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Fuel Monitoring and Electronics control of Dispenser for Fuel Station

Nang Khin Su Yee[1], Theingi[2], Kyaw Thiha[3]

1, 3(Department of Mechatronic Engineering, Mandalay Technological University, Myanmar)

2 (Rector, West Yangon Technological University, Myanmar)

Abstract:

This paper intends to construct and design of the fuel monitoring and electronics control of dispenser for fuel station. It consists of two sections; hardware implementation for control section and software implementation section. Some fuel stations which used the flow rate sensors cannot get satisfactions both customers and dealers. The reason is that the fuel volume can increase or decrease due to the temperature changes depending on the places and times. The system can solve the disadvantages of it. The system controls for the compensation in volume flow rate with controller. In order to solve this problem, PIC16F877A is used as a controller to control the time taken for each data representation customer requests from the keypad and LCD (liquid crystal display) is also used as display unit in this system. And then computer is also used as a control station by using VB.Net. The status of the fuel levels is also monitored from the computer. MikroC is used for software implementation of the system In order to control time taken.

***Keywords* — fuel compensation system, volume flow rate, controller, and software.**

I. INTRODUCTION

In current days fuel stations are operated manually. These fuel pumps are time consuming, require more manpower [1] and do not get the accurate fuel amount for both customers and deals. Flow sensors were used to measure the fuel amount in these fuel stations. The [2] operates a remote monitoring system for pump output monitoring in distributed fuel stations in Nigeria by recreating a fuel dispenser with an Atmel 89C52 microcontroller based system which has an added feature of being able to send collated data via its serial port to a web enabled PC to enable access of this data from anywhere in the world using a web enabled device [2]. The error in oil dispensing to the tank may varies from person to person and Sometimes it depends on the way of measuring also. Hence it is required to have oil dispensing unit which will be able to function irrespective of time, place and person [3].

In this research, the controller will compensate the fuel volume depending on the temperature changes. PIC16F877A is used as a controller for this purpose. LM35DZ will sense the environmental temperature and then it will send analogue signal to the controller as input signal. Depending on the input signals, the controller will control the total fuel pumping time with compensation time. The fuel level in the tank is monitored by the level sensor. The metal probes are used in this control used as fuel level sensor. The block diagram of the system is shown as in fig.1.

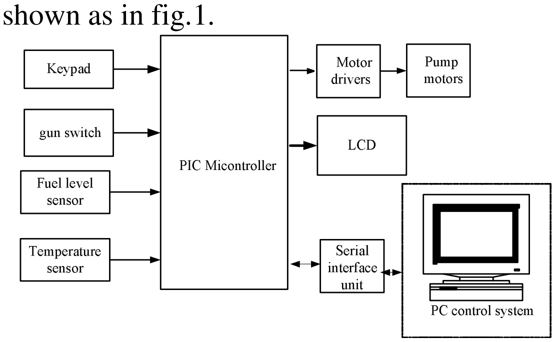

Fig.1 Block Diagram of the System

II. HARD WARE IMPLEMENTATION OF THE SYSTEM

There are many important factors to consider in gasoline dispenser control system. They are pipe length and design, tank design and flow rate. But the main purpose of the paper is to design the electronic control circuit.

A. *Selecting of fuel Pump*

Pipe Length between pump and dispenser – 100ft x 0.3048 = 30.48m

Pipe length between dispenser and oil gun -10ft x 0.3048 = 3.048m

The height of the ground tank = 13ft must be taken in this design.

Total height of the system = tank height + height from gun to the ground

$$= 13 + 4 = 17\text{ft} \times 0.3048$$
$$= 5.182\text{m}$$

Gasoline of density at 16°C = 680kg/m^3

Take the values of ρ and g as 680kgm^{-3} and 9.81 ms^{-2}.

Nominal flow rate: 600lpm to 1000lpm available: 3/4Hp, 1Hp or 2 Hp.

The suitable pump 0.75Hp submersible Pump with efficiency 80% is selected.

