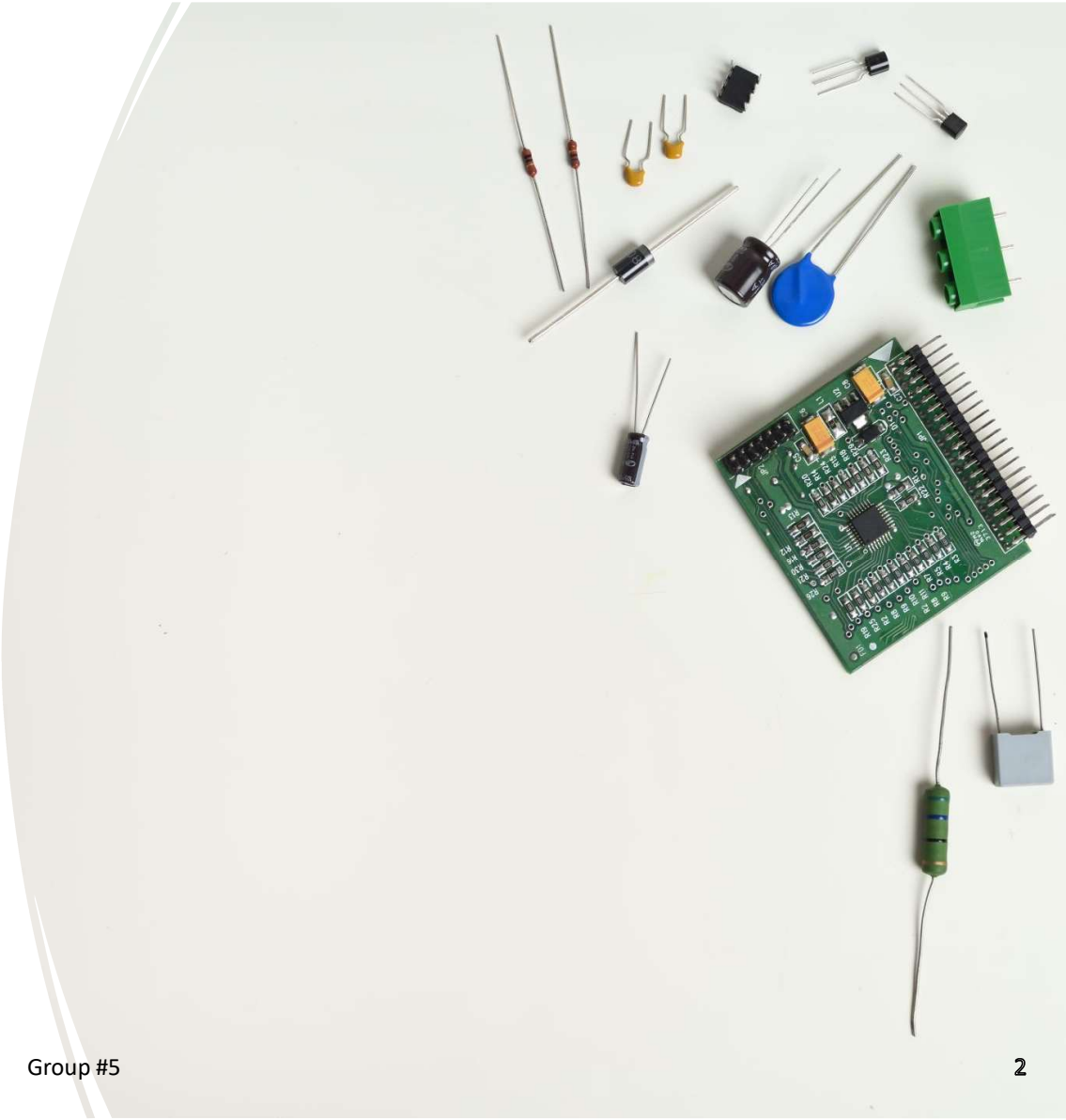
Revolutionizing Aquaculture with Real-time water quality monitoring system using ESP32

