

## Intelligent Digital Multi-purpose Vehicle Instrument

**Abstract.** This paper analyzed and studied the development and needs of the vehicle instrument. By the electronic circuit and microcontroller technologies it achieved the high-precision digital display of the speed, and the mileage and the fuel, and also this vehicle instrument realized the function of password protection, and alcohol concentration detection and reversing radar measuring the distance. Practice shows that the digital vehicle instrument has an intuitive digital display and high intelligence.

**Streszczenie.** Przedstawiono nowy inteligentny mikroprocesorowy instrument pokładowy samochodu. Instrument pozwala nie tylko mierzyć prędkość i dystans, ale także wykrywa obecność alkoholu i działanie radaru. (Inteligentny cyfrowy wielofunkcyjny instrument pokładowy pojazdu).

**Keywords:** vehicle instrument; digital display; intelligent; multi-purpose

**Słowa kluczowe:** instrument pokładowy pojazdu, pomiar prędkości.

### Introduction

With the development of society, the vehicle ownership is more and more, and it has brought great convenience to the people's work and life, but also it has brought our own security and safety issues related to a lot. Vehicle instrument is the most important information exchange interface between the driver and his vehicle. It plays an important role in the man-machine dialogue by providing information needed in safety and economizing. According to the survey, as a result of our pilots annual drunk driving accidents caused by 2.5 million, resulting in about 50,000 deaths and direct economic losses amounting to 1.3 billion. In addition, due to more uncertainties of transport for the personal safety of the driver there is a big threat. As a result, study vehicle protection and control is a direct bearing on people's physical and mental health event, and there is a wide range of social benefits and long-term economic benefits [1]. With electronic technology advancement, development of new sensors and display components, electronic computer in the vehicle instrument has been extensively applied. The electrification and digitalization of the vehicle instrument, which can provide the driver with high-precision data and avoid many disadvantages caused by traditional mechanical and electrical mechanical meters, has become an inevitable trend. Therefore, it attracts more and more attention all over the world.

### Microprocessor

Vehicle instrument structure should try to be brief and the size of the microprocessor should be minimized to the limit. At the same time, they should meet the real-time measurement accuracy needs. Besides, the microprocessor must have a faster computing speed, sensitive reaction and a higher accuracy. The mileage data is a calculated number of former speed, and each operating procedures has to call the results of the last operation. Therefore, the CPU must have fast erasable memory capacity, and when the CPU is out of power, data will not be lost. The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer [2, 3].

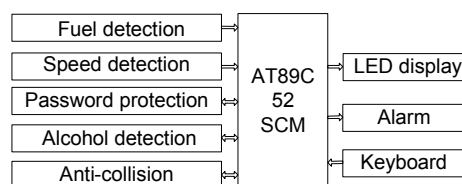
The AT89C52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, three

16-bit timer/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89C52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The idle mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The AT89C52 has a total of six interrupt vectors: two external interrupts (INT0 and INT1), three timer interrupts (Timers 0, 1, and 2), and the serial port interrupt. The power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset. To sum up, using 89C52 microprocessor can simplify the hardware circuit design and enhance the system reliability greatly.

### System design

The multi-purpose vehicle instrument was completed coordinately by the hardware circuit system and software system. The hardware system has mainly completed a variety of sensor signals in the acquisition, conversion, as well as information display, and so on; software system has mainly completed the signal processing and controlling. In the system design, the solution had used the modular design, and the system was divided into relatively independent sub-system modules: fuel detection, speed detection, password's lock system, alcohol detection system, anti-collision system, alarm and reset circuit, and so on. The principle component of the system hardware is shown in Fig. 1.

Fig.1. Vehicle instrumentation hardware block diagram



The pulse signal, output of speed sensor, becomes the standard square-wave signal after amplifying, separating through the processing of pre-pulse processing circuit filter. Then, it is sent into SCM completing speed measuring and mileage computing. The analogue signals, output by the fuel liquid level sensor, going through the conversion course of pre- voltage-signal-processing circuit, is sent into input port for internal A/D converter of 89C52. Then, the LED module shows the measuring results sending by 89C52.

The password protection system was set up a password with four decimal digits as its code, and it enhanced anti-theft function of motor vehicles. Alcohol detection system used gas sensors to detect the driver's alcohol concentration of breath, which can effectively prevent the driver from drunk driving. The anti-collision system calculated the launch point barrier to the actual distance, so it may effectively prevent the collision event's occurrence.

