Design of automotive detector based on real-time waveform display of single-chip microcomputer LCD

Jiahuan Zhao, Miaozhong Sun, Yuanli Xu

(School of Mechanical Engineering, Tianjin University of Science and Technology, Tianjin, 300222)

Abstract: Automobile testing provides an important basis for automobile performance parameter evaluation and fault diagnosis, and portable automobile detector is the main topic of current research and development. Based on the 2.4-inch TFT LCD display connected to the ILI9325 drive interface of MC9S12XET256, this paper uses C language to program the eight-channel real-time data waveform display car detector on the CodeWarrior platform. The problem that poor continuity exists in displaying real-time wave is able to be solved by a curve interpolation method. Relevant display functions for LCD dynamic waves are performed by programming. The software interface for the automobile tester is designed. Finally, the reliability of the tester is certified by the compared results by using the tester and INV 3062 type data acquisition instrument to test relevant sensors of the Passat automobile electrical training platform at the same time.

Keywords: Freescale MCU;Data acquisition;ILI9325 drive interface; LCD display;Car detector

I. Introduction

Automotive fault diagnosis and performance parameter evaluation are based on vehicle testing data. Handheld car detectors are gradually popularized due to their portability and versatility, and the prospects are promising . The handheld detector is realized by connecting the single-chip microcomputer main control chip to the liquid crystal display (LCD). LCD displays have the advantages of small size, convenient interface control and programmable drive, and are widely used in intelligent meters, display terminals .

How to realize multi-channel dynamic real-time waveform display of LCD has become a key technical problem to be solved. In recent years, the study of the waveform curve of the measured data measured by LCD display has been reported. For example, Qin Gang et al. established the coordinate conversion relationship between measurement parameters and display module pixels on the basis of discussing the principle of image conversion pixel matrix, and used the method of scrolling screen refresh to realize the dynamic display of real-time curves. Yu Hongying et al. first wrote the drawing point function to draw the point plot, then used the least squares method to fit the straight line, and finally drew it into a dynamic curve. Aiming at the problems of poor continuity and large data dispersion when drawing real-time curves, the author uses the method of curve interpolation when tracing and drawing, and sets it into 8-channel data sampling and real-time voltage curve display, which can better monitor the condition of automotive equipment.

