

Sensor Network based Thermal Power Plant Interlock Control and Remote Monitoring System

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ABSTRACT: Due to harmful working environment and remote location of Thermal power plant sites, it is dangerous and time expensive to operate and maintenance. As the demand for power increases, increasing safety and reducing operating and maintenance cost plays a vital role in increasing the reliability of the power plant. As the Thermal power plant has to work for 24 hours and 365 days, it is not possible to monitor the parameters in site at each and every moment. So remote monitoring is also needed. This project develops a sensor network based interlock control and remote monitoring system. The system mainly consist Temperature sensor, Pressure sensor, Flow sensor, Level sensor, RPM sensor, PH sensor, Vibration sensor, Voltage sensor. All the sensors data is processed using ARM processor. Using this system we can control the operation of Thermal power plant in auto mode and monitor the parameters in work place. Also we can communicate the sensor data to other PCs in remote locations using GSM technology.

KEYWORDS: ARM Processor, GSM module, Monitoring and Control, Thermal Power plant, Wireless Sensor Networks (WSNs), ZIGBEE module.

I. INTRODUCTION

In Thermal power plant, Combustion of coal in the boiler converts the water into steam in boiler tubs. This steam with high pressure and temperature flows into Turbine and rotates Turbine shaft. This Turbine shaft is connected to the Generator shaft. By rotating Turbine Shaft Generator shaft also rotates and Power will be generated. Temperature, Pressure and Flow are the three main parameters to be controlled in steam and water.

Boiler tubes will be puncture if temperature of steam increases. So, temperature of steam should be monitored and controlled.

Increase in pressure and flow of steam increases the speed in rotation of turbine shaft which causes a great damage to the Turbine and Generator. So, pressure and flow of the steam should be monitored and controlled. In Boiler drum 50% of water and 50% of steam is present. Increase in % of steam in Boiler drum increases the pressure in it. If Pressure in drum increases the drum may blast. So, level of steam should be monitored and controlled.

If RPM in Turbine increases the blades present in the turbine may damage. So, RPM of turbine shaft should be controlled.

For pure water PH value is 7. If it is less than 7 the water is said to be acidic in nature. If it is greater than 7 the water is said to be basic in nature. Acidic water corrodes the Boiler Tubes. Basic water forms coagulations when it is heated. If coagulated steam fall on turbine blades causes damage to blades and produce vibrations in Turbine. So, PH value should be measured and controlled.

Vibrations in Turbine and Voltage given to the auxiliary motors should be measured for operation and maintenance purpose.

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In this paper we mainly concentrate on how to control and monitor the temperature, pressure and flow of steam, level in steam drum, RPM (Rotations Per Minute) of turbine shaft and PH (Presence of Hydrogen ions) of water in Boiler drum. We also measure and monitor the vibrations generated in Turbine and voltage given to the motors. Wireless sensors are mainly aimed to monitor and control various parameters in thermal power plant with relatively low power consumption.

II. RELATED WORK

Previously in thermal power plants there is no advanced technology to operate in auto mode. The major disadvantages of existing system are

- There is no Interlock control.
- There is no monitoring in remote place.
- Aimed for oil processing [1] industries.
- There is no auto control of PH value in steam and less number of sensors is used.
- Takes more time to process sensor data.
- Number of parameters monitored and controlled is less.

The power plant operating system in this paper adopted wireless communication technology and embedded systems. This paper mainly discusses the hardware and software of embedded components used in the system. It improves the safety and reliability of the system. This paper overcomes the disadvantages of existing system and improves the efficiency of thermal power plant. The major advantages of this project is

- Interlock control of different parameters of steam.
- Monitoring in remote and workplace.
- Controls PH value of steam.
- Processing speed is fast compared to the existing system.
- All the parameters in the plant are considered and increases the safety and reduces the man power.

The monitoring and controlling section of this system mainly consists of LPC3130 microcontroller with ARM9 processor, the sensor data is communicated in work space via ZIGBEE in workplace and via GSM Technology to remote place.

