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IoT Based Water Pollution Monitoring System Using RC Boat

S. Rishikesh[1*], Gautam Moni Patro[1], M. Bhoolakshmi[2], Ch. Bhuvan Kumar[2], U. Deva[2]

[1]*Assistant Professor, Department of Electrical and Electronics Engineering, Avanthi Institute of Engineering & Technology, Makavarapalem, India*

[2]*UG Student, Department of Electrical and Electronics Engineering, Avanthi Institute of Engineering & Technology, Makavarapalem, India*

***Abstract*: Water bodies such as lakes, canals and reservoirs are a major source of drinking water, yet they are increasingly contaminated by domestic sewage, solid waste, toxic effluents and agricultural runoff. Conventional water-quality monitoring relies on manually rowing or motoring a boat across a water body to collect samples for laboratory analysis, a process that is slow, labour-intensive and covers only a few sample points. This paper presents the design and implementation of a remote-controlled (RC) boat that automates this process by combining wireless remote control with Internet-of-Things (IoT) based sensing. The boat carries a pH sensor and a temperature-and-humidity sensor to characterise water quality, and a GPS module to record the location at which the readings were taken. A NodeMCU (ESP8266) micro-controller reads the sensors and the GPS coordinates and streams the data over Wi-Fi to the Blynk IoT cloud platform, where it can be viewed in real time on a smartphone. Boat movement is controlled independently through a 434 MHz RF link using an HT12E encoder/HT12D decoder pair and an L293D motor driver, so that navigation and sensing operate as two decoupled modules. A working prototype was built and tested on a local water body; the system successfully reported live pH, temperature, humidity and GPS values to a mobile device, demonstrating that the approach can replace manual sampling for routine monitoring of lakes and reservoirs.**

***Keywords*: Internet of Things (IoT), water quality monitoring, RC boat, pH sensor, NodeMCU, RF communication, Blynk application, GPS.**

1. Introduction

Water quality plays a critical role in the health of humans, animals and the wider environment, and lakes, canals and reservoirs remain among the principal sources of drinking water. Water pollution - the introduction of pollutants such as domestic sewage, solid waste, toxic chemicals and agricultural runoff into a water body - disrupts aquatic life processes and can compromise entire food chains. Because water is an almost universal solvent, it is highly susceptible to contamination, and while pollution can occur naturally, most high-impact causes are anthropogenic. Excess nutrients from sewage and fertiliser runoff promote algal blooms; as the algae die and decompose, dissolved oxygen is depleted and anaerobic organisms release methane and hydrogen sulphide, harming aquatic life. Contaminated water is also a direct threat to human health, spreading water-borne illnesses such as cholera, dysentery and typhoid.

The first step towards controlling water pollution is the ability to monitor its actual level. Water-quality standards define the allowable limits of parameters such as dissolved oxygen, turbidity, pH and biochemical oxygen demand, but enforcing them requires frequent, distributed measurement across a water body. This project addresses that need with an RC boat that carries water-quality sensors and an IoT communication link, so that a water body can be surveyed quickly and its data made available remotely, without a person having to physically travel to and sample every point on the water body.

2. Existing Method and Motivation

The conventional approach to water-quality monitoring is to take a boat out onto a lake or reservoir and manually collect samples at various points, which are then transported to a laboratory for analysis. This method is accurate but has three practical drawbacks: it requires continuous manual effort each time the water body is checked, it is slow because results are only available after laboratory testing, and it typically samples only a handful of locations, giving an incomplete picture of overall water quality. These limitations motivate an automated, remotely operated alternative that can record and transmit water-quality data in real time from any point on a water body, which is the objective of the system described in this paper.

3. Proposed System

The proposed system is organised into two independent modules: a remote controller (Module 1) that steers the boat, and a control-and-sensing unit (Module 2) built into the RC boat itself that measures water quality and reports it over the Internet. Separating navigation from sensing keeps the RF control link simple and low-power while allowing the sensing sub-system to use Wi-Fi for high-level data transmission.

Module 1 consists of four push buttons, an HT12E encoder and a 434 MHz RF transmitter, powered from a 9 V battery. Pressing a button (or a diagonal pair of buttons, for turning) causes the encoder to serialise the corresponding address/data bits, which are broadcast by the transmitter. Fig. 1 shows the block diagram of this module.

