Implementation of Data Acquisition System Using Rs485 for Industry 4.0 Environment

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Abstract— In the technological ocean of Industry 4.0, depending on individual's feasibility, industries are adopting various wired communication methods for data monitoring, logging and controlling like RS232 and RS485. This research paper present one of the de-facto wired physical layered communication medium for data exchange i.e., RS485 over long range communication, for machines/devices located in big plant. It includes brief finding of popular wired technologies in Industry and details of Physical as well Lab demonstration on proposed implementation of RS485. Although this experiment collects data in real time from slaves, but it can be logged in any data storage medium like on flash memory, SD card depends on individual requirements as well on cloud with internet connection. The laboratory work involves the implementation of latest embedded hardware as well as embedded software to measure Temperature and Humidity parameters (most common parameter in industry).

Keywords: Industry 4.0, RS485, BOM, POC, Industrial Automation

I. Introduction

Devices and Machines play a very vital role in industrial environment to monitor their smooth operation and control over them, needs some communication with them without human intervention.[1] Devices and machine usually have different kind of sensors [1], actuators etc that collects information about operating parameters.

Wired communications are responsible for transmission and collection of information devices so that operational assessments and real-time adjustments can be done. Such as, a big Generator backing Oven process contains the number of Temperature and Humidity sensors, RPM etc. The relevant data need to continuously monitor and transmit via a wired or wireless network for analysis of quality production and intelligent controls on process. [2]

Line drivers and receivers are generally used to swap data between two or more points (nodes) on a network. Different manufacturers developed and provide standards to ensure compatibility between units for reasonable accomplishment of transferring data over specific distances and/or data rates.

A. Serial Communication (RS485)

The data transmission can be performed serially or parallelly, in parallel communication multiple binary digits are transmitted or received simultaneously but in serial communication the process is different the data is transmitted or received bit by bit i.e., sequentially on a communication channel or computer bus. [9]

Although the parallel communication is quit faster as compare to serial communication but it is impractical over a long distance i.e., more then 10-50 meters because of cost constraint, maintainability and synchronization. So, the serial communication became more common for distance greater than 10m. [9]

The Electronics Industry Association (EIA) has provided standards for serial communication most common serial communication are RS485, RS422, RS232, and RS423. Here "RS" stands for Recommended Standard however now these standards are indicated as "EIA". The serial data transmission can be classified with respect to data transmission methodology. [10]

B. Single-Ended Data Transmission

- The signal level/voltage level is measured with respect to Ground.
- The "idle" state (MARK) has the signal level negative w.r.t. Ground.
- The "active" state (SPACE) has the signal level positive w.r.t. Ground
- It has hardware handshaking lines
- It is full Duplex unbalanced signalling
- having bus architecture Point to Point communication
- Max Data Rate is 1Mbps
- RS232 and RS423 communication comes under this category

C. Differential Data Transmission

- The signal level is measured with respect to other
- Single-ended methods are not sufficient for communication over long distances or at high data rates in practical.
- Differential data transmission (balanced differential signal) is most suitable for application.
- Differential signals cancel out the effects of ground interference and induced noise signals that can appear as common mode voltages in a communication.
- RS485 and RS422 communication comes under this category

II. RS485 based implementation

From Last Industrial revolution i.e., Industry 3.0 (Industrial Automation), to communication with Industrial machine/devices industries uses RS485 Bus. In that the main node is called Master device. The Master may be Personal computer or PLC (Programmable logic controller) or any embedded system-based device.

Master should be RS485 enabled or having RS485 converter. Other machines connected over the RS485 Bus are treated as slave machines. To prove this concept a laboratory set up is developed in that one master and two slaves are considered. The detail of implementation is as follows.

A. System Block Diagram of RS485 Implementation in Industrial Automation

The main case implementation of RS485 in Industrial Environment is shown in fig.1. Usually the devices or industrial machines are connected in Master-Slave Architecture. One Device act as a Bus Master i.e., RS-485 enable Master device it may be PC or PLC, or any Embedded System based device.

The other connected devices are act as slaves. Each slave has their own slave-ID. Slave may be located remotely and connected with master through twisted pair cable. The Master is used to control the bus, collect information from slave device, and control the slave device/machine.

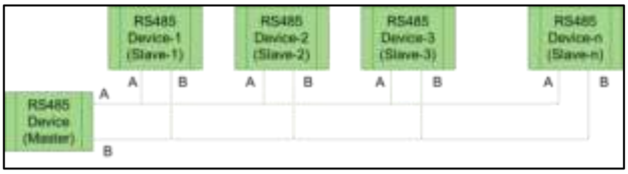


Fig. 1: System implementation of RS-485 based communication interface

B. POC implementation of Circuit RS485 in Laboratory

To connect devices over RS-485, the devices should have basic hardware components so that it becomes RS-485 enable devices. Fig. 2 shows the essential components requirement for both Master and Slave.

