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Automation And Real Time Monitoring of Water Treatment Plant

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Abstract: *the role of automation is growing at a great pace in numerous fields ranging from industry to medicine. The requirement of clean drinking water is on rise with the decrease in the availability of clean sources and for a safe supply of this water a real time monitoring and control system for removing impurities in the water is required. This paper focuses on an ingenious and novel approach of monitoring and building a control system to ensure a safe supply of drinking water with the help of raspberry pi. The use of raspberry pi instead of large PLCs is its compact size and also to increase the cost efficiency and ease of use such that this system can be installed anywhere with minimal help. Real time monitoring of the data from system is done through an IoT cloud platform.*

Keywords: *Raspberry pi; Automation, water treatment, monitoring, IoT, contol system*.

I. Introduction

Water is an essential entity for the sustenance of mankind. Quality of drinking water and good conditions of the water treatment plant are important to ensure safe supply of drinking water. Generally the source for water treatment plants includes water from wells, underground water, lakes, ponds and rivers which contain a variety of impurities. These impurities are chemical and physical in nature and the fundamental factors like ph. dissolved oxygen, conductivity of the water etc. Are to be monitored and controlled. For this automation plays a key role in carrying out these tasks. Normally programmable logic controllers (PLC) are used in water treatment plants for Automation. This article focuses on a control system and novel approach to monitoring for the water treatment plant using "Raspberry Pi " as an ideal alternative to PLCs for automation of small water treatment plants. Raspberry Pi is a mini computer which has ability to control and drive a system which comes with benefits like low cost, great compatibility, small size and ease of use. The sensors used in the project take care of both the chemical properties of water and physical conditions of the water treatment plant. In monitoring, the data that comes to raspberry pi from sensors after converting from analog to digital. This data is continuously checked against the accepted threshold values of respective factors and are continuously uploaded to the IoT cloud server with the help of internet with a frequency of 10 seconds. And if the threshold values are reached the signals are sent by raspberry pi to the control system for initiating the required actions.

II. Overview And Working Of Water Treatment Plant

Generally raw water from various sources are fed into the treatment plant for various processes of cleaning and purification. Most often the processes include neutralizing the Ph. of water, De-ionizing the water to remove conductivity, filtration for sand and dust, sedimentation and coagulation. In the first step of treatment, the raw water flows into the tank and a flow meter checks the amount of water flown in and the temperature of water is recorded by a temperature sensor. The temperature of water is very important physical parameter to consider for the functioning of the water plant. Physical properties of water such as taste, concentration, color and smell of water may change with variation in temperature. The efficiency of coagulation are also temperature dependent and the ph. also decreases when temperature increases. There are various microbiological and chemical aspects related to changes in temperature of water such as growth rate of microorganisms. The most favorable operation range of temperature must be in the mesophilic range which is about 4-39 degrees centigrade. Hence proper care should be taken in maintaining the temperature of the plant. In the second stage the water after adjusted to the proper temperature is tested for ph. by a ph. sensor. Ph. is an indicator which gives the acidity or alkaline condition of water.Ph scale ranges from 0-14 where 7 indicates neutral, <7 indicates acidic and >7 indicates basic. Generally the ph. of the drinking water should be 6-8.5. Greater value of ph. tends to effect the taste of water and also can cause corrosion problems to materials of plant. Low ph. tends to affect the plumbing systems by leaching. Neutralizing filters are used to vary the ph. Calcium carbonate is added for water with ph. > 6 and synthetic magnesium oxide or soda ash is added to water with ph. < 6. After proper neutralization of ph. The water next flows through a chamber where it is tested for

conductivity. Conductivity in water arises due to the presence of mineral salts of elements like magnesium and calcium. These salts are capable conducting electricity by producing free ions when dissolved in water. Therefore the water has to be free from these salts and the concentration is measured in terms of total dissolved solids (TDS). To reduce the TDS content the water has to be taken through a de-ionization or a reverse osmosis process. And the easiest procedure and most economical way to get rid of TDS is by flocculation with FeCl2, Fecl3 or Feno33 and following up with sieving or settling. Ion exchange resins can also be used. The acceptable range of conductivity is from 0.005 to 0.05 s/m.

