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Design and Implementation of a Testing System of Automotive Air Conditioning Based on Delphi

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Abstract

Traditional testing technologies of automotive air conditioning can not meet the need of current high speed development of automotive industry for poor testing efficiency, low accuracy and high cost. In this paper a testing system of automotive air conditioning is designed and realized by using Delphi language and virtual instrument technology. Twelve channel signals of air conditioning performance parameters can be acquired and analyzed simultaneously. The programming frame and the designing interface process are introduced. The positions where sensors are used in the automotive air conditioning are designed. This system is tested by using sine waves produced by two signal generators and some sensors of PASSAT auto electric control test rig. The results verify that this system is reliable and easy to operate.

Keywords: *Virtual instrument, delphi, data sampling, automotive air conditioning, testing system*

1. Introduction

Automotive air conditioning effects comfort of driving, and becomes an indispensable part in the development of automotive industry. Automotive faults often come from it due to its frequent start and run, and its complex conditions. Therefore it is necessary to test all kinds of its performance parameters such as air conditioning compressor power, evaporator air flow rate, cryogen pressure and temperature, *etc.* Different errors are easy to produce using manual methods to read the meters in testing automotive air conditioning, furthermore time and effort is often consumed. Traditional test technology of automotive air conditioning can not meet the need of current high development of auto industry in aspects of test efficiency, precision and cost [1]. There are a lot of automotive air conditioning manufacturers and relational research institutions that are using special automotive air conditioning test devices in recent years. But the most devices are imported, and they are expansive. So it is imperative to develop fast, low price and intellectualized testing instruments to collect and show the data of automotive air conditioning working case [2].

Virtual Instrument (VI) was proposed by American National Instrument (NI) in 1986.NI presented the VI based on bus system such as PC bus. All kinds of testing cards can be plug in PC slots. VI which has traditional testing functions is implemented by programming software in order to reduce much instrument hardware, decrease the cost and shorten the development cycle. Therefore VI will be essential to used to develop a testing system of automotive air conditioning, carrying out fast, entire and perfect estimation [3].

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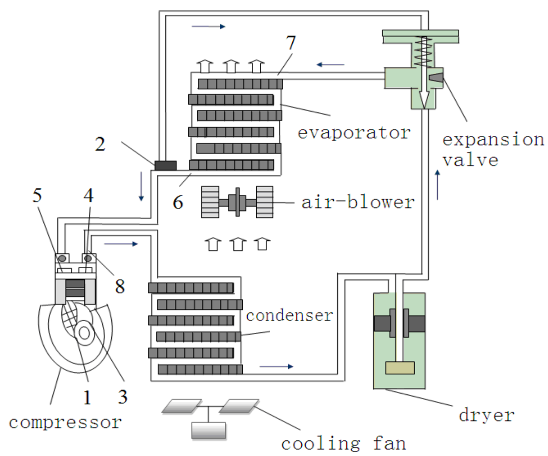
At present the programming languages for VI software development have two type languages: the text language (such as VC++, Visual Basic, Delphi, *etc.*) and the graphics language (such as LabVIEW, HPVEE, *etc.*). LabVIEW is now widely accepted by scientists and engineers, but it must use special data acquisition cards and can bring more cost in preliminary stage [4].

Delphi language is called the fourth programming language, and it is simple, efficient and powerful. Compared with VB and VC++, it is easier to grasp, and stronger to carry out the programming interface. Delphi has such functions: oriented-object style based on windows, fast compiler, powerful database, mature component technology and so on [5]. This paper combines Virtual Instrument technology with Delphi language to design a testing system of automotive Air conditioning.

2. Structure of Automotive Air Conditioning and Relational Sensor Positions

Automotive air conditioning is a refrigeration device to improve the car air quality in the hot days, and offers a comfortable environment for passengers to reduce the driver fatigue. It consists of the following parts: compressor, condenser, dryer, expansion valve, evaporator, air-blower, refrigeration pipes, *etc.* Figure 1 shows its structure.



