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Ethernet Through Industrial Parameter Monitoring

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Abstract

In today's world networking is important part of industrial automation in monitoring of industrial process parameters. To provide this automation we propose a system which uses ARM Processor with Ethernet controller. Monitoring of industrial process parameter is complete system in which sensors are used to collect the data from the actual industrial environment. This actual environment may be the boiler, chemical tank, nuclear reactor or furnaces etc. whose temperature we have to monitor over the Ethernet. The accuracy of data collection depends on type of sensor and process whose parameter is to be monitored. In case of nuclear reactor the accuracy should be high, where as in case of furnaces less accuracy can be acceptable. If we need to connect more serial devices at a time with high data rate at a time which makes the data processing somewhat difficult due to which system performance is poor. Another important factor is distance between sensor and host device, as the distance increases, the length of wire increases, which increases the drop.

Keywords: *Embedded Ethernet, ARM Processor, Web Server.*

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INTRODUCTION

In world numerous factors, temperature, pressure, humidity are most important and the most difficult to control environmental factors. In addition in recent years, energy and environmental problem becomes the hot topics that people concern. Some industries have to be controlled. Temperature monitoring and control is important in industrial environments. Sensors are widely used for measurement of temperature. Usually, a temperature sensor converts the temperature into an equivalent voltage output so we need energy conservation and environmental protection. Monitoring and control is very important in realizing industrial automatization and high efficiency. With the development of modern industry, the requirement for industrial monitoring system is getting higher. The system is process real time data. It is also required in controlling related instruments to change those environment factors such as; temperature, pressure, humidity, speed motion etc. and monitoring remote distance. In wire communication, one clear limitation is we have to put wire ground. This can be difficult to hide, and time consuming in buildings that are already constructed such as; wiring at working place. Another limitations that applies to industrial environments is metal conductors wired between places that potentially have different ground potential rise (GPR) can cause equipment failures when ground voltage at one side of the wire becomes significantly higher than at the other end. Wireless communications and fiber optic communications have been used to prevent the GPR issue because of difficult wiring, limitation of control range of the system and high maintenance cost these systems cannot be used widely. So, we use embedded technology and Ethernet technology for monitoring and controlling action. We will replace SCM (single chip microprocessors) with microprocessors based on ARM technology, which will greatly improve the overall performance of the system.

The application of Ethernet and embedded technology makes the remote monitoring possible and give the stability, reliability, security, and real-time of the data transmission at display at web server [1–7]. It will effectively improve the flexibility, efficiency and maintainability of the control system and reduce the cost of the equipment maintenance.

Based on these reasons, the system will meet the requirement of the microcontroller system.

WEB BASED SUPERVISION AND CONTROL SYSTEM

In recent years, the Internet and networks have proved to be powerful tools for distributed collaborative works. Recent advances in computing, communications, sensing, and software technologies have created a new environment which offers great opportunities for the field of control to expand its applications and its contributions to the economic growth and more developed societies. The rapid growth of communication networks provides several major opportunities and challenges for systems and control. In recent years, the Internet and networks have proved to be powerful tools for distributed collaborative works. Web based automation is a recent development in the industrial sector. The implementation of industrial process control is made possible by the use of Internet. The function of Web-based equipment monitoring system is to collect data information of the onsite equipment, publish it through a Web form, and remotely send the data in the form of the user-defined data transmission style. The data will be published through web server. The remote computer will collect the data and display it on the web page, and it indicates level, for example, temperature in the boiler etc. all these information will be displayed on the web page which also allows all these control the appliances.

In the scheme of the system, the remote I/O data acquisition modules are developed as embedded web servers having static IP with port 80, which can be widely used to diversify industries such as; electric power, petroleum, chemical, metallurgy, steel, transportation and so on. This system is mainly used for the concentrative controlling and monitoring of a variety of electrical and thermal signals such as; voltage, current, thermal resistance and thermocouple in the production process.

The Internet of Things (IoT) is the interconnection of uniquely identifiable embed ded computing devices within the existing Inte rnet infrastructure. Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications (M2M) and covers a variety of protocols, domains, and applications. The interconnectio n of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a Smart Grid.

Integration with the Internet implies that devices will utilize an IP address as a unique identifier. However, due to the limited address space of IPv4 (which allows for 4.3 billion unique addresses), objects in the IoT will have to use IPv6 to accommodate the extremely large address space required. Objects in the IoT will not only be devices with sensory capabilities, but also provide actuation capabilities, (e.g., bulbs or locks controlled over the Internet). To a large extent, the future of the Internet of Things will not be possible without the support of IPv6 and consequently the global adoption of IPv6 in the coming years will be critical for the successful development of the IoT in the future [5–9].

