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Real Time Control and Remote Control Concepts in Industrial Process Monitoring

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Abstract *– Remote Instrumentation is the act of providing control of instruments from remote locations. Real-time control is based on sensor technology. Distributed remote real-time monitoring and control system is based on the ideas of the Internet of Things. The rationale behind real time and remote sensing is for control purpose. This article is aimed at designing and demonstrating the application of a GSM based remote temperature monitoring system for an industrial power plant. It describes the concept of real time and remote control of process variables. The paper treats the basic concept of instrumentation, sensor technology, signal conditioning, different methods of signal transmission, principle of feedback system, as well as automation and control of systems.*

Keywords: *Instrumentation, Process, Remote, Real-time, Feedback, Embedded System.*

1.0 INTRODUCTION:

Every industrial process has a means of measuring and monitoring certain operating parameters for records keeping or control purposes. These measurements are taken by manned operators manually; hence the reliability of accurate records is compromised due to fatigue or ineptitude of the operators. Sometimes, operators required within the plants vicinity could be outrageous, leading to excessive overhead cost. Consider an Industrial power plant, with operating temperatures of 0-40 DegreeC, any attempt for the plants to exceed this temperature limit result to Engine shut down. Consequently, a total breakdown of the engine would require a complete overhauling of the plants. Reasons for hike in temperature could be due to Shortage of oil in the Engine or Overload. However, monitoring the temperature remotely, real-time and applying necessary control would mitigate if not completely eliminate the above short comings.

The relevance of remote monitoring cannot be overemphasized. The traditional method of data communication through cable has various limitations which include; complexity of network, cost of installation, limited coverage, cost of maintenance, human dependent coupled with human errors in taking measurement. However, the schemes of remote monitoring system is to obtain real-time measurement, make measurement possible in areas inaccessible to humans, eliminate errors during measurement, reduces labor cost and incorporate shutdown of the users system remotely. For an organization of any size to remain viable in today's market, a strong and efficient network is vital. Entrepreneurs and Managers are always in search of new solutions to make their businesses as competitive as possible. So, in the current economic challenges where business owners are facing limited resources and shortage of qualified and suitable man power especially in Information and Technology (IT) management, remote monitoring presents an effective solution to achieving the desired results as well as reducing costly down time network.

Instrumentation could be defined as the art and science of measurement and control of process variables within a production or manufacturing area. [1] From time immemorial, process variables were monitored and controlled manually by an operator that patrolled around the instruments and adjusting final control element to obtain the desired set points. With evolution in technology, pneumatic controllers came into existence and mounted in the field to monitor processes and control valves. This drastically reduced the time required for manual monitoring and control by the operator. After some time, the controllers were moved to a central location, all measured signals were transmitted to this central location for monitoring by the operator and outputs signals were sent to the final control element for process adjustment as needed. The basic signal used at that time was a pressure signal between the ranges of 3-15 psi.

More evolution led to the invention of electronic instrumentation in the 1970's. Standards for signal transmission were introduced and were in the order of 1-5volts, and 4-20mA.[2] This innovation led to reduction in maintenance of the equipment as well as increase efficiency and production due to increase in accuracy.

The next evolution of instrumentation came with the production of Distributed Control System (DCS), where both pneumatic and electronic controls were

achieved from a control room. In this type of system, an operator is required to monitor thousands of points about a process from the control room on a screen.

Nevertheless, several methods are used in transmitting data remotely to a monitoring device, which include: wired or wireless. Therefore, this article makes use of one of the best methods of remote monitoring, which is GSM based. The type of modem used integrates a high speed SMS functionality of GPRS and cost effectiveness / area coverage capability of GSM.

2.0 BASIC CONCEPT OF INSTRUMENTATION

What is not measured cannot be controlled; therefore sensor forms the basis of feedback control system. It measures the process variable and transmits a representative of the measured signal to the controller. The process variables could be temperature, pressure, flow, level, force, speed, humidity, PH, etc.

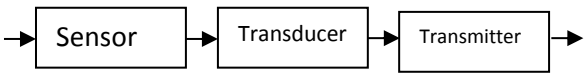


Fig.1.0: Measurement of a magnitude

As shown in figure 1.0, sensor is the primary element that is constantly in contact with the process. The transducer converts energy from one type to another suitable for transmission. The transmitter relays the signal from one point to another point for recording or monitoring purposes.

2.1 Direct and Indirect Measurement: Direct measurement takes place when the object's charateristic to be measured is measured explicitly. For instance, one can measure a height directly with a measuring tape or temperature of an electrical oven could be measured directly using a thermometer. Also, an ammeter could be used to measure electric current directly. While Indirect measurement involves taking measurement of something else and converting it into a measurement of the object's characteristic. For instance, measuring a circuit's current directly and using Ohm's law to convert it into a voltage, i.e. V = IR (volts)

2.2 Manual and Automatic Control: In manual control, the operator directly manipulates the controller output to the final control element to maintain a set point.[3] While in automatic control system, a set point is chosen and is programmed in the system, and the system tries to reach the set point automatically.

