

Study on the Auto Air Conditioning Controller Testing System Based on Lab Windows/CVI

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Abstract

In the testing process of auto air conditioning controller, there are many testing channels, large numerous of data, and complex testing flow, and the research demand of the air condition controller testing system based on the virtual instrument (VI) is proposed in this article. The design methods including the hardware design, the software design, and the human-computer interface design about the air conditioning controller testing system based on the virtual instrument are introduced, and the testing result of the system is provided in this article. By the testing system based on the virtual instrument, many functions such as the parameter testing, the data storage, the real-time data processing, the curve display, and the control logics analysis of the auto air conditioning controller could be realized. This system has many advantages such as intuitive display, quick reaction, high cost performance, and complete data storage, with stronger engineering application values. This system has been used in the production line of certain auto air conditioning controller, with good effect.

Keywords: Auto air conditioning, Controller, Testing system, Lab Windows/CVI, Visual instrument

1. Introduction

Auto air conditioning is a branch in the air conditioning area, and it controls the air temperature, humidity, clearness degree, and wind speed in the auto, and make the airs to flow and distribute in the auto by certain speed, and provide comfortable environment for driver and passengers, i.e. the auto air conditioning equipment should have multiple functions such as refrigeration, heating, airiness, air cleansing, humidification, and dehumidifying.

From the first generation manual mechanical auto air conditioning controller, to the second generation electric auto air conditioning controller, and to the automatic auto air conditioning controller and the multi-temperature region automatic auto air conditioning controller, the auto air conditioning controller has been developed through three stages, and the operation mode of the auto air conditioning controller has been changed largely, from the key-press style, to the knob style, and to the non-panel style. So the requirements about the testing system of the auto air conditioning controller are continually being enhanced.

VI is the system which utilizes the new computer technology to realize and extend the function of traditional instrument, and really realize the self-design and self-definition to satisfy users' special requirements. With VI, engineers and scientists could build the testing system and the automatic control system according to their own demands and the actual circumstances, without various limitations of traditional instruments with fixed functions (provided by manufacturers).

The core of VI is software, and it can realize various testing instruments with completely different functions by running different programs to fulfill various different demands. The software could be designed as various instruments, i.e. "software is instrument". Because the computer could link with the network and the peripheral equipments and other applications quickly, so it is very convenient for various applications such as data acquisition, system control, and remote transmission. By using basically similar even same hardware system, completely different instrument systems could be established in the computer, and realized by the software finally. To update the VI by traditional instruments could not only realize many advantages such as low price and high efficiency, but save charges of development and servicing. The VI system taking the software as the center could not only provide the condition of technical innovation for users, but could largely reduce the production cost.

2. Requirements of system design

The air conditioning system tested in this system belongs to the automatic air conditioning system, with many functions such as aeration, refrigeration, and heating. In the summer, the refrigeration system works, and in the winter, the heating system works, and in the spring and autumn, the mixed system of refrigeration and heating is to dehumidify the winds, and the proportion of the cold wind and the warm wind is adjusted by the mixed air

doors. The refrigeration system is composed by the compressor, the expansion valve, the evaporator, the condenser, the vent-pipes, and the oil return pipe of the safety valve. The heating system is composed by the warm wind radiator, the warm water valve, and the blower, and it uses the surplus heat generated by the engine in the running for heating.

The control of the air distribution of the air conditioning assembly is completed by four motors to control the action of four air doors including the interior and exterior cycling air doors, the mixed air door, the central air door, and the defrosting air door. The interior and exterior cycling air doors are used to control the new air proportion of the auto air conditioning, and the central air door is used to control the flowing direction, and the defrosting air door is used to control the opening and closing of the defrosting air door, and the mixed air door is used to control the mixed proportion of the warm air and the cold air, and when the cold airs are needed, the warm airs will be blocked, and the cold air channels will be opened to release the cold airs, at the same time, when the warm airs are needed, the cold airs will be needed, and all warm air channels will be opened to release warm airs. By adjusting the positions of these four air doors, the conditioning function of air in the car will be realized.

