African Journal of Basic & Applied Sciences 4 (6): 226-229, 2012
ISSN 2079-2034
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DOI: 10.5829/idosi.ajbas.2012.4.6.1121

A Prototyping Model for Fuel Level Detector and Optimizer

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Abstract: There are many sensor based techniques available in the market to measure the liquid level and gives you a close idea of quantity of the liquid, however none can provide you an exact approximation of quantity as in cars by fuel meters what we get an idea of whether tank is full, empty, half full etc. The liquid level detector and optimizer play an important role in tanks to indicate the level of liquid of a particular density. In this paper we have proposed a technique to measure the amount of liquid available in tank. This device digitally displays the level of liquid inside the tanks using load sensor. The measurements are taken so the accuracy level is of 96.36%-98%. Thus it is an efficient device made by keeping in mind the petroleum thefts at the various petrol pumps at the time of filling of tanks.

Key words: Liquid Level Detector · Gauge sensor · Fuel Meter

INTRODUCTION

A fuel level detector (fuel gauge) is a device inside of a car or other vehicle that measures the amount of fuel still in the vehicle. This type of system can be used to measure the amount of gasoline or some other type of liquid. It will typically consist of a sensing or sending unit that measures the amount of fuel actually left and a gauge or indicator that relays this information outside the fuel container. A fuel gauge can be designed in a number of different ways and many gauges have several flaws that can make the readings less than accurate. The two parts of a fuel gauge are the sensing or sending unit and the indicator or gauge [1].

A sensing unit is the part of a fuel gauge found within or connected to the actual fuel storage container on a vehicle. On a car these days, for example, the sensing unit will consist of a float inside the fuel tank, which is connected to a metal rod that runs to a small electrical circuit. The float raises or lowers depending on the amount of gasoline in the fuel tank [1].

As the float moves, the arm it is connected to moves a wiper that is connected to a resistor in that electrical circuit. When the tank is full and the float is at the top, the resistor is moved to one side of the circuit and a large amount of current is able to pass through. As the tank empties and the float lowers, the wiper moves in the circuit, the resistance increases and current reduces. On the other side of the fuel gauge, there is an indicator or gauge that displays information about fuel levels to the driver of a car. This can consist of either a bimetallic strip or a microprocessor connected to the circuit in the sensing unit. As resistance changes in the circuit, current increases or decreases and the bimetallic strip will bend or straighten out depending on changes in current that increase or decrease the temperature of the strip. As the strip changes shape, it will physically move a needle on a fuel display, relaying that the fuel tank is empty, full, or some amount in between. A microprocessor is able to process the changes in current and then sends a signal to a mechanism that moves a needle in a similar way [1].

The design of a fuel gauge, however, creates some potential for errors in accurate fuel measurement. For example, the float in the fuel tank can reach the top of the tank and will not go down until fuel has gone below the bottom of the float. This is why many fuel gauges will read full after some fuel has been used since the float has not begun to descend. Once the float reaches the bottom, it will display that the tank is empty, even if there is still a significant amount of fuel left in the container. The shape of a fuel tank can also affect the accuracy of a fuel gauge, since uneven shapes may not have easily measured volumes [1].

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The fuel level detector presented in this paper digitally displays the level of liquid inside the tanks using load sensor and can be used for measuring the level of any other type of liquid. The fuel (liquid) level is automatically detected by the weighing Mass of the liquid by Load sensor and displaying the output on a Display device (LCD). This system is efficient in measuring the Volume of a Liquid of any density. The input of the system is the weight applied on the load sensor (transducer). Load sensor produces electrical signal corresponding to the weight and the output signal is amplified by the amplifier. The amplified signal given to the ADC which generate digital output given to the microcontroller. Microcontroller is attached with a keypad which is used to select the density of the Liquid to be measured, correspondingly output is obtained on the LCD screen, as well the total amount of liquid to be entered in volume to the tank and the buzzer is rung on the activation of relay when the definite amount of liquid level is reached.

Fuel Level Detector: The Fuel Gauge in Indian Automobiles works on the principle of Variable Resistance. A vertical resistance type sensor is installed in the Fuel Unit that senses the fuel level and accordingly provides resistance value. The gauge works on a magnetic principle, the pointer being attached to a light weight magnet which is pivoted about the centre, as the magnet rotates the pointer swings as well [2]. Thus the sensitivity level is quiet low and the output is the analog value.