HARDWARE IMPLEMENTATION

The hardware (Figure 1) mainly consists of:

1. Sensor
2. Ethernet controller
3. Interfacing
4. Processor
5. LCD
6. PC

Sensor

Sensors are used to collect the data form actual industrial field. Sensor is the device which converts the one form of energy in to another form. It is used to sense various parameters like Temperatures, Pressure, Force, Flow, Light etc. Sensor is classified in to different types depending on their working or changing parameter with reference to measured variable. Sensor whose resistance changes with measured variable.

- Sensor which produces voltage with measured variable.
- Sensor whose electrical output is changes with measured variable.
- Thermister for measurement of temperature.
- Photoresister for light measurement.
- Strain gauge for mechanical strain measurement.

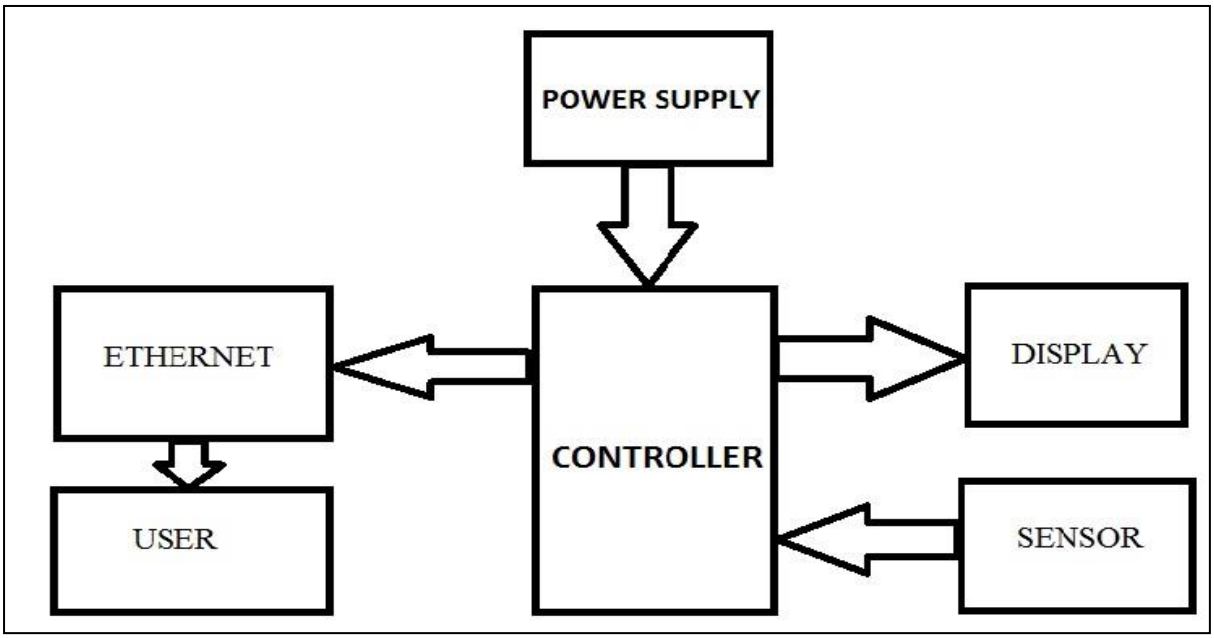

Fig. 1: *Block Diagram of System.*

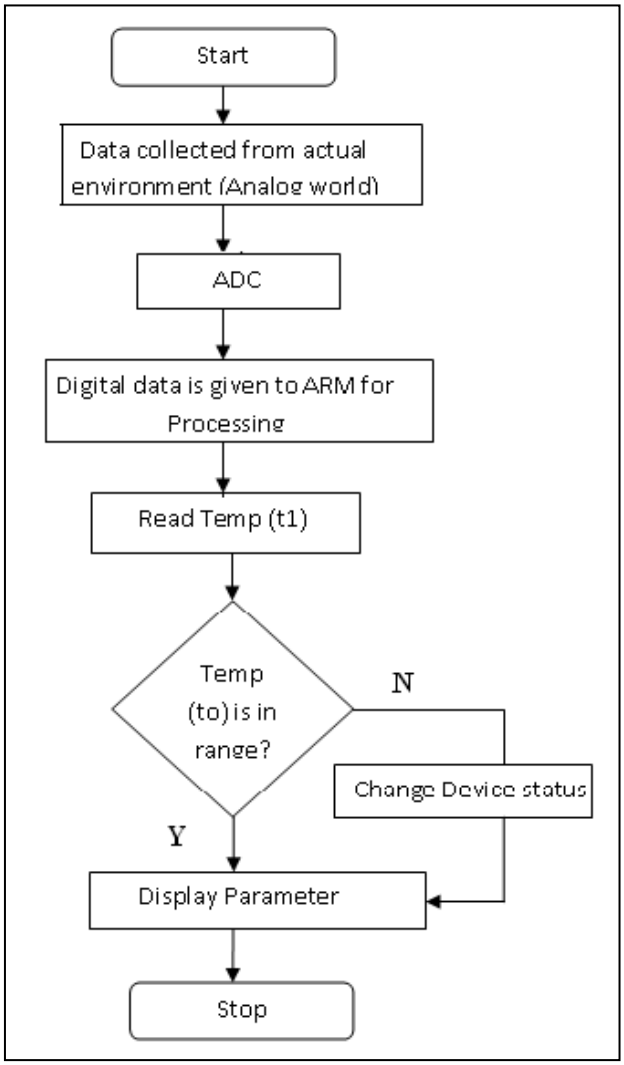

Fig. 2: *System Implementation Chart for One Sensor.*

➢ ***LM 35 Temperature Sensor***

As per system requirements for measuring Temperature the Precision Centigrade Temperature Sensor LM 35 is selected as shown in Figure 2. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies. The operating range of this sensor is 4–30 volts. It gives 10 mv/0c output. Rated for full −55 to +150°C range.

➢ *Level Sensor*

As per system requirements for measuring level of liquid selected Level Sensor, this level sensor gives the output in the form of resistance. So, by using constant current source supply converted that value into voltage.

Ethernet Controller

The concept of embedded Ethernet is nothing but the microcontroller is able to communicate with the network. As now a day's microcontroller is widely used in the industrial field, as most of the devices used in industries are not able to transmit the data over the network. This system mainly consists of SPI communication module, Control module and Ethernet module. Because of this Ethernet module; it is possible to monitor the parameters from longer distance. The ENC 28J60 is Ethernet controller which is designed to serve as an Ethernet network interface for any controller equipped with SPI. It has an internal DMA module for fast data throughput and hardware assisted IP checksum calculations. It incorporates a number of