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Implementation of Contactless Liquid Level Sensing

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Abstract: *Usually, the arises to measure liquid levels in containers, in large industries; where large volumes of liquids are stored, in small scale industries and residential buildings in developing countries that sees many households implementing their own domestic water supply system. Measurements by humans may be influenced by sentiments, fatigues, lack of concentration, and so on, which has led to economic losses due lost liquid and wasted electric power. Therefore, researches have been directed toward development of automatic liquid level sensing technologies. This paper will assist instrumentation researchers to know the state of the art in level sensing technology, and practitioners in selecting the right kind of level sensors for a particular application.*

Keywords: Ultrasonic Sensors, Arduino, Capacitance, Resistivity, Tuning Fork, Microwave/Radar, Optical, Float.

I. INTRODUCTION

Majority of earth's surface is covered with water but less than 5% is useful. So water conserving has become a major issue so certain water management steps are to be taken. Measuring water level is an important task from government and residence side. Thus, existing management systems has to be updated [7]. In this paper, we investigate the water level management using ultrasonic sensor which detects the amount of water present in the tank and returns the capacity of water present in it.

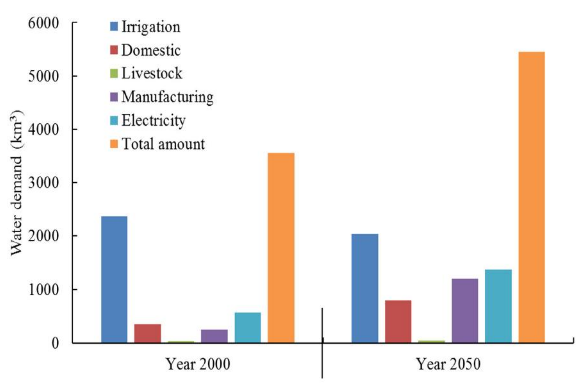

Fig.1: Statistics of water scarcity

The water level management has been a major issue so new methods has to be adopted to control the water level. Here our proposed system works better than existing system. Existing system: The existing system works with many number of wires let us take a tank which is divided into percentages like 10%, 20% . . . . 100%. Every wire is of different size kept at different percentages of the tank . If the water present in the tank is 10% the water touches only one wire so LCD returns the amount of water present in it. This take much time in implementation. As water touches the wires may get damaged. The ultrasonic sensor plays major role in determining the water level present in the tank. This sensor is fitted under the lid of the tank and uses the concept called "echo". The sensor contains two small openings called trig and echo. The trig works like a small speaker in which it sends the ultrasonic waves and the echo acts as a small microphone in which it receives the reflected waves which are sent by trig and this echo returns the distance. So by this we are known of water level in the tank through serial monitor.

1.1 Optical Level Switches

- **Pros** – Compact, no moving parts, high pressure and temperature capability, can detect tiny amounts of liquids
- **Cons** – Invasive as the sensor requires contact with the liquid, requires power, certain thick substances can cause coating on the prism.
- **Applications** – tank level measurement and leak detection applications

There are a range of technical terms used to describe this type of level sensing technology. Optical prism, electro-optic, single-point optical, optical level switch…the list goes on. For this purpose, we will use the term Optical Level Switch. The switch operates very simply. Inside the sensor housing is an LED and a phototransistor. When the sensor tip is in air, the infrared light inside the sensor tip is reflected back to the detector. When in liquid, the infrared liquid is refracted out of the sensor tip, causing less energy to reach the detector. Being a solid-state device, these compact switches are ideal for a vast range of point level sensing applications, especially when reliability is essential. Optical liquid level switches are suitable for high, low or intermediate level detection in practically any tank, large or small. They are also suitable for detecting leaks preventing costly damage. Reflected light, such as in a small reflective tank, mirrored tanks, bubbles, milk or coating fluids can often cause issues with delayed readings[6].

Fig.2: Optical Level Switch

1.2 Capacitance

- **Pros** – Solid-state, can be non-invasive, compact, accurate
- **Cons** – May require calibration, can only be used in certain liquids
- **Applications** – Tank level monitoring in chemical, food, water treatment, power and brewery industries.

Capacitance level sensors operate in the way that process fluids have dielectric constants, significantly different to air. They measure the change in capacitance between two plates produced by changes in level. Two versions are available, one for fluids with high dielectric constants and one with low dielectric constants. Capacitance level sensors work with a range of solids, liquids, and mixed materials. They are also available in contact and non-contact configurations meaning some of which can be attached outside the container/tank. When selecting a device, it is important to know that not every capacitance senor works with every type of material or tank. In addition, the sensor needs to be calibrated to the specific material to excuse the varying dielectric constants and differences in the tank design. As this type of technology is contact based, the reliability of these sensors can be heavily influenced by fluids sticking to the probe[3].

