Industrial Process Parameter Control using Ethernet

N. U. Chipde[1], V. R. Raut[2]

[1] Department of Electronics and Telecommunication, P.R.M.I.T, Badnera, Amravati, Maharashtra, India
[2]Associate Professor, Department of Electronics and Telecommunication, P.R.M.I.T. Badnera, Amravati, Maharashtra, India

Abstract: ***In today's world networking is important part of industrial automation for monitoring and control of industrial process parameters. To provide this automation we implement a system which uses ARM Processor with Ethernet controller ENC 28J60. As most of industrial devices does not have network interface capability so ENC 28J60 will use to provide interface capability. In industries there are several parameters which must be monitor continuously. ENC 28J60 is important part of this system which is used as Ethernet network interface for any controller equipped with SPI. It will satisfy the all specifications of IEEE 802.3, also it has MAC and PHY modules, it will provide faster data transfer using internal DMA. By using RJ 45 connector we can connect a microcontroller to a required MBPS network. To access the ENC 28J60 we have to configure the register and memory. This design basically consists of SPI communication module, processor module and Ethernet interface module. Due to which system has high performance and offers widest range of features viz flexibility, reliability, durability when compared with conventional and old solution to monitor and control.***

Keywords: ENC 28J60**,** Ethernet, ARM

1. Introduction

Monitoring and control 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, nuclear reactor or dairy plant etc whose temperature we have to monitor over the Ethernet. The accuracy of data collection is depends on type of sensor selected and range of temperature to be measured, In case of nuclear reactor the accuracy should be high, where as in case of dairy plant less accuracy can be acceptable. If we need to connect more serial devices at a time with high data rate which make 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 is increases as the length of wire is increases, which increase the drop. The solution for this problem we are replacing previous control methods based on microcontroller with ARM processor and embedded Ethernet interface system. In which host system carry out one communication at a time which reduces its load.

2. Background Study

A wireless communication as most of industrial company's use of wired communication, for this reason the author shows an innovative system that uses a wireless communication between the industrial processes with the different sensors and the central of monitoring. Also, this system involves a serial server device (LABVIEW), which allows monitoring the process via internet through a graphical interface [13].

A closed loop control system incorporating fuzzy logic has been developed for a class of maintenances of temperature in a heating chamber. A unique fuzzy logic controller (FLC) is a structure with an efficient realization and a small rule base that can be easily implemented in existing industrial network [14].

A wireless smart sensor platform targeted for instrumentation and predictive maintenance systems is presented. The generic smart sensor platform with 'plug-and-play' capability supports hardware interface, payload and communications needs of multiple inertial and position sensors, and actuators, using a RF link (Wi-Fi, Bluetooth, or RFID) for communications, in a point-to-point topology. The design also provides means to update operating and monitoring parameters as well as sensor/RF link specific firmware modules 'over-the-air'. Sample implementation for industrial applications and system performance is discussed [15].

A Microcontroller LM3S8962 which communicate with serial data acquisition equipment through SPI. It basically contains SPI module, Processing module and RF trans receiver module (nRF24E1), It uses a CAN network which allow Microcontroller and devices to communicate with each other without Microcontroller [16].

ARM LPC 2138 as a processor and for Ethernet interface it uses DM9000A because ARM having MAC Layer but unable to provide physical interface so it uses a DM9000A which is 48 pin IC. The advantage of this system is that because of ARM system performance is improved, Communication is fast, real time and reliable [18].

3. Hardware Implementation

The hardware mainly consist of

1. Sensor
2. Processor
3. Ethernet controller
4. PC

3.1 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 verious parameters like Teperature, Pressure, Force, RPM etc. In this system we are provide controlling ovar temperature range 40 ºC to 50 ºC and 50ºC to 60ºC and controling RPM of motor at 200[1].

