IOT BASED IV BAG MONITORING SYSTEM

A MINI PROJECT REPORT

Submitted by

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to

the APJ Abdul Kalam Technological University
in partial fulfillment for the award of the Degree of

BACHELOR OF TECHNOLOGY
in
ELECTRONICS AND COMMUNICATION ENGINEERING

under the supervision of

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APRIL 2025

DECLARATION

I hereby declare that this submission is my own original work. To the best of my knowledge and belief, it contains no material previously published or written by another individual, nor any material that has been submitted for the award of any other degree or diploma at any university or institution of higher learning, except where proper acknowledgment is provided in the text.

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ELECTRONICS AND COMMUNICATION ENGINEERING**

CERTIFICATE

This is to certify that the report entitled **"IOT BASED IV BAG MONITORING SYSTEM "**, submitted by **ARYA SASIKUMAR (ATP22EC009)** to APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Bachelor of Technology degree in Electronics and Communication Engineering, is a bona fide record of the project work related to the course **MINI PROJECT**, carried out under our guidance and supervision. This report has not been submitted in any form to any other university or institution for any purpose.

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ACKNOWLEDGMENT

First and foremost, I would like to express my deepest gratitude to **GOD ALMIGHTY** for his infinite grace and guidance, without which this project would not have been completed.

I would like to extend my sincere thanks to the **MANAGEMENT** of Ahalia School of Engineering and Technology for their unwavering support in the successful completion of this project.

My heartfelt thanks go to **Dr. P. R. SURESH**, Principal of Ahalia School of Engineering and Technology, for his valuable support and assistance throughout our project journey.

I would like to express my sincere appreciation to our Head of Department and Project Coordinator, **Dr.ANEESH K and Ms.DIVYA MOHAN** , for Unknown gender continuous guidance and encouragement during this project.

I would also like to convey my heartfelt thanks to **Ms.SWETHA C**, our Project Guide, for Unknown gender expert guidance, instructions, and support throughout the project.

No work can succeed without the proper reference materials and resources. In this regard, I express my profound gratitude to all the teaching and non-teaching staff of our college, whose support and assistance created a conducive environment for the successful completion of my project.

ABSTRACT

Intravenous (IV) therapy is a critical procedure in healthcare, requiring precise monitoring of fluid levels to avoid complications like air embolism, blood reverse flow, or dehydration. Traditionally, the monitoring of IV fluid levels is done manually by healthcare professionals, which may lead to errors or delays in fluid replacement. This paper proposes an **IoT-based IV Bag Monitoring System** that utilizes **ESP8266 microcontroller**, **16×2 LCD display**, **PCF 8574 I2C expander**, **HX711 load cell amplifier**, and a **10kg load cell** to automate the monitoring process. The system continuously measures the weight of the IV bag, and when the fluid level falls below a predefined threshold, it triggers a notification through IoT to alert healthcare providers. Additionally, the data is displayed on the LCD for immediate visual verification. The use of wireless communication enables real-time remote monitoring and minimizes human error in critical care environments. This system not only enhances patient safety but also improves workflow efficiency for healthcare providers, making it a significant advancement in the medical field, especially in the context of the increasing demand for automated healthcare systems.

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Chapter 1

INTRODUCTION

1.1 Socio-Economic Relevance Of The Project

1. **Enhances Healthcare Quality and Patient Safety**: The IoT-based IV bag monitoring system ensures real-time tracking of fluid levels, pressure, and flow rates. By automating the monitoring process, the system reduces human error and improves patient safety, ensuring that patients receive the proper care without the risk of complications such as air embolism or improper fluid delivery. This improves the overall healthcare quality, especially in intensive care units and emergency situations.

2.**Cost Efficiency and Resource Optimization**: The automation of monitoring IV bags reduces the need for continuous manual checks by healthcare staff, allowing them to focus on other critical tasks. This leads to cost savings by optimizing staff time and reducing labor costs. Hospitals and healthcare facilities can use their resources more efficiently, which can also help reduce healthcare costs for patients and providers.

3.**Increased Access to Healthcare in Remote Areas**: The IoT-based system can be particularly beneficial in remote or rural areas where medical staff may be limited. With the IoT-enabled monitoring, healthcare workers can monitor patients' IV bags remotely, minimizing the need for constant on-site checks. This can bridge the gap in healthcare services in underserved regions, making healthcare more accessible and equitable.