III. SYSTEM STRUCTURE

The system structure mainly consists of Transmitter Section, Receiver Section 1 and Receiver Section 2 which are shown in figure 1, figure 2 and figure 3 respectively.

Transmitter section mainly consists of eight sensor networks in this system which senses various parameters in Thermal Power plant. Various sensors used here are Temperature, Pressure, Level, Flow, RPM, PH, Voltage and Vibration Sensors. As the output through these sensors is a physical quantity, they are connected to ADC (Analog to Digital Converter) to convert this analog information to digital format and then this digital information is processed using LPC3130.

The controlling section [2] of this system is of great interest. The entire sensor's data are stored in the processor memory and continuously monitored. If any of the sensors data exceeds or below its threshold level, it indicates the workers through a display device like PC in work place and through a GSM receiver in remote place which have connections to the microcontroller. Also we can automatically control the environment of Thermal Power plant if any sensor level is high or low. Here four external devices are connected to the system. They are Attemperator, Coal Feeder, Atmospheric vent and HP dosing pump.

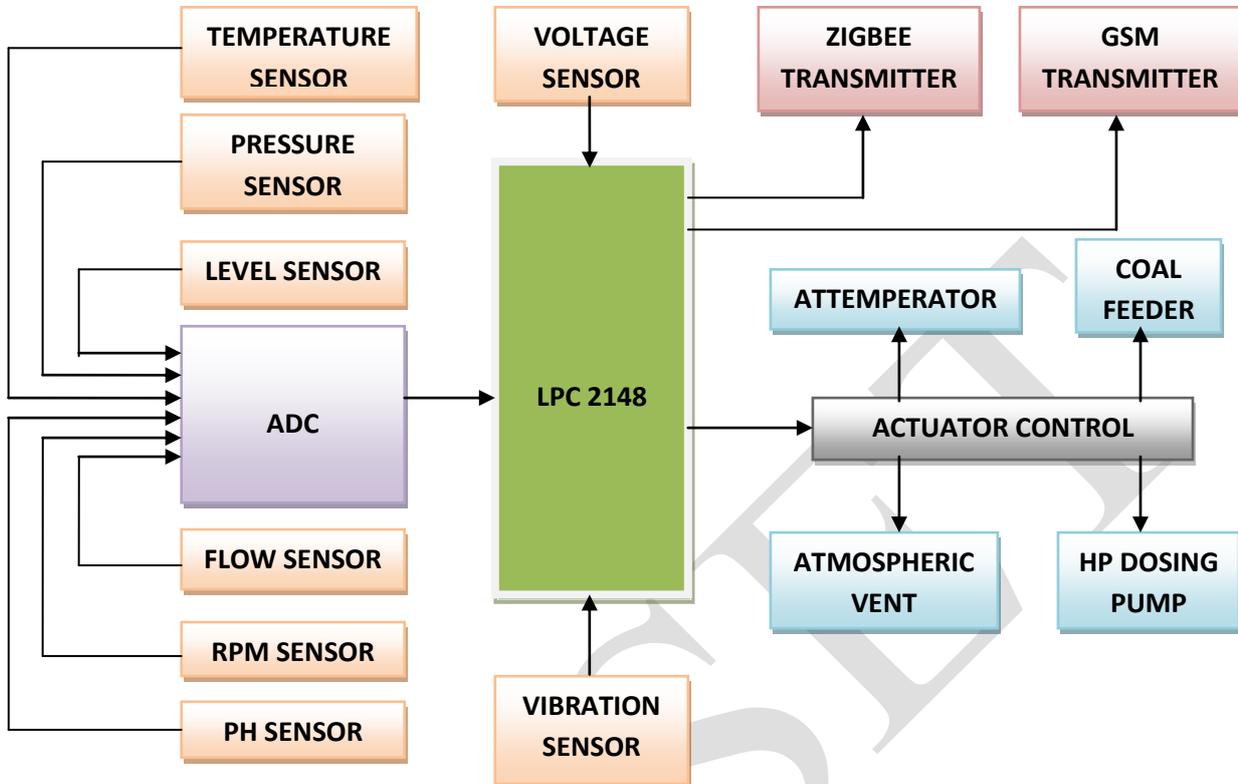


Fig 1: Block diagram: Transmitter Section



Fig 2: Block Diagram: Receiver Section 1



Fig 3: Block Diagram: Receiver Section 2

Not only the sensor's level is indicated to the workers at working environment through PC's using Zigbee module and also transmits this data to GSM receiver present in the remote place. Zigbee transmitter and GSM transmitters are to LPC3130 controller. It continuously checks out the sensor data and sends to the Zigbee and GSM receiver.