These processes remove the basic forms of impurities and which are implemented in our project and also an important physical parameter related to the treatment plant which has to be taken care of is humidity. High humidity levels in environment have a major effect on the plants' infrastructure causing various engineering, electronic and mechanical problems. Increase in humidity levels leads to oxidation on metal surfaces in the plant. To overcome the problems with humidity, proper management techniques such as infiltrators, ventilation, and evaporation mechanisms are to be implemented for a proper function and safe supply of water. For all these processes to function properly an efficient control system have to implemented and a automation of these processes plays a vital role in both monitoring and analysis by reducing costs of labor, implementation in remote locations, better efficiency than manual system, uniformity and ease of operational improvements.

III. Role Of Raspberry Pi In Automation

The major part of the system is the Raspberry pi mini computer model 2 version B. It has 1GB of ram, 40 multipurpose general purpose input output (GPIO) ports and these include various control and communication functions such as controlling motors, UART, SPI, I2C etc. The automation project includes different kinds of sensors, actuators and motors that can be interfaced to the GPIO pins of raspberry pi. The block diagram of the plant with sensors and actuators is as shown in figure.

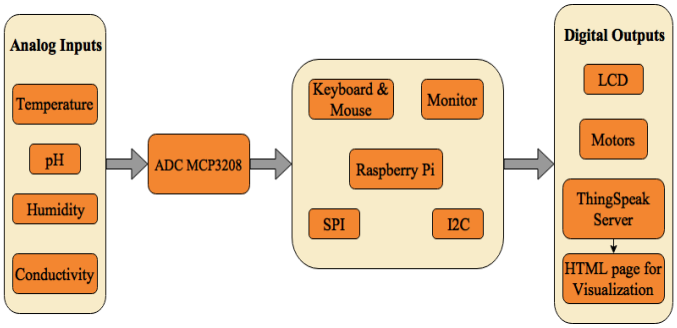

Figure 1: Block Diagram of Water Treatment Plant

As the sensors are analog in nature the ADC IC MCP3208 is used to convert the analog data to digital data and fed to the raspberry pi GPIO. The data is then processed and then through other communication pins theses data is communicated to the motor driver circuits and also simultaneously to the cloud based IoT server where the html page displays the real time data of the respective sensors.

The working and the sequence of operations that are carried out can be explained as follows. When the water is flown through the sensor chambers, the data from the sensors in the plant is converted from analog to digital by an ADC and sent to raspberry pi. This data is checked against the threshold value of the respective parameter which has been already programmed into the pi and if the value is greater than the threshold, the raspberry pi activates a respective control system for decreasing the temperature of water and simultaneously the data is sent to a web server for real time analysis and monitoring. The threshold values and working of respective sensors are as follows.

After the water is flown into the tank, it flows through different sensor chambers one by one where by each respective parameter in the water is measured. The sensors read the parameter and the data is converted from analog to digital by and ADC mpc 3208 and sent to raspberry pi. Here in our project we are using 4 fundamental sensors hence we use 4 channel ADC. This data is processed in the raspberry pi and checked against the threshold value of the respective parameter which is set in the program and if the value is greater than the threshold, the raspberry pi activates a respective control system confined to the sensor to initiate necessary action required to neutralize the abnormality in the water and simultaneously these data points are sent to a IoT cloud based web server called Thingspeak for real time analysis and monitoring. In the case of temperature monitoring the, the allowable range is from 4 to 39 degree centigrade and accordingly the threshold limit is set to 39degree centigrade. Similarly the limits for other sensor parameters like ph. are 6 as acidic limit and 8.5 as basic limit. And in the sensor the digital data read out goes from 0-100 so the acceptable levels in digital read

out translates to 35 for acidic limit and 62 basic limits. Conductivity of water is measured in Siemens per centimeter. The sensor we use to measure conductivity is yl-83 conductivity/rain drop sensor and the digital value threshold in the program is set to 5000 units referring to the value of 0.005 s/m for maximum conductivity of normal drinking water. Humidity in the water treatment plant is the amount of water vapour present in the air surrounding the tank and is measured as Absolute humidity which is the total mass of water vapor present in a given volume of air. When the air is saturated at 30 degrees the humidity ranges from zero to 30 grams per cubic meter, which in digital format is programmed on a 0-100 scale and the threshold limit is set when it crosses the 100 unit level indicating the levels of high humidity.

