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RS485 Data Transmitter through GSM Service to Server Database Logger

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Abstract*: Saving electricity in industries is major concern today. Hence, Energy Management System (EMS) remained preferred area for researchers recently. EMS not only saves electricity, but also monitors and records the electrical consumption data. It also helps diagnose electric machine health, energy efficiency and their reliability against failures. Power management has been one of the most talked about topics in the past decade or so because of the decrease in the energy reserves. Power shutdown is a major problem now-a-days and it occurs because a lot of power is wasted in industries. Our project, "RS485 Data Transmitter through GSM Service to Server Database Logger" deals with this problem in a simple and effective way by logging the energy in different kinds of the energy usage in industries [1]. It also checks power shut downs by knowing the large amount of energy wasted in industries. There are all this performs in an automated process. In this process the Energy meter detects all the parameters like Voltmeters, Ammeters, VAF Meters, Energy Meters, Power Meters, Power Analyzers, Power Factor Meters and so on. All these parameters are transmitted using RS485 based MODBUS protocol by energy meter. The system is based on AVR microcontroller continuously communicating with this energy meter and sending all these parameters using GSM module to the Server Computer for further data logging and monitoring.*

Keywords - *RS485, MODBUS Protocol, AVR Microcontroller and GSM Module.*

I. INTRODUCTION

Energy meters are used worldwide to account for individual usage of electricity at the industry level and commercial usage. Historically these meters have been electromechanical in nature, and periodic on-site reading of the meters was necessary to collect usage information for customer billing. The latest generation of meters is electronic and also provides new features including networked communications, self-test, and intelligent accounting for various time periods of the various parameters. These meters monitor, analyze, and store information on energy usage. Because many utilities promote off-peak consumption, there may be several defined time segments for different energy costs. Therefore, not only total energy consumption is tabulated, but also energy consumption during each of several time segments.

A network connection between meters allows a centralized data collection. This becomes a significant advantage due to the economics, especially as both the number of installed meters and the cost of labor increase. Networked automatic meter reading systems further reduce problems with safety and security, as human access to distributed meters is less important. Installation costs may also be lower, as networked meters have more flexibility in terms of possible locations. There are several choices for communication with meters. One popular method is through a twisted pair of wires, using RS-485 differential signaling as defined by the TIA/EIA-485 and ISO-8482 standards [2].

This method has the advantages of high noise immunity, fast signaling rate, many nodes on a single bus, and a wide base of proven transceivers available. But along with all these advantages there is one main disadvantage which comes out while installing or installed system in the big company or firm is that the twisted pair cables is highly expensive, so for only due to the cost of this twisted pair cable the whole system makes very expensive and also labor cost for pulling and fitting the twisted pair cable is added with this.

Again one not truly disadvantage but problem comes out while installing this system to any old or already well-established company is that from where this wire going to one meter to another meter or to the server where all these meter going to connect for logging. Hence there is a need to find out some other methods for hassle free communication for routing all these existing problems, and also develop the same system with same working by using wireless technologies include various new aspects and features. Because of its advantages, this application report focuses here on the 485-based solutions by using wireless techniques. The system uses Global Services for Mobile (GSM) module as a wireless technology, by using this technology it can communicate all over the world.

II. RS485 BASED COMMUNICATION MODEL

Data is transmitted differentially on two wires twisted together, referred to as a “twisted pair”. The properties of differential signals provide high noise immunity and long distance capabilities. A RS485 network can be configured two ways, “two-wire” or “four wires” [3]. In a “two-wire” network the transmitter and receiver of each device are connected to a twisted pair. “Four-wire” networks have one master port with the transmitter connected to each of the “slave” receivers on one twisted pair. The “slave” transmitters are all connected to the “master” receiver on a second twisted pair. In either configuration, devices are addressable, allowing each node to be communicated to independently. Only one device can drive the line at a time, so drivers must be put into a high-impedance mode (tri-state) when they are not in use. Some RS-485 hardware handles this automatically [4]. In other cases, the 485 device software must use a control line to handle the driver. Mostly, for developing this type of communication system two components are mainly use RS485 and MODBUS protocols. RS485 is sufficiently communicates up to 32 devices at a time but by using MODBUS protocol on the RS485 communication line system can enhance the device connectivity up to 248 devices. Both the protocols are discuss in detail are as follows.

