SMART WATER MONITORING SYSTEM

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Abstract -With the advancements in technology, the internet of things has been a revolutionary concept used in a wide range for technical enhancements. When houses in a city get to work in a smart manner, the city becomes a smart city and in the world where water is a basic necessity for survival, a place cannot be categorized to be smart if the residents cannot save it being a precious resource. Looking into the daily dependency on smart phones, a water monitoring system where the various parameters can be monitored and controlled through smart phones can enhance the quality of water and can save water to a large extent. The data is obtained from the various sensors and is stored in the cloud using the NodeMCU which has an embedded Wi-Fi module in it. This data can then be analyzed using a mobile interface.

Key Words: NodeMCU, IoT,voltage divider, submersible pump, 12V battery, level sensor, ultrasonic sensor, pH sensor, etc.

1.INTRODUCTION

In the ancient era, the information on commercial water use were available from (i)the agencies responsible for the supply of water and for the compliance of Safe Drinking Water Act,(ii)public water suppliers,(iii)wastewater-treatment facilities, etc. The data collected from the individual users were used as a parameter for testing the quality of water supplied and calculating the amount of water consumption depending upon a specified threshold.

The aging of water pipelines can cause corrosive substances such as rust to form over the plumbing systems which might lead to leakage. The other causes of water leakage include excessive water pressure; drastic temperature change or untreated drainage clogs which might increase the risks of pipe bursting. The smart water monitoring system is preferred for the process of water audit which helps quantifying water flows and quality in simple or complex systems thereby reducing the usage of water and improving unnecessary water consumption. All these factors which impose a serious threat to aquatic life have also been affecting the human health causing several water-borne diseases such as typhoid, dysentery, cholera, etc. This leads to increasing demand for network based, automated real-time water quality management system.

2. LITERATURE SURVEY

Jayati Bhatt, Jignesh Patoliya[1] in their paper entitled "Real Time Water Monitoring System" proposed an Internet of Things(IoT) based water quality monitoring system in which the parameters such as pH, tubidity, conductivity, dissolved oxygen and temperature were measured with the help of sensors. These values from the sensors were then processed by a microcontroller which was then transmitted remotely to the core controller that is raspberry pi using a Zigbee protocol. The Zigbee module used here is connected to a controller which manages all the incoming data from the respective devices and transmits the data to IoT through a gateway created on the raspberry pi using FTP. This enables the data to be viewed on the internet browser from any corner of the world.

Cho Zin Myint and others[2] presented a smart water Quality monitoring system consisting of Field Programmable Gate Array design board, sensors, Zigbee based wireless communication module and personal computer (PC) which collects data on the pH, level, turbidity, carbon dioxide content on the surface of water and temperature of water in parallel using different sensors. The paper presented a reconfigurable smart sensor interface device for water quality monitoring system in an IoT environment which interfaces transducers to sensor network using Field Programmable Gate Array development tool used along with a wireless XBee module in order to make the system controllable remotely.

Bhad Vidya and others [3] worked on the water level monitoring in order to reduce the water loss. The periodic water level monitoring system was designed using a microcontroller, water level sensor and a pair of Raspberry pi and DAS. A zigbee module was included to make the information available in real time through message notification or through mobile apps which can help control the sensor remotely. The data transmitted from the sensors is received via the Raspberry pi and thus the entire system is monitored and controlled.

3. SMART WATER MONITORING SYSTEM (SWMS)

In our project, we are using a customizedwebsite for monitoring and controlling the system and network of the pipeline where the signal is received from NodeMCU which is programmed in ARDUINOprogramming language. The system and the mobile have to be within the same wireless network. It receives the data from all the sensors and transfers it to the software with specific IPaddress. The website consists of features such as switching the submersible on and off depending upon the water level in the tank which helps to pump the water into the tank accordingly. In the system level threshold is specified for the signal transmission according to which we will get to know our current status of tank and water supply network as shown in figure-1 below.