*Corresponding author: sripathirishikesh@gmail.com

Fig. 1. Block diagram of Module 1 (remote controller)

Module 2 is the RC boat itself. An RF receiver and HT12D decoder recover the transmitted command and pass it to an L293D motor driver, which drives the two propulsion motors so that the boat moves forward, backward or turns. In parallel, a separate battery, stepped down through a voltage regulator / buck converter, powers a NodeMCU that reads a pH sensor, a combined temperature-and-humidity sensor and a GPS module, and pushes the collected readings to the Blynk IoT cloud over Wi-Fi. Fig. 2 shows the block diagram of this module.

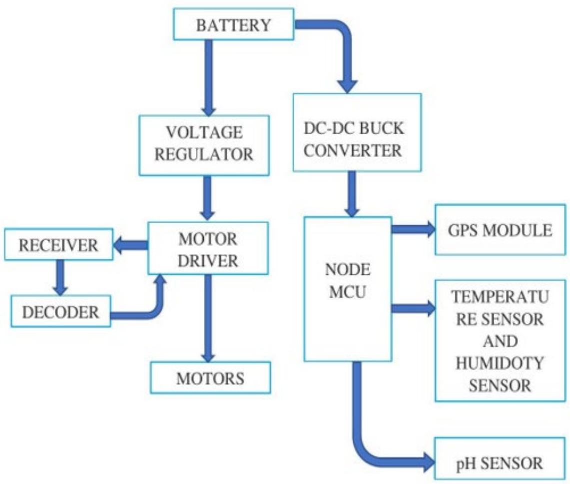

Fig. 2. Block diagram of Module 2 (control unit and sensing unit)

4. Hardware Description

A. HT12E Encoder/HT12D Decoder

The HT12E is a 2^12-series CMOS encoder that converts 12 bits of parallel input (8 address bits and 4 data bits) into a serial stream suitable for RF or infrared transmission; it begins a 4-word transmission cycle whenever its active-low Transmission-Enable pin is asserted. The matching HT12D decoder recovers the 12-bit word at the receiver, checking the incoming serial address against its own address pins three times before accepting the data, and presents the 4 decoded data bits on latched output pins together with a Valid-Transmission (VT) flag. Using a matched encoder/decoder pair with identical address settings keeps the boat from responding to a stray or unrelated RF transmitter.

B. RF Transmitter and Receiver Module

The 433 MHz ASK transmitter/receiver pair carries the encoded command from the remote control to the boat. Compared with infrared, RF does not require line-of-sight and is far less susceptible to interference from other IR sources, giving a usable range of about 50–100 m in open space at a data rate of 1–10 kbps.

C. L293D Motor Driver

The L293D is a dual H-bridge motor-driver IC that can independently control the speed and direction of two DC motors rated up to 36 V and 600 mA continuous current per channel. Its enable and input pins are driven directly by the HT12D decoder outputs, so the diagonal push-button combinations on the remote translate directly into forward, reverse and turning motion of the boat's twin propellers.

D. NodeMCU (ESP8266)

NodeMCU is an open-source Wi-Fi-enabled development board built around the ESP8266 SoC. In this system it is the central controller of the sensing unit: it reads the analog pH signal, polls the temperature/humidity sensor over its digital I/O, receives NMEA sentences from the GPS module through software serial, and pushes all four quantities to the Blynk cloud as virtual-pin writes at regular intervals.

E. pH Sensor

An analog pH electrode and signal-conditioning board measure the hydrogen-ion activity of the water. The sensor output voltage is scaled in firmware (using a calibration offset and slope) to a pH value on the standard 0–14 scale, which is read by the NodeMCU's analog input.

F. DHT11 Temperature and Humidity Sensor

A DHT11 digital sensor provides ambient temperature and relative humidity readings for the air just above the water surface, giving context for interpreting the water-quality readings and for general environmental logging.

G. GPS Module

A GPS receiver continuously acquires satellite signals and outputs the boat's latitude and longitude. This location tag is transmitted alongside the sensor readings so that a given pH, temperature or humidity value can be mapped back to the exact point on the water body at which it was recorded.