Fig. 3: Capacitive Sensor

1.3 Microwave/Radar

Fig. 4: Microwave sensor

- **Pros –** very accurate, no calibration required, multiple output options
- **Cons –** expensive, can be affected by the environment, limited detection range
- **Applications –** Moist, vaporous and dusty environments. They are also used in systems in which temperatures vary

In principle radar works in a similar way to ultrasonic, but the pulses travel at the speed of light and again; the reliability and repeatability can be affected – but this time by the dielectric constant of the fluid. However, radar can provide very precise level information and also compensate for fixed structures within the container. The downside can be that the initial cost of the sensor is relatively high, but several manufacturers are making this technology more accessible to the wider market. These sensors are among the handful of technologies that work well in foam and sticky substances[6].

1.4 Vibrating or Tuning Fork

- **Pros** – Compact, cost effective
- **Cons** – Invasive, number of uses are limited
- **Applications** – level control of liquid, powders and fine grained solids within mining, chemical processing and food and beverage industries.

The vibrating sensor technology is perfect for solid and liquid level control, including sticky materials and foam, as well as powders and fine grained solids. However, the types of applications that can use tuning forks is limited to overfill or run dry type applications and they do not provide continuous process measurement. However can be used in conjunction with continuous level detection systems, acting as alarm points for over-filling and leaks[6].

Fig.5:Tuning Fork

1.5. Conductivity or Resistance

- **Pros –** No moving parts, easy to use, low-cost
- **Cons –** Invasive, liquids need to be conductive, probe erosion
- **Applications –** Tank level measurement for boiler water, reagent monitoring, highly corrosive liquids

Conductive sensors are used for point-level sensing conductive liquids such as water and highly corrosive liquids. Simply put, two metallic probes of different lengths (one long, one short) insert into a tank. The long probe transmits a low voltage, the second shorter probe is cut so the tip is at the switching point. When the probes are in liquid, the current flows across both probes to activate the switch. One of the benefits to these devices is that they are safe due to their low voltages and currents. They are also easy to use and install but regular maintenance checks must be carried out to ensure there is no build up on the probe otherwise it will not perform properly[6].

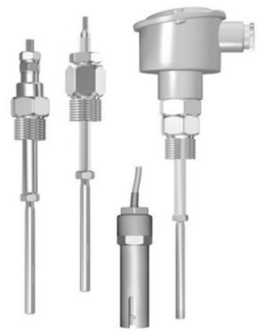

Fig.6: Conductivity sensor

1.6. Float Switch

- **Pros**: Non-powered, direct indication, relatively inexpensive, various outputs
- **Cons**: Invasive, moving parts, large in size, large amount of liquid has to be present before the float makes contact.
- **Applications**: Tank level applications where water, oil, hydraulic fluids and chemicals are being used.

Float switches are one of the most cost effective but also well proven technologies for water level sensing. A float switch includes a magnet within a float and a magnetic reed switch contained within a secure housing. The float moves with the change in liquid and will cause the reed switch to either open or close depending on if it's in air or liquid. Although simple in design, this technology offers long-term reliability at an attractive price point.

Depending on what mounting style the user chooses heavily depends on the design and construction of the tank or container the switch will be situated. Typically, suppliers will offer a range of mounting options with the most common being horizontal/side mounting and vertical Mount[6].

Fig.7:Float sensor

1.7 Ultrasonic

- **Pros –** No moving parts, compact, reliable, not affected by media properties
- **Cons –** expensive, invasive, performance can be affected by various elements in the environment
- **Applications –** Non contact applications with highly viscous and bulk solids. Used in systems that require remote monitoring

Ultrasonic sensors measure levels by calculating the duration and strength of high frequency sound waves that are reflected off the surface of the liquid and back to the sensor – the time taken is relative to the distance between the sensor and the liquid. The length of time in which the sensor takes to react is affected by various elements in the atmosphere above the media such as turbulence, foam, temperature etc. Hence why the mounting position is critical in these devices [2].

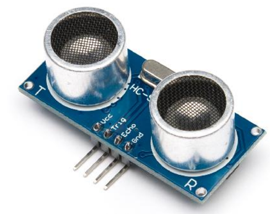

Fig.8: Ultrasonic sensor

II. METHODOLOGY

The idea behind all contactless methods is to measure distance between transceiver and fluid. As said before, we transmit short ultrasonic pulse and we measure travel time

Of that pulse from transceiver to liquid and back to transceiver. Ultrasonic pulse will bounce from liquid level since because change of density of ultrasonic pulse travel medium (ultrasonic pulse first travel through air and bounce of liquid with higher density than air). Because water has higher density, majority of pulse will bounce off.

This method of measuring with ultrasonic sensors is more accurately described as water level measuring and used for water level control. In a tank or container, this will produce the same results. It is important to note, you would need to position the sensor at a fixed point above wherever the water is stored.

