**CHAPTER 1**

**INTRODUCTION**

Presenting the Smart Baby Monitoring System with NodeMCU, a state-of-the-art solution designed to transform how caregivers monitor infants, ensuring their safety and comfort with enhanced efficiency and ease. This system addresses the common challenges parents and caregivers face by integrating advanced sensor technology and automation, delivering real-time insights into the baby’s movements and environment.

Conventional baby monitoring methods often rely on manual observation, which can be prone to errors and lacks continuous tracking capabilities. The Smart Baby Monitoring System resolves these issues by incorporating cutting-edge sensors and automated processes, allowing caregivers to track the baby’s movements, sleep patterns, and environmental conditions seamlessly in real time.

A key focus of the system is its ability to provide continuous monitoring. Using sensors like a microphone to detect sound, the DHT11 for temperature and humidity measurements, and even soil moisture sensors for environmental comfort, the system gives caregivers immediate feedback on the baby's activity and surroundings. Real-time monitoring is essential for quick response, providing valuable alerts and insights into the baby’s overall well-being.

Beyond monitoring, the system features intelligent automation to respond to the baby’s needs. For example, if it detects that the baby is awake or unsettled, it can automatically play soothing music through a connected player to help the baby fall asleep. The system also enables caregivers to remotely operate toys or other interactive devices connected to the cradle through a mobile app, ensuring the baby remains engaged and comfortable.

One of the system's key strengths is its remote accessibility. Caregivers can monitor real-time data and receive alerts from anywhere, enabling them to make timely and informed decisions, even when they are not physically present with the baby. The system is designed to easily integrate with existing baby monitoring devices, offering a seamless, user-friendly experience for caregivers.

In conclusion, the Smart Baby Monitoring System with NodeMCU represents a significant leap forward in infant care technology. Its combination of real-time monitoring, automated responses, and remote accessibility underscores its dedication to enhancing the safety and well-being of infants, while providing peace of mind to caregivers. Through this innovative solution, the system aims to revolutionize baby monitoring, contributing to healthier and happier families.

**1.1: Problem Statement:**

The Smart Baby Monitoring System with NodeMCU addresses a critical problem faced by parents and caregivers: the need for continuous, reliable, and convenient monitoring of infants to ensure their safety and well-being. Traditional baby monitoring methods, such as manual observation or basic audio/video monitors, are often inadequate in providing real-time insights into the baby’s environment and activities. These methods lack automation, real-time data analysis, and remote accessibility, making it challenging for caregivers to monitor the baby effectively when they are not physically present or during their busy schedules.

Conventional baby monitors are often limited to audio or video feeds, requiring caregivers to constantly watch or listen for any signs of distress. This manual approach is prone to errors, especially when caregivers are occupied with other tasks or are resting. It also lacks the ability to monitor critical environmental factors such as room temperature, humidity, and sound levels, which can directly affect the baby’s comfort and health.

Babies often need continuous monitoring, especially during sleep, to ensure their safety. Traditional methods do not provide continuous tracking of the baby’s movements, sleep patterns, or environmental conditions. This gap increases the risk of delayed responses to potential hazards, such as overheating, discomfort, or prolonged crying. Most baby monitoring systems do not have the capability to automatically respond to the baby’s needs, such as soothing the baby when they wake up or providing entertainment. Caregivers must intervene manually, which can be challenging, particularly at night or when they are away from the baby.



Figure 1.1: Smart Baby Monitoring

In today's fast-paced world, caregivers are not always in close proximity to their babies. Traditional baby monitors usually lack remote access, limiting caregivers' ability to monitor their child’s well-being when they are not at home. Without real-time alerts, caregivers may be unaware of sudden changes in the baby's environment or activity, which can lead to delayed responses in critical situations.

Given these challenges, there is a pressing need for an intelligent system that can provide continuous monitoring, real-time data, and automated responses. The \*Smart Baby Monitoring System with NodeMCU aims to solve these problems by integrating advanced sensor technology, automation, and remote access capabilities. The system offers real-time monitoring of the baby’s movement, sleep patterns, and environmental conditions while providing caregivers with immediate alerts and the ability to respond to the baby’s needs remotely.

By addressing the limitations of traditional baby monitoring systems, this project aims to enhance infant care, providing peace of mind to caregivers and promoting a safer, more comfortable environment for babies.

**1.2: Problem Scope**:

The problem scope of the Smart Baby Monitoring System with NodeMCU outlines the specific areas where traditional baby monitoring methods fall short and how this project aims to address those deficiencies. The scope defines the system's key objectives, the limitations it seeks to overcome, and the technological capabilities it plans to integrate in order to improve infant care.

1. Inadequate Monitoring of Environmental Conditions:

Traditional baby monitors, such as basic audio or video monitors, often neglect critical environmental factors that can significantly affect a baby’s health and comfort, such as temperature, humidity, and noise levels. These factors are essential to a baby’s well-being, as extreme conditions could lead to discomfort, disrupted sleep, or health issues. The scope of this project includes incorporating sensors such as the DHT11 for temperature and humidity monitoring and mic sensors for sound detection, allowing the system to track environmental conditions in real time.

2. Limited Insight into Baby’s Activity and Sleep Patterns:

While many baby monitors provide video or audio feeds, they do not offer detailed information about the baby’s activity or sleep patterns. The Smart Baby Monitoring System aims to include movement detection sensors to track the baby’s motion during sleep or playtime. By gathering this data continuously, caregivers can have a better understanding of their child’s habits, helping them detect irregularities like excessive movement, which may indicate discomfort or waking from sleep.

3. Lack of Automation for Immediate Responses:

A major limitation in current systems is the absence of automated responses when the baby shows signs of discomfort or distress. The scope of this project includes automating several functions, such as playing soothing music if the baby wakes up crying or activating toys to engage the baby. These features reduce the need for constant manual intervention and enhance the child’s comfort.

4. Absence of Remote Monitoring and Alerts:

Many conventional monitoring systems require caregivers to be physically near the monitor to hear or see their baby. In modern households, caregivers often need the ability to monitor their child from a distance, whether they are in another room, at work, or outside the home. This project aims to integrate the NodeMCU microcontroller's Wi-Fi capability to provide caregivers with real-time access to the baby’s data via a smartphone app or web interface. The system will also send alerts for abnormal conditions such as high temperature, crying, or a lack of movement, ensuring timely intervention.