3.1.1 Temperature Sensor Types

The main temperature sensors are

a. Thermister.
b. RTD.
c. Thermocouple.

a. Thermister: It is nothing but the temperature dependant resister. In which the resistance of sensor is changes in predictive way with change in temperture .

b. Resistance Temperature Detector (RTD) It's resistance is linearly increases with increase with increase in temperature.

c. Thermocouple It having two dissimilar metal wires joined at hot junction, as temperature varies a signal is measured at cold junction. In this system we using

3.1.2 Temperature Sensor

- LM35 Precision Centigrade Temperature Sensor (Thermister) for controlling 40 º C-45 º C range [2].
- Temperature Probe using 'K'-Thermocouple with Digital Interface for controlling 60ºC-70ºC range [3].

3.1.3 RPM Sensor

Transmitter: IR 333 A (Infrared LED).
Receiver: PT 333-3C (Photo transistor) [4].

3.1.4 Sensor Interfacing

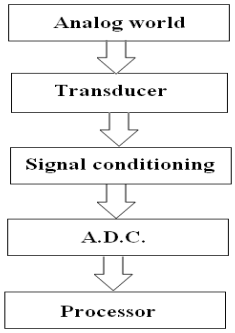

Figure 1: Sensor Interfacing Flow chart

Data collected from actual environment is in analog form but processor will able to process only digital data that's why it is given to Analog to Digital Convertor (ADC) before ADC signal conditioning is require in some cases if output of sensor will not having sufficient magnetude to detect by the next step. The output digital data of ADC is given to the processor for processing, where upper and lower threshold conditions are maintained by using program[5].

3.2 Processer

As a processer we are using LPC 2148 because of following features. It is 32 bit ARM 7 TDMI microcontoller with 40 KB of on chip flash static RAM, 512KB of on chip flash memory, It has In system programming Using on chip boot loader. For interfacing of sensor it has 10-bit ADC with 14 analog input and conversion time as low as 2.44us per channel. The conversion rate can be increase up to 400K samples per second By setting the ADC's serial registers. So most of the data processing is done by ADC so limited software is required for design other tasks. The LPC 2148 can communicate with serial communication through SPI and trasnmit the data to the host computer through ethernet interface . The ARM is the heart of the system as it has high speed of execution and powerfull information processing capability due to pipelined structure, Capability of multi parameter execution. The networking capability of ARM makes it suitable for wide veriety of networking appication[3]-[4].

So analog data gathered from sensor are given to ADC of LPC 2148 where this data is processed and given to the PC and LCD for monotoring. So selection of proper sensor and smart processor will greatly optimize the system performance.[6]-[7]

3.3 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 consist of SPI communication module, Control module and ethernet module. Because of this ethernet module it is possible to monitor and control the parameters form longer distance.

The ENC 28J60 is Ethernet controller which is designed to serve as an ethernet network interface for any controller equiped 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 up to 10MBPS. 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 [8].

3.3.1 ***SPI interface:*** It serves as a primary controller and act as communication channel between ENC28J60.

3.3.2 ***Control register:*** Are used to control and monitor the ENC28J60.

3.3.3 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.

3.3.4Bus interface: It interprets data and commands received via SPI

3.3.5 MAC module: It implements IEEE 802.3 compliant MAC logic.

3.3.6 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. [9]

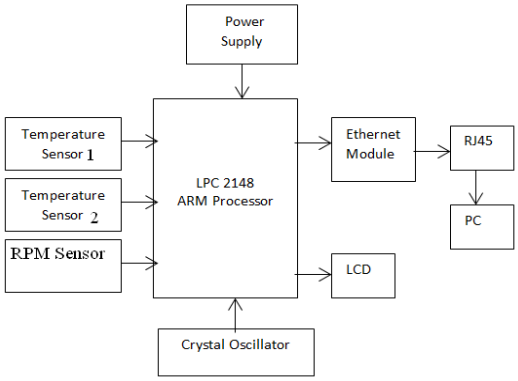

Figure 2: System Block Diagram

4. Interfacing

Interfacing is use to provide proper communication between microcontroller and external device. This may be the parallel or serial communication.

