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Design and Development of a Network Based Data Acquisition System

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Abstract- The paper presents a network based data acquisition system useful for various scientific experiments and monitoring of different process parameters. The system implementation details are reported in the paper. The hardware implementation incorporates the design and development of sensor nodes and display nodes required for the system. Software development includes the development of network control algorithm required for host PC along with the sensor and display nodes. For validating the system four sensor nodes and one display node are installed at different locations at different distances. The collected data, by the system, is also presented in the paper.

Keywords: Data Acquisition System; RS485 Network; Hardware Development; Software Development; Sensor; Signal Conditioning.

1. Introduction

Measurement of various physical parameters is very important in different scientific experiments and equally important in manufacturing or processing plants to monitor and control various parameters. In both cases storage of the measured parameters is also necessary for further analysis of data. For single parameter measurement the objective can be achieved by using measuring instruments like digital multimeter, DSO (digital storage oscilloscope) with storing capability. As the number of measuring parameters increase, the necessity for a dedicated data acquisition system arises. The fundamentals of data acquisition systems (DAQ) are well explained in different books [1–3]. F.J. Ferrero Martin et al. classified DAQs based on the requirements and performance into three categories viz. (1) Computer-based systems, (2) Systems based on autonomous instruments, (3) Modular acquisition systems [4].

A standalone multichannel DAQ can be employed to measure a number of parameters. If measurements need to be taken in a widely distributed area, the sensors are to be connected by long wires. That means the standalone multichannel DAQs can serve the purpose with an expanse of additional cost for cabling the sensors and associated drive circuits or signal conditioning circuits. Moreover, the chance of signal loss increases due to effect of noise or loading in connecting cable. Hence reliability of the system greatly reduces although cost increases. In such a situation a network based data acquisition system is required in which the signal obtained from a sensor is locally processed and processed data is transmitted to a central system in particular format on request. The central system controls the network.

The paper presents the development of a low cost modular data acquisition system using microcontroller based local processing nodes and personal computer (PC) as host or the controller of the network. The nodes are connected to the PC by RS485 [5] network. Sometimes a local display becomes necessary and therefore display node is also incorporated in the system to display parameters. The system is tested by measuring temperature of different environment at different locations.

2. System Description

The developed system is based on RS485 network which is composed of two main parts: node and host. Nodes are of two types viz. (a) sensor node and (b) display node. Sensor nodes are responsible for processing analog signals obtained from sensors (or from signal conditioning circuit) and transmitting the processed data to the host on request. Display nodes perform the task of displaying the required information provided by the host
system. The host system is an IBM compatible PC, which controls the network and also stores the data in files that contain information regarding the nodes and the data obtained from different sensors. The nodes are connected by a two-pair cable, one pair of which is used to carry the data and the other provides the power supply required for the nodes. The block diagram of the data acquisition system is shown in Figure 1.

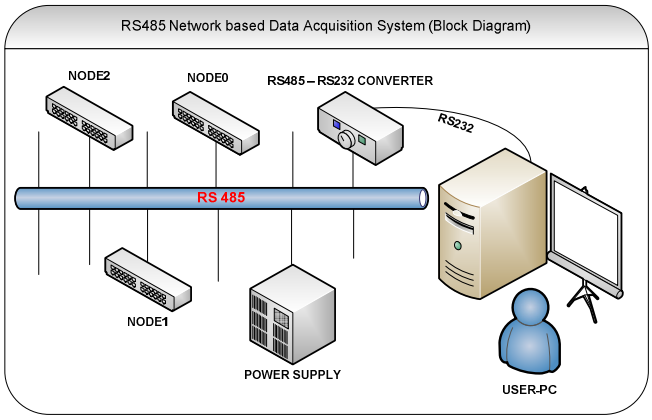

Figure 1. RS485 network based data acquisition system

3. Hardware Implementation

RS485 network is the heart of the system. In order to make the whole system work properly other system components (sensor nodes and display nodes) are designed with network capabilities along with their individual requirements. To reduce system cost the system components are also enabled to receive power from a single power supply unit through the network. The details of different system components are explained in the succeeding sections.