The flow rate of pump is calculated by using the following equation (1).

$$\text{Power} = \gamma QH = \rho g\, QH \qquad (1)$$

$$0.75 \times 746 \times 0.8 = 680 \times 9.81 \times Q \times 5.182$$

$$Q = 0.012948\,\text{m}^3\text{s}^{-1}$$

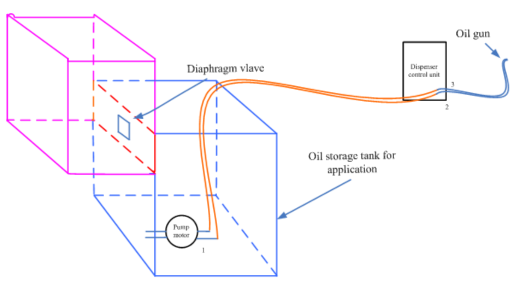

Fig.2 Sketch of the Fuel Station

B. *Monitoring for the fuel tank*

In order to know the level status in the fuel tank, it is very important for fuel station. The fuel level is sensed by using the level senor. The signal from the level sensor is monitored from the master station by using VB.Net. Then the status of the fuel is displayed on the screen in real time.

C. *Controller Design of the System*

In this control system, the pins of the controller are assigned to interface with keypad, LCD (liquid Crystal Display), temperature sensor, computer, gun input switch and fuel pump for a dispenser control unit.

Bit 2 to bit 7 of PORTD is interfaced with LCD to display the output data on. In order to receive the input data from keypad, it is interfaced with bit 0 to bit 6 of PORTB. And bit 2 of PORTC is used as an input switch of dispenser and bit 6 and bit 7 is also interfaced with computer. RA5 is used as output pin to control the fuel pumps. RD0 is used as a input pin to sense the fuel level in the tank. The pin assignment is expressed in below fig.3.

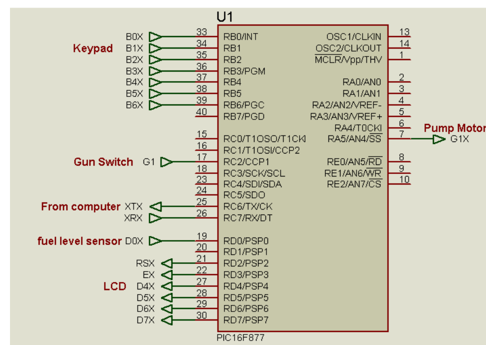

Fig.3 Pin Assignment of the Controller

D. *Keypad Interface*

In this system, keypad is used as data input for customer request. The controller will control the fuel pump depending on the keypad data. The interfacing between the keypad and controller is shown in fig.4.

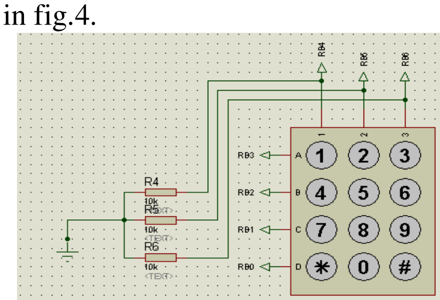

Fig.4 Key Pad Interfacing to Controller

E. *Relay Driver*

In order to drive the relay, the transistor C9014 is used as a switch. In switching operation, the collector saturation current will be calculated by using the equation:

$$-V_{CC} + I_{C(sat)} R_C + V_{CE(sat)} = 0. \qquad (2)$$

And in order to operate as a switch, the transistor is in the saturated region. So the collector current must be greater than the saturation current. The minimum base current is calculated by using (3).

$$I_{C(sat)} = h_{fe} I_{B(min)} \quad (3)$$

And then the base current and the resistor are very important in this circuit.[5] So the base resistor is also calculated by using (4),

$$-V_{BB} + I_{B(min)} R_B + V_{BE} = 0 \quad (4)$$

When the transistor is in saturated region, the relay will operate to drive the fuel pump motors. The pump driver circuit is expressed in the following.

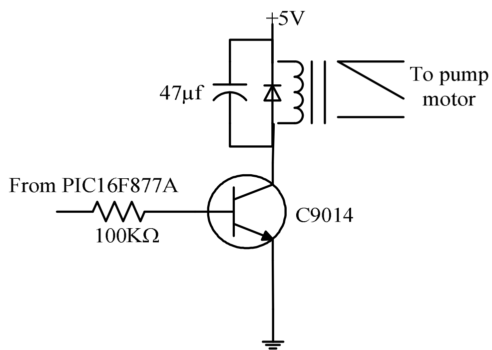

Fig.5 Circuit Diagram of Motor Driver

F. *Pin Configuration of the Display Unit*

Liquid Crystal Display (LCD) is used to display the amount money and count down. The circuit diagram with the default connections between the LCD and the microcontroller will be shown in the following.

