Long Distance, Multi-device communication with Electrical Systems through RS-485 communication

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Abstract— Remote monitoring of Electrical systems in industry is crucial for safe and efficient operation of the system. If the accurate data is available, time-based analysis can be easily performed and intelligent algorithms can be applied for prediction of faults as well as need for system expansion or even maintenance. The proposed work is about development of a communication system which can help in getting accurate real-time data from multiple sensors using the RS-485 communication protocol. The RS-485 is a multi-node sensor network that can be connected to maximum 32 sensors. The proposed work demonstrates multi-node master slave network of RS-485 by connecting different types of sensors like, temperature -humidity, pyranometer etc. The proposed work contributes towards increasing remote monitoring capabilities and collecting large spatial data for electrical systems like renewable energy system, particularly showing the robustness and adaptability of RS-485 in challenging applications.

***Keywords*—** RS-485 Communication protocol, Sensor selection, Data transmission, Remote monitoring system, Industrial automation**.**

I. Introduction

The developing IOT structures and machine learning models for health monitoring and control of physical system is creating the need for gathering the data securely from electrical systems. The proposed work is to develop a data logger that can help monitor the electrical system as well as create a log for historical data for future analysis. RS-485 [1] has become well-known communication protocol due to its reliability, effectiveness, and industrial application applicability. The proposed research is to implement the RS-485 communication protocol for a micro grid scenario with solar PV and other sources installed. This communication can provide a better logging system to analyse the power generated under different environmental conditions. Such system can help in better remote monitoring and control system and also historical data for future analysis of the system.

Error free long distance transmission of data serially is very crucial for IOT and IIOT applications. RS-485 works with twisted pair of wires for a error free transmission with multi drop facility that means it supports up to 32 standard transceivers [2],[3]. The twisted pair of wires generates a differential effect that rejects or cancel out the noise signals. The practical electrical system suffers by electromagnetic interference due to nearby electrical components or parasitic components. But the twisted pairs in RS-485 makes the communication secure. Another important feature of this communication protocol is the ability to connect multiple devices on the same bus through multipoint system [4]. Tus multiple sensor system can be developed for centralized remote control of all practical industrial and commercial systems.

The work is to develop a remote monitoring system as well as maintaining a log for historical data. Implementing a remote monitoring system with RS-485 communication protocol can lead to improved system performance, reduced downtime, and enhanced overall operational efficiency.

The full form of RS is recommended standards. This is the next version of RS-422 communication protocol. This allows communication of a distance up to 1200 meters. This RS-485 communication protocol is very efficient, effective and reliable. The information is transferred in the form of packets in this protocol which gives very less chance for leakage or losing data [4], [5]. Hence, the efficiency of this communication protocol is high.

II. EXISTING REMOTE MONITORING SYSTEMS FOR ELECTRICAL SYSTEMS

Traditionally the most used method for monitoring is SCADA which stands for Supervisory control and Data Acquisition [6], [7]. This is especially used for automation and management of complex industrial processes which are too difficult for human monitoring and control. This is used for reducing waste and improving efficiency. The other existing remote monitoring systems are Cloud based monitoring systems, Wireless sensor networks, machine learning and AI integration, Cybersecurity considerations.

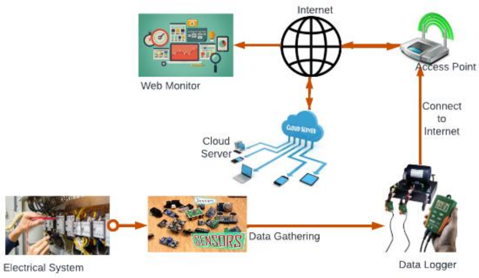

Fig. 1. Block representation of remote monitoring system with data logger.

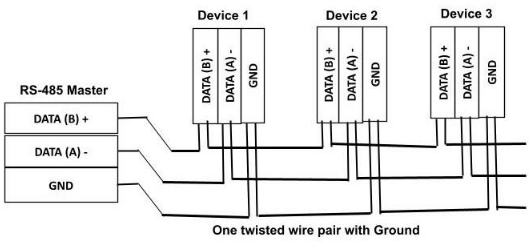

Fig. 2. Multiple sensor connection in RS-485 protocol with one twisted wire pair and ground.

Some of the challenges and limitations of existing systems are data security, reliability, connectivity, comparability, cost of setup, efficiency, leakage of data, interfacing, integration of different parameters. The construction of a remote monitoring system for electrical systems using the RS-485 communication protocol necessitates a methodical approach that includes component selection, communication protocol design and implementation, and rigorous testing and validation methods. The approach described below gives an in-depth account of the actions carried out to accomplish the objectives of this research project.

