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OxySen Pond

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Abstract: Dissolved oxygen - oxygen molecules dissolved in water - is a key indicator of water quality. Like the air we breathe, the survival of aquatic life depends on sufficient levels of dissolved oxygen in the water. When water drops below the level necessary to support life, it causes a significant decrease in water quality, often referred to as low dissolved oxygen (DO). Dissolved oxygen in water is a key parameter for maintaining healthy aquatic life. Different aquatic animals require different concentrations of dissolved oxygen to survive. Dissolved oxygen is usually measured in mg/L or ppm (parts per million). The OxySen Pond (Oxygen Sensing Pond) is a real-time dissolved oxygen monitoring system that covers fish ponds as large as 10 hectares. It consists of 4 nodes, 1 of which is the master node and the remaining 3 are slave nodes. All these slave nodes communicate with the master node, then the master node uses a GSM module to upload public data to the MQTT (Message Queuing Telemetry Transport) cloud, thereby monitoring real-time data remotely and providing precise and accurate recommendations.

Keywords: Dissolved Oxygen, OxySen Pond, Mesh networking, MQTT, ESP32, GSM Module.

I. INTRODUCTION

The oxygen that makes aquatic life possible does not form bubbles, nor does the oxygen that is part of the H_2O water molecule. It is a single O_2 molecule that is dissolved in water and invisible to our eyes. Many species of aquatic macroinvertebrates depend on oxygen-rich water. Without enough oxygen, they can disappear. Even a small change in dissolved oxygen concentration can affect the composition of aquatic communities.

Unlike air, which usually contains about 21 percent oxygen, water contains only a small amount of dissolved oxygen. In water, it is usually expressed in milligrams per litre (mg/l), or parts per million (ppm). At sea level, typical DO concentrations in 100% saturated freshwater can vary from 7.56 mg/L (or 7.56 parts oxygen in 1,000,000 parts water) at 30° Celsius to 14.62 mg/L at 0° Celsius. The amount of dissolved oxygen that a body of water can hold is a function of atmospheric pressure, water temperature, and the number of other dissolved substances in the water. At sea level, fresh water can absorb more oxygen than water at higher altitudes due to the higher atmospheric pressure near sea level [1].

Dissolved oxygen is measured directly in the water using a calibrated dissolved oxygen sensor. This sensor can measure dissolved oxygen in water directly as mg/L or as a percent dissolved oxygen (%DO). Cold water has higher mg/L of dissolved oxygen and higher %DO while warmer, polluted water has lower mg/L and %DO. Healthy water should generally have dissolved oxygen concentrations above 6.5-8 mg/L and between 80-120 % [2] .

Our goal in this project is to improve and increase the life span of the aquatic life living in the pond that would suffocate due to the deficiency or insufficient amount of dissolved oxygen present in the water due to inappropriate and inefficient methods used to add the dissolved oxygen thus, resulting in low water quality for the fishes to survive in.

II. RELATED WORK

[3] describes the development of a low-cost dissolved oxygen measurement system for aquaculture ponds. The system uses a commercially available oxygen sensor and a microcontroller to monitor and record dissolved oxygen levels. The authors found that the sensor was accurate and reliable and could be used to monitor dissolved oxygen levels in real time. In [4], the development of an intelligent dissolved oxygen monitoring system for fishponds based on wireless sensor networks is described. The system uses multiple sensors to monitor dissolved oxygen levels in different locations in the pond and transmits the data wirelessly to a central computer for analysis. The authors in [5] describe the design and fabrication of a microfluidic chip for dissolved oxygen sensing in a fish pond. The chip uses a fluorescence-based oxygen sensor and can be placed in the pond to monitor dissolved oxygen levels. The authors found that the system was accurate and reliable and could be used to monitor dissolved oxygen levels in real-time. Whereas [6] described design information on three types of nodes in a wireless sensor network in detail. Tree topology for WSN is adopted to decrease the packet

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loss rate and improve the reliability of data transmission. Allowing sensor nodes to sleep and reorganizing the data frames are the two approaches used to achieve energy-saving. The WSN unit consists of a number of WSN sensor nodes, some routing nodes and one gateway node. The gateway node automatically creates the wireless network and administrates it according to default or manual configurations. The gateway node is responsible for not only accepting data from sensor nodes but also transmitting them to the monitoring computer in the monitoring centre for further processing using the GPRS module. In [7], the fishpond monitoring system is designed based on stm32 and Zigbee wireless transmission technology. This study uses Zigbee to build up a sensor network to monitor multi-fishponds. The data acquisition unit consists of a temperature sensor and a dissolved oxygen sensor. The sensor data is transferred from the data acquisition unit to the stm32 master controller.

