Implementation of capacitive fluid level sensor

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Abstract-**This paper describes the design and characterization of a fluid-level measurement system based on a grounded capacitive sensor. The sensor electrodes are built with affordable materials: a stainless steel rod. The interface circuit relies on a common relaxation oscillator (which performs a capacitance-to-period conversion) and a microcontroller (which carries out a period-to-digital conversion). Furthermore, a cable with active shielding interconnects the sensor with the interface circuit over a level range of 150cm.In some cases, mechanical solutions are sufficient. For example, a toilet float valve is suitable for shutting off water flow at a determined level. But what if it could detect a fault, send an alert signal to a central monitor and eliminate a disaster like flood by automatically shutting down the input water supply? In today's increasingly resource- and energy-conscious world, mechanical systems are giving way to more sophisticated electronic and electromechanical approaches that add layers of functionality and integration as part of a more comprehensive system. Here embedded microcontrollers, can do a better job, making possible feats that mechanical systems can't reasonably be expected to handle.**

Keywords: **Stainless steel rod, frequency measurement using CRO, VCO, 89c2051 microcontroller, RS-232 communication**

I. INTRODUCTION

Sustainability of available water resource in many reason of the world is now a dominant issue. This problem is quietly related to poor water allocation, inefficient use, and lack of adequate and integrated water management. Water is commonly used for agriculture, industry, and domestic consumption. Therefore, efficient use and water monitoring are potential constraint for home or office water management system. Last few decades several monitoring system integrated with water level detection have become accepted. Measuring water level is an essential task for government and residence perspective. In this way, it would be possible to track the actual implementation of such initiatives with integration of various controlling activities. Therefore, water controlling system implementation [2] makes potential significance in home applications. The existing automated method of level detection is described and that can be used to make a device on/off [3]. Moreover, the common method of level control for home appliance is simply to start the feed pump at a low level and allow it to run until a higher water level is reached in the water tank. This is not properly supported for adequate controlling system. Besides this, liquid level control systems are widely used for monitoring of liquid levels, reservoirs, silos, and dams etc. Usually, this kind of systems provides visual multi level as well as continuous level indication. Audio visual alarms at desired levels and automatic control of pumps based on user's requirements can be included in this management system. Proper monitoring is needed to ensure water sustainability is actually being reached, with disbursement linked to sensing and automation. Such programmatic approach entails microcontroller based automated water level sensing and controlling.

II. BASIC CONCEPTS

The technique of water level monitoring and controlling system concentrated with some basic parts which are softly aggregated together in our proposed method. Basic descriptions of some parts are described below.

A. FLUID LEVEL INDICATOR

For fluid level indication unit we can use some LED light which will work for fluid level indication. By touching different water levels through water level sensor, LED should be indicated as on/off (i.e. on: yes sensor senses water).

B. FLUID LEVEL SENSOR

We did consider fluid like water, diesel, mixture and chemical composition etc. To make special fluid level sensor we would like to introduce some convenient materials such as Iron rod, sensor cable, resistance etc[4]. A connecting rod made by iron and steel which dropped into the liquid level tank. After that we calibrated the various frequency reading at various levels. Here we observed the reading each 1cm.Then we plot the (X-Y) axis graph. Sensor-array probe uses the liquid level as part of the circuit path. The height location of the sensor points correspond to the desired levels to detect, and the contacts are made or coated with a material that won't corrode, oxidize or react with the liquid in the tank. The sensor points can be inserted directly into the tank. Terminal posts on the other side can wire directly to the interface board, but most designers prefer a sensor board that can be inserted and removed in a single location. The fewer holes drilled into a tank, the fewer possible sources of leak and failure but we didn't hole in the tank .we inserted the sensor stainless rod from top to bottom gradually for high resolution and noted the observation. Replicating the same stage will provide as much resolution as needed. The LEDs can be replaced or paralleled with opto-isolator to drive logic signals with high isolation.

The voltages used should not cause electrolysis in the tank. It's important not to build up explosive gasses. One technique is to sense every so often rather than in real time. This ensures that power is off to the entire array for most of the time, only powered up when needed for a quick measurement. Also, shunting each side of the sensor to ground when not in use will not let a charge build up. Sensor will exhibit a lower frequency when liquid levels are higher. A parallel capacitor can set the open-circuit oscillator base frequency. As soon as liquid touches the bottom part of the probe, the capacitance will change abruptly to a lower frequency, which begins the measurement range. As the level rises, more capacitance lowers the frequency linearly. At the highest fill level, the lowest frequency will be measured.

III.555 TIMER IC

A simple oscillator circuit such as a 555 can create a frequency range that a micro can measure. The 555 can also be used to control the pulse width. A typical oscillator can be made using a 555 timer. The frequency of the oscillator indicates the liquid level. A constant current source continuously charges the capacitive sensor to the reference threshold level on the comparator. The comparator will pulse high each time the capacitive sensor reaches the reference threshold level .this closes the switch, discharge the capacitor and resets the counter. Here we used the IC555 as a voltage controlled oscillator.

