Raspberry Pi for Automation of Water Treatment Plant

Sonali S. Lagu
Department of Electronics and Telecommunication
Dwarkadas J. Sanghvi College of Engineering
Mumbai, India.
josh.sonali86@gmail.com

Prof. Sanjay B. Deshmukh
Department of Electronics and Telecommunication
Dwarkadas J. Sanghvi College of Engineering
Mumbai, India.
Vs_deshmukh@rediffmail.com

***Abstract*— clean drinking water is a basic human need. Automation serves a vital role in the safe and reliable operation of a water treatment plant in providing safe drinking water. This paper focuses on an innovative and intelligent control and monitoring system for Water Treatment Plant by using "Raspberry Pi" as an effective alternative to PLCs for the automation of small water treatment plants. Raspberry Pi is a minicomputer which has an ability to control the system comes with advantages like low cost and compact size.**

***Keywords*—Raspberry Pi, Automation, water treatment plant, process control**

I. INTRODUCTION

Water is one of the most important natural resources and is of vital importance for all living things on the earth.

Up to 60% of human body is water. Therefore quality of water we drink is very important. The drinking water should be clean, pure and free of microorganisms and it should be treated and disinfected before consuming it.

Water treatment plants treat the raw water from river, lake, reservoirs or other underground sources and provide safe and reliable drinking water to mankind. Automation is a key to water treatment plant management since it has various tangible and intangible benefits.

Conventionally, Programmable Logic Controllers (PLCs) have been used for automation of water treatment plants. This paper focuses on an innovative and intelligent control and monitoring system for Water Treatment Plant by using "Raspberry Pi" as an effective alternative to PLCs for the automation of small water treatment plants. Raspberry Pi is a minicomputer which has an ability to control the system comes with advantages like low cost and compact size.

Automation of operations involves monitoring and control of various sensors, actuators and motors. These sensors, actuators and motors can be skillfully controlled using Raspberry Pi. Graphical representation of entire water treatment process can be displayed on the LCD connected to Raspberry Pi. Graphical user interface can be designed with the help of programming languages like Python and Tkinter.

II. OVERVIEW OF WATER TREATMENT PLANT

Raw water from river, lake, reservoir or underground water sources is supplied to water treatment plant for the treatment process. Most commonly used processes include coagulation, flocculation, sedimentation, filtration and disinfection.

In the first stage of water treatment plant, the raw water flows through an aeration fountain (as shown in Figure 1). In this stage, oxygen gets dissolved in the water and the ultra violet rays from the sunlight eradicate the microorganisms present in the water.

In the second stage, water undergoes coagulation process. In this process, coagulant such as aluminum sulfate (or alum) is added to water using alum dosing pump (as shown in Figure 1). These coagulant form sticky particles called as 'microfloc' which attract dirt particles. This water with coagulant is mixed gently for longer time with help of flash mixer (as shown in Figure 1). Chemical reaction due to gentle mixing of water and coagulant cause microfloc, dirt, bacteria to form larger particles called as 'floc'. This process is referred to as 'flocculation'.

In the third stage, water exiting the flash mixer enters clariflocculator basin. It is a large tank with low water velocities, allowing floc to settle to the bottom. As particles settle to the bottom of a sedimentation basin, a layer of sludge is formed on the floor of the tank. This layer of sludge must be removed. Water flowing out of clariflocculator is often termed as settled water.

After separating most floc, the settled water is filtered as the fourth and final step to remove remaining suspended particles and unsettled floc. Settled water moves vertically