5. Inconsistent Monitoring of Health-Related Metrics:

Beyond the basics, current baby monitoring systems lack the ability to consistently track and alert caregivers to health-related metrics such as the baby’s comfort level based on environmental factors. This project includes the use of soil moisture sensors as part of environmental comfort assessments, enhancing the system’s ability to provide a comprehensive overview of the baby’s surroundings.

6. User-Friendly and Scalable Design:

The Smart Baby Monitoring System is intended to be scalable and easy to use for caregivers with varying levels of technical expertise. The system’s design scope includes easy integration with existing baby monitoring setups, ensuring that caregivers can expand or enhance their monitoring capabilities without needing complex installations. The interface will be simple and intuitive, ensuring that users can easily access real-time data and control the system.

In conclusion, the problem scope of this project is to address the limitations of traditional baby monitoring systems by introducing real-time environmental monitoring, continuous activity tracking, automated responses, remote access, and health-related insights. By leveraging IoT technology and automation, this project seeks to redefine how caregivers monitor their babies, ensuring safety, comfort, and peace of mind.

**1.3: Advantages of Implementing a Baby Monitoring System with NodeMCU:**

A Smart Cradle Baby Monitoring System integrates advanced technology to ensure the safety and well-being of infants while providing parents with peace of mind. This innovative solution offers several significant advantages that enhance both infant care and parental convenience.

**1. Real-Time Monitoring:**

The smart cradle continuously monitors the baby's vital signs, including heart rate and breathing patterns. This real-time data allows parents to receive immediate alerts in case of irregularities, enabling prompt action to ensure the baby’s safety.

**2. Enhanced Safety Features:**

Equipped with motion and fall detection sensors, the smart cradle can alert parents if the baby moves unexpectedly or if the cradle is disturbed. These safety features significantly reduce the risk of accidents, providing a secure sleeping environment.

**3. Improved Sleep Quality:**

The system tracks and analyzes the baby’s sleep patterns, offering insights that can help parents establish better sleep routines. By understanding their baby’s sleep habits, parents can make informed adjustments to promote healthier sleep.

**4. Connectivity and Convenience:**

With integrated Wi-Fi, parents can monitor their baby remotely through a mobile app. This connectivity allows for real-time updates and notifications, ensuring that parents can stay informed, even when they are not in the same room.

**5. Two-Way Communication:**

The smart cradle includes a two-way audio feature, allowing parents to soothe their baby with their voice, even from a distance. This functionality helps maintain a comforting connection between parent and child.

**6. Customizable Alerts and Notifications:**

Parents can customize alerts based on their preferences, receiving notifications for specific events such as changes in the baby’s heart rate, movement, or environmental conditions. This level of personalization enhances the monitoring experience.

**7. Data Logging and Insights:**

The smart cradle can log data over time, providing valuable insights into the baby’s health and sleeping habits. Parents can track trends and make data-driven decisions regarding their child’s care.

**8. Integration with Smart Home Devices:**

The system can be integrated with other smart home devices, such as temperature control and lighting systems, to create an optimal sleeping environment for the baby. This integration enhances convenience and comfort.

**9. Peace of Mind for Parents:**

Knowing that the baby is being monitored continuously allows parents to relax and focus on other tasks. The combination of real-time alerts and remote access significantly reduces anxiety related to infant care.

The Smart Cradle Baby Monitoring System offers numerous advantages that significantly enhance infant safety and parental convenience. By integrating real-time monitoring, safety features, and connectivity, this innovative solution addresses the modern needs of parents, promoting a nurturing environment for babies while providing peace of mind.

**1.4 Proposed Solution:**

The Smart Cradle Baby Monitoring System aims to enhance infant care by integrating advanced monitoring technologies with user-friendly features. This system leverages IoT (Internet of Things) capabilities to provide real-time data to parents, ensuring a safe and comfortable environment for their babies.

**1. Smart Cradle:** The cradle will be equipped with sensors to monitor vital signs, including heart rate, temperature, and movement. An adjustable rocking mechanism will soothe the baby, with options for parents to control speed and motion.

**2. Mobile Application**: A user-friendly mobile app will serve as the interface for parents. It will provide real-time alerts, detailed analytics, and historical data regarding the baby’s health and sleep patterns. Parents can customize alerts based on their preferences.

**3. Camera and Audio Monitoring:** Integrated high-definition cameras will allow parents to visually monitor their baby remotely. Two-way audio communication will enable parents to soothe their baby from another room.

**4. Environmental Sensors:** The system will include sensors to monitor the room temperature, humidity, and noise levels, ensuring the baby’s environment is optimal for sleep.

**5. Data Analytics:** The collected data will be analyzed to provide insights into the baby’s sleep patterns and overall health. This information can assist in identifying any irregularities early on.

Continuous tracking of vital signs with immediate alerts for any anomalies. Parents can access the system remotely through the app, receiving live updates and being able to interact with their baby. Customizable cradle rocking settings and ambient sounds to promote better sleep.

The system will incorporate robust security measures, including data encryption and secure user authentication. Parents will have control over their data and can opt-in for cloud storage to ensure their information is protected.

The Smart Cradle Baby Monitoring System represents a significant advancement in infant care technology. By combining essential monitoring features with comfort and ease of use, this solution offers peace of mind to parents while ensuring the well-being of their babies.

**1.5 Aim and Objectives**

**Aim:**

The aim of a smart cradle baby monitoring system using NodeMCU in an IoT project is to provide parents and caregivers with real-time monitoring of their infant’s activities and environment. This system integrates sensors and IoT capabilities to track vital parameters such as the baby's movements, crying, temperature, and humidity. With NodeMCU, a low-cost IoT platform, data from these sensors can be transmitted wirelessly to a cloud server or a mobile application, enabling remote monitoring. The system can also send notifications or alarms to the parents' smartphones in case of any abnormal conditions, such as excessive crying or uncomfortable temperature levels, ensuring that the baby receives timely attention.

Moreover, the smart cradle system aims to enhance the safety and convenience of baby care. By automating certain functions like rocking the cradle when the baby cries, it reduces the need for constant physical presence. The use of IoT enables the system to be scalable, allowing additional features like video streaming, sleep pattern analysis, and integration with other smart home devices. The NodeMCU’s versatility in handling multiple sensor inputs and connectivity through Wi-Fi makes it an ideal choice for building an affordable, efficient, and easily deployable smart cradle system.

**Objectives:**

The objectives of implementing a Smart Baby Monitoring System with NodeMCU are as follows:

**Real-time Monitoring:** Continuously track key aspects of the baby’s well-being, including movement, crying, and sleep patterns, to keep parents informed at all times.