The tested air conditioning system includes five sensors at different positions in the car, and the interior temperature sensor on the control panel is used to test the temperature in the car, and the foot sensor at the foot air door is used to test the foot blowing temperature, and the temperature sensor on the bumper is used to test the temperature out of the car, and the temperature sensor at the inlet opening is used to test the inlet air temperature, and the sun sensor under the middle of windshield is used to test the sunniness intensity. The signals of five sensors are in 0~5V, and they are sent to the SCM in the controller to analyze and judge, being the reference signals to exert the function.

The tester must complete various tests of the air conditioning controller, including the power on self test, the fan humidity test, the exterior humidity test, the interior humidity test, the mode motor test, the temperature motor test, the cycling motor test, the fan test, and the back defrosting test. The tester could provide the power supply for the air conditioning controller, and automatically adjust the controller to make it work in the state point, and the input signals and the power supply of the tester must ensure the security of the air conditioning controller, and the tester is required to change the state of the air conditioning controller, and it must have the self-testing function.

3. Whole design of the system

Starting from the testing signal characteristics and the testing requirements of the air conditioning controller, the tester system is composed by the IPC, A/D, D/A, DI/O interface board and boilerplate. The system principle structure is seen in Figure 2. The data acquisition project based on the PCI bus is adopted in this system, including 16 bits A/D acquisition card, 12 bits D/A card, 16 bits channel DI/O card, and the output signals of the main control computer could control the air conditioning controller through isolation and adjustment, and the output signals of the controller is collected and disposed by the main control computer through isolation and adjustment. The tester software system adopts the LabWindow/CVI and SQL ToolKit database development platform of the NI Company. CVI is an interactive ANSIC language development platform which supports the interfaces of various instruments, with the support of good bottom hardware, and it is high-effective virtual instrument programming platform with various intuitional instruments and meters. According to the technical requirements of the comprehensive tester and the testing work flow of the air conditioning controller, the tester software system is mainly divided into three modules, i.e. the system management, the software testing, and the result management.

4. Hardware implementation

The hardware includes the data acquisition circuit plate and the data transmission. The data acquisition adopts the analogy and digital circuits, and the data transmission adopts the PC serial communication and the special bus conversion interface of the General Motors.

4.1 Data acquisition

The data acquisition is mainly completed by the data acquisition circuit card and the circuit interface of the meters to follow and sampling the data. The successive circuit will filter the signals and eliminate unnecessary interfering signals (including the high frequency signals), and because part signals are weak, so some signals will be amplified to quantize above analog signals for the PC to analyze and dispose these signals, and the sampling points and filtering are controlled by the PC machine.

4.2 Data communication

The air conditioning controller and the PC communication adopt the serial transmission protocol, but the controller could not communicate with PC directly, and it needs the special Class 2 communication conversion equipment of the General Motors. Class 2 is a kind of locale communication bus, and it is the special bus system of the General Motors, being similar with the CAN bus, and the used order system is special for the General Motors. Because the tested air conditioning controller is used for general autos, so this communication bus system is used in this system. The communication process could be described as that the working state of the air conditioning controller is simulated through the serial control order, and according to the testing items, the relative control orders transmitted by other parts in the car are simulated to make the controller act according to the requirements, or read and write the data of EEROM.

5. Software implementation

5.1 Performance testing

The testing software is mainly divided into the voltage and current testing part and the function testing part. The voltage and current testing part mainly includes the static current testing, the battery pin current, the ignition pin current, the interior illumination pin current, the reference voltage, and the interior illumination voltage in the working state. This part also adds some additive items including the backlight testing and the node testing. The function testing part is the main part of the controller, and it mainly includes the wind speed switch function testing, the front temperature control testing, the mode control testing, the AC function testing, the back defrosting button function testing, the AI button function testing, the assistant wind motor control testing, and the DTC function testing.

