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

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***Abstract*—The use of Generator has become a very common in almost every passive infrastructure companies, Industries, hospitals, Townships etc, while by using these Generators, a number of challenges are faced by the users and companies. Among all other challenges fuel stealing from the generator fuel tank has become an alarming issue as the price of the fuel is touching sky high day by day. Although many security and safety features are added but the fuel robbery is still out of control and the loss of the companies are immeasurable. So an advanced control system is designed with the PIC microcontroller which can measure the level of fuel in the fuel tank by using a high tech ultrasound sensor and store the data in to a data acquisition system.**

***Index Terms*—real time Clock; I2C; NT-TS601; FAT SPI; PIC; RS232 one wire communication**

I. Introduction

With the modernization of civilization generator has become an important part of power generation source. At any period of electricity crisis like inclement weather or power cut because of electricity shortage a generator is becoming most reliable source of power form big industry to any small apartment [1] - [3] . Standby power generation is a key component of a high availability power system for data centres and network rooms where generator systems with diesel or natural gas engines are the best solution as with battery only short period of power supply is possible [4]. Now-a-days generator installation and its maintenance become a big issue as most of the time generators are located in a remote places. 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

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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.

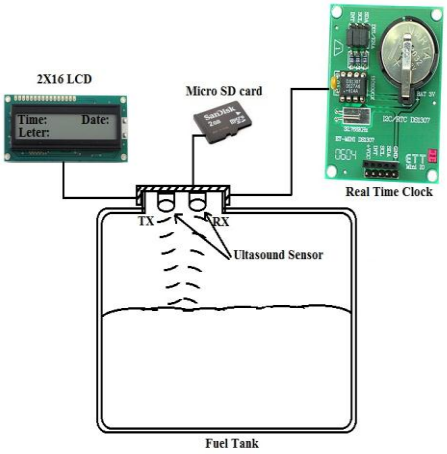


Figure 1 System overview

III. Hardware and Logic Design

A. Real Time Clock

As a Real Time Clock Maxim DS1307 is one of the popular I^2C 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 I^2C interface capabilities make this chip easily to be integrated with widely available microcontrollers that have build in I^2C peripheral.

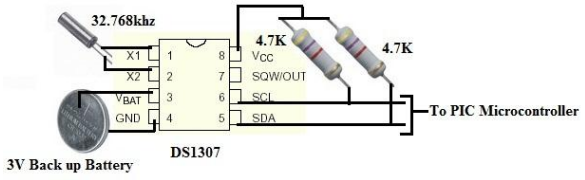


Figure 2 DS1307 Connection diagram

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)

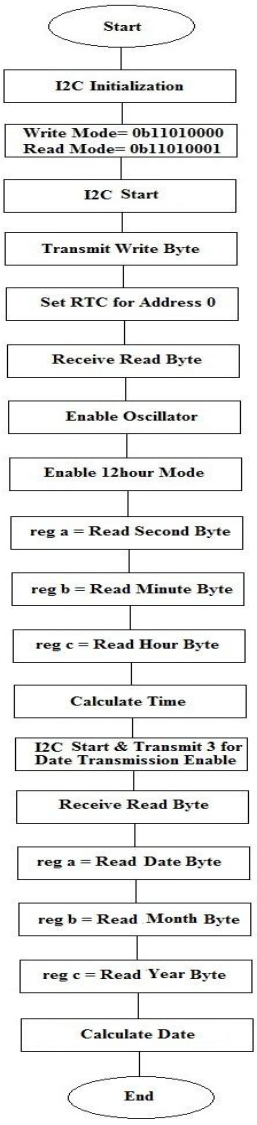


Figure 3 Logic flow of I2C

B. Ultrasound Sensor

Ultrasonic 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].