4.**Improved Hospital Operational Efficiency**: With continuous monitoring of IV fluid levels and conditions, hospitals can automate alerts for fluid replacements or other issues, leading to faster response times. This increases the overall efficiency of hospital operations, allowing medical professionals to take timely action, and thus improving the overall flow of operations. Efficient management in hospitals can lead to better patient care and quicker turnaround times.

5.**Promotes Public Health and Reduces Healthcare Burden**: The IoT-based IV bag monitoring system contributes to the overall public health by preventing medical errors, ensuring proper medication delivery, and reducing complications related to IV infusions. With more reliable monitoring, hospitals can reduce the occurrence of adverse events like infection or improper dosing, which can lead to better recovery rates and fewer repeat hospitalizations. This decreases the overall healthcare burden, helping to lower the national and global costs associated with managing medical errors and long-term complications.

1.2 Existing System

At present, IV (intravenous) bags are a critical component of medical treatment, particularly in hospitals, clinics, and emergency care settings

- **Features:**
  - **Manual Monitoring**: In many healthcare settings, Nurses or doctors visually check IV bags for the amount of fluid and assess the rate at which fluid is being administered to the patient.
  - **Basic Alarms**: Some IV systems have basic alarms that go off when the fluid level is low or the flow rate is abnormal.
  - **Visual Indicators**: Current systems may use visual indicators like marks on the IV bag to indicate how much fluid is left, providing basic information to caregivers.
  - **In-House Monitoring**: Monitoring and control are usually performed within the immediate environment, meaning caregivers need to be physically present in the patient room or ward to manage the IV fluid infusion.
- **Drawbacks:**

– **High Risk of Human Error**: The reliance on human staff for monitoring IV fluids increases the potential for oversight. Nurses or doctors may miss signs of malfunction, fluid depletion, or the presence of air bubbles in the IV line, leading to critical complications like air embolism.

– **No Remote Monitoring**: In many healthcare environments, there is no integration with remote monitoring systems, which means the care team cannot monitor the IV bag status from outside the room. This increases response times in case of emergencies .

– **Delayed Alerts**: In most existing systems, the alarm might not go off until the fluid is almost finished or there's an obvious issue. This can delay the necessary response time to address problems, especially in critical care situations.

– **Lack of Integration with Modern Technologies**: Existing systems often lack integration with modern technologies such as cloud computing, mobile apps, or healthcare management systems. This limits the ability for healthcare providers to have seamless communication or integrate IV monitoring data with other patient monitoring systems.

1.3 Motivation

The main motivation for the IoT-based IV Bag Monitoring System project is to enhance patient safety and improve healthcare efficiency by automating the IV fluid monitoring process. The key driving factors include:

- **Preventing Medical Errors**: It addresses the critical issue of human error in monitoring IV fluid levels, which can lead to life-threatening situations such as over-infusion, air embolism, or reverse blood flow.
- **Real-time Monitoring**: The system ensures real-time tracking of fluid levels and sends notifications to healthcare providers, reducing delays in response time and improving overall care.

- **Improved Patient Care**: By integrating IoT technology, the system offers a more reliable, accurate, and automated approach to IV fluid management, contributing to better patient outcomes.
- **Reducing Workload for Healthcare Professionals**: Automation of the monitoring process alleviates the burden on nurses and healthcare workers, allowing them to focus on other critical tasks, thus improving workflow and efficiency.
- **Remote Monitoring**: With IoT integration, the system can allow healthcare professionals to monitor patients remotely, especially beneficial in cases where constant in-person monitoring is difficult, such as during off-hours or in larger healthcare facilities.

Chapter 2

LITERATURE REVIEW

One of the earliest uses of the Internet of Things (IoT) dates back to the early 1980s when students at Carnegie Mellon University connected a Coke machine to the internet to report its availability and characteristics. Since then, IoT has gradually expanded, supported by various enabling technologies. In the 1990s, sensor nodes were developed, and device-to-device communication was introduced, marking the first use of the term “Internet of Things” [1]. The concept of ‘Smart Healthcare’ emerged in 2009, inspired by IBM’s “Smart Planet” initiative, which utilized sensors to collect data, IoT to interconnect devices, and supercomputers with cloud computing for processing [2]. Although artificial intelligence (AI) and IoT have become integral to the medical industry, human intervention in many medical procedures remains necessary. Intravenous (IV) therapy, for instance, is a common procedure requiring active participation from doctors or nurses. With the advancement of AI, data analytics, and IoT, there is potential to reduce human intervention in such procedures.