**Continuous Baby Safety:** Ensure the safety and well-being of infants by continuously monitoring their movement, sleep patterns, and environmental conditions to prevent potential hazards or discomfort

**Remote Accessibility:** Allow parents to monitor their baby's status from anywhere via smartphones or cloud platforms using IoT connectivity, ensuring they can stay updated even when not at home.

**Automated Cradle Functions:** Automatically rock the cradle or control environmental conditions (like temperature and humidity) based on the baby’s behavior or external factors, offering hands-free convenience.

**Environmental Monitoring:** Ensure that the cradle’s surroundings remain comfortable by constantly checking parameters like temperature and humidity and adjusting accordingly.

**Safety Alerts and Notifications:** Send real-time alerts to parents for abnormal conditions such as excessive crying, unusual movements, or temperature fluctuations, ensuring immediate attention when needed.

**Data-Driven Decision Making:** Collect and analyze data on the baby’s sleeping patterns, activity levels, and environmental conditions to help parents make informed decisions about care routines and identify any potential issues early on.

**Scalable and Customizable Design:** Build a system that can be expanded with additional features, such as video streaming, AI-driven sleep pattern analysis, or integration with other smart home devices.

**Parental Convenience and Peace of Mind:** Enhance ease of baby care by reducing the need for constant physical presence, giving parents confidence that the system will alert them if any action is required.

**Cost Efficiency:** Reduce operational costs associated with manual monitoring and potential incidents caused by delayed responses, optimizing resource utilization and contributing to long-term financial sustainability in infant care practices.

By achieving these objectives, the smart cradle baby monitoring system offers a comprehensive, cost-effective solution for modern baby care. It ensures real-time monitoring, remote accessibility, and safety alerts, providing parents with peace of mind and reducing the need for constant supervision. The integration of automated functions, environmental monitoring, and data-driven decision-making enhances both the convenience and safety of childcare. Additionally, the system's scalability allows for future improvements, making it adaptable to evolving needs while maintaining affordability and efficiency in baby care.

**CHAPTER 2**

**Literature Survey**

The integration of the Internet of Things (IoT) into infant care has paved the way for innovative solutions in baby monitoring systems. A Smart Cradle Baby Monitoring System leverages IoT technologies, wireless communication, and a variety of sensors to monitor critical aspects of a baby’s well-being, such as movement, crying, temperature, and sleep patterns. By offering real-time monitoring, remote accessibility, and automated responses, this system aims to provide a secure, convenient, and efficient caregiving solution for modern parents.

This literature survey delves into relevant research, key components, security and privacy measures, caregiving infrastructure, case studies, and emerging trends in infant care technologies. It examines how these systems have evolved from traditional monitoring methods to smart IoT-based solutions, and how they are shaping the future of childcare.

Historically, baby monitoring systems primarily consisted of audio or video-based monitors, allowing parents to listen to or visually observe their infants. These systems had limited range and functionality, often restricted to simple transmission within the home. They lacked environmental sensing capabilities and remote accessibility, making it difficult for parents to monitor their child when away from the immediate vicinity. As demands for more advanced monitoring increased, the need for intelligent, automated systems became evident.

The introduction of IoT technology in baby monitoring systems has revolutionized infant care by providing remote monitoring, real-time data analysis, and automated responses. With the use of low-cost, Wi-Fi-enabled microcontrollers such as NodeMCU, these systems can collect and transmit data to parents' smartphones, even from a distance.

Several research efforts have emphasized the growing importance of IoT in baby monitoring. These systems monitor the baby’s motion, environmental parameters like temperature and humidity, and send alerts to parents via a cloud platform. Additionally, many smart cradle systems offer automated rocking based on sound or motion detection, showcasing the increasing use of automation in caregiving.

Sensor Technology in Infant Care:

Researchers have explored a wide range of sensors applicable to IoT-based infant monitoring systems. Studies evaluate the accuracy, reliability, and real-time capabilities of sensors such as motion sensors, temperature sensors, and humidity sensors to ensure optimal monitoring of the baby's environment and well-being.

Security and Privacy Measures

As IoT devices become integral to baby monitoring systems, \*security and privacy concerns\* arise. Since these devices transmit sensitive data such as video, audio, and environmental information, they are susceptible to breaches or hacking. Therefore, implementing strong security protocols is critical.

Caregiving Infrastructure:

Smart cradle systems integrate seamlessly into modern caregiving infrastructure by reducing the physical burden on caregivers while ensuring infants receive the care they need. Systems can autonomously rock the cradle when the baby cries, maintaining comfort without requiring constant supervision. Environmental control, such as maintaining the correct temperature and humidity levels, also enhances the caregiving experience. Data-Driven Insights by collecting data on the baby’s sleep patterns, crying frequency, and movements, parents can gain valuable insights into their child’s well-being, leading to more informed caregiving decisions.

Smart cradle systems now provide comprehensive monitoring of the baby’s environment and behavior, ensuring enhanced comfort and safety. While challenges such as security and power consumption persist, ongoing research and technological advancements promise even more sophisticated and secure solutions in the future. As AI, machine learning, and advanced health monitoring features continue to emerge, these systems are set to revolutionize infant care, providing parents with peace of mind and improving the overall quality of care for their children.

**CHAPTER 3**

**Methodology**

Methodology for Implementing a Smart Cradle Baby Monitoring Systemthe development and implementation of a Smart Cradle Baby Monitoring System involves the integration of several technologies, including IoT, sensors, microcontrollers, cloud services, and mobile applications. This section outlines the step-by-step methodology, starting from system design to deployment. Each phase focuses on the technical requirements, system components, and their interaction to ensure effective baby monitoring and automation.

System Design and Requirementsthe first step in implementing a smart cradle system is to define the system architecture and its requirements. The main goal is to provide parents with real-time monitoring of the baby’s movement, environment, and sleep patterns, as well as to implement automated responses like rocking the cradle when the baby cries.

Sensors Integration

The system uses various sensors (e.g., heart rate, temperature, breathing sensors) to continuously track the baby's health. These sensors are embedded in the cradle or in wearable devices.The cradle often has temperature, humidity, and sound sensors to monitor the surrounding environment. If the conditions deviate from safe levels, the system can alert caregivers. Accelerometers and gyroscopes can detect abnormal movements, such as if the baby is rolling over or experiencing distress.

Data Collection

The sensors gather real-time data and send it to a central processing unit (either in the cradle or to a cloud-based platform) for analysis.The collected data includes the baby’s heart rate, temperature, movements, and environmental parameters like room temperature and noise levels.

