



# Analog and Digital Signal Monitoring Over Rs-485 using Modbus RTU

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**ABSTRACT:** In modern industrial applications, reliable monitoring of electrical systems is essential to ensure safety, efficiency and uninterrupted operation. This project presents an Analog and Digital Signal Monitoring System developed with a focus on robust communication and centralized supervision. The local End has an Arduino Uno that acquires analog and digital signals, convert using its 10-bit ADC, and performs threshold-based fault detection. Immediate fault detection is provided locally through LEDs and a Buzzer, ensuring rapid alerting at the site of operation. For centralized supervision, data from the Local end ARDUINO Uno is transmitted over RS-485, a noise-resistant and scalable communication standard capable of supporting long distances up to 1200 meters, and the structured using the Modbus RTU protocol. The Remote end, equipped with another Arduino Uno, receives the data, extracts it, and displays real-time voltage readings, system status and fault conditions on a 16x2 LCD, allowing operators to monitor the system without physically being present at the local end. The system is modular and scalable, supporting multiple Local ends for large industrial setups. Experimental results confirm accurate signal acquisition, reliable communication, immediate local fault alerts and centralized visualization highlighting the system as a practical, robust and scalable solution for industrial monitoring applications.

**KEYWORDS:** Arduino Uno, RS-485, Modbus RTU, Industrial Monitoring, Fault Detection, Signal Acquisition, Embedded Systems.

## I. INTRODUCTION

Industrial systems, such as battery chargers and power monitoring units, require continuous supervision of electrical parameters to ensure safe and reliable operation. Variations in voltage levels, unexpected faults, or component failures can lead to equipment damage, reduced efficiency, and potential safety hazards. In conventional setups, monitoring is often performed manually or through short-range communication techniques, which are limited by delayed response, susceptibility to noise, and lack of scalability. These limitations become more significant in large industrial environments where multiple systems must be monitored simultaneously. Several existing monitoring applications approaches rely on wired communication standards such as RS-232 or basic microcontroller-based local monitoring systems. While these methods provide basic functionality, they are restricted by short communication distances, limited device connectivity, and poor noise immunity in industrial conditions. Wireless solutions have also been explored; however, they may suffer from reliability issues, signal interference and security concerns in harsh environments. Therefore, a robust, long-distance, noise resistant communication mechanism is essential for effective industrial monitoring.

To address these challenges, this project proposes Analog and Digital Monitoring System with a dual-level architecture consisting of a local end and a remote end. The local end implemented using a Ard uno, continuously acquires analog and digital signals from the system. Analog input are digitized using 10-bit ADC and analyzed against predefined threshold values to detect abnormal condition such as overvoltage and undervoltage. Immediate fault indication is provided locally through LEDs and Buzzer, ensuring rapid response at the point of operation.

For centralized supervision, the system utilizes RS-485 communication, which offers high noise immunity, multi-device connectivity, and long-distance transmission capabilities of up to 1200 meters, making it well suited for industrial environments. The acquired data is structured using the Modbus RTU protocol and transmitted to the remote end, which is also based in an Arduino UNO. At the remote end, the data is decoded and displayed on a 16x2 LCD, providing real time information.

communication.

D. Visualizations & Alerts

The fault indication module provides clear visual and audible feedback through LEDs and Buzzer to indicate system status and abnormal condition, ensuring timely user awareness and response. Similarly, the transmitted data via RS-485 is received and decode and display in the LCD display.