packet filtering schemes to limit the number of incoming packets and provides a data rate of 10 MBPS. The MAC module implements IEEE 802.3 compliant MAC logic. The PHY module encodes and decodes data obtained from the twisted pair interface. ENC 28J60 is microchip technology that introduces 28 pin stand alone Ethernet controller. All other Ethernet controllers available in market are more than 80 pins so 28 pins ENC 28J60 will provide good functionality and simplicity.

➢ ***Serial Peripheral Interface (SPI)***

The serial communication is performed by means of two pins that are SI and SO as shown in Figure 3. SCLK provides clock synchronization and CS is the chip select. This communication technique can be implemented between processor and peripherals that have SPI interface. Serial Peripheral Interface Bus in which serial data communication is performed in master/slave mode. In which master device initiates the data frame. This is a full duplex mode of point to point communication. The serial clock, SCLK generated by the master device which is used by the slave. The SS is the Slave Select signal. It is required in active low state for the slave to have communication with master. This is a four wire communication as shown in Figure 3. The SDO or Serial Data Output signal send by the master and after receiving the clock pulse, the slave device responds back with SDI or Serial Data Input signal.

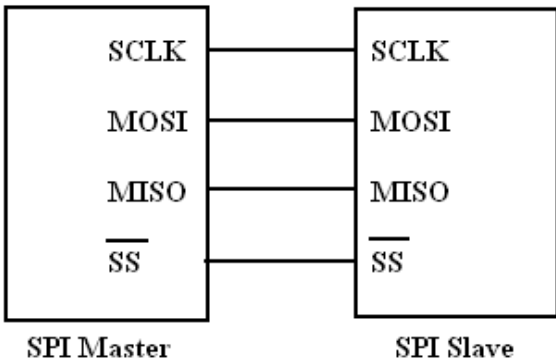

Fig. 3: *SPI Interface.*

When SPI protocol is used between the two devices, the Ethernet Controller generates the data frame and acts as the master while the arm processor acts as the slave device.

1) SPI interface: It serves as a primary controller and act as communication channel between ENC28J60.
2) Control register: Are used to control and monitor the ENC28J60.
3) Dual port RAM buffer: It acts as an arbiter to control the access to RAM buffer, when requirement is made from DMA to transmit and receive the blocks.
4) Bus interface: It interprets data and commands received via SPI.

5) MAC module: It implements IEEE 802.3 compliant MAC logic.
6) PHY module: It encodes and decodes data obtained from the twisted pair. The controller communicates with Ethernet controller via its ADC lines, to initialize the chip, Poll it for packet status and Send/receive the data.