Data Processing and Analysis

Advanced systems use machine learning models to identify patterns in the baby's behavior. For example, algorithms can distinguish between normal and abnormal sleeping or breathing pattern. The system compares real-time data against predefined thresholds or models of normal behavior.

Real-Time Notifications

Parents or caregivers receive real-time notifications via a connected smartphone app if the system detects any irregularities or potential dangers (e.g., breathing difficulties, high temperature). The cradle may also have built-in mechanisms to soothe the baby (e.g., gentle rocking, playing lullabies) based on the analysis of crying or discomfort sounds.

Remote Monitoring and Control

Parents can monitor their baby from remote locations through a mobile app or web interface. Some systems offer live video feeds, enabling caregivers to watch the baby in real time. Through the app, parents can control certain features of the cradle (like adjusting rocking speed or turning on a white noise machine).

Cloud-Based Data Storage and Analytics

Data from the sensors may be stored in the cloud for future analysis, providing long-term insights into the baby's health and development. This data could be shared with healthcare providers for further evaluation or diagnosis. Over time, the system can use the collected data to make predictions about potential risks, like predicting the baby's sleep cycles, detecting early signs of illness, or identifying behavioral trends.

Power and Connectivity

The cradle is usually equipped with power management features, ensuring that critical functions like vital sign monitoring remain active even in the event of power failure. Wi-Fi or Bluetooth Connectivity. The system connects to a central server or a parent’s mobile device via Wi-Fi or Bluetooth to ensure continuous monitoring and communication.

User-Friendly Interface

The system includes a simple, intuitive interface for parents, allowing them to easily check their baby’s condition and adjust settings. In essence, the Smartcradle Baby Monitoring System leverages sensor technologies, data analytics, machine learning, and real-time notifications to create a secure and convenient environment for baby care.

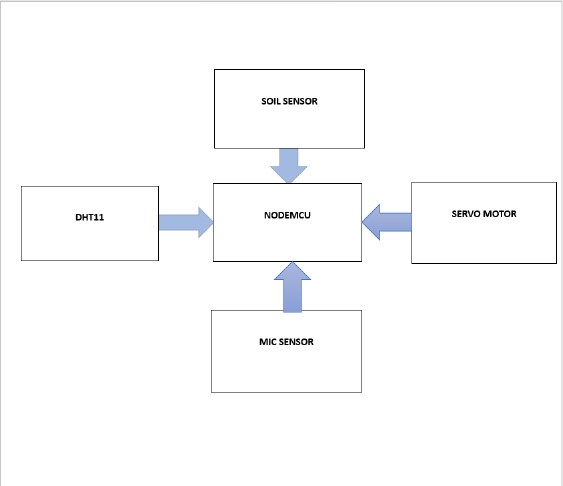


Figure 3.1: Block Diagram

## **3.1 NodeMCU (ESP8266 )**

The NodeMCU ESP8266 is a powerful and versatile IoT development board designed for both beginners and experienced developers. Built around the ESP8266EX microcontroller, it offers built-in Wi-Fi capabilities, enabling seamless connectivity for various applications. With multiple GPIO pins and support for various communication protocols, NodeMCU allows for easy integration with sensors and actuators. Its low power consumption and compatibility with popular programming environments like Arduino IDE make it an ideal choice for smart home projects and other IoT solutions. Overall, its specifications cater to a wide range of innovative applications in the IoT landscape. It supports the Lua script interpreter, allowing developers to program and prototype applications quickly with a simple and flexible interface



Figure 3.2 NodeMCU ESP8266 Pinout

**NodeMCU Specifications:**

**Microcontroller**: The ESP8266EX is a powerful chip that handles processing and controls various functions.

**Operating Voltage**: The board operates at 3.3V, making it crucial to avoid 5V connections to prevent damage.

**Wi-Fi Standard**: Supports 802.11 b/g/n, enabling high-speed wireless connectivity.

**Wi-Fi Frequency**: Operates on the 2.4 GHz band, which is widely used for IoT devices.

**GPIO Pins:** Features 16 general-purpose input/output pins for connecting sensors, LEDs, and other components.

**Analog Pins**: Includes one analog-to-digital converter (ADC) channel for reading analog signals with 10-bit resolution.

**Digital Pins**: Supports multiple digital pins, allowing for digital input and output operations.

**Flash Memory**: Typically equipped with 4MB of flash memory for storing programs and data.

**RAM**: Provides 160 KB of RAM for executing user applications efficiently.

**Reset Button**: Features a reset button that allows users to easily restart the board during development or troubleshooting.