III. PROPOSED SYSTEM

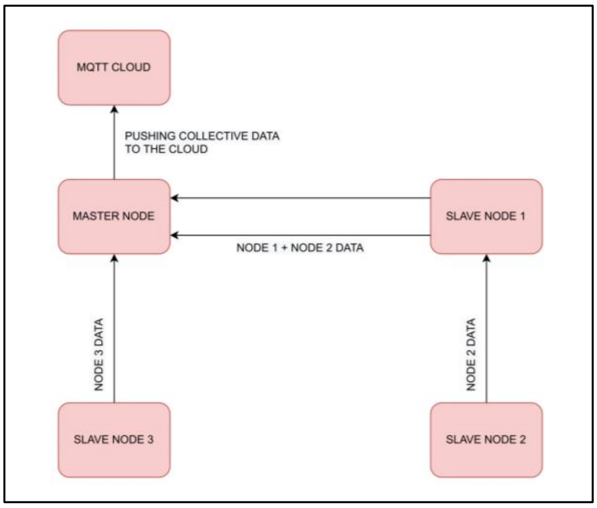

Fig.1. Overall Block Diagram

Fig.1. illustrates the overall block diagram of the proposed system i.e., the OxySen Pond which is a real-time dissolved oxygen monitoring system with the main objective of optimizing the use of dissolved oxygen thus reducing the wastage or inefficient use in today's existing systems. This system consists of 4 nodes spread in a rectangular arrangement in order to monitor a large pond. Out of these 4 nodes, 3 serve as the Slave nodes and the remaining one serves as the Master node. The nodes are completely powered through solar panels and backed up with a battery, each node has its own MCU and DO sensor and additionally, they have a LoRa module for mesh networking (communication between nodes). Master Node has an additional GSM Module which collects the data from all the slave nodes and pushes it to the MQTT cloud for data storage and future analysis.

The block diagram and its brief description of the Master and Slave nodes are classified below: -

A. Master Node:

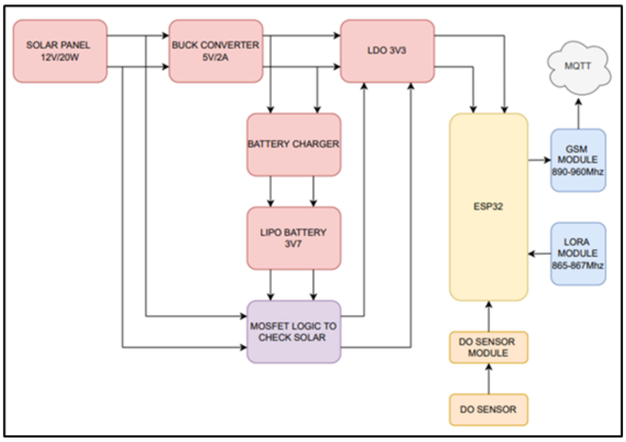

Fig.2. Block Diagram of Master Node

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The block diagram of Master Mode is shown in the above figure. It consists of a Solar panel of 12V/20W which works as a source of the entire system. Next comes the Buck converter (5V/2A) which is used to step down the DC input voltage (12V) and provides the DC output voltage (5V) to the Battery charger required to charge the LIPO battery of 3.7V. The same DC output voltage is given as an input to the LDO (Low Dropout Regulators), which are used to provide a regulated output voltage of 3.3V which is then fed to ESP32 MCU, the heart of this system.

Furthermore, a DO sensor and a module are connected to the ESP32 to control and which is used to sense and measure the amount of DO (Dissolved Oxygen) in the water. Next, we have a LORA Module that is a secure, regulatory-certified, Arm® Mbed™ programmable, low-power RF module, providing long-range, low-bit rate IoT data connectivity to sensors and actuators. At last, it has a GSM module which is used to publish/upload the data collected on the MQTT cloud which is a lightweight, publish-subscribe, machine-to-machine network protocol for Message queue/Message queuing service and is designed for connections with remote locations that have devices with resource constraints or limited network.

