Ilkogretim Online - Elementary Education Online, 2020; Vol 19 (Issue 2): pp. 2359-2368
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2020.02.696823

Securing Water Quality And Motor Functionality With Iot Borewell Monitoring

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Abstract

Due to the rising population and excessive water usage, groundwater levels have declined. Inconsistent rainfall patterns and monsoon failures have forced many people to rely on groundwater, leading them to drill wells for their water supply. Unfortunately, water quality is affected negatively by both natural factors and human activities, including improper waste disposal in landfills. This not only affects water quality but also damages farmland. However, technological advancements such as IoT (Internet of Things), cloud computing, big data, and web-based tools have made it possible to address these significant challenges. These include issues related to poor drinking water quality, increased labor demands, and motor damage due to insufficient monitoring.

To tackle these challenges, we have implemented a project that monitors water quality and motor parameters to prevent motor breakdown. The system incorporates two sensors: a pH sensor for assessing water quality and an ultrasonic sensor for measuring water level and temperature. Additionally, a current sensor is employed to monitor the motor's performance. A single microcontroller chip collects data from these sensors, while a Wi-Fi chip transmits this information from a borewell to the cloud. If the data related to water quality and motor performance deviates from the preset thresholds established in the code, this information is relayed to a mobile application accessible to individuals in the area. This system provides a convenient means to remotely monitor various borewell parameters through a mobile application.

Keywords: Node MCU, IoT interface, pH sensor, DHT-11, Ultrasonic sensor, ACS712.

1. Introduction

Increasing urbanization and rapid economic development have brought forth a host of complex challenges. Among these, water contamination and groundwater depletion stand out as significant concerns for the populace. Commonly monitored water quality parameters encompass pH, turbidity, color, conductivity, dissolved oxygen, chloride, sulfate, ammonia, nitrogen (nitrate, nitrite), organic carbon, phosphate, various metal ions, and more. Traditional methods of water quality testing are resource-intensive, requiring considerable time for sample collection, transportation to laboratories, and analysis. Additionally, these methods may suffer from equipment aging and other issues. Sensors offer a solution to these challenges. They are devices capable of efficiently measuring and transmitting signals, simplifying the monitoring of water quality. The system we have implemented incorporates automation, intelligence, and a monitoring system for both water and motors. The conventional approach to water quality testing involves the collection of water samples from the source, followed by transportation to a laboratory for analysis. This method comes with various drawbacks, such as the need for labor, space, and financial resources, and its time-consuming nature. An IoT-based monitoring system addresses these limitations and eliminates the necessity for a central monitoring center. It continuously detects water parameters, including pH and turbidity, as well as motor temperature and current draw, throughout the day. A single microcontroller chip gathers data from sensors responsible for measuring water and motor parameters. It then processes and analyzes this data. If the measured values deviate from the preset limits defined in the code, the system transmits this information through the IoT gateway. Any abnormalities in water or motor parameters trigger the system to send this information to a mobile application installed by local users, facilitating timely actions and remote real-time water quality monitoring. Typically, Internet of Things (IoT) systems come in two main types: those with sensors and those without. IoT systems perform a range of essential functions, including protocol translation, data encoding, data processing, data management, and data filtering. They collect messages from sensors, store data until it can be pre-processed, and subsequently transmit the results. IoT systems determine whether data at a particular processing stage should be temporary, continuous, or stored in memory. This approach ensures that data can be collected and processed as needed.

2. Literature survey:

[1] Mr. Kiran Patil, Mr. Sachin Patil, Mr. Sanjay Patil, and Mr. Vikas Patil proposed a system for monitoring water turbidity, pH, and temperature using GSM. The traditional manual method of testing these parameters involves collecting samples and sending them to a lab, which is inadequate for today's water quality monitoring needs. They developed an automated system that continuously monitors turbidity, pH, and temperature using a single-chip microcontroller.[2] Jianjun Zhang and colleagues designed an online water quality monitoring system based on IoT and Hadoop to enhance environmental protection. This platform uses wireless detection sensors to collect water quality data and

