Design of Real Time Monitoring System of Fuel Level in the Ground Tanks and Tanks Vehicles

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Abstract

The aim of this research is to reduce the effective cost of design and time assumption in edition two limitations of illegal fuel sales. Anew software unit using PLC (Programming Logic controller) has been designed in order to adjust the fuel level inside the tanks and tracking the path of vehicle. The proposed software is capable of storing detail data received from wireless communication unit that installed in vehicle using internet communication technical. Different reports and SMS can be generating from the received data. The propose system is design to implement monitoring issues and viewing the detail characteristic of vehicle using electronic map based on special software for this application. The final results can be monitored on HMI (Human Machine Interface) which make user to see level of fuel inside tank and any important information. The proposed system can be implemented for wide area based on the simple concepts considered for design.

Keywords: control, SCADA, ladder diagram, curve fitting.

تصميم منظومة مراقبة لمستوى الوقود في الخزانات الارضية وخزانات العجلات

المستخلص:

أن الهدف من البحث هو تقليل كلف التصاميم وتوفير الوقت والحد من عمليات تهريب الوقود وسوف يتم بناء برنامج سيطرة باستخدام وحدة التحكم المنطقي (PLC) وذلك لغرض تحديد مستوى الوقود في الخزانات او الصهاريج ومراقبة وتتبع مسار العجلة كما يقوم النظام بجمع وتخزين بيانات تفصيلية عالية الدقة باستخدام نظام مراقبة يوفر اتصال لاسلكي بشبكة الانترنت ونقل البيانات الى ملقم انترنت ليتم استلامها على شكل تقارير او رسائل SMS ويمكن للنظام الجمع بين نظم المراقبة والاطلاع على مواصفات وخصائص المركبة عن طريق خرائط الكترونية بواسطة برامج متخصصة كما يتم اخراج المعطيات على شاشة مراقبة (HMI) تمكن المستخدم من مراقبة مستوى الوقود في الصهاريج واهمية المشروع تكمن في امكانية تطبيقه مستقبلا على اسطول من الناقلات .

1-Introduction

After reviewing some articles or researches about (Fuel monitoring system), including an article or research in the International Journal of Engineering and innovative technology (IJEIT) researchers by (SachinS.Aher, Kokate R.D.)where they design a control and tracking system built of devices such as microcontroller and (Reed switch), which works according to the principle of(Hall effect) to feel or sense the amount of fuel when filling vehicle tank and the amount of a spent fuel then stored this data in the memory unit within the system. The system is capable of storing several recordings or readings [1].The electronic components items used by their searcher are (MSP430F149 microcontroller, A / D (Analog to Digital Convertor) 12bit converter, 16bit RISC controller), in addition to means of communication serial, real clock to save time tracking and monitoring(Real time clock), then they use stacking system by positioning unit for the purpose of tracking the vehicle, the control system having an intelligent control

system can achieve many tasks for the effective management to fleets of tankers [1].The laboratories dealing with the subject of SCADA (Supervisory Control and Data Acquisition)have the first system to track oil tankers, where was doing the experiments in the laboratory. Also used the PLC as control unit that collect data from sensors.

Then we built a control program for these sensors and then built a monitoring program on (HMI) screen[2].

Vehicle Monitoring: can achieve many thinks:

- Remote censoring of wireless vehicles.
- Lookout of vehicles in 24 hour.
- Control parameters movement and location of vehicles.
- Check of external sensor status.
- Identified the user driving of vehicle.
- The system is wireless data transmission by global mobile system.
- The data is storage in the built-in memory when the network is out of coverage area or busy.
- Operation coverage in worldwide[1].
- The temperature monitoring in the refrigerant.