A presentation by –
Arun Chakkyadath Chandran

Details of role

- Chakkyadath Chandran Arun: Hardware and Software Integration



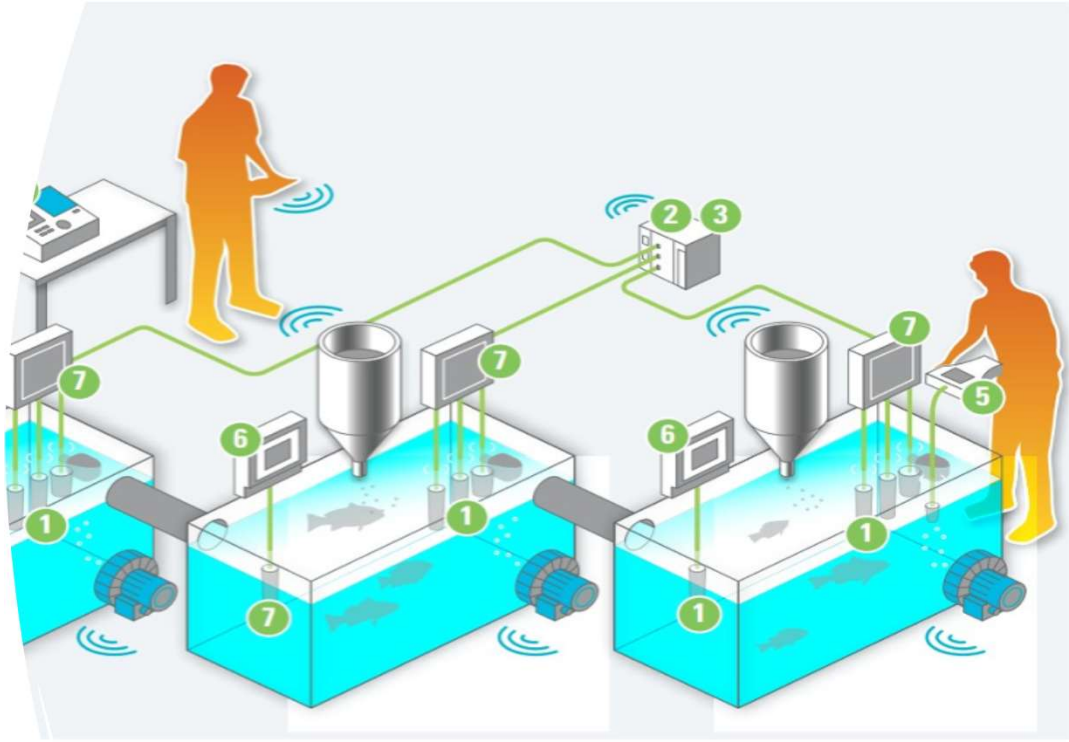
Storyline:

Aqua-agriculture, also **known as aquaculture**, is the practice of **cultivating and farming aquatic organisms including fish, shellfish, and aquatic plants, in controlled environments like tanks, ponds, or enclosures**. It is often considered the aquatic equivalent of traditional agriculture, where land-based crops and livestock are raised.

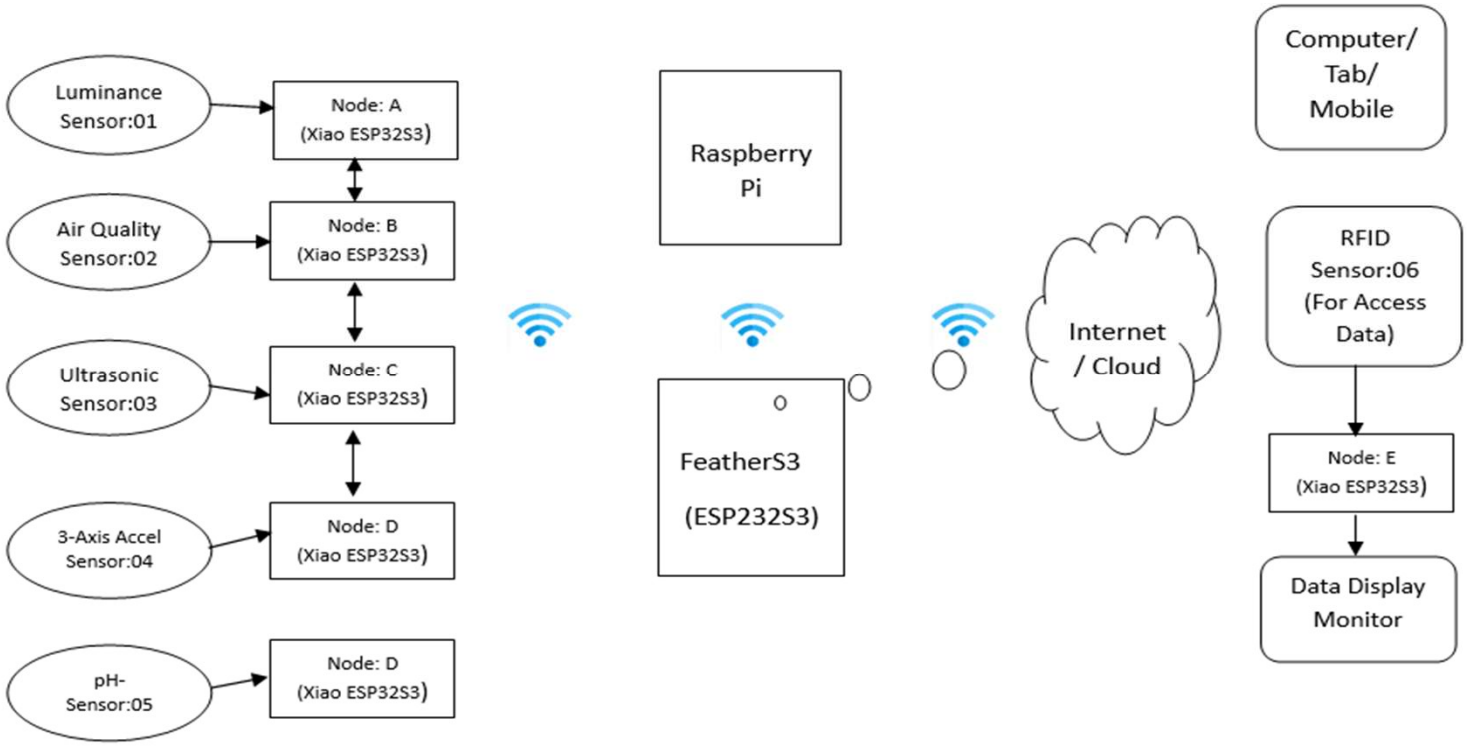
In the present scenario these aquaculture is **monitored manually** by group of men and is **practiced on a small-scale** however in recent years aquaculture has been gaining interest of young farmers and is becoming highly popular among. Since more farmers are opting for this, Thus giving in rise to challenging problems for monitoring and hence loss in profits. **One of the fore-most problem being water preparation before stocking and maintaining certain critical parameters like turbidity, Ph and amount of dissolved oxygen in water during cultivation**.

