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Investigation of Real-time Fuel Consumption Measuring System

Zenglin Zhang [1,2], Xiaoqing Yu[1,2*] and Wenting Han[1,2]

[1]*Northwest A & F University, Shaanxi, Yangling, 712100, China*
[2]*Research Institute of Water-saving Agriculture of Arid Regions of China, Shaanxi, Yangling, 712100, China*
E-mail:zhangzenglin115@gmail.com,yuxiaoqing115@gmail.com, wentinghan200@126.com

Abstract

With the single chip microcomputer as the core, a kind of multi-function detection system of vehicle fuel oil is designed by using sensor and signal processing circuit. Signal can be converted into electrical signal and connected to A/D converter through the oil signal acquisition channel, instantaneous oil signal acquisition channel, respectively. In the system, output data is displayed through the software programming and the corresponding circuits. The tests show that the system can automatically and accurately monitor all cases of the fuel oil and it is very important for the drivers to know the conditions of the vehicle fuel oil.

Keywords: *fuel oil, sensor, control, circuit*

1. Introduction

Currently, vehicle fuel oil parameters measurement mainly uses old mechanical measuring technology that measuring precision is low (Kim, *et al.*, 2013; Chuanfei and Carol, 2011). Fuel oil volume measurement only depends on the oil level and display oil through the float point pressure technology (Haikun, *et al.*, 2008; Wassan, 2006), which anti-interference ability is poor and display is not intuitive.

In foreign countries, electronic technology, sensor technology and digital technology are developed (Berman, *et al.*, 2004; Watfa, *et al.*, 2013; Carle and SimPlot-Ryl, 2004; Sheth, *et al.*, 2005). With the support of microchip technology, the development of automotive electronics industry is quickly and the vehicle oil quantity and instantaneous fuel oil consumption value measurement is in the forefront of the world in the west. Here, microprocessor is widely used as the core of the measurement system (Shen, 2003). Moreover, the external exists all kinds of high sensitivity sensor and the digital display, measuring parameters is not only intuitive but the accuracy is high (Agoston, *et al.*, 2006; Agoston, *et al.*, 2008). In the domestic, automobile fuel oil consumption test mainly uses automobile fuel consumption test device that test scope, accuracy, display, maintenance and reliability are not very ideal. The electronic fuel consumption device developed by some universities and scientific research units can test the average fuel consumption, instantaneous fuel consumption and the cumulative fuel consumption and has graphical display function (Montane and Galvao, 2006; Jahanshahi, *et al.*, 2013), but the measurement precision still need to further improve and the device cost still need to further reduce. Due to the miniaturization, multi-functional, integration and intellectualization of sensor, the continuous improvement of the controller function, at present, the smart fuel consumption test device has being developed at home and abroad. The design uses the single chip microcomputer technology and the digital calibration method to conduct oil measurement for any shape fuel tank, and real-time and precisely display oil values.

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2. System Design

Single chip microcomputer AT89C51 is the core of the whole system. In order to data collection, coordination of the numerical conversion, microcontroller provides CLOCK pulse to A/D conversion circuits (Fu, 2002; Li, 2010; Qiao, 2009; Wang and Zhang, 2009). The internal crystal frequency is set 12 MHz and the ALE signal frequency is 1/6 of the crystal Oscillator frequency. 500 KHz signal is produced after the four point frequency for ALE that as the CLOCK signal is required by ADC0809 converter (National Semiconductor Corporation, 2002). The oil sensor and flow sensor convert the non-electric signal collected into electrical signals, and connect to IN0 channel, IN1 channel A/D converter through the oil signal acquisition channel, instantaneous oil signal acquisition channel, respectively. After starting A/D conversion through the software programming, digital signals converted are sent into microcomputer to do the corresponding conversion. Display and keyboard scanning circuit is mainly responsible for the output numerical display and entering the corresponding function of single-chip microcomputer. Diagram of the system design is shown in Figure1.