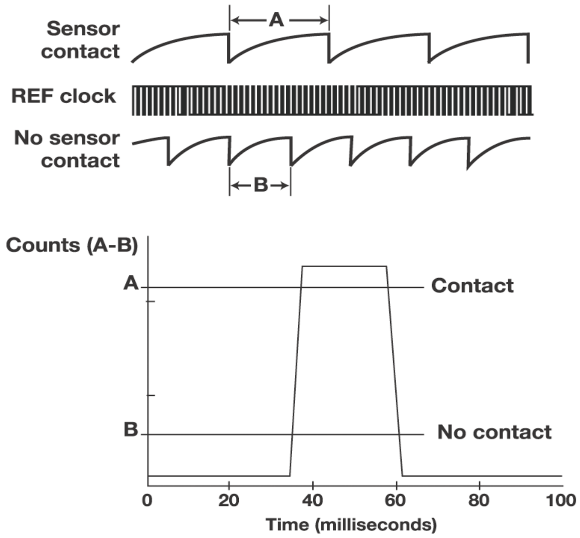

Figure 1.VCO waveform with and without sensor contact

IV.EXPERIMENTAL RESULT & DISCUSSIONS

We obseved the different frequency at diffent level and also observed the different range of frequency for different types of fluid .every fluid have its own dielectric so the relative permittivity becomes changes on changes the fluid.here we observed the data to consider two fluid (water,diesel).we oserved the diffent range of frequency in each case.i performes this result ti take a stainless steel rod of length(150cm).i select the single rod in cylindrical shape diameter(1.2 cm).The insulated electrode is built with a PTFE (commonly known as (Teflon) insulated wire whose nominal internal and external diameters are 1 mm and 1.5 mm[5]. I plot the graph between the increasing level of water and its corresponding frequency. The observed of frequency continuous decreasing on increasing level of water due the variation in capacitance increases on increasing level of fluid. So we observed data continuously on each 1(cm) scale. We observed very precisely.

A .Water level column vs. frequency reading

When we take observation then electronics part should be above water in a waterproof box that is attached to the metal probe frame. The box cannot be separated some distance away from the probe because the capacitance of a cable would be too great compared to the probe capacitance. The output cable can also bring low voltage unregulated DC power to the unit. It can be long and even be under water back to dry land if required. The DC bias provided by the oscillator will make things worse. A low temperature coefficient large capacitor in series between the sensor and the oscillator can solve this problem, but is expensive and will reduce sensitivity. Better to avoid the problem in the first place. Observations are listed below where we show the height of water column and corresponding frequency. Here we took observation these are the basically frequency reading with respect to the level of fluid in the tank. We observed here that on increasing level of fluid, the frequency is decreasing recorded these reading by oscilloscope. These are reading for water. we perform the experiment four times when we start the experiment first time we observed very good frequency response. After that some changes occur even response is too good. Here we showed 105 cm fluid level and continuous monitoring the frequency on each cm. After observing this record, I made the display (bar graph display)[6][7] to show the level of fluid in the tank. We have various frequency on various level .some point are in the recorded data that we observe the large change. It can be due to some external physical condition (temperature, pressure etc).but in increasing the level frequency during various experiments observed very close. it is very sensitive so at the time of measurement we should take proper precautions.

Table 1.measured level and capacitive level sensor frequency

Water Level in tank (cm)	Freq f_1(kHz)	Freq f_2(kHz)	Freq f_3(kHz)
1	4.647	4.132	4.872
2	4.505	3.926	4.7
3	4.411	3.878	4.587
4	4.355	3.817	4.51
5	4.24	3.806	4.386
6	4.202	3.788	4.344
7	4.181	3.745	4.303
8	4.075	3.723	4.244
9	4.016	3.697	4.153
10	3.972	3.64	4.082
11	3.904	3.595	4.013
12	3.838	3.553	3.928
13	3.776	3.487	3.846
14	3.728	3.437	3.817
15	3.648	3.386	3.75
16	3.595	3.36	3.745
17	3.54	3.326	3.704
18	3.509	3.298	3.636
19	3.455	3.259	3.593
20	3.413	3.213	3.531
21	3.362	3.191	3.48
22	3.32	3.185	3.428
23	3.294	3.145	3.377
24	3.243	3.121	3.3
25	3.218	3.096	3.283
26	3.165	3.045	3.238
27	3.106	2.978	3.209
28	3.064	2.945	3.173
29	3.012	2.91	3.147
30	3.001	2.887	3.106
31	2.98	2.838	3.045
32	2.948	2.825	3.027
33	2.91	2.787	2.98
34	2.867	2.759	2.938
35	2.826	2.717	2.921
36	2.806	2.694	2.9
37	2.759	2.677	2.844
38	2.72	2.647	2.817
39	2.68	2.618	2.769
40	2.677	2.593	2.741
41	2.634	2.558	2.716
42	2.614	2.541	2.68
43	2.572	2.498	2.658

Here we calibrated the result up to 43 cm.