Even monitoring certain external parameters linked to surrounding environment such as temperature, pollution and other geographical conditions is a tough job if done manually. Which are normally neglected by traditional farmers.

The Internet of Things (IOT) being an upcoming innovation for all the smart gadgets to connect people remotely. In farming system, **wiring various required sensor to nodes and using these network of nodes for monitoring essential and unique parameter remotely** is what we are achieving by this project/Coursework.



System level Architecture



Sensor’s:

Sensors are fundamental components in modern technology, **enabling machines to interact with and respond to their surroundings with precision and accuracy**. They function by utilizing specialized materials and technologies that exhibit predictable **changes in electrical behavior in response to specific physical phenomena**.
In industries ranging from healthcare to automotive, sensors serve as the essential link between the physical world and digital systems, enabling a wide array of applications from environmental monitoring to precise measurements in industrial processes. Sensors are integral in creating smart, interconnected systems that enhance efficiency, safety, and functionality across a diverse range of applications.

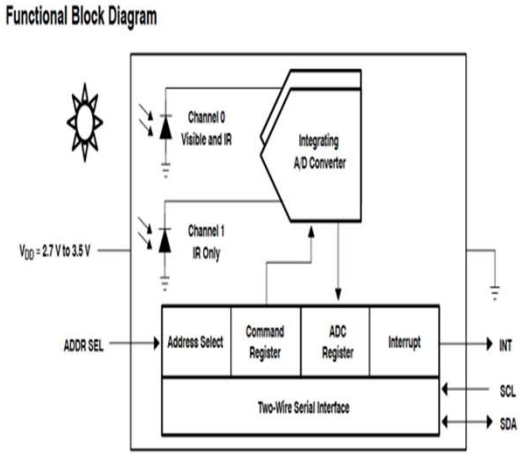
Luminosity Sensor	A luminosity sensor, in the context of turbidity measurement, gauges the amount of light scattered or absorbed by particles in water, providing insights into water clarity and turbidity levels.
Air Quality Sensor	An air quality sensor related to water is a specialized device designed to detect and measure contaminants or pollutants present in the air that may impact water quality, providing valuable insights for environmental monitoring and management.
Ultrasonic Sensor	An ultrasonic sensor related to water level detection uses sound waves to measure the distance from the sensor to the water's surface, providing accurate and reliable data for monitoring water levels in tanks, reservoirs, or bodies of water.
RFID	An RFID sensor, in the context of retrieving data from an MQTT server, is a technology that employs radio frequency signals to communicate and exchange information with the server, facilitating seamless and efficient data transmission for various applications.
Accel 3 Axis LIS3D	An accelerometer measuring fish movements in three axes is repurposed to estimate dissolved oxygen levels by correlating fish activity patterns with water oxygenation, providing a non-traditional approach to real-time aquaculture monitoring.
pH Sensor	A pH meter, in the context of water toxicity, is a specialized instrument that measures the acidity or alkalinity of a water sample, offering critical information for assessing potential hazards to aquatic life due to variations in pH levels.