In general gasohol vehicle censoring system can be represented as in Fig (1).[3]

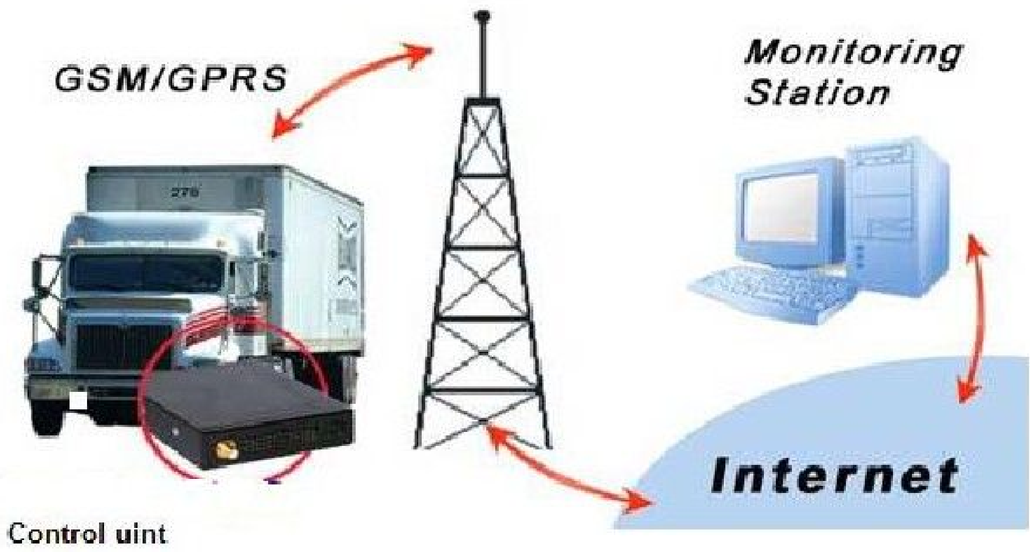


Fig (1): vehicle monitoring system

i- GSM/GPRS module in vehicle

Special vehicle modules or control unit as showing in Fig (1) consist of:

- GPS (Global Positioning System).
- Chip of modem for GSM/GPRS.
- Built-in memory
- Board of microcontroller.

The controller determines its position of vehicle (coordinates) and getting data from sensors and sending this data to the check center.

ii- Network of communication

Channel communication to send data from a vehicle module to a monitoring center (a special Web server or PC with censoring program).

iii- Station of censoring

Censoring station collected and storage all data from vehicle check units, make analysis of that information, visualize vehicle position and road vehicle on electronic map, generating reports on activities of vehicle [3].

2-System Structure

Detailed block diagram of system units are shown in Fig (2) [4].

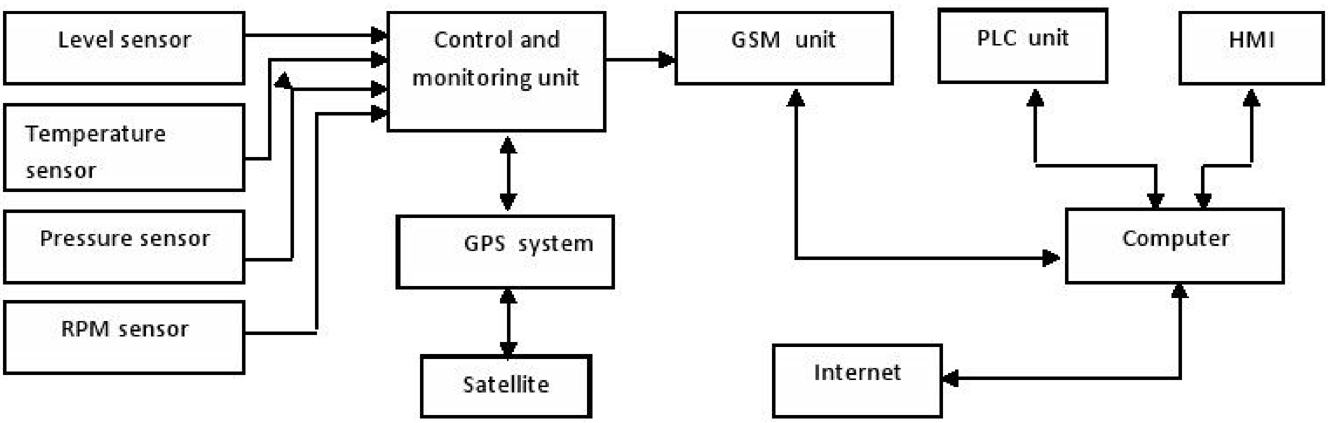


Fig (2): Block Diagram of system units

3-Implementation of fuel level system

This system is used to monitor fuel tanks fixed or moving, such as ground tanks or vehicle fuel tanks. Can be get many data from monitoring process like:-

