
A MICROCONTROLLER- BASED FUEL LEVEL INDICATOR

By

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ABSTRACT

The paper presents a microcontroller-based petrol level gauge for a horizontally mounted underground cylindrical tank. The major blocks are a magnetostrictive level sensor, a microcontroller and a liquid crystal display (LCD) unit. The sensor basically senses the position of a permanent magnet to determine the distance between the permanent magnet and the sensor head. The output of the sensor is an analog signal, which is fed to the microcontroller. In order to determine the contents of tank fitted with petrol level sensor, the microcontroller is programmed with an algorithm employing a mathematical expression for computing data value based on petrol level sensor output and tank dimension. The output of the programmed microcontroller is read out to give the height in meters and volume in litres via an LCD display. The prototype meter measures petrol in the range of 0 to 22.773 litres, with an accuracy of $\pm 1.8\%$, which is acceptable in comparison with commercial analogue petrol level gauge.

INTRODUCTION

In most petrol filling stations, fuel is first discharged into the underground storage tank and subsequently pumped into the dispensing machine as the need arises. There is thus need to know the level of fuel in the underground tank at all times. In the very old method of measuring fuel level, an un-calibrated steel rod is dipped into the tank to give an indication of the approximate level of fuel in the tank in terms of low, medium or high. This is very inaccurate and subject to abuse. The rod may not reach the bottom of the tank or may slant slightly thereby giving an erroneous indication of fuel level. With high cost of fuel, there is the need to ascertain the actual quantity of fuel purchased and the rate at which it is used up so as to minimize fraudulent activities.

A number of methods for level measurement of fuel have been reported. For example, Idris (2004) used a potentiometric transducer and a voltage-controlled oscillator. The frequency of the VCO is converted to a digital display calibrated to indicate the volume of fuel.

However, this approach has two limitations. One of them is the large amount of force required when moving the sliding contacts. Secondly, the sliding contacts can wear out and become misaligned.

Another method is by means of ultrasonic sensors (Sakharov et al (2003), Sighn (2009)). This method uses the principle of sending a sound wave from a piezoelectric transducer to the contents of the vessel. The time it takes the wave to return to the transducer is inversely related to the level of liquid. In addition to the fact that this method is only suitable for containers of uniform dimension, obstacles such as powders, heavy vapour, surface turbulence and ambient noise can affect the returning signal.

Other methods include fibre optic methods (Vazquez et al, 2004, Kersey & Dandridge, 1990, Golnabi, 2004) which are inherently safe and suitable for use for combustible liquids. This is because the light signal propagated through the fibre is modulated not electrical signal. The main problem with this approach

is the electromagnetic interference that affects the support system.

In this paper, a petrol level gauge using a low cost, 10-bit microcontroller, utilizing a high resolution magnetostrictive level sensor is presented. A marked improvement over potentiometers for long stroke position measurement, the magnetostrictive level sensor possesses exceptional linearity, even over lengths up to 120 inches (3 m), with repeatability up to 0.002 % of the measurement range. By utilizing magnetostrictive technology (Fraden, 2010), the proposed gauge requires no contact between parts that cause friction or premature wear, offering high reliability and extended life. In addition, unlike the

existing counterparts, it is not affected by vibration. Both the height and volume of the tank will be displayed unlike existing fuel meters which display either the height or the volume.

SYSTEM DESIGN

Fig. 1 shows the block diagram of the proposed petrol level gauge. A magnetostrictive sensor is used. The sensor output is analog and is fed to analog to digital converter embedded in the 18F4520 microcontroller. The ADC has a 10-bit resolution (Microchip, 2008). The microcontroller scales and processes the signal and the output ASCII data is fed to the liquid crystal display.