2. Circuit diagram design of automotive detector

2.1 Circuit diagram design

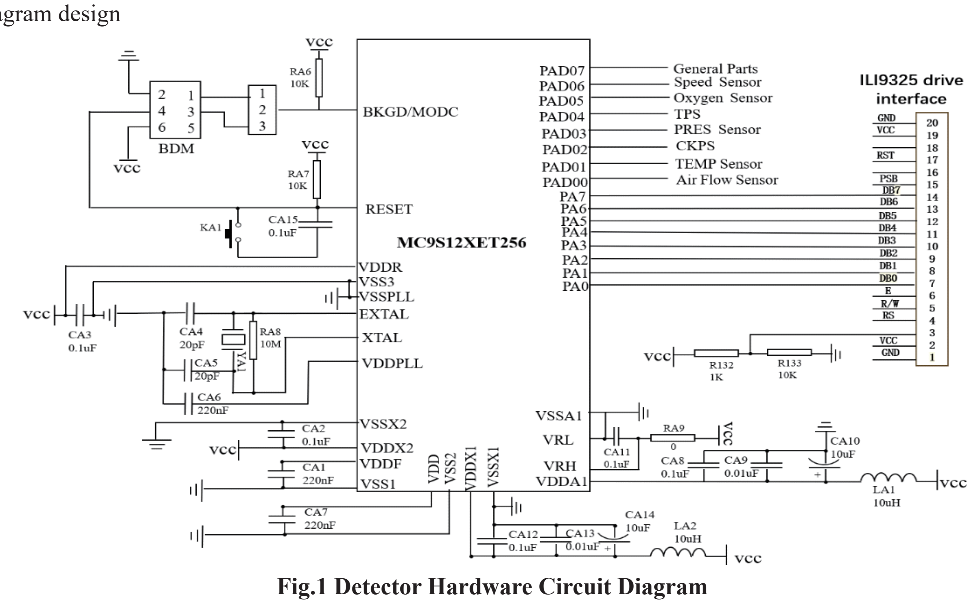


Fig.1 Detector Hardware Circuit Diagram

The detector is based on Freescale MC9S12XET256 microcontroller as the main control chip, which is mainly composed of three parts: the smallest system of the single-chip microcomputer, the A/D data acquisition module and the liquid crystal display module. The design detector can simultaneously test seven sensor signal channels (air flow sensor, temperature sensor, etc.) and one general parts channel.Fig.1 shows the hardware circuit diagram of the automobile detector. The detector is based on the minimum system of the single-chip microcomputer, and the minimum system is composed of MC9S12XET256 chip, reset circuit, crystal oscillator circuit, BDM circuit, PLL circuit and power supply . The eight-bit data line DB0~DB7 of the design ILI9325 drive interface is connected to PA0~PA7 of the MC9S12XET256 I/O interface to control the data input and output of the LCD, and the LCD uses an eight-bit parallel port for communication. The seven automotive sensors tested and an ordinary electrical appliance (marked on the figure) analog signal are connected to PAD00~PAD07 of the A/D port of the single-chip microcomputer. Through A/D conversion, the analog signal is converted into a digital signal and sent to the ILI9325 drive interface through the PA0~PA7 data port, and the single-chip microcomputer communicates with the interface to control the liquid crystal display.

2.2 ILI9325 LCD module

The LCD display uses a TFT-LCD color screen controlled by the ILI9325 chip, which supports 240*320 pixels and can display 262144 true colors. This article adopts the 8-bit interface mode of the i80 system. The ILI9325 driver interface controls the display of letters, numbers, graphics and other symbols, and contains 172,800 bytes of image memory (GRAM) . The LCD display connected ILI9325 driver interface and MC9S12XET256 MCU on the J_LCD1 LCD module interface is connected, each pin connection relationship is shown in Figure 2, the DB0-DB7 of the LCD module is

connected to the DB0-DB7 interface of the MCU, and the control ports RS, RW, RST, etc. are connected to the corresponding ports on the MCU J_LCD1 module.

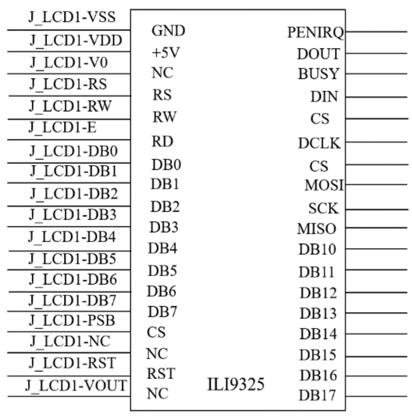


Fig.2 Connection Diagram Between the ILI9325 Driver Interface and the Microcontroller J_LCD1 Module

3. Software design of automobile detector

3.1 Software Design Process

The software design of the detector mainly includes three parts: data acquisition subprogram, liquid crystal display subprogram and main program. The program flow chart of the car detector is shown in Fig.3. First, call the function to initialize the PLL module, ECT module, and A/D module of the single-chip microcomputer. Initiates A/D conversion to acquire and process channel signals. Start the LCD subroutine to call the display function to display the digital voltage and real-time data curve on the LCD screen. Call the interrupt scan function and set the output scan time to 2ms.

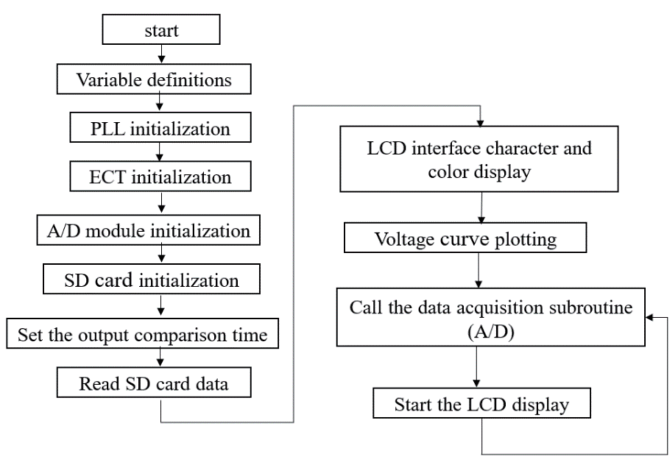


Fig.3 Program flow chart of the detector

3.2 A/D data acquisition module

The role of the A/D module is to convert the voltage analog signal into a digital signal that the CPU can handle. ATDCTL0~ATDCTL5 of the A/D module is the control register, which can be flexibly set according to the required requirements. The main program code is as follows:

ATD0CTL2=0x40; Start A/D conversion, quickly clear zero, and disable interruptions ATD0CTL1_SRES=0;//8-bit analog-to-digital conversion is selected ATD0CTL3=0xC0;//8 channels per conversion, data right-aligned ATD0CTL4=0xFF;//Module clock frequency is

0.5MHz, sampling time ATD clock cycle factor 24

ATD0CTL5=0x10;//AD00 starts the conversion in a single conversion

3.3 Programming of squiggle display

How to realize the display of real-time squiggles on LCD displays is the core problem solved in programming. The acquired data is drawn by the dot tracing method, which converts the acquired data into LCD screen pixel (x, y) coordinates (maximum value x is 240, maximum value y is 320). When the position of the sampled value on the LCD panel is determined, the corresponding coordinate lights up. Due to the close size of adjacent data and the fast scanning speed, the waveform forming a curve showing the voltage trend appears almost continuous . In view of the discontinuities of the data waveform, this paper adopts the curve imputation method. Suppose the current coordinate point is (x2, y2) and the previous coordinate point is (x1, y1), let △ x=x2-x1, △ y=y2-y1. There are three situations to deal with:

1) When △ x>1, △ y>1 or △ y<-1, that is, the horizontal axis is not continuous and the vertical axis is not continuous, a straight line is drawn between the two points.

2) When △ x>1, | △ y|=1, that is, the horizontal axis is not continuous and the vertical axis is continuous, the straight line between (x1, y1) and (x2, y1) is drawn first, and then the points (x2, y2) are drawn.

3) When △ x=1, △ y>1 or △ y<-1, that is, the horizontal axis is continuous and the vertical axis is not continuous, the point is drawn first (x1, y1), and then draw a straight line between this point and the current coordinate. Finally, the line drawing output is performed.

3.4 ILI9325 LCD Driver Program

In order to complete the control of the LCD screen, it is necessary to configure the ILI9325 register, mainly including register initialization, setting the display direction, display area, writing GRAM, etc. . The LCD driver flow is shown in Figure 4.

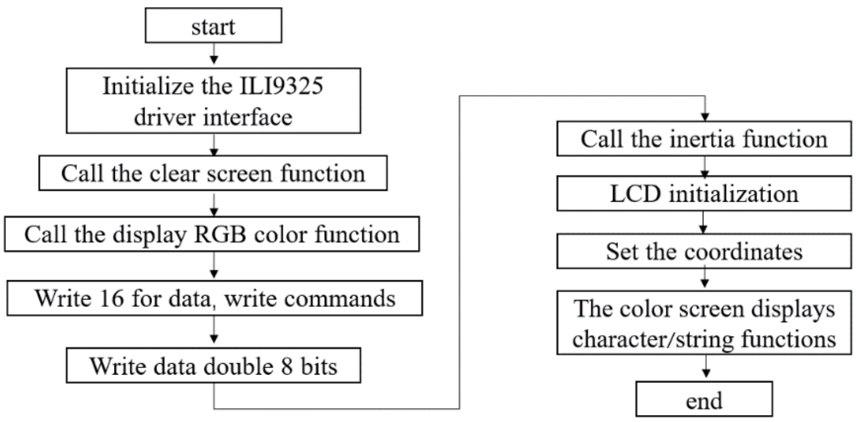


Fig. 4 Flow chart of the ILI9325 LCD driver

The display area is mainly determined by the 0x0050 (HSA), 0x0051 (HEA), 0x0052 (VSA), 0x0053 (VEA) registers, the address is automatically incremented by 1 for each write bit, and the boundary is automatically cycled. By setting the 0x0020 and 0x0021 to achieve memory coordinate movement, write instructions 0x0022 realize the pointer to the GRAM entry. The address of the GRAM will be automatically incremented by 1 according to the setting of AM, ID [1: 0], and the demarcation will be automatically cycled.