PORTD bit 4 to bit 7 are used for LCD data (i.e. RD7 connected to D7, RD6 connected to D6, etc.), bit 2 of PROTD is connected to the RS pin of the LCD, bit 3 of PORTD is connected to the E pin of the LCD is set for 4- bits of operation.

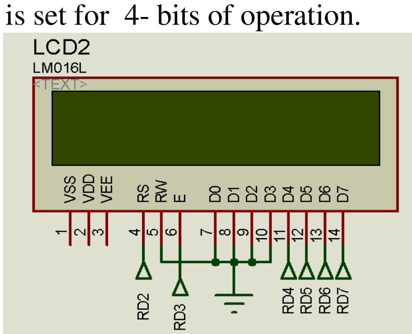

Fig.6 Pin Configuration between the LCD and PIC16F877A

III. DESIGN CONSIDERATION FOR THE SOFTWARE IMPLEMENTATION

In order to calculate the delay time taken from tank to the gun in time based control, the velocities must be calculated firstly. The pipe diameter and flow rate between the pump and dispenser are the same. So the velocity can be calculated by using (5). Pipe diameter between pump and dispenser, $D_1 = D_2 = 2in = 0.051m$

$$Q = \text{cross-sectional area x velocity}$$
$$= A_1 v_1 \quad (5)$$
$$v_1 = Q/A_1$$
$$v_1 = v_2 = 0.012948/0.002 = 6.474ms^{-1}$$

Pipe diameter between dispenser and gun, $D_3 = D_4 = 1.5in = 0.038m$

By continuity equation,

$$A_2 v_2 = A_3 v_3 \quad (6)$$

By using (6), the velocity, $v_3 = 11.66127ms^{-1}$ is got.

The time taken passing through the pipe need to calculate in time based control system of dispenser. This time causes a disadvantage for the customers. This condition was reduced by implementing the Check valve or one way flow control valve in the oil pipe.

Volume Flow rate, Q = cross-sectional area x velocity

$$= A \text{ x pipe length/ time}$$
$$= A \text{ x } s/T \quad (7)$$
$$T_{delay} = T_{(pump\ to\ dispenser)} + T_{(dispenser\ to\ gun)}$$
$$= 4.70806 + 0.2589435 = 4.967sec$$

For both the customers and dealers, the amount of fuel is compensated with the effect of temperature in fuel storage tank. Fuel-dispensing control unit is controlled by temperature compensation.

In order to sense the temperature changes, the temperature sensor is used in fuel-dispensing control unit. If the temperature in oil tank changes 10ºC, the density will change [4]. Then, the fuel volume increases due to temperature changes; it must be calculated by using (8).

Since $m_{ini} = m_{final}$ (mass),

$$\rho_{ini} V_{ini} = \rho_{final} V_{final} \quad (8)$$

where, ρ_{ini} V_{ini} are the initial values at 16ºC.

Volume at 16ºC, V_{ini} = 1 liter = 10^{-3} m^3

If ΔT is 10°C, Δv (volume changes) will be 0.01 x 10^{-3} m^{-3}.

And the volume changes will be 0.01x $10^{-4}m^3$ when the temperature change is 1°C.

So let X be the temperature of the gasoline from the temperature sensor inside the tank.

Temperature changes =(X-16) °C (from temperature sensor)

Volume changes in (X-16)°C of temperature of gasoline

$$= 0.01 \times 10^{-4} (X-16)\ m^3$$

$$V_{com} = 0.01 \times 10^{-4} (X-16)\ m^3 \qquad (9)$$

Where, the value of X is the temperature (°C) of the temperature sensor. After calculating the fuel volume increase or decrease depending on the temperature in the oil tank, the time taken can be calculated depending on the flow rate of pump used in this system.

Since Volume flow rate of pump, Q = $0.012948 m^3 s^{-1}$, it takes 0.077232s for 1 liter.

For 0.01×10^{-4} (X-16) m^3 volume of gasoline, time compensation will be achieved by using (8).

$$T_{comp} = 7.7232 \times 10^{-5} (X-16) s \qquad (10)$$

In the control unit, unless flow rate sensors are used, the controller will control the time taken for the specified fuel volume including temperature effect. In order to control the time for the specified fuel, the total time equation can be calculated. So, for the software implementation of the system, the program is written by using (9) in order to control the system correctly.