A vertical resistance type sensor is installed in the Fuel Unit, which senses the Fuel level according to which it provides the resistance value i.e.

- When the tank is Empty, needle of the Fuel Gauge display shows or points on “E”, in this case resistance is maximum so least current flow in the fuel circuit which is displayed to the driver. This current so less that it is unable to swing the needle of the fuel gauge, thus needle is unmoved, hence it points on EMPTY position.
- Similarly, when the fuel tank is full, the Fuel Circuit detects minimum resistance, hence maximum current flows. This current swings the needle to the extreme position of the Fuel indicator i.e. FULL (F).

Values of Resistance at Various Levels of Fuel: (T= -30 to 60 degree Celsius).

Table 1: Pointer position and relative resistance [3]

Fuel Position	Values of Resistance (in Ohms)
Full	40.0 + - 2.0
Half (1/2)	160.0 + - 7.0
Empty	280.0 + - 3.3

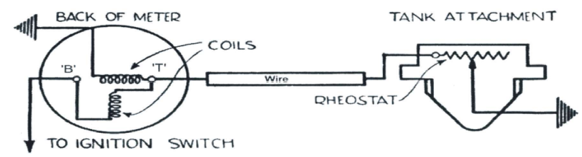


Fig. 1: Variable Resistance Gauge internal circuit [5]

As shown in Fig. 1, the gauge works on a magnetic principle, the pointer being attached to a light weight magnet which is pivoted about the centre, as the magnet rotates the pointer swings as well. Inside the gauge are two coils which form electromagnets, one is across the gauge from left to right (when the gauge is viewed as in the car) and the other coil is vertical, as in the diagram below. As the coils are energized they both have an effect on the magnet attached to the pointer, one is trying to move the pointer to the 'Full' [4] position the other is holding the pointer at 'Empty' [4]. Any change in the strength of the magnetic field created by the second (horizontal) coil will cause the pointer to move relative to the strength of change.

There are three electrical connections on the rear of the gauge; this is where the uninitiated go wrong as they notice the two terminals marked 'B', to the battery and 'T', to the fuel tank, but fail to realize that the body of the gauge MUST be earthed, the third connection, via the central fixing clamp which holds the gauge in the dashboard.

In basic terms when the gauge is connected to the battery (via the 'B' terminal and the body of the gauge) the two coils are both energized which holds the magnet and pointer, in the 'Empty' position. If you look at the diagram you will see that one coil is between the 'B' and 'T' terminals and the second coil is from the 'T' to the earthed body. You will also notice that the tank sender unit is connected to the 'T' terminal and the earth return to the battery, it is therefore connected across the same two connections as the coil in the gauge.

The coil in the tank unit is a variable resistor, or rheostat, which can be shorted out along its length by the action of the arm attached to the float, in effect when the tank is empty all the coil in the tank is in action but when the tank is 'Full' none of the coil in the tank is in action. When the amount of coil in action in the tank changes, because it is connected across the coil in the gauge it changes the effect that the coil in the gauge has in terms of magnetism. This change effect the balance of the magnetic fields in the gauge and the magnet swings moving the pointer. When the tank is 'Full' it effectively shorts out the coil in the gauge and the magnetic effect of the second coil is removed and the pointer swings to its fullest amount.

Prototype Model for Liquid Detector Optimizer: We have integrated digital display of output in mill liters of liquid contained within the tank. The calculations are based on the pre calculated weight of the tank as well on the liquid with the known densities. The weight of the liquid is sensed by the load cell, the density of the liquid is being provided by the user according to the liquid to be filled.

$$Density = \frac{Mass}{Volume}$$

$1gm = 1ml\ for water$

$Volume\ (ml)$

The volume in ml is calculated by the programming in the microcontroller [6] and thus displayed as output to the LCD [7]. Also the total amount to be entered in ml, is the input from the user according to which the relay is activated as soon the desired level of liquid is attained and the buzzer is rung for the reference of the same.