**Communication Protocols**: Supports various protocols like UART, I2C, SPI, and PWM for versatile connectivity.

**Dimensions**: Compact size, usually around 58mm x 26mm, making it suitable for space-constrained projects.

**Power Consumption**: Designed for low power usage, making it ideal for battery-operated IoT devices.

**Development Board**: Comes with a USB interface for easy programming and power management.

**Community Support**: Backed by a strong community, providing extensive libraries and resources for development.

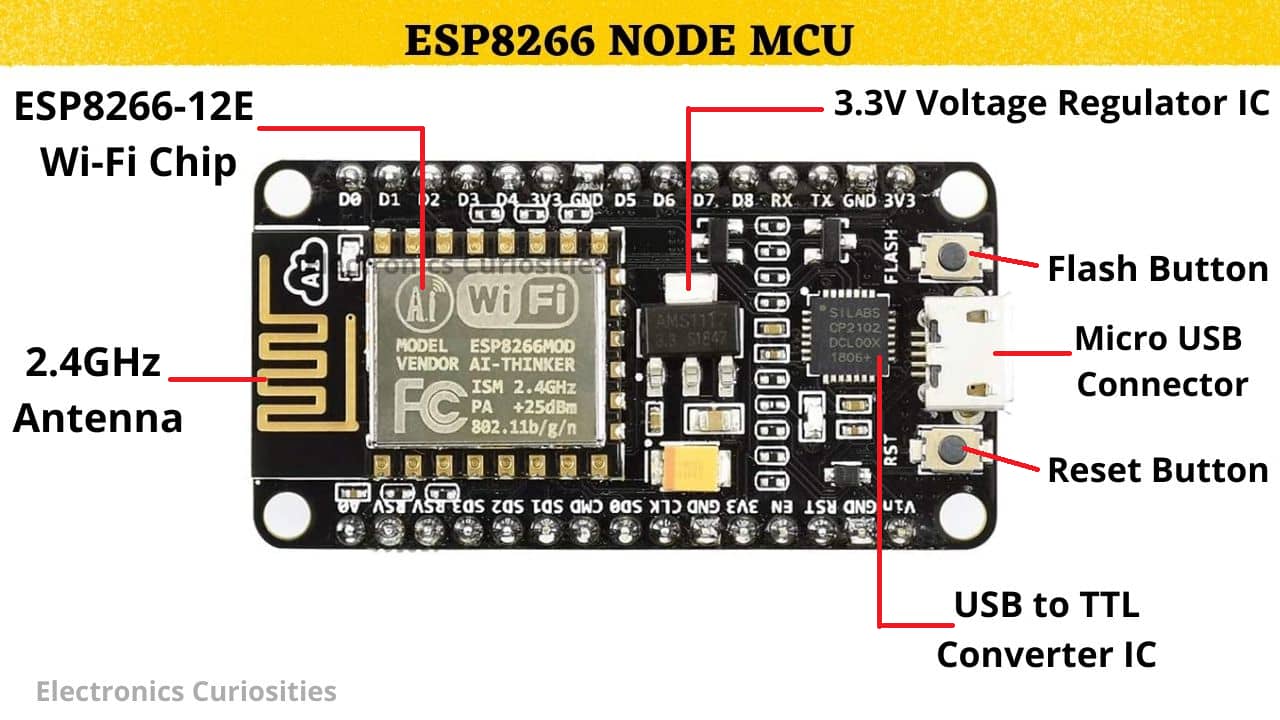


Figure 3.3: NodeMCU Parts

**NODEMCU ESP8266 PINS**

ADC | A0 | GPIO16

EN | Enable | GPIO14

D0 | GPIO16 | GPIO12

D1 | GPIO5 | GPIO13

D2 | GPIO4 | GPIO15

D3 | GPIO0 | GPIO2

D4 | GPIO2 | GPIO9

D5 | GPIO14 | GPIO10

D6 | GPIO12 | GPIO3

D7 | GPIO13 | GPIO1

D8 | GPIO15 | TX (GPIO1)

D9 | GPIO3 (RX) | RX (GPIO3)

D10 | GPIO1 (TX) | D11 (MOSI)

D11 | MOSI | D12 (MISO)

D12 | MISO | D13 (SCK

**ADC**: Analog-to-Digital Converter pin for reading analog sensor values.

**EN** (Enable): Enable pin.

**D0-D8**: Digital GPIO pins.

**D9 (RX) and D10 (TX)**: Serial communication pins for programming and debugging.

**D11 (MOSI), D12 (MISO), D13 (SCK**): Pins used for SPI communication.

**D14 (SDA) and D15 (SCL)**: Pins used for I2C communication.

It's important to note that GPIO pins labeled as "D" (Digital) are typically used for general-purpose digital input/output. Additionally, GPIO pins labeled as "A" (Analog) can be used as analog inputs with the ADC. GPIO pins 6, 7, 8, 9, 10, and 11 have additional functions, so it's advised to refer to the specific NodeMCU documentation for detailed information on pin functionality and capabilities.

**3.2 DHT11**The DHT11 sensor is a low-cost digital temperature and humidity sensor widely used in various applications, including weather monitoring and HVAC systems. It provides accurate readings for temperature in the range of 0 to 50°C with an accuracy of ±2°C, and for humidity from 20% to 80% with an accuracy of ±5% RH. The DHT11 communicates using a single-wire protocol, making it easy to connect to microcontrollers like the NodeMCU. It operates at a voltage of 3 to 5V and requires minimal current, making it suitable for battery-powered projects. Due to its affordability and ease of use, the DHT11 is a popular choice for DIY electronics and IoT projects.



Fig 3.5: DHT11 sensor

**Features of Temperature Sensors:**

1. Temperature Range: Measures temperature from 0°C to 50°C, making it suitable for indoor applications.

2. Humidity Range: Capable of measuring humidity levels from 20% to 80% relative humidity (RH).

3. Accuracy: Provides temperature accuracy of ±2°C and humidity accuracy of ±5% RH, ensuring reliable readings for basic applications.

4. Resolution: Offers a temperature resolution of 1°C and a humidity resolution of 1% RH, allowing for precise measurements.

5. Response Time: Has a relatively fast response time, typically around 2 seconds, for quick updates on environment.

6. Single-Wire Interface: Utilizes a single-wire digital communication protocol, simplifying connections to microcontrollers.

7. Low Power Consumption: Operates on a voltage range of 3 to 5V with minimal current draw, making it energy-efficient for battery-operated devices.

8. Compact Size: Features a small form factor, making it easy to integrate into various projects without requiring much space.

**Principle of Temperature Measurement:**

Different types of temperature sensors work based on various principles. Some common

principles include

Thermocouples: These sensors use the Seebeck effect, where two different metals

connected at two junctions produce a voltage proportional to the temperature difference

between the junctions. The voltage generated is used to determine the temperature.

RTDs (Resistance Temperature Detectors): RTDs are based on the principle that the

electrical resistance of a material changes with temperature. They use materials with a

predictable resistance-temperature relationship, such as platinum, to measure

temperature.

Thermistors: Thermistors are temperature-sensitive resistors that have a resistance that

changes significantly with temperature. They can be either Negative Temperature

Coefficient (NTC) or Positive Temperature Coefficient (PTC) thermistors.

Infrared Sensors: These sensors detect the infrared radiation emitted by an object to

calculate its temperature. They are particularly useful for non-contact temperature

measurement.

Bimetallic Strips: Bimetallic strips consist of two different metals with different

coefficients of thermal expansion bonded together. As the temperature changes, the strip

bends due to the differential expansion, and this bending can be used to measure

temperature.

Semiconductor Temperature Sensors: These sensors use the temperature-dependent

properties of semiconductors, such as diodes or transistors, to measure temperature.

## **3.3 Servo motor:**

The high torque continuous servo motor selected for the project is a specialized DC motor designed for applications requiring powerful and continuous rotation. This motor offers significant torque output, making it suitable for tasks such as limb movement and object manipulation in the humanoid robot. The continuous rotation capability allows for precise control over the robot's various motions, contributing to its overall versatility in assisting the elderly with daily activities.