Software design of instrument as hardware design adopting the same modular design concept makes the application software standardization, modularity. First, it can effectively improve system's reliability and maintainability; the second, it provides a convenient for the expansion of the software system; Third, it has improved the speed and quality of programming. System software is for the whole system and the function modules to manage and control. After the electrical system and initialization, first of all, it access to alcohol content detection system, testing driver's blood alcohol content, and setting the threshold for comparison, in his alcohol level exceeded the threshold conditions, lock ignition system issues voice of the ambulance. Next the system access to the password lock system to verify password, under the error password conditions lock the oil supply system issues a warning sound [4, 5]. Then it access to the ultrasonic distance-measurement system using anti-collision, it is for the ultrasonic wave's propagation speed in the air as the known condition, through ultrasonic transmitter and receiver circuits, and the system collects time received from the launch time to time in order to complete the vehicle away from the monitoring and an analysis of data from the vehicle to judge, gives the drivers corresponding message.

### Speed sensor and signal processing

The vehicle speed sensor is to test the vehicle speed. The current application in the vehicle is the power-speed magnetic sensors, optical speed sensor, speed sensor and centrifugal hall-speed sensors mainly. The magnetic sensor, with simple structure and strong anti-jamming capability, is used extensively in the check of vehicle engine speed. However, it is self-generating, and it outputs very weak signal in the low-speed. Thus, it is unable to be used when the speed is close to zero. Photoelectric sensor has a high resolution, but is vulnerable to outside influence: dust, vibration, and other interference can easily render ineffective. When the vehicle works, it turns as the shaft turning. While the convex tooth on the rotor of sensor made of permanent magnetic materials, through the gap alternatively, there will be a changing magnetic field in the devices. It makes hall voltage produce pulse signal. Then, according to the number of pulses the speed can be detected [6].

From the hall sensor output characteristics, to know that the speed signal is a constant pulse signal, whose frequency is proportional to the speed? However, the sensor output signal is not the standard square wave signal, usually with interference. The main task for pre-signal-processing circuit is to remove the interference signal, shape the signal as the standard square wave, and then input it to the microcontroller. Pre-signal-processing circuit is shown as Fig. 2 [7]. R5 and C6 constitute differential electronic circuit, improving the input waveform so that more steep pulse rising edge can be gained; the transistor Q1 works in the switch state to complete the amplification and drive of the signal, and constitutes photoelectric isolation circuit with the resistor R7, R8 and Optocoupler U10 to enhance anti-jamming capability; regulators diode D3 limits the amplitude of input signal to protect Transistor Q1

launch node from not being broken down by forward reverse voltage.

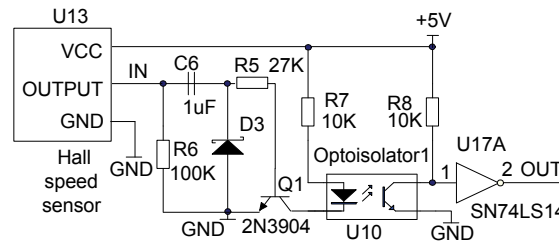


Fig. 2. Pre-signal-processing circuit

The output signal of pre-signal-processing circuit is the standard square wave pulse. Using the 89C52' T0 interruption port to count, meanwhile, timed by the T1 ports, in doing so, the speed and mileage will be work out through calculating the pulse in 1 second. Speed calculation algorithm analysis: The output signal of the pre-processing circuit of speed is standard square wave pulse. Through T0 interruption port of 89C52 to count, at the same time, to time through the T1 port, by calculating pulse in a second to calculate speed and mileage.

Assume that the pulse in a second is  $n$ , the number of teeth of hall sensor is  $n_m$ , vehicle tires radius is  $R$ , and the formula for calculating speed is the formula 1.

$$(1) \quad V = (n/n_m) \times 2 \times 3.14 \times R \text{ (m/s)}$$

From the above, set parameters  $N_m=12$ ,  $R=0.5m$ . To facilitate the calculation, all the numbers is taken the whole, and the conversing speed unit to Km/h, the vehicle speed calculation formula is to become the formula 2.

$$(2) \quad V = (1120 n) / 1200 \text{ (Km/h)}$$

Mileage calculation algorithm analysis: Because speed is unit time travelling distance by the vehicle and the speed value per second is the vehicle's mileage value per second. The formula 3 tells us that the formula of vehicle's Mileage value per second is:

$$(3) \quad S = (314n) / 1200 \text{ (m)}$$

Accumulating each of the measured pace, with cumulative results divided by 1000, if quotient is 1, the mileage value add 1 automatically, the remainder is used for the next cumulative; Otherwise, the results will continue to join the next cumulative. Thus the result of the mileage value is km, and the ceiling of mileage value is 65535 km.

Mileage data repository address assignment: because the mileage calculation must call the results of the last operation, so, in this module, need to store these mileage data, as well as its BCD code to facilitate the calling of calculation and display next time. As mileage values are large relatively, here use double byte to store up. The mileage data repository address is assigned as Table 1.