2.3 Control System: A control system is a set of devices or a system that manages, directs or regulates the behavior of other system(s) to achieve the desired results. [4] Almost every aspects of our day-to-day life are affected more or less by some control system. A refrigerator, an air conditioner, an automatic iron, an automobile all are control system. These systems are also used in industrial process. We find control system in quality control of products, robotics, technology, weapons system, transportation systems, etc. The theory of control is applicable to both engineering and non engineering field.

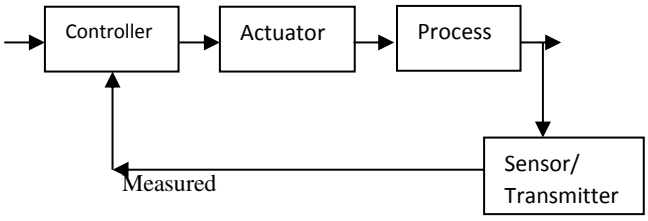


Fig.2.0: Components of a control system

Figure 2.0 is a block diagram displaying the various components of a control system. A typical control system comprises of four major components viz: Process, Actuator, Measurement system (Sensor/Transmitter), and a Controller. The process is the key element of the system and it's the thing that we are trying to control. The dynamics of the process determines the best control performance we can obtain. In a feedback control system, measurement of the process' output is taken, and passed to the controller which figures out what action to take as it compares the signal with the reference input. The signal from the controller passes through an actuator into a process input. A continuous flow loop exists through which signals move from the controller to the actuator, process, and measurement system.

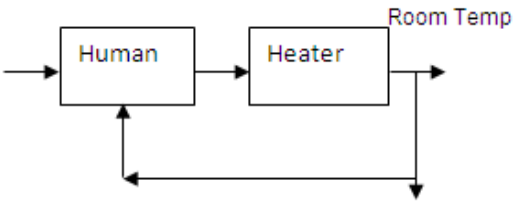


Fig.3.0: ON-OFF Control

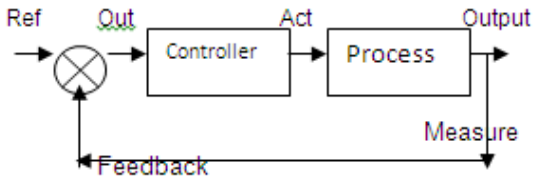


Fig.4.0: Close-loop Operation

In an open loop control system, the controller output is fixed at a value until it is changed by an operator, whereas in a closed loop system, the controller output is the difference between the process variable (Measured) and the set point (Reference). Error, E = Set point (SP or Ref) – Process variable (PV or Measured). It is the error signal that the controller uses to initiate a corrective action.

3.0 DESIGN METHODOLOGY

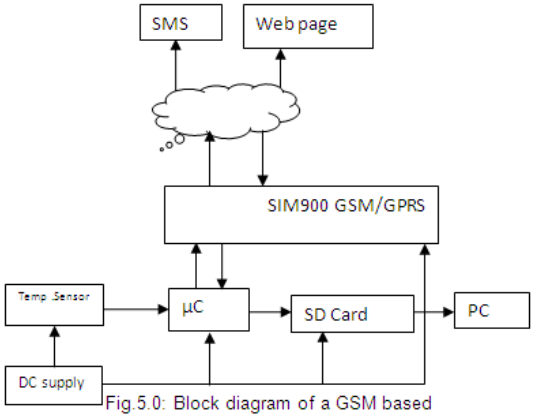
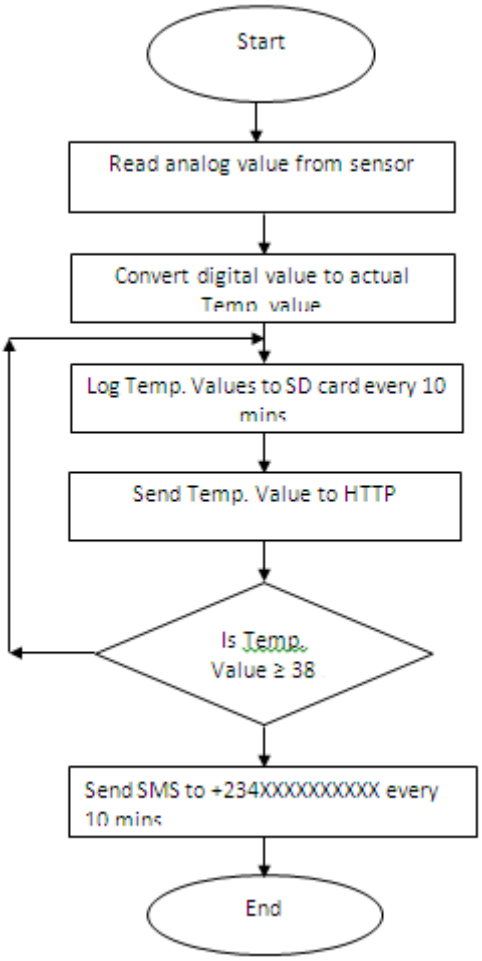


Fig.5.0: Block diagram of a GSM based temperature remote monitoring system.