(1) The temperature and voltage testing. This testing is to control the testing meters by the RS232 serial port, read the current and voltage values on the meter end, demarcate the acquired data in the software, compare the values appointed by the manufacturers, and judge whether the meter is eligible, and display it on the software interface.

(2) The wind speed switches testing. By whirling the wind speed switch, the wind speed control could control the rotating speed of the wind speed motor. The position of OFF means to close the motor, and the positions of 1, 2, 3, 4, and 5 respectively denote the sequent increase of the wind motor, and the positions of 1, 2, 3, 4 link with a resistance module, and the position of 5 is directly controlled by a high-speed relay. The value on the controller end of the hardware will be reflected on the software interface real time, and the testing personnel only needs to compare whether the controller is consistent with the indication position on the interface, to judge whether the wind speed switch of the controller is eligible.

(3) The temperature control testing. The temperature adjustment could be realized by controlling the change of the resistance value of the potentiometer, and the temperature control is realized by controlling the motor position of the mixed air door, and different positions of air door represent different temperatures. The DC motor is adopted, and the motor has the feedback potentiometer which could be adjusted itself to realize the closed loop control. By collecting the feedback voltage of the motor, the testing program could display the position of the current motor on the interface real time.

(4) The mode control testing. This testing is the most pivotal part of the air conditioning controller, and the mode control switch is a 5-position knob switch which controls the outlet wind direction by selecting the mode. The controller has 5 modes, seen in Table 1. Under each mode, the positions of the motors are different, and different combinations could achieve the effects under different modes. For the testing, the feedback voltage collected by the motor could be used to judge whether the correct mode is in use. For example, when the testing personnel knobs the mode switch to the mode of BLEND, three modes will control the motors to rotate until arriving at the appointed position, and here, the feedback voltage of the motor will be compared with the correct feedback voltage under eligible state. The interface will display whether the motor position and the position of the mode switch are eligible, and only by turning the controller switch, the testing personnel could correctly test whether the product is eligible, but not need to test whether the motor is at the right position.

(5) The assistant wind motor control testing. The control mode of the assistant wind motor is the sliding switch, with 5 positions (R+OFF+3gears). When the controller sliding switch is on the position of R, the back controller could control the wind speed of the assistant wind motor, and when the switch is not on the position of R, the front control could control the wind speed of the assistant wind motor. By the hardware, this testing could collect the change values of the controller end to reflect the values on the software interface real time, and the testing personnel could compare the indication positions of the controller and the interface to judge whether the wind

speed switch of the controller is eligible.

(6) The node testing. When the controller works normally, it will send the node information to the Class 2 bus in each 2 seconds, to indicate the controller works normally. The intention of this testing is to test whether this node information is sent, and whether the sending time is 2 seconds, and whether the sent node information is correct. The information of this node and the format is seen in Table 2.

5.2 Interface and data acquisition

The tester must collect the signals in various channels real time and continually, and can realize many functions such as data storage, signal input, and figure display at the same time, so the system must reasonably distribute the system time and adopt the high-speed data caching technology. Except that the motor signals are displayed real time on the panel, other signals are displayed by the digital form or the oscillograph form, and the interface design is seen in Figure 3. To ensure the real-time characteristics of the data acquisition, the display of these signals adopts the time period rolling refurbishing method, and part data is refurbished each time, and the data will be refurbished in each 1.5s. To reduce the data storage time, the data are saved by the 16 bits integer data. To ensure the real-time characteristic of the data acquisition, the data caching technology is adopted, and starting from the testing requirements and the actual instance, the testing program applies 60 MB space of buffer, and all tested data are first saved into the data buffer, not in the disc, until the testing state ends, the data will be saved into the disk. Because the read-write speed of the data buffer equals to the read-write speed of EMS memory and it largely exceeds the speed of the read-write disc, which will save the time and ensure the real-time characteristic of the testing. The real-time data acquisition flow is seen in Figure 4.