3.4 Software interface design

The design interface is shown in Fig.5. Regarding the interface design, a picture is placed on lines 0-34 above the LCD screen, and the name of the car detector and the school are marked on the picture. Due to the small internal storage space of the MCU, the displayed pictures are stored in an external SD card. To save the picture into the SD card and can be read by the MCU, first format the SD card, then use the Image2LCD software to import the picture, and set the output data type to binary (*. bin) format, and then copy bin format file to the SD card. Finally, open the WinHex software, you can see the sector address of the picture in WinHex, write down its physical address 2752 and put the 2752 data to the code unsigned long AddTemp=2752.

The lower area displays real-time voltage data and curves of 8-channel automotive sensors, such as pressure sensors, oxygen sensors, etc.

```
LCD_PutString(1,3 5, “Air Flow Sensor”, White, Red);
LCD_PutString(135, 35,”TEMP Sensor”, White, Red);
LCD_PutString(50, 105,”CKPS”,Yellow2, Magenta);
LCD_PutString(2, 245,”Speed Sensor”, Yellow, Blue);
LCD_PutString(50, 175,”TPS”, Red, Yellow2);
LCD_PutString(130, 105,”PRES Sensor”,Yellow2, Magenta);
LCD_PutString(130, 175,”Oxygen Sensor”, Red, Yellow2);
LCD_PutString(130, 245,”General Parts”, Yellow, Blue);
```

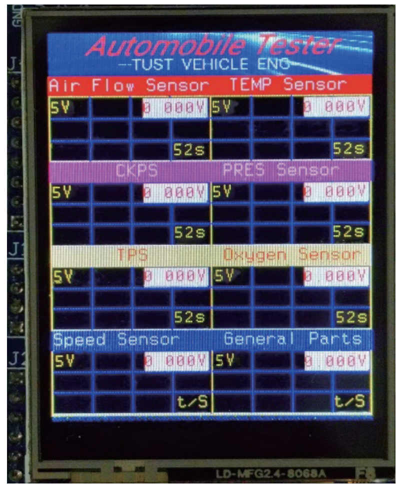


Fig.5. Interface design

4. Test validation

In order to further verify the accuracy and practicality of the car detector, the relevant automotive sensor test of the car was carried out on the Passat automobile electrical training platform. The AD0, AD1, AD4, AD7 interfaces of the designed detector data acquisition module and the 01, 02, 03, and 04 signal lines of the INV3062 collector are respectively connected to the air flow signal voltage line, intake air temperature signal voltage line, throttle positioning potentiometer voltage signal line and throttle potentiometer (General parts) voltage signal line of the automobile. The Passat automobile electrical training platform used in this experiment supports the function of sensor signal acquisition and data display. The field connection test is shown in Fig.6.

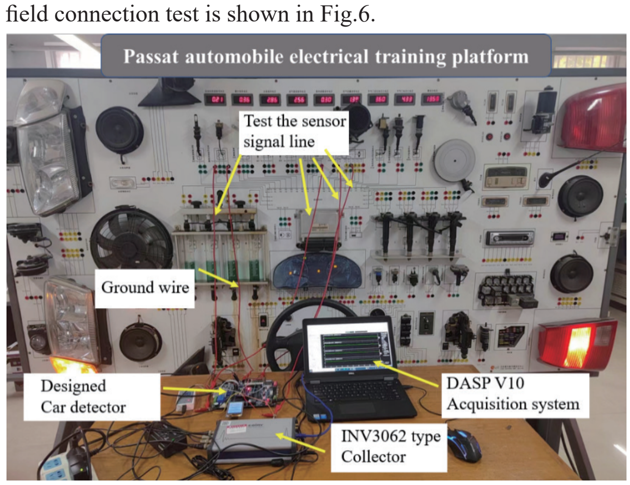


Fig.6. Connection diagram of the automobile detector, INV3062 collector and the Passat training platform

Start the Passat automobile electrical training platform, idle operation, the voltage data value (V) of the sensor displayed on the Passat training platform is shown in Fig.8; The sensor voltage value measured by the car detector and the corresponding real-time waveform curve are shown in Fig.8; The INV3062 collector is connected to a notebook computer, and the data and waveform curves collected by the DASP V10 acquisition system are shown in Fig.9.