The project is broken down into modules as shown in the block diagram in figure5.0.

This project makes use of an Arduino micro controller due to its ease of programming. It is programmed to send temperature values via SMS to the mobile operator, also to HTTP web for monitoring and to SD card for storage / reference purposes. The programming is in two stages; first is the program to control the microcontroller and the second is the program to control the webpage called the web script. The Arduino Nano is programmed with the Arduino software. The ATmega328 comes preburned with a bootloader that allows one to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

The complete analysis of the blocks' function could be grouped into the following stages, viz: signal generation (remote sensing), processing (signal conditioning), transmission, and monitoring. In this section, sensor technology, signal conditioning, various means of signal transmission will be analyzed.



ALGORITHM FLOWCHART FOR TEMPERATURE MONITORING

3.1 REMOTE SENSING

Remote sensing is the science and technology for acquiring information about an object or a phenomenon kept at a distance. [5] Remote sensing depends on the character of the signals and the sensors as well as the attenuation properties of the channel of signal transmission. It could be surprising how sensing could be done without physical contact between the object under observation and the sensor. There is actually a physical contact; reason is because the object to be sensed and the sensor are always immersed in an interacting field, which include gravitational field, electromagnetic field and pressure field. In reality, during contact sensing, the fields of both bodies influence each other to the point where there is

significant amount of force/pressure, which is measured. Remote sensing comprises of three major components: The sensor, the signal, and the sensing.

3.2 SIGNAL CONDITIONING

The signals obtained at the output of a sensor are generally low level and contain some noise and interference, picked up from the environment and from the sensor. Sometimes the measurement process or the sensor introduces a nonlinear distortion which must be linearized. The analog signal therefore must be conditioned by amplification and filtering in order to improve the signal to noise ratio. Such amplification and filtering is usually performed by an instrumentation amplifier, followed by op-amp active filters. Thus, an ADC converts the sensor output into a digital form and input into the computer as a binary number.

3.3 METHODS OF SIGNAL TRANSMISSION

Methods of signal transmission could be classified into two: Wired and Wireless. Wired transmissions include Ethernet, coaxial cable, fibre optics, etc, while wireless transmission include Zigbee, Wifi technology, and Bluetooth technology but all suffer setbacks in terms of cost, coverage, and reliability. Currently, one of the best methods of signal transmission in remote monitoring is GSM based, which has high coverage area capability and cost effectiveness.

In the GSM based data transmission, the type of modem used integrates a high speed SMS functionality of GPRS and cost effectiveness / area coverage capability of GSM. It involves taking measurement of the variables real time and remotely sending the parameters to a monitoring unit (WEB Page / 7-segment display). The coordinates (Longitude and Latitude) of the location are also measured to know the actual location in which the parameters are being monitored.

The system includes transducers which take raw measurement and issue out analog signals to an ADC, the digitized output of an ADC goes into a programmable micro-controller, the micro-controller is programmed to communicate the data to a GSM module through RS-232 serial communication protocol. The GSM module transmits measured parameters to a monitoring unit. Sensors (transducers), ADC, micro-controllers and GSM module make up the transmitting / receiving device, while a web make up the monitoring unit and LCD could be used for display.

3.4 AUTOMATION

Automation is based on the principle of feedback. As the process is going on, the output (process variable) is measured by the sensor (transducer); the signal is feedback and is being compared with the set point (Ref) as in figure 4.0. The difference between the set point and the measured signal is the error signal, which is used by the controller to issue a command to the final control element to take corrective action. This process continues until the dynamic response of a system gradually approaches the desired set point.

4.0 RESULT/DISCUSSION

This report has demonstrated the application of GSM protocol in data acquisition. Temperature data is logged into a storage device and a plot of temperature profile of the power plant could be made for failure prediction.

Analysis of the real-time and remote control concept shows that sensor technology plays a vital role in wireless GSM based data transmission. The various stages involve in automation, starting from the transducer, through signal conditioning, to the controller and finally to the process for corrective action have been clearly elucidated.

5.0 CONCLUSION

Upon receiving an SMS, a facility Manager or plant operator is able to issue out an instruction for physical intervention in order to address any anomaly. The project has achieved a low cost, reliable, and wider coverage remote monitoring system. Data for temperature profile aids potential failures prediction. In a more ideal case, a control circuit could be incorporated into the design to enable control action to be carried out remotely without physical intervention. Therefore, I would recommend an auto remote control system through GSM to be incorporated into the circuit in the future work.

In the analysis, the concept of real time control is based on sensor technology and that of remote control is GSM based. This requires that one masters the knowledge of sensing, control, and actuation, as well as mobile communication.

However, the fast development of the Internet provides remarkable opportunities for Internet-based Automation, which requires one to get abreast of internet programming skills.

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