B. Comparison analysis between actual level and measured level

Here we compared the actual level and measured level. Red line in graph showed the actual level of fluid and blue graph showed the measured level's observed there is no more difference in the actual level and measured level. at starting point of graphs makes some difference because the line of graph not fully overlapped to each other. But when the level of fluid stars increasing the measured level is overlapped not fully but very close. This small difference due to variation of physical condition .it is too precise and accurate. We indicate the level in centimetre scale. axis of graph showed the actual level and y axis showed the measured level .we measured it up to 115cm (approximate).we observed these reading after using capacitive sensing module made by 150 cm stainless steel rod and insulated Teflon cable .i selected the stainless steel rod as hollow cylindrical shape. After drilling bottom of this rod made a hole of 5mm diameter .in case of diesel we observed the reading up to 130 cm. after that to see the result we designed the bar graph display board using 89c2051 microcontroller.

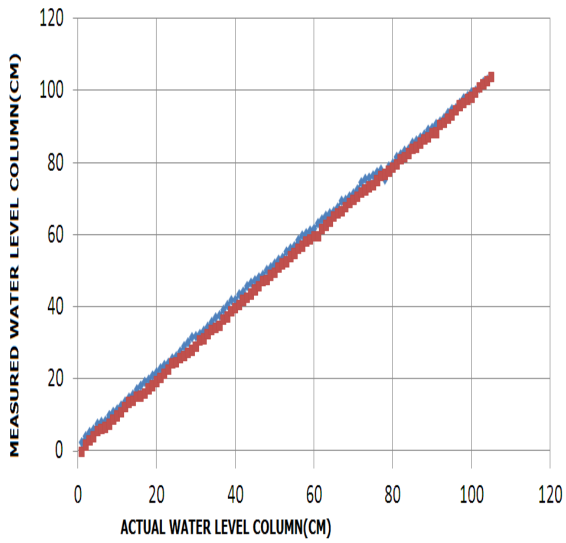

Figure 2.Comparison between actual water level column and measured

V.PROPOSED FLUID LEVEL SENSOR

We designed a small module of capacitive fluid level sensor. The main advantage of this that we can use this for different types of fluid. We made it for continuous level monitoring and real time application's also used to RS-232 communication cable for interface to the computer and bar graph display as a visual indicator. This can be very useful for various type of fluid operation. We made this sensor for various purposes like water, diesel, mixture and also for chemical composition in various industries. Resolution is defined as the smallest reliable measurement that a system can make. The resolution of a capacitive sensing system must be better than the final accuracy the measurement requires. here we proposed the work for continuous level monitoring and real time application. We display the level using bar graph display and recorded data by using Hyperterminal communication. It is continuous data monitoring sensor. For better resolution we made a slot at each 1(cm) and observed frequency in each 1(cm) slot. After that we compared the actual water level column and measured water level column. At starting point a little bit drift occur, after that we obtained absolute good result. We used 89c2051 as a single board computer.

VI.CONCLUSION

The objective of the work presented in this paper is to design an integrated capacitive sensor interface with emphasis on maximizing the performance in relation to the costs. Here we made continuous level measurement To begin with; some typical applications and sensor elements are considered for this design. Next, the electrical properties of the capacitive sensors are characterized as accurately as possible. Then, the most important interface requirements for different applications are considered and the performance. Therefore, the number of modes should be kept to a minimum, with a minimum sacrifice of performance and application range. By analyzing the charge-transfer time constant, we found that the integrator current needs to be programmable. The oscillator frequency, which is inversely proportional to this current, can be set by the user to optimize the interface performance for user-specific applications. In addition to this, a programmable digital divider is available to match the data acquisition rate with the bandwidth of the physical sensor signal. Finally, with an off-chip capacitor, the user can set a desired capacitor range. Often, capacitive sensor elements are connected to the electronic interface circuitry with long wires consisting of cables. To reduce the effects of interference, these connecting wires or cables are shielded. Provisions have to be taken to prevent the parasitic capacitances of these cables from forming direct shunting components for the sensing elements, because without such provisions any changes in these parasitic capacitances would seriously degrade the sensor-system performance. When the capacitive sensor elements are floating, i.e. when none of the terminals have been connected to ground, then they can be read by interface circuits that are intrinsically immune to stray capacitances. Also it is possible to perform two-step measurements in order to extract the value of a floating capacitance separately from the parasitic capacitance. However, safety reasons and/or operating limitations might require one of the electrodes of the sensing elements to be grounded. Here we observed that capacitive sensing module is good but it becomes much effect due to physical environmental condition. We tried to overcome all these problems so we observed very precise and accurate result. We have successfully experiment the system in lab. Resolution is defined as the smallest reliable measurement that a system can make. The resolution of a capacitive sensing system is better than the final accuracy the measurement requires.

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