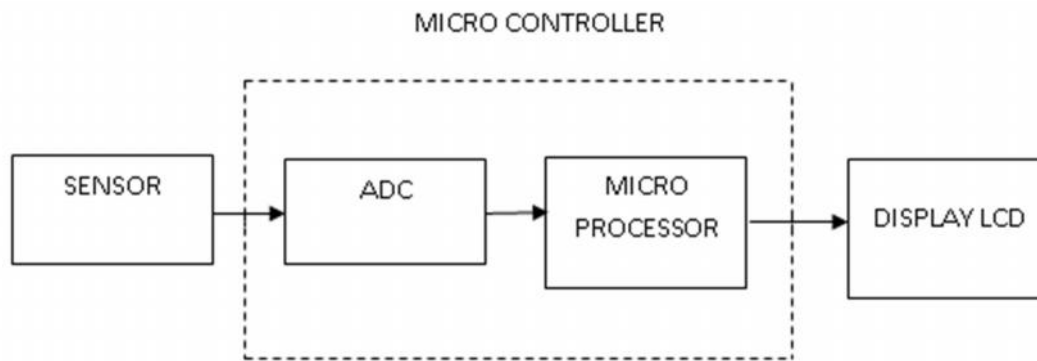


Fig. 1 Block diagram of the proposed level gauge

The tank used is a cylindrical tank mounted in a horizontal position. The vertical capacity and volume of a horizontal cylindrical tank vary with the horizontal

$$V_{cyl} = l \left[\frac{\pi D^2}{4} \cos^{-1} \left(1 - \frac{2x}{D} \right) - \sqrt{Dx - x^2} \left(\frac{D}{2} - x \right) \right] \tag{1}$$

where V_{cyl} = Capacity of the cylindrical tank

D = Diameter of cylinder

l = Length of cylinder

x = Unknown height

The prototype tank was designed by first considering the maximum volume of petrol required. For portability sake it was desired to design a 30 liters

$$V_t = \pi r^2 l \tag{2}$$

Where,

V_t = Volume of petrol tank

r = Radius of petrol tank

l = Length of petrol tank

Choosing l to be 0.52 m, equation (3) becomes

cross-sectional area and is not a linear function of height. The volume is given by (Islam, 2011)

petrol container. Therefore the volume of the petrol tank is given by

$$0.03 = 0.52\pi r^2$$

$$\therefore r = \left(\sqrt{\frac{0.03}{0.52\pi}} \right) = 0.136 \text{ m}$$

$$\therefore \text{Diameter of the tank, } d = 2r = 0.272 \text{ m}$$

The cylindrical shape is obtained considering the circumference (width of the metal sheet) of the tank. The circumference, C, is given by,

$$C = 2\pi r \tag{3}$$

$$\therefore C = 2\pi(0.136) = 0.8546 \text{ m}$$

This circumference and the length of the tank are folded to produce the cylindrical shape.

Fig. 2 shows the flow chart for the system. The microcontroller was programmed using microC in an MPLAB environment.

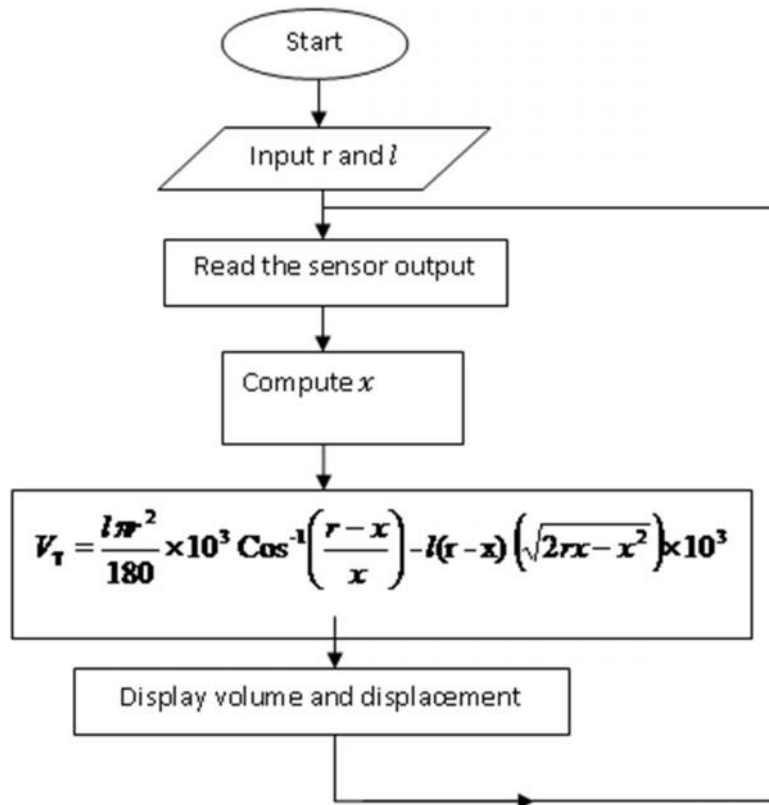


Fig. 2 Flow chart for determining volume of a horizontal cylindrical tank

The schematic circuit diagram of the system is shown in Fig. 3. Basic electronic design techniques were used to determine the values of peripheral

components. A voltage regulator 7805 was used in the power supply to give precisely 5 V voltage and a maximum current of 1 A. The picture of the prototype gauge is shown in Fig 4.

