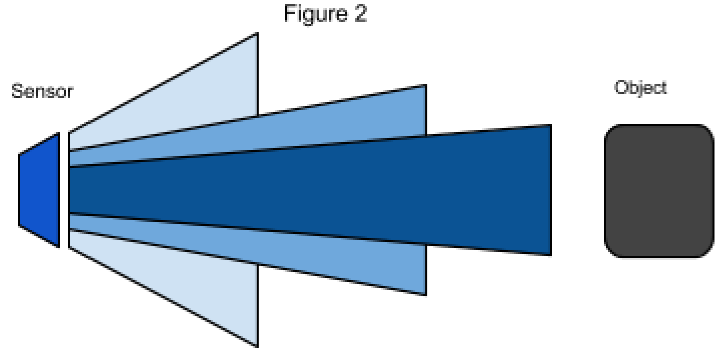
The sensor sends out a sound wave at a specific frequency. It then listens for that specific sound wave to bounce off of an object and come back (Figure 1). The sensor keeps track of the time between sending the sound wave and the sound wave returning. If you know how fast something is going and how long it is traveling you can find the distance traveled with equation 1.

Equation 1. $d = v \times t$

The speed of sound can be calculated based on the a variety of atmospheric conditions, including temperature, humidity and pressure. Actually calculating the distance will be shown later on in this document.

It should be noted that ultrasonic sensors have a cone of detection, the angle of this cone varies with distance, Figure 2 show this relation. The ability of a sensor to detect an object also depends on the objects orientation to the sensor. If an object doesn't present a flat surface to the sensor then it is possible the sound wave will bounce off the object in a way that it does not return to the sensor.

Figure 2



2. HC-SR04 Specifications

The sensor chosen for the Firefighting Drone Project was the HC-SR04. This section contains the specifications and why they are important to the sensor module. The sensor modules requirements are as follows.

- Cost
- Weight
- Community of hobbyists and support
- Accuracy of object detection
- Probability of working in a smoky environment
- Ease of use

The HC-SR04 Specifications are listed below. These specifications are from the Cytron Technologies HC-SR04 User's Manual (source 1).

- Power Supply: +5V DC
- Quiescent Current: <2mA
- Working current: 15mA
- Effectual Angle: <15º
- Ranging Distance: 2-400 cm
- Resolution: 0.3 cm
- Measuring Angle: 30º
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm
- Weight: approx. 10 g

The HC-SR04's best selling point is its price; it can be purchased at around $2 per unit.

3. Timing Chart and Pin Explanations

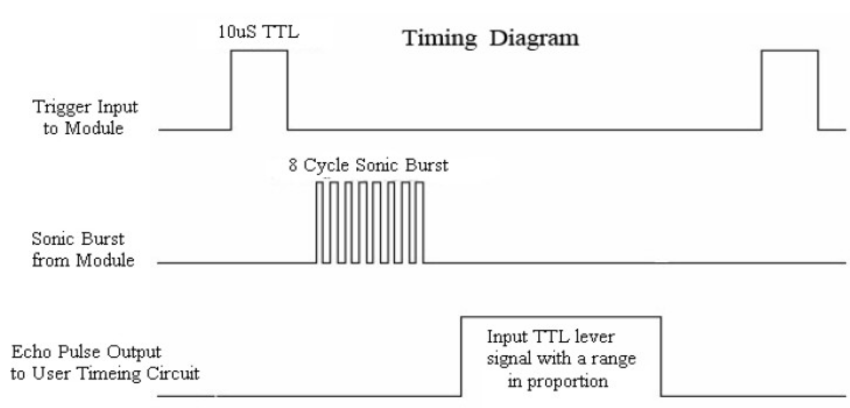
The HC-SR04 has four pins, VCC, GND, TRIG and ECHO; these pins all have different functions. The VCC and GND pins are the simplest -- they power the HC-SR04. These pins need to be attached to a +5 volt source and ground respectively. There is a single control pin: the TRIG pin. The TRIG pin is responsible for sending the ultrasonic burst. This pin should be set to HIGH for 10 μs, at which point the HC-SR04 will send out an eight cycle sonic burst at 40 kHZ. After a sonic burst has been sent the ECHO pin will go HIGH. The ECHO pin is the data pin -- it is used in taking distance measurements. After an ultrasonic burst is sent the pin will go HIGH, it will stay high until an ultrasonic burst is detected back, at which point it will go LOW.

Taking Distance Measurements

The HC-SR04 can be triggered to send out an ultrasonic burst by setting the TRIG pin to HIGH. Once the burst is sent the ECHO pin will automatically go HIGH. This pin will remain HIGH until the the burst hits the sensor again. You can calculate the distance to the object by keeping track of how long the ECHO pin stays HIGH. The time ECHO stays HIGH is the time the burst spent traveling. Using this measurement in equation 1 along with the speed of sound will yield the distance travelled. A summary of this is listed below, along with a visual representation in Figure 2.

