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Raspberry pi based data acquisition system using wireless communication

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Abstract - This paper proposes an advance for process management via a credit card sized single board computer called raspberry pi based multi parameter using wireless communication and microcontroller that measures and controls various parameters in an industry. The system comprises of a single master and multiple slaves with wireless mode of communication and a microcontroller system that can either operate on windows or Linux operating system. The various interesting features are field device communication via USB-OTG enabled Android devices. The objective of the project is monitoring industrial parameters such as water level, temperature, fire detection, gas detection through wireless communication using raspberry pi

Keywords: raspberry pi, USB-OTG, wireless, industry

1.INTRODUCTION

The term data analysis and process monitoring, as used in the context of process applications, collectively refer to the interpretation and evaluation of sampled process measurements. Data analysis as used in this work is intended to describe how data are manipulated and used together with fundamental understandings to infer the state of a physical process. Monitoring, on the other hand, refers to the classification of the data based upon a calibration model of expected behavior so that unwanted situations can be detected and proper control actions can be made. The first part of this research work which resulted in a licentiate thesis (Tano, 1996) focused on the use of a multivariate statistical model to monitor a mineral process with the aim to detect deviations from normal operation and in some extent predict quality properties in the processed material. The method is characterized by a good ability to visualize course of events but a disadvantage is the need of a great number of relevant measurements.

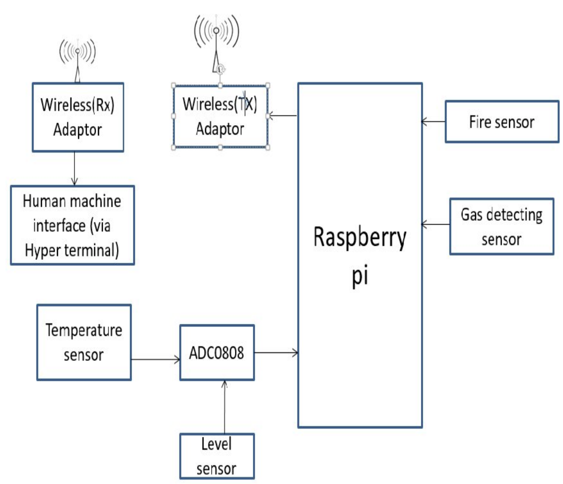
Unfortunately, in many cases process data are of poor quality. Instrument failure, poorly or uncalibrated instrumentation, high noise levels, which all contributes to data problems. Without proper pre-treatment, the necessary interpretation is difficult, if not impossible. This principally limited the application of the method to few and relatively large process sections. Substantial progress in the development of intelligent real-time sensors and data pre-treatment methods has opened new possibilities to study single unit operations. The second part of this work focuses on methods for measuring and modelling of the grinding process. Size reduction is an inevitable unit operation in mineral processing, and comminution is by far the most energy consuming part in mineral concentrators and extremely inefficient, less than 10% of supplied power produce new mineral surfaces, great efforts have been made to improve grinding operations.

The economic potential is substantial if efficiency can be increased just a couple of percent. In general, the only grinding control is to maximize the power drawn by the mill. Unfortunately, the relation between power and grinding performance is a complex and non-linear function. Development of advanced control systems has helped the situation considerably. However, these systems still are lacking relevant information such as mill load, charge position or slurry properties. Sensors capable of delivering this information are therefore of great value. Pre-treatment by wavelet transformation to locate and identify significant events combined with multivariate statistics presents good prospects to estimate the magnitude of variables not directly measurable. Furthermore the application of fundamental physical modelling techniques such as DEM has developed considerably lately, which in the case of grinding has led to increased knowledge and understanding of process phenomena taking place in a tumbling mill. Accordingly, the combined use of advanced measuring techniques as well as the use of both empirical and fundamental mathematical modelling applied on mineral processes is a key approach to increase knowledge and create control strategies for improved product quality and process performance.