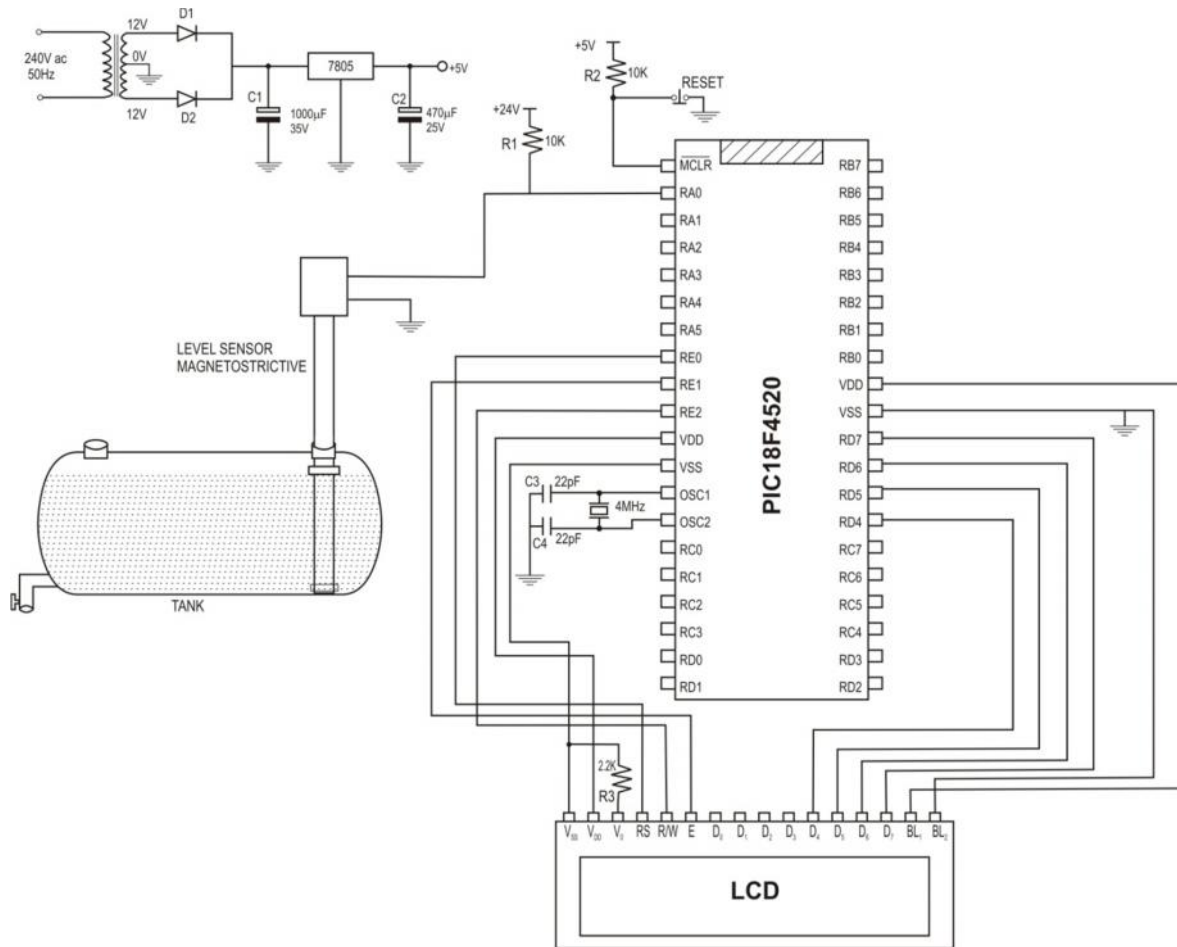


Fig. 3: Schematic diagram of a microcontroller based petrol level gauge



Fig. 4 Picture of the prototype gauge

RESULTS AND DISCUSSION

Simulation was carried out using proteus software and results are shown in Table 1. The first test was carried out to ascertain the calibration of the gauge, using premeasured fuel quantity. The measured

value (M), the expected value (E) and the displacement are shown in Table 2. The second test was carried out to compare with the results obtained in Table 1. Table 3 presents the results of the test.