If Y kyats (monetary unit) are the cost of gasoline for 1 liter, the time must be 0.077232s. So the time taken for 1kyat is 0.077232s /Y s.

And if Z kyats are Customer requests from the keypad (input amount), it can also takes 0.077232 Z/Y s. So, the total time is

$$T_{tot} = 0.077232Z/Y + 7.7232 \times 10^{-5} (X-16) + 4.967s \quad (11)$$

Where, Z = Customers request from the keypad (input amount "kyats")

Y = the cost of gasoline for 1 liter "kyats"

X = the temperature of the gasoline from the temperature sensor "°C"

IV. PROGRAM FLOW CHART

The flow chart is shown in Fig.7 how to operate the system operation. Firstly LCD, keypad and UART is initialized and the controller will read the serial port data of "start signals".

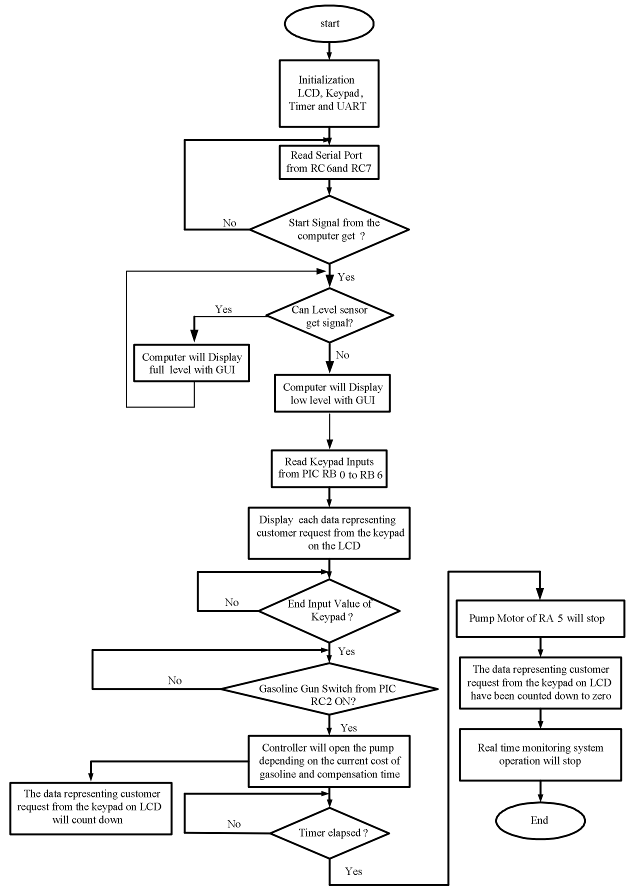

Fig.7 Program Flow Chart of the System

If the start signal is actuated, the controller continues to read the level sensor signal. The output graphic level will display depending on the status of sensor. And then continue to read the keypad signal. In this system, 4x4 keypad is used. A keypad is simply an array of push buttons connected in rows and columns.