1-compressor rotation rate sensor 2-evporator temperature sensor 3-compressor torque sensor 4-cryogen high pressure sensor 5-cryogen low pressure sensor 6-evaporator intake air flow rate sensor 7-evaporator outtake air flow rate sensor 8-cryogen temperature sensor

Figure 1. Structure of automotive air conditioning and positions of installed sensors

The principle of air conditioning is that: In the process of refrigeration, the engine drives the compressor, and the compressor absorbs the gas cryogen inside the evaporator to compress vapor in high temperature and high pressure, then sends them to the condenser. At the meantime the temperature of the refrigeration vapor is higher than the temperature outside the car. The cryogen will spread out the heat of the condenser .The gas cryogen becomes liquid to flow into the dryer. It is dried and filtered. The liquid cryogen volumes will increase rapidly to become liquid-fog mixtures which come into the evaporator in the low temperature and low pressure state. The liquid-fog cryogen absorbs the air hot in the evaporator to make the air temperature decease when the car circulating air is flowing through the evaporator. Finally the cooled air is sent into the car through the air-blower. The next circulating begins while the vaporized refrigerant vapor is absorbed again into the compressor [6, 7].

The working state of automotive air conditioning depends on the correct outputs of its performance parameters, and these performance parameters can be measured by corresponding sensors to estimate the automotive air conditioning. Twelve performance parameters are selected for testing: engine rotation rate, compressor rotation rate, compressor torque, cryogen high pressure, cryogen low pressure, cryogen temperature, indoor temperature, evaporator temperature, evaporator air intake temperature, evaporator air outtake temperature, evaporator intake air flow rate and evaporator outtake air flow rate. Figure 1 shows where their relational sensors are installed in the testing system of the automotive air conditioning.

3. Design and Programming Realization of Testing System

The testing system of automotive air conditioning consists of two parts: hardware and software based on PC-DAQ (PC+data acquisition card) architecture.PCI2006 type data acquisition card is selected with 14 bit A/D,12bit D/A,400kHz sampling frequency ,16 twin pole/32 single pole analog input channels and two analog output channels etc.. Analog signal voltage scope is -5V-+5V.I/O drive program has been offered for Windows XP. With the help of this drive program, Delphi language is used to carry out data sampling in three modes: non-empty inquiry mode, half-fullness mode and interrupt mode. This programming selects the non-empty inquiry mode [8].

3.1. Programming design

Figure 2 shows the programming framework of the testing system of automotive air conditioning.

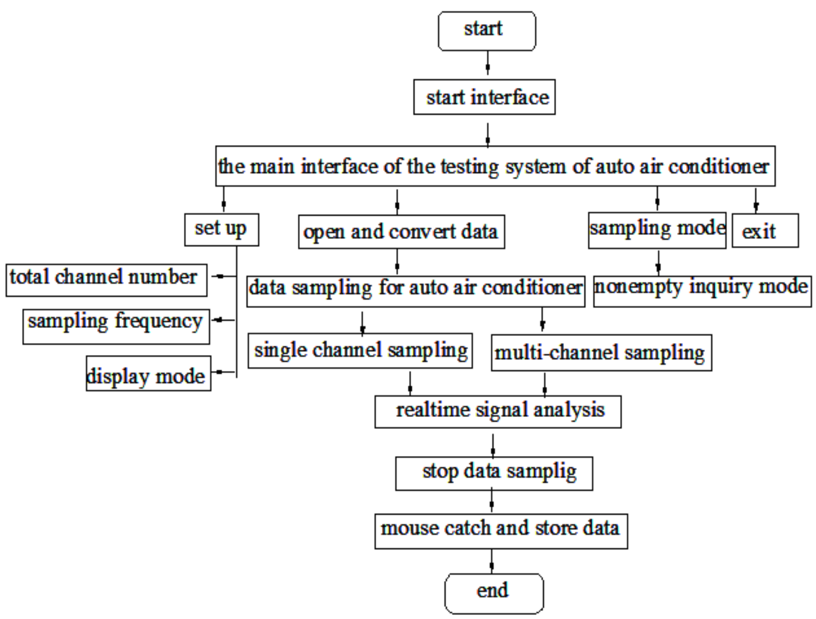


Figure 2. Programming framework of the testing system of automotive air conditioning

3.2. Programming design of the system interface

After the start interface has been run with the title “WELECOME TO THE TESTING STSTEM OF AUTOMOTIVE AIR CONDITIONING”, the main system interface then presents like Figure 3. It consists of three parts.

(1)In left part, twelve channels parameters as above explained are presented in data mode. When programming, in the left top of the main interface a GroupBox component is set up in which arranges twelve RadioButton components about performance parameters, three Label components about converting parameters, fifteen Edit components about data display, one Label component about mouse catch and one Edit component about corresponding voltage display.