B. Slave Node:

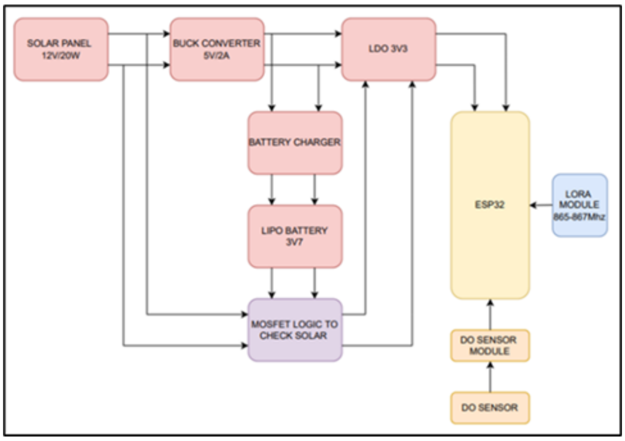

Fig.3. Block Diagram of Slave Node

Fig 3. shows the block diagram of the Slave Node. The working of the Slave node is similar to that of the Master Node and the only difference here is, that it does not have a GSM module to publish the data on the MQTT cloud. The data collected by all the Slave nodes is given to the Master Node and then it collectively shares/uploads the data on the cloud.

IV. REQUIREMENTS

A. Hardware:

1) ESP 32 Development Board - ESP32 Development board is based on the ESP WROOM32 WIFI + BLE Module. It is a compact, simple system development board that is simply placed into a solderless breadboard and is powered by the most recent ESP-WROOM-32 module. It includes the micro-USB connector, LDO regulator, reset and boot mode buttons, USB-UART bridge, and all the essential support circuitry for the ESP-WROOM-32. The developer has access to all crucial GPIOs.
2) Solar Panel 12V/20W - Solar panels capture sunlight as a source of radiant energy, which is converted into electric energy in the form of direct current (DC) electricity.
3) LIPO Battery 3.7V/10000mAh – A Lithium Polymer battery is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte.
4) LDO 3.3V - A low-dropout regulator is a DC linear voltage regulator that can regulate the output voltage even when the supply voltage is very close to the output voltage.
5) Dissolved Oxygen Sensor - It is used to measure dissolved oxygen concentration in water based on the quenching of luminescence in the presence of oxygen.
6) GSM Module - A GSM modem or GSM module is a device that uses GSM mobile telephone technology to provide a wireless data link to a network.
7) Printed Circuit Board (PCB) - A PCB is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or signal traces etched from copper sheets laminated onto a non-conductive substrate.

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8) Discrete Components like TH and SMD -
TH: Through-hole is a manufacturing scheme in which leads on the components are inserted through holes drilled in PCBs and soldered to pads on the opposite side.
SMD: Surface Mount is a method in which the electrical components are mounted directly onto the surface of a printed circuit board (PCB).

B. Software:

1) Arduino IDE (Integrated Development Environment) - The Arduino Integrated Development Environment - or Arduino Software (IDE) It has a menu system, a toolbar with buttons for common functions, a message area, a text console, and a text editor for writing code. To upload programs and communicate with them, it connects to the Arduino hardware.
2) Altium Designer - Altium Designer (AD) is a PCB and electronic design automation software package for printed circuit boards. It is developed by Australian software company Altium Limited. Altium Designer's suite encompasses four main functional areas, including schematic capture, 3D PCB design, field-programmable gate array (FPGA) development and release/data management. It integrates with several component distributors for access to the manufacturer's data.