2.scope of the project

The overall aim of the present work is to show how an advanced sensor system can be used to collect data that contain information of the monitoring process and from these data derive multivariate models to monitor and characterize changes in operating conditions. An objective of this thesis is also to determine the influence of the significant factors that vary in an ordinary monitoring process and how these variations are reflected in the measured signal. To further understand the behavior in the communication is applied and an attempt to validate the modelling results with obtained practical sensor measurements is demonstrated. 4 Continuous Monitoring of industrial Processes with a Special Focus on industrial

BLOCK DIAGRAM



Interfacing of physical parameters like Temperature and Water level identifier in Slave-1 module. Data acquired from each parameter is collected in Slave-1 and sent to Master module ZigBee transmission. process management via a credit card sized single board computer called raspberry pi based multi parameter monitoring hardware system designed using RS232 and microcontroller that measures and controls various global parameters. The system comprises of a single master and multiple slaves with wireless mode of communication and a raspberry pi system that can either operate on windows or Linux operating system. The parameters that can be tracked are current, voltage, temperature, light intensity and water level. The hardware design is done with the surface mount devices (SMD) on a double layer printed circuit board (PCB) to reduce the size and improve the power efficiency. The various interesting features are field device communication via USB-OTG enabled Android devices, on field firm ware update without any specific hardware and remote monitoring and control

3.HARDWARE DESCRIPTION

3.1 RASPBERRY PI

Overview

Raspberry Pi seems to be new in the world and many people really don't know what the Raspberry Pi is. Raspberry Pi can be defined as a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you would expect a desktop computer to do, from browsing the internet and playing high definition video, to making spreadsheets, word-processing, and playing games. It is great bonding with Arduino and can do a lot with Arduino.

3.2 Gas sensor module

In current technology scenario, monitoring of gases produced is very important. From home appliances such as air conditioners to electric chimneys and safety systems at industries monitoring of gases is very crucial. **Gas sensors** are very important part of such systems. Small like a nose, gas sensors spontaneously react to the gas present, thus keeping the system updated about any alterations that occur in the concentration of molecules at gaseous state.

Gas sensors are available in wide specifications depending on the sensitivity levels, type of gas to be sensed, physical dimensions and numerous other factors. This Insight covers a **methane gas sensor** that can sense gases such as ammonia which might get produced from methane. When a gas interacts with this sensor, it is first ionized into its constituents and is then adsorbed by the sensing element. This adsorption creates a potential difference on the element which is conveyed to the processor unit through output pins in form of current. What is this sensing element? Is it kept in some chamber or is kept exposed? How does it get current and how it is taken out? Let's find out in this Insight!!!

Image shows externals of a standard gas sensor module: a steel mesh, copper clamping ring and connecting leads. The top part is a stainless steel mesh which takes care of the following:

Filtering out the suspended particles so that only gaseous elements are able to pass to insides of the sensor.

- ✓ Protecting the insides of the sensor.

- ✓ Exhibits an anti-explosion network that keeps the sensor module intact at high temperatures and gas pressures.

In order to manage above listed functions efficiently, the steel mesh is made into two layers. The mesh is bound to rest of the body via a copper plated clamping ring.

The connecting leads of the sensor are thick so that sensor can be connected firmly to the circuit and sufficient amount of heat gets conducted to the inside part. They are casted from copper and have tin plating over them. Four of the six leads (A, B, C, D) are for signal fetching while two (1, 2) are used to provide sufficient heat to the sensing element.

The pins are placed on a Bakelite base which is a good insulator and provides firm gripping to the connecting leads of the sensor.

