



AUTOMATED MILK QUALITY MONITORING AND COLLECTION SYSTEM

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ABSTRACT :

Quality assessment and record keeping at rural milk collection centres are still largely manual, which leads to delays, measurement errors and disputes between farmers and collectors. This paper presents an automated, IoT-based milk quality monitoring and collection system built around an ESP32 microcontroller. A pH sensor gauges the acidity of the milk, an LDR-based optical arrangement provides an indication of fat content, a load cell with an HX711 amplifier measures the quantity, and a DS18B20 sensor records the milk temperature. Each farmer is identified uniquely using an RFID tag and an MFRC522 reader, so that every collection is linked to the correct record. The ESP32 controls the entire process, shows the farmer ID, weight, fat percentage and pH on an LCD, and uploads the readings over Wi-Fi to the Blynk IoT platform, where they are stored and can be monitored remotely. The system is intended to reduce manual work, remove disputes, ensure transparency, and enable accurate and faster payment to farmers. It is cost-effective, reliable and suitable for rural milk collection centres to improve efficiency and maintain proper digital records.

Keywords: Embedded Systems, ESP32 Microcontroller, IoT, Blynk, RFID, pH Sensor, Load Cell, Milk Quality Monitoring.

1. INTRODUCTION

Milk is one of the most widely consumed food products, and the dairy sector is an important source of livelihood in rural areas. At most village collection centres, the quality and quantity of the milk brought by each farmer are still checked manually and noted in registers. This is slow, depends on the skill of the operator, and can lead to inaccurate records, disagreements over the price paid, and delays in payment. Because the price of milk depends on parameters such as fat content and acidity, reliable and transparent measurement is essential for both the farmer and the dairy.

Advances in embedded systems and the Internet of Things (IoT) make it possible to automate this process at low cost. Low-power microcontrollers with built-in Wi-Fi, such as the ESP32, can read several sensors, display results locally and send the data to a cloud platform in real time. Radio-frequency identification (RFID) further allows each farmer to be identified automatically, so that every reading is stored against the correct person without manual entry.

This project focuses on designing an automated milk quality monitoring and collection system. The main objectives are: (i) to develop an IoT-based smart system for automatic milk quality testing by measuring fat content, pH and quantity, while enabling remote monitoring based on milk quality; and (ii) to identify each farmer uniquely using an RFID tag and RFID reader, ensuring secure and error-free milk collection records.

2. LITERATURE SURVEY

Several researchers have studied sensor-based approaches to assessing milk quality. [1] reported a low-cost Arduino-based system that detects multiple parameters of milk in order to identify adulteration. [2] presented an Arduino-based arrangement of sensors for real-time monitoring of milk purity, aimed at safer dairy consumption. These works show that inexpensive microcontrollers and sensors are sufficient for on-site screening of milk.

[3] proposed a smart system for milk quality analysis combined with a billing system, which highlights the value of linking quality measurements directly to payment. On the instrumentation side, [4] described the rapid and automated measurement of milk adulteration using a 3D-printed optofluidic micro viscometer, demonstrating that optical and physical properties of milk can be used for quality assessment.

Building on these studies, the proposed system combines quality sensing (pH, fat indication, temperature), quantity measurement, RFID-based farmer identification and cloud-based data logging on a single ESP32 platform, so that testing, identification and record keeping are performed together in one automated step.

3. MODELING AND ANALYSIS

3.1 Block Diagram

Figure 1 shows the block diagram of the proposed system. The milk sample is applied to the pH sensor, the fat sensor and the load cell, and the farmer's RFID tag is read by the RFID reader (RC522). The outputs of all these units are given to ESP32, which acts as the central controller. A power supply feeds the controller and the sensors. The processed data is sent to the database on the Blynk IoT platform and is also shown on a 16×2 LCD display as weight, fat percentage, pH and farmer ID.