(2)Middle window part displays each real-time waveform of performance parameters. Mouse can be used to pick up points in the waveform, showing corresponding voltages in left corner to get parameter voltages easily. A WaveImage component is set up with 593×601 pixels size to display twelve sampled waveforms whose heights can be adjusted automatically. Under the window, A DataCollectStatus component is arranged to present sampling condition (running or not running).

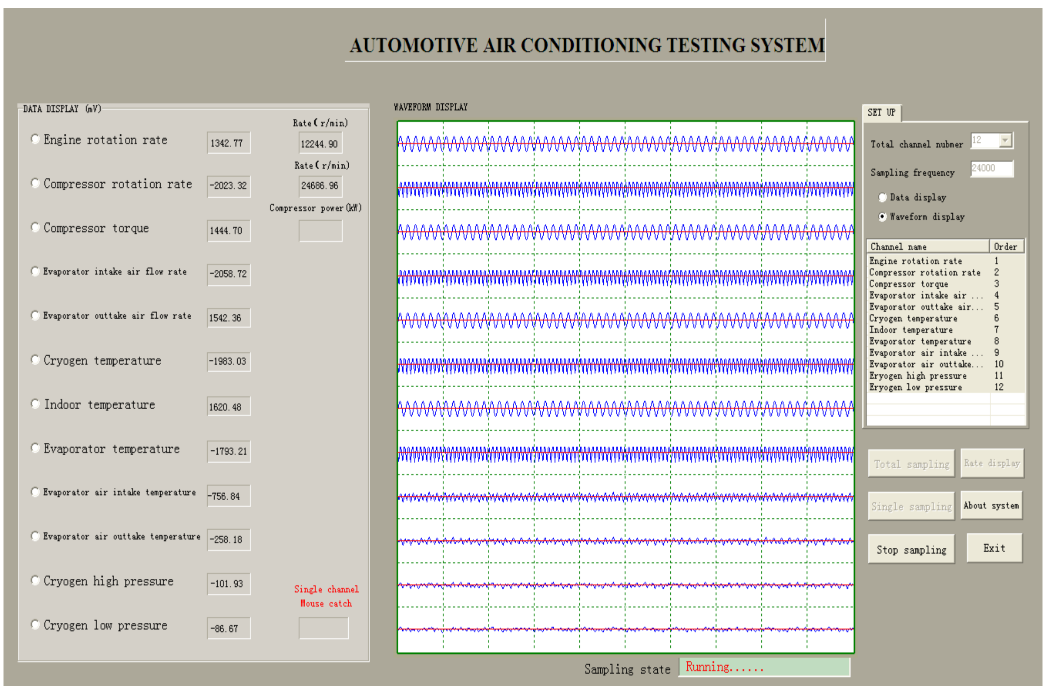


Figure 3. Interface of testing system and results of total channel sampling

(3)In right part, a PageControl component with 193×368 pixels size is set up for displaying relational sampling parameters such as channel number, sampling frequency, display mode. Then a TlistView component with 193×329 pixels size is used to show channel contents below. Under the PageControl, there are six Button components: Total channel sampling, Single channel sampling, Stop sampling, Rotation rate display, About system and Exit.

In testing process, we need input channel total number, sampling frequency, display mode (data or waveform).Then we click the total channel sampling Button to display twelve maximum channel waveforms simultaneously. If we want to test one parameter, we need chose the left corresponding RadioButton and click single channel sampling Button. We can use mouse to pick up the instantaneous voltages on the waveform. This is very important to observe performance parameter changes.

4. Test Confirmation

In order to validate the designed testing system, Figure 4 shows the test framework which uses two plans to carry out. One is to use signal generator to produce standard sine waveforms. The other one is to uses relational actual sensor signals to be sampled [9, 10].