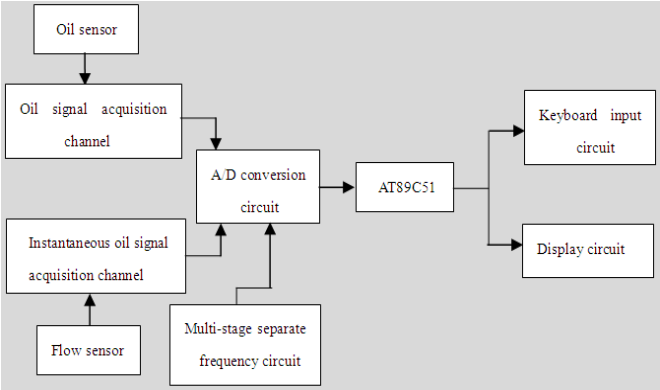

Figure 1. Diagram of System Design

In view of faults of the current common fuel oil level sensor, a new fuel oil level sensor is chosen. The sensor reflects high and low of the remaining fuel level by utilizing a linear relationship between the output voltages of hall unit and the magnetic field. The sensor has the good linearity, measuring precision and high resolution features, moreover, amplifier circuit of the sensor has linear correction function which make output has more linear.

System uses differential pressure type flow sensor that is also called throttle type flow sensor that convert the instantaneous flow of the fluid in pipe into the pressure difference of before and after of the throttle device by using the throttle device in the pipeline. Flow measurement system of differential pressure type flow sensor is mainly composed of the throttle device and the differential pressure gauge.

Single chip microcomputer has very wide application, fast development as an important branch of microcomputer. At present, the single chip microcomputer is developing towards the CMOS, low power consumption, small volume, high capacity, high performance, low price and peripheral circuit in the equipment. There have already developed hundreds of series type machine since the single-chip microcomputer was born. 51 series is one of the outstanding ones, AT89C51 single chip microcomputer has become the mainstream of development. AT89C51 single-chip microcomputer is also convenient for system maintenance and management.

Because the time required of A/D conversion is not too high when this measurement is used to test A/D conversion signal. Besides, A/D conversion used 8-bit resolution is enough to meet the design requirements. ADC0809 is chosen as A/D conversion chip. ADC0809 is control logic CMOS components with eight A/D converter, 8 road multiple-

road switch and microprocessor compatible. It is successive approximation type A/D converter, ADC0809 can directly connect with single chip microcomputer.

3. System Hardware

The acquisition circuit of oil signal is shown in Figure 2. Voltage converted from oil value is set in the range of 0-5V in the simulation environment in order to make sending signal value of the internal sensor in tank satisfy voltage range of A/D converter conversion. The voltage signal AC filters through a 10KΩ resistor R1, and then is sent into the voltage followed U1 that connected to A/D converter IN0. The oil signal is collected when A/D converter begin to work and collect IN0.

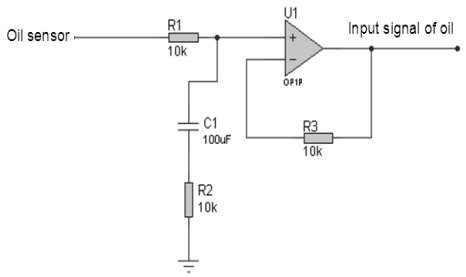

Figure 2. An Acquisition Circuit of Oil

Signal acquisition circuit of instantaneous oil consumption is shown in Figure 3. Differential pressure transmitter converts the pressure measure difference into voltage signal when vehicle do a series of movements such as the starting, speeding up and slowing. Firstly, the impurities signals need to be removed, then, signals are sent to the evolution circuit, finally, the root of signals are sent to A/D converter. In order to satisfy the voltage range of A/D converter conversion, voltage value is set in the range of 0-5V. The voltage signal AC filters through a 10KΩ resistor R4 then gets rid of impurities signals affection and sends into the evolution circuit. The root of signals connects to A/D converter IN1. The instantaneous oil signal is collected when A/D converter begin to work and collect IN1.