Table 1. Mileage data repository address assignment

Mileage	16-bits data		BCD code data (bit)				
	High 8bits	Low 8bits	10k	1k	100	10	1
Address	72H	73H	53H	54H	55H	56H	57H

### Fuel sensor and signal processing

The sensor is mainly used for detecting oil fuel tank. It is stimulant output liquid-level sensor whose structure principle is shown as Fig. 3.

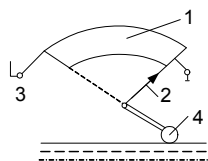


Fig. 3. Float-type fuel level sensors

While the sensor floater 4 moves up and down with the level of oil, the vane 2 slides on resistance 1. Thus, the resistance value between cramp iron and floater is changed, making detection circuit produce different signals. When the whole resistor connected to the external fixed voltage, the oil film can be measured through the voltage changes of vane to the ground wire. Oil signal has a relatively slow rate of change, but it is inevitable there will be some interference. To make input voltage fit ADC0809A/D converter input requirements, the front adjustment signal processing circuit is designed. Residual fuel tank volume measurement circuit is shown in Fig. 4.

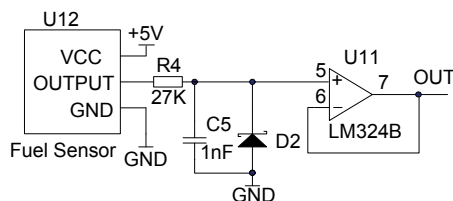


Fig. 4. Fuel level pre-processing circuits

When the surface is stable, sensor outputs a stable voltage. R4 and C5 constitute a first-order inertial filter module which has a damping coefficient with a purpose to eliminate bumpy surface impact in travelling. Oil calculation algorithm analysis: As ADC0809 is 8-bit of successive approximation A/D converter chip, the total fuel tank is 100L, ADC0809 conversion results is  $n$ , then the calculation formula for oil is the formula 4.

$$(4) \quad L = (100n) / 256$$

The quotient of the calculation results is integer value of oil.

### LED display

The vehicles often run in the wild or in relatively harsh operating conditions. Thus, it requests electronic display devices of high reliability. Usually, light emitting diode (LED), vacuum fluorescent display (VFD) and LCD display (LCD) are chosen, because of their good performance and display. VFD and LCD, as small displays, are developing towards large dashboards. Working under special conditions, vehicles require their display devices of low drive voltage and power consumption. LED has the features of low power consumption, large capacity; high brightness, strong seismic performance, and LED have no radiation, no pollution, meeting the demands of modern society. Obviously, it is ideal to choose LED displays for vehicles.

### Password lock subsystem

Password lock subsystem mainly achieves the following function: before the start to drive the vehicle, first of all, the system must enter a password, if the password is correct, the system can supply oil and normally start; If you enter the password is wrong, the oil supply system will be locked, not oil, the vehicle can not start and vehicle alarm system

issues a warning sound to attract the attention of the owners [8, 9]. In order to improve the system of confidentiality and flexibility and adopt four decimal digits as password's code, it can modify the password after password disclosure.

Hardware circuit is constituted of programmable interface circuit by 8255, typing the password circuits and error alarm circuits, and other parts. 8255 series is Intel's MCS-80/85 generic programmable parallel input/output interface chip, which has three 8-bit parallel I/O ports, the port function is due to software's options, and it has the versatility and flexibility in the use of good workmanship.

Type the password using the 4×4 matrix keyboard, corresponding to the password you enter, then let keys in the ranks of the lines cross, once a key is pressed, linked to its line of line and out of line that is connected. If you do not press the button, the line is disconnected and out of line. Scan using the keyboard is the usual way of progressive scan, in order to make each line out lower and the rest high input, and then read the signal line. Through progressive scan to determine the ranks of the button, according to the ranks of its look-up table to get his address, it is to be the key to his re-key process in the process.

KD9561 integrated chip is the core of error alarm circuit. The KD9561 integrated chip has many advantages of an operating voltage range, a small quiescent current, small size, low price, sound realistic, easy to control, etc. It can issued machine guns, whistle, ambulances, fire engines sound in accordance with the different requirements. KD9561 has an internal oscillator, the metronome, tone generator, the address counter, control and output stage, and so on. In the two-chip input pin SEL1 and SEL2 on different levels, you can call different internal procedures, external speaker drives circuit LS1, and the police will have different sound.

