Surface Water Quality Analysis & Real Time Monitoring System

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Abstract --As for every parameter of water quality, we have traditional method to test water quality. The conventional method of testing water quality involves gathering water manually and sending it to the laboratory to test and analyze various parameters of water. This method is time taking i.e. wastage of man hours, energy and highly expensive. Also there is a need to improve water quality monitoring system to identify whether the determined water quality is suitable for purposed used. So we have to solve this problem by using automatic real-time water quality analysis and reporting using SCADA. Initially we are focusing on review of this area. For water quality analysis we have consider basic parameters of water like Temperature, pH, Dissolved Oxygen and Turbidity. So this paper is only for selection of various better sensors. We present in this paper the comparison of various sensors with its required graph and output. This paper is helpful to select the precise and good quality of sensors.

***Keywords*:-Internet of Things(IoT), Water Distribution System (WDS), Aquatic ecosystem, Electrochemical Impedance Spectroscopic (EIS), ,pH, Temperature, Turbidity, Dissolved Oxygen (DO) etc.**

I. INTRODUCTION

Intelligent monitoring and reporting system is defined as the method which is used to monitor, control, manage and optimize the network by using various computational methods that will provide relevant tools and information. For achieving this IoT is key part of intelligent system, which connects people and devices using wireless sensor technology. It is a fast developing research area in military, energy management, healthcare and many more. The concept of IoT was proposed by Kevin Ashtom to demonstrate a set of interconnected devices. The Water Distribution Systems (WDS) is very important research because it affects on economic growth of our country. WDS having mainly two issues: First is water loss due to leakage and second is pollution of water. It is affecting health and safety of the people. According to World Health Organization (WHO) in 2017 around 2.1 billion people around the world lack safe drinking water.

Figure 1: Basic Idea of IoT based Water Quality Analysis System

A sensor does sensing tasks, and there are many kinds of sensors are made to monitor many kinds of information such as temperature, optical, acoustic, chemical, electromagnetic, and radiation, to name just a few. Sensors provide a tremendous societal benefit when integrated into devices, machines, and environments. In aquaculture, any change in the water environment such as pH level, dissolved oxygen, and temperature will affect the elements of chemistry, biology and the health of the cultured species. Therefore, it is important that any change must be monitored and notified to the farmers so that they can adjust the environment according to save the cultured species. Conventional methods of analyzing the water quality requires much time, energy and labors. Internet of things (IoT) has achieved a great focus due to its faster processing Intelligence. This paper focus on discussing review and selection of precise sensors for next development of “Review of Real Time Water Quality Analysis and Reporting system based on IOT”.This paper deals with the monitoring of water quality by mainly considering the physical and chemical properties like Temperature, pH, Dissolved Oxygen and Turbidity of water.

II. LITERATURE SURVEY

Comparative study of various sensors like Temperature, pH, Dissolved Oxygen, Turbidity.

2.1 Comparative study of different Temperature Sensors

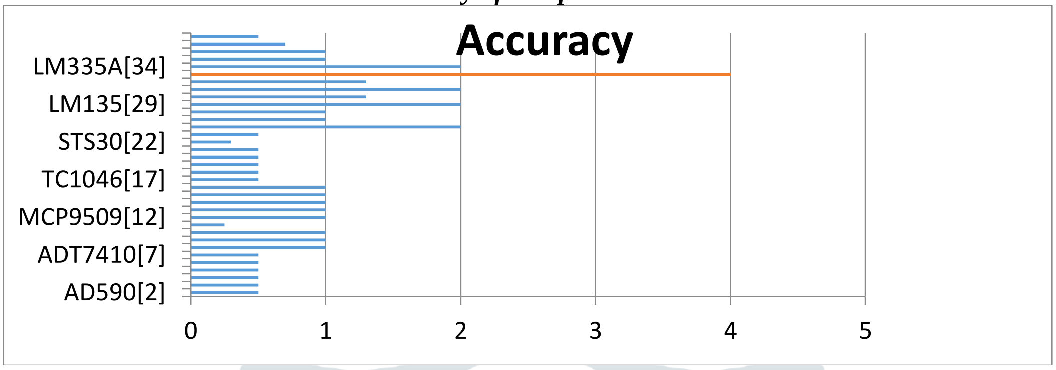
Table 2.1.1: Comparison of various temperature sensors