978-1-4799-6892-3/15 $31.00 © 2015 IEEE
DOI 10.1109/ICCUBEA.2015.109

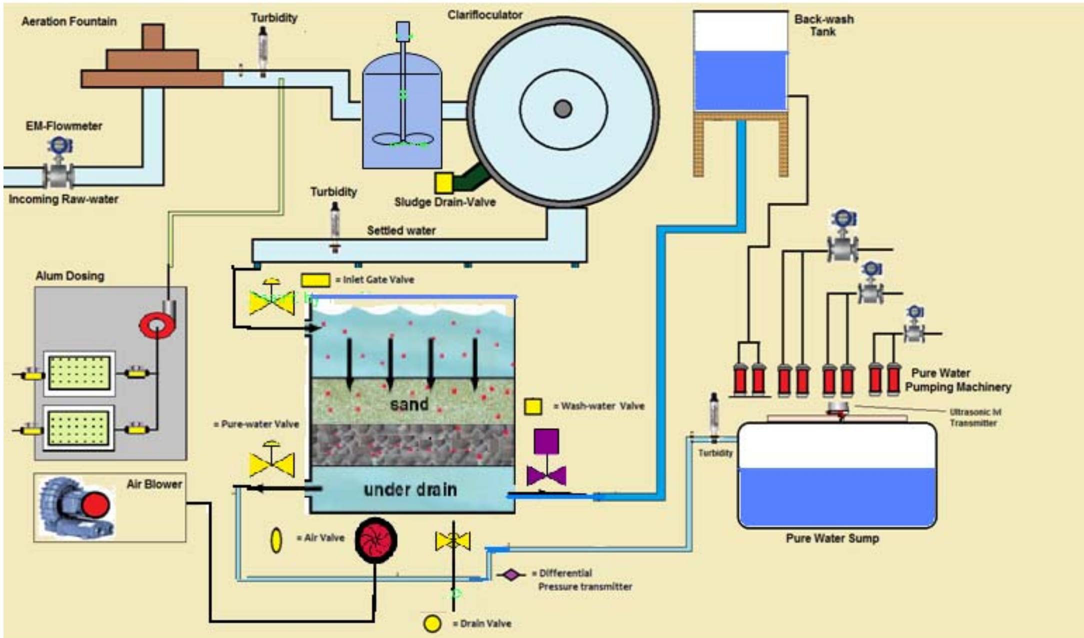


Figure 1: Graphical representation of automation of water treatment plant

through the filter bed consisting of layers of sand, gravel and activated carbon or anthracite coal (as shown in Figure 1). This step removes turbidity and organic compounds, which contribute to taste and odour.

To clean the filter bed, water is passed quickly upward through the filter, opposite the normal direction (called back flushing or backwashing) to remove embedded particles. Prior to this step, compressed air may be blown up through the bottom of the filter to break up the compacted filter media to aid the backwashing process; this is known as air scouring. This contaminated water can be disposed of, along with the sludge from the sedimentation basin.

Filter bed with single cell has one inlet valve (settled water comes in), one outlet valve for pure water, drain valve, air blower and backwash water valve. Backwashing process is often triggered by differential pressure sensor installed in filter bed which senses the difference between the pressure of settle water and pure water.

Chlorine is added to water as disinfectant. Turbidity of raw water, settled water and pure water is measured using turbidity sensors to maintain quality of water. Pure water from the filter bed is ready for consumption and is stored in pure water sump.

Automation is a key to water treatment plant management since it has various tangible and intangible benefits. Tangible benefits include reduction of labour cost, reduction in travel time to secluded locations, operational improvements, etc while the intangible benefits include uniformity in class of treated effluent, better data collection, better monitoring and security, etc.

III. Role of Raspberry Pi in the automation of water treatment plant

Heart of the system is Raspberry Pi minicomputer. Raspberry Pi model B has dedicated general purpose input outputs (GPIO) pins. These GPIO pins can be accessed for controlling hardware such as LEDs, motors, and relays, which are all examples of outputs. As for inputs, raspberry pi can read the status of buttons, switches, or various sensors. Some GPIO pins Raspberry Pi have alternate function such as UART, SPI, and I2C etc.

Automation of water treatment plant involves different types of sensors, actuators and motors which can be interfaced with Raspberry Pi GPIO pins. Block Diagram of Automation of water treatment plant using Raspberry Pi is as shown in figure 2. LCD Display can be connected to composite PAL of Raspberry Pi. Number of GPIO pins of Raspberry Pi is limited. It can be extended using IO expender IC e.g. MCP23008 which has I2C interface as shown in figure 2.