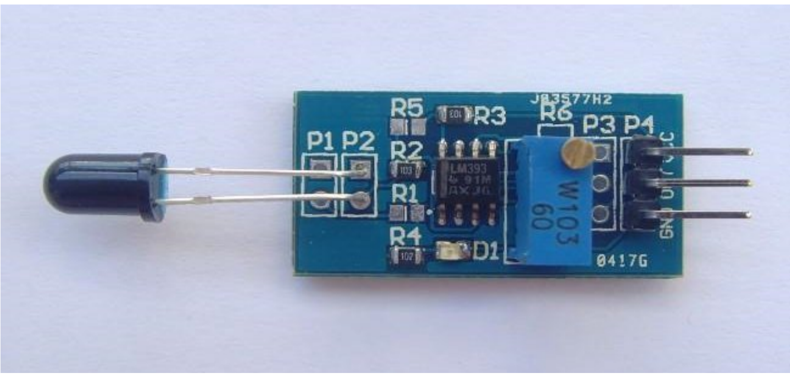
The top of the gas sensor is removed off to see the internals parts of the sensor: sensing element and connection wiring. The hexapod structure is constituted by the sensing element and six connecting legs that extend beyond the Bakelite base. Using a ceramic substrate increases the heating efficiency and tin oxide, being sensitive towards adsorbing desired gas' components (in this case methane and its products) suffices as sensing coating

The leads responsible for heating the sensing element are connected through Nickel-Chromium, well known conductive alloy. Leads responsible for output signals are connected using platinum wires which convey small changes in the current that passes through the sensing element. The platinum wires are connected to the body of the sensing element while Nickel-Chromium wires pass through its hollow structure. While other wires are attached to the outer body of the element, Nickel-Chromium wires are placed inside the element in a spring shaped. Image shows coiled part of the wire which is placed on the inside of the hollow ceramic

Image shows the ceramic with tin dioxide on the top coating that has good adsorbing property. Any gas to be monitored has specific temperature at which it ionizes. The task of the sensor is to work at the desired temperature so that gas molecules get ionized. Through Nickel-chromium wire, the ceramic region of the sensing element is subjected to heating current. The heat is radiated by the element in the nearby region where gases interact with it and get ionized. Once, ionized, they are absorbed by the tin dioxide. Adsorbed molecules change the resistance of the tin dioxide layer. This changes the current flowing through the sensing element and is conveyed through the output leads to the unit that controls the working of the gas sensor.

3.3 FIRE/FLAME SENSOR MODULE

A key aspect of fire protection is to identify a developing fire emergency in a timely manner, and to alert the building's occupants and fire emergency organizations. This is the role of fire detection and alarm systems. Depending on the anticipated fire scenario, building and use type, number and type of occupants, and criticality of contents and mission, these systems can provide several main functions. First they provide a means to identify a developing fire through either manual or automatic methods and second, they alert building occupants to a fire condition and the need to evacuate. Another common function is the transmission of an alarm notification signal to the fire department or other emergency response organization. They may also shut down electrical, air handling equipment or special process operations, and they may be used to initiate automatic suppression systems.



4.9.1 GENERAL DESCRIPTION:

Flame sensor is the most sensitive to ordinary light that is why its reaction is generally used as flame alarm purposes. This module can detect flame or wavelength in 760 nm to 1100 nm range of light source. Small plate output interface can and single-chip can be directly connected to the microcomputer IO port. The sensor and flame should keep a certain distance to avoid high temperature damage to the sensor.

The shortest test distance is 80 cm, if the flame is bigger, test it with farther distance. The detection angle is 60 degrees so the flame spectrum is especially sensitive. The detection angle is 60 degrees so the flame spectrum is especially sensitive

SPECIFICATIONS:

- On-board LM393 voltage comparator chip and infrared sensing probe.
- Support 5V/3.3V voltage input.
- On-board signal output indication, output effective signal is high level, and the same time the indicator light up, output signal can directly connect with microcontroller IO.
- Signal detection sensitivity can be adjusted.
- Reserved a line voltage compare circuit (P3 is leaded out).
- PCB size: 30(mm) x15(mm).