3.1. RS485 to RS232 Converter

Most of the IBM PCs come with standard COM port (RS232 Communication Port) but not with RS485 communication port. Therefore a RS485 to RS232 converter is designed. The block diagram of RS485 to RS232 is shown in Figure 2. The main components in the circuit are MAX232[6], MAX485[7] and BC557[8]. MAX232 is used to shift the level in RS232 communication and MAX485 is used to drive the line in RS485 communication. The BC557 automatically switches the transmission and reception pin of MAX485 on arrival of data form RS232 side or from RS485 side. Two LEDs (Light Emitting Diodes) show the status of transmission and reception.

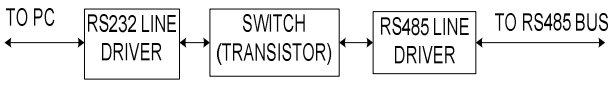

Figure 2. RS485 to RS232 Converter block diagram

3.2. Sensor node

Sensor nodes are local processing units with network capabilities. ATmega8 [9] microcontroller is used in the sensor nodes for processing the analog signals obtained from sensors through signal conditioning circuit and also for communicating to the network. ATmega8 microcontroller has integrated ADC (analog to digital converters) with 10-bit resolution and 6 analog input channels in PDIP (plastic dual in-line package) package. Reference voltage of the ADC can be set externally or internally by software. Internal setting provides band-gap reference of 2.5V. Since ATmega8 has a maximum internal oscillator frequency of 8MHz, to get higher clock speed, external crystal oscillator of frequency 11.0592MHz is used, which also gives 0% error while communication with PC at standard baud rates. The circuit block is shown in Figure 3.

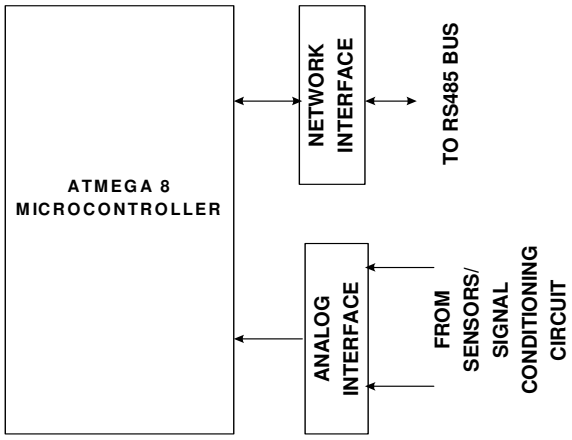

Figure 3. Block diagram of Sensor Node

The integrated 10-bit resolution ADC has non-linearity of 0.5 LSB and ±2 LSB absolute accuracy.

3.3. Display node

The display nodes are network enabled 7-segment display module with three fields of display:

1. Node numbers (2 digits)
2. Temperature (3 digits) and
3. Reserved for other parameter (2 digits).

In the field of node number the assigned number for a particular sensor node is displayed and the following fields display the measured parameter of that sensor node. Using only one display node measured parameter of more than one sensor node can be displayed sequentially by changing the node number.

The display module composed of AT89C2051 [10] microcontroller and MAX7221 [11]. MAX7221 is a 7-segment display driver which can drive 8 digits and can be controlled through SPI. The circuit schematic of the designed display module is shown in Figure 4.

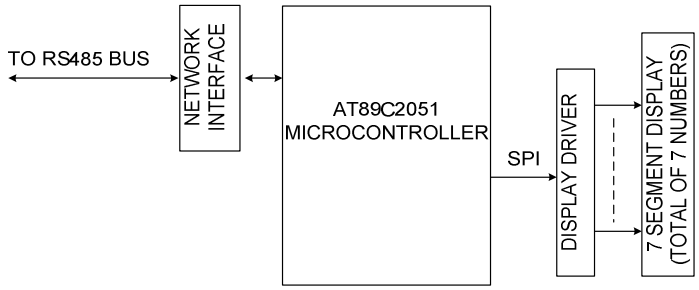

Figure 4. Block diagram of Display Node

4. Software and algorithm development

For the system to work properly three algorithms are developed.