1. Function of LPC2148

LPC is a family of microcontroller ICs by NXP semiconductors (formerly Philip semiconductors).The LPC chips are based on the 32-bit RISC ARM cores from ARM Holdings, such as Cortex-M4F, Cortex-M3, Cortex-M0+, Cortex-M0, ARM9 and ARM7 cores.

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The LPC 2141/2/4/6/8 microcontrollers are based on a 32/16 bit ARM7TDMI-S processor with real time emulation and embedded trace support with an embedded high speed flash memory ranging from 32KB to 512 KB. It is a general purpose 32-bit microprocessor that offers high performance and very low power consumption and its architecture is based on RISC principles.

The main features of LPC2148 include

- 8 to 40 KB on-chip static RAM.
- 128 bit wide interface /accelerator enable high speed 60 MHz operation.
- In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software.
- USB 2.0 full speed compliant device controller with 2 KB of end point RAM.
- One or two 10-bit A/D converters provide a total of 6/14 analog inputs.
- Single 10-bit D/A converter provide variable analog output.
- Two 32-bit timers/external event counters, PWM unit and watchdog.
- Multiple serial interfaces including two UARTs, two fast 12C-bus, SPI and SSPwith buffering and variable data length capabilities.

2. Function of zigbee

Zigbee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios. Zigbee is based on an IEEE 802 standard. Though low-powered, Zigbee devices often transmit data over longer distances through intermediate devices to reach more distant ones, creating a mesh network: i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad-hoc networks make them suitable for applications where a central node can't be relied upon.

Zigbee is used in applications that require a low data rate, long battery life, and secure networking. Zigbee has a defined rate of 250 Kbits/sec, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that require short-range wireless transfer of data at relatively low rates. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other WPANs [3], such as Bluetooth or Wi-Fi.

3. Function of GSM

A digital communication system used for mobile technology is the Global System for Mobile Communication (GSM), which is the most popular standard for mobile phones today. The GSM system transmits the digital information through the atmosphere by conveying the information to an analog waveform.

The GSM Receiver is used to receive the digital data in remote area from work place. The digital data contains information about various parameters measured by the sensors in the work place. A GSM transmitter module is used at the transmitter side which is connected to the ARM processor and a GSM receiving module like mobile phone is used to receive the digital information in remote area.

IV. HARDWARE DEPLOYEMENT

1. Function of Temperature sensor

The measurement of temperature is one of the fundamental requirements for environmental control, as well as certain chemical, electrical and mechanical controls. Many different types of temperature sensors are commercially available, and the type of temperature sensor that will be used in particular application will depend on several factors. For example, cost, space constraints, durability, and accuracy of the temperature sensor are all considerations that typically need to be taken into account.

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In this paper we use BMP180 pressure sensor shown in figure. Various applications include Precise GPS navigation, Indoor and outdoor navigation leisure, sport and health monitoring, weather forecast, vertical speed indicator.

3. Function of Level sensor

Level sensors detect the level of substances that flow, including liquids, slurries, granular materials, and powders. All such substances flow to become essentially level in their containers (or other physical boundaries) because of gravity. The substance to be measured can be inside a container or can be in its natural form (e.g. a river or a lake).

The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally the latter detect levels that are excessively high or low.



Fig 6: Level sensor

Also important are the application constraints: price, accuracy, appearance, response rate, ease of calibration or programming, physical size and mounting of the instrument, monitoring and control of continuous or discrete (point) levels.

4. Function of Flow sensor

Flow sensor is used to measure the flow of steam from boiler drum to the turbine. In this paper we are going to use the rotor flow sensor.