PIN CONFIGURATION:

1. VCC
2. OUTPUT

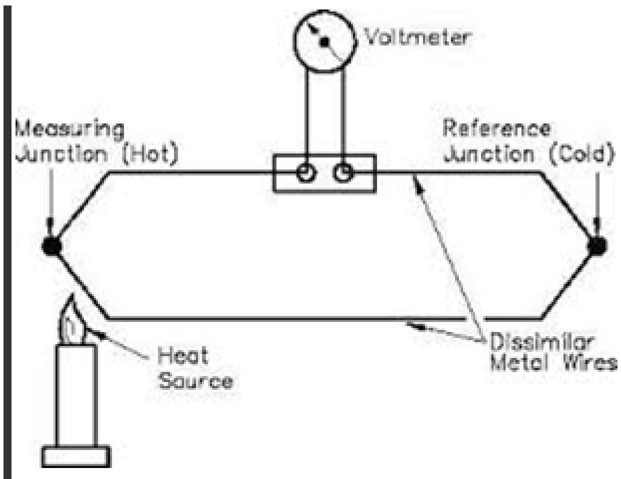
3.4 TEMPERATURE SENSOR

Temperature is the most often-measured environmental quantity. This might be expected since most physical, electronic, chemical, mechanical, and biological systems are affected by temperature. Certain chemical reactions, biological processes, and even electronic circuits perform best within limited temperature ranges. Temperature is one of the most commonly measured variables and it is therefore not surprising that there are many ways of sensing it. Temperature sensing can be done either through direct contact with the heating source, or remotely, without direct contact with the source using radiated energy instead. There are a wide variety of temperature sensors on the market today, including Thermocouples, Resistance Temperature Detectors (RTDs), Thermistors, Infrared, and Semiconductor Sensors.

THERMOCOUPLE:

It is a type of temperature sensor, which is made by joining two dissimilar metals at one end. The joined end is referred to as the HOT JUNCTION. The other end of these dissimilar metals is referred to as the COLD END or COLD JUNCTION. The cold

junction is actually formed at the last point of thermocouple material. If there is a difference in temperature between the hot junction and cold junction, a small voltage is created. This voltage is referred to as an EMF (electro-motive force) and can be measured and in turn used to indicate temperature.



Thermocouple

The RTD is a temperature sensing device whose resistance changes with temperature. Typically built from platinum, though devices made from nickel or copper are not uncommon, RTDs can take many different shapes like wire wound, thin film. To measure the resistance across an RTD, apply a constant current, measure the resulting voltage, and determine the RTD resistance. RTDs exhibit fairly linear resistance to temperature curves over their operating regions, and any nonlinearity are highly predictable and repeatable. The PT100 RTD evaluation board uses surface mount RTD to measure temperature. An external 2, 3 or 4-wire PT100 can also be associated with measure temperature in remote areas. The RTDs are biased using a constant current source. So as to reduce self-heat due to power dissipation, the current magnitude is moderately low. The circuit shown in figure is the constant current source uses a reference voltage, one amplifier, and a PNP transistor.

Thermistors: Similar to the RTD, the thermistor is a temperature sensing device whose resistance changes with temperature. Thermistors, however, are made from semiconductor materials. Resistance is determined in the same manner as the RTD, but thermistors exhibit a highly nonlinear resistance vs. temperature curve. Thus, in the thermistors operating range we can see a large resistance change for a very small temperature change. This makes for a highly sensitive device, ideal for set-point applications.

Semiconductor sensors: They are classified into different types like Voltage output, Current output, Digital output, Resistance output silicon and Diode temperature sensors. Modern semiconductor temperature sensors offer high accuracy and high linearity over an operating range of about 55°C to +150°C. Internal amplifiers can scale the output to convenient values, such as 10mV/°C. They are also useful in cold-junction compensation circuits for wide temperature range thermocouples. A brief details about this type of temperature sensor are given below.