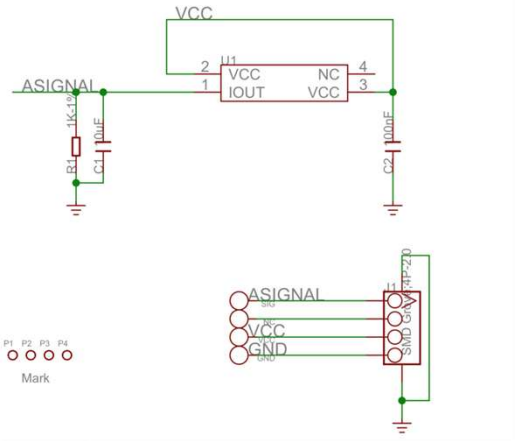
Sensor #1 Luminosity Sensor

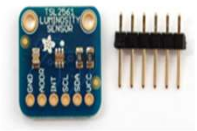
Measuring turbidity of the water:

- The TSL2560 and TSL2561 are second-generation ambient light sensor devices. Each contains two integrating analog-to-digital converters (ADC) that integrate currents from two photodiodes. Integration of both channels occurs simultaneously.
- the conversion result is transferred to theChannel 0 and Channel 1 data registers, respectively. The transfers are double-buffered to ensure that the integrity of the data is maintained. After the transfer, the device automatically begins the next integration cycle.
- Communication to the device is accomplished through a standard, two-wire SMBus or I 2C serial bus.
- Luminance measurement range: 0 ~ 1000 Lux

Luminosity Sensor	A luminosity sensor, in the context of turbidity measurement, gauges the amount of light scattered or absorbed by particles in water, providing insights into water clarity and turbidity levels.







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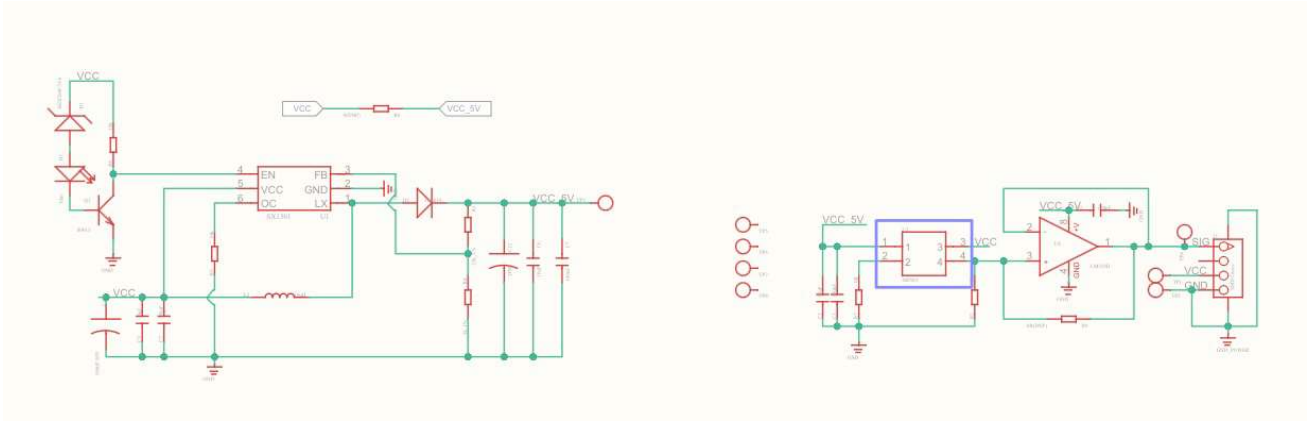
Sensor #2 Air Quality

Detect toxic gases above water to judge whether the surrounding environment is safe:

- It can respond to carbon monoxide, alcohol, acetone, thinner, formaldehyde, and other slightly toxic gases.
- **Toxic sensors** use circuits applied to a silica chip. When toxic gas comes into contact with the circuitry, it lowers the electrical resistance. The processor detects the change and causes the alarm to sound.

Air Quality Sensor	An air quality sensor related to water is a specialized device designed to detect and measure contaminants or pollutants present in the air that may impact water quality, providing valuable insights for environmental monitoring and management.