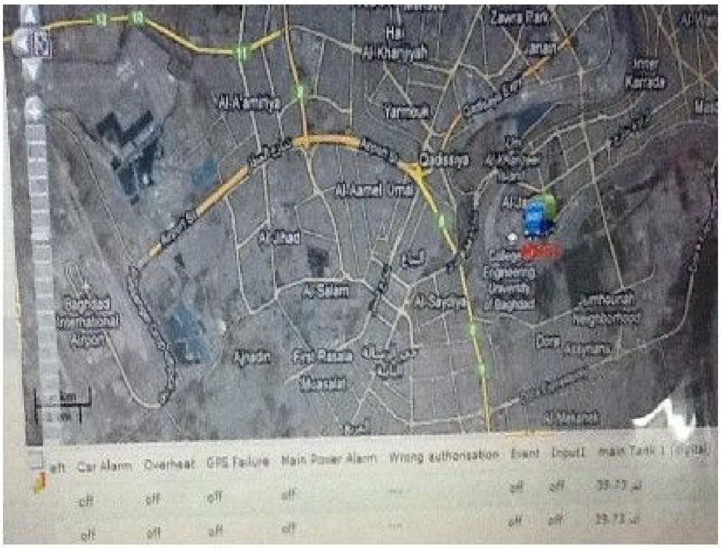


Fig (3): vehicle position on earth

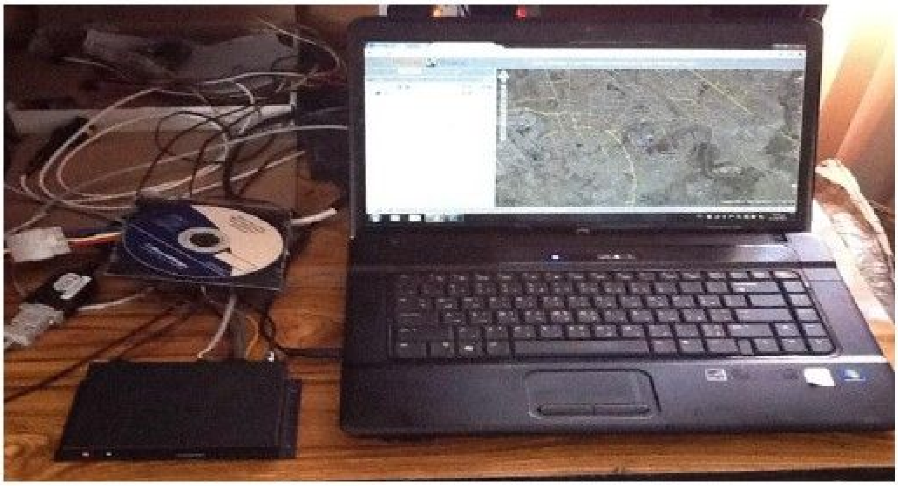
- Vehicle position on earth showing in Fig(3)
- Temperature of vehicle fuel tank.
- A mount and level of fuel in tank.
- Time the vehicle is operated.
- Vehicle speed.

Component of monitoring system are:

- Personal computer with Internet.
- Electronic monitoring and control unit with all accessories.
- Special system program.
- Sensors
- GPS and GSM unit.
- Simcard.
- Conductors.

SCADA Laboratories in our office has own the first system that has our experiments on measuring the level of fuel in the tank doing on it. Where the sensor is installed on a small Tank as shown in Fig (4-a).[5]