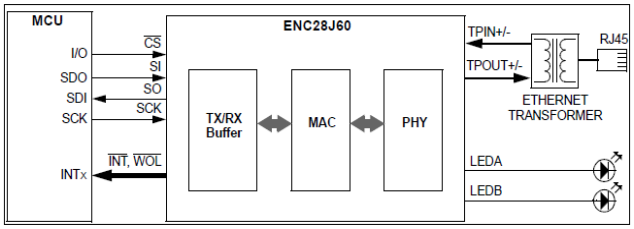

Figure 3: ENC 28J60 based interfacing

4.4.1 Serial Peripheral Interface (SPI)

The serial communication is performed by means of two pins that are SI and SO as shown in Figure. 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 2. 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.

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. [10]-[11]

5. System Implementation

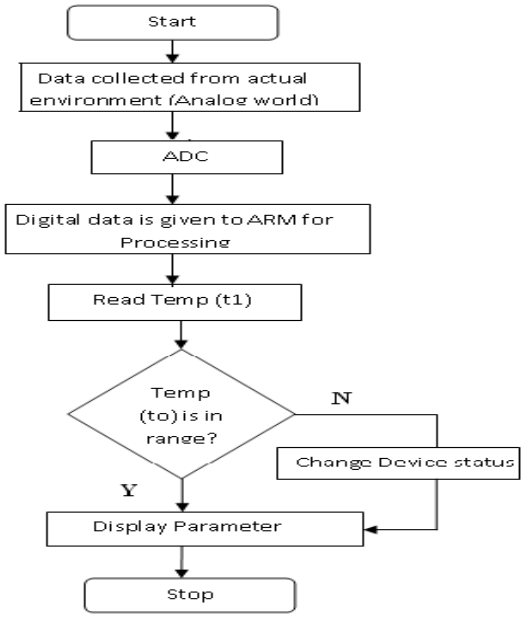

Figure 4: System implementation chart for one sensor

As shown in figure system work start with data collection with the help of sensor for example temperature sensor this data is then converted from analog to digital with the help of inbuilt 10-Bit ADC in LPC2148, then this digital data is given to ARM for processing where measured temperature is compaired with given range if temperature is in range then just display it on LCD and PC through Ethernet. If temperatureis out of range then we are change the device status so that temperature can get back within range [12].

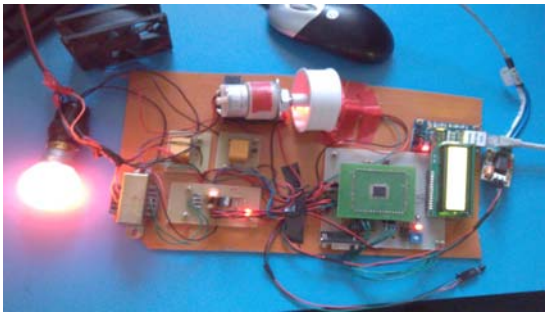

Figure 5: Experimental setup

6. Result

This system fast and accurate to monitor and control the industrial process parameter on real time basis using Ethernet. ENC 28J60 Embedded Ethernet Controller is smallest Ethernet controller in the market with 28 pins only due to which design is simple for the remote control within LAN with low power consumption.

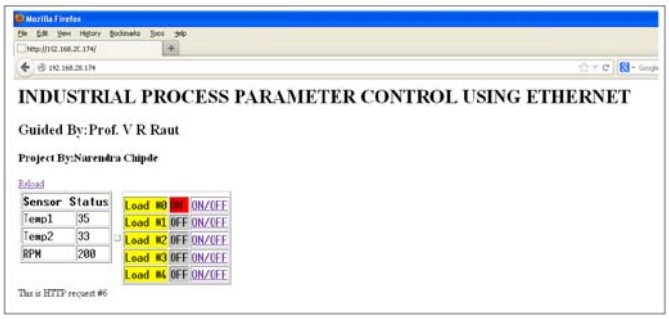

Figure 6: Control window

This window is used to monitor and control the industrial parameter through which perticular parameter is monitored and controlled. Load two is manualy control where as other loads are automaticaly controlled.