In this context, Bhavasaar et al. [3] proposed a smart monitoring and alerting system for IV therapy. The system used load cells, or weight sensors, to detect the liquid level in the IV bag by measuring the weight or force applied on the sensor. While load cells are simple and widely used, those capable of detecting the small weight variations in an IV bag nearing emptiness are costly and difficult to find. The implemented system used a ZigBee module to alert the nurse station when the IV bag was about to be emptied. ZigBee, a low-cost, low-power wireless technology, proved to be an effective alerting system. However, since the alert is directed to a stationary nurse station, it might be missed if the nurse is away.

Rao and Supriya [4] improved upon this with the use of ultrasonic sensors to detect liquid levels and IR emitter-detectors to monitor drop counts. While this system was efficient, it required modifications to the IV bag design and could lead to inconsistencies in liquid flow rate.

In another approach, R et al. [5] used an IR sensor to monitor liquid levels and the Blynk IoT platform to transmit real-time data to the nurse's mobile device, alongside a servo motor to control liquid flow. Although this approach automated fluid management, it added complexity to the system and was prone to wear and tear.

Other systems proposed by Arulious et al. [6] used Light Dependent Resistors (LDR) for monitoring,while Wei et al. [7] employed capacitive sensors to detect the IV bag contents. However, these approaches had their limitations. LDRs could give false alerts due to environmental temperature changes, and capacitive sensors were sensitive to slight variations in electrode distance.

Harsha Chauhan et al. [8] presented an autonomous IoT-based monitoring device that reduced the need for regular monitoring, especially at night, thereby reducing the risk of patient harm.

Similarly, Dragana Oros et al. [9] proposed a smart IV infusion system for remote liquid detection and monitoring, divided into three parts: the sensing and computation layer, the communication layer, and the user layer. This system offered real-time monitoring, which was particularly useful for patients receiving chemotherapy. Partha Pratim Ray et al. [10]developed a non-invasive system based on IoT to monitor IV fluid levels in real-time, alerting nurses when the bag was nearly empty.

Further, Moorthy et al. [11] proposed a method to stop the IV fluid flow when the bag was empty, using a load cell and a solenoid valve integrated with an Arduino controller. This approach prevented the IV fluid from continuing to flow without sending alerts.

Rosdi and Huong [12] introduced an intelligent infusion pump system for remote management, which utilized an Arduino-based microcontroller, optical sensors, and the Blynk app to monitor IV flow.

Mathew et al. [13] proposed a system using a flow meter with NodeMCU to automate flow control and alert nurses when the fluid level reached a set threshold. The system used a buzzer as a reminder.

Tanwar et al. [14] suggested an IoT-based platform for IV infusion monitoring that used an ultrasonic sensor for easy deployment and an LDR to detect air embolisms, preventing potential life-threatening issues like strokes or respiratory failure.

Additionally, R et al. [15] proposed an automated glucose monitoring system that controlled glucose flow based on the bottle weight. These studies demonstrate a variety of methods incorporating wireless technologies such as Bluetooth, ZigBee, and GSM/GPRS, as well as sensors like load cells and ultrasonic sensors. However, systems based on Bluetooth tend to limit the nurse's mobility due to range constraints, while those relying on nurse stations for alerts are less effective when the nurse is away or unavailable. The limitations in existing systems highlight the need for a more practical, flexible solution. The proposed system aims to address these shortcomings through a simple, effective design.

Chapter 3

PROJECT DESCRIPTION

3.1 Working Principle

Working principle of the IoT based iv bag monitoring system involves several steps:

- **Step 1: Initialize the System**

  - Power Up: Initially, the ESP8266 microcontroller and all connected components (load cell, HX711 amplifier, LCD, and LED) are powered up by the power supply (e.g., 5V adapter or battery).

  - Component Initialization: The ESP8266 initializes the sensors (HX711 with load cell), LCD screen, and other components. The system is ready to begin monitoring the IV bag.

- **Step 2: Reading the Load Cell Value**

  - Load Cell Function: The 10kg load cell detects the weight of the IV bag. The load cell reacts to the weight of the IV bag (filled with fluid or running low on fluid). It converts the applied force into a tiny electrical signal (analog).