Table 1: Simulation Readings of Displacement and Volume

x(m)	0.011	0.025	0.039	0.051	0.063	0.074
V _s (litres)	0.392	1.297	2.415	3.586	4.864	6.092
x(m)	0.085	0.095	0.105	0.113	0.122	0.130
V _s (litres)	7.301	8.474	9.667	10.728	11.793	12.783
x(m)	0.138	0.146	0.153	0.160	0.166	0.173
V _s (litres)	13.766	14.667	15.485	16.287	17.004	17.701
x (m)	0.179	0.185	0.190	0.196	0.201	0.206
V _s (litres)	18.315	18.965	19.474	19.960	20.420	20.851
x(m)	0.211	0.215	0.220	0.225	0.229	0.233
V _s (litres)	21.205	21.530	21.818	22.065	22.237	22.350

Table 2: Measured and Expected value of the measurand

x(m)	0.019	0.033	0.044	0.054	0.063	0.072
M(Liters)	0.908	1.947	2.946	3.983	4.958	5.979
E(Liters)	1	2	3	4	5	6
x(m)	0.081	0.098	0.106	0.114	0.122	0.130
M(Liters)	6.965	7.976	8.987	9.974	10.948	11.989
E(Liters)	7	8	9	10	11	12
x(m)	0.138	0.147	0.155	0.164	0.173	0.182
M(Liters)	12.973	13.939	14.966	15.974	16.956	17.972
E(Liters)	13	14	15	16	17	18
x(m)	0.182	0.193	0.204	0.217		
M(Liters)	18.941	19.969	20.956	21.973		
E(Liters)	19	20	21	22		

Table 3: Tests Meter Readings of Displacement and Volume

x(m)	0.011	0.025	0.039	0.051	0.063	0.074
V _T (litres)	0.391	1.305	2.487	3.670	4.958	6.188
x(m)	0.085	0.095	0.105	0.113	0.122	0.130
V _T (litres)	7.468	8.713	9.824	10.873	11.999	12.973
x(m)	0.138	0.146	0.153	0.160	0.166	0.173
V _T (litres)	13.939	14.821	15.688	16.539	17.163	17.972
x(m)	0.179	0.185	0.190	0.196	0.201	0.206
V _T (litres)	18.560	19.190	19.676	20.311	20.747	21.158
x(m)	0.211	0.215	0.220	0.225	0.229	0.233
V _T (litres)	21.541	21.807	22.167	22.441	22.611	22.758

The results obtained indicate very slight discrepancies when values of Table 1 are compared with those of Table 3. These differences are the errors. Graphs of these two values, i.e. Tables 1 and 3 are plotted in Fig. 5. The graph shows that the volume of the petrol in a horizontal cylindrical tank is

proportional to the displacement of the sensor for both the practical and simulation.

An error analysis was performed between the simulated values and the measured values using the formula of equation (4).

$$\text{Error} = \left| \frac{\text{measured value} - \text{calculated value}}{\text{measured value}} \right| \tag{4}$$