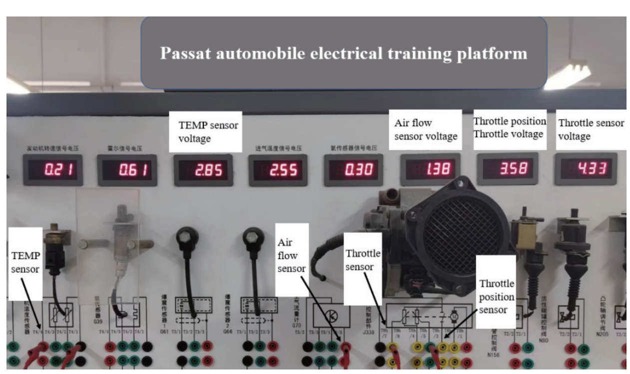
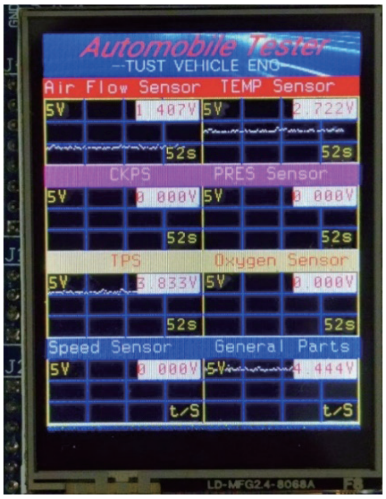


Fig.7. Passat automobile electrical training platform test diagram



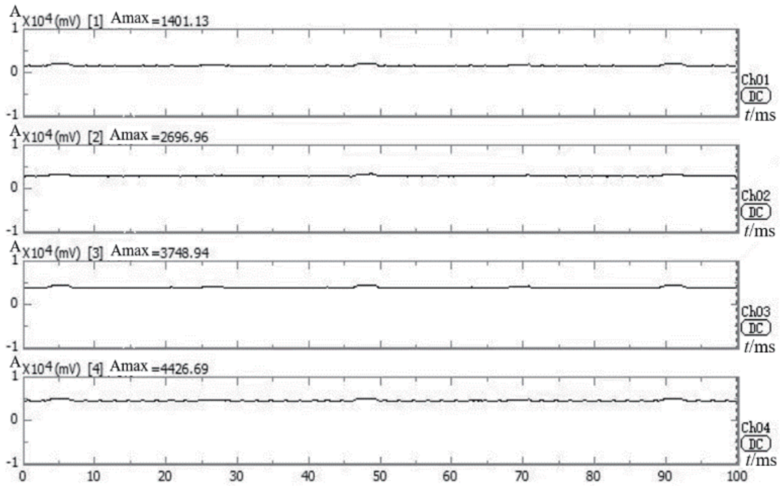


Fig. 8. Voltage data and real-time waveform measured by automobile detector

Fig.9 Voltage data and waveform collected by INV3062 collector

After analysis, the four voltage waveforms displayed by` the automobile detector in Fig.9 and the four voltage waveform curves collected and displayed by the INV3062 collector in Fig.10 are in good agreement, and the waveform change law is also the same. The corresponding four voltage data are also shown in Fig.9 and Fig.10. The measured data and comparative errors between the automobile detector and the Passat vehicle electrical training bench and INV3062 collector are shown in Table 1.

