Real Time Generator Fuel level Measurement Meter Embedded with Ultrasound Sensor and Data Acquisition System

Sadeque Reza Khan  
Department of Electronic and Communication Engineering  
National Institute of Technology, Kurnataka, India  
sadeque_008@yahoo.com

Arifa Ferdousi  
Department of Computer Science and Engineering  
Varendra University, Rajshahi, Bangladesh  
arifaferdousi@yahoo.com

Siddique Reza Khan  
Department of Computer Science and Engineering  
MIST, Dhaka University, Dhaka, Bangladesh  
remond_007@yahoo.com

Although all the issues are alarming and can be given most importance but in this project work the preference is given to the unanticipated issue that is fuel theft from the fuel tank of a generator as most of the generator companies are counting a loss of millions of currencies because of this unusual fuel loss. Diesel theft is an international problem, with news of fuel theft are coming from the modern countries like Australia, the UK and New Zealand as well as across the US and in the developing countries like India, Bangladesh etc fuel stealing rate is incredibly high [5]. With the increasing rate of fuel this issue of fuel theft has become a major annoyance for the owner of different generator companies. So to prevent this problem, different sensors like capacitive sensor [6]-[9], WGM method [10], ultrasound sensor [11], [12] etc are used. These sensors are really helpful to prevent oil theft but problem is now-a-days oil theft is done mostly by the officials. In most of the generator sites the company used to supply the fuel for a whole month as the majority of the generators are located remotely. At the time of reload the fuel in the tank, generator operator and the official person present at the location are used to take away a superior quantity of petroleum and in a manner that sensors could not identify the mishap. As a result the company owners are still counting loss in a large margin as they do not have any data of how much quantity of petroleum is reloaded and how much is used regularly and they are unable to blame anyone because of less evidence against these robbers present in the hand of those owners. To prevent this, a microcontroller based measurement system is developed which can accurately measure the fuel quantity and can
store the data frequently with current time scale. So with this control system owners can easily identify how much fuel is reloaded and how much is used and also can point out the missing rate of fuel from a generator site by studying the data present in the data acquisition system.

II. PROPOSED SYSTEM

The system contains an Ultrasound Sensor module, Liquid Crystal Display (LCD) to show the updates, a micro SD card for data acquisition and Real Time Clock (RTC) to give accurate time and date. The whole system is controlled by two PIC microcontrollers 18F4520.

III. HARDWARE AND LOGIC DESIGN

A. Real Time Clock

As a Real Time Clock Maxim DS1307 is one of the popular I²C 8-pins IC which uses 32.768 kHz crystal [13], [14]. Equipped with Automatic Power-Fail Detect and Switch Circuitry the Maxim DS1307 will continue to operate accurately even though the main power supply is lost and with its I²C interface capabilities make this chip easily to be integrated with widely available microcontrollers that have build in I²C peripheral.

![DS1307 Connection diagram](image)

1) I²C protocol:

I²C is used to allow multiple devices to connect to each other with fairly slow data transfer rates with serial data bus protocol [15]. The I²C protocol uses master and slave methods, the master which is usually the microcontroller while the slave can be any I²C device such as Real Time Clock DS1307. I²C communication requires two ports, one for the serial data called SDA (serial data) to communicate with SCK pin the other for synchronize clock called SCL (serial clock) to communicate with SDI pin of PIC Microcontroller IC [16].

Time Calculation:

Variable 1 = reg_a AND 0x0F
Variable 2 = (reg_a >> 4) AND 0x07
SECOND = Variable 1 + (Variable 2 * 10)
Variable 1 = reg_b AND 0x0F
Variable 2 = (reg_b >> 4) AND 0x07
MINUTE = Variable 1 + (Variable 2 * 10)
Variable 1 = reg_c AND 0x0F
Variable 2 = (reg_c >> 4) AND 0x01
HOUR = Variable 1 + (Variable 2 * 10)

Date Calculation:

Variable 1 = reg_a AND 0x0F
Variable 2 = (reg_a >> 4) AND 0x03
DATE = Variable 1 + (Variable 2 * 10)
Variable 1 = reg_b AND 0x0F
Variable 2 = (reg_b >> 4) AND 0x01
MONTH = Variable 1 + (Variable 2 * 10)
Variable 1 = reg_c AND 0x0F
Variable 2 = (reg_c >> 4) AND 0x0F
YEAR = Variable 1 + (Variable 2 * 10)
B. Ultrasound Sensor

Ultrasound sensors are characterized by a low-cost and by the possibility of being used in environments and situations where it is not possible to use more complex sensors as camera systems and laser devices, optical sensors [17]. In this work, NT-TS601, which is shown in Fig. 4, ultrasonic electric telemeter modules were employed as ultrasonic transmitter and receiver [18], [19].

![TS601 ultra sound module and its pin configuration](image)

This module can measure a distance within 0.03-3M effectively and transform the data into impulse of different width. At first 5us pulse is applied through the pin SIG of the module which triggers the transmitter to generate 40 kHz ultra sound signal string. At the moment the receiver catches the reflected wave it generates a high pulse width which corresponds to the time that the signal takes to reflected back. By using this pulse width we can measure the distance as well as the fuel level.

Distance Calculation:
\[ D_1 = \text{Pulse Width (us)} \times 32 \]
\[ \text{DISTANCE} = \frac{D_1}{100} \text{ cm} \]
\[ \text{Decimal Point} = D_1 \mod 10 \]

Total distance = (DISTANCE + Decimal Point) cm

Fuel Amount Calculation:
\[ D_1 = \text{Pulse Width (us)} \times 32 \]
\[ \text{DISTANCE} = \frac{D_1}{254} \text{ inch} \]
\[ D_2 = D_1 \mod 254 \]
\[ D_2 = D_2 \times 100 \]
\[ D_2 = \frac{D_2}{254} \]

\[ \text{LITRE1} = \text{DISTANCE} \times \text{LITRE\_VALUE} \] (preset value)
\[ \text{LITRE2} = D_2 \times \frac{\text{LITRE\_VALUE}}{100} \]

Total Litre = LITRE1 + LITRE2

This calculation is calibrated for 10 MHz crystal oscillator.

By using this ultrasound sensor module and the calibrated calculation given the accuracy of 95-97% can be easily achieved which is adequate and almost precise one.

<table>
<thead>
<tr>
<th>Pulse Width</th>
<th>Distance (cm)</th>
<th>Litre (Measured by Controller)</th>
<th>Litre (Original Amount)</th>
<th>Accuracy %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger of 5us</td>
<td>200 us</td>
<td>200 us</td>
<td>64</td>
<td>503</td>
</tr>
<tr>
<td>Trigger of 5us</td>
<td>200 us</td>
<td>300 us</td>
<td>96</td>
<td>756</td>
</tr>
<tr>
<td>Trigger of 5us</td>
<td>200 us</td>
<td>500 us</td>
<td>160</td>
<td>1260</td>
</tr>
<tr>
<td>Trigger of 5us</td>
<td>200 us</td>
<td>600 us</td>
<td>192</td>
<td>1512</td>
</tr>
</tbody>
</table>

Here Preset of LITRE\_VALUE/inch = 20 Litre

C. Data Acquisition System

To store the Fuel level with its corresponding date and time data consecutively a micro SD card is used with an adapter in this system. The microSD memory Card is a functionally compatible with the SD Memory Card but is smaller in dimensions and its communication is based on an advance 8-pin interface and the microSD memory Card host interface supports regular SD or miniSD Memory Card Adapter and operates as an SD Memory Card [20],[21]. In microchip it is easily possible to interface with SD card through FAT32 file system using SPI. With SPI peripheral PIC microcontroller is the “master” and the SD card is the “slave”. The SD card uses SPI mode 0, this means the clock signal starts low and the data input samples data when the clock transition to high.