4.1. Algorithm for host:

This algorithm is developed for the host to control the network. The software for the developed algorithm is written in C language and compiled in Turbo C++ IDE to run on the host PC. The flowchart of the developed algorithm is shown in Figure 5 (a).

4.2. Algorithm for sensor node:

The Sensor Node algorithm is developed to process the task requested by the host. The developed algorithm is implemented on ATmega8 microcontroller. AVR studio 4 IDE [12] is used to develop the firmware written in C language. The flowchart of the developed algorithm is shown in Figure 5(b).

4.3. Algorithm for display node:

The developed display algorithm controls the 7-segments of the display module according to the host command. The code is written in C language and compiled in Keil µ-Vision IDE [13] and implemented on AT89C2051 microcontroller. The flowchart of the developed algorithm is shown in Figure 5(c).

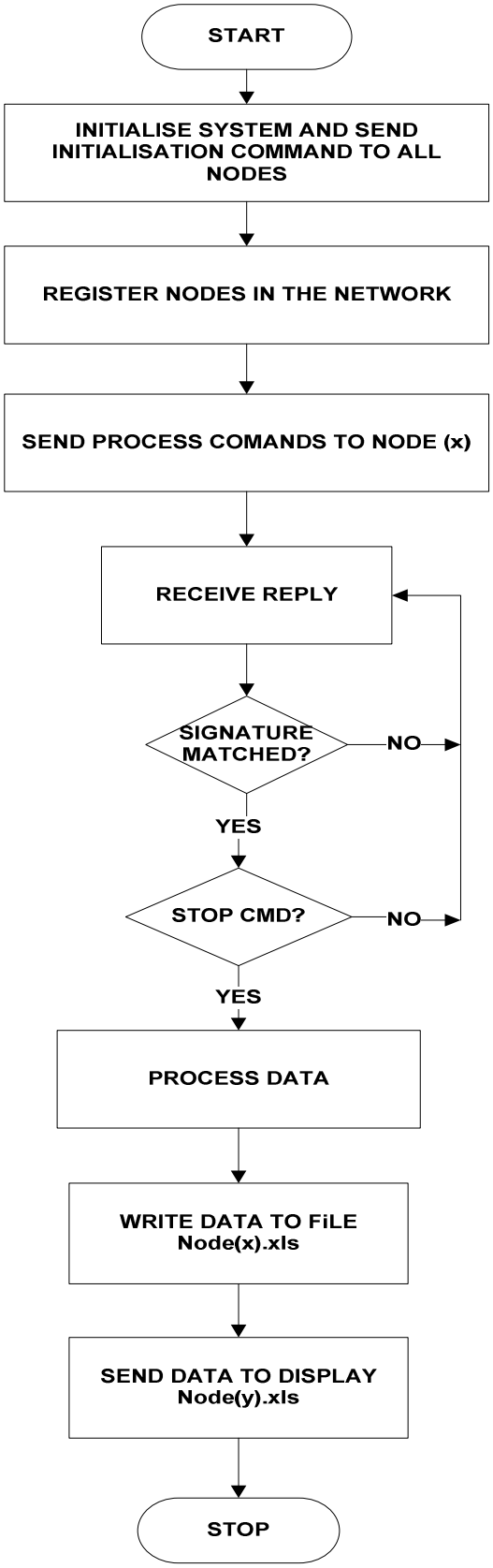

Figure 5(a). Flowchart for host

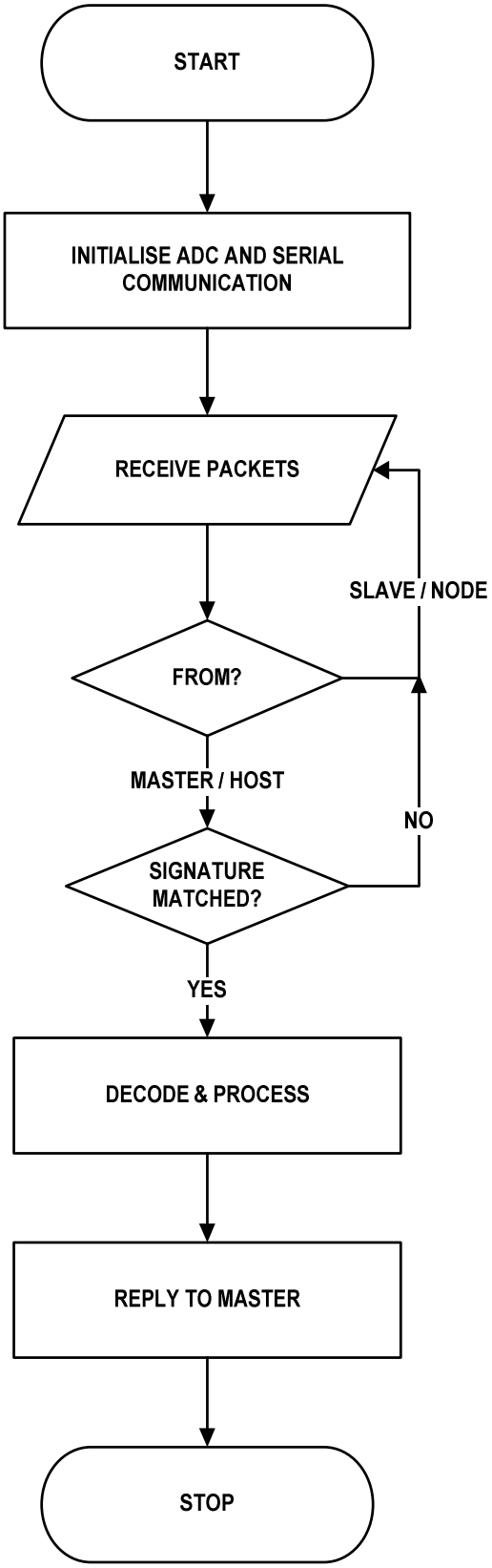

Figure 5(b). Flowchart for sensor node

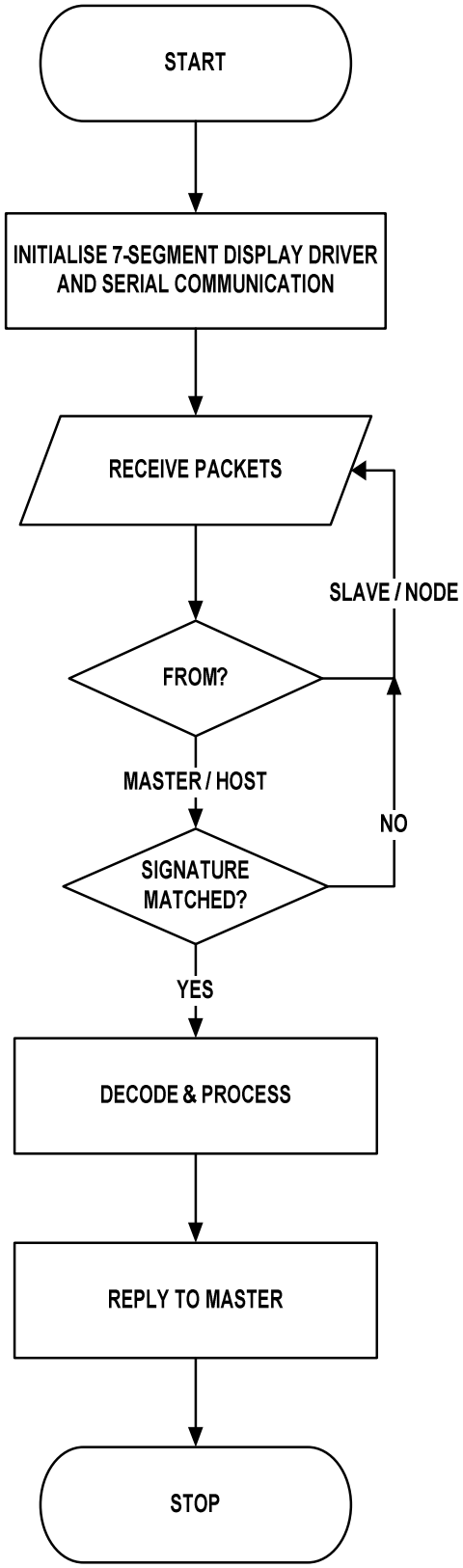

Figure 5(c). Flowchart for display node

5. System Testing and Results

For testing of the developed system, four Sensor Nodes and one Display Node were installed on different places in the Dept. of Instrumentation & USIC and in Dept. of Physics of Gauhati University. The system was run for one month.