H. Power Supplies

The navigation module is powered from a 9 V battery. The sensing module uses a separate 9 V supply stepped down by a DC-DC buck converter to 5 V for the NodeMCU and sensors, while the receiver/motor-driver section uses an L7805 linear regulator to derive a stable 5 V logic supply from the drive battery, isolating logic-level circuitry from motor switching transients.

I. Propulsion and Mechanical Structure

Twin 9 V DC motors, each coupled to a propeller through a flexible shaft, provide forward and reverse thrust; running the two propellers differentially allows the boat to turn. The hull is built from extruded polystyrene (XPS) sheet, chosen for its high strength-to-weight ratio, buoyancy and ease of shaping, which keeps the electronics enclosure well above the waterline.

5. Circuit Design and Implementation

A. Remote Transmitter Circuit

Fig. 3 shows the transmitter circuit. The encoder's eight address pins (A0–A7) are grounded so that they match the corresponding address pins on the decoder; its four data pins (AD8–AD11) are each wired to one side of a push button, with the other side of each button returned to ground. A 1 MΩ resistor across the oscillator pins sets the encoder's internal clock rate, and the DOUT pin feeds the DATA input of the RF transmitter directly. Pressing a button pulls the corresponding data line low, causing the encoder to transmit that address/data word for as long as the button is held.

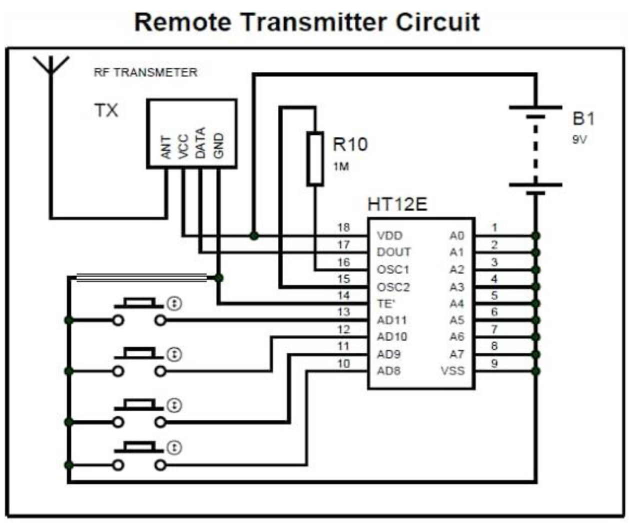

Fig. 3. Circuit diagram of the remote transmitter

B. Receiver and Motor Driver Circuit

Fig. 4 shows the receiver-side circuit. The RF receiver's DATA output feeds the HT12D DIN pin directly; once three consecutive matches are found against the (grounded) local address bits, the decoder latches the 4 data bits on D0–D3 and asserts VT. These four lines drive the L293D's Input 1–4 pins, so each button press on the transmitter maps to a specific combination of motor directions. A 33 kΩ resistor sets the decoder's oscillator frequency, an L7805 regulator supplies a clean 5 V logic rail, and a separate, higher-current supply feeds the L293D's motor-voltage pin (Vs) so that motor switching does not disturb the decoder's logic supply.

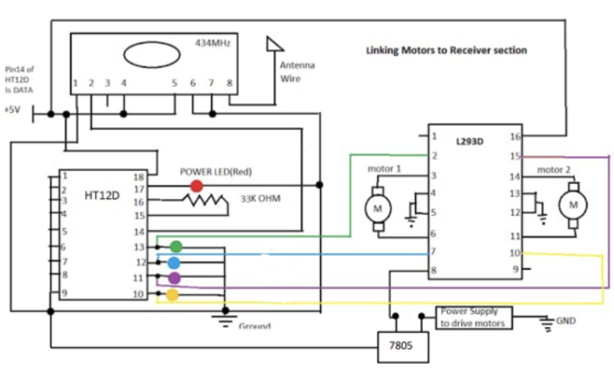

Fig. 4. Circuit diagram of the receiver and motor-driver section

C. Sensing Unit Circuit

Fig. 5 shows the sensing-unit wiring. A 9 V battery feeds a DC-DC buck converter set to a regulated 5 V output, which powers the NodeMCU, the pH sensor board and the temperature/humidity sensor. The pH sensor's analog output is wired to the NodeMCU's A0 pin; the GPS module's TX and RX lines connect to two NodeMCU GPIO pins configured as a software-serial port; and the temperature/humidity sensor's data line connects to a third GPIO pin. All grounds are returned to a common node so that the analog pH reading is not corrupted by ground-loop noise from the motor section.