(a) level Sensor in the tank



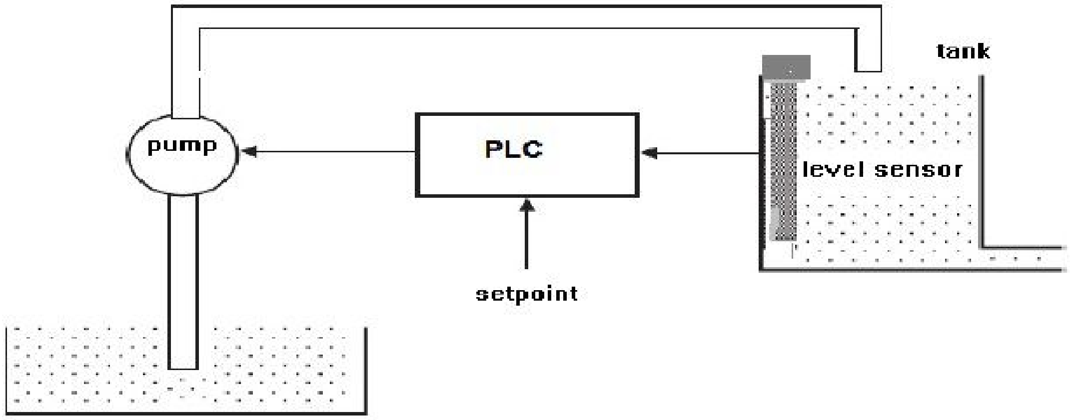
(b) Special program

Fig. (4): The hardware &software of monitoring system

4- Case study of leveling control system

To understand the control system of fluid level which are used in control application to control on the fluid level so considered a case study of a liquid level control in a tank.[6]

Fig. (5) shows atypical liquid level control system and schematic as a block diagram of this system shown in Fig (6). Enter the liquid tank using the pump, after some processing inside the reservoir leaves liquid from the bottom of the tank. The condition for this system is to control the rate of fluid delivered by the pump so that the liquid level inside the tank is at the desired point.[7]



Fig(5): typical level control system.

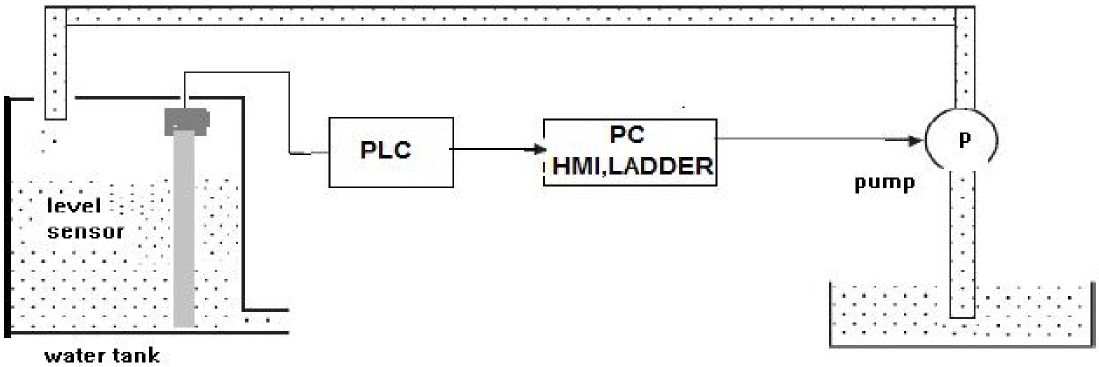


Fig (6): schematic as a block diagram of this system

5-Mathematical model

The 1st order system is described. The tank acts as a liquid capacitor where fluid enters and leaves the tank [8].

$$Q_{in} = Q + Q_{out} \qquad (1)$$

Where Q_{in} is the liquid flow rate into the tank, Q the rate of fluid storage, and Q_{out} the liquid flow rate out of the tank .If A is the cross section area of the tank, and h the height of fluid in the tank,(1) can be written as

$$Q_{in} = A\frac{dh}{dt} + Q_{out} \tag{2}$$

The discharge coefficient of the tank effect on the fluid flow rate, height of the liquid in a tank, the gravity constant, and the area of the tank. Which

$$Q_{out} = Cd\, a\sqrt{2gh} \tag{3}$$

Where Cd is the discharge coefficient of the outlet tank, the tank area outside allow, and the gravity constant (g) (9.8 m / s ^ 2).

From (2) and (3) the result is:

$$Q_{in} = A\frac{dh}{dt} + Cd\, a\sqrt{2gh} \tag{4}$$

Equation (4) shows the relation between the rate of flow and the rise of liquid within the reservoir is nonlinearity. This equation can be linearized for small disturbances around the point of operated.