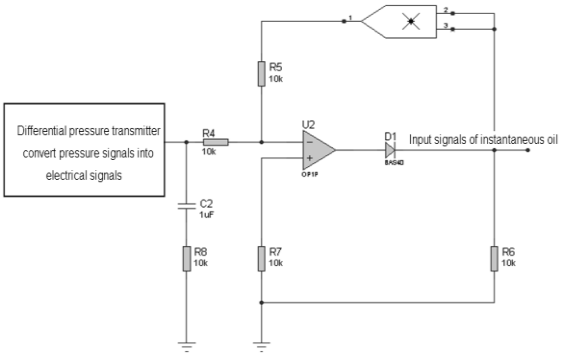

Figure 3. An Acquisition Circuit of Instantaneous Oil Consumption

8255A is an extension I/O interface. Data line D0-D7 connects with P0-P7 of single chip microcomputer and accept the data input of single chip microcomputer. $\overline{CS}$ is the chip selection that connects with the P2.7 of single chip microcomputer. 8255A has been chosen because of it is set to be low level in the software design. A0, A1 connect with address latches 74LS373 and control A, B, C work. Control method of 8255A is that A, B are output, A connects with the control of the LED display, B connects with their bit control. Read signal $\overline{RD}$ connects with P3.7 of single chip microcomputer. 8255A send

data to single chip microcomputer when it sends out read instructions. Write signal $\overline{WR}$ connects with P3.6 of single chip microcomputer. The single chip microcomputer input data into A, B of 8255A respectively and display them when it sends out write instructions. The single chip microcomputer input data written instructions, single chip microcomputer to input data mouth and then displayed. Display circuit is shown in Figure 4.

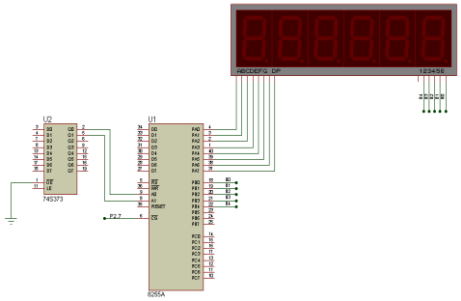

Figure 4. Display Circuit

4. Software Design

The main program of system consists of measurement, the interrupt, operation, display module. Flow chart of the main program is shown in Figure 5.

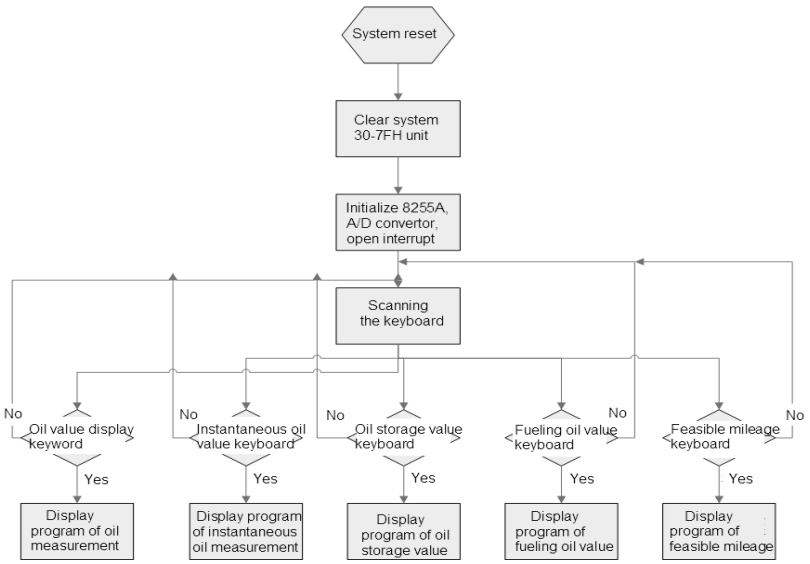

Figure 5. Flow Chart of the Main Program

8255A work address port is predefined. P0, P2 of the single chip microcomputer are address port in the software design and the P2.7 is set for low level. So A port address of the 8255A is set for #7FFCH, B port address is set for #7FFDH, control word port address is set for #7FFFH. Both A and B port are set for output, the content of the control word is #80H. The top bit is 1 and the other bit is 0 in a byte means that the highest bit 1 allows control word to work. Moreover, both A and B port are the output port down zero, so they are 0. Single chip microcomputer transmits the form code of the show digital quantity to the A port of 8255A, then transmits them to LED to display. The B port as control port and write bit control command to bit control port to make LED is sequentially lighted in the program execution. Furthermore, Light time of each decoder delays 1ms or so, then, it

shows next. Circulating shows from the first bit after all display bits are realized. The flow chart is shown in Figure 6.