Fig 7: Flow sensor

The flow sensor is shown in figure. Main specifications of flow sensor is

- Bright, Visual indication with choice output
- Flow range from 1 LPM to 227 LPM

5. Function of RPM sensor

RPM sensor is used to measure the number of rotations that a turbine moving shaft will rotate per minute. In this paper we are going to use AM4096 magnetic encoder chip from Renishaw shown in figure.



Fig 8: RPM Sensor

All of the sensor and processing electronics have been placed within the compact silicon design. The rotation of a simple north/south magnet is picked up by the AM4096's sensor and provides absolute positional information output to an accuracy of better than 0.1 degree.

6. Function of PH sensor

The most common PH sensor is the glass electrode. It is used in many industry applications and in a wide variety of fields. The glass-electrode method has a high reproducibility, and it can measure PH of various solutions.

Here we are using an electro chemical PH sensor. A PH electrode is a potentiometric or electrochemical sensor that has a voltage output.



Fig 9: PH Sensor

A potentiometric sensor consists of two electrochemical cells or electrodes.

- The glass electrode, sometimes called the measuring electrode or active electrode
- And the reference electrode.

The electric potential created between the glass electrode, and the reference electrode is a function of the PH value of the measured solution. So once the potential difference has been measured, we can calculate the PH value.

7. Function of Voltage sensor

The interface of various sensors to a controller like the Brain Stem GP 1.0 module typically involves either conditioning or converting voltage levels in the range the controller requires.



Fig 10: Voltage Sensor

Many systems use A/D converters to make the sensor value relevant in a program or data logging configuration. These converters have a fixed range of voltages they can convert from with 0-5 volts being by far the most common.

Sensors often create voltages in different ranges than those required by the controllers they are being interfaced to which requires the conversion of one voltage to another. This conversion often breaks down into a combination of one or more of three types- amplification, dividing and shifting.

8. Function of Vibration sensor

Vibration sensor is used to measure the number of vibrations produced in turbine in a given amount of time. In this paper we are using Piezo disk vibration sensor shown in figure.

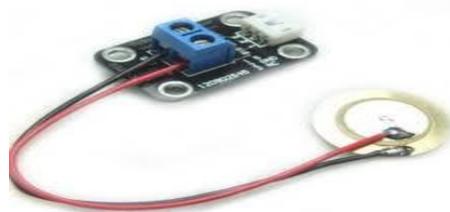


Fig 11: Vibration Sensor

The three parameters representing motion detected by vibration sensors are displacement, velocity and acceleration. Selections of sensors depend on frequencies of interest and signal levels involved. If the RPM of the turbine increases than the desired value, it produces heavy vibrations which cause great damage to the moving blades of the turbine. So we should monitor the vibrations of the turbine periodically.

9. Function of ADC

In this paper we are using ADC0808 converters to convert the analog data coming from various sensors to digital data. The ADC0808 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital converter, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree a successive approximation register.

The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TRI-STATE outputs. The design of the ADC0808, AD0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The ADC0808, ADC0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications.

10. Function of UART

A Universal Asynchronous Receiver/Transmitter is a type of "Asynchronous Receiver/Transmitter", a piece of computer hardware that translates between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232.

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A UART is usually an individual integrated circuit used for serial communication over a computer or peripheral serial port. UARTs are now commonly included in microcontrollers. A dual UART or DUART combines two UARTs into a single chip.

The UART controller is the key component of the serial communication subsystem of a computer. It takes bytes of data and transmits individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

11. Function of Attemperator

It is an output valve which spars cool water on boiler tubs when temperature of steam exceeds the breakpoint range. The valve will be closed if the temperature is in required range. Temperature is directly proportional to the pressure, which is if temperature increases pressure also increases.

12. Function of Coal Feeder

It is used to load coal in to the boiler. If the temperature and pressure is less then we should supply more coal through coal feeder. If the temperature and pressure is low then we should decrease coal feeding.