2.1 Failsafe RS485 Protocol

TIA-485-A, also known as EIA-485 or RS-485 [5], is a standard defining the electrical characteristics of drivers and receivers for use in balanced digital multipoint systems. The standard is published by the Telecommunications Industry Association/Electronic Industries Alliance (TIA/EIA)[6]. Digital communications networks implementing the EIA-485 standard can be used effectively over long distances and in electrically noisy environments. Multiple receivers may be connected to such a network in a linear, multi-drop configuration [7]. These characteristics make such networks useful in industrial environments and similar applications.RS485 allows multiple devices like maximum 32 devices to communicate at half-duplex on a single pair of wires, plus a ground wire at distances up to 1200 meters (4000 feet). Both the length of the network and the number of nodes can easily be extended. Screened twisted pair cable should be used. All “A” connections should be connected together using one conductor of the twisted pair cable; all “B” connections should be connected together using the other conductor in the pair. The cable screen should be connected to the ground terminal as shown in the figure below. There must be no more than two wires connected to each terminal, this ensures that a “Daisy Chain or “straight line” configuration is used. A “Star” or a network with “Stubs (Tees)” is not recommended as reflections within the cable may result in data corruption.

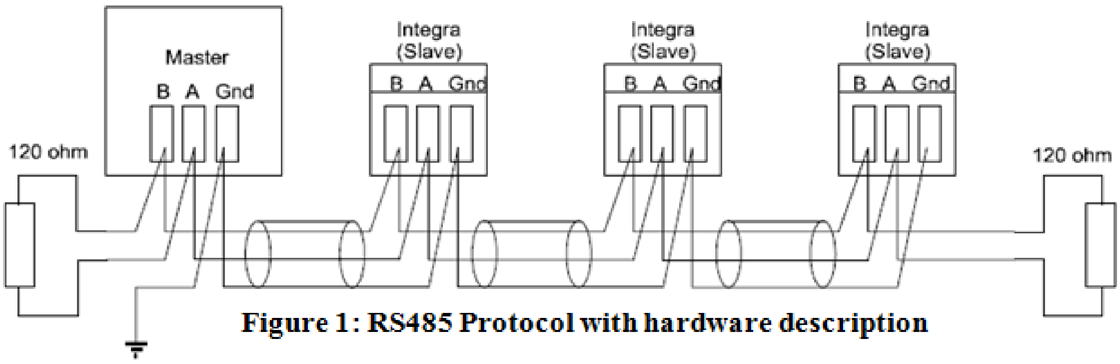

Figure 1: RS485 Protocol with hardware description

2.2 MODBUS Protocol

MODBUS is a serial communications protocol originally published by Modicon for use with its programmable logic controllers (PLCs). Simple and robust, it has since become a de facto standard communication protocol, and it is now a commonly available means of connecting industrial electronic devices [8]. The main reasons for the use of Modbus in the industrial environment are:

- Developed with industrial applications in mind
- Openly published and royalty-free
- Easy to deploy and maintain
- Moves raw bits or words without placing many restrictions on vendors

Modbus enables communication among approximately 247devices connected to the same network. Modbus is often used to connect a supervisory computer with a remote terminal unit (RTU) in supervisory control and data acquisition (SCADA) systems [9]. Each device intended to communicate using Modbus is given a unique address. In Modbus networks, only the node assigned as the Master may initiate a command. A Modbus command contains the Modbus address of the device it is intended for (1 to 247). Only the intended device will act on the command, even though other devices might receive it (an exception is specific broadcast able commands sent to node 0 which are acted on but not acknowledged). All Modbus commands contain checksum information, to allow the recipient to detect transmission errors. The basic Modbus commands can instruct an RTU to change the value in one of its registers, control or read an I/O port, and command the device to send back one or more values contained in its registers. Modbus protocol based communication is shown in the following figure.

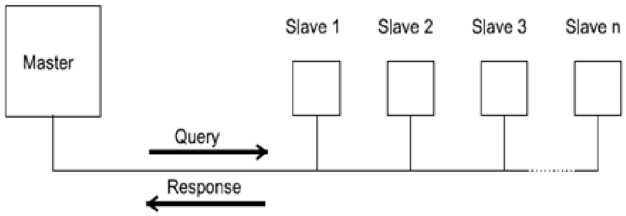

Figure 2: MODBUS Protocol communication model

2.2.1 MODBUS Message Format

The MODBUS protocol defines the format for the master's query and the slave's response. The query contains the device (or broadcast) address, a function code defining the requested action, any data to be sent, and an error-checking field [10]. The response contains fields confirming the action taken, any data to be returned, and an error-checking field. If an error occurred in receipt of the message, or if the slave is unable to perform the requested action, the slave will construct an error message and send it as its response [11].

Query

The example illustrates a request for a single 16-bit Modbus Register.