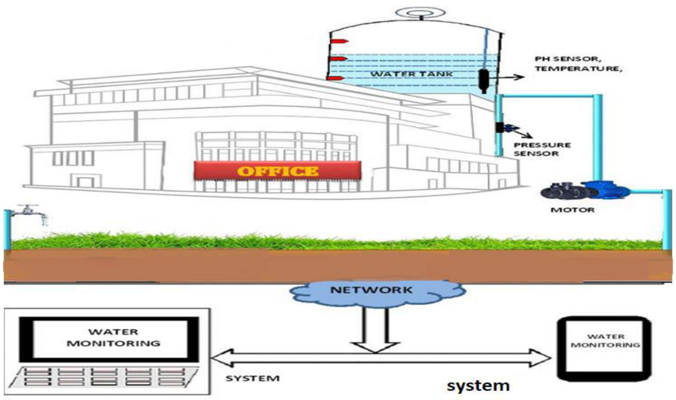

Figure-1: Block diagram for general SWMS architecture

(Courtesy: Internet)

The figure-2 is the integrated circuit block diagram of the project. First we are using the 220V power supply to run the submersible pump to pump the water from the lower water reservoir into the overhead tank. The submersible is, in turn, connected to a relay of 8-amperes to turn on\off the submersible. We are using 3 sensors for the system. The first being the ultrasonic sensor to detect the water level in the overhead tank. The prescribed limit of water level will be set in the Arduino MCP. And this in turn will be connected to the server as termed as client server 1. The second being the temperature and pH sensor to detect the purity and temperature of the water. The pH of the water will be measured by recording the voltage output. The pH is dependent on the voltage output and is based on Nerst equation. The pH sensor is connected to the pH sensor circuit which in turn is connected to the server termed as client server 2. The third being the leakage rope sensor which detects any leakage in the pipeline to reduce water loss. The leakage rope sensor is connected to the signal receiving circuit which in turn is connected to the server as termed as client server 3. All the 3 sensors are controlled by a voltage regulator, which regulates a 12 V DC voltage to respective 5 V to each sensor. And all the three clients are in turn interconnected to the main server (ESP2866). This main controller, also called mega has an inbuilt Wi-Fi module which makes it handy for the system to get connected to the software unit without much physical contact.

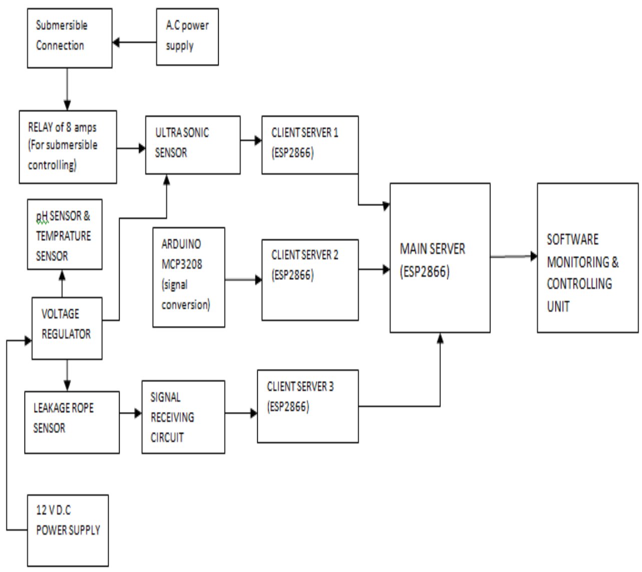

Figure-2: Block diagram of proposed SWMS Framework

3.1. PRINCIPLE OF ULTRASONIC SENSOR

In ultrasonic method of fluid lever measuring, the idea behind all contactless methods is to measure the distance between transceiver and fluid. We transmit short ultrasonic pulse and measure travel time of that pulse from transceiver to liquid and back to transceiver. Ultrasonic pulse will bounce from liquid level due to change in the density of ultrasonic pulse travel medium (ultrasonic pulse first travel through air and bounce off the liquid with higher density than air). Because water has higher density, majority of pulse will bounce off.