When the flow rate Q_{in} income is constant, the flow rate through the nozzle reaches the fixed state value of $Q_{out} = Q_0$.The liquid height reaches h_0.where

$$Q_0 = Cd\, a\sqrt{2gh_0} \tag{5}$$

If consider a small disturbance in the input flow rate about the fixed -state value, obtain it

$$\delta Q_{in} = Q_{in} - Q_0 \tag{6}$$

From the result, the level of fluid will be perturbed about the steady-state value by

$$\delta h = h - h_0 \tag{7}$$

After, substituting (6) and (7) into (4) is defined in (8)

$$A\frac{d\delta h}{dt} + Cd\, a\sqrt{2\, g(\delta h + h_0)} = \delta Q_{in} + Q_o \tag{8}$$

Equation (8) linearized by use the Taylor series and taking the first period.

$$f(x) = f(x_o) + \frac{df}{dx}\Big|\frac{(x-x_o)}{1!} + \frac{d^2 f}{dx^2}\Big|\frac{(x-x_o)^2}{2!} \tag{9}$$

The first term, take only

$$f(x) - f(xo) \approx \frac{df}{dx}\,|(x - x_o) \tag{10}$$

$$\delta f(x) \approx \frac{df}{dx}\,|\delta x \tag{11}$$

Linearizing (8) using (11), the results in (12)

$$\frac{d\delta h}{dt} + Qo\frac{\delta h}{2h_o} = \delta Q_{in} \tag{12}$$

Taking the Laplace transform of (12), the transfer function is 1^{st} order system for small perturbations about the steady –state value for tank:

$$\frac{h(s)}{Q_{in}(s)} = \frac{1}{As+Q_0/2h_0} \tag{13}$$

These units pump, level sensor and power amplifier are simple with relative gains. I/p & o/p relationships of these units can be written as:

$Q_p = K_p V_p$

For the level sensor

$V_l = K_l h$

Q_p is the flow rate of pump, V_p the pump voltage applied, V_l the level sensor voltage as output, K_p .K_l ,are constant.

So, The block diagram of level control system is as shown in Fig (7)[8].

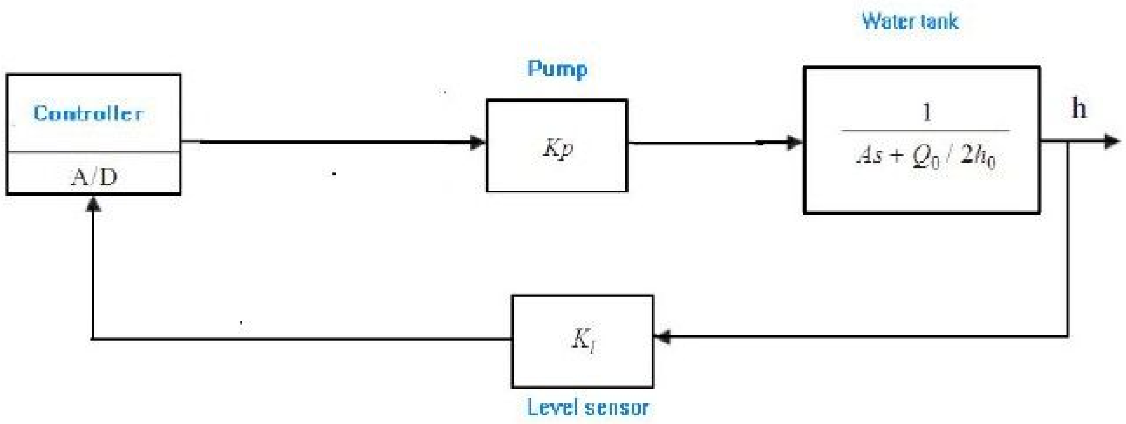


Fig (7): The block diagram of level control system

6- Calibration process

Initially we conducted the calibration process for the sensor to read the values correctly and accurately during real time operation .And by a special program on the computer we get a table of values represent (the amount of fuel in liters) and the values in form of a digital code (represents the volume of fuel) It is necessary to bring this table to draw a diagram representing the calibration chart that will appear[4].This chart will show linear relationship between the values represented by equation of first degree as follows:-