store it in the Hbase server.[3] Bojan Palmar and the team developed an automated system for monitoring the quality of river water in Serbia. Automatic stations monitor basic parameters like temperature, pH, and dissolved oxygen concentration. Additional automatic stations on the river Tisa include sensors for turbidity, ammonium ion, and chlorophyll.[4] Vaishnavi V. Daigavane introduced an affordable IoT-based water quality monitoring system capable of measuring parameters such as temperature, pH, turbidity, and flow. The core controller is the Arduino model, and sensor data can be accessed on the internet via Wi-Fi.[5] T. Hasan and Samiha Khan designed a GSM-based automatic water quality control analysis system. This system includes pH sensors, turbidity sensors, conductivity sensors, a single-chip microcontroller data acquisition module, an information transmission module, a monitoring center, and more. It continuously monitors various water quality parameters under the control of a single-chip microcontroller.[6] D.B. Palamkar discussed a system for monitoring and controlling three-phase induction motors using PLC and SCADA technology, commonly used in various industrial applications.[7] Prof. M.S. Badmera proposed a PLC and SCADA-based condition monitoring system for three-phase induction motors. The system offers features like speed control, direction control, and parameter monitoring on a SCADA screen.[8] K. Rajasekar and the team developed a system for measuring and analyzing water quality using GSM. A single-chip PIC microcontroller continuously monitors water quality parameters and sends data to the monitoring center via GSM, promptly reporting any anomalies.[9] S. Pingle described an automatic system for measuring and reporting water quality based on GSM. The system includes PIC microcontrollers, water quality sensors, a base station, a monitoring center, and other components. It monitors parameters such as pH level, dissolved oxygen, turbidity, and temperature.

3. Problem definition

People continue to rely on groundwater to overcome water scarcity. As a result, monitoring water quality is critical and should be done in a timely way. Motor failures can cause substantial damage, thus it is critical to check both water quality and motor characteristics concurrently.

4. Hardware description ph sensor:

pH serves as a crucial indicator of a liquid's acidity or alkalinity, closely linked to the concentration of hydrogen ions within the liquid. It is measured on a scale that spans from 0 to 14, where a pH of 7 represents a neutral solution. When the pH value falls below 7, it characterizes an acidic solution, and when it rises above 7, it indicates a basic solution. Essentially, pH reveals the presence of free hydrogen and hydroxyl ions in the water. More free hydrogen ions denote acidity, while an abundance of free hydroxyl ions indicates alkalinity.

Chemicals in the water can influence the pH level, making it a vital tool for tracking chemical changes in the water. The pH scale is logarithmic, and extreme pH values, whether too high or too low, can impact the suitability of water for various purposes.

Elevated pH levels can result in a bitter taste, whereas low-pH water can corrode or dissolve metals and other substances.

To measure water acidity across the 0-14 range, pH sensors are employed. Various types of sensors are used to assess different water qualities. For instance, a pH sensor can be applied in diverse scenarios, including laboratory experiments, acid-base titrations, monitoring pH levels in aquariums, and assessing water quality in rivers and lakes.

Current sensor:

When an electric current flows through a conductor, it leads to a voltage drop, and this relationship between current and voltage is defined by Ohm's law. Accurately measuring current is crucial for the proper operation of electronic devices. Monitoring voltage is a passive task that doesn't impact the device's operation. In contrast, measuring current is an active and somewhat intrusive task that can't be directly assessed like voltage. To measure current in a circuit, you need a specialized sensor, and the ACS712 Current Sensor is designed for this purpose. The ACS712 Current Sensor is a fully integrated sensor IC that operates based on the Hall effect. It provides a non-invasive way to measure and calculate the amount of current passing through a conductor without disturbing the performance of the system. This sensor features a 2.1kV RMS voltage isolation capability and incorporates a low-resistance current conductor. To detect current, the sensor uses a linear, low-offset Hall sensor circuit, which is positioned on the surface of the IC, along a copper conduction path. When an electric current flows through this copper conduction path, it generates a magnetic field, and this magnetic field is then detected by the Hall effect sensor. The thickness of the copper conductor is such that it allows the sensor to withstand currents up to five times the rated value, ensuring its robustness. Importantly, the terminals of the conductive path are electrically isolated from the sensor's leads (pins 5 through 8). This feature allows the ACS712 current sensor to be used in applications that require electrical isolation without the need for expensive isolation techniques like opto-isolators.