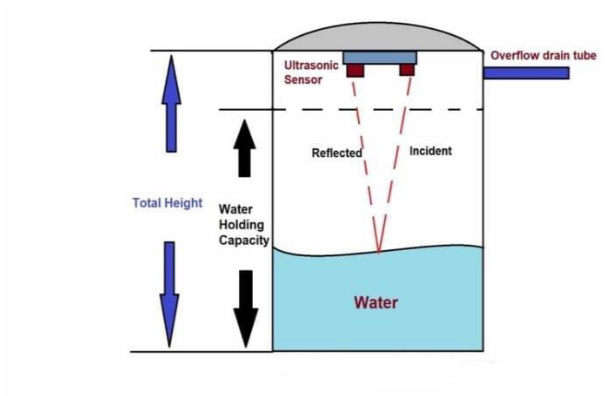

Figure-3: Ultrasonic sensor demonstration

The circuit is simple. We just have two components: HC-SR04 ultrasonic sensor as shown in figure-4 and ESP8266 NodeMCU as shown in figure-5.

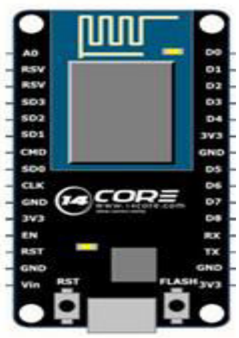

Figure-4: An ultrasonic Sensor

Figure-5: An ESP8266 NODE MCU

The Trigger pin of ultrasonic sensor is connected to D0 and echo pin is connected to D1 as shown in figure-6. The ultrasonic sensor requires 5V supply which can be obtained from VU pin. We soldered wires to ultrasonic sensor (we used FTP or UTP cable; it can be one of them) as reflected in figure 6. Then we installed the sensor in small custom made housing from acrylic glass. Casing with sensor in it was sealed off and mounted on tank's cover.

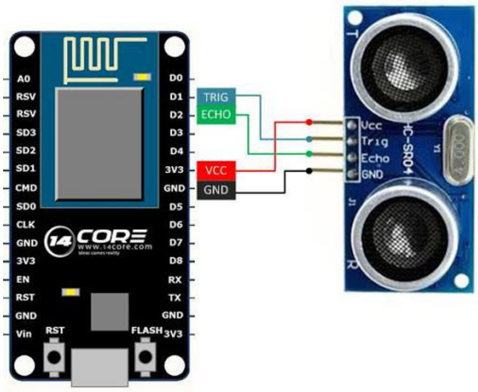

Figure-6: An integrated circuit for ultrasonic sensor

3.2. PRINCIPLE OF pH SENSOR

The pH sensor play important role in the water purification method. pH of a solution can range from 1 to 14 "pH stands for hydrogen power" , which is a measurement of the hydrogen ion concentration in the body.

pH is an alternative way of expressing the concentrationof Hydrogen Ions. Mathematically, pH is the negative logarithm of molar concentration of Hydrogen Ions $[H^+]$.**pH= -log** $[H^+]$

The response of a pH electrode is defined by the Nernst Equation:

$$E = E_0 - 2.3 (RT/nF)*pH$$

Where E_0 is a constant
R is the gas constant
F is the Faraday constant
T is the temperature in Kelvin and
n is the ionic charge

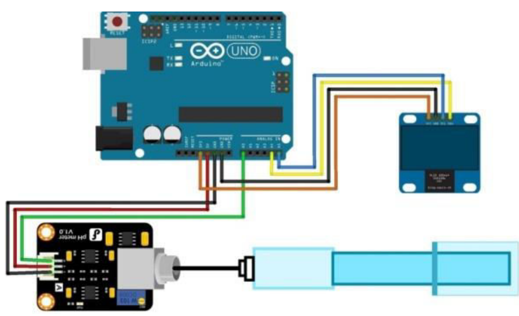

Figure-7: pH sensor circuit diagram

The figure-7 represents a nodeMCU ESP8266 power supply circuit diagram. This is a 5v regulated power supply that is used to power the Wi-Fi module Nodemcu ESP8266. The voltage regulator LM7805 is used in the circuit. J1 is the female power jack and this is where we connect a 12V adapter, battery. Two 470microfarad capacitors are attached to the voltage regulator input and output side. In series, a 330 ohm resistor is connected to an LED of 2.5V. This is a resistor that is inherently restricting. The voltage regulator output is connected to the NodeMCU ESP8266 wireless module's Vin pin and the input is connected to the ground. SV1 and SV2 are the headers for the signal junction.