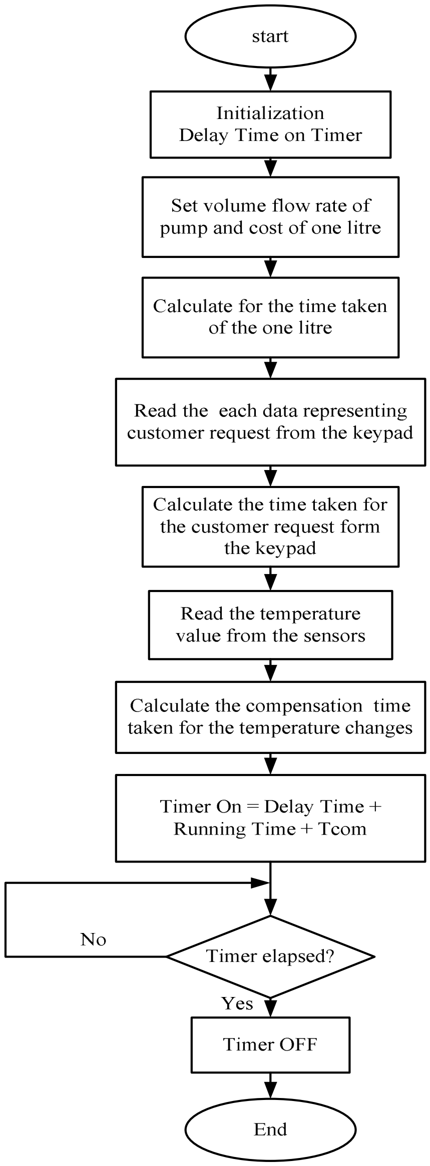

Fig.8 Time Control Flow Chart of the System

The key is scanned by bringing each X row low in sequence and detecting a Y column low to identify each key in the matrix. And then if the end input value of keypad is received, the controller is read whether the gasoline gun switches is "ON" or not. If it is "ON", the respectable pump motor rotates with respect to time depending on key and compensation time. The PIC will control depending on the computer command signals. If the "stop signal" is got, the operation will terminate. Otherwise, the operation will do again in the beginning.

It is very important to control time depending on the temperature and fuel amount of customer requests from the keypad in modern fuel dispenser control. So the total time taken concludes "delay time, compensated time, and running time". How to calculate the total time taken is displayed in fig.8.

V. RESULTS OF THE SYSTEM

At first, LCD and UART are initialized to begin the system process. And the controller will wait the start signal from the serial port. The statuses of pump motors are controlled by the start signal from the computer.

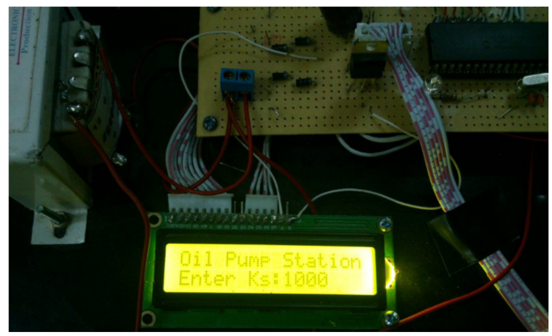

Fig.9 Decreasing Count to Zero Depending on Time Control

In this control system, the main control station is the computer. Only the allowable signal from the computer is got, the controller continues to control the process depending on the gun switch. The "unlock" condition of the controller is displayed on the LCD.

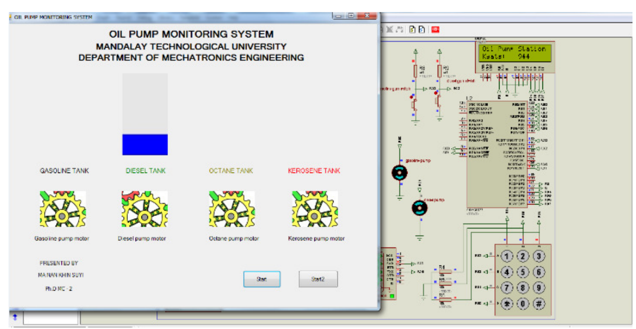

Fig.10 Simulation Result of Monitoring the Fuel Level from the Computer

When the start signal is sent from the computer, the welcome message will be displayed on LCD and then pump is ready to pump the fuel depending on the gun switch. And then the costs of the desired fuel must be entered from the keypad.

After the amount money had been pressed on the keypad, the pump motors will drive to pump the fuel. This amount is decreased to zero according to the time taken.

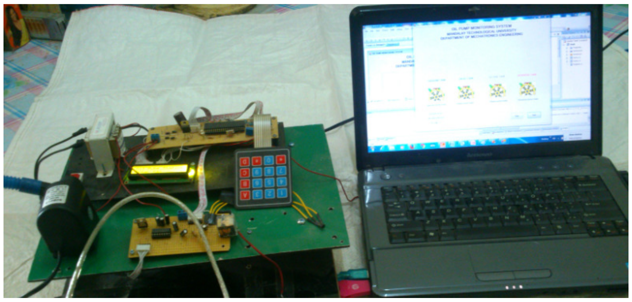
Fig.11 Photo Result of the Dispenser Control Interfacing with Computer

VI. CONCLUSION

Modern fuel dispenser control unit is flexible both customers and dealers in every sensors, and without using the flow rate sensors, it can compensate volume flow rate depending on temperature. It is also economical because the system depends on the software. It can be used to dispense any of the fluids (like water, oil, vegetable oil, workshop greases etc...).This system will be more convenience and safety for the customers.

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