Sr. No.	Manufacturer	Part Number	Designation	OT min	OT Max	Accuracy (Typical)	Input Voltage Range
1	Analog Devices	AD590[2]	IC Temperature Transducer	-55	150	0.5	4 to 30V
2	Analog Devices	AD592[3]	Precision IC Temperature Transducer	-25	105	0.5	4 to 30V
3	Analog Devices	AD22105[4]	Resistor Programmable Thermostatic Switch	-40	150	0.5	2.7 to 7V
4	Analog Devices	ADT6402[5]	Pin-Selectable Temperature Switches	-55	125	0.5	2.7 to 5.5V
5	Analog Devices	ADT7310[6]	16-Bit Digital SPI Temperature Sensor	-55	150	0.5	2.7 to 5.5V
6	Analog Devices	ADT7410[7]	16-Bit Digital I^2C Temperature Sensor	-55	150	0.5	2.7 to 5.5V
7	Analog Devices	TMP35[8]	Voltage Output Temperature Sensor	+10	125	1	2.7 to 5.5V
8	Analog Devices	TMP36[9]	Voltage Output Temperature Sensor	-40	125	1	2.7 to 5.5V
9	Analog Devices	TMP37[10]	Voltage Output Temperature Sensor	+5	100	1	2.7 to 5.5V
10	Microchip	EMC1072[11]	SMBus / I2C Multi Temperature Sensor	-40	125	0.25	3.0 to 3.6V
11	Microchip	MCP9509[12]	Resistor-Programmable Temperature Switch	-40	125	1	2.7 to 5.5V
12	Microchip	MCP9700[13]	Voltage Temperature Sensor	-40	150	1	2.3 to 5.5V
13	Microchip	MCP9700A[14]	Voltage Temperature Sensor	-40	150	1	2.3 to 5.5V
14	Microchip	MCP9701[15]	Voltage Temperature Sensor	-10	125	1	3.1 to 5.5V

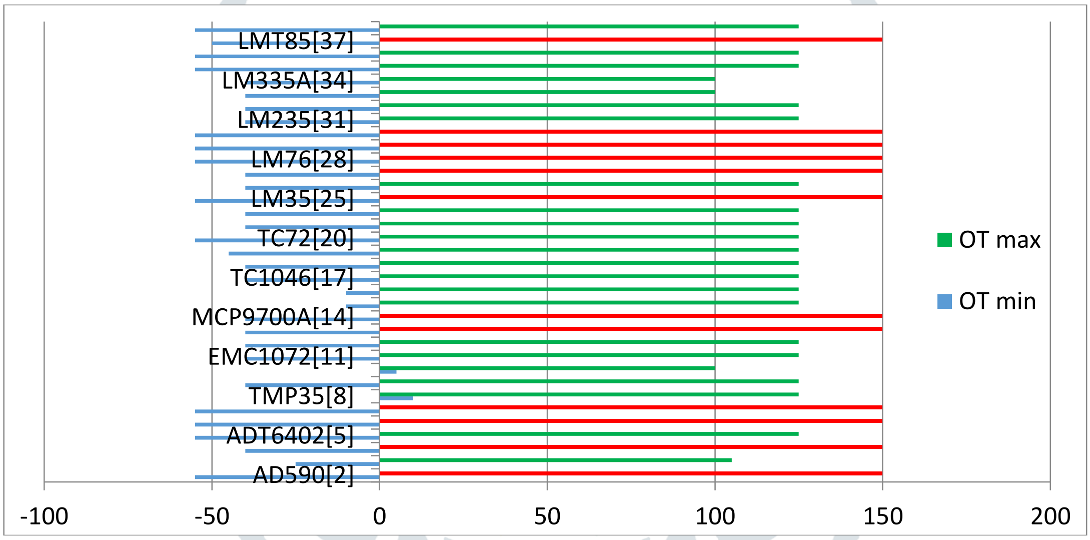
Sr. No.	Manufacturer	Part Number	Designation	OT min	OT Max	Accuracy (Typical)	Input Voltage Range
15	Microchip	MCP9701A[16]	Voltage Temperature Sensor	-10	125	1	3.1 to 5.5V
16	Microchip	TC1046[17]	Voltage Temperature Sensor	-40	125	0.5	2.7 to 4.4V
17	Microchip	TC1047[18]	Voltage Temperature Sensor	-40	125	0.5	2.7 to 4.4V
18	Microchip	TC6501[19]	Temperature Switch	-45	125	0.5	2.7 to 5.5V
19	Microchip	TC72[20]	SPI Temperature Sensor	-55	125	0.5	2.7 to 5.5V
20	Microchip	TC74[21]	SMBus / I2C Temperature Sensor	-40	125	0.5	2.7 to 5.5V
21	Sensirion	STS30[22]	I2C Temperature Sensor	-40	125	0.3	2.7 to 5.5V
22	Texas Instruments	LM35[25]	Analog Output Temperature Sensor	-55	150	0.5	4 to 30V
23	Texas Instruments	LM50[26]	Analog Output Temperature Sensor	-40	125	2	4.5 to 10V
24	Texas Instruments	LM73[27]	Temperature Sensor with IC2/SMBus Interface	-40	150	1.0	2.7 to 5.5V
25	Texas Instruments	LM76[28]	Temperature Sensor with IC2/SMBus Interface	-55	150	1.0	4.5 to 5.5V
26	Texas Instruments	LM135[29]	Temperature Sensor	-55	150	2	-
27	Texas Instruments	LM135A[30]	Temperature Sensor	-55	150	1.3	-
28	Texas Instruments	LM235[31]	Temperature Sensor	-40	125	2	-
29	Texas Instruments	LM235A[32]	Temperature Sensor	-40	125	1.3	-
30	Texas Instruments	LM335[33]	Temperature Sensor	-40	100	4	-
31	Texas Instruments	LM335A[34]	Temperature Sensor	-40	100	2	-
32	Texas Instruments	TMP 100	Temperature Sensor with I2C/SMBus Interface	-55	125	1	2.7 to 5.5V
33	Texas Instruments	TMP101[36]	Temperature Sensor with I2C/SMBus Interface	-55	125	1	2.7 to 5.5V
34	Texas Instruments	LMT85[37]	Analog Output Temperature Sensor	-50	150	0.7	1.8 to 5.5V

