Implementation of Smart Sensor Interface Network for Water Quality Monitoring in Industry using IoT

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Abstract

Objectives: To collect data and receive relevant information about the environment and other physical phenomena such as changes happening in our habitat, industries and our local environment where there are a lot of process taking place involving air; water, soil, etc. Method/Analysis: In all these Wireless Sensor Network plays a huge role and has been globally implemented. It is incorporated with latest technology Internet of Things. Findings: This technology is used for implementing Smart Sensor Interface for Industrial monitoring, and other health monitoring facilities and their surveillances. Novelty/Improvement: In this paper, we tried to implement the smart sensor interface network in industries and collect the data about the water quality parameter and update them in the cloud using IoT. Data is available to the public through the cloud website and social networking like Facebook.

Keywords: Internet of Things, PIC Microcontroller, Smart Sensor Network

1. Introduction

Internet of Things is the implementation of a network of sensors and other devices through the means of electronic and other software in order to get data about that physical device. Wireless Sensor Network is basically implemented by installing a network of small sensors across the devices or environment in which we require the data and these sensors will give information about those surroundings for every instance of time. IoT representation is the best for long-term industrial data acquisition WSN technology. In order to meet the requirements for long-term data acquisition in IoT, the devices are maintained such that multiple data received from sensors at the same time, are more accurate and reliable using industrial WSN. As the day to day, life goes on a lot and lots of technologies are invented day by day and in that case, IoT gets the major eye with its development which leads the manufacturers to do a lot of research on IoT and its associated multiple Sensor Network system. With the wide availability of the similar types of devices in the market, are very specialized in their working concept so that only individual installation of these is not feasible and it won’t give the required output so that to see the changes in the environment multiple interfaces are required. There are a lot of restrictions with this interface device due to the peculiar properties of some sensors connected to the network, the rate of sampling required and the type of signal, etc.

In the mainstream data interface devices, Micro Control Unit (MCU) is used as the core controller and it has two advantages namely low cost and low power consumption, due to which it is easy to implement everywhere. Each task is completed step by step by using interrupts. The parallel connectivity leads to improper data collection due to failure of some devices, because of the delay in nanoseconds or milliseconds.

However, in IoT environment, different industrial WSNs utilize a lot of complex and different kinds of sensors. At the same time, each sensor has its own requirements for their working and different users have their own applications accordingly sensors are required. For every newly connected sensor to the interface device in the IoT, there is a need to write a complex and cumbersome sensor driver code and data collection procedures. This poses great challenges to the researchers.
2. Internet of Things

A new trend is forming in the era of ubiquity, with the advancements in Internet technologies and WSNs. “IoT” is all regarding the physical things talking to each other. Here, machine-to-machine (M2M) communications and person-to-computer communications are extended to “things”. Smart sensor technologies including WSN, nanotechnology, and miniaturization are the key features of IoT. Since IoT is related to an outsized range of wireless sensing elements, it generates an enormous range of information

The Sensor data acquisition interface equipment is the key part of IoT applications. WSN is the foundation of other advanced applications in IoT environment and data collection is the essential application of WSN. IoT is a major drive that provides support for service composition with various applications. The architecture of IoT consists of three layers: Perception layer, Network layer and the application layer. The designed data acquisition interface is mainly applied to the perception layer. The perception layer of IoT mainly features sensors, RFID readers, cameras, M2M terminals, and various other data collection terminals. The integration and collaboration of various environments and collection of sensor data are given by the data acquisition interface is shown in Figure 1. A good example of such a workflow is the water environment monitoring system that adopts sensors to detect pollution and water quality.

One of the main applications of IoT is Water environment monitoring where complex water quality information, is used to determine the water environmental quality instantly. However, presently, in the market there are only a very few data collection devices that are dedicated to water quality monitoring. Such devices ensure high speed of data acquisition from multiple sensors and can adapt to complex and various sensor types as well. Therefore, a WSN data acquisition interface is designed for the monitoring of water environment. The other applications in IoT are also needed to collect the sensor data. If the data acquisition interface is compatible with the sensor involved in the application of IoT, it will greatly promote the IoT development. So the IEEE1451.2 standard intelligent sensor protocol is combined to design and implement a reconfigurable smart sensor interface for industrial WSN in IoT environment.

![Figure 1. Block diagram.](image)

3. Implementation

3.1 The Introduction of the Hardware

The overall structure consists of a PIC Microcontroller which gets information from the sensors. The outlet water which is coming from the industry is implemented with the pH sensor, temperature sensor and Turbidity sensor.