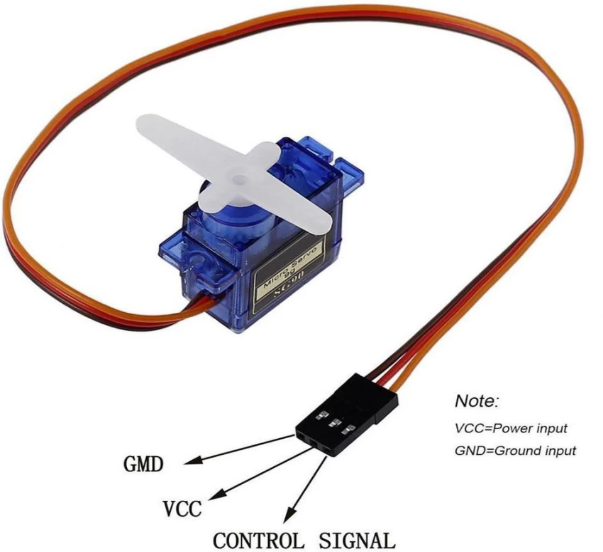
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Figure 3.5 Servo motor

**Details of servo motor**

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly, and a controlling circuit. First of all, we use gear assembly to reduce RPM and to increase torque of the motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now the difference between these two signals, one comes from the potentiometer and another comes from other sources, will be processed in a feedback mechanism and output will be provided in terms of error signal. This error signal acts as the input for the motor and the motor starts rotating. Now the motor shaft is connected with the potentiometer and as the motor rotates so does the potentiometer and it will generate a signal. So as the potentiometer’s angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches a position that the output of potentiometer is the same as the external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation the motor stops rotating.

**Features of Servo Motor:**

**Precision Control:** Servo motors offer precise control over angular position, velocity, and acceleration. They can accurately follow commands to achieve specific motion profiles, making them ideal for applications requiring precise positioning.

**High Torque-to-Size Ratio:** Despite their compact size, servo motors can deliver high torque output, making them suitable for applications where space is limited but high torque is required.

**Feedback Mechanism:** Servo motors typically incorporate a feedback mechanism such as an encoder or resolver, which provides real-time feedback on the motor's position and velocity. This feedback allows for closed-loop control, ensuring accurate motion control and position accuracy.

**Fast Response Time:** Servo motors have fast response times, allowing them to quickly adjust to changes in command signals and maintain precise control over motion profiles. This responsiveness makes them suitable for dynamic applications with rapidly changing motion requirements.

**Variable Speed:** Servo motors can operate at variable speeds, allowing for smooth acceleration and deceleration profiles. This feature is essential for applications requiring precise speed control and smooth motion transitions.

**Wide Range of Sizes and Configurations:** Servo motors are available in a wide range of sizes and configurations to suit different application requirements. They can vary in terms of power rating, form factor, mounting options, and shaft configurations.

**High Efficiency:** Servo motors are designed for high efficiency, minimizing energy consumption and heat generation during operation. This efficiency makes them suitable for applications where energy efficiency is a priority.

**Low Maintenance:** Servo motors typically have a long service life and require minimal maintenance. The use of brushless designs reduces wear and tear, resulting in reliable operation over extended periods.

**Connection:**

The VCC (Red Wire) and GND (Black Wire) pins of servo motor are connected to 5V and GND pins of Arduino Uno while the Signal pin (Yellow Wire) is connected to digital pin of NodeMCU.

**Specifications:**

* Operating voltage: 4.8 V - 7.2 V
* Running Current 500 mA – 900 mA (6V)
* Stall Current 2.5 A (6V)
* Temperature range: 0 ºC – 55 ºC
* Control System: Analog
* Operating Angle: 180 degree
* Required Pulse: 900us-2100us
* Direction: CCW
* Operating speed: 0.17 s/60º (4.8 V), 0.14 s/60º (6 V)
* Dead band width: 5 μs
* Wire length: 30cm

Connector: 3 pin 'S' type female header

* Weight: 55 g
* Dimension: 40.7 x 19.7 x 42.9 mm approx.
* Stall torque: 9.8 kgf·cm (4.8 V ), 11 kgf·cm (6 V)

**3.4 Soil moisture sensor**

The moisture of the soil plays an essential role in the irrigation field as well as in gardens for plants. As nutrients in the soil provide the food to the plants for their growth. Supplying water to the plants is also essential to change the temperature of the plants. The temperature of the plant can be changed with water using the method like transpiration. And plant root systems are also developed better when rising within moist soil. Extreme soil moisture levels can guide to anaerobic situations that can encourage the plant’s growth as well as soil pathogens.

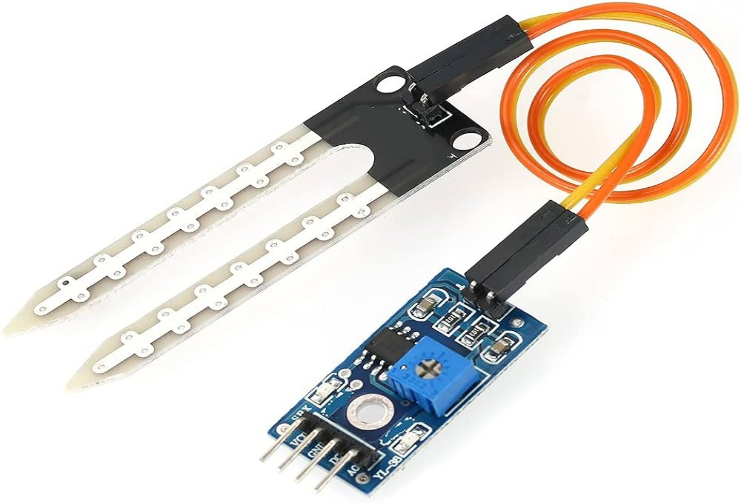


Figure 3.6 Soil Moisture sensor

**Working Principle:**

This sensor mainly utilizes capacitance to gauge the water content of the soil (dielectric permittivity). The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent.

This sensor makes it perfect to execute experiments within science courses like environmental science, agricultural science, biology, soil science, botany, and horticulture.

**Connection:**VCC pin is used for power

A0 pin is an analog output

D0 pin is a digital output

GND pin is a Ground

**Specifications:**The required voltage for working is 5V

The required current for working is <20mA

Type of interface is analog

The required working temperature of this sensor is 10°C~30°C

**3.5 Mic sensor**

Sound Sensor Module is one type of module used to notice the sound. Generally, Sound Sensor Module is used to detect the intensity of sound. The applications of this module mainly include switch, security, as well as monitoring. The accuracy of this sensor can be changed for ease of usage. Sound Sensor Module employs a microphone to provide input to a buffer, peak detector, and amplifier. This sensor notices a sound, & processes an o/p voltage signal to a microcontroller. After that, it executes the required processing. This sensor is capable of determining noise levels within DBs or decibels at 3 kHz 6 kHz frequencies approximately wherever the human ear is sensitive. In smartphones, there is an android application namely a decibel meter used to measure the sound level.