Sr. No.	Manufacturer	Part Number	Designation	OT min	OT Max	Accuracy (Typical)	Input Voltage Range
35	Dallas	DS18B20	Temperature Sensor with 1wire interface	-55	125	0.5	3 to 5.5V

2.1.2 Accuracy of Temperature Sensors



2.1.3 Range of Temperature Sensors



2.1.4 Features of LM35 Sensors:-

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- Operates From 4 V to 30 V • Less Than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

***2.1.4.1 LM50 Sensors*: -** The LM50 and LM50-Q1 devices are precision integrated-circuit temperature sensors that can sense a –40°C to 125°C temperature range using a single positive supply. The output voltage of the device is linearly proportional to temperature (10 mV/°C) and has a DC offset of 500 mV. The offset allows reading negative temperatures without the need for a negative supply.[25]

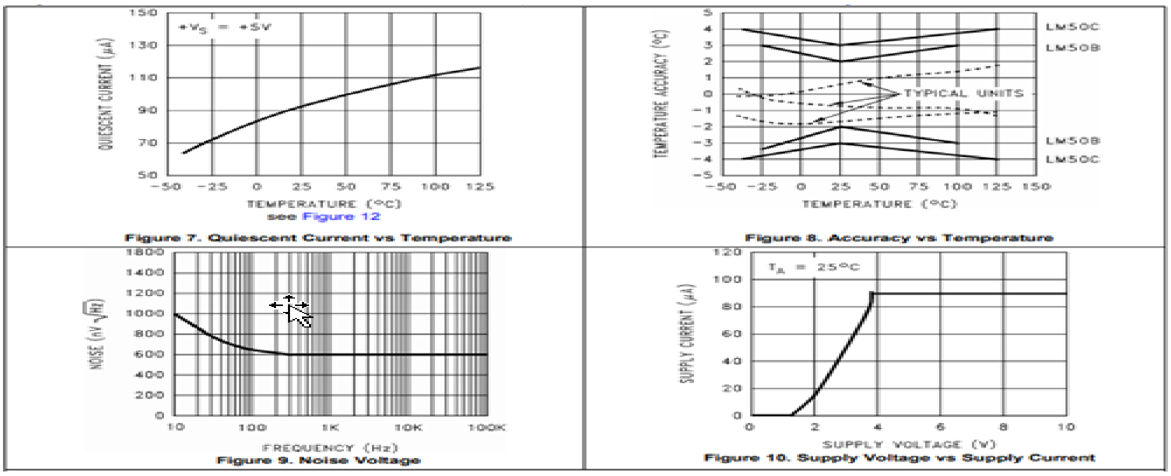


Figure 2: Result analysis of LM50 Sensor

2.1.5 Features LM50 Sensors:-

- LM50-Q1 is AEC-Q100 Grade 1 Qualified and is manufactured on an Automotive Grade Flow
- Calibrated Directly in Degrees Celsius (Centigrade)
- Linear + 10 mV/°C Scale Factor
- ±2°C Accuracy Specified at 25°C
- Specified for Full –40° to 125°C Range
- Suitable for Remote Applications
- Low Cost Due to Wafer-Level Trimming
- Operates From 4.5 V to 10 V
- Less Than 130-µA Current Drain
- Low Self-Heating: Less Than 0.2°C in Still A
- Nonlinearity Less Than 0.8°C Over Temp
- UL Recognized Component

2.2 Comparative study of different pH sensor