The RS-485 communication architecture ensures reliable data transmission between the microcontroller and attached sensors. Data transmission and reception formats are defined to ensure consistency and interoperability across devices. Error-checking and correction protocols [8] are implemented to improve data communication reliability over the RS-485 network. The remote monitoring system is thoroughly tested in a controlled lab environment. This comprises functional testing of each sensor, data transmission and reception tests, and ensuring the communication protocol's quality [9] [10].

III. IMPLEMNETATION

The development and deployment of a remote monitoring system for electrical systems leveraging the RS-485 communication protocol produced informative results, offering a comprehensive understanding of the system's functionality, reliability, and scalability. The findings are provided through an examination of data gathered from laboratory testing, real-world deployment, and a comparison with existing systems. The block representation of complete system is shown (fig. 1).

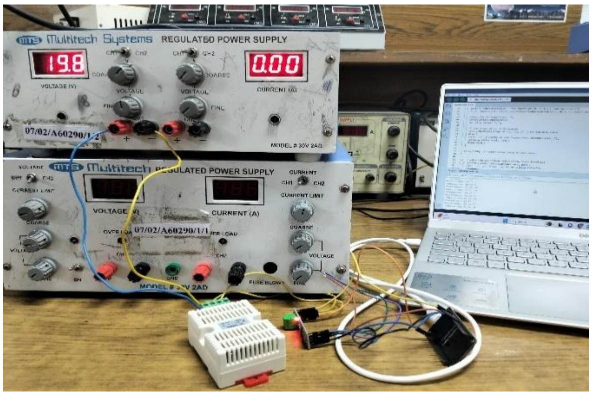

Fig. 3. Testing a Temperature and Humidity Transmitter Modbus SHT20 Sensor XY-MD02 with ESP-32 and interface plot of temperature with time.

	A	B	C
1	created_at	entry_id	Temperature
2	2024-03-07T12:21:27+05:30	1	40
3	2024-03-07T12:21:46+05:30	2	40
4	2024-03-07T12:22:05+05:30	3	40.3
5	2024-03-07T12:22:23+05:30	4	40.1
6	2024-03-07T12:22:42+05:30	5	43.4
7	2024-03-07T12:23:01+05:30	6	41.4
8	2024-03-07T12:23:19+05:30	7	45.4
9	2024-03-07T12:23:38+05:30	8	40
10	2024-03-07T12:23:57+05:30	9	40
11	2024-03-07T12:24:16+05:30	10	39.9
12	2024-03-07T12:24:34+05:30	11	46.3
13	2024-03-07T12:24:53+05:30	12	44.7
14	2024-03-07T12:25:12+05:30	13	42.7
15	2024-03-07T12:25:31+05:30	14	39.9
16	2024-03-07T12:25:49+05:30	15	39.8
17	2024-03-07T12:26:08+05:30	16	39.7
18	2024-03-07T12:26:27+05:30	17	39.9
19	2024-03-07T12:26:46+05:30	18	40.9
20	2024-03-07T12:27:05+05:30	19	39.8
21	2024-03-07T12:27:23+05:30	20	39.7
22	2024-03-07T12:27:42+05:30	21	39.7
23	2024-03-07T12:28:01+05:30	22	46.9
24	2024-03-07T12:28:20+05:30	23	40
25	2024-03-07T12:28:39+05:30	24	39.8
26	2024-03-07T12:28:57+05:30	25	39.8
27	2024-03-07T12:29:16+05:30	26	41

Fig. 4. Temperature Data collected form SHT20

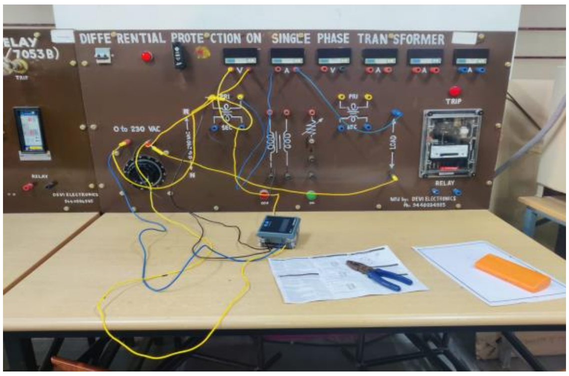

Fig. 5. Connection of energy meter LG 2599 to an electrical system to measure voltage, current, power and power factor.