Ultrasonic sensor:

Ultrasonic sensors operate by emitting sound waves at a frequency that falls outside the range of human hearing. These sound waves are then sent out, and the sensor waits for them to bounce back. It calculates the distance by measuring the time it takes for the sound wave to travel to the target and return, much like how radar works with radio waves. The sensor determines the distance to an object by assessing the time it takes for the ultrasonic pulse to return.

The core principle behind this module is quite simple. It generates an ultrasonic pulse at a frequency of 40kHz, which travels through the air. If there's an obstacle or object in its path, the pulse reflects to the sensor. By measuring the time it takes for this round trip and taking into account the speed of sound, the sensor accurately calculates the distance to the object.

While some sensors employ separate components for sending and receiving sound, it's also possible to integrate these functions into a single device. In this integrated sensor, the ultrasonic component alternates between transmitting and receiving signals. Such integrated sensors can be designed in a smaller form factor, which is beneficial for applications where size is a critical factor.

Ultrasonic sensors are readily available and cost-effective compared to other sensor technologies like radar. They perform well in conditions where other sensors might encounter difficulties, such as when dealing with dust or smoke. However, it's worth noting that if an object is made of a material that absorbs sound or is shaped in a way that deflects sound waves away from the sensor, it may result in inaccurate distance measurements.

The formula for calculating distance using ultrasonic sensors is Distance = ½ × Time × Speed of Sound. At a temperature of 20°C (68°F), the speed of sound is approximately 343 meters per second (1125 feet per second), though this value can vary depending on temperature and humidity conditions.

Temperature sensor:

The DHT11 sensor is composed of two primary elements: a capacitive humidity sensor and a thermistor for temperature detection. The capacitive humidity sensor consists of two electrodes separated by a humidity-absorbing substrate that acts as a dielectric. Changes in humidity levels result in modifications to the capacitance value between these electrodes. The integrated circuit within the sensor processes these variations in resistance values and converts them into digital data. The temperature sensor, depicted in Figure 3.5, employs a Negative Temperature Coefficient (NTC) thermistor. This thermistor exhibits a decrease in resistance as the temperature rises. The DHT11 sensor has a temperature measurement range of 0 to 50 degrees Celsius with an accuracy of 2 degrees. It also measures humidity in the range of 20 to 80% with an accuracy of 5%. The sensor operates at a testing rate of 1Hz, providing one reading per second. The DHT11 is compact and operates on a voltage range of 3 to 5 volts. It consumes a maximum current of 2.5mA during measurements.

Voltage regulator:

The voltage regulator IC 7805 belongs to the 78xx series of voltage regulator ICs and is a fixed linear voltage regulator. The "xx" in 78xx represents the specific fixed output voltage that the IC provides. In the case of the 7805 IC, it delivers a regulated +5V DC power supply. This IC also includes provisions for attaching a heat sink to manage heat dissipation.

The voltage regulator, as shown in Figure 3.6, is designed to accept input voltages of up to 35V. It can provide a stable 5V output for any input voltage less than or equal to 35V, which is its upper limit. The typical input voltage range is between 7V and 35V, and this voltage is applied to the input pin. The unregulated voltage is connected to this pin for regulation.

The ground pin is connected to the neutral or ground, and the output pin provides the regulated voltage, typically falling within the range of 4.8V to 5.2V.

ESP-8266 WI-FI module

The Wi-Fi Module with the ESP8266 is an all-in-one System-on-a-Chip (SoC) that includes a built-in TCP/IP protocol stack. It allows any microcontroller to access your Wi-Fi network and can operate as a host for an application or manage all Wi-Fi networking tasks, freeing up the application processor's resources. The ESP8266 module comes with pre-loaded firmware that supports AT command sets, making it easier to connect it to your Arduino device and effectively transforming it into a Wi-Fi Shield.