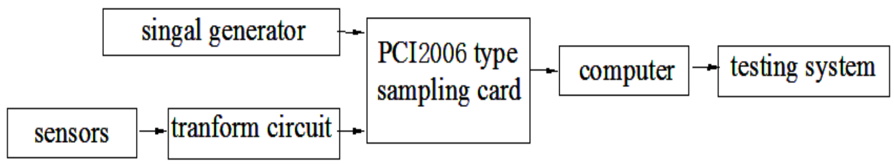


Figure 4. Framework for testing system to be validated

4.1. Signal generators for testing

Engine rotation rate signal is a periodic pulse signal like a sine .Therefore a standard sine can be used to simulate the rotation rate signal to calculate the rate size. Two DXI type signal generators are used to output 200Hz （corresponding rotation rate 12000r/min） and 400Hz (corresponding rotation rate 24000r/min) standard sine waveforms respectively. Eight channels are selected to connect with the two signal generators, 1,3,5,7 channels to the 200Hz sine generator, and 2,4,6,8 channels to the 400Hz sine generator. Figure 3 shows a testing interface of total channel sampling and displays clearly eight channel real-time waveforms in the middle window and corresponding dynamic data in the left. Channel one is engine rotation rate displaying 12244r/min (204.07Hz).Comparing with 200Hz sine, the relative error is 2.03%. Channel two is compressor rotation rate displaying 26086.96r/min (434.78Hz).Comparing with 400Hz sine, the relative error is 8.69%. There exists a bit error owing to incorrect signal input. The other last four channels display about zero voltage.

4.2. PASSAT auto electric control test rig

In order to further validate the testing system of automotive air conditioning, some channels of the system will connect with some sensors of PASSAT auto electric control test rig to set up a test platform.1,4,6,7 channels corresponding to engine rotation rate, evaporator intake air flow rate, cryogen temperature, indoor temperature respectively connect with the four sensors of test rig, that is engine rotation rate, air flow rate, cooling water temperature and air intake temperature, seen in the figure 5.The other channels link to ground. The test is carried out in auto idling condition.

Figure 5 shows the voltages (V) of engine rotation rate, cooling water temperature, air intake temperature and air flow rate in the idling condition of PASSAT auto electric control test rig. This testing system is used to sample the above signals three times.

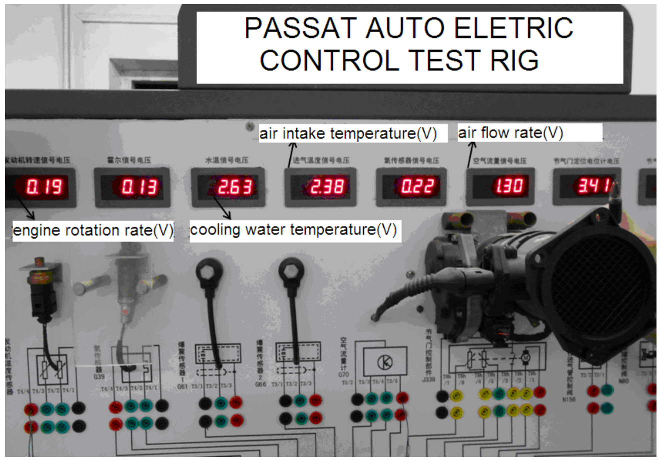


Figure 5. Relational parameters voltages in the idling case of test rig

Figure 6 reveals the total channel testing interface among certain time.