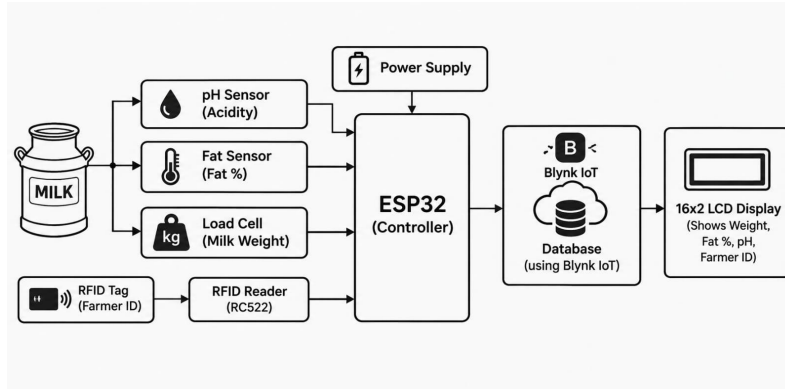


Figure 1: Block Diagram

3.2 Hardware Description

The prototype is built around an ESP32 development board. The circuit diagram is given in Figure 2 and the pin assignment is summarised in Table 1. The hardware consists of the following units.

- **ESP32 controller:** The ESP32 processes the sensor information, displays the measured values and amount on an LCD, and communicates the collected information through Wi-Fi to Blynk IoT for remote monitoring and storage/visualization.
- **pH sensor:** The pH sensor provides an analog signal corresponding to the acidity level of the milk, this analog value is read by the ESP32 through GPIO32 using its ADC input.
- **Load cell with HX711 amplifier:** A 10 kg load cell is used to measure the quantity of milk. The small electrical signal produced by the load cell is conditioned and digitized using an HX711 amplifier. The resulting signal and is connected to GPIO26 (DT) and GPIO27 (SCK).
- **DS18B20 temperature sensor:** It is used to measure the temperature of the milk and sends the reading to GPIO33.
- **LDR sensor:** The analog reading provide by the LDR sensor is connected to the GPIO 32 pin of an ESP 32. It is used to indicate the presence of fat content in the milk.
- **MFR522 RFID reader and tags:** RFID technology enables a farmer to be identified using an RFID tag and reader. In the proposed system, farmer identification is performed before or during collection so that the measured milk information can be associated with the correct collection record.
- **16×2 I2C LCD:** The LCD provides local display of collection information. It states that weight, fat percentage, pH value, Temperature and amount are displayed on the LCD.
- **Power supply:** a 12 V DC supply is stepped down to 5 V using a buck converter; a 3.3 V regulator supplies the modules that operate at 3.3 V.

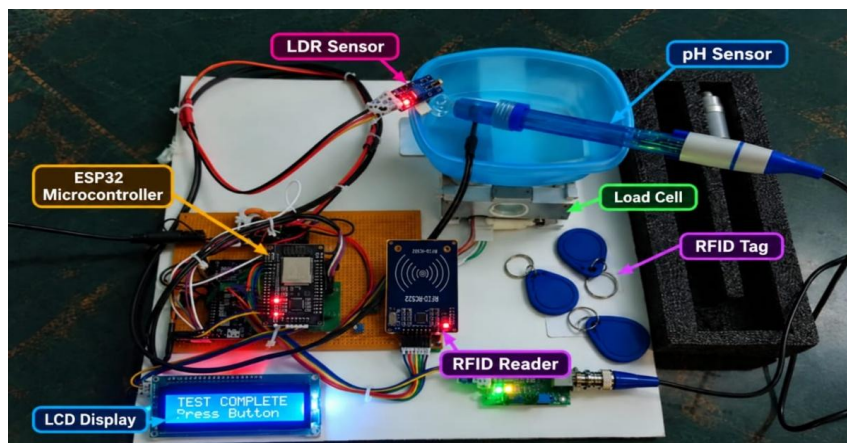


Table 1: ESP32 pin assignment

S. No.	Module / Sensor	ESP32 Pin(s)	Function
1	pH sensor (analog out)	GPIO32 (ADC)	Acidity measurement of milk
2	Load cell + HX711 amplifier	GPIO26 (DT), GPIO27 (SCK)	Quantity / weight of milk
3	DS18B20 temperature sensor	GPIO33 (DQ)	Milk temperature
4	LDR sensor (analog out)	GPIO34 (ADC)	Fat-content indication
5	MFRC522 RFID reader	GPIO22 (RST), GPIO21 (SDA/SS), GPIO18 (SCK), GPIO23 (MOSI), GPIO19 (MISO)	Unique farmer identification
6	Push button	GPIO25	Manual user input
7	16×2 I2C LCD	I2C (SDA, SCL)	Local display of readings