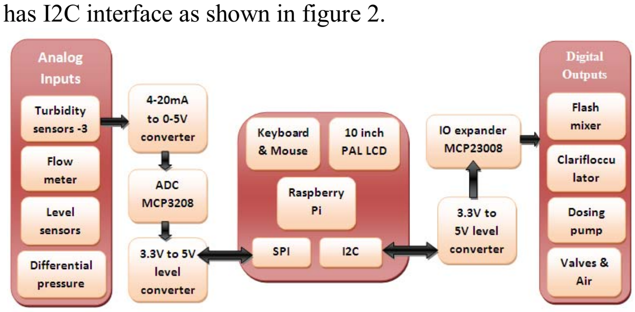


Figure 2: block diagram of Automation of water treatment Plant

Ultrasonic flow meter measures the rate of flow of water to the plant. Ultrasonic flow meter has 4-20 mA output which corresponds to water flowing with unit liters/sec. Raspberry Pi cannot read analog input since there are only digital inputs present on the board. So, analog output of flow meter (4-20ma) is converted into 0-5 volts. We can use analog to digital convertor MCP3208 which converts 0-5 volts into 12 bit digital output. MCP3208 is 12 bit 8 channels ADC which can be interfaced with Raspberry Pi using SPI protocol.

Turbidity of incoming water, settled water and pure water is measured using turbidity sensors having 4-20 mA output. User can monitor real time data of flow meter, turbidity and status of aeration fountain on the simple GUI designed using Python and Tkinter as shown in Figure 3.

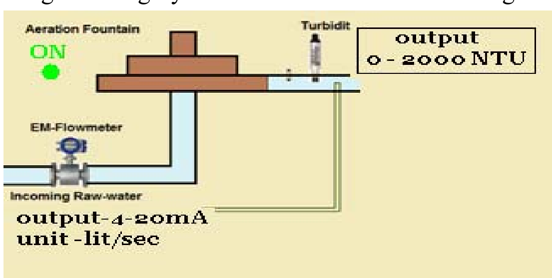


Figure 3: GUI Aeration Fountain, Flow meter, Turbidity

Once the flow of water has been detected, Raspberry Pi switches ON one of the digital output to turn ON the flash mixer. Also alum dosing pump is switched ON by Raspberry Pi to commence the process of coagulation and flocculation as shown in Figure 4. Two digital output pins of Raspberry Pi are used to control clariflocculator. Once the clariflocculator is switched ON by Raspberry pi GPIO, settled water flows towards filter bed.

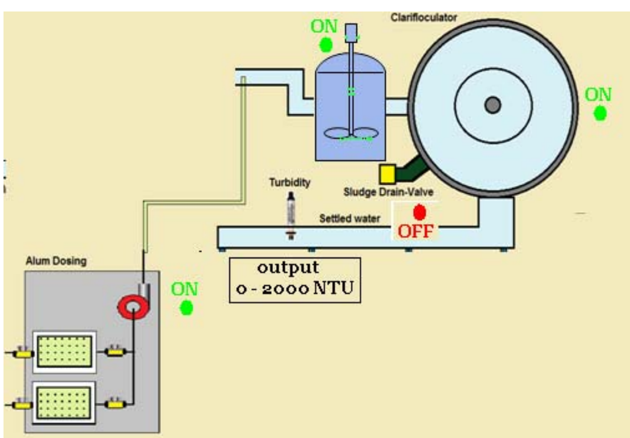


Figure 4: GUI Status of Alum dosing pump, Flash mixer, Clariflocculator

The inlet valve needs to be opened for filtration process. Similarly outlet valve for pure water is controlled by Raspberry Pi. This can be seen in Figure 5.