  - Signal Amplification: Since the load cell's signal is very small, it requires amplification. The HX711 amplifier increases the analog signal to a level that can be processed by the ESP8266 microcontroller.

  - Data Conversion: The HX711 then converts the amplified analog signal into a digital signal, which the ESP8266 microcontroller can process.

- **Step 3: Signal Processing by ESP8266**

- Processing the Weight Data: The ESP8266 receives the digital data from the HX711. It processes the data to calculate the weight of the IV bag.

- Threshold Comparison: The ESP8266 compares the weight with a pre-set threshold value (e.g., a weight limit indicating the IV bag is running low on fluid). The threshold is set based on the required amount of fluid for the patient.

- **Step 4: Displaying the Data on LCD**

  - 16x2 LCD Display: The weight of the IV bag is displayed on the 16x2 LCD screen. This shows real-time data for healthcare staff to monitor the current weight of the IV bag. It uses the PCF 8574 I2C module, which helps to reduce the number of connections and make wiring more manageable.

  -Data Update: The LCD updates the displayed weight value periodically so that healthcare staff can see the real-time status of the IV bag.

- **Step 5: Alert via LED and Mobile App**

  - Threshold Monitoring: If the weight of the IV bag falls below the threshold, it means the IV fluid is about to finish. The ESP8266 microcontroller triggers an LED indicator (Red LED) to turn ON, signaling to the healthcare team that the IV bag needs attention.

  - IoT Notification: Simultaneously, the ESP8266 sends the data to a Blynk App (or any other IoT platform). This notification alerts the healthcare staff remotely that the IV bag is almost empty, and it needs a refill or replacement.

- **Step 6: LED Indicator**

  - The LED will stay ON as long as the IV bag's weight is below the set threshold, giving a visual alert to nearby personnel. This serves as an immediate indication that action needs to be taken.

  - The LED turns OFF once the weight goes above the threshold, indicating that the IV bag is within an acceptable weight range.

- **Step 7: Power Supply Management**

- The system runs on a 5V DC power supply to provide power to the ESP8266, LCD, and other components. Depending on the project setup, this power could come from an AC adapter or a 12V battery.

- **Step 8: Remote Monitoring**

  - Blynk App: The ESP8266 sends real-time data to a mobile app (such as Blynk) via Wi-Fi. This app can show the current weight of the IV bag and send notifications when the weight falls below the threshold. This ensures healthcare professionals can monitor multiple patients' IV bags from a remote location.

- **Step 9: System Reset**

  - When the IV bag is replaced or refilled, the weight goes back up above the threshold. The system resets, and the LED turns OFF, with notifications cleared from the mobile app.