5.3 Database management of testing data

The testing signals of the air conditioning controller are numerous, and the testing items are complex, and the testing not only requires to test, display, and storage signals real time, but also analyze and dispose the testing result, and judge the performance of the air conditioning controller, and automatically generate the testing report. Starting from the requirements of the testing, the testing technology based on the database is adopted in this system which could save the signals collected real time, the result of testing analysis by the form of database, and transfer the search result of database to Excel directly to generate the testing report, and return the testing data when searching for the performance analysis and fault diagnosis. The air conditioning controller has many testing signal channels and complex testing types, and in the research, production, and using, the performance and state of the air conditioning controller are required to be recorded to adjust the parameters of the air conditioning controller. In the design, the database management system could solve above problems. In the structured design of the database, the tester integrates the system information (including testing time, the testing type, and the controller type), the control signals, and the testing result into one record of the database. The system could provide the multi-level searching and inquiry based on SQL, and according to the testing type, the testing time, and the controller type, the comprehensive inquiry could be realized, and the search result could be directly enter into Excel to generate the testing report. If the testing result includes the testing data, the testing data could be redisplay offline with different refurbishing speed for the performance analysis and the fault judgment of the controller.

6. Conclusions

Through long time's running and practical using, the testing system has been proved that it has many advantages such as high testing precision, quick testing, simple operation, and clear data management. At present, this system has been successfully applied in the research and production of the air conditioning controller, which has fully validated the reliability, stability, and security of the system.

References

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Table 2. List of the controller working modes

Name of Mode	Air diffusion direction
FRONT DEFROST	Air outlet of front windshield
BLEND	Air outlets of front windshield and floor
UPPER/FACE	Air outlet of meter panel
BILEVEL	Air outlets of meter panel and floor
FLOOR/FOOT	Air outlet of floor