This is a Sound Sensor module with a small Microphone. Some Applications like interactive voice switch and loudness level indicator are very suited for this module.

****

Figure 3.7 Mic sensor

**Working Principle:**

This high sensitivity sound detection module detects sounds between 48 and 66 dB and has an analog as well as a digital output.

The AO or analog output creates a real-time output voltage signal of the microphone, whereas the DO or digital output depends on the sound intensity and the threshold that has been set.

**Feature:**There is a mounting screw hole of 3mm.

5v DC power supply

With analog output

There are threshold level output flip

Power indicator light

The comparator output is light

High Sensitivity Sound Microphone Sensor Detection Module

Electric condenser microphone

Low-level output signal used for sound control light

**Specifications:**Has two outputs: AO, analog output, real-time output voltage signal of the microphone

Uses 5V DC power supply,Has power indicator light,The comparator output is light

There are 3mm mounting screw holes, which are powered by a 5v DC power supply.

**ESP32 CAM**

The ESP32-CAM is a low-cost, powerful module that integrates an ESP32 microcontroller with a camera. It's widely used for projects that involve video streaming, facial recognition, or capturing images due to its affordable price and compact size. Here's an overview

ESP32 Microcontroller

Dual-core 32-bit processor.

Supports 2.4 GHz Wi-Fi and Bluetooth.