3.1.1 Block Diagrams

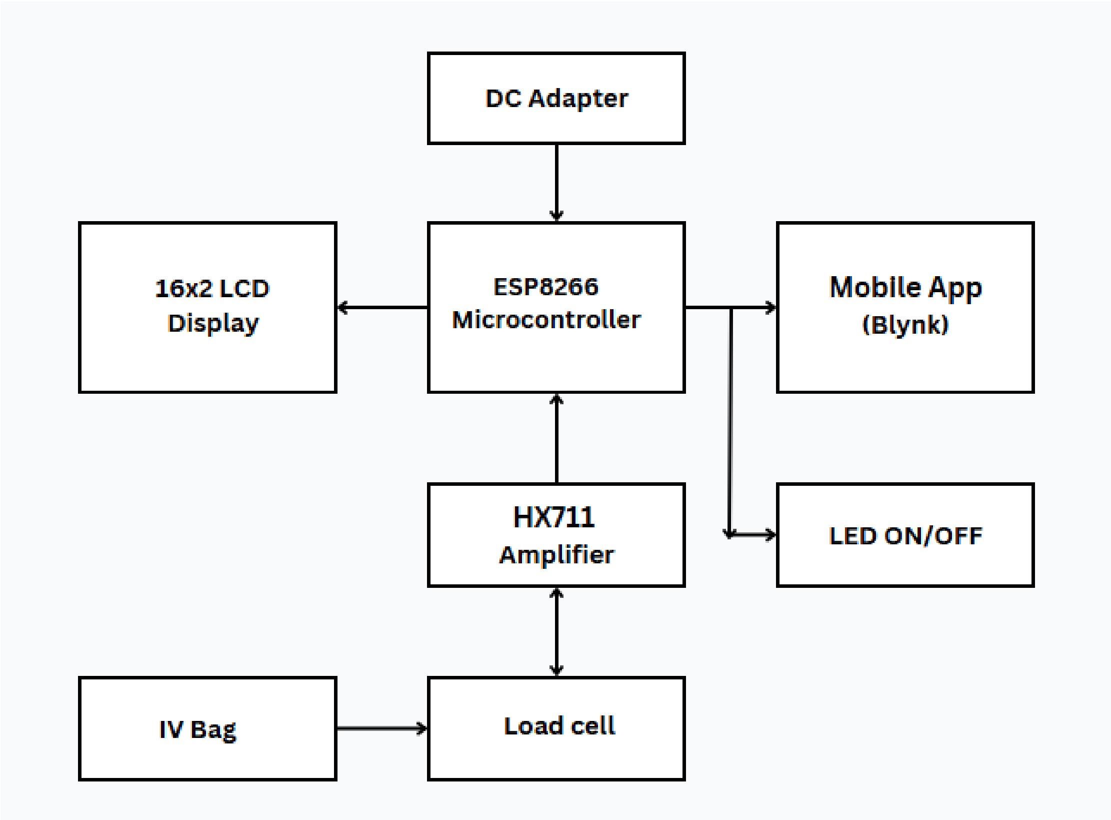

Figure 3.1: Block diagram

- **Power Supply**: The system is powered by a DC adapter providing necessary power to all components (ESP8266,LCD,HX711,etc.).
- **Data Acquisition (Load Cell)**:A load cell is attached to the IV bag, which senses the weight of the IV bag and detects any changes in weight as the fluid is dispensed.
- **Signal Amplification (HX711)**:The load cell output is very weak, so an HX711 amplifier is used to amplify the signal coming from the load cell, making it readable by the microcontroller.
- **Microcontroller Processing (ESP8266)**: The amplified signal is sent to the ESP8266 microcontroller. The ESP8266 reads the data and processes the weight value. It compares the weight of the IV bag with a preset threshold value.

- **Displaying the Weight (16x2 LCD)**:The weight is displayed on a 16x2 LCD screen, providing real-time feedback to healthcare professionals.
- **Notification and Alert (Mobile App & LED):**If the weight drops below the threshold (indicating the IV bag is nearly empty), the ESP8266 sends a notification to the Blynk mobile app. Simultaneously, an LED is turned on as a visual alert to inform that action is required (refill or change the IV bag).
- **End Process:**The system continuously monitors the weight of the IV bag, ensuring that notifications and alerts are triggered when necessary. This helps the medical staff to avoid running out of IV fluid unnoticed.