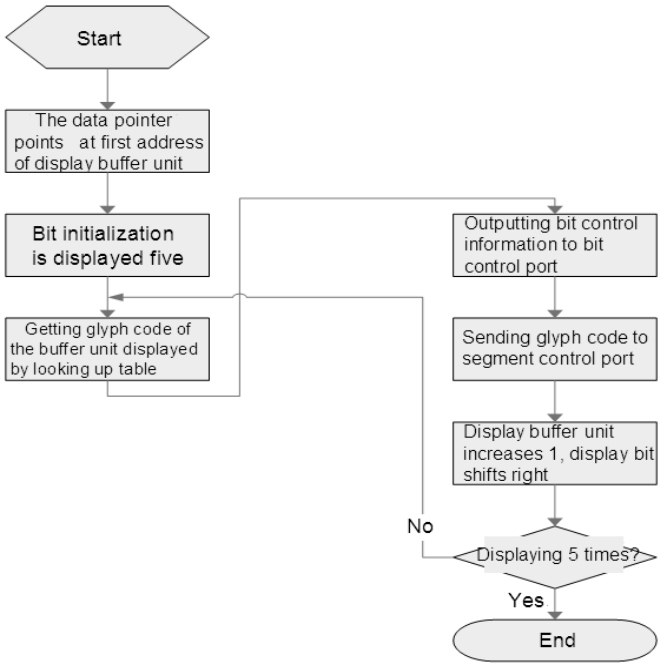

Figure 6. Flow Chart of Display Program

5. System Tests and Results

The whole design principle of the system is shown in Figure 7. The biggest measurement range of instantaneous oil consumption is set for0~10L/100KM, the largest measuring voltage signal is set for 5v in order to conveniently test, simulation is shown in Figure 8.