13. Function of Atmospheric vent

If the level of steam in steam drums increases then the vent will be opened and steam flows in to atmosphere. It decreases the level and flow of steam and rotation of turbine shaft.

14. Function of HP dosing pump

If the level of PH changes then this pump induce chemical in to water to balance the ph of steam.

V. APPLICATIONS

Wireless sensor networks are used in wide range of applications, mainly in monitoring and control of various industries [5] [6]. Some of them include power plants, oil and gas, cold chain and machine health monitoring, in pipelining etc [7].

VI. EXPERIMENTAL RESULTS

If the sensors value exceeds, corresponding actuator will be turned ON or OFF as required and the parameters are monitored in work space in a PC using Zigbee. The parameters mainly monitored are Temperature, Pressure, Flow, Level and PH. The Visual Basic software is used to display the monitoring parameters in a PC.

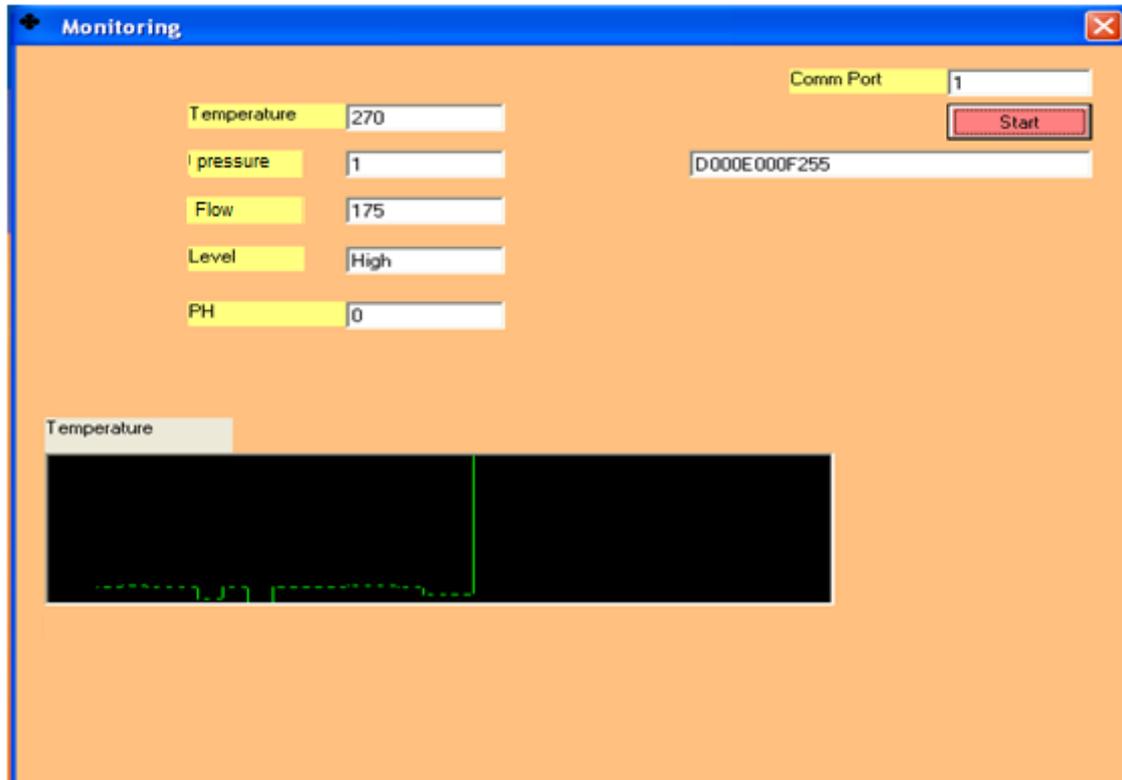


Fig 12: Experimental Result

VII. CONCLUSION

The hardware and software design of an embedded monitoring system for real time applications is presented in this paper. Vibration signals have been analyzed to detect the mechanical faults and necessary steps are taken to reduce the faults. The implementations of analysis technique in time and frequency domain are given. The proposed system sensor network based thermal power plant interlock control and remote monitoring system is verified with different levels of severity.

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