E. Power Supply Module

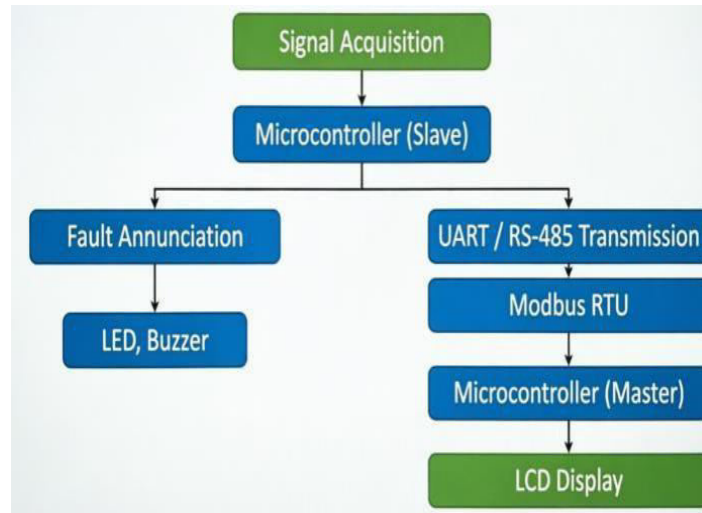


Fig.1. Block diagram of the proposed real-time signal monitoring system

II. LITERATURE SURVEY

Several studies have explored RS-485 and Modbus-based communication systems for industrial monitoring and control. Le et al. [1] implemented Modbus over RS-485 and Ethernet for real-time monitoring of electrical and environmental parameters using microcontroller-based systems. Alzahrani et al. [2] combined CAN bus and Modbus RTU to enhance communication in electric vehicle charging systems. Mulyadi et al. [3] demonstrated Arduino-based Modbus RTU implementation for industrial signal monitoring, focusing on protocol framing and master-slave communication.

These studies collectively highlight the importance of integrating analog and digital signal monitoring with robust communication protocols, forming the foundation for the proposed system that combines Arduino Uno, RS-485, and Modbus RTU for efficient fault detection in industrial monitoring systems.

The power supply module provides the required regulated DC voltages for the operation of the system components. It converts AC mains supply into stable 12V and 5V DC to ensure safe and stable power delivery to microcontrollers and other peripheral devices.

TABLE I. THRESHOLD TABLE

VOLTAGE (V)	RANGE	STATUS
< 2 V		Under Voltage
2 V – 4 V		Normal
> 4 V		Over Voltage

## IV. RESULTS

### METHODOLOGY

This proposed system consists of five major elements:

#### A. Acquisition of Input Signal

The system utilizes two types of input devices: trim potentiometer for analog input and a push button for digital input. The push button provides discrete ON/OFF input signals. These are connected to slave Arduino uno.

#### B. Microcontroller

The Arduino Uno acts as the core processing module. Two boards are employed, configured as Master and Slave units. The slave units read analog and digital signal from input device process them which means the analog value is converted to discrete steps using ADC peripherals.

#### C. Communication Module

The system employs RS-485 to enable robust data transmission between master and slave. It is a differential serial communication standard that uses two signal lines A and B to transmit data. Similarly, Modbus RTU is widely used industrial communication protocol that enables structured and reliable data exchange. It follows Master-Slave architecture where the master initiates the communication requesting data from slaves and the slaves responds to the master upon request received. This mechanism ensures synchronized and efficient Here, the experimental outcome of the proposed project Analog and Digital Signal Monitoring over RS-485 using Modbus RTU. The system operated effectively under various input conditions, successfully monitoring the signals. Fault detection was detected promptly and appropriate alerts were generated.

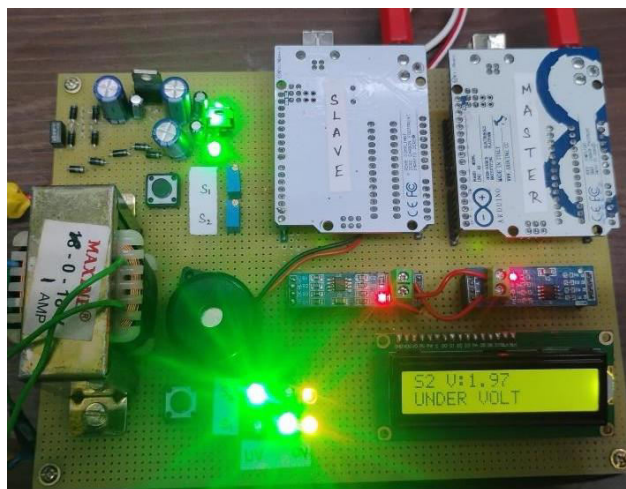


Fig.2. Hardware Prototype

### APPLICATIONS

Such a system can be implemented for various applications in real life, such as:

- Battery charger monitoring
- Power distribution units
- Manufacturing plants
- Control panels



## V. CONCLUSION AND FUTURE WORK

The real-time signal monitoring system based on a low-cost setup using microcontroller can successfully exhibit its operation.

In comparison to the conventional detection approaches that demand expensive equipment, the proposed system focuses on designing by considering integration in one pipeline: signal acquisition, conversion, and real-time visualization. Obtained results serve as strong evidence.

The future work will include validating this system on a larger and multidrop capability. Further work will also include Cloud based or IoT integration. Further extensions include SCADA based monitoring and data trend analysis.

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