Table 2.2.1 Comparison of various pH sensors

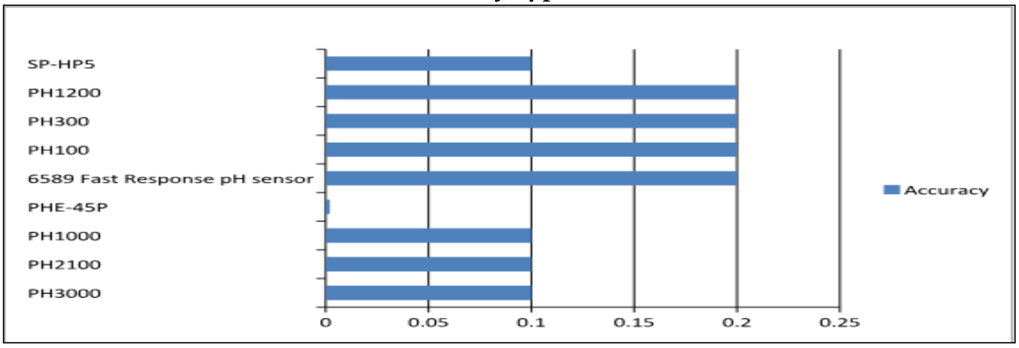
Sr. No.	Name of sensor	Min range	Max Range	Accuracy	Min OT	Max OT
1	PH3000	0	14	0.1	0	100
2	PH2100	0	14	0.1	0	80
3	PH1000	0	14	0.1	0	60
4	PHE-45P	0	14	0.002	-5	95
5	6589 Fast Response pH	0	14	0.2	0	50
6	PH100	2	12	0.2	0	50
7	PH300	2	12	0.2	0	50
8	PH1200	2	12	0.2	0	50
9	SP-HP5	5.5	8.5	0.1	5	50

***2.2.1.1pH-100 Sensor [4]*:** The waterproof ExStik® PH100 pH meter by Extech is an accurate, rugged and reusable stick pH meter with some unique data storage features that make it exceptionally easy to use and considerably enhance its usability. The flat surface electrode allows you to measure pH in liquids, semi-solids and solids and limits electrode breakage and clogged junctions. The Renew indicator tells you when it's time to replace your electrode. The CAL alert ensures consistently accurate readings by telling you when you need to recalibrate

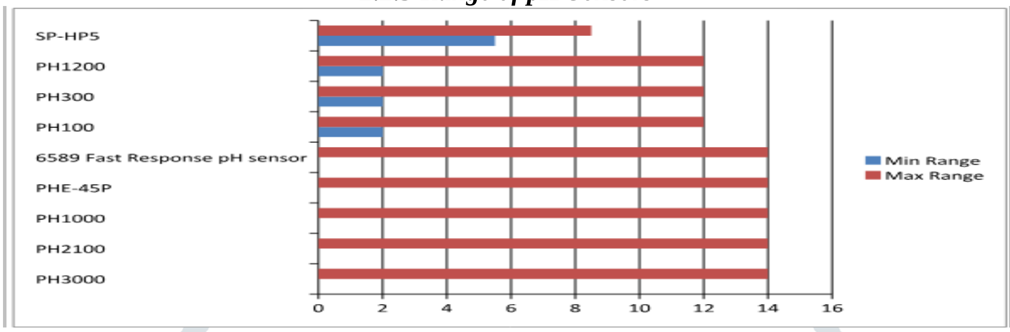
***2.2.1.2 pH-1200 Sensor [6*]:** The YSI pH1200 is an accurate and reliable instrument for the measurement of pH and mVs. With an IP65 water and splash resistant enclosure, the pH1200 is a bench top unit that provides laboratory-grade measurements. Featuring a pH range of 0.00 to 14.00 with ±0.01 accuracy and a mV range of -1999 to +1999 mV with ±0.05% ±1 digit accuracy, the pH1200 displays reading on a large, backlit display with an ea sy-to-use keypad. An auto lock feature will hold the readings on the display once they reach stabilization