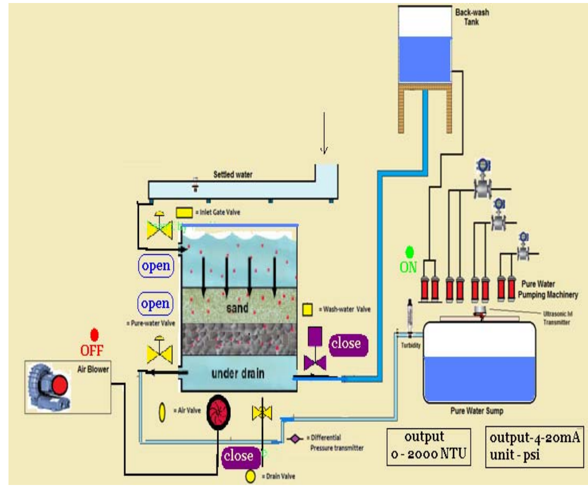


Figure 5: GUI Filter bed normal operation

Differential pressure sensor is installed in filter bed which has 4-20 mA output. Raspberry Pi reads the output of differential pressure sensor. When the pressure of settled water is 1.8 times more than pressure of pure water, Raspberry Pi isolates filter bed from rest of the plant by closing inlet and outlet valve and initiates backwash process. In backwash process, Raspberry Pi switches on the air blower. Drain valve and backwash water valve is opened by Raspberry Pi. Once the filter bed is washed and cleaned, Raspberry Pi switches off the air blower, closes the drain valve and backwash water valve, and opens the inlet and outlet valve. Level sensor is installed in pure water sump. Pumps are operated by Raspberry Pi depending on the water level in sump. This can be seen in Figure 6.

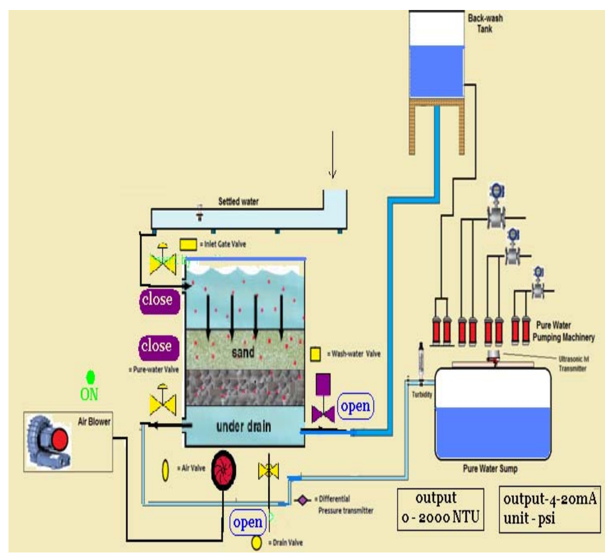
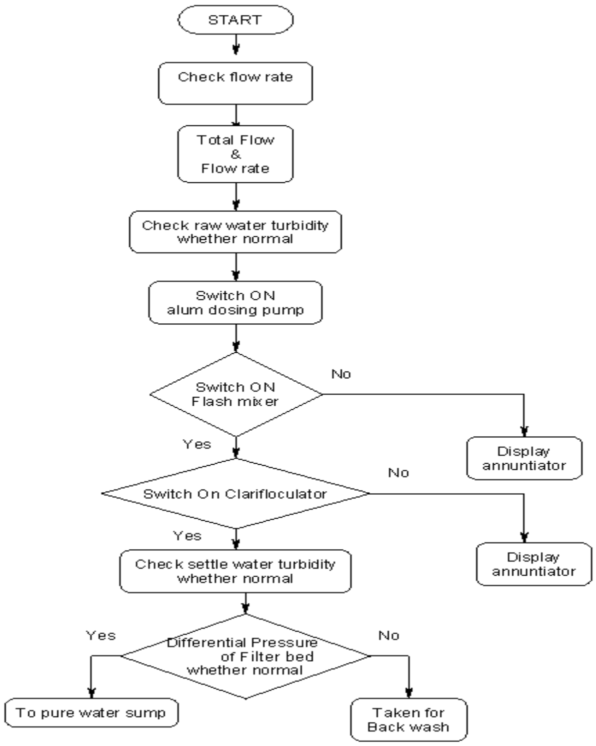


Figure 6: GUI Filter bed backwash operation

IV. FLOWCHART OF SEQUENCE OF OPERATION

.