- Microcontroller (May be PC or PCL)
- RS-485 chip for Level converter
- Power Source
- Any Sensor/Relays/Actuators/ Solenoids
- Any Display or Keypad (optional)

In block diagram sensor is not connected in master module.

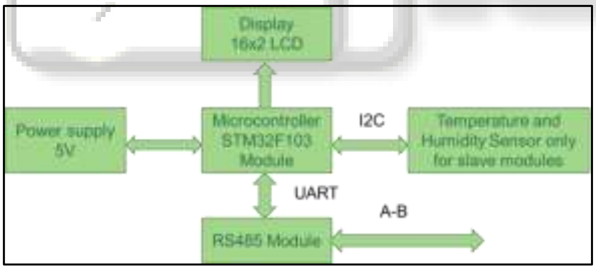


Fig. 2: Fundamental hardware block diagram for RS-485 based Laboratory setup

C. Schematic of RS485 Enable Device

The schematic of RS485 enable device is shown in fig. 3. For POC purpose following components is taken

- Microcontroller (STM32F103 Bluepill Board)
- RS485 Chip (MAX491E)
- Display (16x2 LCD)
- Temperature and Humidity Sensor (DHT112 for slave only)
- Keypad (optional)
- Power source (any 5V Adaptor)

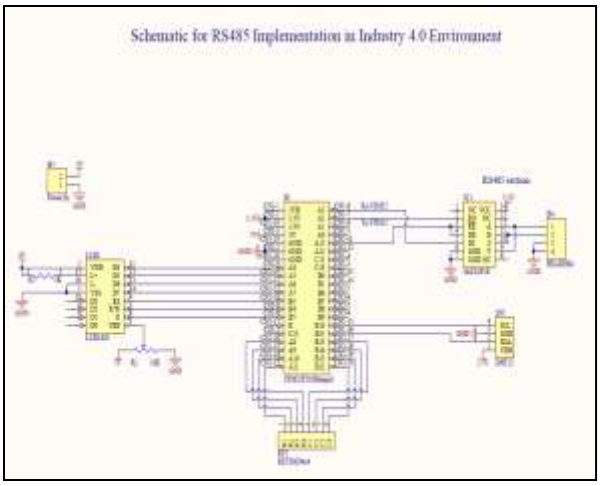


Fig. 3: Schematic of RS485 enable device

D. Board Bring Up and System Set Up in Laboratory for of POC RS485

For POC purpose one master without sensor and two slaves with Temperature and Humidity sensor with 16x2 LCD display are used. RS485 system setup with all the components is shown in fig. 4.

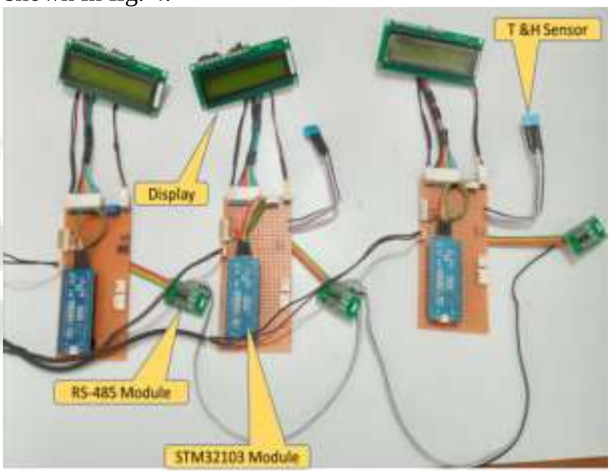


Fig. 4: RS-485 system setup in lab

E. BOM (Bill of Material)

Bill of Material of for master module which includes all the components required for implementation of RS485 is tabulated in table I.

Component	Qty	Costing in INR
STM32F103Bluepill	1	350
Max491	1	80
HEADER 2 Pin	1	8
Power Supply 5V	1	100
HEADER 4 Pin	3	36
LCD1602	1	150
Resistance 1K	1	1
Pot 10K	1	10
Master Module Cost		735

Table I: Master Module Rs485

Bill of Material of for Slave-1 Module which includes all the components required for implementation of RS485 is tabulated in table II.

Component	Qty	Costing in INR
STM32F103Bluepill	1	350
Max491	1	80
HEADER 2 Pin	1	8
Power Supply 5V	1	100
HEADER 4 Pin	3	36
LCD1602	1	150
Resistance 1K	1	1
Pot 10K	1	10
Temp and Humidity Sensor DHT12	1	100
Slave-1 Module Cost		835

Table II: Slave-1 Module-RS485

Bill of Material of for Slave-2 Module which includes all the components required for implementation of RS485 is tabulated in table III.

Component	Qty	Costing in INR
STM32F103Bluepill	1	350
Max491	1	80
HEADER 2 Pin	1	8
Power Supply 5V	1	100
HEADER 4 Pin	3	36
LCD1602	1	150
Resistance 1K	1	1
Pot 10K	1	10
Temp and Humidity Sensor DHT12	1	100
Slave-2 Module Cost		835

Table III: Slave-2 Module-RS485

The cumulative system cost of implementation of RS485 for data acquisition is tabulated in table IV.