$y = ax + b$

Where y: fuel volume digital code, x: amount of fuel in liters

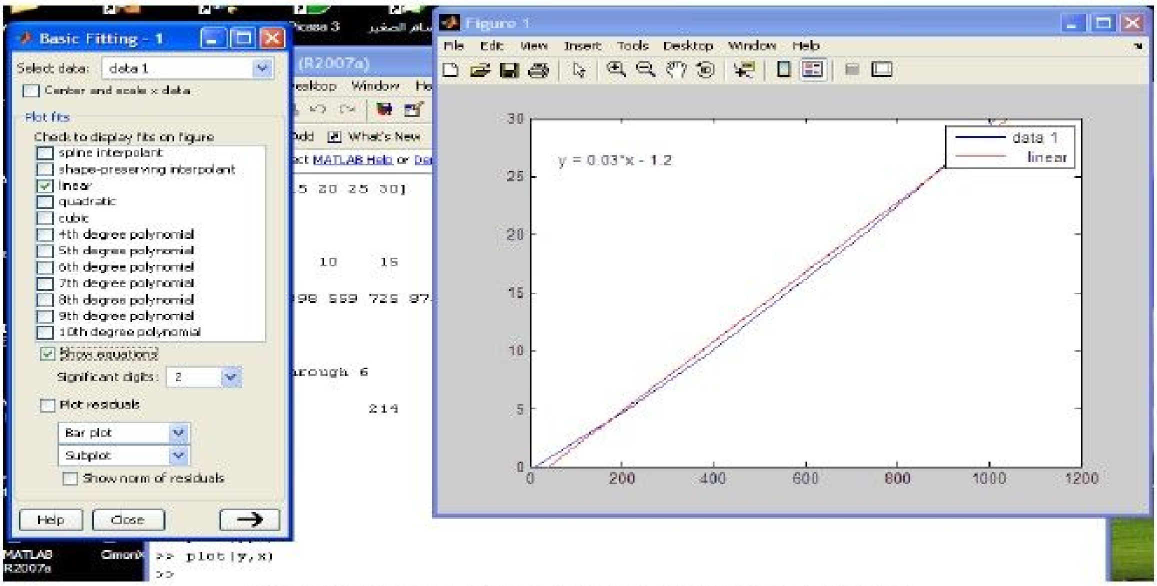
a, b: constants

It is necessary to feel the maximum and minimum value for the fuel level in tank and the rest of the values as shown in Table (1): -

Table (1)

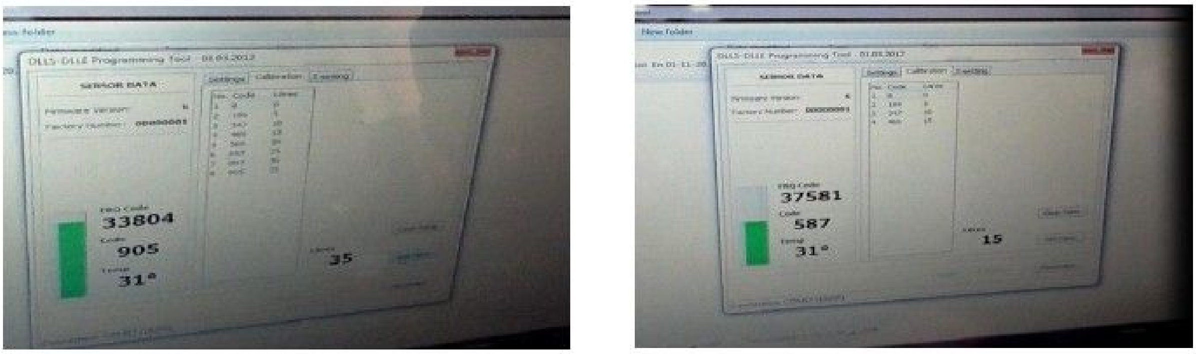
NO.	Y (fuel volume code)	X (liters)
1	77	0
2	2120	5
3	4520	10
4	6760	15
5	8600	20
6	10500	25
7	12300	30
8	14200	35
9	16000	40

Then we draw the relationship between these two variables by MATLAB and then making a curve fitting process to get the best result and find the values of a, b in the equation to generate calibration chart as showing in Fig (8).