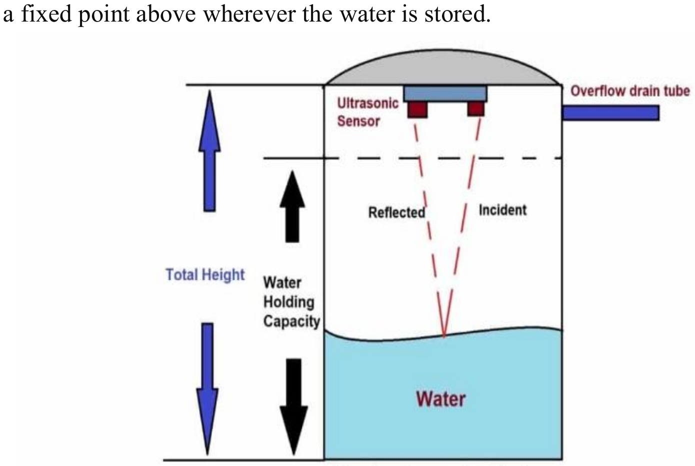

Fig.9: Block diagram of tank and sensor setup

Fig.9 shows installment of sensor at the top of the tank which contains liquid in it. The sound wave is reflected by the liquid surface and received by the same sensor. It is converted into an electrical signal. The time between the transmission and reception of the sound wave is used to calculate the Measure of the distance to the surface of the liquid.

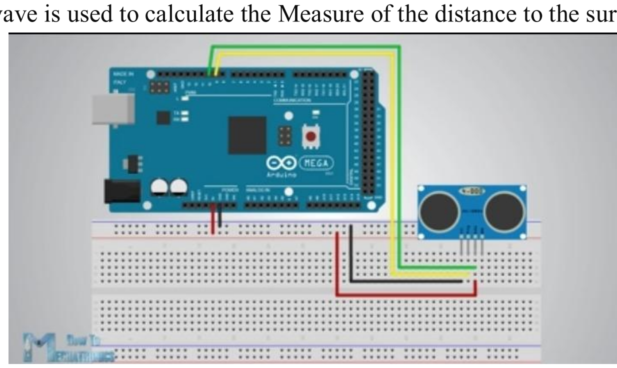

Fig.10: Circuit Digram of Arduino and Ultrasonic sensor connections

Fig.10 shows Trigger and Echo pins of ultrasonic sensor are connected to the 9th and 10th input pins of the arduino. Further, Ground and VCC of both arduino and sensor are conncted accordingly.

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III. RESULT AND DISCUSSION

As we fluctuate water level in tank ,we can see the fluctuation on serial monitor also. If we increase water level in tank, we will get increased height of water level on serial monitor and if we decrease water level in tank, we will get decreased height of water level on serial monitor. As shown in Fig.11 , we calculate height of tank and code the program of arduino in such a way that height from water surface to sensor gets subtracted from total tank height and gives output of actual water level. Here are some readings performed using this setup.We can see some approximations in manually calculated measurements. Also we have calculated capacity of the tank according to water level height.

Serial Monitor Output (in cm)	Manual Measurement (in cm)	Capacity (in litre)
5	5	25
10	9.8	49
15	14.9	74.5
20	19.6	98
25	24.9	124.5
30	29.8	149
35	34.7	173.5
40	39.4	197
45	44.7	223.5
50	49.5	247.5
55	54.8	274
60	59.9	299.5
65	64.4	322
70	69.5	347.5
75	74.6	373
80	79.9	399.5
85	84.7	423.5
90	89.8	449
95	94.4	472
100	99.5	497.5

Fig.11: Table of readings taken using project setup

For example, the initial manual measurement of the water level is 5cm after some water is filled in the tank. The serial monitor shows 5cm output. And according to the manual measurement we calculate capacity as 25 Litres(5 x 5)

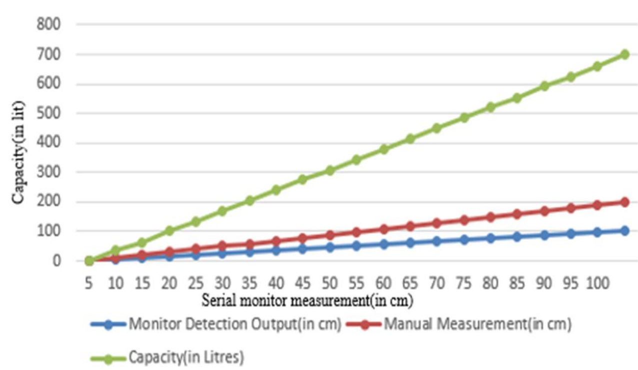

Fig.12: Graph of output details

X-axis shows monitor detection output and
Y-axis shows Capacity of the tank according to the water level.
According to the Fig.12, we can conclude values of measurements of serial monitor and manual mesurements are approximately same.

IV. CONCLUSION

In the present situations, water necessity is very high. Population is growing linearly day by day but the necessities are not being fulfilled at the same rate.

Among most dangerous problems water scarcity is major issue we need to resolve that problem at easiest way.

- Tanks are being overloaded, due to improper maintenance this issue arises. So when we adopt the technologies like proposed system we can handle this issues.
- The system is in appropriate in the areas where sound rays are produced with in the same frequency of ultrasonic sensor.

FUTURE SCOPE

This project can be used in automation by connecting it to water pump and regulating the water input in the tank.

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