V. SOFTWARE DESCRIPTION

The SD card contains the Raspberry Pi's operating system. The recommended OS for raspberry pi is Raspbian. Once the Raspbian OS is written and saved on SD card followed by booting procedure, raspberry pi is ready to use. Procedure to install necessary packages for the ue of I2c and SPI protocols is as follows.

Open LXTterminal and Update list of packages:

```
pi@raspberrypi ~ $ sudo apt-get update
```

Install i2c-tools tools and python-smbus:

```
pi@raspberrypi ~ $ sudo apt-get install i2c-tools python-smbus
```

Program can be written in Python and graphical user interface can be designed using Tkinter programming language. Below piece of program shows that different library has been imported.

```
from Tkinter import *
import ttk
import spidev
import time
from Adafruit_MCP230xx import *
```

VI. RESULT

Below figure 7 shows the assembly of hardware such as Raspberry Pi, 10 inch LCD, USB hub to which keyboard and USB mouse is connected, power supply, Relay card, 4-20 mA to 0-5 V converter board, digital input output board and 5 volts to 3.3v converter board for interfacing raspberry Pi GPIOs. Main graphical screen can be seen on LCD.

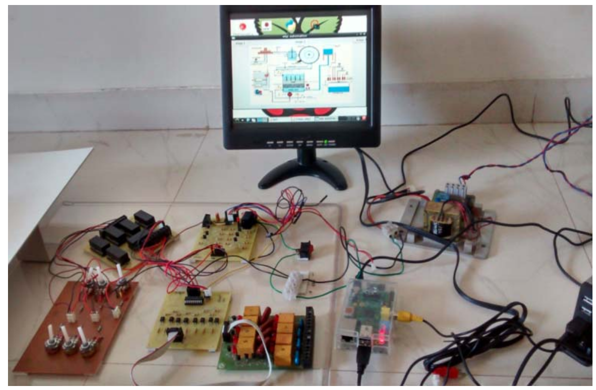


Figure 7: assembly of hardware and result on GUI

Below figure 8 shows model of water treatment plant. Two DC motors are connected to flash mixer and clariflocculator. Green and Red Led are connected to display status of valves and dosing pump.