Slave Address	Function Code	Start Address (Hi)	Start Address (Lo)	Number of Points (Hi)	Number of Points (Lo)	Error Check (Lo)	Error Check (Hi)

Figure 3: MODBUS Protocol Query generalized format

- **Slave Address:** 8-bit value representing the slave being addressed (1 to 247), 0 is reserved for the broadcast address. The SPR and Integra products do not support the broadcast address.
- **Function Code:** 8-bit value telling the addressed slave what action is to be performed. (3, 4, or
- 16 are valid for Integra)
- **Start Address (Hi):** The top (most significant) eight bits of a 16-bit number specifying the start address of the data being requested.
- **Start Address (Lo):** The bottom (least significant) eight bits of a 16-bit number specifying the start address of the data being requested.
- **Number of Points (Hi):** The top (most significant) eight bits of a 16-bit number specifying the number of registers being requested.
- **Number of Points (Lo):** The bottom (least significant) eight bits of a 16-bit number specifying the number of registers being requested.
- **Error Check (Lo):** The bottom (least significant) eight bits of a 16-bit number representing the error check value.
- **Error Check (Hi):** The top (most significant) eight bits of a 16-bit number representing the error check value.

Response

The example illustrates the normal response to a request for a single 16-bit Register.

Slave Address	Function Code	Byte Count	Data (Hi)	Data (Lo)	Error Check (Lo)	Error Check (Hi)

Figure 4: MODBUS Protocol Response generalized format

- **Slave Address:** 8-bit value representing the address of slave, which has just responded.
- **Function Code:** 8-bit value which, when a copy of the function code in the query, indicates that the slave recognized the query and has responded. (See also Exception Response).
- **Byte Count:** 8-bit value indicating the number of data bytes contained within this response
- **Data (Hi):** The top (most significant) eight bits of a 16-bit number representing the register(s) requested in the query.
- **Data (Lo):** The bottom (least significant) eight bits of a 16-bit number representing the register(s) requested in the query.
- **Error Check (Lo):** The bottom (least significant) eight bits of a 16-bit number representing the error check value.
- **Error Check (Hi):** The top (most significant) eight bits of a 16-bit number representing the error check value.

III. PROPOSED WORK

The whole function of this system is distributed in two parts first one is mainly reads the data from energy meter by using RS485 protocol process it and transmits wirelessly to the server end and the secnd part receives data wirelessly and logged it into server computers memory. The system can use this data for the further process. Here the working flow shows in the flowchart form as follows.

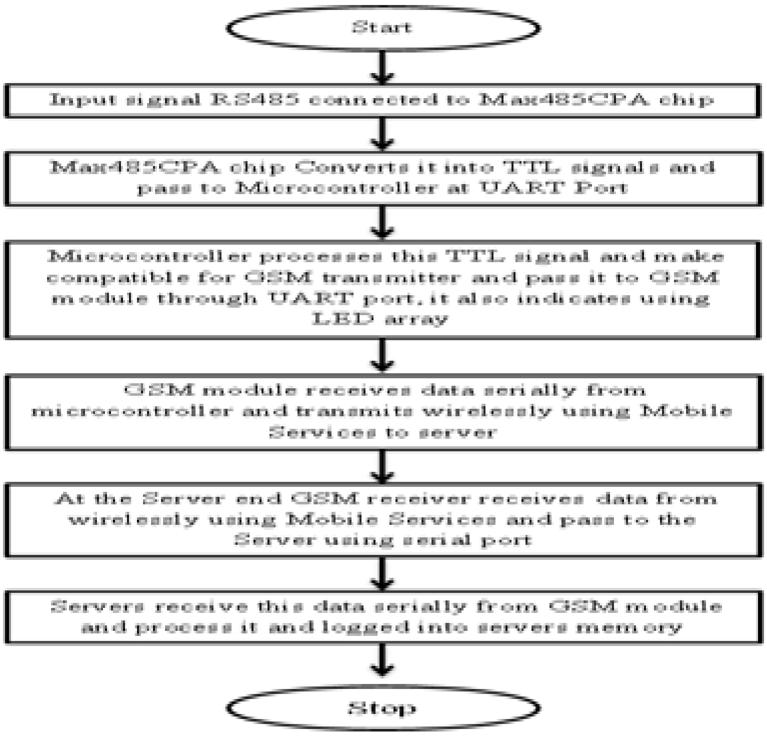

Figure 5: Full Functional Flow Chart of the System

3.1.1 Transmit section at Energy meter end

The transmitter section contains main blocks as RS485 to TTL Convertor unit, AVR microcontroller as a central processing unit, Indicator unit using LEDs and GSM module as a Transmitter to server database logger.

