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Industrial Process Parameter Monitor using Ethernet

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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 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. In this paper we are focus on Sensor selection criterion, because correct selected sensor will receive data correctly and further it will processed by the system. ENC 28J60 is another 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 processor 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.**

Keywords- *ENC 28J60, SPI* **,** Ethernet, ARM.

I. INTRODUCTION

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 furnance etc whose temperature we have to monitor over the ethernet. The accuracy of data collection is depends on type of sensor and process whose parameter is to be monitor, In case of nucleare reactor the accuracy should be high, where as in case of furnance less accuracy can be accepteble. If we need to connect more serial devices at a time with high data rate at a time which make the data processing some what dificult 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 replaceing 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 reduses its load.

II. HARDWARE IMPLEMENTATION:

The hardware mainly consist of

1. Sensor
2. Processor
3. Ethernet controller
4. Interfacing
5. RJ 45
6. PC
7. LCD

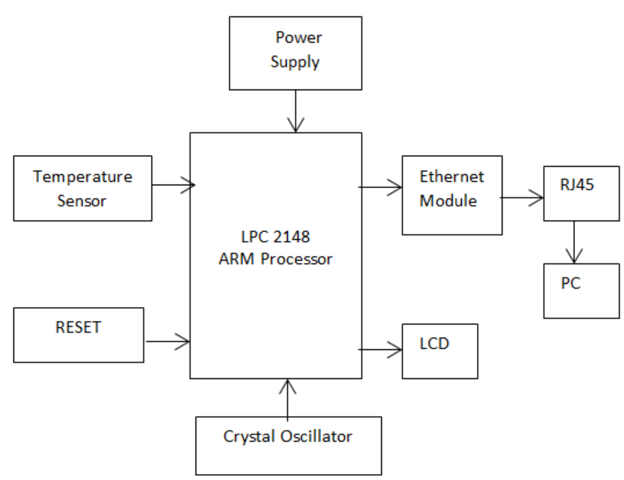

Fig 1. System Block diagram

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, Flow, Light etc. Sensor are classified in to different types depending on there working or changing parameter with referance to measured variable.

-Sensor whose resistance is changes with measured variable.

-Sensor which produces voltage with measured variable.

-Sensor whose electrical output is changes with measured variable.

-Thermister for measurment of temprature.

-Photoresister for light measurment.

-Strain guage for mechanical strain measurment.

1.1 Sensor selection parameters: To select the sensor for the measurment of perticular variable we have to consider its several parameters.

1.1.1 Maximum operating temperature: is the maximum body temperature at which the thermistor will operate for an extended period of time with acceptable stability of its characteristics. This temperature is the result of internal or external heating, or both, and should not exceed themaximum value specified.

1.1.2 Maximum power rating: maximum power rating of a thermistor is the maximum power which a thermistor will dissipate for an extended period of time with acceptable stability of its characteristics.

1.13 .Dissipation constant: It is the ratio, (in milliwatts per degree C) at a specified ambient temperature, of a change in power dissipation in a thermistor to the resultant body temperature change.

1.1.4 Thermal time constant: It is the time required for a Sensor to change 63.2% of the total difference between its initial and final body temperature when subjected to a step function

1.1.5 Resistance-temperature characteristic: It is the relationship between the zero-power resistance of a Sensor and its body temperature.

1.1.6 Temperature-wattage characteristic: It is the relationship at a specified ambient temperature between the Sensor temperature and the applied steady state wattage.

1.1.7 Current-time characteristic: It is the relationship at a specified ambient temperature between the current through a Sensor and time, upon application or interruption of voltage to it.

1.1.8 Stability: It is the ability of a Sensor to retain specified characteristics after being subjected to designated environmental or electrical test conditions.

1.1.9 *Interchangeability*: It refers to how closely a sensing element follows its nominal resistance versus temperature curve.

1.1.10 Repeatability: The degrees to which two successive readings of a temperature sensor agree refer to its "repeatability". That is, a sensors ability to repeat the same behavior under the same conditions for any given temperature, even though it has been used and exposed to different temperatures, refers to its repeatability (e.g. its ability to remain stable over many heating and cooling cycles).

1.1.11 Corrosion and Contamination: Corrosion is the process by which the metal element wire converts from its pure form to a more complex compound or metal oxide, which will tend to increase the resistance of the pure metal. As the corrosion works through the surface of the metal, it reduces the cross-sectional area of the conductor raising the resistance of the element independent of any temperature change. This makes the choice of a noble metal like platinum an important one for helping to inhibit corrosion.

1.1.12 Shock and Vibration: Prolonged mechanical shock and vibration can alter RTD readings and even drive intermittent or complete failure. These effects are additional contributors to sensor drift and reduced stability in RTD measurement systems. Most industrial RTD elements are fully supported by a bobbin and packing material that stands up well to extreme shock and vibration.

1.1.13 Insulation Resistance: If the sensing elements and leads are not completely insulated from the case or sheath of the RTD, then the case can form a parallel resistance path or shunt across the element that will lower its apparent reading. Most industrial RTD elements will have insulation resistances on the order of 100MΩ or more, making this error contribution negligible.

1.1.14Lead Wire Resistance: RTDs generally use copper leads bonded to the platinum element. These leads normally connect close to the element and close to each other (so that both junctions will be at same temperature), in order to prevent Seebeck voltages from also affecting the measurement. However, the resistance of the copper leads can still negatively affect the measurement, in particular where the RTD element is a long distance from the measuring instrument, or where a two wire RTD sensor is used.

1.1.15 Self Heating: Heat energy is generated while applying current to excite the RTD element in order to measure its signal.

1.1.16 Response Time or Time Constant: The time constant of an RTD refers to the speed with which its element changes resistance in response to a change in contact temperature.