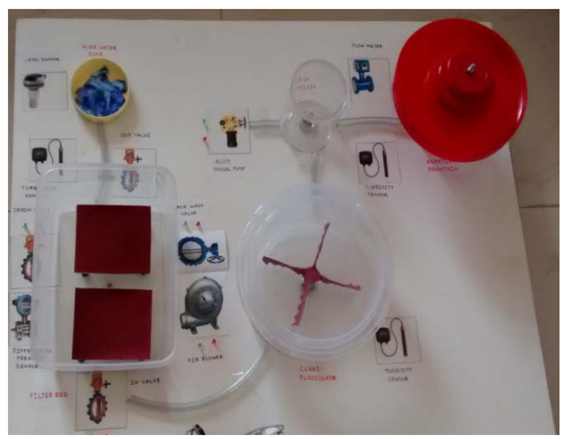


Figure 8: model of water treatment plant

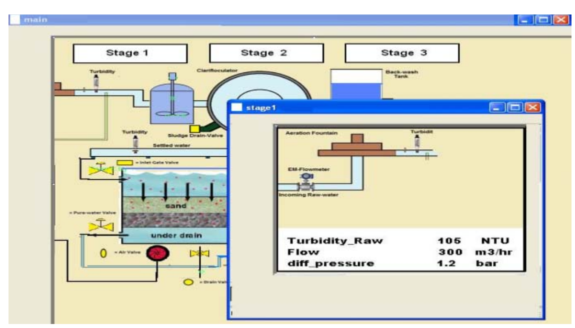


Figure 9: GUI of stage 1

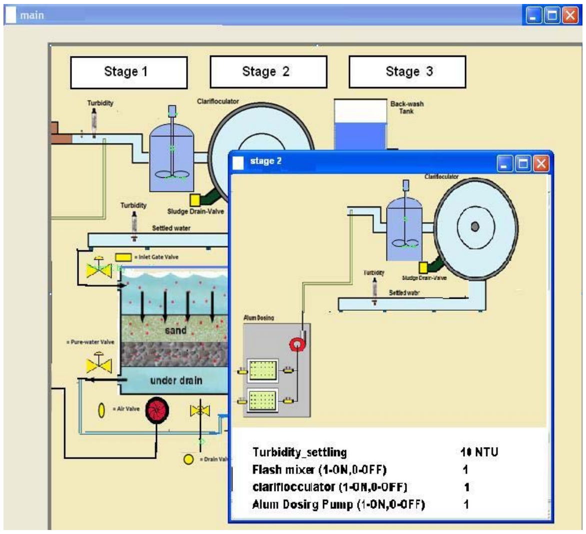


Figure 10: GUI of stage 2

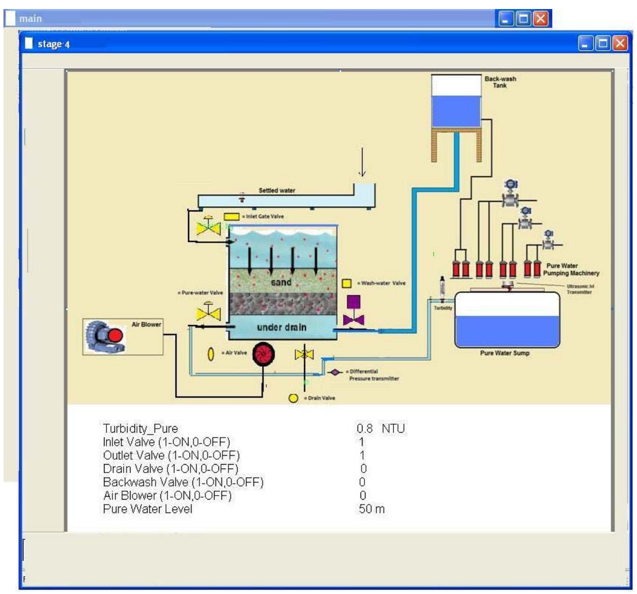


Figure 11: GUI of stage 3

Above figures 9, 10 and 11 shows Graphical User representation of stage 1, stage 2 and stage 3 respectively. Current status of various parameters can be monitored with the help of this GUI which is designed using Tkinter based on Linux operating system installed on Raspberry Pi.

VII. Conclusion

Raspberry pi based automation is a novel and advance technology. Automation serves a vital role in the safe and reliable operation of a water treatment plant in providing pure drinking water. Raspberry Pi simplifies the process of automation and increases the efficiency of Plant. Use of raspberry pi dramatically reduces the price of the system.

References

[1] Matt Richardson and Shawn Wallance, Getting Started with Raspberry Pi (USA, O'Reilly Media, 2012)

[2] Eben Upton, Raspberry Pi user guide

[3] Maik Schmidt, Raspberry Pi – A quick-start guide

[4] BCM2835 ARM Peripherals, Broadcom, 2013

[5] Brendan Horan, Practical Raspberry Pi

[6] Irfan Jamil, "Technical Communication of Automation Control System in Water Treatment Plant", International Journal of Innovation and Applied StudiesISSN 2028-9324 Vol. 4 No. 1 Sep. 2013, pp. 28-36

[7] Firoozshahi, A., "Innovative and intelligent industrial automation for water treatment plant in large Gas Refinery," Advanced Computer Control (ICACC), 2010 2nd International Conference, Vol. 1, PP.164-168, 27 March, 2010.

[8] S. Marsili-Libelli , G.M. Maietti, "Energy-saving through remote control of a wastewater treatment plant," Proc. SIDISA Conference, Florence, June 24-28, 2008.

[9] United states Environmental Protection Agency, "The History of Drinking Water Treatment", February 2000

[10] S.T.Sanamdikarand, K.R.Harne, "Advanced Method for Sewage Water Treatment", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-1, Issue-2, 2012