Advantages of Proposed Prototype Model:

- No use of variable Resistance, thus device output does not vary non-linearly with temperature.
- Gives digital numeric display of Volume of the liquid in the tank.
- As all the components used are in the form of IC’s therefore no Back EMF problem occurs.
- With the attachment of the Buzzer (or a DC Motor), which activates on reaching a preset value, we can avoid costly and dangerous overflowing of tanks.
- Can be used with Multiple liquids i.e. we cannot use same device to measure volume of Gasoline, Water, Honey etc. as we can set value of density of any particular liquid.
- Simple Volume calculation Mechanism.
- No need of Tank/Vessel dimensions, therefore, no Complications and Errors in case Tank dimensions are not accurate.
- Thus it is very linear device.

Table 2: Pre-requisite data contents [8]

Name of Fuel	Temperature (in Celsius)	Density (in Kg/ml)
Gasoline	15.5	0.73
Diesel	15	0.8-0.95
Water (Pure)	4	1
Water (Sea)	25	1.021

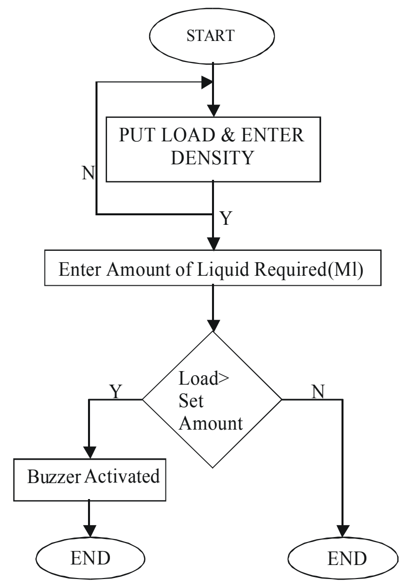


Fig. 2: Fuel level detector Operation Flow

Some Pre-Requisite Data and Experimental Assumptions:

- Pure water has the Density 1 kg/l.
- At approx 4 Degree Celsius, pure water has its highest density.
- Specific Density (Relative Gravity) of a substance is the ratio of substance to the density of water at 4 Degree Celsius.

RESULT AND DISCUSSION

We have analyzed the errors obtained as per following data set.

Maximum Load that we can on our Load Sensor is 10kgs.

It displays 8 Bit data by LED’s and send them in parallel to Microcontroller.

$$Analog\ Value = Number \times Step\ Size$$

or

$$Step\ Size = \frac{Analog\ Value}{Number\ of\ Steps}$$

Table 3: Experimental results

Name of Liquid	Mass (in Gms)	Density (in gm/ml)	Volume Practical (in ml)	Volume Theoretical (in ml)	% Error
Salty water	1000	1.021	1000.00	979.43	+2.057
Gasoline	1000	0.737	1428.57	1356.86	+5.019
Diesel	1000	0.832	1250.00	1201.92	+3.846

As Load sensor displays 8 Bit Data,

$$There\ fore,\ Number\ of\ Steps = 2^n - 1$$

where n= number of bits (here n=8)

$$Step\ Size = \frac{10}{2^8} - 1 = \frac{10}{255}$$

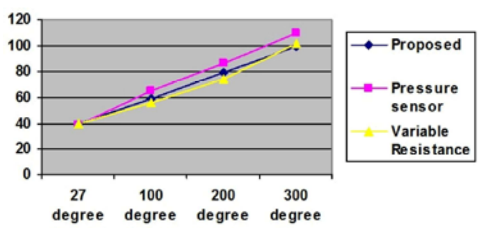
$Step\ Size = 0.3921 = 0.04 Kgs\ (approx.)$
$Step\ Size = 40 gms$

This means that with each LED which glows, weight Increases by 40gms e.g. If only First 2 LED's glow (out of 8),

Its Digital Value will be $= 1 \times 2^0 + 1 \times 2^1 = 3$

This means Analog Output must be = 3×40= 120gms
% Mean Error = (2.057+5.019+3.846)/3 = 3.64%
Therefore the Functioning of Generic Digital Gauge has been verified with % error of 3.64.

Comparison of Various Transducers Output V/s Temperature:



*Vertical axis shows Volume in ml (output)
*Horizontal axis shows Temperature

CONCLUSION

This paper presents a prototype model of Fuel Level Detector with accuracy of 96.36% - 98%. This model also applicable to other types of liquid. The main component in Fuel level detector is the load sensor which generates the signal based on the weight of liquid available in tank.

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