Design of a mobile shared test cabinet of auxiliaries controller

Qingyong Zhang1,2*, Shaowei Zou1, Yaru Wang1, Zhenfei Lu1,3, Weiping Lin1

1School of Mechanical and Automotive Engineering, Fujian University of Technology, Fuzhou 350118, China
2Fujian Key Laboratory of Automotive Electronics and Electric Drive (Fujian University of Technology), Fuzhou 350118, China
3Digital Fujian Industrial Manufacturing IOT Lab, Fuzhou 350118, China

*Corresponding author: zhqy@fjut.edu.cn

Abstract. The test parts in the split state of auxiliaries controller used for pure electric bus exists some problems. This paper designs the auxiliary controller through electrical principle design, test cabinet structure design and so on. Through static analysis, simulation of the actual load is performed to verify the strength of the cabinet and the reliability of the design. Finally the design of a mobile shared test cabinet of vehicle auxiliaries controller is completed.

The design of the test cabinet improves the layout of test parts for auxiliary controller, achieves mobile testing, and completes the integration of the corresponding functions. It can save space, clarify function division and store goods, which reduces the burden of testers and make testing easy and simple. It also can reduce operator connection error rate and greatly improve testing efficiency.

1. Introduction

The auxiliary controller is an integrated controller specially designed for new energy vehicles. It is suitable for pure electric passenger cars. According to the number of integrated modules, it can be divided into three-in-one auxiliary controller, four-in-one auxiliary controller etc. It possesses the advantages of modular integration, compact structure and high security advantages, which makes it operate reliably and steadily, widely used in new energy vehicles[1,2].

The functions of auxiliary controller includes insulation test, voltage test, salt spray test, waterproof test and performance test. For performance testing, electric air compressor, power auxiliary motor, testing tooling, computer and batteries occupy a larger space. The application of a portable auxiliary controller test device is becoming more and more convenient. The existing test platforms are basically arranged separately. According to different test items, it integrates the corresponding instruments and equipment. Therefore, it occupies a large space, and also due to the complexity of the circuit it leads to
lower test efficiency and higher error rate. The lack of integrated design of a variety of auxiliary controllers doesn’t make it achieve shared use. The high quality makes it difficult to carry and the single function doesn’t make it test different controllers.

2. **Electrical principle design of test cabinet**

2.1. **Design process**

2.1.1. **The selection of test components.** Based on the electrical system diagram of an electric bus, shown in figure, relevant parts need to be applied:

1) Test tooling is the tool used by accessory controller when testing. It integrates the functions of vehicle control system, receives signals, sends out signals to auxiliary controller and supply power to each module of auxiliary controller through high voltage distribution.

2) Computers are used to run testing procedures.

3) CAN transceiver is used to receive program running signals and send signals to test tooling.

4) The batteries are used for low voltage power supply and DC/DC module output.

5) The main controller converts the DC power into three-phase AC to supply power to the load motor. It also contains the receiving and outputting terminal, in which the receiving signal terminal is connected with the CAN transceiver and the outputting terminal is connected with the load motor.

6) Load motor is used to simulate the running condition of real vehicle.

7) Electric-air compressor motor, electric-assisted motor and the automobile electronic cooling water pump play the different functions.

![Figure 1. Electrical system diagram of an electric bus.](image)

According to the rated power, working voltage and the related functions of each module of the auxiliary controller, combined with the electrical system composition diagram of an electric bus (Fig. 1), the relevant test components are selected.

2.1.2. **The design of the test circuit.** After the regulated power supply passes through the positive and negative distributors, it is divided into the main controller 1, the main controller 2 and the test tooling through insurance and relay. It supplies 540V high voltage power for the main controllers. Two main controllers are designed to avoid being damaged and need to be pre-charged. In order to avoid direct
power-on damage of high voltage to its components, it is necessary to design the circuit, and two main controllers and test tooling need to design insurance and relays for protection. According to the voltage and current, choose relay, fuse and so on. Through testing toolings various kinds of test lines are outputted and the connection terminals are connected to the vehicle accessories controller to provide the corresponding power for the modules in the accessories controller.

The electric air compressor and the electric power assistant of the auxiliary controller are directly connected with the external electric air compressor and the electric power assistant motor through connecting terminals to provide three-phase electricity. Both motors are connected mechanically with two load motors powered by two main controllers. When testing, the load of air compressor and electric power motor is provided to simulate the real vehicle test.

2.2 The result of design.

According to the test circuit, test functions are integrated, and the electrical schematic diagram is designed, shown in Fig. 2

![Electrical schematic diagram](image)

**Figure 2.** Electrical schematic diagram

3. The structural design of the test cabinet

3.1 The design of test cabinet layout

Firstly select the processing technology. Sheet metal has the advantages of small amount of processing, light weight, easy cutting, big strength and shape specification. It can be used to manufacture large and complex parts that meet the requirements of the product's function and appearance, and make stamping die manufacturing simple. Moreover, the production efficiency is high and the production cost is low, so the test cabinet design uses the sheet metal process [5, 6].