This is because we should be more cautious about the water which is let to the environment rather than processing it since it affects most of the environmental factors.

The length of the experimental data can be flexibly adjusted according to the number of sensors connected to the system. The data bit without connected sensors will display 00. After a sensor is connected to the system, the system will automatically search for data format of the equipment through a predefined physical interface and the corresponding relation of the spreadsheet. Then, the system completes standard conversion of the data format automatically. Finally, the transformed data are presented on the serial port terminal.

3.2 pH Sensor

The pH of a solution is an indication of how acidic or basic (alkaline) it is. The pH sensor in Figure 2 is used to measure whether a solution is acidic or not. The pH level of pure water is 4. It is caustic if higher than 4 and if it is less than 4 it is basic. A pH measurement loop is made
up of three components, the pH sensor, a preamplifier; and an analyzer or transmitter. The pH sensor includes a measuring electrode, a reference electrode, and a temperature sensor. A pH measurement loop is essentially a battery. The positive terminal is the measuring electrode and the negative terminal is the reference electrode.

The measuring electrode is sensitive to the hydrogen ion concentration and it develops a potential (voltage) directly proportion to the hydrogen ion concentration in the solution. The reference electrode gives a stable potential using which the measuring electrode can be compared. The reference electrode potential does not change with the changing hydrogen ion concentration when immersed in solution. The solution in the reference electrode makes contact with the sample solution and the measuring electrode through a junction thus completing the circuit. A temperature sensor is necessary to correct for this change in output as the output of the measuring electrode changes with temperature (even though the process remains at a constant pH). This can be done using the analyzer or transmitter software.

The LM35 provides accuracy range of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. The device guarantees lower cost as it does not require any trimming or external calibration. The linear output, low output impedance and precise inherent calibration of the LM35 device make its interfacing to output and control circuitry especially easy.

The device in Figure 3 may be used with single or dual power supplies. LM35 has very low self-heating (less than 0.1°C in still air) as the device draws only 60 μA from the supply. The operating temperature is around −55°C to 150°C. The LM35-series devices are packaged in hermetic TO transistor packages.

The important phenomenon used is temperature of the outlet water, since it gets direct contact with the environment. The normal temperature should be always maintained or else it affects the ground and normal ground water

The temperature of the outlet water should be monitored constantly because it gets direct contact with the environment. The outlet water should be maintained at a normal temperature or else it would affect the ground water table. The LM35 series temperature sensors are preferred for this application since they are precision integrated circuit devices. The sensor output voltage is linearly proportional to the Centigrade temperature. The main advantage of this sensor over the other linear temperature sensors calibrated in Kelvin is that the user need not subtract a large constant voltage from the obtained output in order to get a convenient centigrade scaling.

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Figure 2. Typical pH sensor.

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Figure 3. Temperature sensor.

3.4 Turbidity Sensor

Turbidity Sensor is used to find the relative clarity of a liquid is shown in Figures 4 and 5. Turbidity is an optical characteristic of water. It is the amount of light that is scattered by material in the water when a light passes through the water sample. Higher the intensity of Turbidity gives water a cloudy or opaque appearance. Turbidity is measured in nephelometric turbidity units (NTU). If the reflection is 90 degrees, then the water is pure. The deviation of 5 degrees on both sides is allowed for general conditions. During low flow (base flow), many rivers have fewer turbidities, usually less than 10 NTU. Turbidity readings can be used as an indicator of water pollution. The turbidity sensor has an optical system which includes a tungsten-filament lamp, a 90° detector and a transmitted light detector. The 90° detector monitors the scattered light. The ratio of the signals from the 90° detector and transmitted light detectors is calculated using the instruments microprocessor. This ratio technique corrects for interferences from color and/or light absorbing materials (such as activated carbon). This technique also compensates for fluctuations in the
lamp intensity, providing long-term calibration stability. This design minimizes stray light and hence increases measurement accuracy.

Figure 4. Internal view of turbidity meter.

3.5 LCD

LCD is an electronic display module. A 16X2 LCD display finds a wide range of applications in many circuits and devices. LCD’s are usually preferred over seven segments and other multi segment LEDs because they are economical, easily programmable and they have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. LCD stands for Liquid Crystal Display is shown in Figure 6. LCD is widely used because of the following reasons.