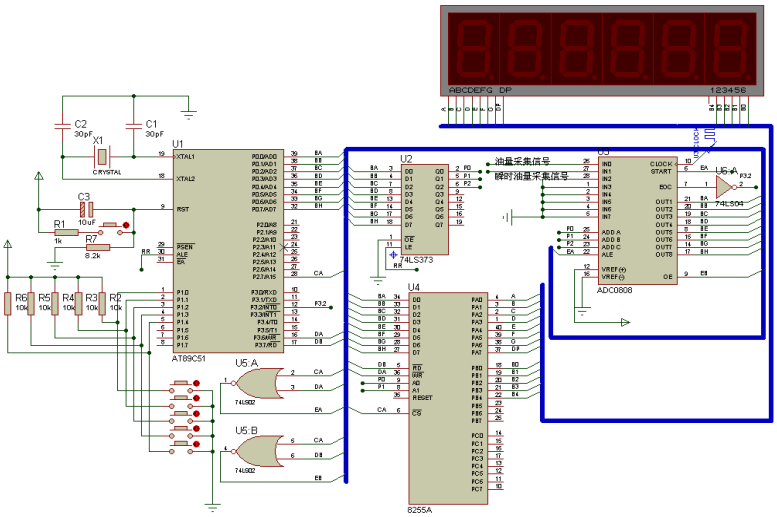

Figure 7. Flow Chart of Display Program

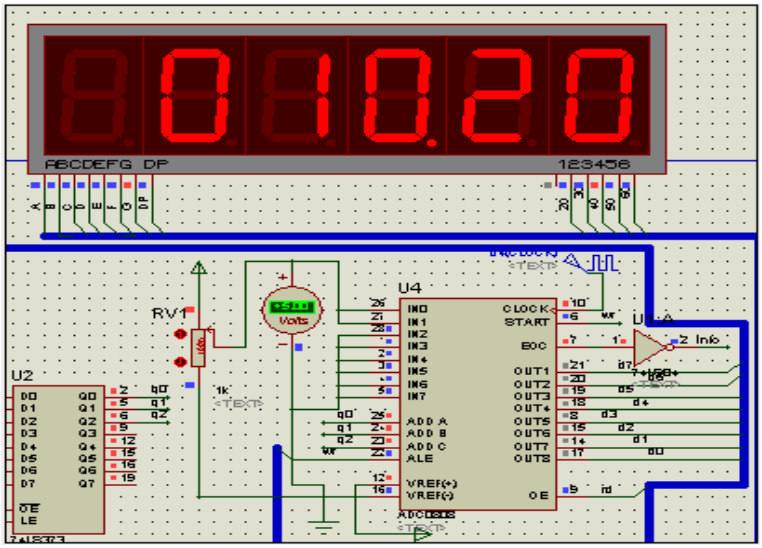

Figure 8. Test of Instantaneous Oil Consumption

In the process of simulation, the instantaneous oil consumption value is measured 10.2L/100KM when voltage value is the maximum 5v, which differ by 0.2 with the presupposed value 10L/100KM.

6. Conclusions

The system consists of two parts: (1) data acquisition part: MCU as the core, system realizes the averaging of data multiple collection through the software programming and transfers them to the display part through numerical hexadecimal conversion, which avoids the larger error defect of the traditional pure hardware design; (2) the display part: system uses the seven segment display decoder that the range currently can be used in cars. Oil measurement precision is ±0.04 L. The decoder can be installed on the original oil detector that has small influence on the original detection system. It can also be installed separately, which do not affect the aesthetic and structure of the vehicle and also can avoid other faults because the oil pump damage caused by too little oil. The fuel oil monitoring system is convenient and easy, can be used in different vehicles that only need to write different procedures in its internal ROM.

Simulation tests shows that the system can realize measurement of the remaining oil, instantaneous oil consumption, fueling oil up and feasible mileage. The system running is well, the result is correct, and makes the system circuit PCB and assembly simulation.

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Authors

Zeng L. Zhang, received his B.S. degree from Department of Mechanical and Electric Engineering, Harbin institute of Technology, Harbin, and M.S. degree from Department of Mechanical and Electric Engineering, Northwest A & F University, Shaanxi, China in 2000 and 2007, respectively.

Currently, he is a teacher in Department of Mechanical and Electric Engineering, Northwest A & F University, Shaanxi. He is pursuing Ph.D. degree under the supervision of Prof. Pu T. Wu. His current research interests are in Agricultural Water-Soil Engineering and Wireless Sensor Networks.

Xiao Q. Yu, received the B.S. degree from Department of Information Engineering, Lanzhou University of Finance and Economics, Lanzhou, China in 2006. She received her M.S. degree and Ph.D. degree from Department of Mechanical and Electric Engineering and Department of Water Resources and Architectural Engineering, Northwest A & F University, Shaanxi, China in 2009 and 2013, respectively.

Currently, she is pursuing postdoctor degree from Department of Water Resources and Architectural Engineering under the supervision of Prof. Wen T. Han. Her current research interests are in Agricultural Water-Soil Engineering and Wireless Sensor Networks.

Wen T. Han, received his B.S. degree from Department of Mechanical and Electric Engineering, Northwest Agriculture University, Shaanxi, China in 1996. M.S. and Ph.D. degree from Department of Mechanical and Electric Engineering, Northwest A & F University, Shaanxi, China in 1999 and 2004, respectively.

Working Experiences:

2005-present: researcher, Institute of Soil and Water Conservation of Chinese Academy of Sciences Northwest A & F University, National Engineering Research Center for Water Saving Irrigation at Yangling.

2004-2005: Assistant Professor, Department of Mechanical and Electric Engineering, Northwest A & F University.

2001-2004: A lecturer, Department of Mechanical and Electric Engineering, Northwest A & F University.

Research Interests:

Information monitoring of crop and environment; Intelligent control for precise irrigation; water distribution Simulation of sprinkler irrigation; Development of nozzle

Currently, he published academic papers more than 30, including SCI and EI articles 16; the national invention patent 6.