- Low self-heating,
- ±1/4˚C of typical nonlinearity

and also in test, measurement and communications. A digital temperature is a sensor, which provides 9-bit temperature readings. Digital temperature sensors offer excellent precise accuracy, these are designed to read from 0°C to 70°C and it is possible to achieve

±0.5°C accuracy. These sensors completely aligned with digital temperature readings in degree Celsius

3.5LEVEL MEASUREMENT

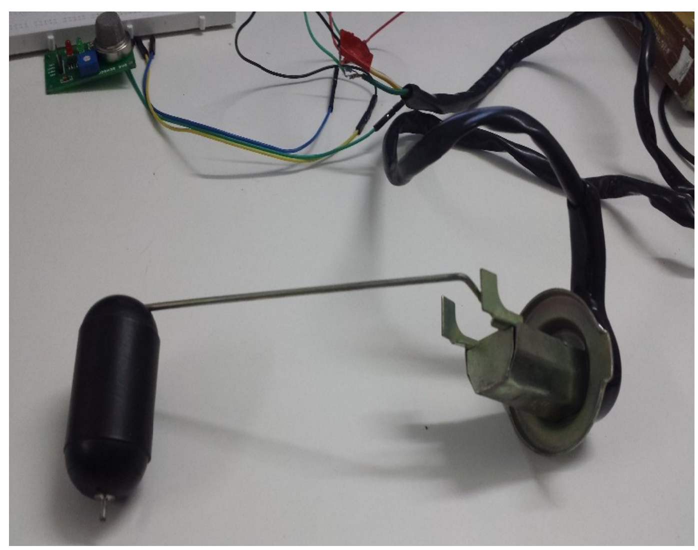
In industry, liquids such as water, chemicals, and solvents are used in various processes. The amount of such liquid stored can be found by measuring level of the liquid in a container or vessel. The level affects not only the quantity delivered but also pressure and rate of flow in and out of the container Level sensors detect the level of substances like liquids, slurries, granular materials, and powders. 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.

Wide spectrum of sensors is available in the market and commonly, they are classified based on the specific application of the sensor. Sensor used for measuring humidity is termed as humidity sensor, the one used for measurement of pressure is called pressure sensor, sensor used for measurement of displacement is called position sensor and so on though all of them may be using the similar sensing principle. In a similar fashion, the sensor used for measurement of fluid levels is called a level sensor.

Quite obvious from its name, level sensors are used to measure the level of the free-flowing substances. Such substances include liquids like water, oil, slurries, etc as well as solids in granular/powder form (solids which can flow). These substances tend to get settled in the container tanks due to gravity and maintain their level in rest state. Level sensors measure their level against a pre-set reference.

They are important not only in nuclear plants but in lot many applications. Every car, truck and motorcycle is equipped with a fuel level sensor to measure the amount of gasoline left in the fuel tank. In addition, there are sensors for level measurement of engine oil, brake / power steering fluid, cooling water, windshield cleaning liquid, etc. Industrial applications include liquid level sensing in water treatment tanks, transport and storage tanks, in the petrochemical industry for liquids such as petrol, etc. Liquid level measurement is important in household applications for devices such as automated coffee machines, water dispensers, juice squeezers, water evaporators, steamers, fridges and freezers, boilers, heating systems, dishwashers, washing machines, steam irons, etc

In short, level sensors are one of the very important sensors and play very important role in variety of consumer/ industrial applications. As with other type of sensors, level sensors are available or can be designed using variety of sensing principles. Selection of an appropriate type of sensor suiting to the application requirement is very important.



Continuous level sensors measure the level to determine the exact amount of substance in a continuous manner.

Point-level sensors indicate whether the substance is above or below the sensing point. This is essential to avoid overflow or emptying of tanks and to protect pumps from dry run.

From the application point of view the considerations are:

- Price
- Accuracy
- Response rate
- Ease of calibration
- Physical size and mounting of the instrument
- Monitoring or control of continuous or discrete levels

f 115 volts ac is applied to the primary of

4.RESULTS AND CONCLUSIONS

RESULTS

To design multi parameter monitoring system using Microcontroller that measures and controls various global parameters and the system comprises with wireless mode of communication. These process were managed using microcontroller. The parameters that can be tracked are Gas, temperature, light intensity and water level.

The system comprises of a single master and multiple slaves with wireless mode of communication and a microcontroller system that can either operate on windows or Linux operating system. Microcontroller can sends data to the other system using wireless communication.