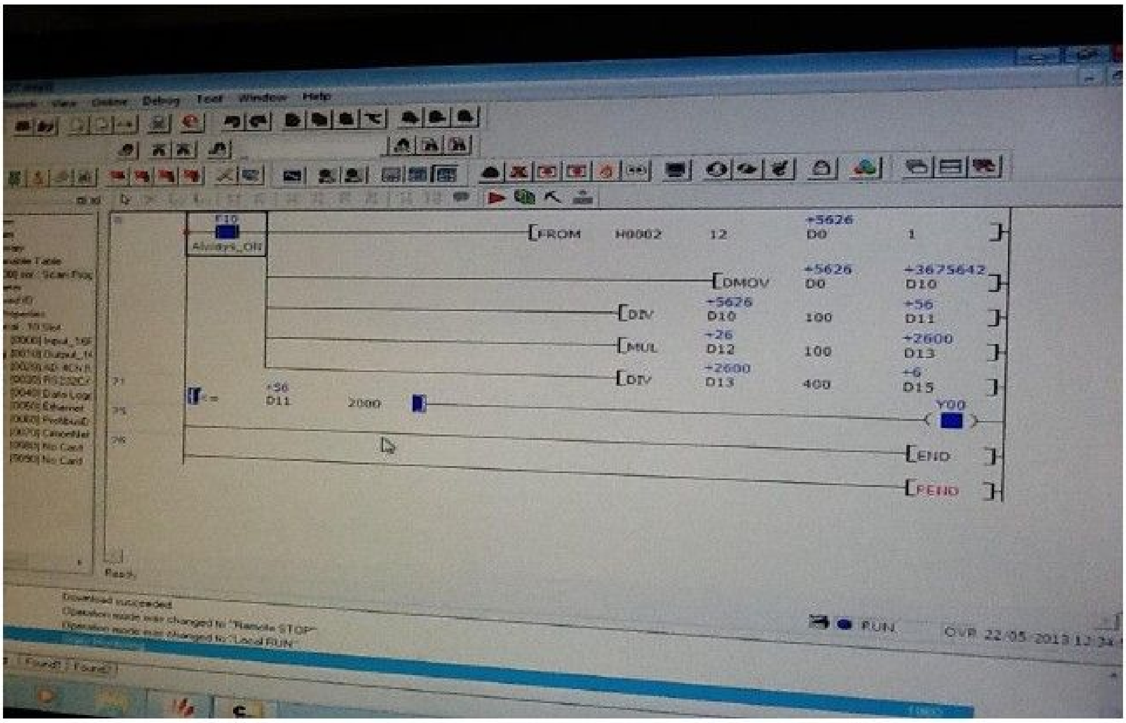
<u>Fig(8):</u>Curve fitting process in MATLAB

After completing find the equation and find the values of a, b, which will be used again in the program for the purpose of complete calibration process of sensor in order to find the real values during real operation as shown in HMI in Fig (9).



Fig(9): Real values during real operation in HMI

$Y=0.0025x+0.94$ from curve fitting process. This equation we obtained is very important because it used in ladder program of CIMON PLC as shown in Fig (10).