In each Sensor Node one LM35 temperature sensor was connected in channel-0 of the ADC. The host PC program generated one log file and four files for recording the data. The data are also displayed the information on the Display Node. Table 1 shows the installation location of nodes and their distances from host PC.

The recorded data is available on the corresponding files that are generated by the host PC program. The following four temperatures versus time plots show the variation of temperature recorded on an arbitrary day.

The test nodes are installed at different distances, because in actual practice the situation demands such variable distances. From the curves it is observed that the profile of temperature variation in different condition is different and also observed that the maximum temperature is attained at around 2 p.m.

Table 1: Installation details of different nodes.

Node No.	Type	Location	Distance from host (m)
1	Sensor Node	Dept. of Instrumentation & USIC (2nd Floor)	30
2	Sensor Node	Dept. of Instrumentation & USIC (Workshop)	80
3	Sensor Node	Dept. of Physics(1st Floor)	200
4	Sensor Node	Dept. of Instrumentation & USIC (1st Floor)	10
5	Display Node	Dept. of Instrumentation & USIC (1st Floor)	12

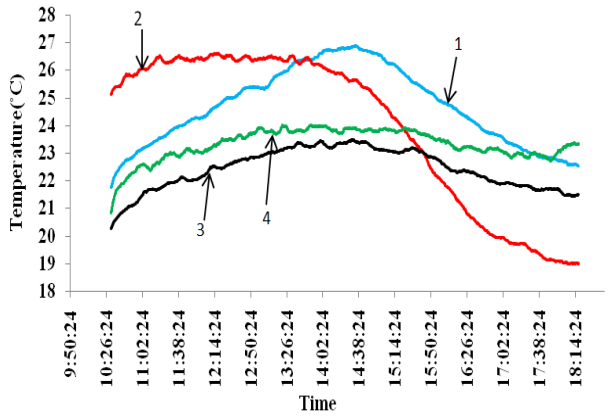

Figure 6. Variations of temperatures in different environmental conditions are shown. Curve 1 shows the variation in 2nd floor of Instrumentation department (distance 30m), Curve 2 shows the variation in workshop of Instrumentation Department (distance 80m), Curve 3 shows the variation in 1st floor of Physics Department (distance 200m), Curve 4 shows the variation in 1st floor of Instrumentation Department (distance 12m).

6. Conclusion

A RS485 network based data acquisition system is designed and developed which can be used in data collection for scientific experiments. The system can also be used for monitoring of process parameters in manufacturing and process industries. Although only temperature is measured during test, other parameters can also be measured with proper sensor and signal conditioning circuit. Use of common power supply unit

in the system eliminates the requirements of extra wiring for power supply. Since the sensor nodes have the capability of processing, overhead on PC reduces in data processing. Many signal processing tasks such as linearization, offset adjustment etc. can be embedded on the sensor node processor. The system can be easily expanded just by adding more number of identical sensor nodes or display nodes for which modification in software is very little. Although a number of new technology have been developed in data communication, RS485 network with proper configuration can provide an easy and good option for data collection and monitoring.

7. References

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