### Alcohol detection subsystem

When the system detects concentration of alcohol, other gases and external interference is inevitable. So this system had selected a higher degree of integration MQK2 type gas sensors, which has high sensitivity and selectivity, long life and stability of reliable and so on. MQK2 type gas sensors is fixed in plastic or stainless steel in the body cavity by the micro-gas sensors, ceramic tubes and sensitive layer, electrodes and measuring the sensor heaters pose. The sensor through setting the external circuit's parameters, can make that the sensors output is 0 to 5 V voltage value, and it has voltage stability, external interference small, and so on. Because gas sensor output is stable from 0 to 5 volts, the  $S_nO_2$  sensor can be directly output value of the data collected through ADC0809 into SCM processing, and determining whether more than the threshold, more than sound alarms when the ambulance and lock the ignition system; not more than normal start.

The system software of alcohol detection includes alcohol data acquisition subroutine, data processing subroutine, display subroutine, sound and light alarm subroutine, and so on. After boot device initialization, the LED display subroutine calls revealed that measurements such as the interface. When the obtain data is exceed to the threshold, the subroutine alarm would have activated and issued the sound and light alarm and locked the ignition system. If there is no more than the threshold, the vehicle will start normal [10].

The hardware designed a sound and light alarm circuit. When the detected alcohol level has exceeded the pre-determined threshold, SEL1 and SEL2 should been high, then the alarm circuit should have issued a warning sound of ambulance.

Table 2. Experimental results

Analogue instruments			Digital instruments		
Mileage	Speed	Oil	Mileage	Speed	Oil
2500.2	Estimates 38 km/h	35L	2500.2	37km/h	34.5L
1236.6	estimates 84km/h	The second line	1236.6	87km/h	4.9L
120.4	More than 60 km/h scale	Intermediate scale tank	120.4	62km/h	15.1L
25.5	Estimates 110 km/h	Minimum threshold alarm	25.5	118km/h	0.9L

### Reversing radar ranging subsystem

Ultrasonic ranging principle is shown in Fig. 5. When the ultrasonic transmitter in some direction launches an ultrasonic, the timer runs at the same time of launch time, ultrasound spread by air, they return as soon as over obstacles on the way, and ultrasound receiver received reflected wave will immediately stop timing. In the air the speed of ultrasound spread is  $c$ , according to the recorded time, we can calculate the firing distance away from the barrier, the formula 5 for calculating the distance:

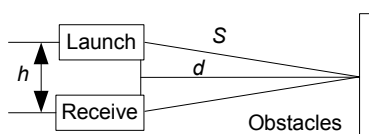


Fig. 5. Ultrasonic ranging schematic

$$(5) \quad d = \sqrt{s^2 - \frac{h^2}{2}}$$

Generally, if  $s \gg h$ , then  $s \approx d$ , and so it is the following formula 6.

$$(6) \quad d = s/2 = (ct)/2$$

To choose MA40S4R/S ultrasonic sensors, the key of ultrasonic ranging system is to measure sound wave propagation time. Based on the 89C52 ultrasonic ranging system, ultrasonic transmitter is a single chip from the P1.0 sending a pulse, after driving circuit MA40S4S ultrasonic sensor-driven launch ultrasonic. At the same time, the counter starts counting, ultrasound reflected in the face of obstacles and is received by the MA40S4R ultrasonic sensors, and then a pulse signal received CX20106A chip by SONY is passing through amplification, limiting, band-pass filtering, detection, integration, such as plastic a series of transformations, the ideal output pulse, and then access the SCM INTO side as the external disruption, which has been the dissemination of time to calculate the distance, and then judge, reminding drivers to carry out the corresponding operation.

In the distance measurement system, to set the ultrasonic speed of sound and then calculate the value of distance, and then let the value compare with the set threshold, if detected distance is greater than 2m, after a certain period of time, re-launch and detect; if the distance is less than 2m, the system will give the driver some tips, according to the tips, drivers can prevent effectively the occurrence of collision incident.

### Experimental results

The instrumentation is tested for Chery QQ3 0.8 MT as an example. In all kinds of special circumstances, test result shows that it can also work with the same truck and table consistent with the basic instructions, and also it is the more intuitive and stable, and it meets the design expectations and demands. The test results are shown in Table 2.

### Conclusion

Experiment shows that the instrument achieves 3 bits digital display of vehicle speed and oil capacity, and 5 bits digital display of mileage, and it overcomes the shortcomings of the traditional instrument, which is function mono, low-precision, slow response, so that the new multi-function instrument has good stability, visual display, high safety factor. So, the instrumentation is simple, small size, low system cost, ease to lower vehicle production costs; it's digital display accords the visual habits of people and is convenient for drivers to operate more accurately according to the information shown by instrument, and its warning devices achieving real-time alarm, remind motorists of driving reasonably to avoid accidents from occurring. The instrument effectively improves vehicle safety and comfort, ease of operation, So that the system will be widely applied.

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