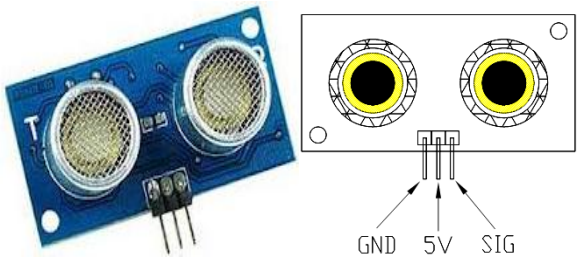


Figure 4: TS601 ultra sound module and its pin configuration

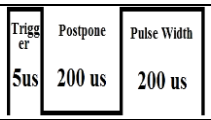
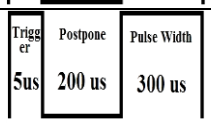
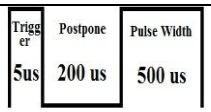
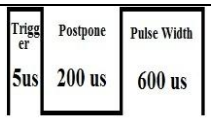
This module can measure a distance within 0.03-3M effectively and transform the data into impulse of different width. At first 5us pulse is applied through the pin SIG of the module which triggers the transmitter to generate 40 kHz ultra sound signal string. At the moment the receiver catches the reflected 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:
D1 = Pulse Width (us) * 32
DISTANCE = D1/100 cm
Decimal Point = D1 MOD 10
Total distance = (DISTANCE+ Decimal Point) cm
Fuel Amount Calculation:
D1 = Pulse Width (us) * 32
DISTANCE = D1/254 inch
D2 = D1 MOD 254
D2 = D2*100
D2 = D2/254
LITRE1 = DISTANCE*LITRE_VALUE (preset value) \inch
LITRE2 = D2*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 I. PRACTICAL DATA

Pulse Width	Distance (cm)	Litre (Measured by Controller)	Litre (Original Amount)	Accuracy%
	64	503	492	97.7%
	96	756	741	97.9%
	160	1260	1230	97.5%
	192	1512	1470	97.1%

Here Preset of LITER_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.

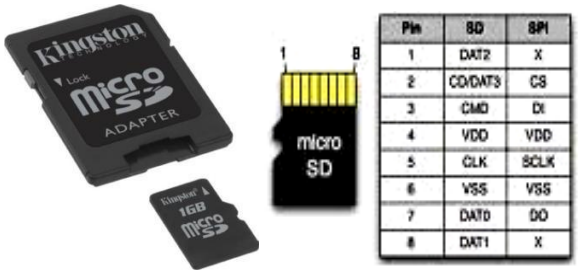


Figure 5 Micro SD card adapter and pin configuration

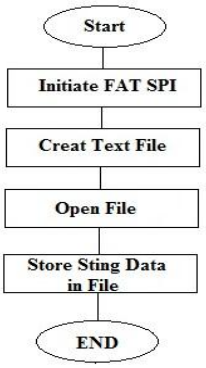


Figure 6 Logic flow of FAT system

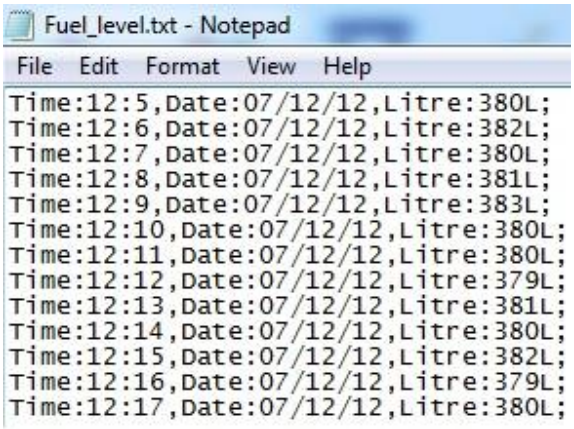


Figure 7 Collected data from micro SD card

D. Controller Unit

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

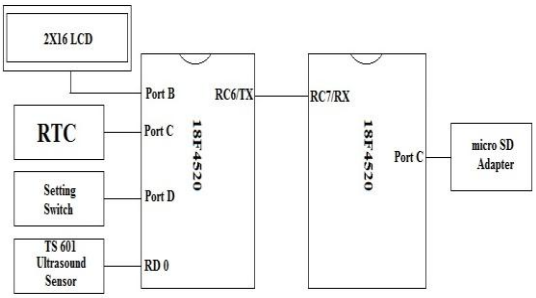


Figure 8: Overall circuit diagram

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

Figure. 9 (b): Tank size measurement

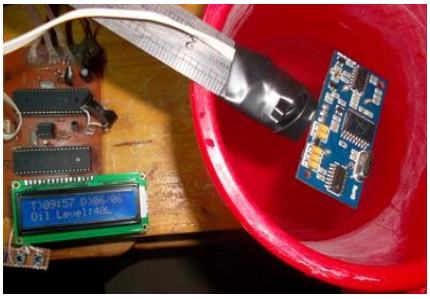


Figure. 9 (c) Oil level measurement with oil in the tank

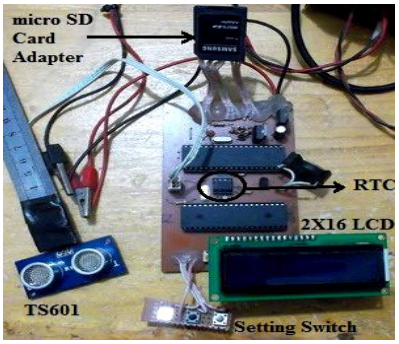


Figure 9(d): Implemented circuit

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.

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