Fig(10): ladder diagram of level sensor in real operation

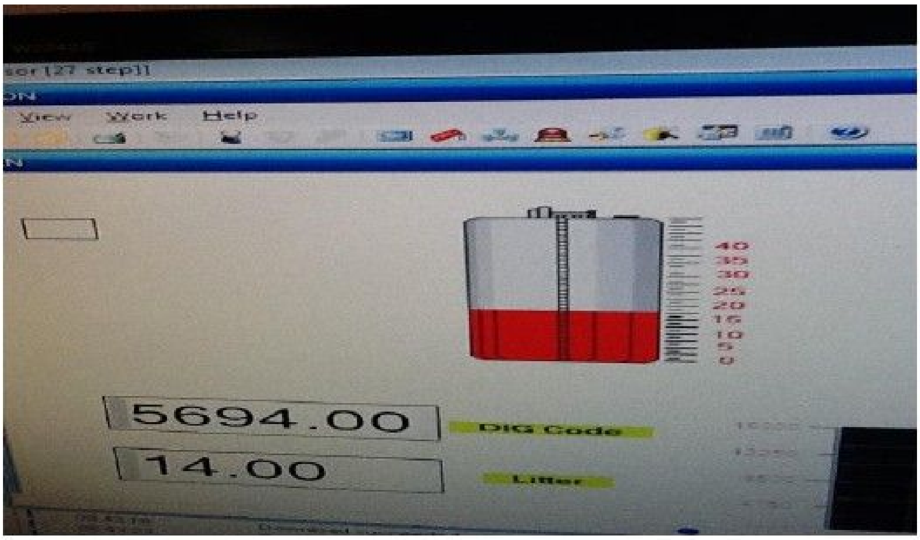


Fig (11): Real time monitoring of level sensor on HMI

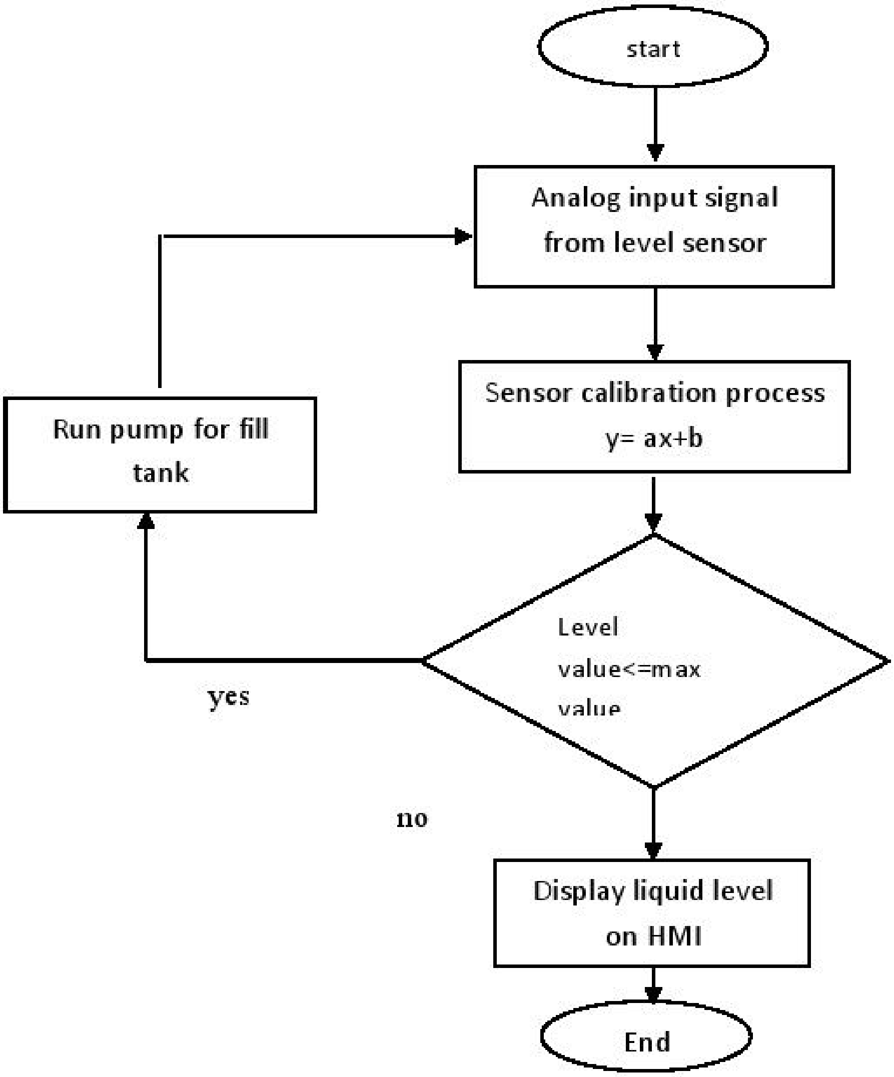


Fig (12): Flow chart represents the monitoring system

Conclusions

The system using the mobile network as a means for the transfer of reports by receiving SMS messages, where system containing an electronic simcard private with network to use as a means for moving messages. And by the GPS which is placed on vehicle and connect with satellite, can be find the location of fuel vehicle, where we received the data associated with fuel vehicle tank and the data of sensors by means of connection with main server .The monitoring system check the current location of vehicle, Real fuel consumption, points of visit, job performance or analysis of the cause of failure of work.

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