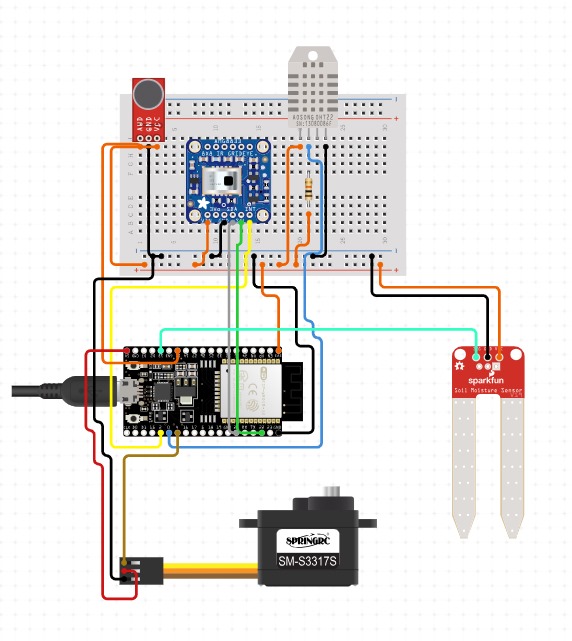


Figure 3.8 ESP32 CAM

# **CHAPTER 4**

# **Design and Coding**

## **4.1 Circuit Diagram**



## **4.2 Code**

## #include <ESP8266WiFi.h>

## #include <Firebase\_ESP\_Client.h>

## #include "addons/TokenHelper.h"

## #include "addons/RTDBHelper.h"

## #include <Servo.h>

## #include <DHT.h>

## #define WIFI\_SSID "123456789"

## #define WIFI\_PASSWORD "123456789"

## #define API\_KEY "AIzaSyCLNpnnqKZE40UnVSCWMYhmDlzzH7ffpjI"

## #define DATABASE\_URL "https://cradle-c01ff-default-rtdb.firebaseio.com/"

## FirebaseData fbdo;

## FirebaseAuth auth;

## FirebaseConfig config;

## unsigned long sendDataPrevMillis = 0;

## bool signupOK = false;

## const int micPin = D1;

## const int servoPin = D4;

## const int dhtPin = D3;

## const int wetSensorPin = D5;

## const int wetLED = D7;

## Servo servo;

## DHT dht(dhtPin, DHT11);

## void setup() {

## pinMode(micPin, INPUT);

## pinMode(wetSensorPin, INPUT);

## pinMode(wetLED, OUTPUT);

## servo.attach(servoPin);

## Serial.begin(9600);

## dht.begin();

## WiFi.begin(WIFI\_SSID, WIFI\_PASSWORD);

## Serial.print("Connecting to Wi-Fi");

## while (WiFi.status() != WL\_CONNECTED) {

## Serial.print(".");

## delay(300);

## }

## Serial.println();

## Serial.print("Connected with IP: ");

## Serial.println(WiFi.localIP());

## // Configure Firebase

## config.api\_key = API\_KEY;

## config.database\_url = DATABASE\_URL;

## if (Firebase.signUp(&config, &auth, "", "")){  //in double quotes we have to give our email and password

## Serial.println("Firebase authentication successful");

## signupOK = true;

## }

## else{

## Serial.printf("Firebase signup error: %s\n", config.signer.signupError.message.c\_str());

## }

## Firebase.begin(&config, &auth);

## Firebase.reconnectWiFi(true);

## }

## void loop() {

## int micValue = digitalRead(micPin);

## float temperature = dht.readTemperature();

## float humidity = dht.readHumidity();

## int wetValue = digitalRead(wetSensorPin);

## if (micValue == HIGH) {

## // Rotate servo from 0 to 90 degrees

## for (int angle = 0; angle <= 90; angle += 1) {

## servo.write(angle);

## delay(15);

## }

## // Rotate servo from 180 to 0 degrees

## for (int angle = 90; angle >= 0; angle -= 1) {

## servo.write(angle);

## delay(15);

## }

## Serial.println("soundValue:");

## Serial.println(micValue);

## Serial.println("Sound detected");

## } else {

## servo.write(0);

## Serial.println("No sound detected");

## }

## if (wetValue == HIGH){

## digitalWrite(wetLED, HIGH);

## Serial.println("Wetness detected");

## } else{

## digitalWrite(wetLED,LOW);

## Serial.println("No Wetness detected");

## }

## // Control temperature LED

## if (temperature > 30) {

## digitalWrite(wetLED, HIGH);

## Serial.println("Temperature is HIGH: Fan ON");

## } else {

## digitalWrite(wetLED, LOW);

## Serial.println("Temperature is LOW: Fan OFF");

## }

## // Print temperature to the serial monitor

## Serial.print("Temperature: ");

## Serial.print(temperature);

## Serial.println(" °C");

## Serial.print("Humidity: ");

## Serial.print(humidity);

## Serial.println("%");

## // Send micValue to Firebase

## // setting time to read data

## if (Firebase.ready() && signupOK && (millis() - sendDataPrevMillis > 1000 || sendDataPrevMillis == 0)){

## sendDataPrevMillis = millis();

## if (Firebase.RTDB.setInt(&fbdo, "main/micValue", micValue)){

## Serial.println("micValue data sent to Firebase");

## Serial.println("PATH: " + fbdo.dataPath());

## Serial.println("TYPE: " + fbdo.dataType());

## }

## else {

## Serial.println("Failed to send micvalue data to Firebase"+ fbdo.errorReason());

## }

## if (Firebase.RTDB.setFloat(&fbdo, "main/temperature", temperature)){

## Serial.println("temperature data sent to Firebase");

## Serial.println("PATH: " + fbdo.dataPath());

## Serial.println("TYPE: " + fbdo.dataType());

## }

## else {

## Serial.println("Failed to send temperature data to Firebase"+ fbdo.errorReason());

## }

## if (Firebase.RTDB.setFloat(&fbdo, "main/humidity", humidity)){

## Serial.println("humidity data sent to Firebase");

## Serial.println("PATH: " + fbdo.dataPath());

## Serial.println("TYPE: " + fbdo.dataType());

## }

## else {

## Serial.println("Failed to send humidity data to Firebase"+ fbdo.errorReason());

## }

## if (Firebase.RTDB.setInt(&fbdo, "main/wetValue", wetValue)){

## Serial.println("WetValue sent to Firebase");

## Serial.println("PATH: " + fbdo.dataPath());

## Serial.println("TYPE: " + fbdo.dataType());

## }

## else {

## Serial.println("Failed to send WetValue to Firebase"+ fbdo.errorReason());

## }

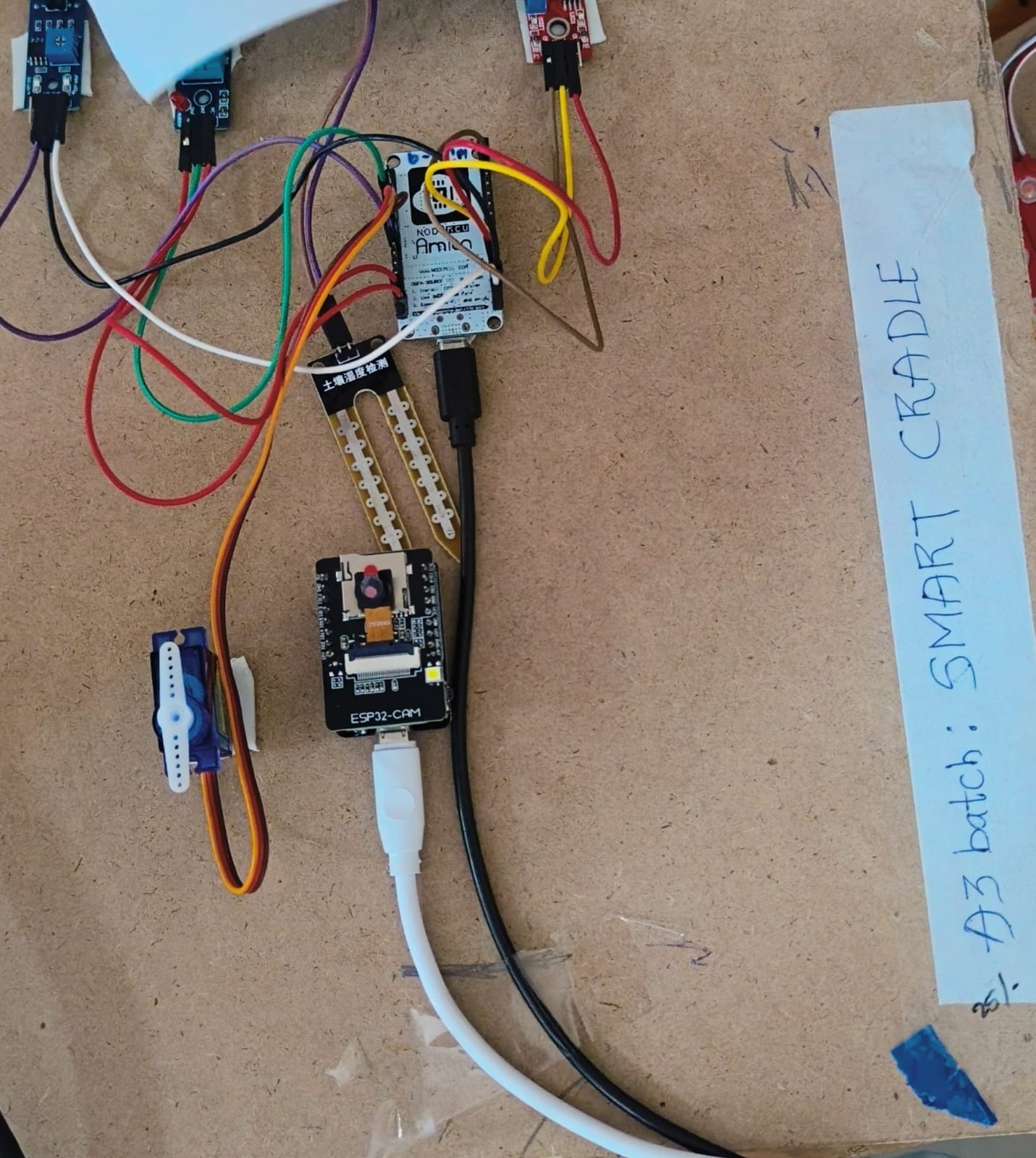
## delay(1000); // Adjust the delay time as needed

## }

## }

# **CHAPTER 5**

# **Results and Conclusion**

**Result**

The Smart Cradle Baby Monitoring System successfully demonstrated its core functionalities, including real-time monitoring of vital signs, environmental conditions, and remote accessibility via a mobile application. User feedback indicated high satisfaction with the system's ease of use, responsiveness, and the effectiveness of alerts. Data analytics provided actionable insights into the baby's sleep patterns, helping parents make informed decisions regarding their infant's care.

**Conclusion**

The Smart Cradle Baby Monitoring System significantly enhances infant care by combining advanced monitoring technologies with user-friendly features. By providing real-time data and insights, the system ensures a safer and more comfortable environment for babies while offering peace of mind to parents. Future improvements may include additional health monitoring features and integration with other smart home devices to further enhance its capabilities.