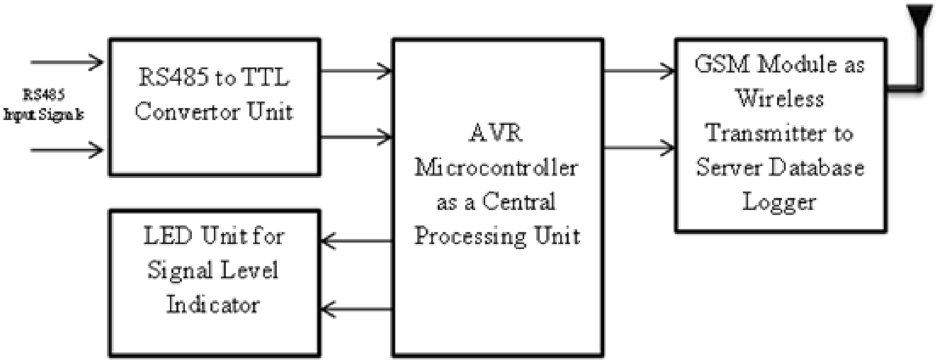

Figure 6: Block Diagram for Transmitter Unit of RS485 Data Transmitter through GSM Service to Server Database Logger

In the first block, external twisted pair shielded RS 485 signal caring cable connected as input of the system, it is directly connected with MAX485CPA chip at the points A & B, and there are positive voltage caring core of the twisted pair cable connected with "A terminal" and respectively negative voltage caring core connected with "B terminal".

The A and B connections to the SPR (System Protection Relay) and Integra Products can be identified by the signals present on them whilst there is activity on the RS485 bus. RS485 transfers the data depending on the potential difference between the two communication wires. The polarity defines the logic state of the signal. This TTL signal output is direct connected to ATtiny841 AVR Microcontroller on USART (Universal Synchronous/Asynchronous Receiver Transmitter) pins (RXD & TXD Pins). Then Microcontroller use these signal and process it according to GSM transmission format. This is the very important block in this block diagram, this block having ATtiny841 AVR Microcontroller who receives data in the serial (TTL) format from Max485 Driver chip through USART0 and process it and pass this processed data to GSM module through USART1. This Microcontroller having two USARTS, this is the specialty of ATtiny841 microcontroller. That's why we select this Microcontroller.AVR Microcontroller pass data processed data to SIM900 technology based GSM Module through USART1. GSM module provides the industry standard serial RS232 interface for easy connection to computers and other devices, it provides serial TTL interface for easy and direct interface to microcontrollers and optionally available USB interface for easy interface to laptops, computers.

The SIM900 allows an adjustable serial baud rate from 1200 to 115200 bps (auto-baud by default). It also comes with an onboard wire antenna for better reception. Board provides an option for adding an external antenna through an SMA connector; it can be used for GSM based Voice communications, Data/Fax, SMS, GPRS and TCP/IP stack. It can be controlled through standard AT commands. GSM modem works on low power consumption of 0.25A during normal operations and around 2A during transmission. The LED Unit for Signal Level Indicator block contains only LED array with current limiting resistors which is directly connected with microcontroller port pins for indicating some like conversion error, line break error or any other error or indicates signal level.

3.1.2 Receiving section at Server (Computer end)

The second part receiver section always ready to receive data, in this part there is main two blocks one is GSM module who receives data whenever transmitter transmits it and pass to the server and remaining block is Server Computer who receives data and logging it after processing.

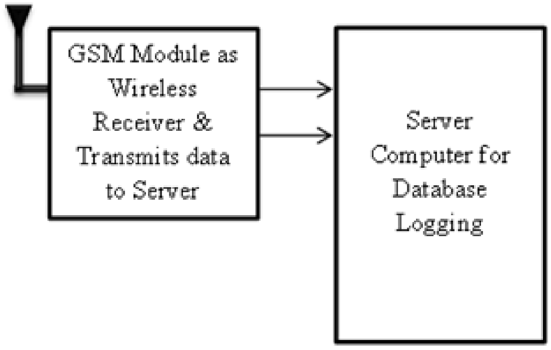

Figure 7: Block Diagram for Receiver Unit of RS485 Data Transmitter through GSM Service to Server Database Logger

There is another GSM module in the system but it works totally opposite from the previous one. It receives data wirelessly using mobile services but whenever transmitter transmits it, after receiving process this received data pass to the server using well known serial protocol (RS232 protocol). The SIM900 allows an adjustable serial baud rate from 1200 to 115200 bps (auto-baud by default). Server computer is the main block of the whole system which also acts like a master of the system who mainly holds the data which is receives from GSM module using RS232 protocol, then after process it and logs in particular data format into memory.

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