Module	Qty	Costing in INR
Master	1	735
Slave-1	1	835
Slave-2	1	835
RS- 485Wiring Cost@Rs 50 per Meter	200	12000
Total Set UP Cost		14405

Table IV: Total POC Cost RS485

F. Embedded Software Flow

The embedded software is written in C-Language for STM32F103 controller in Keil-IDE. For POC implementation two type of embedded software is written one for Master as shown in fig.5 and One for Slave as shown in fig.6. In Master software the flow of program is sequential. After power up hardware, program initialize microcontroller system through system initialize function then, program initialize relevant microcontroller inner hardware through program like: UART, GPIO for Display. After that program enters in continuous loop where, program continuously fetch Slave-1 and Slave-2 in defined interval over UART and collect their parameter of temperature and humidity and shows collected information on 16x2 LCD display.

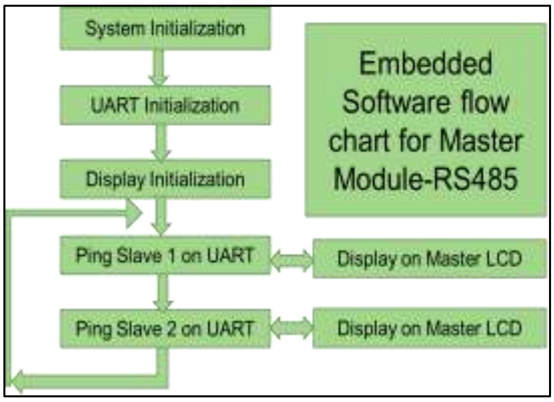


Fig. 5: Master Module software flow diagram

In Slave software the flow of program is sequential. The initialization process is like the Master software only some additional microcontroller hardware initialization, since it has additional temperature and humidity sensor.

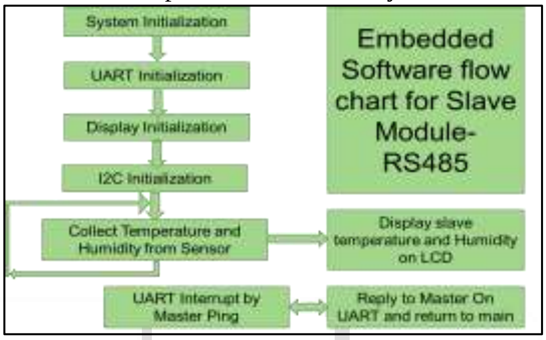


Fig. 6: Slave module software flow diagram

After power up hardware, program initialize microcontroller system through system initialize function then, program initialize relevant microcontroller inner hardware through program like: UART, GPIO for Display and I2C for Sensor.

After that program enters in continuous loop where, program continuously fetch the temperature and humidity sensor and collect the parameter in defined interval over I2C and shown these on its own 16x2 LCD display the modules also keeps the last read parameter in RAM so that whenever the UART interrupt raise the Slave module share these parameters with Master module.

III. RESULT AND DISCUSSION

Testing is conducted in point to multidrop mechanism in that the master will send command to one of the slaves and gather the temperature and humidity data and shows the acquired data in masters display similarly master send command to another slave and gather the data and display it in parallel the slave is showing it own parameters. The setup functioning is shown in fig.7.

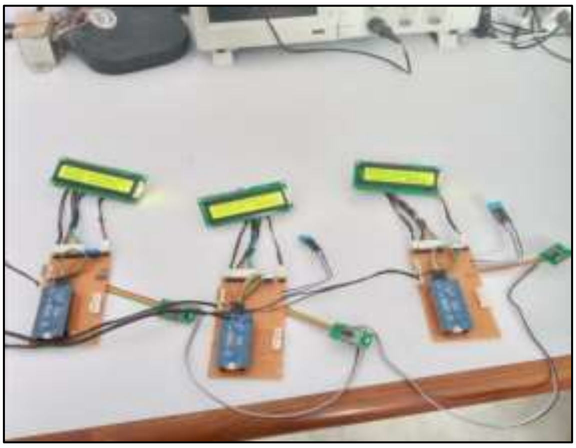


Fig. 7: System testing results of lab setup (RS485)

The live System shows the result on display as per algorithm is tabulated in table V.

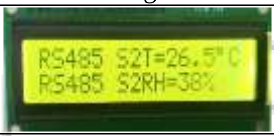
Master Reading Slave1 Ping	Slave1 Reading
	
Master Reading slave2 Ping	Slave2 Reading
	

Table V: RS-485 System Lab Setup Testing Result

IV. CONCLUSION

We have implemented data acquisition system using RS485 for industry 4.0 environment. It is a wired communication method for data monitoring, logging and controlling over long range for machines/devices. The BOM cost for POC is also mention. The system is able to record data and displayed the result directly on LCD display. This system works well in adverse industrial environment without any problem.

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