- They are cost effective. It is easy to display numbers, characters and graphics unlike LEDs, which are limited to numbers and a few characters. The LED should be refreshed by the CPU to keep displaying the data but it is not necessary in the case LCD.
- Ease of programming for characters and graphics.
- They are specialized for being used with the microcontrollers. They cannot be activated by standard IC circuits.

The model described here is of low price and most frequently used in practice. It can display messages in two lines with 16 characters each. It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. It is also possible to display symbols that the user makes on their own. It automatically shifts the messages on display (shift left and right), adjusts the appearance of the pointer, backlight and so on.

Interfacing LCD with PIC microcontroller.

The pins RS, RW, E, D0 - D7 should be interfaced the microcontroller. We connect the Data bus on port A and the RS, RW, E on port B. (You can save pins by using LCD in Nibble Mode (4 data pins) and permanently grounding the RW line (always in write mode) An Intelligent LCD will need only a few Commands and data for functioning.

Figure 5. Turbidity sensor.

Figure 6. LCD display.

4. Working

Generally, there are two types of industries, first in which the outlet water should be monitored. Those industries include tanning industries, dye, etc., which the outlet water is the main concern to monitor as it affects the outside environment. The second type of industry is that where the stage by stage process is monitored. Those include food industries. The sensor network is implemented depending upon the type of industries. The sensors are installed in different stages of the industries or in the outlet water where it has to be governed. The sensors are used to measure the temperature, pH and turbidity of the water. The collected data from the sensor is normally analog in nature. The sensors have an inbuilt analog to digital convertor circuit and hence the output is available in the digital form. These sensors give data for every instance of time. This data is sent to the PIC16F877A microcontroller. The data collected in the microcontroller is established to the internet by using Internet of Things. The data is stored in the cloud and is updated every instance of time. It is published in the cloud website and it is uploaded to the social media such as Face book where a private page
belonging to IoT is created and the status regarding the pH, temperatures and turbidity values is uploaded every instance of time. The people who like the Face book page or cloud page can get the details of the water quality in the industry.

5. Results

The result for reference purpose is displayed on the LCD screen and the values are updated on the website and face book. The values include temperature, pH and turbidity.

Figure 7 shows the values displayed on the LCD screen where TMP represents temperature and WCON represent Turbidity and pH represents pH of the water. Figure 8 shows the data uploaded on the cloud website. Figure 9 shows the face book page where the data is uploaded.

6. Application in Water Quality Monitoring

Environmental consciousness and the importance of keeping the environment clean has been developing in
the minds of the people due to the detracting conditions of the earth and the fact that we have to handover the earth in a friendly way to our fourth coming generations. Water is an important factor to live in the world and hence these water quality monitoring will help to preserve a lot of factors such as diseases caused due to impure waters and avoiding underground water getting contaminated. Water Quality monitoring will help the government to keep pollution free, if suppose an industry produces more harmful water after processing or it uses impure water during processing this helps to indicate the mistake which would be helpful for the government to warn the company or take some advisable actions towards the factory. This can be also being implemented in the municipal water control boards so that purity of water coming from the main area reserve to each street can be found and this can be made accessible to the public so that the people living in the society can be aware of the purity of water they are drinking and also helpful in maintaining the water quality which will be available for the general public.

Benefits as follows:
- Water quality, temperature, pH of the water can be monitored in real time.
- Multiple nodes can be installed in different areas in a single pond.
- Low power consumption

7. Application in Metro Water Management

This system can be implemented in the metro water management to govern the quality of water right from the beginning to the end user. Hence it helps the public as well as the government to detect any adulterations or problems in the supply and can rectify the problems in an easy and in a convenient and fast way. For example, if someone gets the drinking water with turbidity, they can easily identify the place of the problem where it gets adulterated by just checking the values of turbidity from the source to the subject’s destination. It can be done within matters of a second. It is highly useful for Government purposes

8. Conclusion

This paper brings about the installation of Smart Sensor Network for monitoring the Water Quality in Industries Using the IoT environment. The system works by real time and a very high-speed data acquisition in IoT helps the project to be feasible and more reliable. Any types of sensor based on the requirement can be used in this system and hence it has a wide band application. The sensor collects data using the applications of IoT. The main design method of the implementation of a smart sensor network for monitoring water quality in Industries using IoT is described in this paper. Finally, by taking real-time monitoring of water environment in IoT as an example, we verified that the system achieves good results in practical application.

9. References


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