2.2.1.3 pH-300 Sensor [9]: Hanna Instruments pH300, pH301 and pH 302 are professional bench-top pH meters for pH, ORP (Oxidation Reduction Potential), ISE and temperature measurements. Their built-in microprocessor ensures accurate and user friendly operation. pH measurements are automatically compensated for the temperature effect (ATC). These meters come equipped with a large, easy-to-read LCD which shows the pH or mV or ION (for pH301 only) with temperature simultaneously.

2.2.2 Accuracy of pH Sensors



2.2.3 Range of pH Sensors



Above charts gives comparative study of pH sensor based on their accuracy and operating range.

2.3 Comparative study of different Dissolved Oxygen Sensors
2.3.1 Study in detail few Dissolved Oxygen sensors
2.3.1.1OPTISENS ADO 2000

The OPTISENS ADO 2000 is an amperometric dissolved oxygen sensor with a galvanic electrode cartridge consisting of membrane covered electrodes in an electrolyte solution. Oxygen enters the electrode cartridge via the membrane. The essential potential to reduce oxygen at the silver cathode and oxidise lead at the lead anode is provided by the customised electrode/electrolyte system (galvanic cell). No external power supply and time consuming polarisation is needed. The resulting electrochemical current is measured as it depends on the concentration of oxygen. The complete cartridge is easily replaceable without the need of exchanging the electrolyte solution.

Figure 3: OPTISENS ADO 2000

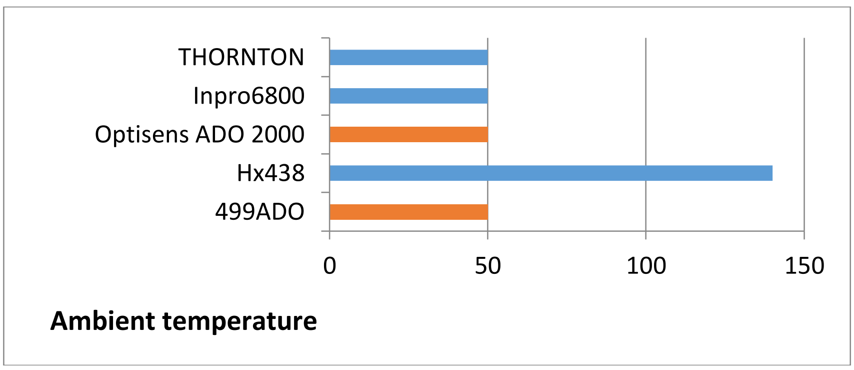
Amperometric dissolved oxygen (ADO) sensor for water and wastewater industry
- Stainless steel housing for harsh applications
- Longer maintenance intervals due to large electrolyte reservoir
- Easy maintenance via electrode cartridge replacement

2.3.1.2 Dissolved Oxygen Sensor LIQ-PDS-499ADO

A robust sensor for reliably measuring dissolved oxygen
The Rosemount TM 499ADO dissolved oxygen sensor is an easy to use amperometric sensor with a rugged construction. This sensor is ideal for measuring dissolved oxygen in aeration basins in municipal and industrial wastewater treatment plants.

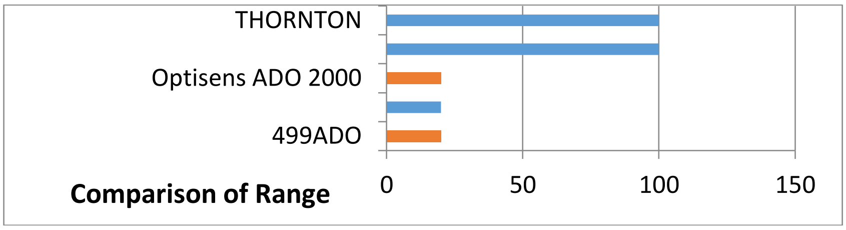
2.3.2 Ambient temperature of Dissolved Oxygen Sensors

Following chart shows comparison of ambient temperatures of DO sensors



2.3.3 Range of Dissolved Oxygen Sensors

Following chart shows comparison of range of Dissolved Oxygen sensors



2.4 Comparative study of different Turbidity Sensors

Table 2.4.1: Comparison of various Turbidity sensors

Given below is the list of turbidity sensors selected for this project and their important parameters.