The highest error recorded is

$$\text{error} = |(22.773 - 22.363)/22.773| = 0.018 \text{ or } 1.8 \%$$

Therefore, accuracy = ± 1.8 %

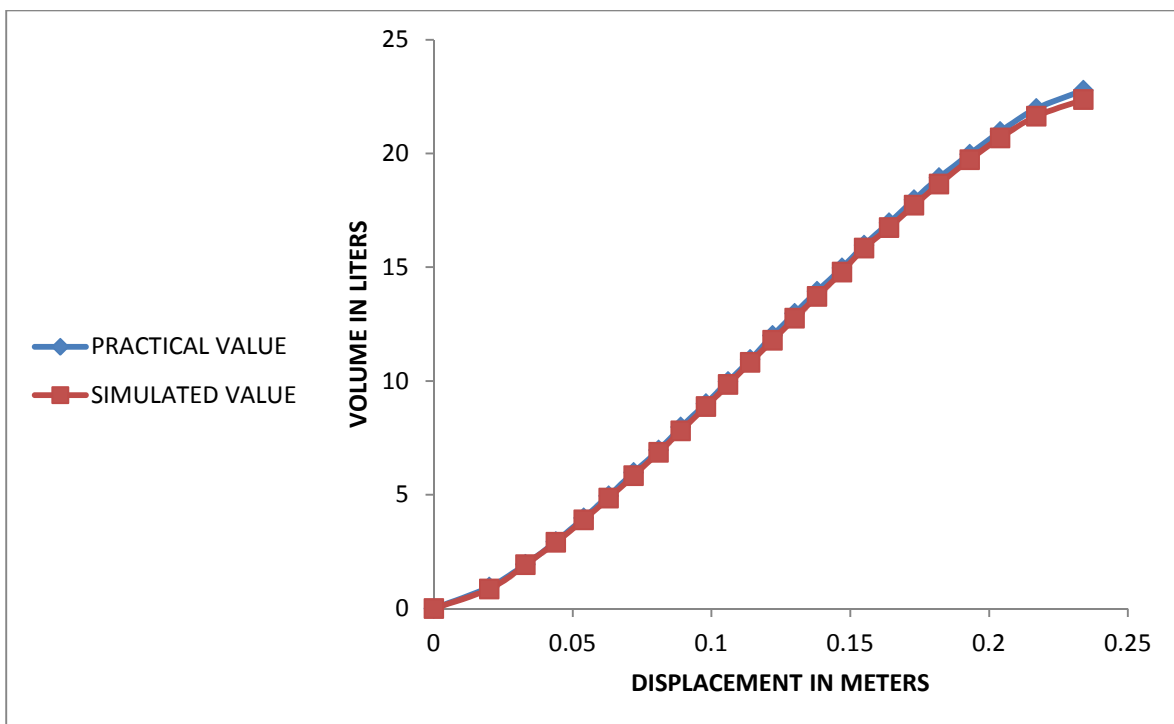


Fig. 5 Graph of volume versus displacement for both practical and simulation value

CONCLUSION

A digital petrol level gauge was implemented using microchip’s 18F4520 10-bit microcontroller. An additional feature is the use of magnetostrictive level sensor technology, possesses exceptional linearity, even over lengths up to 120 inches (3 meters), with repeatability up to 0.002 % of the measurement range. Besides, no contact between parts that causes friction or premature wear, offering high reliability and extended life. The developed meter measures petrol in the range of 0 to 22.773 litres, with an

accuracy of ±1.8 %, which is acceptable in comparison with commercial analogue petrol level gauge

REFERENCES

Fraden, J. (2010). *Handbook of Modern Sensors: Physics, Designs, and Applications*. Springer Science & Business Media, LLC.

- Golnabi, H. (2004). "Design and Operation of a Fiber Optic Sensor for Fluid Level Detection," *Optics and Lasers in Engineering*, Vol. 41, pp 801-812.
- Idris, K. (2004). Development of a digital fuel meter for cylindrical tank, Unpublished MEng Dissertation, Department of Electrical Engineering, Bayero University, Kano.
- Islam, M. S. (2011). A comprehensive analysis of amount of liquid in a horizontally mounted right cylindrical tank. *Global Journal of Science Frontier Research*, vol. 11, issue 8, pp. 22-26.
- Kersey, A. D., and Dandridge, A. (1990). "Application of Fiber-Optic Sensors," *IEEE Transactions on Components, Hybrids, and Manufacturing Technology*, Vol 13, No. 1,
- Microchip, T. I. (2008). PIC18F4520 Data Sheet, www.microchip.com.
- Sakharov, V. E., Kuznetsov, S. A., Zaitsev, B. D., Kutnetsova, I. E., and Joshi, S. G. (2003). "Fluid Level Sensor Using Ultrasonic Lamb Waves" *Ultrasonics*, Vol 4, pp 319-322.
- Singh, S. (2009). *Industrial Instrumentation & Control*. New Delhi: Mc Graw-Hill Publishing company Ltd.
- Vazquez, C., Gonzalo, A. B., Vargas, S., and Montalvo, J. (2004). "Multi-Sensor System Using Plastic Optical Fibers for Intrinsically Safe Level Measurement," *Sensors and Actuators A*, Vol. 116,.