1. Set TRIG to HIGH
2. Set a timer when ECHO goes to HIGH
3. Keep the timer running until ECHO goes to LOW
4. Save that time
5. Use equation 1 to determine the distance travelled

Figure 3
Source 2



Source 2

To interpret the time reading into a distance you need to change equation 1. The clock on the device you are using will probably count in microseconds or smaller. To use equation 1 the speed of sound needs to determined,which is 343 meters per second at standard temperature and pressure. To convert this into more useful form use equation 2 to change from meters per second to microseconds per centimeter. Then equation 3 can be used to easily compute the distance in centimeters.

Equation 2. $Distance = \frac{Speed}{170.15\ m} \times \frac{Meters}{100\ cm} \times \frac{1e6\ \mu S}{170.15\ m} \times \frac{58.772\ \mu S}{cm}$

Equation 3. $Distance = \frac{time}{58} = \frac{\mu s}{\mu s/cm} = cm$

4. Wiring the HC-SR04 to a Microcontroller

This section only covers the hardware side. For information on how to integrate the software side, look at one of the links below or look into the specific microcontroller you are using.

The HC-SR04 has 4 pins: VCC, GND, TRIG and ECHO.

1. VCC is a 5v power supply. This should come from the microcontroller
2. GND is a ground pin. Attach to ground on the microcontroller.
3. TRIG should be attached to a GPIO pin that can be set to HIGH
4. ECHO is a little more difficult. The HC-SR04 outputs 5v, which could destroy many microcontroller GPIO pins (the maximum allowed voltage varies). In order to step down the voltage use a single resistor or a voltage divider circuit. Once again this depends on the specific microcontroller you are using, you will need to find out its GPIO maximum voltage and make sure you are below that.

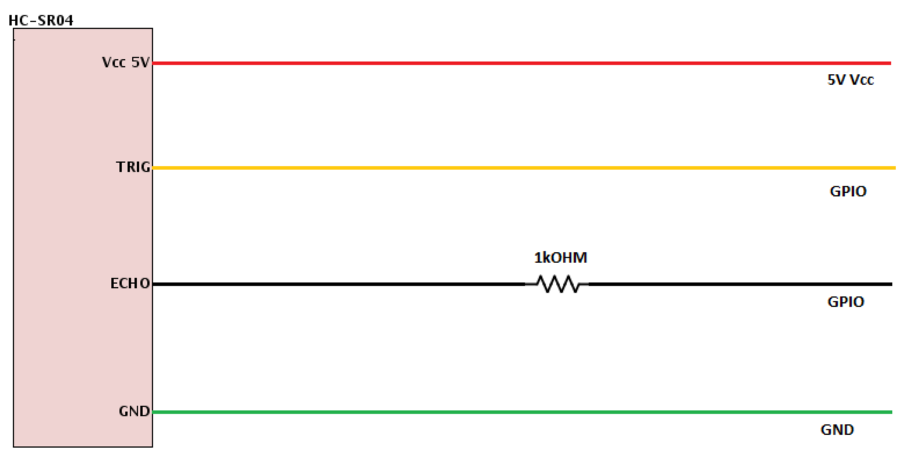
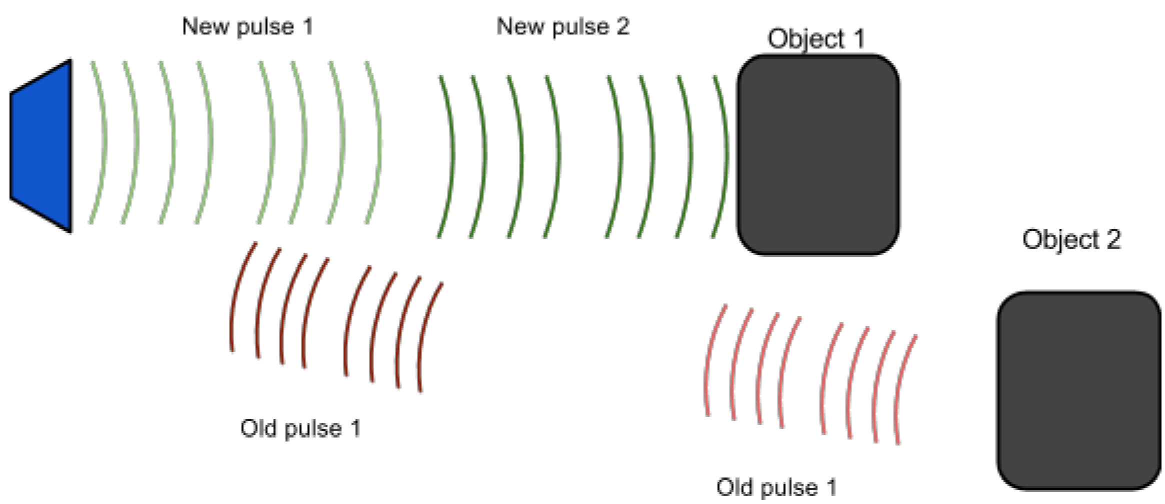