Sr. No.	Name of Turbidity Sensor	Sensing distance (in mm)	Min OT	Max OT	Operating Supply Voltage (in V)
1	TSW-10	5.7	-30	80	5
2	TSD-1	5.7	-10	90	5
3	165D6042P003	5.7	-30	80	5
4	TST-10	5.7	-10	90	5

2.4.2 Study in detail few Turbidity sensors

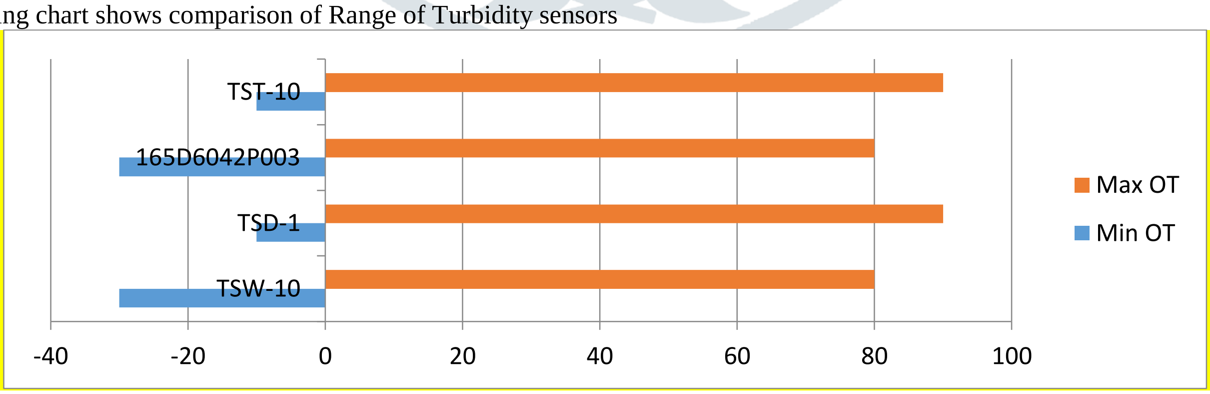
2.4.2.1TSD-10 [9]: The TSD-10 module measures the turbidity (amount of suspended particles) of the wash water in washing machines and dishwashers. An optical sensor for washing machines is a measuring product for a turbid water density or an extraneous matter concentration using the refraction of wavelength between photo transistor and diode. By using an optical transistor and optical diodes, an optical washing machine sensor measures the amount of light coming from the source of the light to the light receiver, in order to calculate water turbidity.

2.4.2.2 165D6042P003 [8]: The 165D6042P003 module measures the turbidity (amount of suspended particles) of the wash water in washing machines and dishwashers. An optical sensor for washing machines is a measuring product for a turbid water density or an extraneous matter concentration using the refraction of wavelength between photo transistor and diode. By using an optical transistor and optical diodes, an optical washing machine sensor measures the amount of light coming from the source of the light to the light receiver, in order to calculate water turbidity.

2.4.3 Graphical Study of different Turbidity Sensors

Ambient temperature of Dissolved Oxygen Sensors

Following chart shows comparison of Range of Turbidity sensors



III. METHODOLOGY

3.1 Block Diagram of Generalized Measurement System:-

We are doing literature survey to select precise sensor for our “Water Quality Analysis and Reporting (SCADA)”. For the same we had collected data from IEEE papers, Official Website of Sensor manufacturing company etc on Temperature, pH, Dissolved Oxygen and Turbidity of a water. Then we had convert collected information or data in to knowledge by comparing in a table and different charts. From comparative chart we have get information about who is precise water quality sensor for our purpose. So in this way we had selected various sensors like **temperature sensors-**LM35 series and LM 50, **pH sensors-**PH100, PH300 and PH1200 are recommended keeping in mind the cost efficiency. **Dissolved Oxygen sensor-**OPTISENS ADO 2000 and 499ADO are recommended keeping in mind the cost efficiency. **Turbidity sensor-**TSD-10 and 165D6042P003 turbidity sensor for further implementation. After this we will integrate all selected final four sensors together to test water quality based on different parameters. Then collecting all information real time over a long distance on server system. Taking real time reading using drone or IoT based technology. At server we will analyse data using SCADA software.