The red wire is attached to the 5v of the Arduino.The black wire is connected to the ground of the Arduino. The blue wire is connected to the analog pin A0 of the Arduino. The Nodemcu ESP8266 Wi-Fi module's TX and RX pins are linked with Arduino's Pin number2 and Pin number3.The ground of the Arduino is connected to the ground pin of nodeMCU module as demonstrated.

3.3. PRINCIPLE OF LEAKAGE SENSOR

R718WB is a leak detection wireless communication device as shown in figure-8. R718WB can detect the status of leakage through an external dual-core non-positioning water rope sensor, and send the data to data center through the wireless network which is in remotely established. It uses the SX1276 wireless communication module. SX1276 wireless communication module 2 section ER14505 batteries (3.6V/section) parallel power supply leak detection Base with magnet attached to iron objects. Input power of 2x3.6V lithium.Batteries (3.6V2400mah/section). Its battery life is 5 years. (Conditions:- ambient temperature 25 °C, 15 min.)

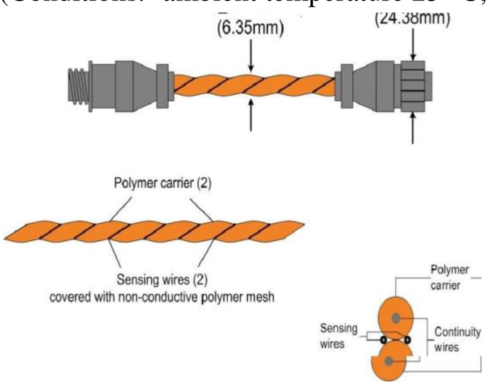

Figure-8: leakage rope construction

Essentially, we are creating a voltage dividerin between the two power rails and feeding that into the NodeMCU Analog input as shown in figure-9.

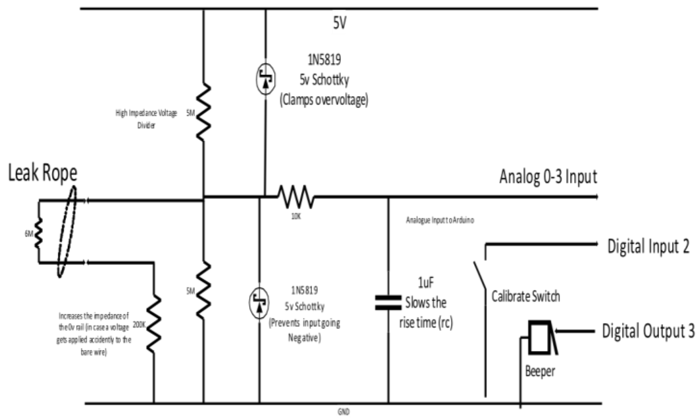

Figure-9: leakage rope circuit diagram

The 1N5819 Schottky Diodes are used to protect the NodeMCU and clamp the input voltage from exceeding 5V or 0V.

The two 5 MΩresistors form the voltage divider, as the impedance (resistance) is so high, even the slightest conductivity to ground will cause the voltage to go down, which is read by the analog input of the NodeMCU. The Leak rope has a ~6 MΩ resistor on the end; this pulls the input low by about 10%. We used this as a way to detect the presence of the rope (because without it, we would not be able to figure out if it was connected or not).

The beeper is a simple beeper, it only draws 20milli ampere- anything bigger would require a transistor to drive it.