Grove Air Quality Sensor - 101020078



Sensor #3 Ultrasonic

measuring water level

- With ultrasonic sensors, we can find the water depth calculation by finding the distance between the transceiver and the surface of the water. The sensor will transmit a short ultrasonic pulse, and we can measure the travel time of that pulse (the echo) to the liquid and back
- The formula distance = speed*time is used to calculate the distance. Suppose, water level is placed at a distance of 10 cm away from the sensor, the speed of sound in air is 340 m/s or 0.034 cm/µs and assume time taken to travel the sound wave is 294 µs. finally, The water level distance from sensor is 5cm. (.034*294/2)

Speed of sound:

$speed = 340\ m/s = 0.034\ cm/\mu s$

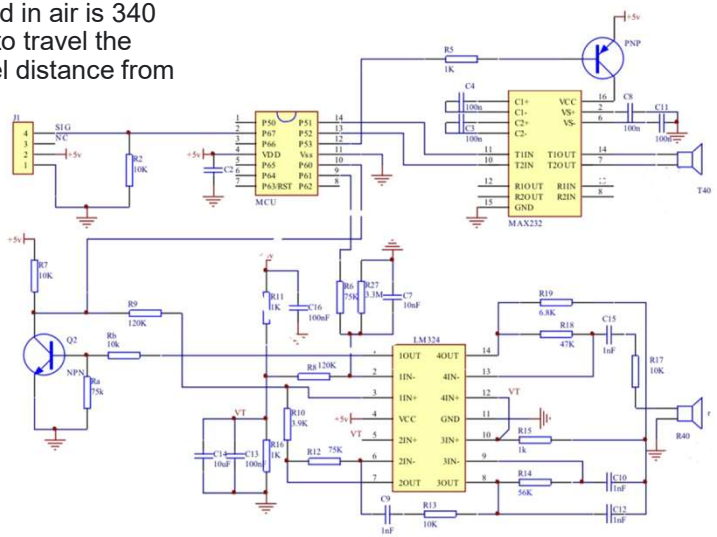
$time = distance/speed$

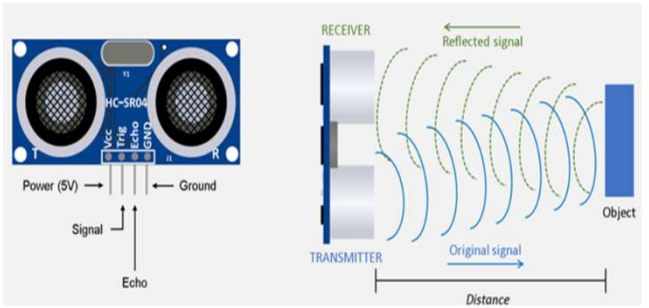
$$time = \frac{10}{0.034}\mu s = 294\ \mu s$$

$$distance = \frac{speed * time}{2}$$

$$distance = \frac{0.034 * 294}{2}$$

Ultrasonic Sensor	An ultrasonic sensor related to water level detection uses sound waves to measure the distance from the sensor to the water's surface, providing accurate and reliable data for monitoring water levels in tanks, reservoirs, or bodies of water.





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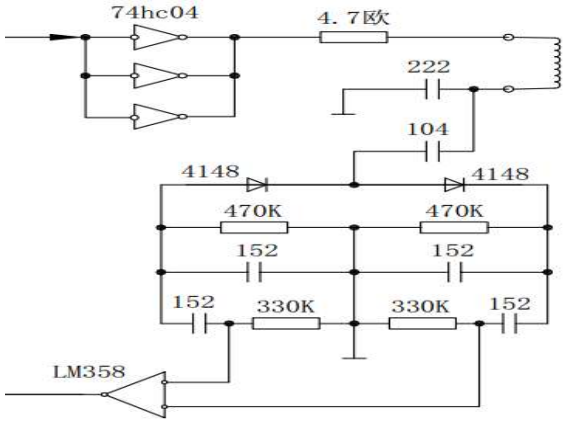
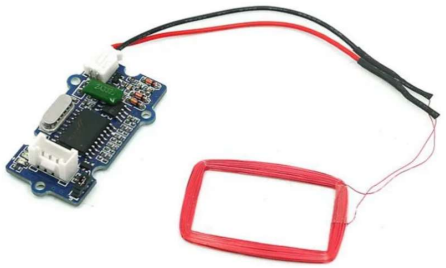
Sensor #4 RFID

Radio-Frequency Identification

- Contactless IC card (also known as radio frequency card, RFID) realizes communication with data through radio waves or electromagnetic induction.
- The low-frequency 125k protocol is a communication protocol for radio frequency identification (RFID) technology. Its working principle is to transmit data through low-frequency electromagnetic waves of 125kHz, thus realizing non-contact automatic identification and data acquisition.
- The read range for RFID tags varies based on factors including type of tag, type of reader, RFID frequency, and interference in the surrounding environment or from other RFID tags and readers. Active RFID tags have a longer read range than passive RFID tags due to the stronger power source.
- The Grove-125KHz RFID Reader is a module used to read EM4100 RFID card information with two output formats: UART and Wiegand. It has a sensitivity with maximum 7cm sensing distance

RFID	An RFID sensor, in the context of retrieving data from an MQTT server, is a technology that employs radio frequency signals to communicate and exchange information with the server, facilitating seamless and efficient data transmission for various applications.