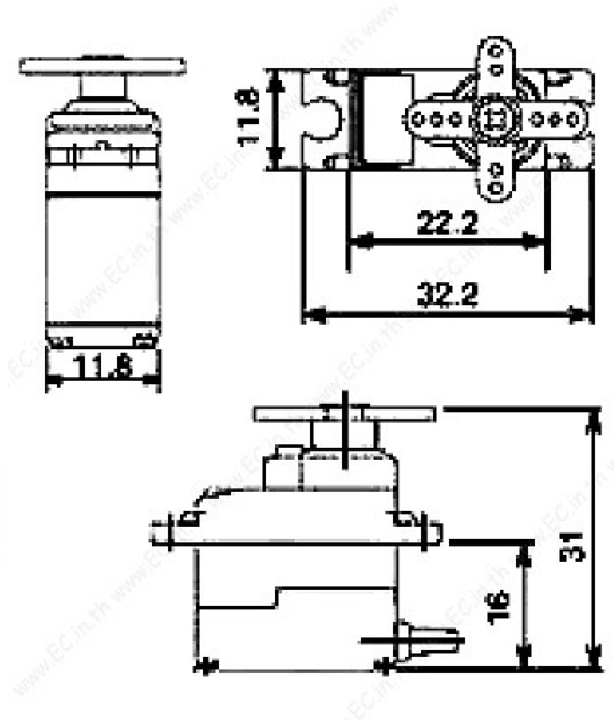
Figure 4

5. Errors and Bad Readings

Ultrasonic sensors are great sensors -- they work well for many applications where other types of sensors fall short. Unfortunately, they do have weaknesses. These weaknesses can be mitigated and worked around, but first they must be understood. The first weakness is that they use sound. There is a limit to how fast ultrasonic sensors can get distance measurements. The longer the distance, the slower they are at reporting the distance. The second weakness comes from the way sound bounces off of objects. In enclosed spaces it is possible, if not probable that there will be unintended echos. The echos can very easily cause false short readings. In Figure 2 a pulse was sent out. It bounced off of object 1 and returned to the sensor. The distance was recorded and then a new pulse was sent. There was another object farther away, so that when the new pulse reaches object 1, the first signal will reach the sensor. This will cause the sensor to think that there is an object closer than is actually true. The old pulse is smaller than the new pulse because it has grown weaker. The longer the pulse exists the weaker it grows until it is negligible. If multiple sensors are being used, the number of echos will increase along with the number of errors. There are two main ways to reduce the number of errors. The first is to provide shielding around the sensor. This prevents echos coming in from angle outside what the sensor should actually pick up. The second is to reduce the frequency at which pulses are sent out. This gives more time for the echos to dissipate.



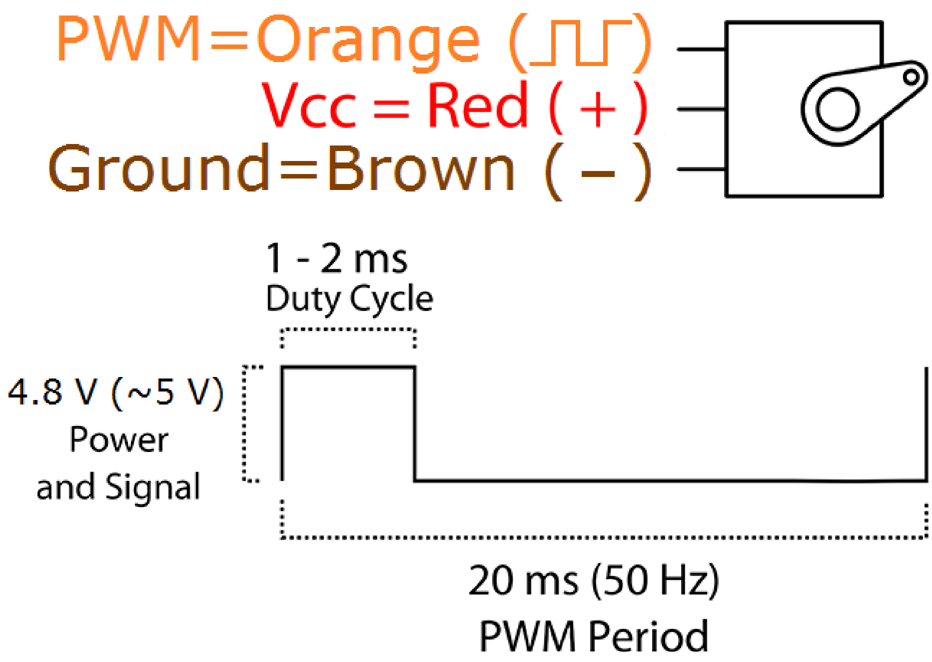
SG90 9 g Micro Servo



Tiny and lightweight with high output power. Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but *smaller*. You can use any servo code, hardware or library to control these servos. Good for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. It comes with a 3 horns (arms) and hardware.

Specifications

- Weight: 9 g
- Dimension: 22.2 x 11.8 x 31 mm approx.
- Stall torque: 1.8 kgf·cm
- Operating speed: 0.1 s/60 degree
- Operating voltage: 4.8 V (~5V)
- Dead band width: 10 µs
- Temperature range: 0 ºC – 55 ºC



Position "0" (1.5 ms pulse) is middle, "90" (~2 ms pulse) is all the way to the right, "-90" (~1 ms pulse) is all the way to the left.