3.3 Software Description

The Blynk IoT platform is integrated with the ESP32 to enable remote monitoring of the collected data. The ESP32 establishes a Wi-Fi connection and transmits the processed sensor information to the Blynk dashboard. The received data can be monitored remotely through an internet-connected device. This provides convenient access to milk quality and quantity information without requiring direct observation of the collection unit. The IoT integration enhances the overall monitoring capability and automation of the proposed system.

Blynk is an IoT platform used for remote monitoring of the collected milk data. The ESP32 sends the processed sensor values to the Blynk platform through Wi-Fi. The data can be viewed remotely using a connected device. It enables convenient monitoring of milk quality and quantity parameters. This feature improves the overall automation and accessibility of the system.



Details of the measurement

The screenshot shows the login interface of the 'Milk Collection Management System'. The header features a milk glass icon and the text 'Milk Collection Management System' and 'Multi Customer · Automatic Hardware Detection'. The main section is titled 'Customer Login' with the instruction 'Sign in to see your milk collection'. It contains three input fields: 'Customer Name' (with a dropdown 'Select / type customer'), 'Customer Code' (with 'Enter code'), and 'Password' (with 'Enter password'). A 'LOGIN' button is at the bottom.

3.4 Working Principle

The system begins with the farmer placing an RFID tag near the reader, allowing the ESP32 controller to identify the farmer uniquely. Once identification is complete, the milk is poured into the measuring container where multiple sensors are positioned to collect data continuously. These sensors include a load cell with HX711 for measuring the quantity of milk, a pH sensor to check acidity levels, a DS18B20 sensor to record the temperature, and an LDR to estimate fat content. The ESP32 processes all these values in real time and compares them against predetermined threshold ranges stored in its memory. If any measured parameter deviates from the standard limits, the system flags the sample as contaminated. The processed results, including weight, fat percentage, pH value, and farmer ID, are displayed on the LCD for immediate feedback. Simultaneously, the ESP32 uses its Wi-Fi capability to send the recorded data to the Blynk IoT database. This ensures that the information is stored securely and can be accessed remotely. Farmers and administrators can monitor and visualize the data through the IoT platform, enabling transparency in milk collection. The system not only ensures quality control but also supports fair payment calculations based on the quantity and quality of milk supplied. By integrating sensors, microcontroller processing, and IoT connectivity, the solution provides a modern, automated approach to dairy management. It reduces manual errors, enhances trust between farmers and buyers, and promotes efficiency in milk collection centers. Ultimately, this smart dairy monitoring system combines technology with agriculture to improve productivity, accountability, and food safety.