7. Conclusion

This is low cost method for monitoring and controling the industrial parameter like temperature RPM etc remotly The ARM can communicate with PC using serial port using RS 232, It support online supervision using private LAN. By using embedded hardware and software we can control the require industrial parameter and industrial automation using Ethernet with high accuracy.

Referances

[1] www.facsstaff.bucknell.edu/mastascu/elessonsHTML/sensors/TempR.html.

[2] Nationa Semiconductor, datasheet, LM 35 Precision Centigrade Temperature Sensors,November 2000

[3] Sunrom technology, Temperature Probe using 'K'-Thermocouple – Digital Interface, June 2010.

[4] Everlight Electronics Co-Ltd, Technical data sheet, Photo transistror and LED

[5] The 8051 Microcontroller and Embedded Systems Using Assembly and C Second Edition Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay

[6] Philips semiconductor, "LPC 2142/2146/2138", prelimnary datasheet,rev.0.1,JUNE2005.

[7] www.microbuilder.edu/tutorials/LPC 2148.

[8] Microchip Technology Inc. "ENC 28J60 Data Sheet"' 2008.

[9] Bin Tan, Bo Yuan and Bing Zhu, " The Design of ethernet controller interface circuit based on ENC28J60" Proceding of second International Symposium on networking and network security(ISNNS'10) 2-4 April 2010.

[10] Florin ravigan, Niculae boteanu, Adrian mircea drighiciu, "Ethernet interface for a system of automation with microcontroller", Annals of the university of Craiova Electrical Engineering series No 35, 2011, ISSN 1842- 4805

[11] Dhananjay patil ,"Industrial Parameter control and monitoring using LAN ",IRNET explore ,7th Oct.2012

[12] U. suneetha, K. tanveer alam, N. Anuja latha, B.V. S.goud,B. ramamurthi, " Ethernet based remote monitoring and control of temperature by uning Rabbit processor", International journal of advanced computer science and applications (IJACSA), Vol.3 , Nov 9, 2012.

[13] Tatiana Del Pilar Mateus Guerra, Camilo Ernesto Pardo Beainy, Manuel Felipe Rodriguez Perez,' Remote Monitoring System With Wireless Access To Industrial Processes', 978-1-4244-6742-6/10/$26.00 ©2010 IEEE

[14] Md. Rabiul Islam, M. A. Goffar Khan* and M. F. Rahman," Microprocessor based Temperature Monitoring and Control System using Fuzzy Logic Controller. 5th International Conference on Electrical and Computer Engineering ICECE 2008, 20-22 December 2008, Dhaka, Bangladesh.

[15] Harish Ramamurthy, B. S. Prabhu and Rajit Gadh and Asad M. Madni," Wireless Industrial Monitoring and Control using a Smart Sensor Platform" IEEE sensor journal Fall 2007.

[16] S.A.N. Sandeep, P. Malyadri, "ARM-based Embedded Ethernet Interface Design Using DAC System, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-1, Issue-6, August 2012 .

[17] V. L. Varaprasad Nagulal, M. Venkateshwara Rao, T. Raghvendra Vishnu, Embedded Ethernet monitor and controlling using web browser[C], [IJESAT], International Journal of Engineering Science and Advances Technology, Volume-2, Special Issue -1, 1-5.

[18] Mr M.R. Gaikar, Prof S.G.Galande, Prof. D.B.Rane "Ethernet Controller ARM Processor" International journal of Electronics communication and soft computing science and engineering volume 2 issue 1

Author Profile

Narendra U. Chipde received the B.E. Electronics & Telecommunication Engineering from Sant Gadge Baba Amravati University, Amravati in 2005. During 2005-2006, he worked as production Engineer in BG-LI-IN Electricals PVT. LTD. Aurangabad, currently pursuing M.E. Digital Electronics from P.R.M.I.T. Badnera, Amravati.

Prof V. R. Raut is currently working as Associate Professor in Electronics & Telecommunication Department of P.R.M.I.T. Badnera – Amravati. He has to his credit several papers in the peer reviewed national and international journals of repute. He has also co-authored a book published by Lombard publishing, Germany. His areas of interest are VLSI design, reconfigurable computing, embedded systems and digital signal processing.