3.4. PRINCIPLE OF TEMPERATURE SENSOR

A temperature sensor component is basically a thermocouple or resistance temperature detector, which provides temperature measurement in a client readable form through an electrical signal.Operating Voltage is from 3.5V to 5.5V, Operating current is from 0.3mA (measuring) 60uA (standby), Output Serial dataTemperature Range is from 0°C to 50°C,Humidity Range is from 20% to 90%,Resolution ofTemperature and Humidity both are 16-bitAccuracy: ±1°C and ±1%.

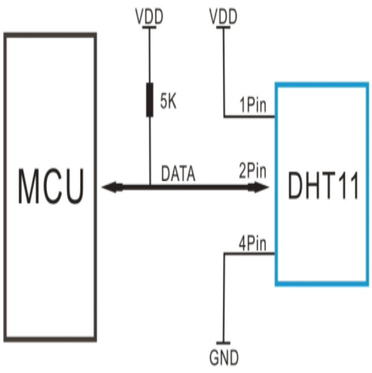

Figure-10: The DHT11 Sensor and outputs serial data

The data pin is connected to an input/output pin of the MCU and a 5k resistor is used as shown in figure-10. The data pin outputs the value of temperature and humidity as serial data. Interface DHT11 with Arduino then there are libraries for it to give a quick start.The output given out by the data pin will be in the order of 8bit humidity integer data and 8bit of Humidity decimal data and 8 bit temperature integer data and 8bit fractional temperature data and 8 bit parity bit. To request the module to send all these data, the I/O pin has to be momentarily made low and then held high as shown in the timing diagram (figure-11).

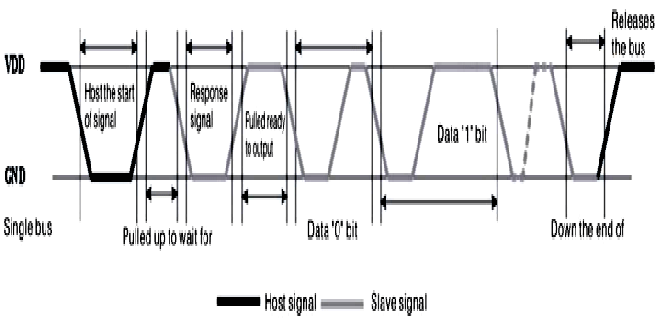

Figure-11: DHT11–Temperature-Sensor-Working-waveform

4. INTEGRATION FROM HARDWARE TO SOFTWARE

After we are done with the hardware part, now we have to integrate the hardware part to the software module.

4.1.INTEGRATION OF DHT11 HUMIDITY AND TEMPERATURE SENSOR AND WEB SERVER WITH NODEMCU:

For this project we are building a standalone web server with an ESP8266 that will display the humidity and temperature with DHT11 sensor using NodeMCU.

The web server that we are creating can be accessed with any device that has a browser on our local network.

Parts required for this project are:

*ESP8266 development board.

*DHT11 for temperature and humidity sensor.

*4.7k Ohm resistor.

*Breadboard.

* Jumper Wires.

Circuit Wiring:

Before moving forward we have to wire the DHT11 temperature and humidity sensor to the ESP8266.

* We shall be taking GPIO5 (D1) of the ESP8266 and connect the data pin of the sensor.

* Connect the VCC and GND of the DHT11 sensor to the ESP8266 which is being powered through the battery of 5V supply. In our case, we are using an Arduino micro-controller for the supply.

* After all the connections are done; we now have to connect the ESP8266 to our local network for being able to provide us with the appropriate response.

* Installation of the DHT Library for the ESP8266:

To be able to read from the sensor, we'll use the DHT11 library from Adafruit. To use this we also need to install the Adafruit Unified Sensor library. These are the required steps:

1. Open you Arduino IDE and go to Sketch -> Include Library -> Manage Libraries, the library shoud open.

2. In the library manager, download the DHT library to work with Adafruit .

3. After installing the library from Adafruit, type "Adafruit Unified Sensor", in the search box, and then install it.

After installing all the required libraries, don't forget to restart the Arduino IDE.

*Installation of the ESPAsyncWebServer library and ESPAsync TCP Library:

The building of the asynchronous web server will require to use ESPAsyncWebServer library that gives a convineint way to set the up the web server.