3.1.2 Flow Chart

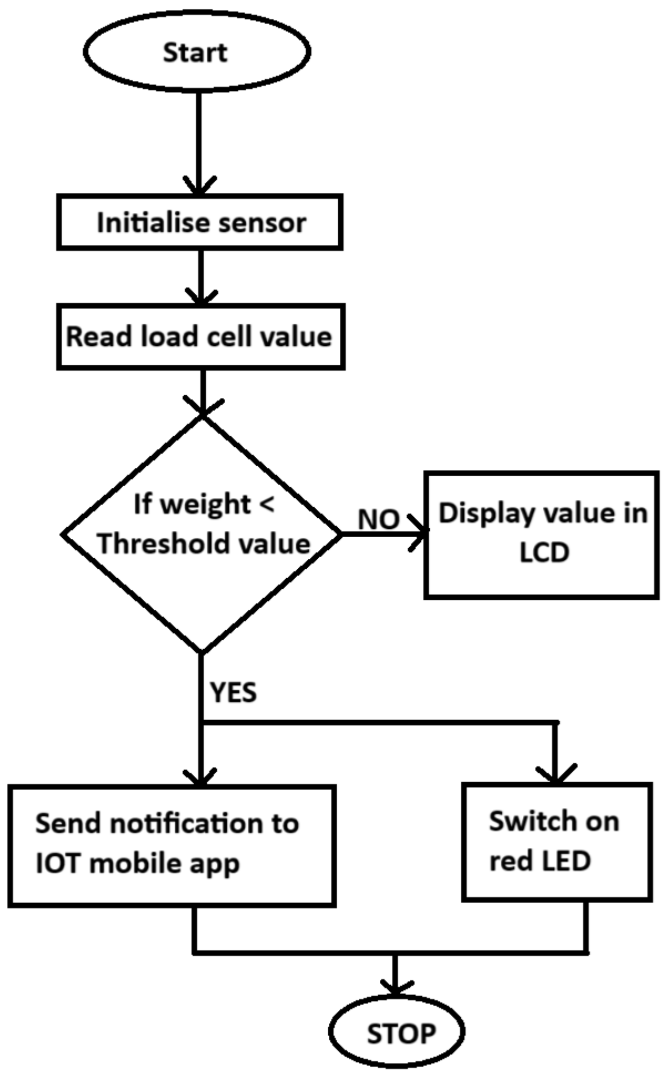

Figure 3.2: Flow chart representation

3.2 Software Requirements

- Blynk App
- Arduino IDE

3.3 Hardware Requirements

- ESP8266 Microcontroller
- Load Cell
- HX711 Amplifier
- PCF8574
- 16x2 LCD Display
- 220 Ohm resistor
- Red LED

3.4 Hardware Design

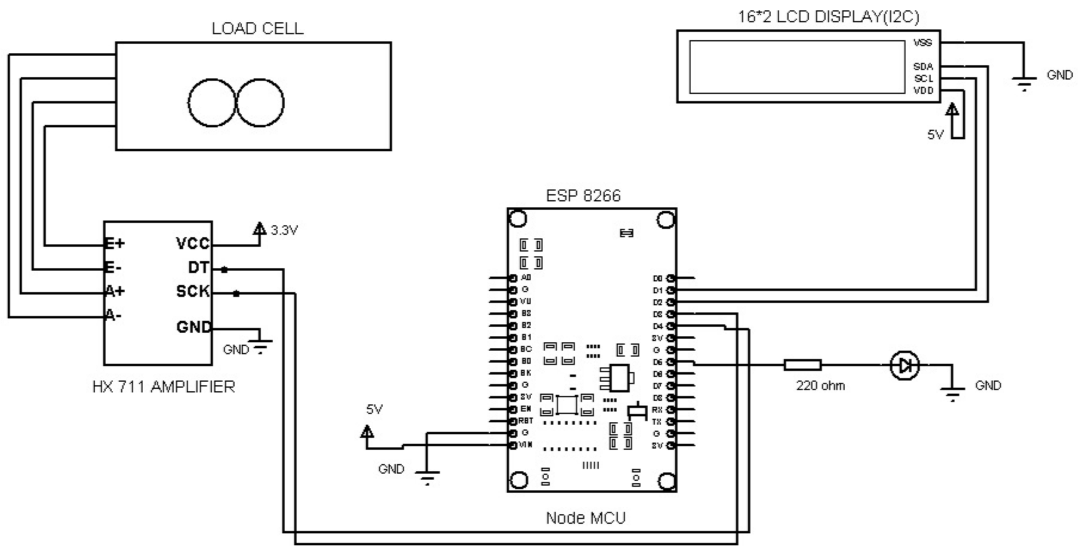

Figure 3.3: Hardware design

3.5 Component Description

3.5.1 ESP8266

Figure 3.4: NodeMCU Development Board/kit v0.9 (Version1)

- The **ESP8266** is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability. It is a similar chip with a built-in 1 MiB flash memory, allowing the design of single-chip devices capable of connecting via Wi-Fi.
- **Processor**: L106 32-bit RISC microprocessor core based on the Tensilica Diamond Standard 106Micro running at 80 or 160 MHz
- **Memory**:
- 32 KiB instruction RAM
- 32 KiB instruction cache RAM
- 80 KiB user-data RAM
- 16 KiB ETS system-data RAM

- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 17 GPIO pins
- I'C (software implementation)

3.5.2 Load Cell

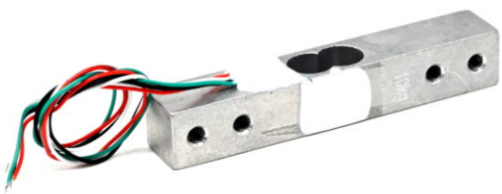

Figure 3.5: Load Cell

load cell sensor is engineered for precise weight measurement within a range of 10 kg. This screw-fastened model ensures easy installation and robust stability in various applications. With high output sensitivity and minimal drift, it delivers accurate readings consistently. Compact in design, this load cell is perfect for integration into equipment where space is limited, making it an excellent choice for industrial and commercial use.