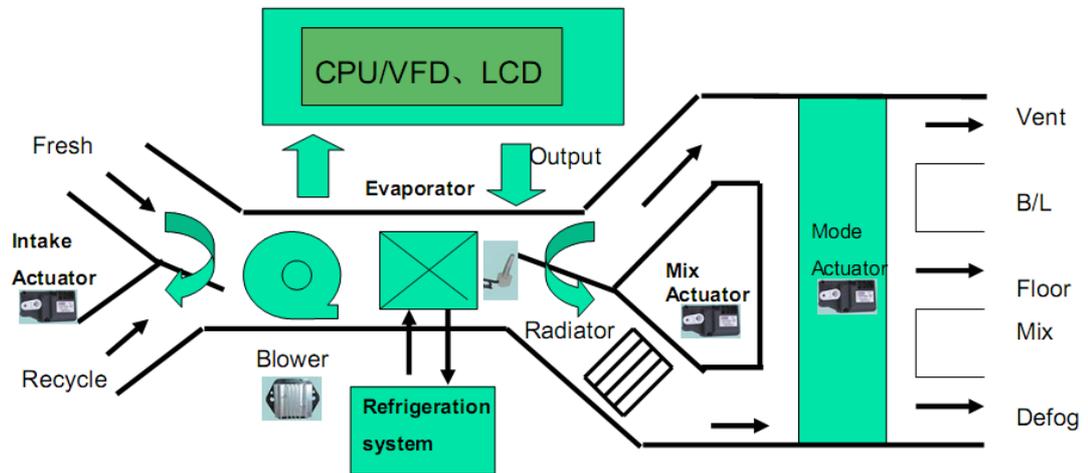


Figure 1. Assembly of the Air Conditioning Controlling System

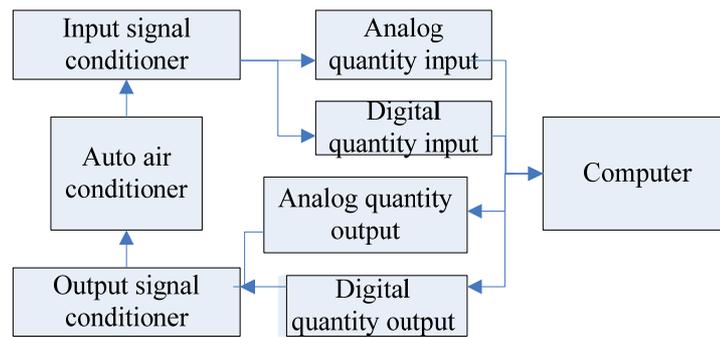


Figure 2. System Principle and Structure

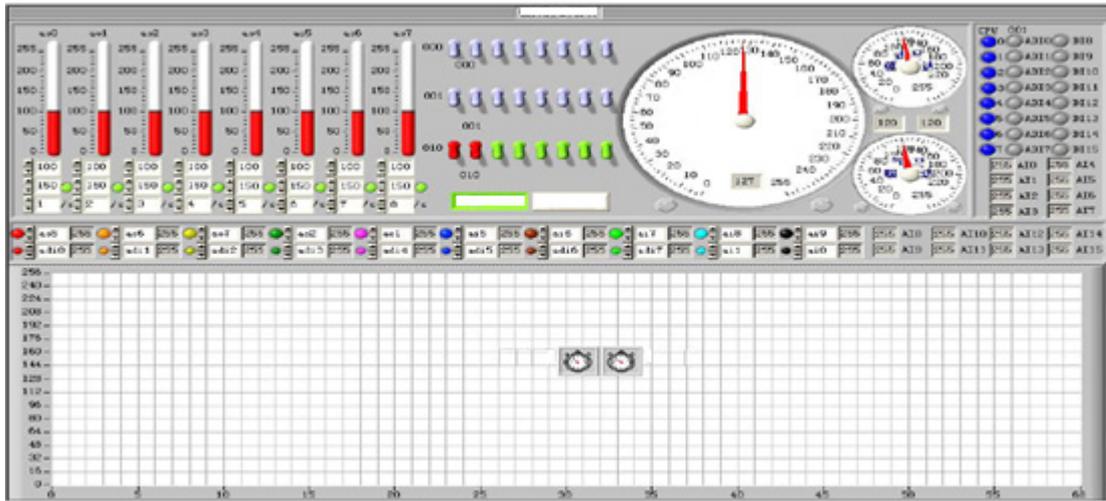


Figure 3. Interface of Testing System

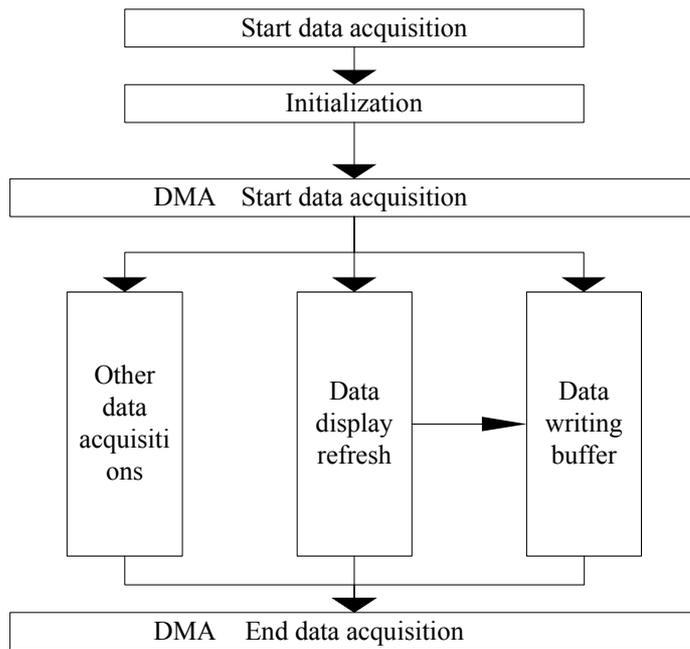


Figure 4. Data Acquisition Flow