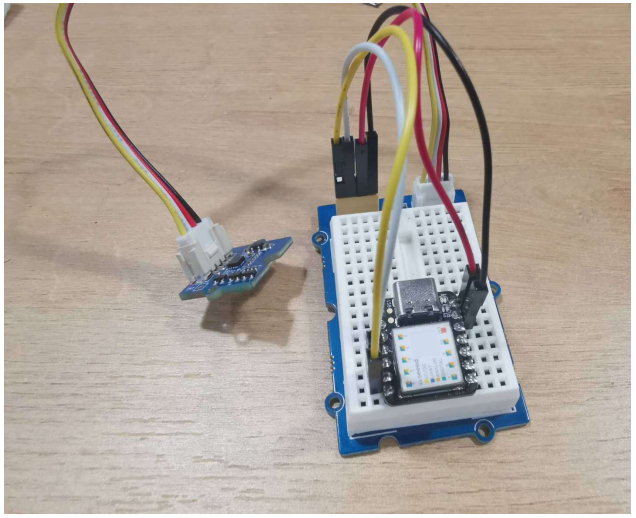


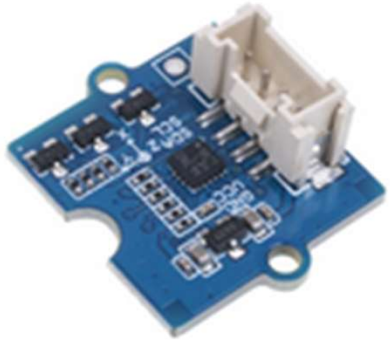
Sensor #5 3-Axis Accelerometer

dissolved oxygen based of fish movements:

Accel 3 Axis LIS3D	An accelerometer measuring fish movements in three axes is repurposed to estimate dissolved oxygen levels by correlating fish activity patterns with water oxygenation, providing a non-traditional approach to real-time aquaculture monitoring.

- It is based on the LIS3DHTR chip which provides multiple ranges.
- Support I2C, SPI, and ADC GPIO interfaces. Besides, this accelerometer can also monitor the surrounding temperature to tune the error caused by it.
- Measurement range: ±2g, ±4g, ±8g, ±16g, multiple ranges selection





Sensor #6 Ph Sensor

Measuring pH value:

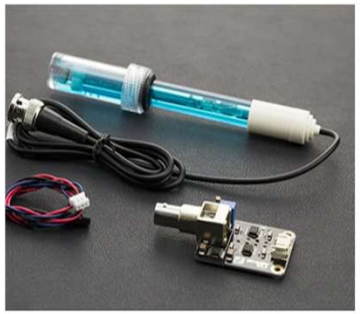
- The sensor works by comparing the electric potential of a pH-sensitive system to the potential of a stable reference system. The sensing system uses a pH-sensitive glass bulb which changes voltage proportionally to the concentration of hydrogen ions. A sensing electrode measures the potential of the glass bulb.
- A sensing electrode measures the potential of the glass bulb. The sensor is filled with a potassium chloride (KCl) solution which conducts electricity between the pH-sensitive glass and the sensing electrode.
- The instrument reads the signal from the pH electrode, the reference electrode, and the temperature and then calculates the pH using the Nernst equation:

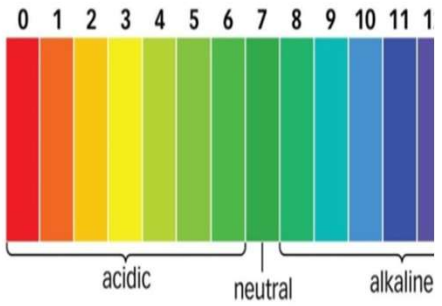
$$E_m = E_o + (2.3RT/nF) \log [H^+]$$

- The meter has a good accuracy range, providing pH measurements at ± 0.1pH (25°C)
- Meauring Range: 0-14pH
- Measuring Temperature: 0-60°C
- Measurement Accuracy: ±0.1pH
- Response Time: <=1min