IV. Flowchart For Sequence Of Operation

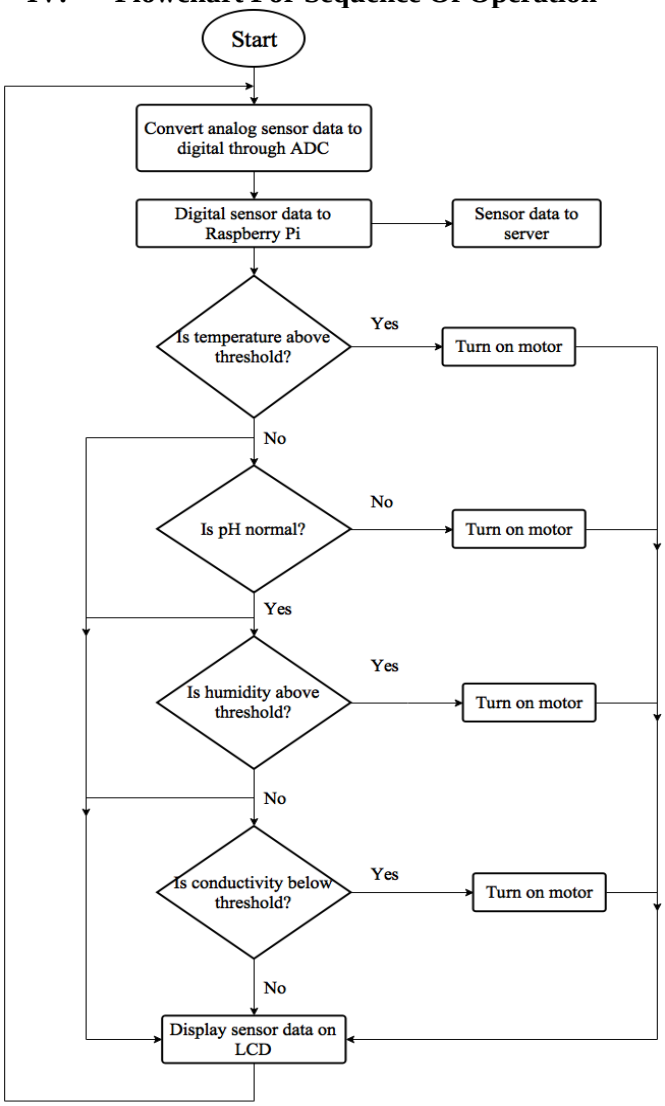

Figure 2: Flow Chart for Sequence of Operation

V. Software And Thingspeak Iot Cloud Server

The software mainly used in our project is python. Raspberry pi is a Linux based distro and the OS used is Raspbian. The OS is booted on startup through an external memory card. All the required packages and libraries for communication and control are pre-loaded and to update them to the latest version we can do it from the terminal as follows.

pi@raspberry~$ "sudo apt-get update && sudo apt-get upgrade"

The program for control system and comparison of threshold values is written in python and the webpage for analysis and monitoring is written in html languages. The code for importing libraries for LCD display, water treatment and web page can be seen as follows. And the main code can be written after importing these libraries.

import spidev

```
import time
import web
import lcd1 as lcd
import water
```

The compiler used for writing python code IDLE.