Secondly select the processing materials. GB Q235 steel has stable energy dissipation capacity and the yield value is about 235MPa. Because of its moderate carbon content, its comprehensive performance is good, and its properties such as strength, plasticity and welding are well matched. The test cabinet requires that the steel plate used should have good welding performance and cold stamping performance, and also consider reducing the cost of the entire equipment [7, 8]. The test cabinet is designed with Q235A steel plate.
Finally, combined with the common thickness specifications of sheet metal, comprehensively consider the load capacity, cost, refer to the relevant design finished product, the selected sheet metal thickness is 2.0mm.

According to the dimensions of each component integrated in the test cabinet and the layout of each layer, determine the dimensions of the test cabinet. Combined with the design of lines, the integrity of components is ensured. The parts are welded together to ensure that they have certain strength properties[9]. Complete the distribution module, support plate, panel design, test cabinet drawer and keyboard drawer design in turn.

3.2. The design results
The design of mobile auxiliary controller test cabinet is completed, as shown in Fig. 3-Fig. 4.

![Figure 3. Outline diagram of test cabinet](image1)

1. Roof 2. Indicator light 3. Right front prop 4. Computer front panel 5. Computer 6. Test cabinet drawer 7. Embedded handle 8. Keyboard drawers 9. Terminal panel 10. Front panel 11. Floor 12. Universal wheel 13. Left side panel 14. Lock buckle 15. Left rear prop 16. Left front prop 17. Steering knuckle 18. Rear main panel 19. Main control rear panel 20. Right side panel 21. Right rear prop

![Figure 4. Layout diagram of test cabinet](image2)

22. Computer fixed plate 23. Drawer runner 24. Keyboard drawer runner 25. Test tooling 26. Test tooling support plate 27. CAN transceiver 28. Battery pack 29. Battery distribution module support plate 30. Second main controller 31. Support block 32. First main controller 33. Support of second main controller 34. Support rack for battery pack and distribution module 35. Support plate of second main controller 36. Battery block 37. Distribution module 38. Groove 39. Insulation detector 40. Socket 41. Socket box

![Figure 4. Layout diagram of test cabinet](image3)
4. Discussion on design reliability

4.1. The finite element model of the test cabinet
The type of grid mainly depends on the geometry of the structure, the load applied and the required calculation precision. The cabinet is mostly shaped with thin plate parts. The main controller and battery pack are reduced to the quality points. The test cabinet adopts Q235 and the Young modulus is 210GPa and Poisson ratio is 0.3. The finite element model after mesh division is shown in Fig. 5.

![Figure 5. Mesh generation of the model](image)

4.2. Imposition of load
The main load of the test cabinet is the first four layers, namely the layer of the first main controller, the layer of the second main controller, the layer of battery pack and the layer of distribution module. The load analysis is only applied to these four layers. Among them, the additional load of the layer of first control is 200 N vertical plane downward force, the additional load of the layer of the second control is 200 N vertical plane downward force. The additional load on the layer of battery group and the layer of distribution module is 200 N vertical plane downward force, and the additional load on the layer of tooling is 50 N vertical plane downward force.

The entire test cabinet is supported and fixed by four universal wheels, so the two bottom surfaces of the universal wheels are completely restrained by the simplification.

4.3. Result analysis
The analysis results are shown in Fig. 6 and Fig. 7.

![Figure 6. Equivalent stress diagram of model](image)  ![Figure 7. Results of model deformation](image)

According to the analysis results, the maximum deformation of the cabinet is 0.052mm, and the maximum stress is 2.085Mpa. Compared with the mechanical performance parameters of structural steel Q235, the design strength and rigidity of the cabinet meet the design requirements, and the design is reliable. According to the analysis chart, the test cabinet has a large stress on the welding of the
support frame. Therefore, it is necessary to carry out proper reinforcement during processing to increase the structural strength of the bottom of the cabinet or to select a higher strength material.

5. Conclusion

In this paper, through the design of electrical principle and test cabinet structure, the mobile test cabinet of vehicle accessory controller is developed and the static analysis is performed to analyze the strength of the cabinet structure. Through simulating the strength of the cabinet in the actual load test, the reliability of the test cabinet is verified. The test cabinet has the advantages of compact structure, space saving, functional integrated partition, high efficiency, high reliability, low maintenance cost and shared test cabinet is realized.

This design breaks through the design of the existing test cabinet, and modularize integration of the test tooling of auxiliary parts controller of pure electric buses. Besides, the ingenious design can be adapted to the testing of a variety of auxiliary parts controller of different vehicles, which is also very advantageous in performance.

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