To send data collected from sensors to remote cloud storage, a Wi-Fi module is necessary, and we've chosen the NodeMCU ESP8266 Wi-Fi module for this purpose. This SoC module features an integrated processor and 9 pins for general-purpose input and output, as well as Rx and Tx pins for data transmission and reception. The Tx and Rx pins of the ESP8266 are linked to the 2nd (Tx) and 3rd (Rx) pins of the Arduino Uno, allowing temperature and humidity data to be transmitted. The NodeMCU ESP8266 has an input voltage of 3.3V.

DC Motor

An electric motor is an electrical device that converts electrical energy into mechanical power. The fundamental operating principle of a DC motor is as follows: "Whenever a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force." This force's direction is determined by Fleming's left-hand rule, and its magnitude is given by the formula F = BIL, where B represents the magnetic flux density, I is the current, and L is the length of the conductor within the magnetic field.

Fleming's left-hand rule can be visualized by extending the first finger, second finger, and thumb of your left hand so they are perpendicular to each other. The first finger represents the direction of the magnetic field, the second finger indicates the direction of the current, and the thumb shows the direction of the force experienced by the conductor carrying the current.

When armature windings are connected to a DC power source, electric current flows through the winding. The magnetic field can be generated either by field windings (electromagnetism) or by using permanent magnets. In this setup, the armature conductors carrying current experience a force due to the magnetic field, following the previously mentioned principle. The commutator is segmented to ensure unidirectional torque. Without this segmentation, the direction of the force would reverse each time the conductor's motion direction within the magnetic field changed. This is the fundamental principle of how a DC motor operates.

5. Proposed methodology

Working:

Implementing IoT-based centralized borewell monitoring is a wise approach, particularly in the face of labor shortages and the suboptimal maintenance of open borewells. Detecting motor dry runs, where an increase in temperature precedes motor breakdown, is crucial. Therefore, monitoring motor temperature is essential. Additionally, it's important to continuously monitor water quality parameters such as pH (indicating water acidity, alkalinity, and suitability for drinking) and turbidity (reflecting water clarity and purity).

To achieve this, a pH sensor is used for assessing water quality, and a DHT11 sensor is employed to detect dry runs in the motor. Elevated motor temperature is a key indicator of potential issues. A current sensor (ACS712) is also integrated to monitor the motor's current consumption, providing insights into whether the motor is operating under load or not. Furthermore, an ultrasonic sensor is employed to measure the depth of water in the borewell.

The pH sensor is placed within the borewell containing water, while the temperature and current sensors are positioned near the motor. These sensors collect data under operational conditions when the motor is running, and the borewell has water. Wired connections are used to transmit the sensor data to an Arduino Uno, which processes the data and then forwards it to an ESP8266 NodeMCU.

The ESP8266 NodeMCU, functioning as a Wi-Fi chip, establishes network connectivity for the entire system by serving as a local hotspot. The data collected from the sensors is relayed from the Arduino to the ESP8266 NodeMCU, which enables wireless communication with the server, facilitating remote data transmission.

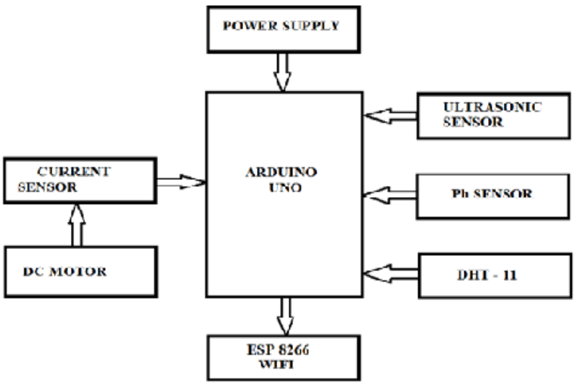

Figure 1: Flow diagram

Working principle:

The proposed system is depicted in Figure 1 through a flowchart. The DC motor is monitored for power consumption using a current sensor, which is connected to the analog pin (A0) of the Arduino. Meanwhile, the ultrasonic sensor's trigger and echo pins are linked to digital pins 9 and 10 on the Arduino. The pH sensor is connected to the 2nd and 3rd pins of the Arduino, and the DHT-11 sensor is attached to the 7th pin of the

Arduino.
To facilitate data exchange, the TX (transmit) pin of the ESP-8266 Wi-Fi module is connected to the RX (receive) pin of the Arduino, and vice versa. The transmitted data is sent to the ThingSpeak platform, where you need to register and log in to your account to begin. Create a new channel to collect data on temperature, pH, current, and turbidity. Once you create a new channel, you will receive a unique API key for each channel. Remember to include these API keys in your program to specify the destination channel for sending data.