➢ ***Ethernet Module***

Figure 4 shows Serial to Ethernet module which is used in system. The Serial-to-Ethernet (S2E) module is a simple product that provides serial to Ethernet communications. Existing systems that lack Ethernet connectivity but have a UART or RS-232 port can be easily upgraded by the addition of the S2E module. Client can access this serial to Ethernet Module on remote location through IP address.TCP/IP protocol is used for communication to the client on remote location.

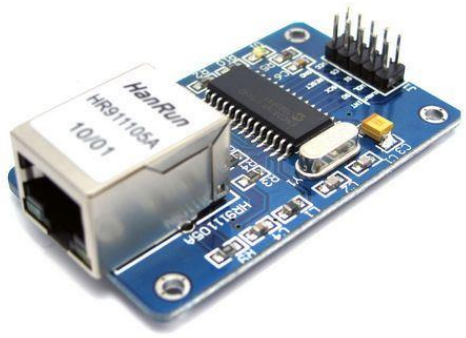

Fig. 4: *Ethernet Module.*

The MDL-S2E module provides the following features:

- LM3S6432 microcontroller.
- 10/100 Mbit Ethernet port.
- Two serial ports, configured as data communication equipment (DCE), include RTS/CTS for flow control.
- Module supports 5 V and 3.3 V supplies.
- Protocols include ARP, IP, ICMP, UDP, TCP, HTTP, DHCP, and Telnet.
- Multiple mounting options.

- *LM 35 Temperature Sensor*

The LM35 series are precision integrated-circuit temperature sensors, with an output voltage linearly proportional to the Centigrade temperature. Thus the LM35 has an advantage over linear temperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or Trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55 to +150°C temperature range. The device is used with single power supplies or with plus and minus supplies. As the LM35 draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 is rated to operate over a −55 to +150°C temperature range, while the LM35C is rated for a −40 to +110°C range (−10° with improved accuracy).

- *Level Sensor*

As per system requirements for measuring level of liquid selected Level Sensor, this level sensor gives the output in the form of resistance. So, by using constant current source supply converted that value into voltage.

- *Speed Sensor MOC 7811*

MOC 7811 shows Speed Sensor. It has internally LED and transistors. It gives output in between ground and +vs. By measuring pulses in between these two outputs we measured the speed of device in rpm. The output of speed sensor is directly connected to the interrupt pin of LPC 2148.

Interfacing

Interfacing is used to provide proper communication between microcontroller and external device. This may be the parallel or serial communication. So we got level of liquid in the form of voltage. That voltage is amplified by using differential amplifier.

Processer

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 to 512 kB. It RISC microprocessor is designed to provide a cost-effective and high performance micro-controller solution for hand-held devices and general applications. A

128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. Analog data gathered from sensor are given to ADC of LPC 2148 where this data are processed and given to the PC and LCD for monitoring.

LCD

A liquid-crystal display (LCD) is a flat panel display or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images or fixed images which can be displayed or hidden such as; preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. LCDs are used in a wide range of applications including computer monitors and signage. They are common in consumer devices such as; DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in most applications.

Personal Computer (PC)

A user is a person who uses a computer or network service. A personal computer (PC) is same as general-purpose computer which is used to display parameter of sensor. On the other hand that is used in monitoring controlled action in industries [4–8].

BOARD USE REQUIREMENTS

The board usage purpose the PC should contain the following requirements: PC with ablest 2.0 GHz processing speed or higher version CPU, at least 512 MB or above RAM, USB Port, Serial Port and Ethernet Port. Windows XP OS Integrated Development Environment (IDE). Keil software with version 4, Flash magic for software loading in to the hardware LPC1768 board. Electrical connectors, power supply of 12 volt.

SOFTWARE DESCRIPTION

Keil microvision 4, is the compiler software used here. For editing, Embedded C language is used. The code will write in Embedded C and this code will be loaded in LPC1768 CORTEXM3 board by Flash magic software. The flash magic is the software which is used to load the source code in processor, it communicates between PC and processor. At PC side HTML is used to design a web page.

This HTML is an interface with Ethernet (TCP/IP) protocol. In Flash magic the baud rate is always 9600 and oscillation is 12 MHz, com port we can use either 1 or 2.

CONCLUSION

This is small, simple and low-cost system which improves the industrial parameter monitoring and controlling process. Flexible Embedded network system with Ethernet controller web server in the system; provides access to the parameters under the control of system through a device web page.

A web server can be embedded into any appliance and connected to the LAN. So the appliance can be monitored and controlled from remote places through the browser on a desktop. We can design real time monitoring and controlling of industrial parameters with the help of Ethernet. That provides authentication, encryption, and integrity services for wireless system that increases security level of the system and total reliability of the system.

Our system can be extended for sensing malfunctioning in industrial machines and making corrective measures in it. More and more automation is being handled via remote communication.

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