A. Data collection from the system

The fundamental goal of the remote monitoring system is to monitor the system performance through the values collected from different sensors in real time. Such systems can also be used to collect accurate and real-time data from numerous sensors installed in an electrical infrastructure. The data obtained covers a wide range of electrical factors, such as voltage levels, current flows, power usage, and other pertinent metrics. In the present work irradiance meter, temperature sensor and energy meter(that can sense voltage, current, active power, reactive power and power factor) that are RS-485 protocol compatible are used. The Microcontroller used is ESP-32, that act as interface between sensor network and remote user interface. In the initial stage of analysis, sensors are connected individually to ESP-32, then through a max-485 long distance data transmission of data is verified at receiving end. Later multiple sensors are connected on a single channel through a pair of twisted cable (fig. 2). Each sensor has a slave id, each slave will send the sensor data only after receiving a request for master. Modern devices allows around 256 sensor connections to single RS-485 channel. The received data transmitted through internet on cloud as well as can be displayed in form of graphs in user interface. ESP-32 is also connected to a memory card through a card reader module, so that in case of internet failure the data can be retrieved from memory card.

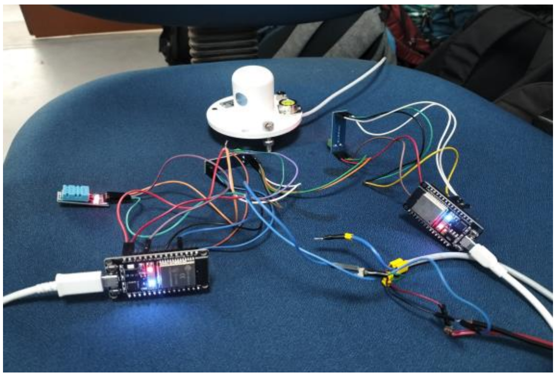

Fig. 5. Irradiance meter testing in lab environment to receive irradiance data.

B. Analysis of system performance and reliability

The Temperature and Humidity Transmitter Modbus SHT20 Sensor XY-MD02 is tested with ESP-32 controller as transmitter master and as well as receiver. The hardware connection and data plot received in user interface are shown (fig. 3). The time series data of temperature can also be collected for further analysis as well as predicting future temperature of the location. The sample time series data of temperature and MODBUS compatible energy meter LG 2599 connections are shown (fig. 4). The setup is tested by increasing the distance between transmitter and receiver. The differential signalling of RS-485 was critical in reducing signal distortion and guaranteeing the integrity of transferred data. Throughout the testing period, the remote monitoring system demonstrated exceptional stability. Continuous operation without substantial performance loss was observed, proving the system's robustness even after extended monitoring periods. The system demonstrated adaptability to dynamic situations by effectively responding to quick changes in load, voltage, and other factors. This versatility is essential for systems working in situations with changing operational needs. The system is also tested for irradiance meter and temperature sensor near a solar PV panel. The hardware testing of transmitter and receiver for a sample system along with a irradiance sensor connection for Modbus system are shown (fig. 5). The temperature and solar irradiance plot of a location with time are shown in mobile user interface (fig. 6). Thus real time data can be accurately received in time series as well as graph form for the user.

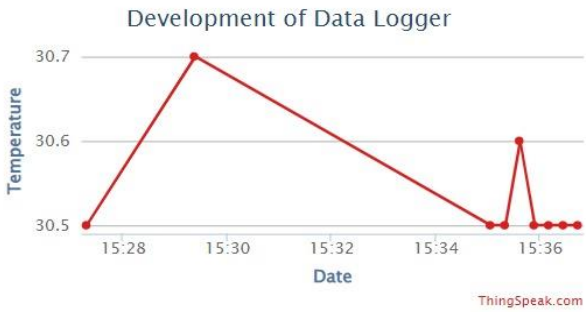

Fig. 6. Testing of irradiance and temperature data received through RS-485 plotted in IOT platform thingspeak.

IV. CONCLUSION

The conclusion marks the end of the research trip, summarizing major findings, explaining the contribution made to the field of remote monitoring systems, and providing directions for future research. Advancements in communication protocols, the implementation of effective remote monitoring, and the introduction of new possibilities for industrial automation are all part of the field's contribution. The system, which informs decision-making processes, is a key asset in guaranteeing the reliability and stability of electrical systems.

As the research concludes, the next step is to continue exploring and innovating. Suggestions for future study create the framework for improving the system, integrating cutting-edge technologies, and solving emergent difficulties. The trip does not end here; it continues into a realm of possibilities in which remote monitoring systems are not simply tools, but essential components of smart, adaptive, and sustainable infrastructures. The accurate and real time data collected through the proposed system, opens the door for many data analytic approaches for electrical systems including machine learning, deep learning, time series analysis etc.

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