Following diagram shows basic idea about how to test water quality using Phys-Chemical property of water.

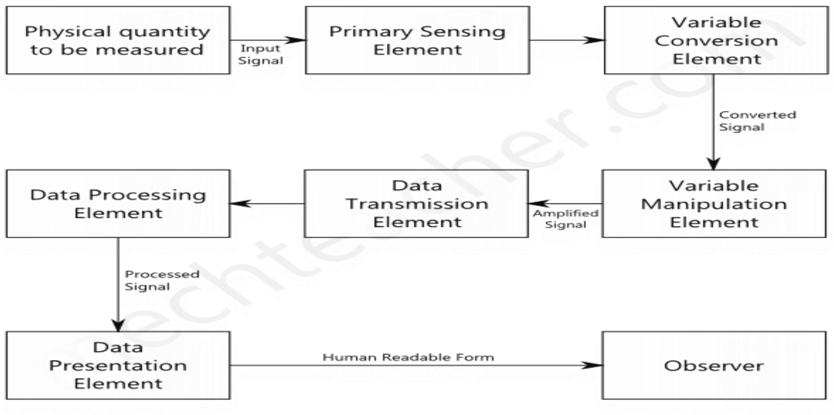


Figure 4: Basic Block Diagram of Measurement System

Components of Generalized Measurement System:-
A generalized measurement system consists of the following components:

1. Primary Sensing Element:
The primary sensing element receives signal of the physical quantity to be measured as input. It converts the signal to a suitable form (electrical, mechanical or other form), so that it becomes easier for other elements of the measurement system, to either convert or manipulate it.

***2. Variable Conversion Element*:**
Variable conversion element converts the output of the primary sensing element to a more suitable form. It is used only if necessary.

3. Variable Manipulation Element:
Variable manipulation element manipulates and amplifies the output of the variable conversion element. It also removes noise (if present) in the signal.

4. Data Processing Element:
Data processing element is an important element used in many measurement systems. It processes the data signal received from the variable manipulation element and produces suitable output.
Data processing element may also be used to compare the measured value with a standard value to produce required output.

5. Data Transmission System:
Data Transmission System is simply used for transmitting data from one element to another. It acts as a communication link between different elements of the measurement system. Some of the data transmission elements used are cables, wireless antennae, transducers, telemetry systems etc.

6. Data Presentation Element:
It is used to present the measured physical quantity in a human readable form to the observer. It receives processed signal from data processing element and presents the data in a human readable form. LED displays are most commonly used as data presentation elements in many measurement systems.

IV. CONCLUSION

Water quality monitoring is a critical step towards the identification, re-establishment and maintenance of the water sources which became polluted over time due to various human beings and other factors. In this paper an efficient, low power, real time water quality monitoring system based on wired and wireless sensor networks is compared. We have compared selected water quality sensors like Temperature, pH, Dissolved Oxygen and Turbidity. After comparing various available sensors we selected two to three sensors for our water quality analysis purpose. In which temperature sensor is LM35 series and LM 50 temperature sensors are precision integrated-circuit temperature devices. By comparison of pH sensor listed data it is clear that some sensors are unnecessarily high range and/or are of high ambient temperature tolerance. So we selected PH100, PH300 and PH1200 are recommended keeping in mind the cost efficiency.

The sensors whose range is in between 0 – 20ppm are more than enough for the given application similarly the water temperature rarely rises above 50^{o}C in ambient conditions hence sensors like OPTISENS ADO 2000 and 499ADO are recommended keeping in mind the cost efficiency.

By all of the above Turbidity sensor data it is clear that out of compared four sensors anyone can be used for real time water quality analysis since there is not a huge amount of differences between them. Here we are selecting TSD-10 and 165D6042P003 turbidity sensor for further implementation. Hence the sensor must be selected depending upon the cost of project compared to that of sensor.

V. FUTURE SCOPE

As future work, more sensors are to be included in this system to measure additional parameters including chloride, fluoride and conductivity. The inclusion of the latest technologies such as Wireless Network Virtualization and Edge Computing for real-time and effective monitoring of the water quality parameters in a lake or river will make the current proposed system more innovative.

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