![Micro SD card adapter and pin configuration](image)
For this project two 18F4520 PIC microcontrollers are used. This series of PIC microcontroller contains 32k bytes of program memory along with 13channel 10bit ADC and 36 I/O pins [22]. Here two ICs are used as the clock pin for RTC and micro SD card is same for 18F4520. So in this project separate microchip is used for interfacing RTC and memory device. Both these microcontroller are interfaced by RS232 one wire communication protocol where data is transferred as a string from one microcontroller, whose responsibility is to collect data of Fuel level and Time Period to another microcontroller, whose responsibility is to store data in memory card as a form of string. And their communication is synchronized by using a NPN transistor. String can be manipulated by the following code:

```
Variable Name (String) = ToString$(Variable Name)
```

String variables can directly stored in to micro SD card as text format.

### E. Display Unit

For display section a 2x16 line LCD (Liquid Crystal Display) is used.

### IV. OPERATION PRINCIPLE

This project contains two 18F4520 PIC microcontrollers that are connected using RS232 one wire protocol through TX and RX pin of port C. First 18F4520 IC contains a LCD to display time, Date and Fuel level and it is interfaced in port B of PIC. RTC DS1307 is interfaced in port C and setting switches are connected in port D. TS601, the ultrasound module is interfaced in RD0. The data of time, date, and fuel level is transferred to another 18F4520 in the form of string. Micro SD card adapter is connected in the port C of that microcontroller and data is stored as direct string in the memory device. Settings option is authorized by using a dedicated password for every single device.

```
Password = A*1000+B*100+C*10+D*1
```

Here A, B, C and D are declared variables to hold the digits pressed by the UP and DOWN setting switches.

### V. RESULTS

![Figure 9 (a): Password protected System](image)

![Figure 9 (b): Tank size measurement](image)

![Figure 9 (c) Oil level measurement with oil in the tank](image)
Here Fig. 9(a) is showing the password option of the implemented system to enter in the settings option. Fig. 9(b) is showing the tank size measurement option to calibrate the fuel level amount. Fig. 9(c) is showing the measurement of fuel by using the ultrasound sensor. Fig. 9(d) is presenting the overall implemented circuit.

VI. CONCLUSION

As the fuel theft is becoming a major problem for the generator companies, this designed device can be a real relief for the owners of those companies. Although the current sensors like capacitance sensor present in the market can provide security from the external thieves but those are unable to ensure the security of the fuel tank from the internal burglars of the companies. By installing this fuel meter in the fuel tank the company management can track easily that how much fuel is reloaded in the tank and how much is used every minute as the micro SD card will store data after a change of a minute. Settings option is also secured through a password so that no one but only the authorized person can change the settings. So in the era of high fuel price the generator companies can prevent fuel robbery from the hand of their own technical staffs by using this real time fuel measurement meter. This whole system is also robust, accurate and low cost as well.

REFERENCES


Arifa Ferdousi received B.Sc. and M.Sc. degree in ICE from University of Rajshahi, Bangladesh, in the year of 2007 and 2009 respectively. Currently she is working as a lecturer in the department of CSE in Varendra University, Rajshahi, Bangladesh. Her research interest includes electronics system design, OFDM, Advanced LTE Wi-Max and Bangla speech recognition system using Neural Network. She is the member of Bangladesh Electronic Society (BES).

Sadeque Reza Khan received B.Sc. degree in Electronics and Telecommunication Engineering from University of Liberal Arts Bangladesh and continuing his M.Tech in VLSI from National Institute of Technology Kurnuka (NITK), India. Currently he is in study leave from his Institution where he was working as a lecturer in the department of Electrical and Electronic Engineering in Prime University, Bangladesh. His research interest includes VLSI, Microelectronics, Control System Designing and Embedded System Designing.
Siddique Reza Khan is a Computer Science Engineer from Military Institute of Science and Technology (MIST) under Dhaka University. His Research field covers Artificial Intelligence and Robotics. He also seeks some of his interest in control system designing.