pH Sensor

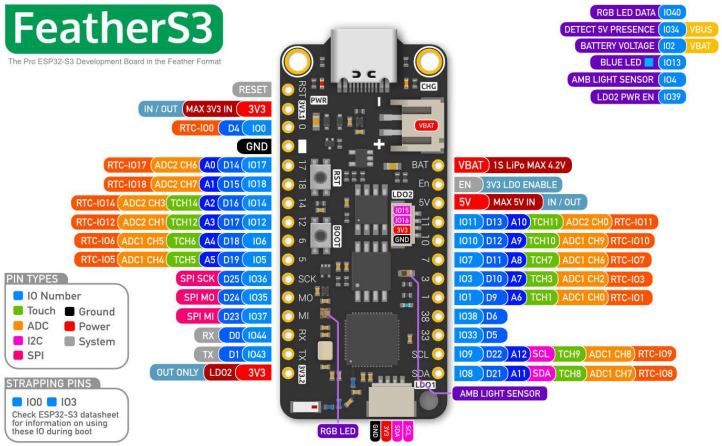
A pH meter, in the context of water toxicity, is a specialized instrument that measures the acidity or alkalinity of a water sample, offering critical information for assessing potential hazards to aquatic life due to variations in pH levels.

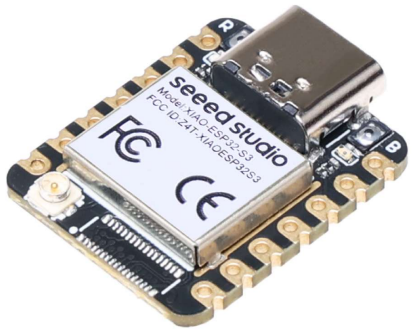




Comm. Protocol #1 Bluetooth

- The ESP32, which has built-in Wi-Fi and Bluetooth capabilities, is well-suited for tasks like sending HTTP requests and receiving HTTP responses from web servers
- This allows the ESP32 to communicate with other Bluetooth devices, including smartphones, Bluetooth sensors, and other BLE or Classic Bluetooth peripherals.

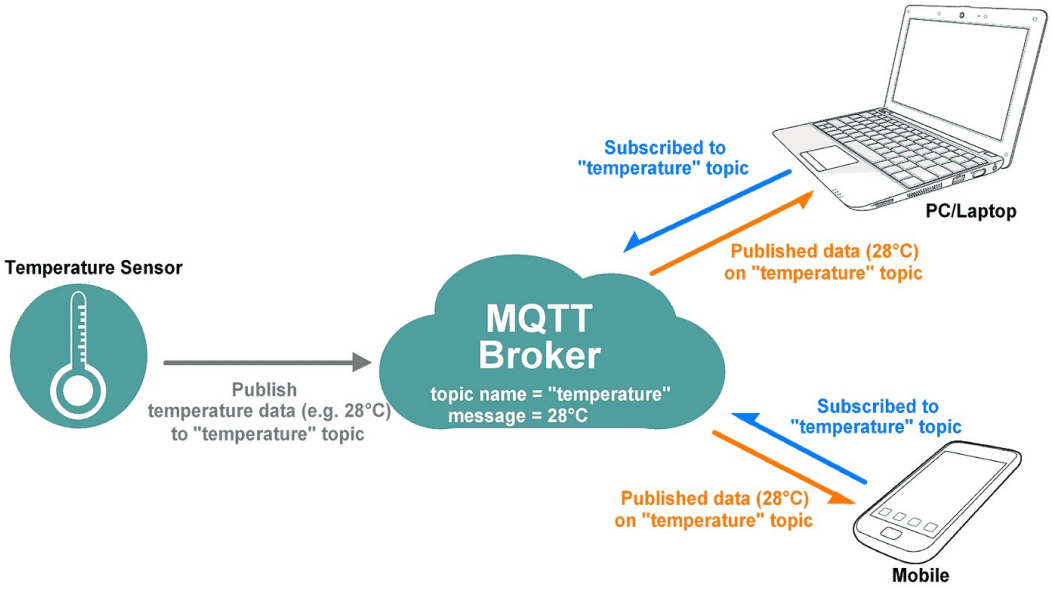




Comm. Protocol #2 TCP/IP (MQTT)

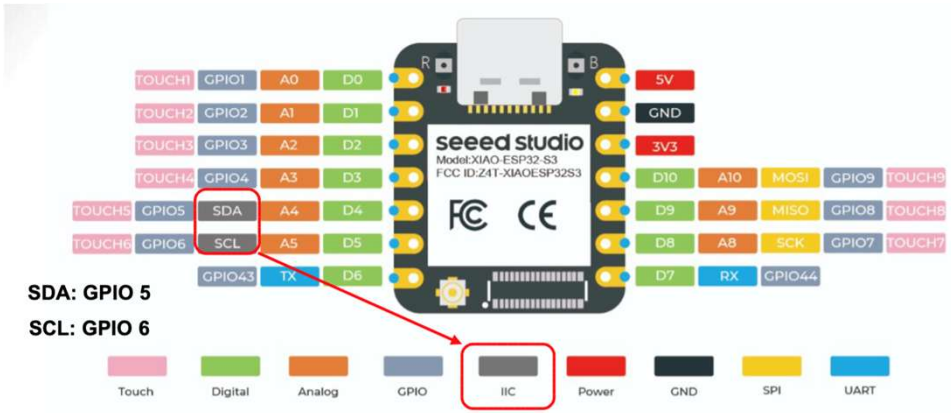
stands for Message Queuing Telemetry Transpor:

- lightweight and efficient messaging protocol designed for reliable communication in environments with limited bandwidth and high-latency or unreliable networks.
- **Publish-Subscribe Model**: MQTT follows a publish-subscribe messaging pattern. In this model, there are clients (devices or applications) that publish messages on specific topics, and there are other clients that subscribe to those topics to receive messages. This model allows for decoupled and asynchronous communication.
- **Scalability**: MQTT can be used in large-scale deployments, and brokers can be distributed to handle a high number of connected devices.



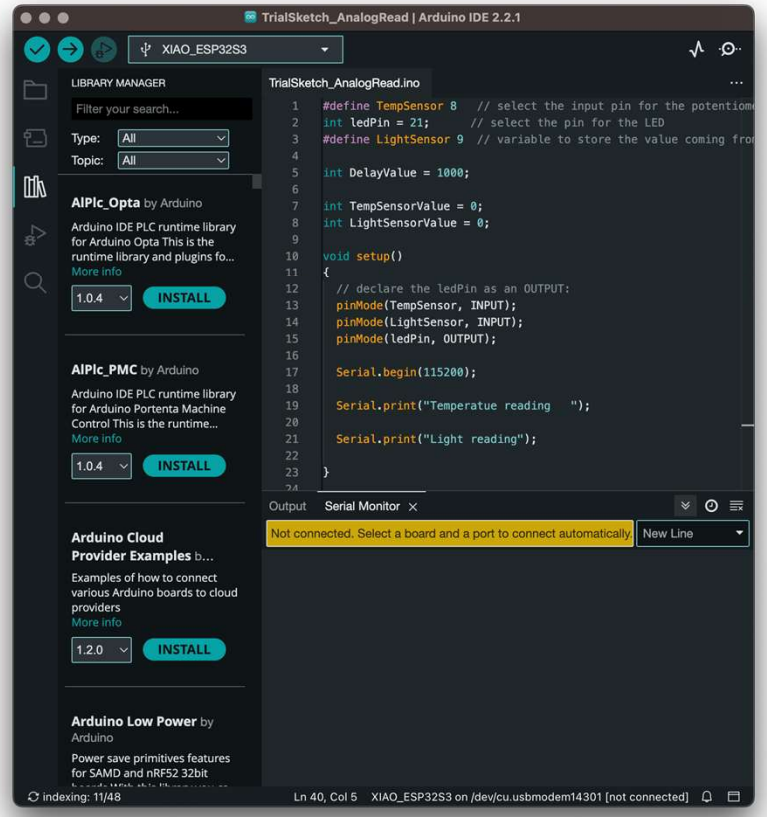
Comm. Protocol #3 I2C

- With I2C, data is transferred in messages. Messages are broken up into frames of data. Each message has an address frame that contains the binary address of the slave, and one or more data frames that contain the data being transmitted.
- The message also includes start and stop conditions, read/write bits, and ACK/NACK bits between each data frame.



S/W Dev. IDE #1 Arduino

- It is an open-source software platform designed to simplify and streamline the process of programming and developing applications for Arduino microcontroller boards
- Code Editor: The IDE includes a code editor with syntax highlighting and basic code completion, making it easier to write and edit sketches.
- Library Manager: The IDE has a library manager that allows users to easily add and manage libraries (pre-written code modules) to extend the functionality of their projects. Many Arduino libraries are available for various sensors, displays, communication modules, and more.
- Serial Monitor: The IDE includes a serial monitor tool that enables developers to communicate with their Arduino board and view real-time data sent by the board. This is useful for debugging and monitoring sensor readings.
- Board Manager: The IDE supports multiple Arduino boards, and the board manager helps users select the appropriate board type and install board-specific drivers and configurations.



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Referneces

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- Karthik.V, Haritharan.S, Sreekar.B, "Real Time Monitoring of the Environmental parameters of an Aquaponic System Based on Internet of Things", UG student in Department of Electronics and communication Engineering, Velammal Institute of technology, Chennai, India. 2017 Third International Conference on Science Technology Engineering and Management (ICONSTEM).
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