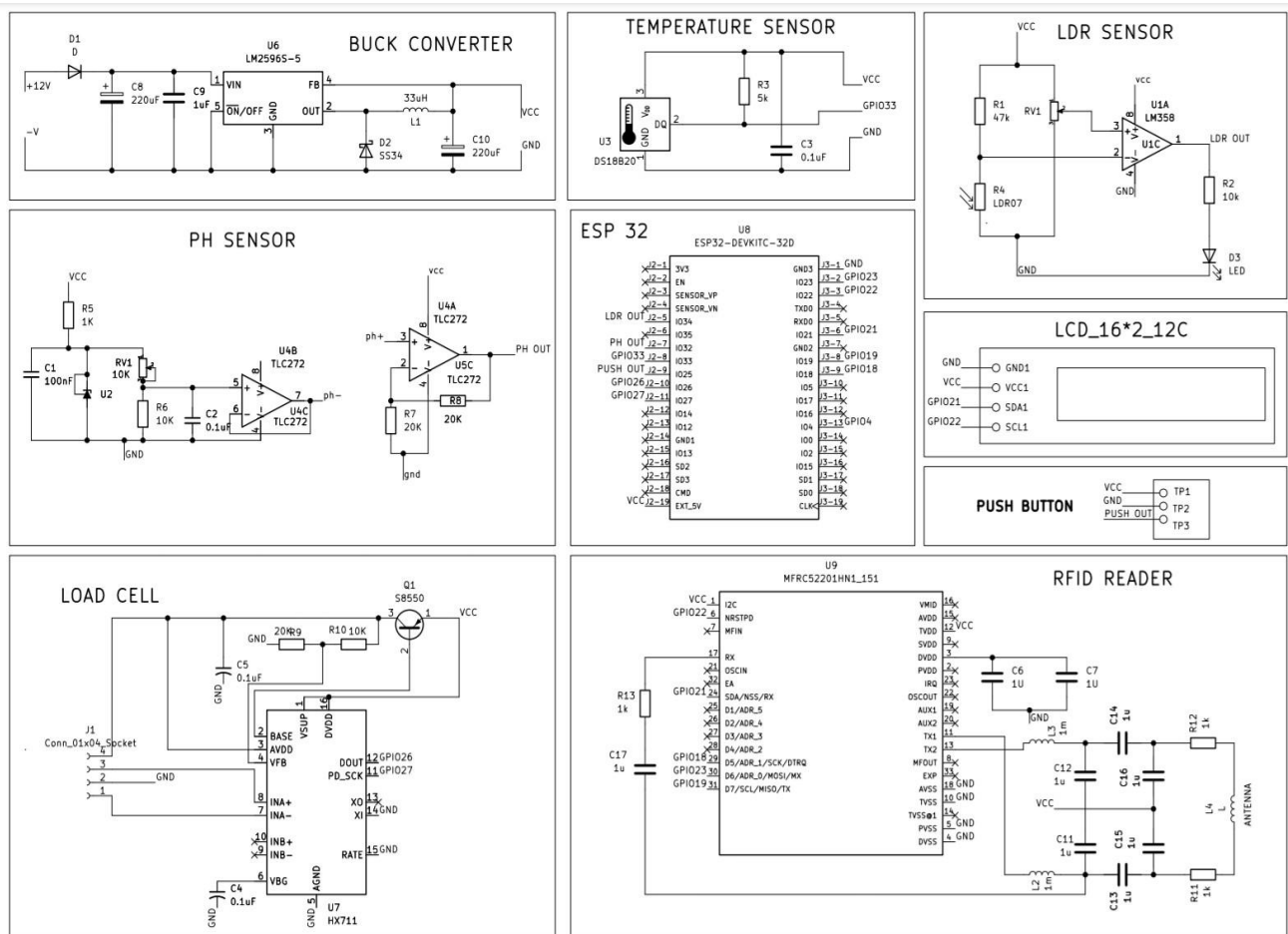


Figure 2: Circuit Diagram

4. RESULT AND DISCUSSION

The pH sensor is used to measure the acidity of the milk and deliver the analog value to the ESP32 ADC on GPIO32, so that changes in acidity can be detected. The load cell, through the HX711 amplifier connected to GPIO26 and GPIO27, is expected to give the quantity of milk collected. The DS18B20 will report the milk temperature on GPIO33, and the LDR will give an analog reading on GPIO34 that indicates the presence of fat in the milk.

The ESP32 is expected to connect to Wi-Fi and send the collected data to Blynk IoT, where the readings can be monitored, stored, and visualised remotely. Because each record is tied to a farmer through the RFID tag, the collection data will be secure and free from manual entry errors. The local LCD gives immediate feedback at the collection centre, while the cloud record gives the dairy a transparent history of every collection.



Overall, the proposed system is expected to reduce manual work, eliminate disputes, ensure transparency, and provide accurate and faster payment to farmers. Its low component cost makes it practical for rural milk collection centres.

5. CONCLUSION

The Automated Milk Quality Monitoring and Collection System was successfully designed and developed to simplify the milk collection and monitoring process. The system integrates the ESP32 microcontroller with pH, fat sensing, temperature and quantity measurement units. RFID technology is used for automatic farmer identification, while the LCD provides real-time display of the measured parameters. The Blynk IoT platform enables remote monitoring of the collected information through Wi-Fi. The developed system reduces manual effort, minimizes recording errors, and provides an efficient method for monitoring milk quality and quantity. Overall, the proposed system provides a compact and practical solution for automated milk collection centres.

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