V. SIMULATION RESULTS

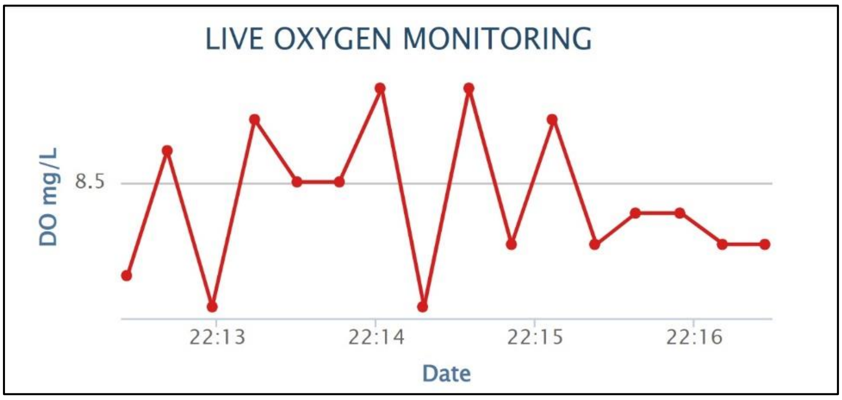

Fig.4. Live Oxygen Monitoring in MQTT Server

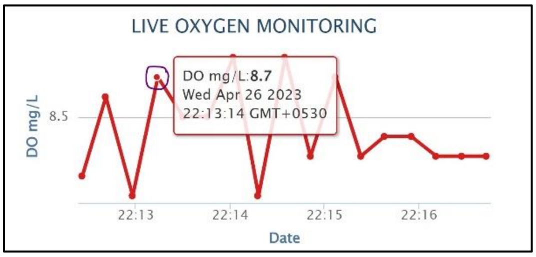

Fig.5. DO Concentration at 22:13

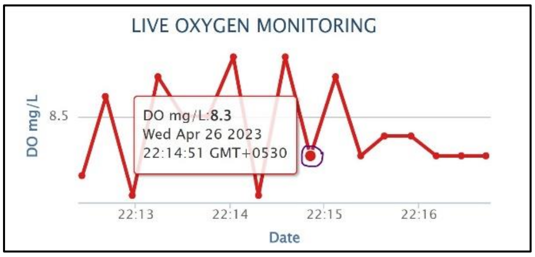

Fig.6. DO Concentration at 22:14

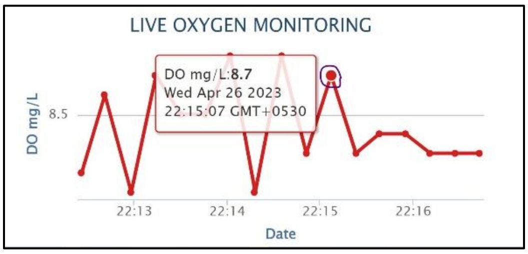

Fig.7. DO Concentration at 22:15

The Fig.4., Fig.5., Fig.6. & Fig.7. show the live Dissolved Oxygen (DO) concentration monitoring of the water in mg/L in the MQTT server at different time stamps which are uploaded/published using the GSM module that is further

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connected to the heart of this system i.e., with the ESP32 module of the Master node. The Master node has the collective readings of the entire pond as a result of mesh networking which connects nodes directly, dynamically, and non-hierarchically to all the 3 Slave nodes which possess their own DO concentration readings that cooperate with one another to efficiently route data to the Master Node using LORA Module providing long range, low-bit rate IoT data connectivity.

VI. CONCLUSION AND FUTURE SCOPE

With less time, less work, and greater profitability, this Embedded System integrated with the Internet of Things-based oxygen sensing and monitoring system makes it quite simple to increase the rate of survival of aquatic life by accurate sensing of the dissolved oxygen present in the water. The main aim of this system is to make it more innovative, convenient, and efficient compared to other existing systems. This system can be deployed in remote locations that devices with resource constraints or limited networks. In this project, a prototype includes sensing element nodes and data storage. The sensing element nodes are deployed on the field for sensing the dissolved oxygen seamlessly. Thus the "OxySen Pond based on sensing DO using ESP32" has been designed and tested successfully. It has been developed by integrating features of all the hardware components used. The system has been tested to function automatically. Thus, the functionality of the entire system has been tested thoroughly and it is said to function successfully.

Dissolved oxygen sensing has a wide range of potential applications in various industries such as environmental monitoring, aquaculture, food and beverage processing, pharmaceuticals, and wastewater treatment. The future scope of dissolved oxygen sensing is promising as the demand for real-time monitoring and control of dissolved oxygen levels continues to increase in various industries. Some of the potential developments in dissolved oxygen sensing include: -

1) Miniaturization: With the development of nanotechnology, it is possible to create miniature sensors that can be implanted directly into living organisms to monitor their oxygen levels.

2) Improved Sensitivity: Further improvements in sensor technology will enable sensors to detect dissolved oxygen levels in even more challenging environments and at lower concentrations.

3) Integration with Other Sensors: Sensors that can detect multiple parameters, including dissolved oxygen, pH, temperature, and conductivity, will provide a more comprehensive picture of the water quality.

4) Live Monitoring: With the help of IoT and cloud connectivity, we can also provide live monitoring of the existing pond which will not only sense and measure but also control the quantity DO concentration in the water to the owner of the pond which will help him monitor effortlessly thus, improving the survival rate of aquatic life and the overall water quality which will be coign of vantage for fish farming.

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Our heartfelt thanks go to the participants who were involved in the study and provided us with the data that formed the basis of our research. Without their cooperation and support, this project would not have been possible.

Lastly, we would like to thank our families and friends for their unwavering support and encouragement throughout our academic journey. Their love, understanding, and motivation have been a constant source of inspiration and strength for us. In conclusion, we are deeply indebted to all those who have contributed to this project, and we hope that our work will make a meaningful contribution to the field of Embedded Systems and the Internet of Things.

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