FEATURES

- Exceptional output sensitivity of 1.0±0.1 mV/V for precise weight measurement.
- Ensures secure and stable installation for reliable performance.
- Dimensions of 75×12.7×12.7mm allow for versatile installation options.

3.5.3 HX711 Amplifier

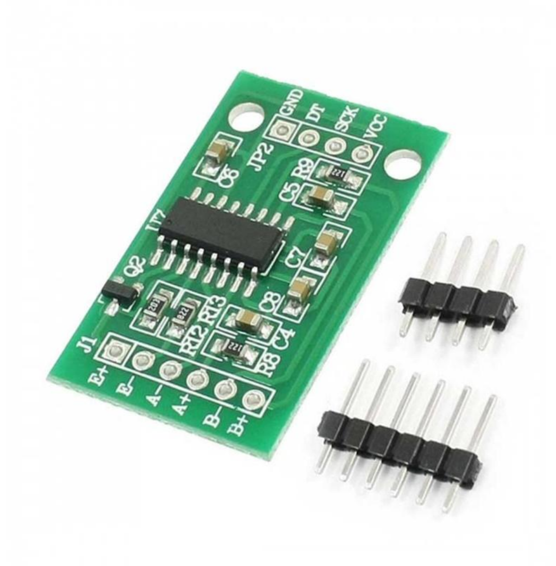

Figure 3.6: HX711 Load Cell Amplifier Module

The HX711 is a high-precision load cell amplifier designed for weighing scales and industrial applications. It integrates a 24-bit analog-to-digital converter (ADC) with a built-in low-noise programmable gain amplifier (PGA), enabling accurate measurement of load cells' resistance changes to determine weight. With its dual-channel capability, the HX711 allows for the connection of multiple load cells, making it suitable for various weighing applications.

FEATURES

- **High Precision**: 24-bit resolution for accurate weight measurements.
- **Selectable Gain**: Three gain settings (32, 64, and 128) to accommodate different load cell sensitivities.

- **Two Differential Input Channels**: Supports connection of two load cells, enhancing flexibility.
- **Built-in Power Supply Regulator**: Supplies power to the load cell and ADC, simplifying design.
- **Simple Interface**: Communicates via a two-wire interface (Clock and Data), making integration with microcontrollers straightforward.
- **Low Noise**: On-chip active low noise PGA for clean signal amplification.
- **Data Rate Options**: Selectable output data rate of 10 samples per second (SPS) or 80 SPS.
- **Power-On Reset:** Ensures stable operation upon power-up.

3.5.4 PCF8574

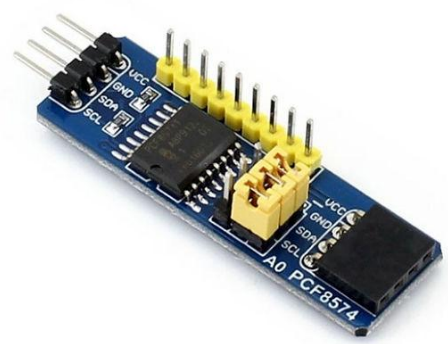

Figure 3.7: PCF8574T 12C I/O Extension Board Module

The PCF8574 IO Expansion Board is used as remote 8-bit I/O expander for I2C-bus. Up to 8 PCF8574 IO Expansion Board can be connected to the I2C-bus, providing up to 64 I/O ports.The PCF8574 IO Expansion Board features I2C pinheader on one side, and I2C connector on the opposite side.Hence, it’s more flexible to connect the board to your development system. The board also supports I2C cascading, allowing the use of multi module connected to the I2C bus at the same time by connecting the pinheader and connectors.

FEATURES

- **I2C Interface**: Communicates over the I2C bus, allowing multiple devices to share the same two data lines (SDA and SCL).
- **8-bit I/O Port**: It has 8 quasi-bidirectional I/O pins that can be individually configured as inputs or outputs.
- **Addressing:** Up to 8 devices can be connected on the same I2C bus by adjusting the 3-bit hardware address (A2, A1, A0 pins).
- **Low-power CMOS technology**: Reduces power consumption, making it suitable for battery-powered devices.
- **Interrupt Output (INT):** Generates an interrupt signal when the inputs change, enabling efficient handling of input events without constantly polling the device.