Lastly, replace the placeholders for the Wi-Fi network name and password with your actual network credentials, which will enable the system to connect to your Wi-Fi network.

6. Result and discussion

Figure 2: Graph of the pH

Figure 2 displays a graph depicting the pH value in water. In this graph, a pH value ranging from 7 to 8 indicates that the water quality is excellent and suitable for

drinking. Conversely, when the pH value exceeds 9, it signifies that the solution is alkaline (base).

Figure 3: Graph of the Temperature

In Figure 3, you can observe a graph representing the temperature values of the motor. Typically, the normal temperature range for the motor falls between 31°C to 36°C. However, if the temperature surpasses this range and goes beyond, it can lead to motor

damage.

Figure 4: Graph of the current

Figure 4 illustrates a graph depicting the current drawn by the motor. This graph serves as a valuable tool for monitoring the current consumption of the motor, providing insights into its operational status and efficiency.

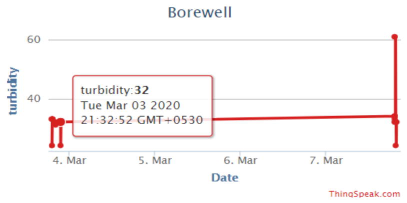

Figure 5: Graph of the turbidity

Figure 5 shows the turbidity value which can be calculated from the pH value

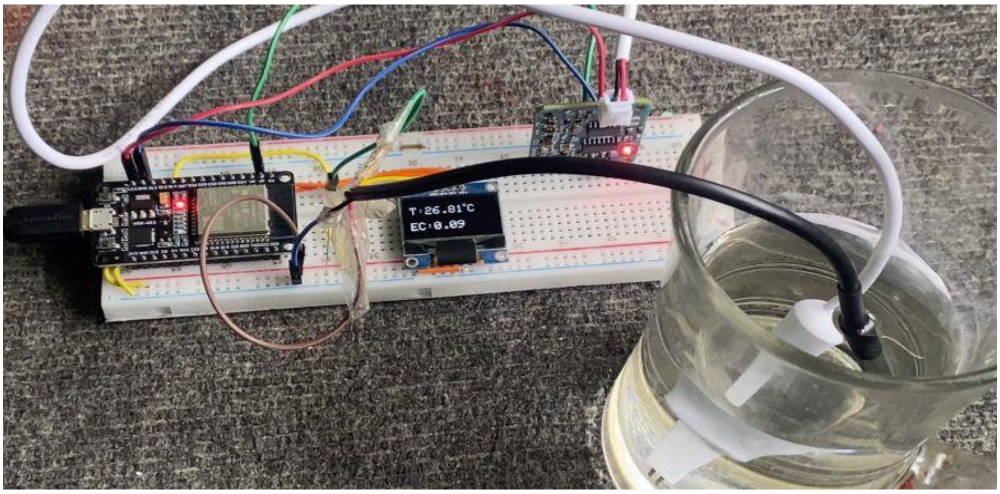

Figure 6: IoT-based water quality and motor monitoring in borewell

7. Conclusion

The field of the Internet of Things (IoT) is growing quickly, and it allows devices to function independently without human involvement. This project aims to use IoT technology to continuously monitor water quality and motor parameters in a specific environment. The system collects temperature, pH, and current data and sends it to a remote cloud storage system using Wi-Fi. This allows for real-time graphical analysis of the data. The system is affordable, compact, and saves time by identifying irregularities promptly. It can also be used in industrial settings to oversee motor performance and assess the quality of wastewater before it is released into water bodies.

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