Thing Speak is an open data platform and API for the Internet of Things that enables you to collect, store, analyze, visualize, and act on data from sensors or actuators, such as Raspberry Pi. We create a channel on ThingSpeak to which the sensor data is uploaded. In the channel, we create a chart for each sensor, i.e., temperature, pH, humidity, conductivity. Using the ThingSpeak API, we upload each sensor data to the respective chart at a regular interval. For writing data to the chart, we need a key called Write API Key which is generated when we create a channel and is available in the API keys tab on ThingSpeak website in our account. The data uploaded can be visualized in the form of a line graph, bar chart or a pie chart in each chart. We can get the sensor data from ThingSpeak by embedding the iframe of each chart in a HTML document for easy access.

VI. Results

The simulation and working figures containing the assembly of hardware such as sensors, raspberry pi, LCD monitor, on board LCD display, ADC, power supply boards, relay and motor driver circuits, motors, LCD display can be seen in the following figure 3

Figure 3: Assembly of Hardware

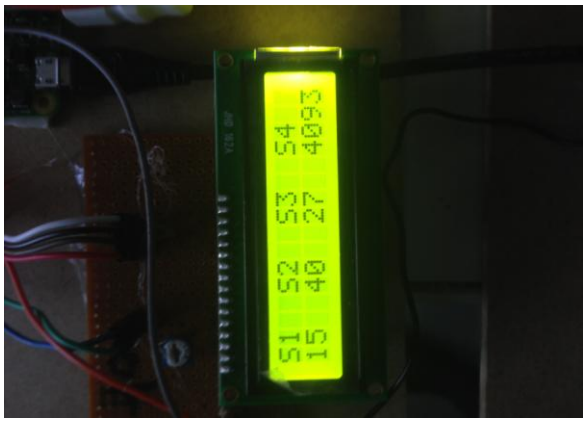

Figure 4: sensor values displayed on LCD

Figure 4 shows the values of the respective sensors displayed on the on board LCD display. Here S1 implies temperature, S2 implies pH, S3 implies Humidity and S4 implies conductivity.

Figure 5: Data from conductivity sensor

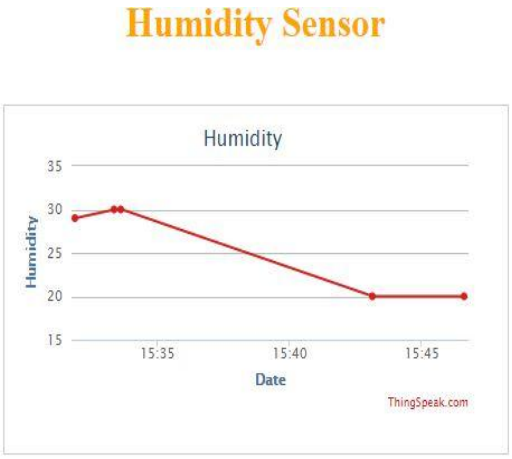

Figure 6: Data from humidity sensor

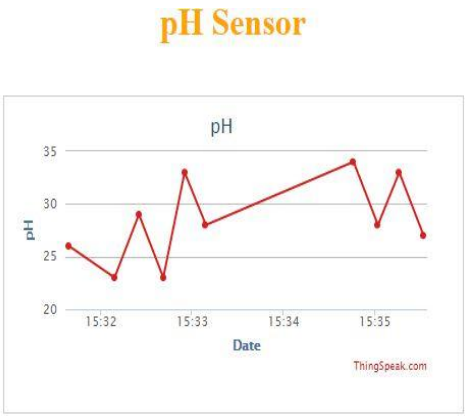

Figure 7: Data from pH sensor

Figure 8: Data from Temperature sensor

The figures 5,6,7,8 show the charts which give real time data of the respective sensors. This data can be accessed through internet from anywhere in the world.

VII. Conclusion

Automation system and real time monitoring plays a key role and has a great impact on any systems with varying functional parameters. It also helps to provide many valuable insights into the future of how things like water treatment; emergency systems etc. are to be designed. Use of Raspberry pi reduces the price of the system by a great extent and also simplifies the process of automation thereby increasing the efficiency of the whole system.

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