The various interesting features are field device communication via USB-OTG enabled Android devices. Process Control and Monitoring system is developed to monitor the process value and control the values on needed without human interface.

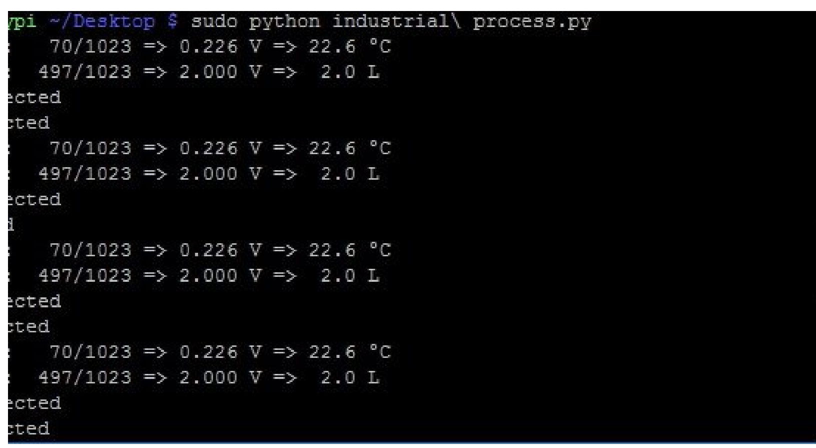
Thus, it can be defined as a mechanism removing as much human interaction as technically possible and desirable in various domestic processes and replacing them with programmed electronic systems. For the development of such

design of raspberry pi industrial process monitoring

system, Raspberry Pi is used as the main node which is used for both monitoring and controlling purposes

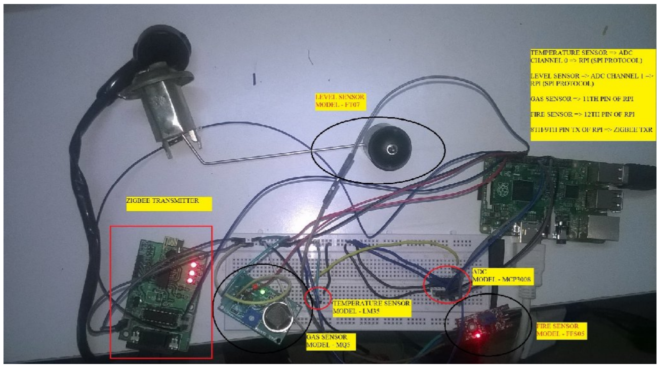
The main controlling and manipulating device can be taken as the Raspberry Pi as all the logical and mathematical tasks are perform in it. The monitoring application as well as the controlling application is developed in Raspberry Pi as it is the only computer in the system to do the tasks. The laptop in the system is just to monitor the website developed in Raspberry Pi through network.

OUTPUT RESULT:



Raspberry pi based data acquisition system output

HARDWARE SETUP:



Hardware

CONCLUSION:

Monitoring industrial parameters such as water level, temperature, fire detection, gas detection through wireless communication using raspberry pi are monitored successfully. The system can be enhanced for wave form representation of data in an excel sheet using raspberry pi. The additional slaves can be added for measures various other parameters. Also controlling action can be set for some predefined cases in the master module which enables the automatic operation at certain cases. A dedicated video processor can be used in raspberry pi to display graphical and three dimensional view of the industry. ZigBee with its excellent low-power capability provides an excellent alternative for Bluetooth and RFID in terms of power and performance. Support for ZigBee is currently being added and will be reported separately. This project having features such as Remote monitoring Wireless communication Easy to implement, High efficiency. Multi parameter monitoring system using Microcontroller that measured and controlled various global parameters and the system comprises with wireless mode of communication. These processes were managed using microcontroller. The parameters that can be tracked are Gas, temperature, light intensity and water level. The system comprises of a single master and multiple slaves with wireless mode of communication and a microcontroller system that can either operate on windows or Linux operating system. Microcontroller can sends data to the other system using wireless communication.

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