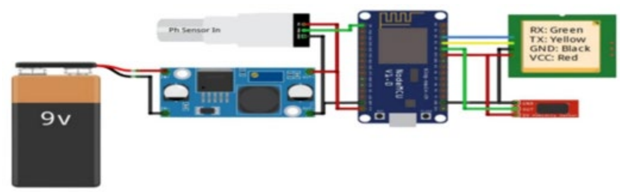

Fig. 5. Circuit diagram of the sensing unit

6. Software Implementation

Firmware for the NodeMCU was written and uploaded using the Arduino IDE. The sketch includes the DHT, TinyGPS++ and ESP8266 Wi-Fi/Blynk libraries. In the main loop, the firmware parses NMEA sentences from the GPS module and, once a valid fix is obtained, writes latitude and longitude to Blynk virtual pins V1 and V2; reads humidity and temperature from the DHT sensor and writes them to V3 and V4; and reads the analog pH sensor, converts the raw ADC value to a pH reading using a linear calibration ((rawValue − offset)/scale), and writes the result to V5. Blynk.run () is called on every iteration so that the connection to the cloud stays alive and the mobile dashboard updates continuously. On the Blynk mobile application, gauge widgets bound to V1–V5 display the boat's live location, humidity, temperature and pH value, so that a user anywhere with internet access can monitor the water body without being physically present.

7. Results and Discussion

A working prototype (Fig. 6) was assembled on a polystyrene hull with the navigation electronics, sensing electronics and batteries mounted in a waterproof enclosure. The RC boat responded correctly to all four control commands from the remote transmitter, moving forward, reversing and turning as expected. With the sensing module powered on and connected to a Wi-Fi hotspot, the NodeMCU successfully streamed live data to the Blynk dashboard.

Fig. 6. Assembled RC boat prototype with sensing and navigation electronics

Fig. 7 shows a representative snapshot of the Blynk application during a test run on a local water body: a latitude of 17.681° and longitude of 82.995°, a relative humidity of 40%, an ambient temperature of 32.4 °C and a pH value of 7.829, indicating mildly alkaline, near-neutral water. Because each reading carries a GPS tag, successive runs can be used to build a spatial map of water quality across the surveyed body rather than a single point value, which is the main advantage of this system over manual sampling.

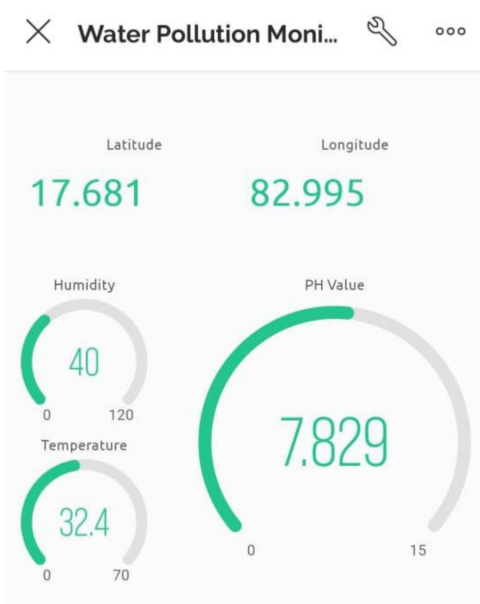

Fig. 7. Blynk application dashboard showing live GPS, humidity, temperature and pH readings

8. Conclusion

This paper presented an IoT-based water pollution monitoring system built around a remote-controlled boat, in which navigation is handled by a dedicated 433 MHz RF encoder/decoder link and water-quality sensing is handled by a NodeMCU that reports pH, temperature, humidity and GPS location to the Blynk cloud in real time. Compared with the conventional practice of manually sampling water and sending it to a laboratory, the proposed system removes most of the manual effort and delay, is low-cost, and is easy to operate. Because the architecture only requires replacing or adding a sensor and updating the corresponding firmware routine, it can be extended to monitor other water-quality parameters, or adapted to other application areas such as air-pollution or industrial-effluent monitoring, without redesigning the navigation module.

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