Table 1Measured data and comparative error between the detector and the Passat training platform and INV3602 collector

Parameter	Air flow Sensor (V).	temperature Sensor (V).	Throttle position Set sensor (V).	Throttle potentiometer (V)
The car detector	1.407	2.722	3.833	4.444
The Passat automobile electrical training platform	1.38	2.85	3.58	4.33
INV3062 collector	1.401	2.697	3.748	4.427
Detector and training platform relative error	1.96%	4.49%	7.07%	2.63%
The relative error of the detector and the INV3062 collector	0.43%	0.93%	2.27%	0.38%

From the analysis of the results in Table 1, it can be seen that the data measured by the detector is compared with the data measured by the Passat training platform, with a maximum error of 7.07% and a minimum error of 1.96%; Compared with the measurement data of INV3062 collector, the maximum error is 2.27%, and the minimum error is 0.38%. The analysis results show that the real-time voltage curve of the automobile detector is good and the data measurement accuracy is good, which confirms its reliability. The detector can measure the performance parameters of automotive sensors and other automotive common electrical appliances.

5. Conclusion

For the current portable car detector display channels are few, the real-time waveform display effect is not ideal. This paper designs a 2.4-inch TFT LCD display based on MC9S12XET256 microcontroller connected to ILI9325 driver interface chip. The detector can realize the function of synchronous display of seven channel sensors, one ordinary electrical voltage data and corresponding real-time waveform curve. In terms of programming, the key programming techniques of ILI9325 driver and real-time waveform display function on liquid crystal display are solved, and the detector system interface is designed. Through the INV3062 collector and the detector, the four channels of the Passat training platform were tested at the same time, and the data error and real-time dynamic waveform display were compared, and the consistency was good, which verified the reliability of the automobile detector.

References

[1]. M. Z. SUN, Y. LEI, "Design and Implementation of an Automobile Engine Tester Based on Type MC9S12XET256 MCU", UPB Scientific Bulletin, Series D, vol. 80, no. 2, 2018. pp. 79-90.

[2]. X. XIAO, D. Z. YIN, W. J. WANG, C. H. WU. Design and implementation of LCD driver based on FPGA. Ordnance Automation, vol. 41, no.2, 2022, pp. 57-59+64.

[3]. G. QIN, C. D. DUAN, L. LI, J. DAI. Graphics and curve display method of color liquid crystal module. Application of Electronic Technology, vol. 38, no. 3, 2012, pp. 54-56+59.

[4]. H. L. LIU. Design of signal acquisition and analog output system for automobile engine sensor. Harbin University of Science and Technology, 2020.

[5]. C. ZHANG, B. YU, Z. H. LIANG. Circuit design of automotive body control module system based on MC9S12XET256MAL. Electronic Test, vol. 10, no. 6, 2015, pp. 11-12+6.

[6]. Q. HUANG. Design of UDS diagnostic instrument for electric vehicle based on MC9S12XET256. World of Electronic Products, vol. 22, no. 6, 2015, pp. 50-53.
[7]. K. WU. Multi-channel AD synchronous acquisition and implementation technology based on JESD204B technology. Electronic Quality, vol. 4, no. 4, 2018, pp. 34-36.
[8]. X. J. LI. Design and implementation of automotive fault diagnostic instrument for embedded system. Microcomputer Application, vol. 35, no. 1, 2019, pp. 132-134.
[9]. Y. R. HU, F. F. Guo, Y. K. Yang. Design of touch display screen based on handwriting teaching system. Software, vol. 35, no. 4, 2014, pp. 116-117+120.
[10]. J. M. WANG, S. M. YIN, H. B. CHEN. Design of real-time data acquisition and display system of Fourier transform imaging spectrometer based on FPGA. Electronic Devices, vol. 40, no. 1, 2017, pp. 103-107.
[11]. Y. T. HE, J. P. HUANG, Z. Y. Guo, H. G. LIU. Environmental parameter measurement system and its liquid crystal display design. Journal of Nankai University (Natural Science Edition), vol. 47, no.2, 2014, pp. 30-33+85.
[12]. L. J. SUN, F. T. He. Research on TFT-LCD LCD image control system based on ARM. Journal of Huang gang Normal University, vol. 32, no. 3, 2012, pp. 41-45.
[13]. H. Y. WANG, M. T. Yuan. Software and hardware design of real-time curve display of liquid crystal display. Industrial Control Computer, vol. 28, no. 1, 2015, pp. 79-80.
[14]. Y. X. SONG. TFT-LCD true color LCD screen display control of FPGA. MCU and Embedded System Application, vol. 17, no. 4, 2017, pp. 41-42+50.