3.5.5 Other Components

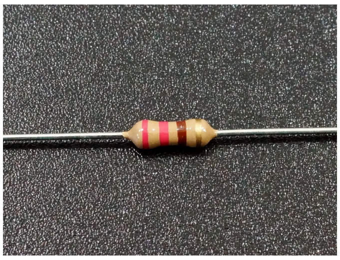

Figure 3.8: 220 Ohm Resistor

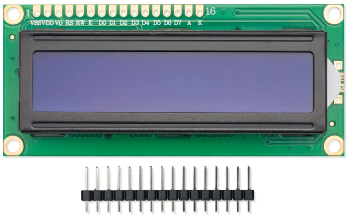

Figure 3.9: 16x2 LCD Display

Figure 3.10: Red LED

Chapter 4

RESULTS AND DISCUSSIONS

The IoT-based IV Bag Monitoring System was successfully designed and tested. The system utilizes an ESP8266 microcontroller, a 16x2 LCD, a HX711 load cell amplifier, and a 10kg load cell to monitor the weight of the IV bag. The weight data is continuously monitored and displayed on the LCD for real-time feedback. When the IV bag's fluid level falls below the predefined threshold, the system triggers an alert via the Blynk mobile app, notifying healthcare personnel about the situation.

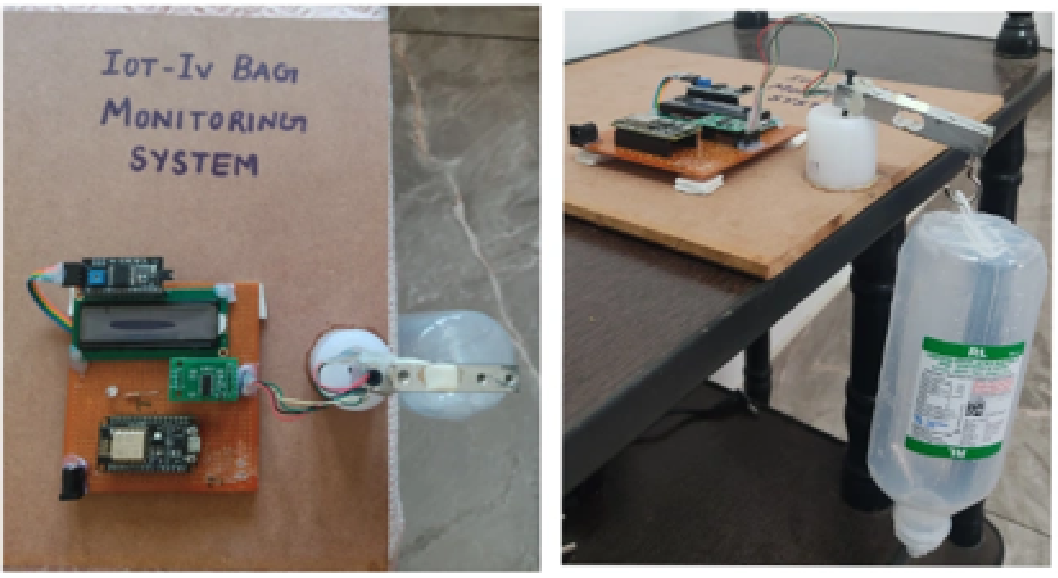

Figure 4.1: Output

Overall, this system holds great potential for improving patient safety by enhancing IV monitoring in healthcare facilities. It also serves as a prototype for future advancements in IoT-based medical solutions.

Chapter 5

FUTURE SCOPE

The future scope of our project involves several enhancements and expansions that could significantly improve its functionality, reliability, and application in healthcare environments:

- **Integration with hospital management systems:** This system can be integrated with existing hospital management systems for real-time tracking and centralized monitoring of multiple patients.
- **Multiple sensor integration**: Adding sensors like temperature or pH sensors can help monitor the quality and safety of IV fluids, expanding the system's capabilities.
- **Wireless charging and long battery life:** Implementing wireless charging technologies and power-saving techniques could extend battery life, making the system more practical for continuous use in hospitals.
- **Advanced alert system:** Future versions could send alerts to pagers or central alarm systems in addition to mobile notifications, ensuring that no alerts are missed in busy environments.
- **Data analytics and cloud integration**: Cloud integration could allow for data analytics, enabling predictive maintenance and the monitoring of trends in IV fluid usage and patient health.
- **Smart IV management system**: Expanding the system to include automatic regulation or flow control of IV fluids could make it more advanced, allowing for both monitoring and active management of the IV process.

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