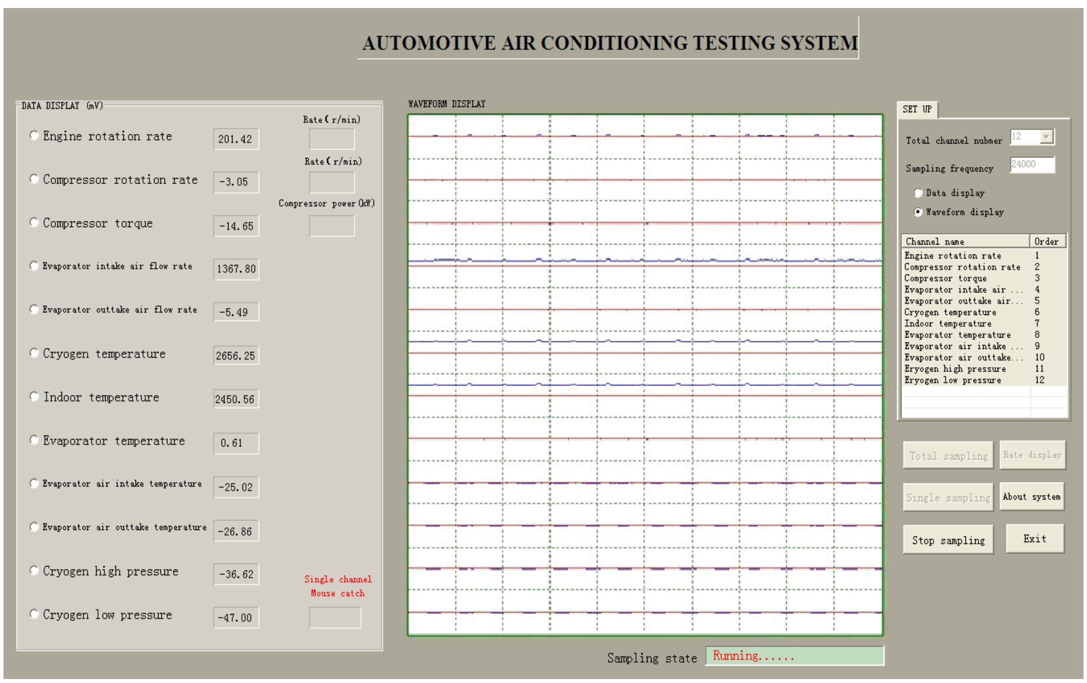


Figure 6. Interface of total channel data sampling

In the right part, the total channel number is set up 12, the sampling frequency is 24000Hz, that is the single channel sampling frequency is 2000Hz.In the left part, the data of 1,4,6,7 channels appears, the others display about zero. In the middle window, the 12 sampled real-time waveforms (blue waveforms) are presented, 1,4,6,7 waveforms are clear to see, the others are near zero. The above test is according with the changing condition of the sensors.

Table 1 shows comparison of test results between PASSAT auto test rig and the testing system. From the table, the comparison results reveals that testing error is very small in allowable range, to validate the testing system of automotive air conditioning is reliable and the programming is successful.

Table 1. Comparison of test results between PASSAT auto test rig and the testing system

Auto test rig (V)	Testing system (three times，mV)	Relative error（%）
Engine rotation rate：0.19	Engine rotation rate：201.42，194.70，194.70	6.01，2.47，2.47
air flow rate：1.30	Evaporator intake air flow rate：1367.80，1354.37，1341.55	5.22，4.18，3.20
Cooling water temperature：2.63	Cryogen temperature：2656.25，2701.42，2663.57	1.00，2.72，1.28
Air intake temperature：2.38	indoor temperature：2450.56，2485.96，2467.65	2.96，4.45，3.68

5. Conclusions

With the help of the Virtual Instrument and Delphi language, the designed testing system of automotive air conditioning is able to sample and display continuously the performance parameters of automotive air conditioning in order to indicate the working condition. According to the standard voltages, the sampled data can be used to diagnose the faults of automotive air conditioning. This testing system can be used in process of development, manufacture and maintain of automotive air conditioning, and can be also used in teaching experiment of auto service engineering specialty. The testing system is designed according with the demands of china current automotive air conditioning industry to improve test technology of china automotive air conditioning, and change the state of importing test devices.

References

[1] K. -H. Seok, J. Ko, C. -W. Park and Y. S. Kim, "A study on frequency monitoring system for Korean wide-Area power protection based on Virtual FDR", International Journal of Control and Automation, vol. 5, no. 1, **(2012)**, pp. 119-136.
[2] X. Bao, "Study on fault diagnosis of automotive air conditioning system", Journal of Beijing Industry Vocation Technique College, vol. 8, no. 2, **(2009)**, pp. 37-39.
[3] D. Liu, C. Yin and A. Lu, "Platform development of electronic measuring instrument based on virtual instrument technology", Instrument Technology and Sensors, no. 9, **(2011)**, pp. 23-25.
[4] J. Liu, "Design of Virtual Instrument based on LABVIEW", China Electronic Industry Press, Peking, **(2003)**.
[5] R. Liu, "Course of Delphi language programming", China Mechanical Industry Press, Peking, **(2009)**.
[6] Y. Ma, "Technology of automotive air conditioning", China Mechanical Industry press, Peking, **(2008)**.
[7] R. Wang, "Automotive air conditioning", China Mechanical Industry Press, Peking, **(2007)**.
[8] M. Sun, J. Cheng and B. Tan, "Design and realization of auto testing instrument based on Virtual Instrument", Foreign Electronic Measurement Technology, vol. 28, no. 9, **(2009)**, pp. 57-60.
[9] J. Fu and Z. Li, "Develpment of auto testing experiment rig based on Virtual Instrument technology", Mechanical Design and Manufacture, no. 8, **(2009)**, pp. 154-156.

[10] C. Lee, D. Jung and K. -W. Lee, "Design and Implementation of Small Scale Electric Power Management System", International Journal of Control and Automation, vol. 6, no. 3, **(2013)**, pp. 375-382.

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