The ESPAsyncWebServer library needs the ESPAsyncTCP library to work appropriately, so we'll download that also from the internet.

After all the things are done we'll proceed with writing some code.

1.Importing all the libraries

-->First we have to import all the libraries.

2. Setting credentials for the network.

--> We have to insert our network credentials, so that the ESP8266 can connect to our local network.

3. Then we have to define the GPIO pin that we are using for reading the input from the DHT sensor. Then instantiate the DHT object with type and pin.

4. Create an AsyncWebServer object on port 80.

5.Don't forget that the variables used for the temperature and humidity values should be of float type.These values get updated in a loop.

6. The Web Page:

The web page contains one heading and 2 paragraphs: one paragraph to display the temperature and another to display the humidity.

This kind of web page can be easily created using some knowledge of HTML and CSS.Some styling is required and few ideas on how to display icons and how to automatic updates.

7. Now comes the Setup process:

In the setup (), initialize the Serial Monitor for debugging purposes. Initialize the DHT sensor and then connect it your local network and print the ESP8266 IP address.

When we make a request to the root URL, we send the HTML text that is there in the index_html variable. The placeholders will get replaced by the right functional values.

We need to add two handlers to simultaneously update the temperature and humidity readings. When we receive a request for the temperature URL, we'll simply need to forward the updated temperature values.Because it is a plain text it needs to be sent as characters, so we use the c_str() method. The same process is repeated for the humidity.

And now, we can start the server.

8. Now comes the uploading part:

We make sure to have the right board and COM port selected, for whichwe need to go to the tools section up at the top and select the NodeMCU 8266 12E board and select the COM which has been indicated on the bottom right of our screen, and we are good to go.

Now press the Arduino IDE upload button.

9.Esp8266 IP address:

After we are done with uploading the code, we check the serial monitor and there we find the IP address that we need to copy and open it in our web-browser. So the all traffic that has been generated is directed to that URL.

4.2.INTEGRATION OF pH SENSOR:

1.Circuit diagram for the ultrasonic sensor:

-->NodeMCU esp8266 12e that we are using for our project works on 3.3 volts and the pins are also 3.3V TTL compatible. Whereas ultrasonic in the other case works on 5 volts. We cannot power this sensor directly with NodeMCU 3.3V power output pins.

-->We can use a power supply which can output 5V as well as 3.3V or we can use separate power supply for hcsr04 sensor and for the NodeMCU. Don't forget to ground 3.3V and 5V are made common.

-->Echo and trigger pins of the hcsr04 sensor are directly connected to GPIO-2 and GPIO-0 or D4 and D3 pins of nodemcu.

2. Moving on to the coding part:

-->Code is written in the Arduino IDE. It is open source so we can use and modify it according to our needs.First, download the NodeMCU esp8266 support library for the Arduino ide. If not, then first install it. Let's now move on to the ultrasonic distance calculation.The sensor doesn't calculate the distance the by itself , but it registers the time that it has taken to leave the transmitter and bounce back to the receiver and then changes this time to distance according to the formula.

4.3.INTEGRATION OF LEAKAGE ROPE SENSOR:

The circuit will be same as given in the principal section, so the resistance wire of 0.5ohm will be rapped around the whole leakage supply, and when there is a leakage,it beeps and the client part of it will send this signal as a 'YES' to the server, the user then gets to know that there is a leakage.So it is more of boolean system that will give only 2 values: a YES or a NO.

5. RESULT& SIMULATION

The simulation result of ultrasonic sensor as shown in figure-12:

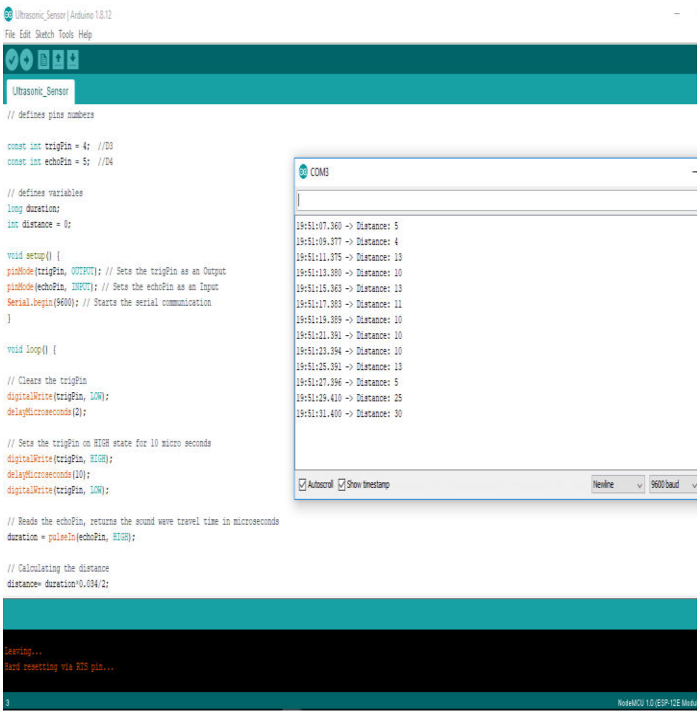

Figure-12: simulation of ultrasonic sensor

The simulation result of pH sensor is shown in figure-13:

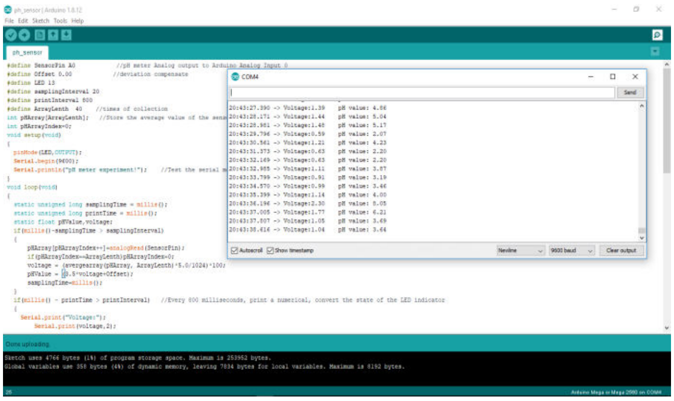

Figure-13: simulation of pH sensor

The simulation result of temperature & humidity sensor as shown in figure-14:

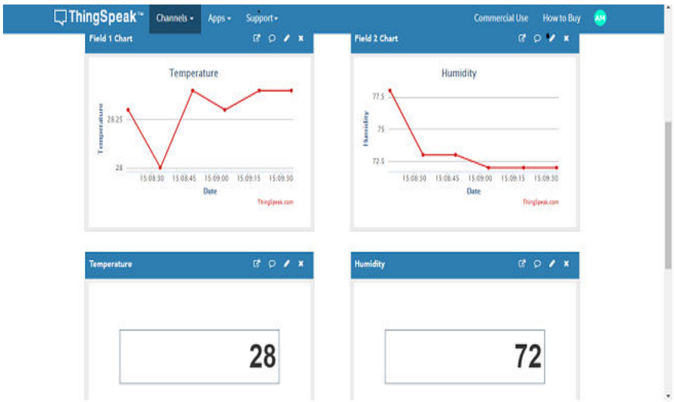

Figure-14: simulation of temperature & humidity sensor

DRAWBACKS

The smart Water Monitoring System has drawbacks such as:

i) high equipment costing,
ii) complicated circuiting,
iii) low measurement precision and
iv) Long processing time.

3. CONCLUSION

The system enhances water monitoring by reducing the human intervention, reducing cost and using the smart Internet of Things technology. The system is used to avoid the enormous loss and wastage of water through uncontrolled use at home or offices making the system more likely to be economical, convenient and fast. This smart water monitoring system monitors the three parameters: level, purity and leakage thereby enabling the user to know the status of the pipes and tank being used by entering the credentials online and giving an indication of the parameters so as to know where exactly the system needs repair. Therefore, this paper gives a brief knowledge on how to monitor the precious resource and save it.

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BIOGRAPHIES

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