1.2 SENSOR TYPES

The main temperature sensors are

1.2.1 Thermister.

1.2.2 RTD.

1.2.3 Thermocouple.

1.2.1 Thermister: It is nothing but the temperature dependant resister. In which the resistance of sensor is changes in predictive way with change in temperture . It classified in two broad categories

NTC: In which resistance of sensor is decreases with increase in temperature.

PTC: In which resistance of sensor is increase with increase in temperature.

So in short thermister is thermaly sensitive resister that exhibits a change in electrical resistance with change in temperature. This change in resistance is measured by passing dc current through it and measuring drop across it.

1.2.2 RESISTANCE TEMPRATURE DETECTOR (RTD)

It's resistance is linearly increases with increase with increase in in temperature. It is available in 2-wire, 3-wire and 4- wire. A 2- wire RTD in which signal is affected by the distance between sensor and host system. Where as in other two losses are compensated. RTD is metal base temperature sensor, as we know that metal resiatance is will increase with increase in temperature. That's why RTD can be manufactured from different metal to satisfy the different requirment of temperature ranges to be measured. One of the important parameter of RTD is temperature coefficient of resistance.

$$TCR = \frac{\left[\frac{Resistance\ at\ 100^{\circ}C - Resistance\ at\ 0^{\circ}C}{100}\right]}{Resistance\ at\ 0^{\circ}C} --- 1$$

So sensors made from different metal having its own advantages and disadvantages, Copper has the most linear change in resistance for a given temperature change. But coppers low resistance makes it difficult to measure small changes in temperature.

Nickel is not a very stable material its resistance is varies from band to band of temperature. But its advantage is that it is much less expensive than Platinum but the process which are used to stabilize the nickel are makes it expensive than Platinum.

Platinum has reasonably high resistance and good temperature Coefficient and mostly it does not react with contaminant gases in air and extremely stable from band to band temperature variation.

1.2.3 THERMOCOUPLE

It having two dissimilar metal wires joined at hot junction, as temperature varies a signal is measured at cold junction. It is available in J-type and K-type Thermocouple. Its advantages are Low cost, small size, wider temperature range and having faster response time than RTD, but its disadvantages are it is less linear and less accurate than RTD and sensitive to electrical noise.

Following table shows the comparison between all temperature sensors which helps to select the particular sensor depending on designers requirement.[8]

Attribute	**Thermocouple**	**RTD**	**Thermistor**
Cost	Low	High	Low
Temperature Range	Very wide -350°F +3200°F	Wide -400°F +1200°F	Short to medium -100°F +500°F
Interchange ability	Good	Excellent	Poor to fair
Long-term Stability	Poor to fair	Good	Poor
Accuracy	Medium	High	Medium
Repeatability	Poor to fair	Excellent	Fair to good
Sensitivity	Low	Medium	Very high
Response	Medium to fast	Medium	Medium to fast
Linearity	Fair	Good	Poor
Self Heating	No	Very low to low	High
Point (end) Sensitive	Excellent	Fair	Good
Lead Effect	High	Medium	Low

Table I: Comparison of Temperature sensors

2.0 PROCESSER:

As a processer we are using LPC 2148 because of following features. It is 32 bit ARM 7 TDMI Processor with 40 KB of on chip flash, Static RAM, 512KB of on chip flash memory, It has In system programming/ In

Application Programming. Software 400ms of full chip erase and 256 bytes of programming in 1ms. For interfacing of sensor it has 10-bit ADC with 14 analog input and conversion time as low as 2.44µsec 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, Due to which 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, Multi level moniroring. The RISC architecture and large memory space made us to choose this processor. The networking capability of ARM makes it suitable for wide veriety of networking appication.

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]

3.0 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 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 of 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.[3]

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

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

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.

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

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

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. [3, 13]

4.0 INTERFACING

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

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.

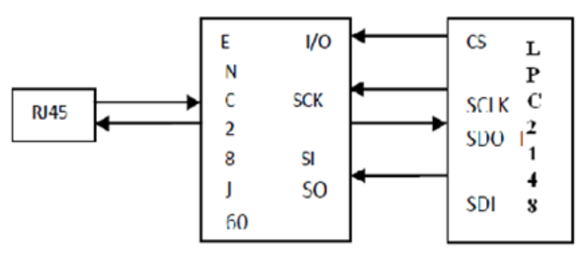

Figure 2 Serial peripheral interface (SPI)

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. This communication mode is good if there is only a single master and slave device and suitable for high data rate and achieves a data speed of up to 10 Mbps. Simple hardware interfacing and low power requirements are some of the features of this communication protocol.[6]

5.0 REGISTERED JACK 45 (RJ45)

A standered LAN cable can be connected using RJ 45 connector. It is 8P8C (8 Position 8 Connector) modular connector commonly used to terminate twisted and multiconductor flat cable. These connectors are commonly used for Ethernet over twisted pair. It is used to improve the signal anti-interferance capability.[7]

III. RESULT

The objective of this system is to monotor the industrial process parameter on real time basis using Ethernet. ENC 28J60 Embedded Ethernet Controller for the remote control within LAN. This system has advantages that is has small size, Realiability, and low power consumption.

IV. CONCLUSION

This is low cost method for monitoring the industrial parameter like temperature remotly PT 100(RTD) is better because it is suitable for all industrial application in which temperature from -200 C to 600 C ,It is acurate, less expensive and easy to use. Its output is relativly large changed with temperature as copmare with thermocouple. The ARM can communicate with PC using serial port using RS 232, It support online supervision using not only private LAN but also using Public network. By using embedded hardware and software we can control the require industrial parameter and industrial automation using Ethernet with high accuracy. If we select the proper sensor depending on the range of temprature measure or industrial environment, we can increase the sensitivity of this system.

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